ERICSSON

REDESIGN & SUSTAINABILITY ANALYSIS - REMOTE RADIO UNIT & CARRYING FEATURE

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ABSTRACT

The competition on the telecom market is becoming tougher every day. Large Chinese companies are growing fast, competing for the world's customers. Ericsson AB is to this day one of the largest actors on the market, known for their high quality products, telecom innovations as well as their sustainability work. These are all areas which has taken the company to the top, where it intends to stay for a long time ahead.

Ericsson AB's portable telecom products are becoming smaller and smaller all the time. New technologies of better and faster telecom solutions puts higher demands on these products. The company wants to further strengthen their brand through visual and sustainable design. A large step towards this differentiation has come through the implementation of a uniform design language. One aspect which Ericsson AB wants to improve is the intrusion on the semantic expression of these products by their handles. By performing a thorough analysis on the previous handles, competitors and other types of handles as well as performing users studies several innovative carrying feature concepts has been derived. Through evaluating the concepts with Ericsson AB, a slim, subtle, flexible yet ergonomically adapted handle has been developed. It has been refined and developed to fit the requirements of Ericsson AB and their customers as well as being well adapted towards proper ergonomic handling of heavy items.

To finalise the handle and providing the possibility properly evaluating the mechanical and industrial design of the concept, a rapid prototyping the mock-up has been produced. It is fully working and possible for Ericsson AB to benchmark and by minor adjustments take into production. As a final step in the process of this thesis, Ericsson AB got a patent, for this flexible and modular carrying solution granted in the spring of 2013.

Parallel to the handle redesign, a thorough sustainability analysis of Ericsson AB sustainability work and the product of Remote Radio Unit (RRUS) 12 was performed. The sustainability analysis showed what parts of the product are impacting the environment the most, established through a l ife cycle analysis. It also shows how Ericsson AB can improve their sustainability work by collaboration within the organisation. The result is compiled as number of sustainability guidelines, a map of the present materials used within the RRUS 12 as well as other possible materials, a map over transportation routes and finally data from the life cycle analysis.

The thesis provides Ericsson AB both with a new finalised innovative, flexible and modular handle for their portable products as well as a thorough analysis on how their sustainable work and design can be further improved.

ACKNOWLEDGEMENTS

For this master thesis to become reality, Chief Technology Officer at Ericsson AB, Ulf Ewaldsson has been of great significance. I am deeply thankful for getting the opportunity to work with a world leading company, to further develop my skills in engineering and sustainable industrial design.

Throughout the process of writing this thesis, many actors within the organisation of Ericsson AB has been important in helping me reaching the aim. First of all Mikeal Thelin Manager at Ericsson AB Industrial design has been of great assistance and guidance. Mr Thelin has provided information and been very helpful in the process of decision making, which has led to the final result of the thesis.

Jens Kallin at the Ericsson AB Industrial design department has throughout the whole process of this thesis been a very good source of information, opinions and assistance. I would like to thank Jens for his kind participation and patience during the this 20 week period.

During the pre-study, material engineer Anders Pettersson of Ericsson AB has provided information for the sustainability analysis as well as for the material selection for the final design. Stephen Rodgers and Richard Trankell of Ericsson AB provided valuable data on recycling and the company's sustainability work. To know how and what packaging materials are used by Ericsson AB through the process of production, assembly and selling of products, Beatrice Buzsaky Johansson and Jonathan Huele has been very helpful.

For assistance regarding mechanical design and technical solutions, mechanical designer and engineer, Tom Andersson has been very obliging and understanding in providing useful information and demands. Anders Jaghe helped out in the final stages of the ideation process, providing possible mechanical solutions in solving a flexible handle.

To be able to perform and compile the data gathered from the usability-test, three test-users were kind enough to participate and provide this data on the usage-situation of the present RRUS 01 & 11 handles. I would like to thank Ulf Williamsson, who also was helpful during the evaluation process, Torsten Ericsson and Johan Jakobsson for their participation.

Mats Johansson of Ericsson AB has been very helpful in providing accurate data on usability and ergonomic aspects regarding handles. During the design process, Ericsson AB has, parallel to this thesis, been developing a concept handle for the 2012 Mobile World Congress in Barcelona. Main performer of this project was Oriol Mogas Bartomeu, he has been of great significance in supporting the carrying feature redesign of this thesis as well as CAD-modelling.

As a final stage of the thesis, a rapid prototype-mock-up was made of the redesigned carrying feature concept. To be able to produce this mock-up, Bertil Logstedt at Ericsson AB mechanical workshop in Kista, Sweden has been very helpful.

My mentor at Chalmers University of Technology, Pontus Engelbrektsson, has assisted me with feedback when needed.

As a final word I would like to thank all of Ericsson AB and especially the Industrial design department in letting and helping me to realise this master thesis.

Yours Sincerely

Hampus Regnér

EXPLANATIONS

"0-Position" - The position of the flexible handle when it is not interacted with. A subtle and slided/folded down position of the carrying feature

Base-plate (Brackets) - The area which connects the grip-area of the handle to the RRUs. Either integrated into the handle or separate parts which are connected to the grip-area of the handle

Cable-connections - The part which enables cables to be connected to the RRUs to provide communication and power. A specially designed cable-socket commonly placed in the bottom of the RRUs

Carrying feature - A feature which enables carrying and lifting of an item, such as a handle or harness

C-C - Centre to centre, regarding the distance between the centres of two holes

CoG - Centre of gravitation

Internal-body - The body of the RRUs products holding and shielding the internal technical features.

Cut-out - a part of the product which is "chopped off" exposing a different layer of the product. It can be an immersed area of the product which is visible as well as enabling some kind of function

DfD - Design for Disassembly, a method of designing products to enable easier disassembly

DfE - Design for Environment, a department within the Ericsson AB organisation

Drop and stop - When a product is dropped and then stopped in mid air when being hoisted. This puts large forces on the carrying feature as well as the product

Finger-grooves - Grooves in a grip which allows the fingers to fit firmly to the handle

Grip-area - The area on the handle which the palm of the user's hand grips around

Grip-space - The area of space in-between the bottom of a handle and the surface below. This is the area in which the fingers are placed when gripping a handle through a power-grip

HL94 - Fire resistance standard used within choice of materials

Portable product - Referring to a RRUs or any other smaller radio tower mast placed product possible to carrying by a single user

Power-grip - A type of grip which allows the user's hand to get a steady and firm grip around, for example, a handle

Remote Radio Unit, RRUs - A device which sends, transmits and converts radio data signals to enable wireless mobile communication

Radio tower mast - a steel tower where telecom devices are placed for receiving and transmitting data signals. The steel tower can be sited in cities or at site-locations of communication-stations

Sealing and fastener spline (spline) - The spline which seals and joint the two halves of the internal-body. Housing a sealing gasket as well as screw-joints, securing water-resistance of the product and sealing the technical features housed inside

Specialists and service-installation workers - Persons installing and mounting Ericsson RRUs and other telecom devices to enable mobile communication

Sun-cover - The exterior plastic cover of the RRUs, shielding the internal-body from outer forces.

"Words of value" - Words which are derived from and in combination of the image- and expression-broad. The "Words of value" are to portray the images, showing what the product is portraying and is to portray when redesigned

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1. INTRODUCTION

1.1 Background

As the competitive situation is constantly growing, it is necessary to differentiate products, from the competitor's, to be able to successfully compete on the market. One way of doing this is through design; visual design as well as functionality, usability as well as sustainability.

The telecom market is undergoing constant expansive growth and Ericsson AB has a clear focus on competitive differentiation. The differentiation is not only visible through quality and reliability of their products, but also through providing a uniform visual expression as well as improved functionality and usability. With the newly initiated Industrial design department at Ericsson Kista, a lot of the product development has come to include more optimised design. This includes design which is to portray Ericsson AB's core-values, heritage as well as providing user-optimised products.

The competition on the market has grown considerably the last few years and Ericsson AB's competitors, mainly large Chinese telecom providers, offer cheap solutions which compete for the users all over the world. Ericsson AB is known for its quality products, but with today's tough competition it is important to differentiate the company through many different aspects. Ericsson AB has the advantage of the strong Swedish design heritage as well as the current social interest in sustainability.

Remote Radio Units (RRUs) are one of the current products in the Ericsson AB product family, and works as transmitters for telecom/radio signals, such as 3G-networks.

1.2 Purpose

The purpose of this master thesis is to contribute to strengthening the Ericsson AB's RRUs on the market, which will help differentiate the product from the competitors'. Through redesign, improve the usability, functionality and visual aesthetics of the carrying feature and by this improve the semantic expression of the RRUs as a whole. The redesign shall help to better suit the needs of the users; specialists and service-installation workers.

Another purpose is through a sustainability analysis of the reference RRUs optimise choice of materials, production, upgradability, modularity and recycling. By regarding the environmental impact, it will strengthen the products through a social responsibility. The sustainability analysis can also provide improvements as well as providing cheaper and alternative choice of materials, transportation and production methods.

1.3 Aim

One of the two major aims of this master thesis is to analyse and redesign the carrying feature of Ericsson's Remote Radio Units, RRU. The RRUs consist of a product family of approximately ten units, where three present models will work as reference products for the redesign. The redesign will focus on the carrying feature, and the final result will be presented as a realistic concept which has taken some regard to production possibilities. It will include improvements on the carrying feature's usability, functionality, visual aesthetics as well as environmental impact and to some extent production possibilities. The carrying feature shall work for several portable products varying from 5 to 40 Kg.

The second aim of the thesis is to distinguish an environmentally sustainable profile for the RRUs product group. The sustainable profile will be portrayed, in the best possible way, through optimisation of the environmental impact of the product. The sustainability profile will be compiled from an analysis of the reference RRUs and the company's methods of sustainability work.

The redesign shall be based on usability, sustainability and Ericsson AB's design values. The thesis will not consider function of the RRUs, how it transmits data or the stations where it is being placed.

1.4 Objectives

Provide a finalized redesigned concept of the RRUs carrying feature, based on a thorough analysis.

- The final concept will be visualized, CAD-model and possibly a mock-up
- The redesign should be well adapted and uniform to the design of the current Ericsson AB RRUs product family
- The final concept shall have regarded the topic of sustainability to minimise the environmental impact.
- The redesign shall be based on the analysis of the users, for optimal improved usage
- The redesign shall be performed so that the final concept has taken production possibilities in regard and is suited to work with the existing functions and components on Ericsson AB's RRUs
- The sustainability analysis will foremost deal with choice of materials, production methods, upgradability, modularity, recycling and Ericsson AB's sustainability work

1. INTRODUCTION

1.5 Methods

Several relevant product development methods has been used to optimise the redesign, to achieve the best result possible.

The methods used will all relate to methods educated at the engineering programme; Industrial design engineering at Chalmers University of Technology, with restriction to some adaptations to suite the project.

1.5.1 Pre-study

Product analysis - Ericsson AB and reference RRUs

In order to fully understand the background of the project and what shall be redesigned, it is important to analyse the company and the products thoroughly. The product analysis will include design, functionality, quality, usability and sustainability.

Image board

It is important at an early stage conclude what the reference products represents and transmits. An easy way to do this is to gather images related to the products, in an image board. The images portrays in what situation the products are used and what they represents, this has worked as a foundation for the redesign. The image board has been used in the initial stages of the pre-study.

Competitor analysis

To be able to conclude Ericsson AB's situation and position on the market, it was important to perform a competitor analysis. Ericsson AB's major competitors on RRUs will, in the best possible way, be analysed on design, functionality, quality, usability and sustainability. The competitor analysis has been crucial when redesigning the carrying feature. It has layed the foundation, together with the product analysis, on the redesign and also to distinguish how to differentiate the carrying feature from the competitors'.

SWOT-analysis

A SWOT-analysis was used to show and understand Ericsson AB's strengths, weaknesses, opportunities as well as threats. The information has been vital in providing help when redesigning the carrying feature. It has portrayed what had to be regarded for the carrying feature to strengthen Ericsson AB's role on the market. The SWOT-analysis has been regarded together with other information gathered in the pre-study.

Sustainability analysis

The two reference RRUs has been analysed in a sustainability perspective, with the focus on choice of material, production methods, upgradability, modularity, transportation, recycling and Ericsson AB's sustainability work. As sustainability is a recent topic of focus for Ericsson AB, it is important to obtain a sustainability profile for their RRUs. The analysis includes a life cycle assessment and states what sustainability aspects to regard for the future design and development of RRUs.

Usability- & user-test

As the RRUs are foremost handled by specialists and service-installation workers, it was important for the redesign to fully suit the user's needs. Users was asked to participate in a survey concerning the use of the references RRUs carrying features to find possible improvements which was evaluated.

Interviews

As part of the analysis, it was important to gather information from relevant actors. This has be done through interviews, both with developers, manufacturers and users.

1.5.2 Design process

Expression board

The expression board shows what the finished redesigned concept shall portray and represent. The expression board was made in the initial stages of the design process and works as a guideline throughout the design process.

Mind-mapping

To find possible solutions of how to enable a new type of integrated subtle carrying feature, a mind-map was performed. In the mind-map all possible ideas generated was linked together which led to many innovative concepts to get generated.

Brainstorming

One obvious and easy method to generate ideas and concepts is to brainstorm everything that comes to mind and put it on paper. Every idea is worth considering as it might have features that can be of use for the redesign. The brainstorm was adapted to suit the situation and was performed solo as well as together with relevant actors.

1. INTRODUCTION

Sketching

As a compliment to brainstorming, sketching was used for ideation and concept generation. Sketching was an iterative process throughout the whole design phase, as this process was a constant flow.

Prototyping

During the redesign, prototyping was a vital tool to generate and evaluate ideas and concepts. Prototyping consists of making very basic prototypes to portray concepts and get a tactile and visual interpretation of the product.

Pugh-matrix

To evaluate concepts and ideas generated in the ideation process, a Pugh-Matrix was used. Generated concepts was weighted towards the present carrying features of reference RRUs on how well they fulfil the required and relevant aspects.

Evaluation meetings

To evaluate concepts generated and conclude which concept to further develop and finalise, evaluation meetings was set up with relevant actors at Ericsson AB. The opinion and knowledge of relevant actors was crucial when concluding which concept was most suitable in regard to the requirements of the project and Ericsson AB.

1.6 Flow chart

To be able to hold maximum control of the project, a flow chart has been created. The flow chart helps to keep the project on track and control where each process fits into the project as a whole. The flow chart will be of guidance throughout the whole master thesis. See Picture 1.1 - Flow chart.

1.7 Time frame - GANTT chart

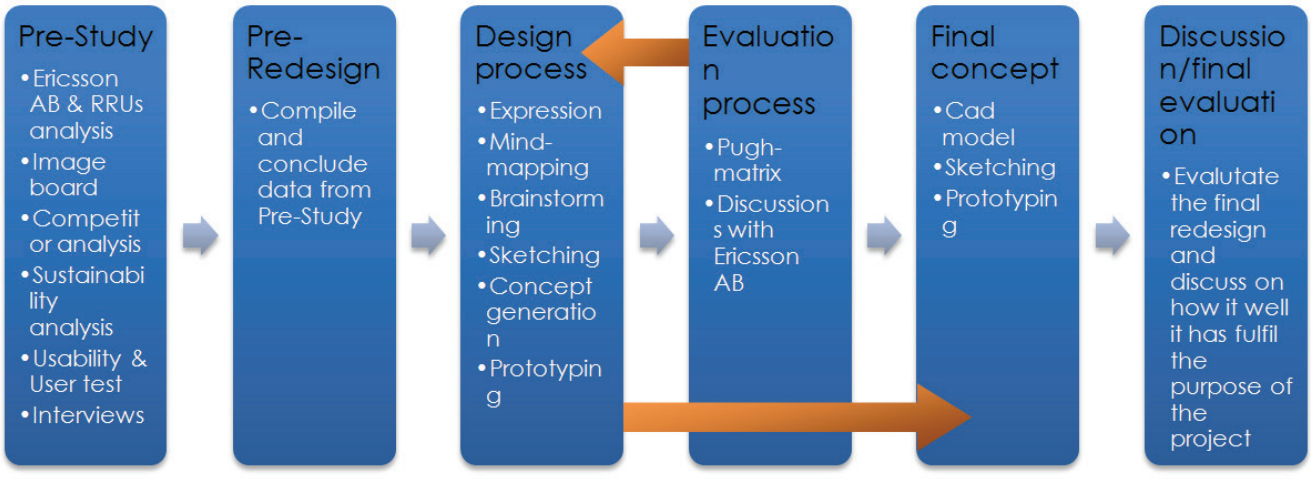
As the project is large and stretches over 20+ weeks, it is necessary to in the best possible way make thorough time plan. The time plan will help to keep the project on track, and it is easy to cross off finished parts. The time schedule is portrayed as a Gantt-chart and shows when each part/ process is to be dealt with. The project will stretch from 1st off November 2011 till the 30th of March 2012. See Appendix I - GANTT Chart.

1.8 Areas of focus

This master thesis has the possibilities of being extremely large. There is an obvious need to focus the "areas of concern" to be able to optimise the redesign within the time frame. As the product is not a commercial "every man's product" there is no need for an exclusive focus on visual aesthetics, however it defiantly has to be considered and will be dealt with regarding to Ericsson AB's design-values. Visual design can also help the product to blend into the environment it is being placed and used in.

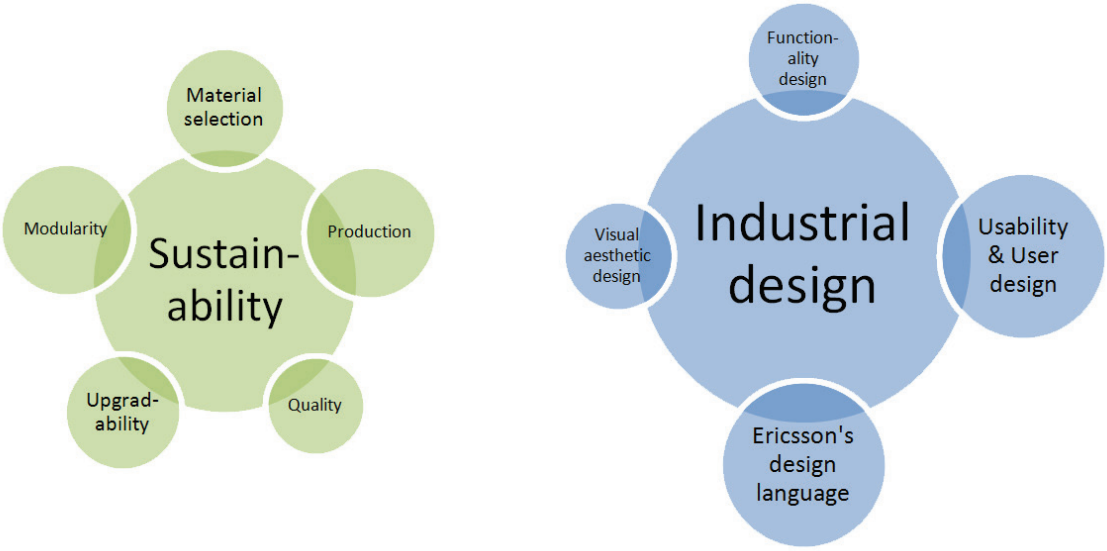
The users of Ericsson AB's RRUs are foremost specialists and service-installation workers, so there is a great need to address the redesign to their needs. This leads to focus the "areas of concern" towards usability, functionality and innovation. The redesign shall concern optimisation in regard to usage of the carrying feature of the RRUs.

One aspect of great concern for Ericsson AB as well as a necessity for competing on today's market is sustainability. The aspect of sustainability will be a focus area throughout the master thesis. It will be a significant part of the pre-study as well as the design phase. See Picture 1.2 - Areas of focus.



Picture 1.1 - Flow chart. Regnér (2011).

1. INTRODUCTION



Picture 1.2 - Area of focus. Regnér (2011). The size of the figures are the weight of concern they will have throughout the master thesis.

1.9 Risk analysis

There are possible situations, mainly during the pre-study, where outer forces may affect the time schedule and process of the project. The excursions, usability and user tests involves other participants which means that the time schedule has to, possibly, be adapted to fit the needs of everyone involved. There is a need to be aware of the possibility of a slow flow and a "bottleneck-effect". The main parts of the master thesis that might slow down the flow are; The competitor analysis: as it might be hard to find accurate and valid data from the competitors. The usability- and users-tests, interviews as well as manufacturing of the mock-up are areas in risk, as these parts are dependent on other participants.

1.10 List of Requirements

To be able to know what the redesigned carrying feature is to fulfil, a thorough List of Requirements has been established together with Ericsson AB and the manager of industrial design department, Mikael Thelin. The list will help established and conclude how the carrying feature is to work, for it to be suitable for Ericsson AB and their customers. The list is to be closely regarded and referred to during the redesign-process.

2. PRE-STUDY

2.1 Ericsson AB - A brief introduction

Ericsson AB is a large Swedish Telecom company initiated in 1878 by Lars Magnus Ericsson. Since the beginning Ericsson AB has always been inventing the future and crossing boundaries through providing telecom services worldwide. As a world leading telecom-company with over 40% of the worlds mobile services running through the company's products, Ericsson has loyal customers in over 180 countries worldwide.

Ericsson AB alone stands for many groundbreaking inventions such as; GSM, 3G, 4G, Bluetooth and many more solutions, which have totally change our society to this day. Kallin (2011).

As a world leading company, Ericsson AB has a clear vision and set of core-values which can be seen throughout their line of products. ERICSSON AB - Company facts (2011).

- Vision - In an all-communicating world, be the initiator and Prime Driver who will lead the way into the future. Help and ease people all over the world to communicate through voice, data, images and video in a fun and easy way. ERICSSON AB - Company facts (2011).

- Core-values - Respect, professionalism and perseverance can be seen in the company's work, way's of business and how they connect to people all over the world. ERICSSON AB - Company facts (2011).

Sustainability is a major point of interest for Ericsson AB, due to constant environmental stress. The company puts great efforts into reducing its environmental impact as well as contributing to minimizing world wide poverty. This is partly done through providing communication solutions and ensuring that technology is a force of good and lasting change. ERICSSON AB - Corporate responsebility (2011).

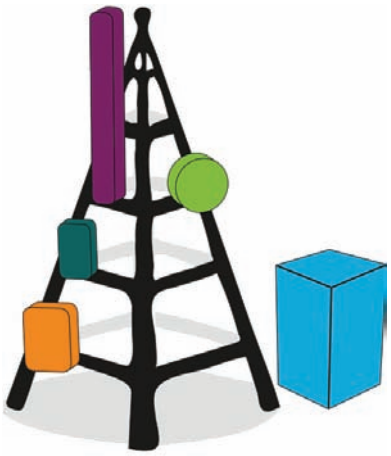
The vision and core-values will be important factors to acknowledge in this thesis.

2.2 Remote Radio Unit - Background

Remote Radio Units (RRUs) are used to send and receive radio data for mobile communication. It is a vital part of the transmitting system of mobile communication. The RRUs works together with a Digital Unit, which converts radio codes to digital codes for 3G and 4G networks, and an Antenna which transmits the digital coding. The RRUs can also work together with a Mini Link, which wirelessly transmits data between the communication stations. See Picture 2.1 - Radio tower mast. However the Mini Link is not required to use with the RRUs and the Antenna, instead cables could be used to transmit data between communication stations. Kallin (2011).

Instead of using a Remote Radio Unit and a Digital Unit separate, these can be incorporated in a ground based Radio Based Station, RBS. However, the radio transmitting unit is called Radio Unit when placed inside the RBS instead of using a Remote Radio Unit. Only the radio tower masts and wall mounted Remote Radio Units will be dealt with in this master thesis.

One interesting aspect of Ericsson AB's products, which also goes for their RRUs, is that the buyer of the products is not the same person who is using it. The product is not a consumers market product, and the users dealing with the product is foremost specialists, installation workers and to some extent manufacturers. Kallin (2011).



Picture 2.1 - Radio tower mast. Kallin (2011).

Radio Remote Unit (RRU) - Large rounded box

Data Unit (DU) - Small rounded box

Antenna - Rectangular shape

Mini Link - Cylinder

Radio Based Station (RBS) - Large box with sharp edges

2. PRE-STUDY

2.3 Design-values

Ericsson AB uses a very clear and distinctive design process and way of designing, in all their products dealing with transmitting telecom data. The method consist of dividing the product into different layers, which hold different kinds of expressions, choice of materials, tolerances, production methods and usability aspects. These desgn-values are under implementation within Ericsson AB, and products developed prior to 2011 has not ben designed with this in regard. ERICSSON AB - Design-Values (2011). The design-values unifies the semantic expression of Ericsson AB's products and helps differentiate the products from the competitors'. Thelin (2011).

The combination of the different "product layers" all play a vital part in making the design expression as a whole. The external layer is the one most "present" to the spectator and consists of a glossy high quality finish plastic. The internal layers are more strucual and are made of cast aluminium with a finish of not as high quality with rougher surface. ERICSSON AB - Design-Values (2011). Different layers holds different colour tones, the "structureal" internal-body parts are of a darker grayish tone while the external plastic casing is of a lighter grayish tone. Parts intended for or indication of human interaction are differentiated with accent colours, differentiating them from the external and internal parts. ERICSSON AB - Design-Values (2011).

Picture 2.2 - Ericsson AB RRUS 12, Design Language shows the design language of Ericsson AB. The lighter coloured gray of the external plastic sun-cover is of very high finsish. The rougher internal-body of a darker gray tone is of a rougher metal finish. The handle is in this case seen as a part of the interna-body, why it holds the same colour scheme and material. ERICSSON AB - Design-Values (2011).

Picture 2.2 - Ericsson AB RRUS 12, Design Language. Kallin (2011)

2.4 Remote Radio Unit - The reference products

For the redesign of the carrying feature, three of Ericsson AB's present RRUs and their carrying features will work as reference products. These three RRUs are representative for the product family; the RRUS 01 is the first and latest generation single TX (band) RRUs and RRUS 11 is the first generation of dual TX (band) RRUs developed by Ericsson AB. See Picture 2.3 - Ericsson AB RRUS 01, See Picture 2.4 - Ericsson AB RRUS 11. Together with the RRUS 11 will the RRUS 12 be acknowledged as this is the latest updated RRUs about to be released in 2012. The RRUS 12 holds a visual and technical facelift compared to the RRUS 11. The RRUS 12 shown at the 2011 & 2012 Mobile World Congress in Barcelona was designed after the new design-values. See Picture 2.5 - Ericsson AB RRUS 12, Barcelona 12 Handle. Both reference products, RRUS 01 and 11 are still in production and are being used by telecom providers all around the world. However, none of them have been developed in regard of the new design-values. Kallin (2011).

Picture 2.3 - Ericsson AB RRUS 01. Regnér (2011)

Picture 2.4 - Ericsson AB RRUS 11. Kallin (2011)

2. PRE-STUDY

Picture 2.5 - Ericsson AB RRUS 12, Barcelona 12 Handle. Kallin (2011)

2.4.1 RRUs features

The Remote Radio Units shall house a lot technical features. Features that are to be housed in the RRU:

- A cooling system
- Inlet and outlet of air for the cooling system
- House necessary electronic parts - Transmitters, receivers, power units
- Cable-connection possibilities - in- and outlet cables
- Possibilities of opening up the product for installation and repairs
- A protective cover which shields the technical function from outer forces such as weather and theft
- A steady durable mount for attaching the product to a radio tower mast or a wall
- Carrying feature - for the product to be carried with and/or hoisted by by the installation and service workers (sometimes used and installed in rough and harsh environments)

It is important to consider the parts of the features listed above and try to optimise them in a design, usability and sustainability perspective for the redesign to fulfil all the requirements.

A RRU can weigh up to 40 kg and is sometimes to be carried to the height of 150 meter up into radio towers masts. However the RRUs did not always hold any kind handle/carrying feature which disables easy handling. It is not uncommon for the buyer to ask for customised products, without a carrying feature. The carrying feature is sometimes considered to add unnecessary weight and volume. Thelin (2011).

A RRUs consists of a radio unit among other things, which sends and transmits radio data. This technical part is only a small physical part of the RRUs as a whole. The major part of the product consists of an "structural" internal-body and cooling flanges which helps air to flow through the product to cool the technical parts, otherwise risking overheating. See Picture 2.6 - Cooling flanges. Cooling flanges are used instead of fans as they minimise the risk of failure, a broken fan will be hard to replace when the RRUs is placed in a rough environment. Thelin (2011).

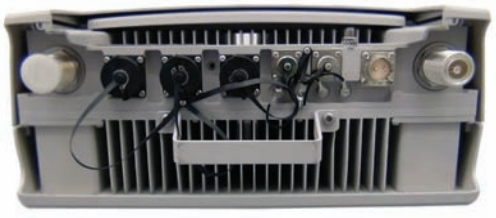
Picture 2.6 - Cooling flanges, RRUs 11 Regnér (2011)

For air to pass through the cooling flanges, the RRUs are fully open in the bottom and top of the sun-cover. In some cases are the back of the product open to some extent for air to flow through freely. As a RRUs is not always placed vertically, it is important to have outlets aiming upwards for the warm air to leave the cooling flanges. When a product is placed on an angle which does not let warm air exit through the top of the RRU, the performance is drastically lowered. Providing good air-flow within the products is extremely important for the performance to be optimised. Kallin (2011).

There is very little space within the internal-body to house a handle, as most of the die-casted aluminium is needed to house the vital technical features and cooling flanges. All the material and volume of the RRUs fills a function. This indicates that there is no room to house a carrying feature integrated into the internal-body, not fitted on the outside. Thelin (2011). If the carrying feature shall be integrated, the total volume of the product will be increased due to the low free space. Ericsson AB does not include handle, feet and external sun-cover when calculating the total volume of a product. This means that adding an integrated handle will increase the volume.

For the RRUs to work it needs power, this is delivered by cables connected to the product. The radio signals and data is also transmitted and received through cables leading to and from the RRUs. An alarm-function is also connected to the RRUs through cables. All reference products have their cable outlets in the bottom of the product. See Picture 2.7 - Cable-connection. Kallin (2011).

2. PRE-STUDY



Picture 2.7 - Cable-connections RRUS 11. Regnér (2011)

For the specialists and the service installation workers to properly install and service the RRUs, they have to be able to easily interact with the crucial features of the RRU. This is done through lifting or dismounting of the sun-cover which shields the crucial features from outer forces. The sun-cover of the RRUs is designed to be able to open; only using one hand. The service installation workers often have to hold on to the radio tower mast with his/her other hand. Kallin (2011).

For the RRUs to properly be installed and mounted to a radio tower mast or wall, it needs a steady and durable mount. RRUs do not have to be aimed in a specific direction for them to work properly, so the mount mainly holds the function of steadily securing the product.

The aspect of ergonomic carrying of Ericsson AB's RRUs has not always been a major focus. This is something that has been truly acknowledged the last few years. Ergonomically optimised carrying features are important for the further development of RRUs and other hand handled products. Kallin (2011), Thelin (2011).

2.4.2 Specs

The dimensions and specs of Ericsson AB's RRUs vary some between the three reference RRUs, most products are of the similar size and weight. The actual weight of the reference products are similar; the RRUS 01 hold a weight of approximately 20 kg while the RRUS 11 weights around 22 kg and the RRUS 12 25 kg. The size dimensions of the RRU varies some as well, the RRUS11 & 12 are approximately 406x446x148 mm, without the handle included in the height, (HxWxD) and the RRUS 01 is 650x350x120 mm. Eriksson (2011).

The product is set to have a lifetime of performing and lasting for up to 10 years. Thelin (2011).

The materials of the reference products vary depending on model and section of the products. RRUS 01 and 11&12 have an internal-body made out of die-cast aluminium. The cover however varies between the reference products, as the RRUS 01 has a cover maid out of bent sheet metal and the RRUS 11&12 has a cover made from injection-moulded PC/ABS-plastic. Pettersson (2011). For further information on materials, See Chapter 2.18.1 Sustainability analysis - Material.

2.5 Carrying features on the reference Remote Radio Units

The reference products, RRUS 01, 11 & 12, have carrying features which have not been optimised for ergonomic handling. The carrying features on the reference products can be seen as a part of the internal-body with regards to the design values. However RRuS 01 and 11 has not been developed with these design-values in regard. This is due to them being developed before these values were implemented.

2.5.1 Ericsson AB - RRUS 01

The carrying feature on the RRUS 01 is stationary and placed on the backside of the product. It enables the user to carry the product during installing and handling. The handle can be seen as a part of the internal-body and is not visible when in or not in use, if not inspected from the backside. Compared to some other carrying features of Ericsson AB RRUs, this is handle is placed relatively hidden on the product's backside. See Picture 2.8 - Handle RRUS 01.

Picture 2.8 - Handle RRUS 01. Regnér (2011)

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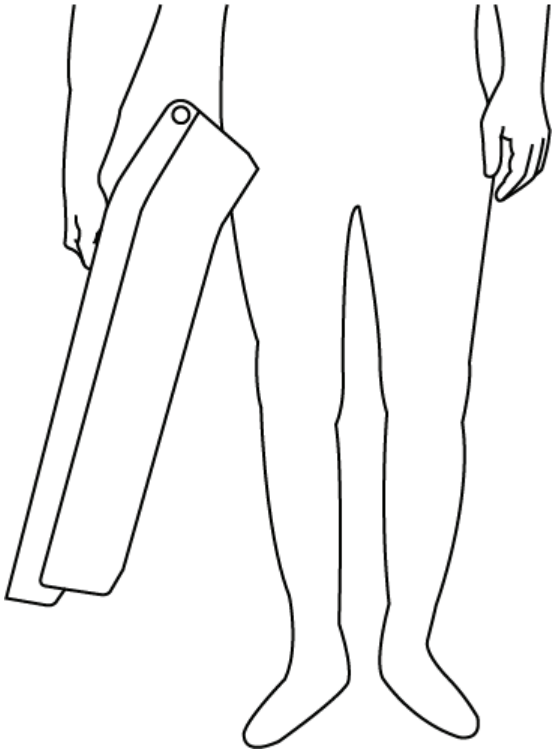
The handle on the RRUS 01 is a solid part of the backside of the product, a relativley thin matte brushed steel sheet which has the handle punched out of it. See Picture 2.8 - Handle RRUS 01. The punched out area containing the handle, is placed just above the middle of the back-piece. If the handle was to break, to replace it the whole back-piece has to be replaced. This would mean extensive hard work as well as be expensive and hard to do, when the product is mounted to a wall or a radio tower mast.

The material and colour of the handle is a smooth matte grey-golden stainless steel. Ergonomically the handle is far from optimised, which can be established when the heavy product is carried. The handle feels sharp when the RRUs is lifted, and the inside edge of the handle almost cuts into the finger tips of the user. Another aspect of the design is that a support rail runs along the middle of the handle, this support rail is in the way of the fingers when the product is being carried. See Picture 2.8 - Handle RRUS 01.

Another interesting aspect with the RRUS 01 and its carrying feature, is the angle the product takes on while being carried. When the product is picked up trough its handle, the product takes on an angle of approximately 20°. This makes the carrying sequence very hard and uncomfortable. See Picture 2.9 - Lifting angle. Combining this issue of uncomfortable and un-ergonomically handling with trying to install the product high up in a radio tower mast, the sequence can be understood to be very complicated.



Picture 2.9 - Lifting angle. Regnér (2011)

The product is hard to handle and carry with one hand due to its heavy weight, placement of the handle as well as the angle the product takes on while being carried. The RRUS 01 does not hold any second handle which enables easier handling while installing the product. The handle does not either include any feature to enable hoisting. Two separate loops are instead placed in the top back corners of the product to connect the hoisting gear to. See Picture 2.10 - Lifting loops.

Picture 2.10 - Lifting loops. Regnér (2011)

Due to the fact that the RRUS 01 has the handle placed on the back, the handling of the product while holding it up towards a wall or mount, is practically impossible. There are no obvious ways to place your hands while installing the product, as when it is held from its handle the hands are in the way of mounting it.

As the handle is placed on the backside of the RRUS 01 and no indications of proper usage are placed next to it, the design is not fully intuitive. The handle is hidden and could just as well be a part of the ventilations cut-outs. See Picture 2.8 - Handle RRUS 01.

2.5.2 Ericsson AB - RRUS 11&12

The carrying features on the RRUS 11 & 12 are placed on top on the RRUs. See Picture 2.11 - Handle RRUS 11. Regnér (2011), See Picture 2.12 - Handle RRUS 12. Regnér (2011). It is mounted on top of the internal-body through two M6-bolts which are to handle the full load of the RRUs while being lifted or hoisted. As the handle is mounted onto the product and not integrated in the design, it is easy to exchange it if broken. They are stationary and visible at all times as they cannot be folded or in any way hidden from sight.

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Picture 2.11 - Handle RRUS 11. Regnér (2011)

Picture 2.12 - Handle RRUS 12. Regnér (2011)

The handles can be seen as a part of the internal-body, as they hold the design-values of this category. A rougher grey part made from die-casted aluminium. The material is uniform with the material used in the internal-body parts. The same can be seen on the handle of the RRUS 12, designed with the design values of the internal-body.

The handle on RRUS 12 is slightly modified compared to the handle on the RRUS 11. The RRUS 11 was developed in China by the local Ericsson AB's R&D department. The R&D department at Kista, Sweden was not involved in this development process. The handle on the RRUS 12 is slightly redesigned by Ericsson AB's R&D department in Kista, Sweden to be more comfortable, easy to handle and better enable hoisting. Vallin (2011).

The RRUS 12 handle is slightly more adapted to fit the users' hands, as it is slightly slimmer in the middle to fit the palm of the hand. Another minor change in the RRUS 12 handle is that it is about 20 mm longer as well as all the edges and surface transitions are much smoother to provide a more comfortable grip compared to the RRUS 11 handle. The difference in length of the two handles has also affected the C-C measurements of the handles' mounting areas. This difference means that the handles are not modular in-between the two products.

The RRUS 11 handle is omewhat to short in regard to optimal ergonomic aspects. Johansson (2011). This has provided complications for service installation workers. In Texas, USA for example, service installation workers has complained about the handle not being large enough to fit their hand when wearing thicker gloves. Kallin (2011).

The handles are very intuitive and speak to the user how they are to be used while handling and carrying the product. As the carrying features are handles, it is easy for the user understand how the features are to be used. Because of the handles being so intuitive, no colour indication is used to indicate interaction possibilities. Thelin (2011)

The ergonomic- and user-aspects of the handles are much better than the handle integrated into the RRUS 01. However the top of the handle is open and holds fairly sharp edges on the RRUS 11. These edges and surface transitions cuts into the palm of the user's hand when the product is lifted from the ground and carried. See Picture 2.13 - Handle RRUS 11 Side. Compared to the RRUS 01, the handle on the RRUS 11 & 12 enables CoG-lifting without any tilt. This aspect makes the sequence of lifting fairly easy. The product holds a heavy weight which still makes it hard to handle for a single person.

Picture 2.13 - Handle RRUS 11 Side. Regnér (2011)

As the handles are stationary, their visual appearance is present at all times. This means that the RRUs as a whole can tend to portray a suitcase hanging from a radio tower mast or a wall. See Picture 2.4 - Ericsson AB RRUS 11, See Picture 2.5 - Ericsson AB RRUS 12, Barcelona 12.

The handle used for the RRUS 12, holds a smart feature which simplifies the control of the RRUs while hoisted up into a radio tower mast or up onto a rooftop. The feature is a small crease in the lower surface of the upper part of the handle. See Picture 2.12 - Handle RRUS 12. This crease enables CoG-hoisting of the RRUs through letting the hoisting-line slide through the crease and centre the RRUs, while in air. By centring the RRUs while being hoisted, it stabilises the hoisting sequence and minimises the risk uneven loads simplifying the task of hoisting. The centring crease is a feature developed for the yet unreleased RRUS 12, and cannot be found on the handle of the RRUS 11.

In the bottom of RRUS 11 next to the cable-connections, is a second handle placed. See Picture 2.7 - Cable-connections RRUS 11. Regnér (2011). This handle enables the user to more easily carry the RRUs horizontally, for example when lifted out of the packaging material. The shape and design of the bottom handle is much simpler than the handle placed on top of the product. It is made from one piece of die-casted aluminium, with the thickness of approximately 3 mm. The thickness is a definite issue as the handle is very sharp and uncomfortable to handle. It cuts into the palm of the user's hand, providing a lot of discomfort. Another aspect of the bottom handle is that if a rope is led through the handle, for more controlled hoisting, the stress and tear on the rope

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can be substantial. See Picture 2.14 - Rope connected to RRUS 11. This can be fixed through connecting the rope to the handle with a safety hook instead of letting the rope slide through the handle itself.

Picture 2.14 - Rope connected to RRUS 11. Regnér (2011)

On the bottom of the RRUS 12, a different type of support handle is placed, a combined feature both working as feet and handles. This feature is made out from two hollow die-casted aluminium rounded rectangles, enabling the product to stand on. See Picture 2.15 Product feet RRUS 12. The feature also works as support-handles to the main handle placed on top of the product. They ease handling of the heavy RRUs while carrying, lifting and/or installing.

Picture 2.15 - Product feet RRUS 12. Regnér (2011)

2.6 Handle dimensions - reference products

To conclude what dimensions are optimal for the redesign of the carrying feature, the reference carrying features have been measured and analysed.

The design of the carrying feature of the RRUS 01 is substantially different to the design of the carrying features of the RRUS 11 & 12. However it is just as important to regard the design and the dimensions of the carrying feature of the RRUS 01, as this one is still in use.

2.6.1 Ericsson AB - RRUS 01

The handle of the RRUS 01 is large and can almost be seen as over-dimensioned for a human hand, even if gloves are worn. A hole surrounds the handle for the hand to be able to grab the actual handle, which is integrated into the back-piece of the RRUs. See Picture 2.8 - Handle RRUS 01. The hole surrounding the handle is almost 350 mm long and 120 mm high which provides plenty of room for the hand to properly grip the handle, to enable carrying. The handle itself is approximately 175 mm long, the width is 25 mm and the depth, which is the area that fills the palm of the hand, is only 13 mm. Because of the thin grip-area, handling the product is not optimised for comfort. The handle is much longer than the one fitted on the RRUS 11 & 12. The sheet metal which the handle is punched out of is only 2 mm thick, making the handle wobbly when handling. See Picture 2.16 - Dimensions Handle RRUS 01.

Length (total) - 349 mm

Length (grip area) - 174 mm

Width - 25 mm

Depth - 13 mm

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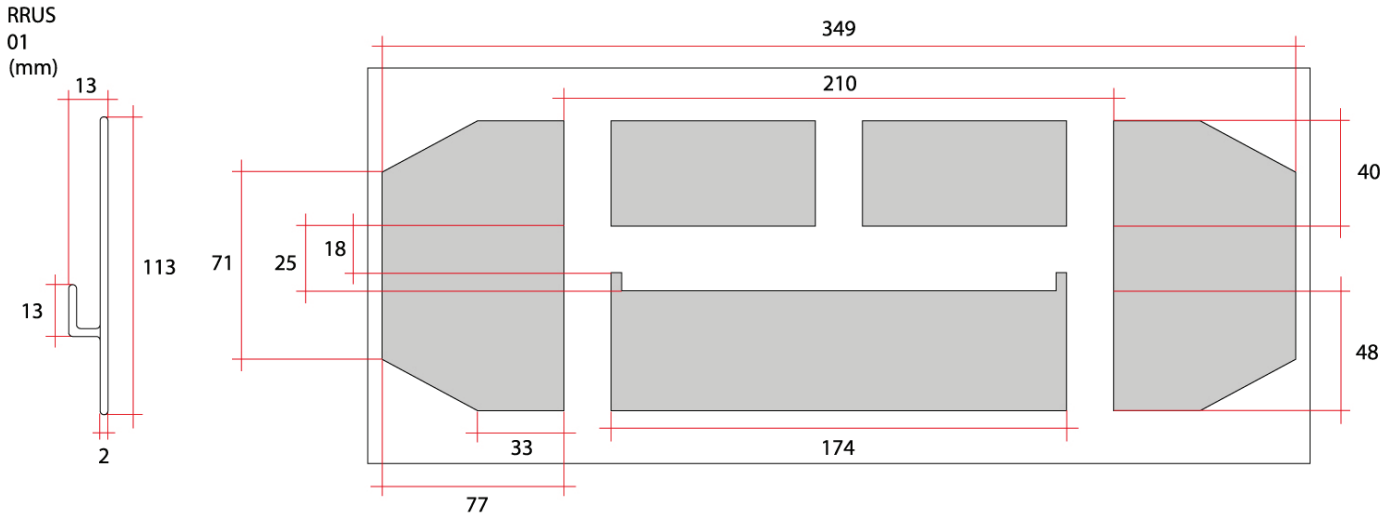

Picture 2.16 - Dimensions Handle RRUS 01. Regnér (2011)

2.6.2 Ericsson AB - RRUS 11 & 12

The handles of the RRUS 11 & 12 are much more "handle-like" and better adapted to fit a human hand than the RRUS 01 handle. They are smaller but hold a more comfortable and smooth design which provides better handling and a steadier grip. The handles are a little bit wider and hold a bigger depth than the RRUS 01 handle. The handle on the RRUS 11 stands 55 mm above the top of the RRUs with a grip-area height of approximately 12 mm. The grip-area holds a length of approximately 85 mm and total length of the handle is almost 162 mm. The width is 26 mm which includes a material thickness of 3 mm.

The handle of the RRUS 12 is much like the handle on the RRUS 11 however it is not as wide with a width of 24 mm in the ends of the handle. The middle section on the handle is even slimmer with a width of 21 mm, this enable a hand to steadily grip around it. The length of the grip-area is 95 mm. The material thickness is a little bit thicker than its predecessor with a width of 4 mm. Except for the dimensional differences and the added integrated crease, the handles of the RRUS 11 & 12 are very much alike. See Picture 2.17 - Dimensions Handle RRUS 11, See Picture 2.18 - Dimensions Handle RRUS 12.

RRUS 11

Length (total) - 162 mm

Length (grip area) - 80 mm

Width - 26 mm

Height (total) - 55 mm

Height (grip area) - 12 mm

C-C: 145 mm

RRUS 12

Length (total) - 180 mm

Length (grip area) - 95 mm

Width (ends) - 24 mm

Width (middle) - 21 mm

Height (total) - 56 mm

Height (grip area) - 41 mm

C-C: 160 mm

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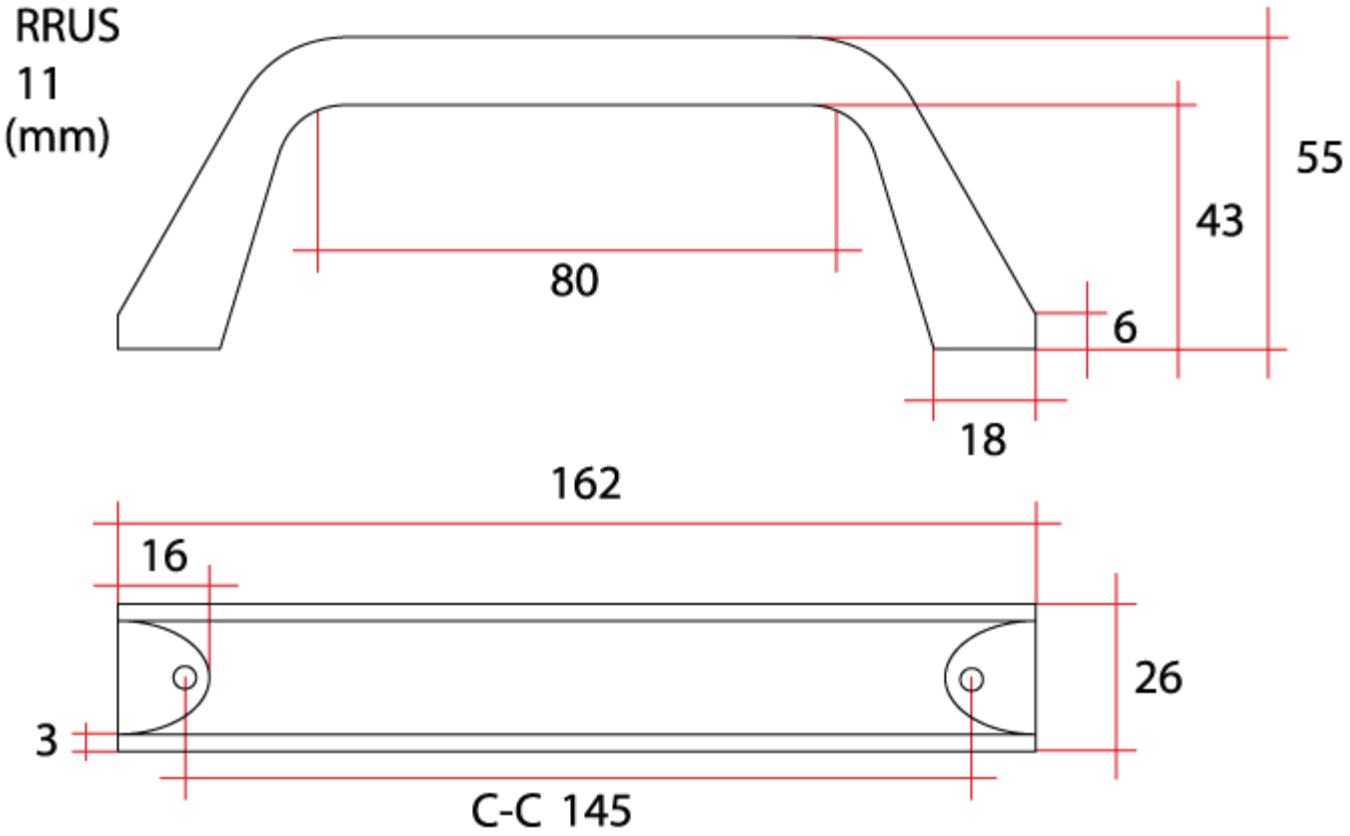
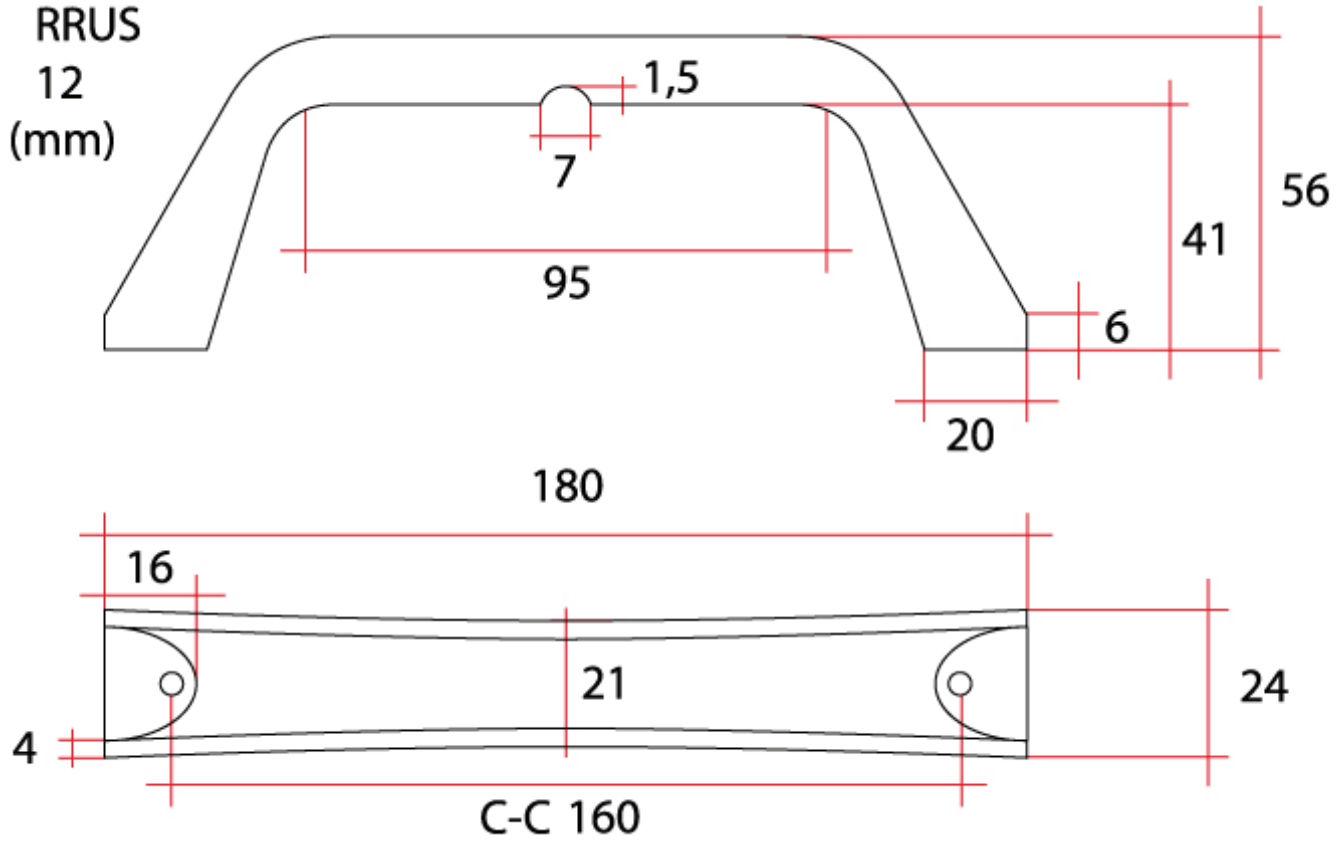


Picture 2.17 - Dimensions Handle RRUS 11. Regnér (2011)



Picture 2.18 - Dimensions Handle RRUS 12. Regnér (2011)

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2.7 Competitor analysis

To be able to get a good understanding of the products and the competition on the market is, it is important to conduct a competitor analysis. The competitor analysis can help establish how the competitors work and what to acknowledge in the redesign of the carrying feature.

Ericsson AB is a large actor on the market of telecom products, alone standing for about 40 % of communication solutions and telecom products on the world market. Together with their major competitor, the two stand for 80 % of the worlds market. Thelin (2011).

The major competitors of Ericsson AB are the Chinese based electronic companies of Huawei and ZTE. Ericsson are competing against a few more actors much smaller than both Huawei and ZTE, not making out as big threat. Kallin (2011), Cevenell (2011). Among the other competitors are Nokia-Siemens, Motorola, Fujitsu and Nortel but because of the lower competitive threat, these actor will not be dealt with in as big depth in this competitor analysis. AFP/The Local (2011), Kallin (2011), Cevenell (2011).

2.7.1 Huawei

Ericsson's major competitor on the telecom market is the Chinese based telecom company of Huawei Technologies Co. Ltd. Huawei is the largest telecom provider in China and together with Ericsson AB the largest provider in the world. Huawei is a fairly young company compared to Ericsson AB and was established as late as 1988. Since then the company has grown remarkably and has to this day over 100 000 employees worldwide.

The company does not only develop and produce telecom products providing mobile communication, they also produce more consumer-based products. This includes wireless broadband devices and Smart-phones. HUAWEI (2011).

The competitor situation with Ericsson AB is only concerning the market of telecom products and social communication solutions. Since the high competition, both companies are very secret about their products, especillay what is under development but also what already exists on the market. Thelin (2011).

Huawei are very fast on developing and releasing new updated products. During the last 10 years they have grown considerably to become a major competitor to Ericsson. Kallin (2011). The company puts large efforts in breaking ground on the worlds telecom market, holding large sales and service offices all over the world. This enables Huawei to deliver exactly what the customer wants very fast and efficient. something that can be hard for many other competitors. Kallin (2011), The Economist Newspaper Limited (2011), CSC staff, Shanghai (2009).

All and all, Huawei is a cheaper alternative than Ericsson AB when it comes to telecom solutions. Kallin (2011), The Economist Newspaper Limited (2011). However this always differs depending on each deal. Ericsson AB has put large efforts into developing products that are capable of withstanding any type of outer impact. The products are not always in need of being capable of withstanding the most extremes outer forces. This means that Huawei's products might work just as well in climate conditions not affected by extreme outer impacts. Kallin (2011).

2.7.2 ZTE

One competitor that has done a remarkable rise on the telecom market is the Chinese based company ZTE. ZTE was established in 1985 and provides a wide range of telecom products, both consumer-oriented as well as more non consumer-oriented products such as mobile telecom products, providing mobile data communication. ZTE (2011), Tidningarnas Telegrambyrå (2011).

ZTE has become a real and major competitor to Ericsson AB over the last few years. To this day ZTE is the fifth largest actor providing telecom, 3G and 4G solutions on the world market, with market shares of approximately 5 %. Abboud (2011). The company counts on a rise within the product sales of approximately 30 %, only during 2011. ZTE clearly states that they aim to become one of three top providers of telecom solutions worldwide in the next couple of years. The Chinese actors are not majorly affected by the economic recession in Europe and America. This means that they see a great possibility of expanding their sales in these parts of the world to 60 - 70 %, from today's sales of approximately 54 % of their total sales quota. CSC staff, Shanghai (2009), Tidningarnas Telegrambyrå (2011), Abboud (2011).

The fast and expansive growth of ZTE worldwide as well as in Europe and the Americas, means that the company already is and will continue be a major competitor to Ericsson AB.

ZTE is competing for market shares and are doing so successfully. Tidningarnas Telegrambyrå (2011). They are providing cheaper telecom solution than their competitors, but as price is becoming a more and more important aspect, they can successfully compete for the customers. As for ZTE's products, like Huawei's products, there is not always a need for top end quality products, being able to withstand all kinds of outer impacts. In many aspects, price is just as good reason for investing. In places where the issue of theft and security cannot be secured, it might not be the obvious solution to choose an expensive product. Kallin (2011), Abboud (2011).

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2.7.3 Products

Due to the high secrecy level, it has not been possible to get hold of any actual Remote Radio Unit from any of Ericsson AB's competitors to perform a thorough analysis on. The products have had to be analysed from pictures concerning the products and their visual appearance. The analysis will be as thorough as possible, with regards to the information obtained. The issue of secrecy also leads to assumptions based on observation of the competitors products will occur, as hard facts are very hard to get hold of.

How the competitors' products work and if they function likewise to Ericsson AB's products are extremely hard to tell. However, as Ericsson AB is the inventor of GSM, Bluetooth, 3G, 4G and many more telecom solutions, their competitors has to buy a licence to be able to use and supply their customers with these telecom solutions. Thelin (2011). This indicates that the products has to some extent look and function fairly similar to Ericsson AB's products.

When studying the aesthetics and the visual appearance of the competitor's products, it is hard to conclude if there is any uniformity in the design within each brand. It is however concluded that neither of Ericsson AB's competitors uses a uniform design language to create familiarity or any kind of visual branding between their products.

Huawei - Huawei A

The first Huawei reference product will be referred to as Huawei A. It looks somewhat like Ericsson AB's RRUS 11, thought holding differences in the sun-cover and the shape. See Picture 2.21 - Huawei A, 3. The product is higher, less wide but thicker than the RRUS 11 & 12. The higher and slimmer Huawei A RRUs provides an expression of being somewhat smaller than the reference products. The actual size in comparison is not possible to conclude, but it is assumed that the shape of the Huawei A gives an impression of it being small, yet thick. See Picture 2.20 - Huawei A, 2.

The sun-cover covers both the front and back of the product, however holds cut-outs in the top and bottom which enables air-flow for better cooling. See Picture 2.22 - Huawei A, 4. The product holds added surfaces on all sides which are possible to exclude. Underneath these extra surfaces are mounts found, making it possible to attach many RRUs to each other. See Picture 2.21 - Huawei A, 3.

Colour wise the product holds the same type of colour scheme as Ericsson AB's products before introducing the present design-values. Light grey and whitish colours are used, probably to minimise the heat absorption from the sun. See Picture 2.19 - Huawei A, 1, See Picture 2.20 - Huawei A, 2, See Picture 2.21 - Huawei A, 3, See Picture 2.21 - Huawei A, 4.

Screws and bolts are all visible as part of exterior surfaces. This enables easy access to the vital parts within the product as well as provides a robust and quality expression. See Picture 2.22 - Huawei A, 4. The exterior surface, which the telecommunication users interact with, transmits a kind of ungraceful and solid expression. In a visual design aspect, the exterior surface is cluttered with different surface features, cut-outs and constructional features, all providing an unappealing expression. See Picture 2.19 - Huawei A, 1, See Picture 2.21 - Huawei A, 3, See Picture 2.22 - Huawei A, 4.

A carrying feature can clearly been seen, placed one side of the Huawei's A RRUs, much like the handle placed on top of Ericsson AB's RRUS 11 & 12. See Picture 2.19 - Huawei A, 1, See Picture 2.22 - Huawei A, 4. It can be thought to be made as a solid piece, moulded from die-casted aluminium. It holds a more square shape than the handle placed on Ericsson AB's RRUS 11 & 12, however the dimensions seems to be almost likewise. See Picture 2.11 - Handle RRUS 11, See Picture 2.12 - Handle RRUS 12. In the image, holes which house screws can clearly be seen; these holes would probably indicate that the handle is screwed into the internal-body of the product. This indicates that the handle, just as on Eriksson AB's RRUS 11 & 12, is fixed and cannot be hidden. One interesting aspect is that the Huawei A RRUs does not hold any support handle in the bottom of the product enabling better and easier hoisting.

It is hard to distinguish any pros and cons, which differentiate the handle of the Huawei A RRUs compared to the handle of the reference products. All handles seem to fill the function of enabling carrying before the design aspects of being discrete, subtle and flexible.

Picture 2.19 - Huawei A, 1. Kallin (2011)

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Picture 2.20 - Huawei A, 2. Kallin (2011)

Picture 2.22 - Huawei A, 4 . Kallin (2011)

Picture 2.21 - Huawei A, 3 . Kallin (2011)

Huawei - Huawei B

The second Huawei reference product, will be referred to as Huawei B. The exterior sun-cover seems to some extent protect the vital technical features. It is also a vital part of the semantic expression. The sun-cover covers the front and the sides, these are the areas of the product mainly visible when placed on a radio tower mast or a wall.

The sun-cover seems to be made out of either a polymer plastic or pressed sheet metal. On top of the sun-cover a row of cut-outs are placed possibly letting air through the cooling flanges. The cut-outs are made visible by housing them in a raised area of the cover, coloured in a matte grey colour. The rest of the cover holds a matte light grey colour palette, probably to minimise the heat absorption within the cover.

No carrying feature has been possible to define, which concludes two possible scenarios; either is a carrying feature not included or it is hidden/flexible, placed on the back/bottom/top of RRUs.

The two different RRUs of Huawei A & B might have different purposes. The Huawei B are more likely to be used closer to the telecommunication service users, placed on walls, clearly visible at all times. This is concluded through its sleeker design as well as tendency of being somewhat smaller and neater.

For images see reference: mobilecomms-technology.com (2011)

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ZTE A & B

Two different ZTE RRUs has been evaluated, one unidentified model which will be referred to as ZTE A. The other one being the 2007 model ZXWR R8840 which will be referred to as ZTE B. ZTE's RRUs are rough and visualises a more functional and technical semantic expression. Both the ZTE A and B holds its cooling flanges fully visible on the exterior surfaces, not covered by any kind of sun-cover shielding it from outer forces. These surfaces are fairly cluttered and solid, providing the RRUs with the look of being very technically advanced and developed for function before aesthetics. All screws, hinges and cable-connections are visible and not covered by any exterior surface. Both ZTE A & B are made from, what can be seen as, die-casted aluminium providing an exterior cover for the vital technical features housed inside. The colour scheme of ZTE two products is uniform and corresponds to some degree with the internal-body of the Ericsson AB's RRUS 11. As the internal technical features are sensitive and need good cooling, using a cool light grey colour palette helps to minimise the heat absorption within the external material exposed to sun-rays. Kallin (2011). This corresponds with the theory of the Albedo-effect. Klimatordlista (2011).

Holding the cooling flanges exteriorly and open to the air, provides good cooling for the technical features placed inside the body. Not covering the cooling flanges with any kind of sun-cover, makes them sensitive for heat absorption. As the sun-rays hit the product, they heat up the internal-body, which impair the effect of the cooling system. The exterior surfaces of the body provide a solid and heavy expression. The products look to be sturdy and withstand the impacts of nature, when placed outside.

ZTE B was of 2007 the smallest and lightest RRU available on the market, with its weight of only 17 kg and a volume of 19 litres. 3G.co.uk (2007).

The carrying feature of the two ZTE RRUs are both placed of the side of the products. This indicates that when the product is placed on a wall or a radio tower mast, the user has to support his/her grip of the product with the other hand. When carried the products takes on a 90° angle and tilts to the side compared to how it is to be mounted.

The carrying feature of ZTE A looks similar to the carrying feature of Ericsson AB's RRUS 11. It looks to be a little bit longer than the one on the RRUS 11, however otherwise very similar. It looks to be a fixed handle not possible to hide or diminish. The handle is likely to be made from die-casted aluminium just as Ericsson AB's products. It is bolted on to the body of the RRU. This type of handle is very intuitive, but on the other hand tends to intrude on the semantic expression of the product as a whole.

On the ZTE B the carrying feature looks a bit more refined and adapted to the user. The carrying feature is a handle placed on the side of the RRUs, just as on ZTE A. The handle is bolted on to the body of the product with two large sturdy bolts. The ZTE B is assumed to be lighter and smaller than many other RRUs on the market making the product easier to handle. The handle holds the shape of human fingers on the inside of it, finger-grooves. These are probably intended to provide a more ergonomic and comfortable usage situation. Except from the creases for the fingers, the handle is very similar to the other fixed handles on the market.

For images see reference: ZTE RRUS A - Converge! Network Digest (2009), ZTE RRUS B - 3G.co.uk (2007).

2.8 Carrying features on other heavy products

There are many different types of carrying features which enables handling and lifting. On heavy-duty products many carrying features seem to focus more on functionality than the aspect of ergonomics and aesthetics. When it comes to light-weight products, the carrying feature seems to be easier to adapt for ergonomics, flexibility and aesthetics. Heavy-duty products mostly hold fixed simple handles fully visible or flexible handles either built for strength or being small and neat.

2.8.1 Fixed handles

Much like the handles placed on the Ericsson AB's RRUS 11 & 12, many heavy products house fixed heavy-duty handles. These handles are visible at all times but provide a steady durable grip as well as being able to withstand large forces. Like the Ericsson AB reference RRUs, these handles are often bolted on to the outside of the body of the item. It is not uncommon for the handles to be integrated into the body of the product. See Picture 2.23 - Screwdriver case. The integrated fixed handles provide a sleeker and uniform aesthetic expression, even though always visible. The fixed handles are often made from moulded plastic or some kind of metal to be able to withstand large forces.

Picture 2.23 - Screwdriver case. Regnér (2011)

2.8.2 Flexible handles

The flexible handles found on many heavy-duty products are mainly of two different kinds; either the foldable version of the heavy-duty fixed handle, See Picture 2.24 - Flexible

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Camera case Handle. Carrying features (heavy-duty) on other heavy products, or a neater foldable handle made from bent metal bars. See Picture 2.25 - Bent steel handle. The ergonomic aspect of these handles are in many cases neglected to some extent, whereas the function of heavy-duty lifting has been the main focus area.

Picture 2.24 - Flexible Camera case Handle. Regnér (2011)

Picture 2.25 - Bent steel handle. Regnér (2011)

The flexible handles made from bent metal, have regarded the aspect of aesthetics more than the other type of flexible handles studied. However, these handles are smaller and provide less grip area, which makes the lifting sequence more uncomfortable. See Picture 2.25 - Bent steel handle. It is hard to handle and lift heavy items with handles like these for a longer period of time, they hurt and tense the muscles.

2.8.3 Other carrying features

Other types of carrying features are for example ones made from plastic or leather straps, like the ones commonly used on music amplifiers. See Picture 2.26 - Amplifier collapse band. The patented product of "STRAP-A-HANDLE", a handle made from heavy-duty cargo straps, enabling easy carrying of ungraceful heavy objects. See Picturen 2.27 - Handle strap solution. The "STRAP-A-HANDLE" is a separate product not integrated with the item being carried. This means that it is very modular and adaptable to fit almost anything that is not too heavy to carry. STRAP-A-HANDLE (2011).

The plastic/leather straps placed on many music amplifiers, enables handling and lifting of these heavy items, not uncommon to hold a weight of 15-30 kg. These types of handles are very discrete and tend not to intrude on the overall semantic expression. They also allow fairly comfortable handling as they are soft and adapt to the shape of the hand. The handle also enables carrying when needed and slides back and hides when not interacted with, also being very intuitive and easy to use. See Picture 2.26 - Amplifier collapse band.

Picture 2.26 - Amplifier collapse band. Regnér (2011)

Picture 2.27 - Handle strap solution band. Regnér (2011)

It is important to analyse and regard the already present solutions of heavy-duty carrying devices on the market, these might provide clues for the redesign.

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2.9 SWOT- ANALYSIS ERICSSON AB

The pre-study has provided a lot of data on Ericsson AB, their products and their position on the market. A SWOT-analysis has be used to compile this data into simple and clear information.

The SWOT analysis shows what Ericsson AB is today; a strong, innovative, reliable company providing high quality products. Their weaknesses, which can affect the company, is that their products are expensive compared to their competitors. They are also slow in development of new customised products in comparison with their major competitors Huawei. Kallin (2011). This is an area of concern where Ericsson AB can further develop their operation. Ericsson AB's products are also somewhat heavier due the better performance, which can be an area of weakness if investors are looking for small and neat products. Kallin (2011).

The fact that Ericsson AB is an innovative company, many of their competitors are interested in getting hold their innovations. The aspect of innovations is a great possibility, yet it can also be a weakness and threat due to theft. Espionage and the fast growth of their major competitors are the largest threats.

Good and unified design as well as focusing the product development towards sustainability can strengthen the brand and help Ericsson AB to keep being the market leader. Their strengths are the aspects which has taken Ericsson AB to the top. If they can further strengthen these aspects as well as improve on their weaknesses and threats, Ericsson AB can keep this spot for many years to come. The aspects concluded in the SWOT-analysis shall be regarded in the redesign in the best possible way. See Picture 2.28 - SWOT-analysis.

STRENGTH

WELL ESTABLISHED AND RECOGNISED BRAND

SWEDISH HERITAGE

KNOWN FOR QUALITY

LARGEST ACTOR

INVENTOR OF MANY MARKET LEADING SYSTEMS

BUILDING A UNIFORM DESIGN LANGUAGE

A NEWLY INITIATED INDUSTRIAL DESIGN DEPARTMENT

INSTALLATION WORKERS STATES THAT ERICSSONS PRODUCTS ARE THE BEST TO HANDLE AND WORK WITH

LONG HISTORY OF TELECOM AND PU

DURABLE AND SAFE PRODUCTS

SUPERIOR PRODUCT PERFORMANCE COMPARED TO COMPETITORS

MANAGEMENT IS COMMITTED TO FOCUS ON INDUSTIAL DESIGN AND USABILITY

EXTREMLY COMPETENT AND SUCCESS-DRIVEN STAFF

WEAKNESSES

EXPENSIVE PRODUCTS

SLOW PU-PROCESS COMPARED TO COMPETITORS

HEAVY PRODUCTS

BEING MARKET LEADERS - COMPETITORS SPY AND STEAL SOLUTIONS

EXPENSIVE PERSONELL AND PU-PROCESS

OPPORTUNITIES

FOCUS ON SELLING TELECOM SOLUTIONS (4G E.G.) INSTEAD OF PRODUCTS

DEVELOP THE BEST AND MOST UNIFORM PRODUCTS

DIFFERENTIATE ERICSSON FROM COMPITITORS THROUGH THE SEMANTIC EXPRESSION

DIFFERENTIATE ERICSSON FROM COMPETITORS THROUGH PROVIDING SUSTAINABILITY SOLUTIONS

THREATS

NOT ALWAYS A NEED FOR TOP QUALITY PRODUCTS

CHINESE SOMPETITORS ARE GROWING FAST/TAKING MARKET SHARES

ESPIONAGE

SLOW CUSTOMISATION PROCESS

SLOWER PU-PROCESS THAN CHINESE COMPETITORS

PICTURE 2.28 - SWOT-ANALYSIS. REGNÉR (2011)

2. PRE-STUDY

2.10 Focus users

The focus users of the RRUs and its carrying feature differ from the buyers of the product.

Buyers

The buyers and investors of telecom systems and RRUs are mainly countries, cities and telecom companies who provide telecom and communication solutions within society. The buyers buy high quality products which hold a neat and professional visual appearance. The buyers do not usually interact with the products, as this is dealt with by specialists and service installation workers. Thelin (2011).

Service installation workers/specialists and production workers

The users that most closely interact with the RRUs and its carrying feature, are specialist persons who are installing, serving and manufacturing the product. These users interact with the product on a close level, where they are to solve tasks while handling the product. The installation and service specialists handle the product both on the ground and up in radio tower masts. They have a straight forward interaction situation where they are to mount, install or service the product. It is not uncommon that the user has to be able to handle the RRUs with only one hand, as the other hand has to be used to hold on to the radio tower mast. For these users; easy handling, usability and ergonomically designed products are crucial as their job will be much easier and safer. Thelin (2011).

While being produced and manufactured, the products are possibly handled in different steps and sometimes even at different locations. The product might be picked up and handled many times during manufacturing, which means many heavy lifts for these users. Users handling the RRUs in production and manufacturing are in need of the product being easy to handle and ergonomically designed to ease their work situation.

Telecom and social communication users

The telecom and social communication users do not usually interact with the product of RRUs. As these users usually only deals with the services provided, they do not physically interact with the products. The most common way the telecom users come in contact with RRUs and other service providing products, is through the visual expression the product transmits when placed in radio tower masts and on walls. Thelin (2011).

The users interact with the visual appearance of the product, and if designed well together with strong branding, the users can directly tell if the product is of a specific brand.

Design in regard of the users

The redesign of the carrying feature has to be done in close consideration of all the possible users. All the user groups are important to regard within the redesign. The design of the carrying feature has to be appealing and suitable for the buyers, as the product has to be sold for it to fill any kind of function for Ericsson AB. The product has to be ergonomically optimised and designed to fit the needs of the installation and service users, to ease handling and installation. It also has to fit the users of the products services, who normally do not get to interact with the interface of the product.

To consider all the crucial users, involves a lot of design aspects, however if done properly the carrying feature can work for both optimal usage as well as aesthetics.

2.11 Image board

To be able to conclude what values and expressions the carrying feature being redesigned holds, an image board has been made to portray this. The image board will help showing how the products are used and handled, which are important aspects to consider later in the redesign. An image board will portray the expressions and what is transmitted through the reference handles of the RRUS 01 and the RRUS 11 & 12. The images portrayed in the image board will help to distinguish "Worlds of value". These words will help conclude the expression and values of the reference products carrying features, which will be regarded during the redesign. See Picture 2.29 - Image board.

"Words of value":

Solid - a solid peace, non-flexible

Functional - provides good functionality, enables carrying of an heavy object

Raw - raw and harsh, how the carrying features feels

Sharp - sharp edges, leads to uncomfortable handling (mainly concerning the RRUS 01 & 11 carrying features)

Rough - rough surface, die-casted aluminium (RRUS 11 & 12)

Ungraceful - non-flexible, provides an ungraceful expression

Uncomfortable - uncomfortable handling, non-ergonomic

Hard to use - does not enable easy handling (concerning when the products is to be lifted for installation or mounting)

Tilt - product tilts during usage, RRUS 01 while lifted and RRUS 11 while hoisted

2. PRE-STUDY

Picture 2.29 - Image board. Image References see Reference list

2.12 Concept RRUS handle design by Ericsson AB

At the 2012 Mobile World Congress in Barcelona, a world leading telecom exhibition, Ericsson AB was showcasing a number of new inventions and products. Mobile World Congress (2011). One of the products being shown at the exhibition was a new modular foldable handle for their RRUs product family. During this master thesis Ericsson AB started a parallel project where they designed and developed a concept handle to showcase at the 2012 Mobile World Congress in Barcelona. The handle shall be foldable, fit to most of Ericsson AB's RRUs, fit the design-values as well as be durable.

As the project is closely related to the work of this master thesis, it can be of some significance. Ericsson AB's method of working and how the handle was developed will be studied in the pre-study.

For the 2012 Mobile World Congress in Barcelona, many new and redesigned products and projects will be showcased to show where Ericsson AB is headed and what they can offer their customers. Thelin (2011). Among the products being showcased is a new antenna, minilink and several other telecom solutions. In week 47 of 2011 it was initiated that a new better suited foldable handle was to be developed. There are no foldable handles available on any of the present Ericsson AB RRUs. However a mock-up foldable handle was shown at the 2011 Mobile World Congress in Barcelona. See Picture 2.30 - Barcelona 2011 Concept Handle. As shown in Picture 2.30 - Barcelona 2011 Concept Handle, the handle is foldable, provides good grip-area and holds two different materials for optimised handling. The handle enables folding and locking through two ball-springs placed inside the bottom of the handle. See Picture 2.31 - Barcelona 2012 Concept Handle function. These ball-springs locks the handle in the upright position when the handle is to enable handling and vice versa when the handle is to be down and hidden. The material used in the foldable 2011 Barcelona mock-up handle is milled aluminium together with a rubber material which enables soft handling and a good grip. Kallin (2011).

For the 2012 Mobile World Congress in Barcelona, Ericsson AB wants to further develop the foldable concept handle to showcase something slimmer and better adapted than the 2011 Mobile World Congress in Barcelona concept. Aspects which shall be improved are to minimise the material use as well as improve the locking mechanism. It became obvious that using two different materials was too expensive in production and material cost. The feature of adding a more smooth and comfortable material for the grip-area was good however not necessary, why it will not be a part of the redesigned 2012 version. Kallin (2011)

2. PRE-STUDY

Picture 2.30 - Barcelona 2011 Concept Handle. Kallin (2011)

Picture 2.31 - Barcelona 2012 Concept Handle function. Kallin (2011)

The ball-springs of the handle fulfilled the requirement of locking and enabling folding, however they were too hard to adjust for equivalent alignment. The handle is not used frequently during the products lifespan. The locking and folding mechanism is in risk of corrosion and permanently getting stuck. See Picture 2.31 Barcelona 2012 Concept Handle function.

With regard to ergonomic aspects provided by Sr Industrial Designer HW Usability, Ericsson AB, Mats Johansson, it became clear what was needed to be included in the redesign. The handle should be as slim as possible to not interfere on the semantic expression and the cooling flanges preventing proper cooling. However it was very important to regard the basics of handle design to properly fit the users and enable optimal handling. Johansson (2011).

The design and semantic expression of the handle was performed by, discussed and evaluated by the Ericsson AB's industrial design team with final decision from Mikael Thelin - Manager, Industrial Design.

The process of redesigning the handle was performed through an ordinary product development process. However the pre-study was based on the reactions, response and functionality of the previous developed foldable handle, 2011 Mobile World Congress in Barcelona concept. The process was very quick and only involved two weeks of intense work.

The main objectives of the 2012 Mobile World Congress in Barcelona coincides well with requirement of the handled which is to be developed and redesigned as a part of this master thesis.

A few ideas were generated, however two solutions was chosen to further develop and focus on; a sleeker and slimmer improved version of the 2011 Mobile World Congress in Barcelona handle as well as a foldable version of the already present fixed handles on the RRUS 11 & 12. From these two solutions, three concepts were generated for evaluation and finalisation.

The three concepts are all similar in the design however enables attachment and folding in different ways. All concepts are designed to fold around the axle of a base-plate connected to the top of the RRUs. The concepts allow this connection differently which means that the size of handle varies some between the concepts. Just as the present handles of the RRUS 11 & 12, the three concepts hold a contoured shape in the top. This enables a round surface to grab without adding any extra unnecessary material. See Picture 2.13 - Handle RRUS 11 Side. Regnér (2011).

2.12.1 Concept 1

The first concept is a foldable shackle-shaped handle, placed on the top of the RRUs. The handle is connected to the internal-body of the RRUs through a base-plate which also allows folding over an axle. The concept allows the handle to be as low as possible. This is due to the thin flat base-plate not raising the total height of the handle and taking up the 40 mm space needed for a hand to properly grab it. The handle holds a straight design with thin flat sides, giving the impression of the handle being weak. One aspect concerning Ericsson AB with this handle is that it might be too weak and not durable enough to handle the weight of the heavy RRUs. Another aspect is that the concept is not regarded fully suitable for the Ericsson AB design language as well as it intrudes more than it fits the total semantic expression of the products. See Picture 2.32 - Barcelona 2012 Concept 1.

Picture 2.32 - Barcelona 2012 Concept 1. Mogas Bartumeo (2011)

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2.12.2 Concept 2

The second concept is also a foldable shackle handle however it holds a more looped shape. This shape provides the handle with the impression of being more durable and strong, even though the sides are flat and thin. The base-plate of the handle which enables mounting and folding is more solid then on Concept 1. It is one solid piece, shaped to minimise volume but at the same time enable a strong and durable connection to the shackle grip. The solution of shaping the base-plate as ramp enables the handle to be as low as concept one, not taking up of the 40 mm necessary gripping space. The solution makes the whole handle look uniform as a solid loop, enabling folding. One aspect that concerned the industrial designers and product developers at Ericsson AB was that the base-plate has to be a littler wider than on the third concept. See Picture 2.33 - Barcelona 2012 Concept 2.

Picture 2.33 - Barcelona 2012 Concept 2. Mogas Bartumeo (2011)

2.12.3 Concept 3

The third and final concept is very similar to Concept 2, however the major difference is that the base-plate is higher but not as wide. This makes the handle even more uniform as it fulfils a loop within the handle. The solution enables a smaller base-plate. This means that the total height of the handle will be greater. This is due to the fact that a hand is to fit within the handle with a free space of 40 mm. The solution enables a tough and durable folding joint around the axle as well as a very uniform look. The aspect of concern of this concept is that the total volume of the handle is greater than the other concepts. This is something that is not desired by Ericsson AB. The solution is not as well adapted to the semantic expression of the products and intrudes on the total design of the RRUs. See Picture 2.34 - Barcelona 2012 Concept 3.

Picture 2.34 - Barcelona 2012 Concept 3. Mogas Bartumeo (2011)

2.12.4 Final concept

The final concept chosen by Ericsson AB to be shown at the 2012 Mobile World Congress in Barcelona, holds features from all three previously generated concepts.

It mainly is a combination of Concept 1 and 2, where the basic shape of Concept 1 is used together with the base-plate of Concept 2. The base-plate is made flat to minimize the intrusion on the whole semantic expression of the RRUs. However the ends of the base-plate, which are connected to the handle, are made thicker to provide a steady durable folding feature. By integrating a feature of using a thin base-plate but still steady durable connection axle areas, the handle can be made lower. This enables good ergonomic handling without being intrusive. Mogas Bartumeo (2011).

The handle is foldable to 105°, from a folded down position to stand straight as well as fold 15° to the other side. By allowing 105° of folding the handle is made more comfortable to handle, as it provides some extra flexibility while carrying. By not allowing it to fold a fully 180°, meaning that handle is controlled not to fold to the "wrong" side which can obstruct the air-flow and affect the cooling system when the handle is folded down. Mogas Bartumeo (2011). See Picture 2.35 - Barcelona 2012 Final concept flexibility.

The handle holds the feature of a hoisting groove, just as the RRUS 12 handle, to enable easier CoG hoisting. See Picture 2.36 - Barcelona 2012 Final concept front. Another feature which is similar to the present RRUS 12 handle is that it is rounded in the grip-area. This is to provide possibility of a good power-grip. However the sides of the handle

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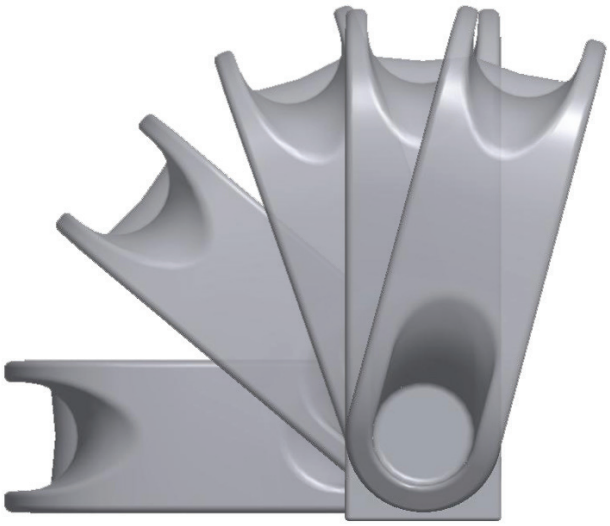
are made flat instead of a hollow-rounded shape as on the top. See Picture 2.31 - Barcelona 2012 Concept Handle function. This makes the handle strong and durable while at the same time minimising the material needed. Mogas Bartumeo (2011).



Picture 2.35 - Barcelona 2012 Final concept flexibility. Mogas Bartumeo (2011)

Via two M6 bolts the handle is connected to the top of the RRUs. The bolts are bolted through the base-plate into the RRUs which provide a steady and durable mount. They will be able to withstand the forces of lifting and hoisting the product from its handle.

The handle is made as two parts, the handle and the base-plate. They are connected with screws which are screwed in from the sides of the bottom of the handle into the base-plate. See Picture 2.31 - Barcelona 2012 Concept Handle function. These screws work as the axles which the handle folds around. Within the handle, a stop bolt is placed next to one of the screw-axles. This bolt slides within a cut-out section of the base-plate, which disables the handle to flex more than the desired 105°. See Picture 2.31 - Barcelona 2012 Concept Handle function. A ball-spring is placed in the within the connection area of the base-plate which enables locking of the handle in the "0-position". By placing a ball-spring, the handle can be controlled to always lock into a down-folded position which minimises the risk of intrusion on the RRUs semantic expression. See Picture 2.31 - Barcelona 2012 Concept Handle function. A ball-spring was first though to be excluded for a different locking mechanism. However due to a time shortage in the development process, this already tested mechanical solution was used anyhow. Mogas Bartumeo (2011), Kallin (2011).

To further secure this, a spring is placed along the screw-axis. This spring will secures that the handle always folds back to a flat "0-position". The whole purpose of having a flexible handle is to be able to fold away when not needed. If the handle always stays upwards, the purpose of folding is unnecessary. A spring which always brings the handle back down can be seen as necessary. See Picture 2.37 - Barcelona 2012 Final concept down.

Picture 2.37 - Barcelona 2012 Final concept down. Mogas Bartumeo (2011)

The short time of development before the 2012 Mobile World Congress in Barcelona did not enable to fully develop the spring-function which had to be left out. This is thought be included if the handle becomes production-ready. The 2012 Mobile World Congress in Barcelona handle is only a concept mock-up, and is not production-ready as of today.

The material used will be die-casted aluminium if the handle will go to production further on. The mock-up concept for the 2012 Mobile World Congress in Barcelona however is milled from aluminium. This was a more appropriate method for this occasion.

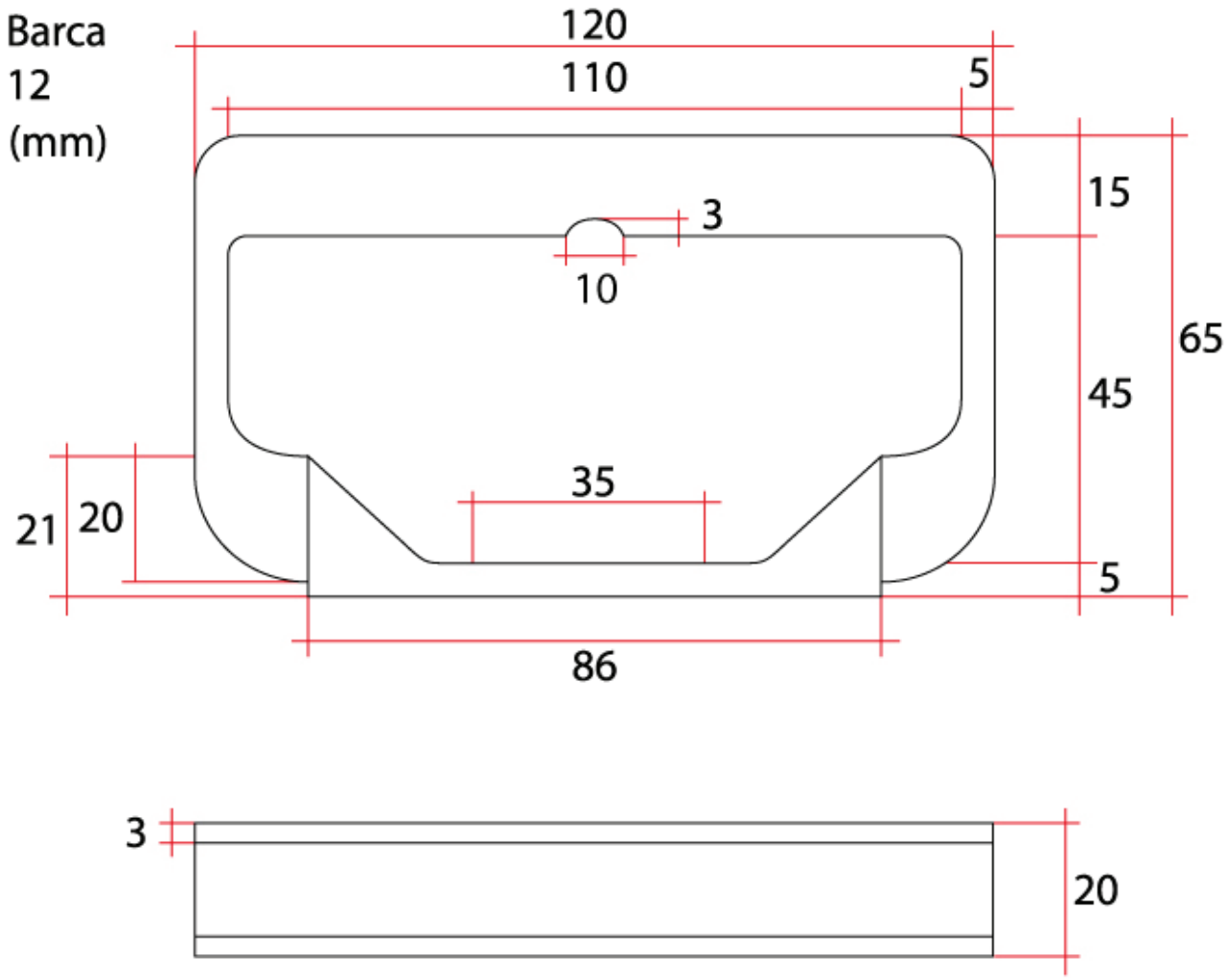
The handle was designed by the industrial designer Oriol Mogas Bartomeu at Ericsson AB with assistance of industrial designer Jens Kallin and final decision from Mikael Thelin.

2.12.5 Dimension of 2012 Barcelona handle

The handle has adapted dimensions well in regard to optimized ergonomic aspects. However it still holds a very sleek and subtle design. The grip-area has been increase to 110 mm, compared to the reference RRUs carrying features, which is regarded as minimum if the handle was to be properly ergonomic adapted. Johansson (2011). The grip-space is set to 45 mm which is plenty for a large hand wearing gloves. As the handle is connected to the top of the RRUs through a centred base-plate which is 5 mm in height, it rises 25 mm above the top of the RRUs when folded down.

The actual grip-area is 20 mm wide and 15 mm high, which a little bit on the low side in regard to optimised ergonomic aspects when designing handles for products heavier than 18 Kg. The 25+ mm in height which are optimal has been compromised for the handle to be as slim and sleek as possible, minimal intrusion on the total semantic expression. See Picture 2.38 - Dimensions Barcelona 2012 Handle.

2. PRE-STUDY



Picture 2.38 - Dimensions Barcelona 2012 Handle. Regnér (2011)

2.13 Concept sliding handle design by Ericsson AB

Late in the product development process information was provided that a previous sliding handle had been developed for some of Ericsson AB's portable products. The handle proved to be very similar to one of the initial concept generated later in the ideation process. The handle is placed within the split-lines of the products external cover and is slided out to a grippable-position, allowing the user to lift and handle the product. The handle was developed as a concept with a mock-up and has not been further developed. Kallin (2011).

Fitted inside the split-lines, the handle provides a sleek and subtle expression as well as hides when not interacted with. See Picture 2.39 - Sliding handle. To pull the handle out to enable lifting, the sun-cover holds circular cut-outs allowing the users fingers to grab the handle. See Picture 2.39 - Sliding handle. The grip-area of the handle is connected to two arms by two axis-joints, allowing the grip-area to swing around the arms. The arms are connected to the grip-area in one end, and in the other end to a brace on the internal-body which allows the arms to slide back and forth enabling it to take on different positions. See Picture 2.40 - Sliding handle, connections.

See Picture 2.39 - Sliding handle. Kallin (2011)

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One technical feature except from the sliding arms is that the arms are made in two pieces, working as a telescope. The arms are made longer when the handle is pulled out to enable handling, allowing the users hand to properly grab the handle. See Picture 2.40 - Sliding handle, connections.

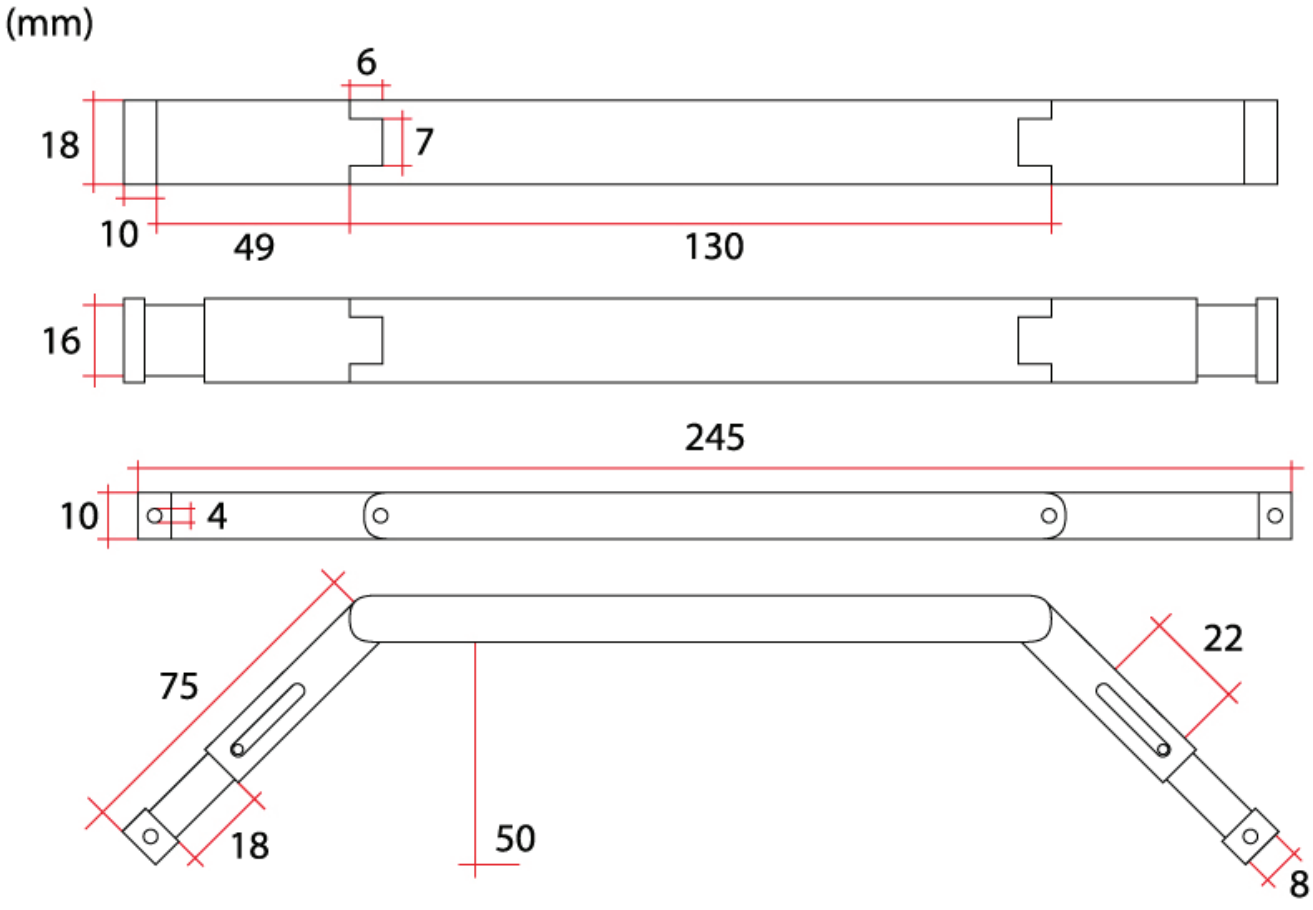
See Picture 2.40 - Sliding handle, connections. Regnér (2011)

When the product is lifted through the handle, it is tilted 90° to the side in regard to how it is to be mounted on a wall or radio tower mast. The 90° tilt is due to the fact that the handle is placed within the split-lines on the side of the RRUs. The handle and feet of the product are placed opposite to each other allowing the product to stand on its feet when placed on the ground using the handle. However this is a 90° angle compared to the mounting position, denoting that the feet are clearly visible on the side of the RRU when mounted.

2.13.1 Dimension of sliding concept handle

The dimensions of this handle have been measured and the grip-area holds the necessary measurements to fulfil the optimal ergonomic aspects. However as the handle is flat and thin is it not comfortable to handle. Neither has it been designed in regards to ergonomic aspects. See Picture 2.41 - Dimensions Sliding Handle.

The handles technical function will be regarded in the final design of the carrying feature in the master thesis.



Picture 2.41 - Dimensions Sliding Handle. Regnér (2011)

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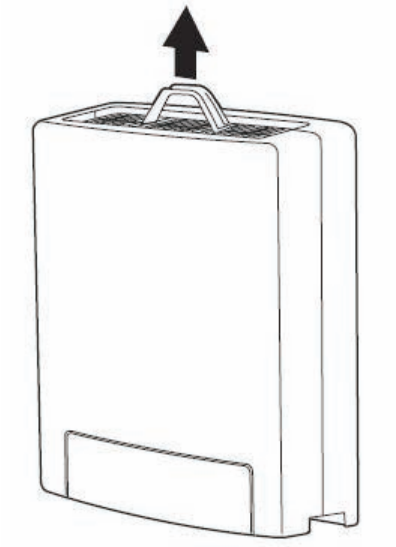
2.14 Recommendations from Ericsson AB Installation Instruction - RRUS 11

For the service and installation workers to understand the proper usage, handling and installation of the product, Ericsson AB has conducted a manual. This manual shows and instructs the installation specialists how the product is to be placed, handled, connections of cables and so forth. The manual is conducted within Ericsson AB by developers and employees with good knowledge about the product and how it is interacted with in actual real environments.

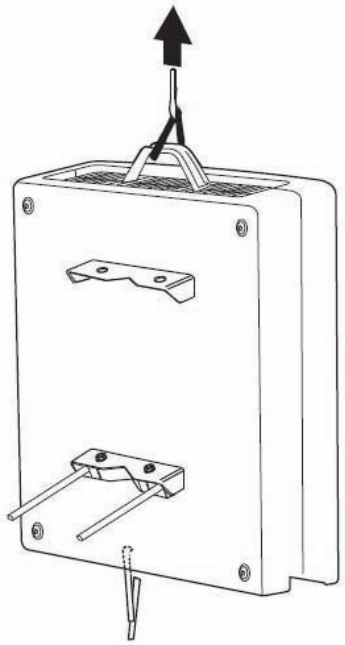
The manual for the installation procedure of RRUS 11 has been studied to obtain information about the handling situation. This manual is relevant as the RRUS 11 and 12 are similar. The manual can be regarded as fairly suitable for RRUS 12 as well. It was updated as late as in November 2011., however this is a continues process.



See Picture 2.42 - Proper handling RRUS 11. ERICSSON AB - Installing Remote Radio Units (2011)

In the manual is it clearly stated how the product is to be picked up from the ground and carried; from the handle mounted on top of the RRUs. See Picture 2.42. Proper handling RRUS 11.

When a RRUs is to be installed and mounted to a mast or a wall, it is recommended that it is hoisted to position. The RRUs is to be connected to a hoisting line in the top mounted handle, to enable hoisting. A line is also recommended to be placed in the bottom of the RRUs to enable more stabilisation and vertical positioning while hoisting. See Picture 2.43 - Proper hoisting RRUS 11. The hoisting sequence also enables the product to be held still and positioned accurately while installing and mounting the RRUs.



See Picture 2.43 - Proper hoisting RRUS 11. ERICSSON AB - Installing Remote Radio Units (2011)

When it comes to installing and mounting the RRUs to a wall, it is not described in the installation manual how the product is to shall be lifted or handled. The manual shows clearly how it shall to be mounted to its mounting-brackets when placed on the wall. However the manual has not at all regarded how the product is to get to this height. It is not stated if the product is to be lifted by its handle, the body of the RRUs or being hoisted. This makes it hard for the user to now exactly how the product shall be handled if hoisting is not possible. It is not clear if the handle is to be used to position the RRUs to its mounting-brackets. ERICSSON AB - Installing Remote Radio Units (2011).

There is little focus on the ergonomic aspects and how the product shall be handled while lifted. The manual is focusing on the technical elements of how the product shall be installed, mounted and properly connected through cables.

Together with the installation manual, Ericsson AB has constructed an installation video on how to mount and install a RRUS 11 to a radio tower mast.

The installation video shows how the user shall climb up into the radio tower mast wearing proper climbing gear. The users is first to mount the mounting-brackets to the mast and then the mounting brackets to the RRUs, to enable a sturdy and durable installation. The product shall be hoisted to position through its handle by a second installation worker operating from the ground. It is clearly stated in the installation video that there should always be at least two installation workers present at all times when installing, servicing and mounting a RRU onto a mast.

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2.15 Usability- & user-test & Interviews

Ericsson AB sells their communication systems mainly to cities, governments and telecom providers. This means that there are different end users, the initial buyers of the products, the service and installation workers and the ones using the services provided. The products go through many different merchant middlemen who make it hard to get in touch with the end users who install and service the products. This aspect as well as the issue of secrecy makes it almost impossible, as Ericsson AB states it, to actual get in contact and perform tests with these installation and service users. Kallin (2011). Within Ericsson AB there is a department dealing with installation and handling training, this department is called Business Unit Global Services, BUGS. BUGS together with I&V, Identification & Verification, are the departments within Ericsson AB working closest to the end users. However their possibilities of interacting with the end users are limited as well. They get to train the end users, however following up to analyse usability is limited. Williamsson (2011).

Three employees from BUGS and I&V will work as representatives for the end users in the usability-tests, as they have close connection to the end users. Usability studies and interviews will be performed with these test-users, in the best way possible. This is to conduct what aspects of the carrying feature which shall be improved to optimise usage, usability and ergonomics.

The Usability-test will try to conclude how effective the products are to use and how well the tasks are solved. It will also show how efficient the products are to use, time used to solve a task and faults involved in the process of solving the tasks. The last and very important aspect is how satisfactory the use is, how well the products solved the specific tasks. The aspect of satisfaction is very important in the development of a carrying feature, as this means how well it helps the user to solve the tasks in a satisfactory way. If the level of satisfaction is high, this can be verification if the products are well designed and developed. Rexfelt (2009).

Other important aspects to try to conclude through the usability-tests are how intuitive the products are and how easy it is to learn how the products shall be used. If the products enables possibility for experienced users to use their full potential during usage as well as the re-usability possibilities of the products,. Rexfelt (2009).

Ericsson AB has compiled a template document over the usability process used to test and evaluate their products. This document will be regarded when designing the usability-tests for it to properly suit both the needs of Ericsson AB as well as the method taught at Chalmers University of Technology.

Ericsson AB always performs their usability-tests in two parts, the Concept Usability Session (CUS) and the Prototype Usability Session (PUS). The CUS is performed early in the product development process and the PUS is performed later to evaluate the design. However, Ericsson AB's usability guidelines are very general and not specifically adapted to fit the needs of the product development and industrial design process. Only one set of usability-tests will performed during this master thesis. It will function as a CUS, to conclude what is to be redesigned to optimise usability. The PUS will be excluded as the final redesigned concept instead will be evaluated using other evaluation methods. ERICSSON AB - Enclosure & Power Usability (2010).

The usability-tests will be performed on the two existing carrying features on the reference products of RRUS 01 & 11 to conclude how well they solve two specific tasks of lifting and hoisting. The RRUS 12 will not be evaluated as it is closely related to the RRUS 11 as well as of the fact of it being hard to obtain. Three test-users from the BUGS and I&V departments within Ericsson will test both the reference products in two situations. The usability-test will not regard the RRUs as a whole, but instead focus on the function and usability of the carrying features. The tests will be performed in Ericsson AB's temporary usability lab with realistic equipment, hoisting and placement.

In this type of usability-test, with regard to what is to be concluded; functionally, user and ergonomically optimisation, the subjective result will be more interesting and useful than the objective result. One goal is to detect the faults in handling of the product and understand how and why these faults occur, to be able to fix the issues and provide a better product after the redesign. The goal is not to conclude how often the fault occurs, however it can be interesting in the aspect of knowing if it is a common occurrence. To know how the users participating in the usability-test, feel about the products tested and what they think is good or bad and why so, can be useful data. Obtain a general impression of the usage situation and the users' experiences are desirable. Rexfelt (2009). See Appendix III - Usability test.

2.16 Conclusions from the usability-tests

All the users, participating in the usability-tests, hold large knowledge and previous experience of handling and installing Ericsson AB's RRUs. Some of the users had previously worked as installations specialists and all of them have a long background within Ericsson AB. Since their previous knowledge of handling RRUs, they had no problems in concluding and predict how to handle the products. All users predicted the RRUS 11 to be more intuitive and easy to handle than the RRUS 01.

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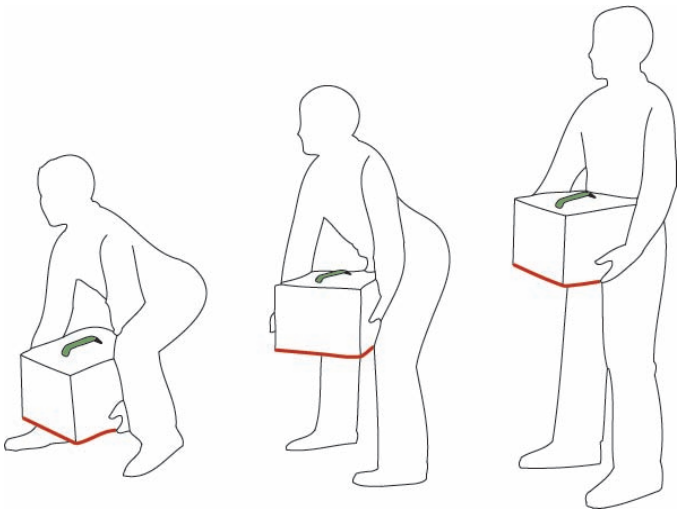
The actual lifting sequence itself was stated by all users to be much easier with the RRUS 11. This was mainly due to the product not taking on an angle like the RRUS 01 does. See Picture 2.09 - Lifting angle. The handle on the RRUS 11 is easier to understand and know how to handle. However after the first usage situation, there is no problem understanding how to handle even the older RRUS 01.

2.16.1 Lifting sequence

The users were to lift the products from the ground up to a height of 1,5 meter. This is a realistic situation which occurs when a RRUs is placed and installed on a wall. Williamsson (2011). During this part of the usability-test, a very important and fascinating aspect was concluded; none of the users lifted the product through its handle. They stated that the handle does not enable lifting to a height of over 0,5 meter over the ground. Most users had to grab the bottom of the product, by the exterior sun-cover corners, to be able to lift the product from the ground up. Picture 2.44 - Lifting without a handle. Regnér (2011). The handles are placed so that a lift to a height of 1,5 meter is not possible. One user however, used the handle to lift the RRUs to the specific height of 1,5 meters. When the product was to be placed on a wall for installation, the user had to let go of the handle, replace his grip and grab the bottom of the RRUs instead.



Picture 2.44 - Lifting without a handle. Regnér (2011)

The same user had problems finding and understanding the handle of the RRUS 01. The user did not find the handle to be very intuitive. However it was stated that the product was fairly easy to handle even though a slight angle occurred during lifting. After some tries the user instead realised that the products was easier to handle without the handle and instead grabbed the product from the bottom from the very start. The handle can without doubt withstand the forces; however its placement makes it unusable as the hands takes on uncomfortable positions while lifting.

All users stated this way of lifting the product as not optimal. Especially the RRUS 01 was regarded as uncomfortable to handle this way. The uncomfortable handling was mainly due to sharp edges on the surfaces of the sun-cover which had to be grabbed to enable lifting. One user stated it to be hard to grab the products to enable lifts, especially the RRUS 01 as its sun-cover is wobbly and sharp.

Even if not being able to use the handles for lifts over 1,5 meters, especially one user states it to be totally unnecessary to enable lifting to this height by the handles. The user refers to the fact that the handle was developed to enable horizontal carrying and not lifting to a height of 1,5 meter.

All users stated that installing and mounting a product is always performed by at least two persons. When installing a RRUs on a wall, at least two persons are always present at all times. One person holding the product in place while the other one is mounting and installing it. However, when installing a product in a radio tower mast there shall always be at least three installation service men present, one or two on the ground and one or two in the mast.

As the handles of both the RRUS 01 & 11 are useless when mounting and installing a RRUs, the ergonomic aspects are hard to conclude. However, the ergonomic aspects of the lifting sequence of the two products can be concluded anyhow. One user stated the products to be very heavy, which leads to a very un-ergonomic lifting experience. All test-users stated that the RRUS 11 is better ergonomically adapted to be lifted without the handle, as it is smoother in its exterior design. The combination of the useless handles and the heavy weight of the products makes the lifting sequence, to a height of 1,5 meter, very un-ergonomical and hard.

One user stated that some pain is involved in the lifting sequence. The pain is moderate and occurs when lifting the products from the bottom. The hands get cut from the edges of the products and the cable-connection placed here. One other user stated that there is no pain at all involved in the lifting sequence even though that the hands have to be placed on sharp edges and cable-connections. The user stated that the areas which are gripped, in the bottom of the products, are smooth without any problems of getting a sturdy comfortable grip.

One aspect that the redesigned RRUs carrying feature is to enable, is for the user to easily and comfortable handle the product only using one hand. This includes carrying as well as installation. This feature was tested in the usability-tests. When it comes to carrying and lifting to a height of 0,5 meter over the ground, both the RRUS 01 & 11 handle enabled this. However when the product was to be lifted to a height of 1,5 meters to enable mounting and installing, it was not possible to neither use the handle or handle the product with only one hand. The handle is placed in the wrong place and the products are much too heavy to in any way enable one handed lifting and installation. This

was also confirmed during the usability-tests, especially by one user how had previously been working with site installations of Ericsson AB's RRUs.

The handle of the RRUS 11 was, by all test-users, considered to be very strong and durable. The handle on the RRUS 01 was however considered weak and too wobbly. On the handle of the RRUS 01 material-plasticity could be seen to occur when the product was lifted and handled. This confirms the statements of the test-users.

There are a few aspects that the test-users find possible to further develop and improve in the redesign of the RRUs carrying feature. One aspect is to develop a smoother softer handle which might hold two materials. This will mean a more comfortable handling situation. However it has previously been concluded by the R&D at Ericsson AB that using two different materials, like the 2011 Mobile World Congress in Barcelona concept handle, will be too expensive and unnecessary. Another aspect is to make the handle ergonomically more adapted to the shape of the users' hands. This could be done through integrating finger-grooves into the handle for it to enable better grip and easier handling. One user states the necessity of implementing and developing a carrying feature which enables handling while lifting and installing the RRUs on a wall. This can mean that not only a single handle is to be developed but just as well many carrying features working together to enable easy solving of the task.

Another user desired a carrying feature which is flexible and easy to hide when not in use. It is also desired for the handle to be somewhat slimmer than the handle placed on the RRUS 11 to enable more comfortable and better gripping and handling.

All users stated that the products are too heavy to handle easily, even if the design of the handles has been regarded.

All and all the handle on the RRUS 11 were perceived to be much more user-friendly and comfortable to handle while lifting the product. However there are great improvement possibilities for it to enable even more user-friendly handling as well as subtleness. This especially concerns the issue of the handles not being usable when lifting the product to a height of over 1,5 meters over the ground.

2.16.2 Hoisting sequence

In the hoisting sequence of the usability-test, the users were to connect hoisting equipment and hoist the product to the height of 1,5 meter, using its carrying feature if possible. This sequence is a common occurrence when the product shall be lifted up into a radio tower mast to enable installation. As the products are so heavy, hoisting is the most common way of getting the RRUs high up in the mast. Williamsson (2011).

All users predicted the hoisting to be fairly easy to perform with a slight advantage for the RRUS 11, which was seen to be easier to handle than the RRU 01. The handle of the RRUS 01 does not enable hoisting as the handle on the RRUS 11 does. One user stated a prediction of the RRUS 01 to hang with an angle while being hoisted. Another user predicted that the hoisting loops of the RRUS 01 were to deform and bend while the product is being hoisted. The sheet metal they are made from was predicted to be too weak.

Most test-users found it to be very easy and intuitive to access and connect all the vital equipment to the RRUs to enable hoisting. One user even stated that there is an installation user manual which is provided by Ericsson AB to each installation service man to demonstrate the proper installation procedure of each product. See Chapter 2.14. However, another test-user with less previous knowledge of installing and handling RRUs, had serious problems understanding where and how the hoisting equipment should be placed on the RRUS 01. This has to be regarded, as the product is not being intuitive enough in the aspect of enabling connection of the hoisting equipment. The user had to be guided to understand how the hoisting equipment should be connected. However, stated afterwards that after being guided that the learnability was very high. After the first try the user understood the process and will be able to fully and properly repeat the task without risk of further mistakes.

All users stated that both RRUs are very easy to hoist and handles very well in the air. The RRUS 01 was stated to have the advantage of not taking on any tilting angle while being hoisted, as the hoisting loops are well placed CoG of the product. The RRUs 11 takes on a slight angle while being hoisted. This can however be neglected, as this angle is so small and does not affect the hoisting sequence.

One very interesting aspect that all users stated was that one person standing on the ground below the radio tower mast is handling the hoisting. Another person up in the mast receives the product at the top and prepares for mounting.

Some users found the RRUS 01 to be harder to attach the hoisting equipment to, and stated at the same time that it is not reference standards to use safety-hooks to enable hoisting. Instead it is more common that the cheapest most easily accessible hoisting equipment is used. This can include thick ropes with a diameter of 30 mm made from e.g. cotton.

All users stated the ergonomic aspect of hoisting the products are the same. It is closely related to the products heavy weight, prior to the design of the handle or the loops.

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The RRUS 01 does not enable hoisting through its handle. However the test-users found the handle of the RRUS 11 to enable hoisting exemplary well.

The issues relating to pain caused when hoisting and interacting with the hoisting equipment connected to the RRUs differed some between the users. One user thought the lift is very painful, mainly because of the sheer weight of the products. One other user did not experience any pain at all during hoisting. However stating that it is easy to cut yourself on the sharp edges of the hoisting loops of the RRUS 01, when connecting the hoisting equipment.

All users found the RRUS 01 hoisting loops to be a little weak, in risk of deforming and because of its sharp edges cut the rope, if no safety hooks are used while hoisting. The handle of the RRUS 11 was seen to be very rigid and sturdy, able to withstand the forces of hoisting very well.

The level of comfortable handling the product while being hoisted varied some, closely related to the level of pain experienced. One user found the products fairly uncomfortable to handle due to its high weight, the same test-user experience some level of pain during the test session of hoisting the RRUS. Another user did not experience any level of pain and also found both RRUS to be very comfortable to handle. No areas are in need of improvement as stated by this user.

The users argued for some improvements to regard when redesigning the handle to better enable hoisting. One user argued for the handle to be better balanced to enable the products to hold a straight angle while hoisted. It should also be very intuitive and easy to connect the necessary equipment needed to hoist the RRUs. The most important aspect though, was to minimize the total weight of the RRUs.

Another user did not find any reason to modify the handle to enable hoisting better, he stated that improvements can always be found but in regard to cost, the present solution definitely fulfils the requirements.

2.16.3 Summarising

Non of the handles on the reference products enabled lifting to a height of 1,5 meter. The handles were useless when trying to do any kind of lifting other than lifting the product straight up to a height of 0,5 meter, only allowing horizontal carrying from one point to another. The handle on the RRUS 11 enabled lifting and horizontal transportation well. However on the RRUS 01, this aspect was not accomplished with as great success.

All tasks were completed, however the handle did not always enabled a proper solution for solving the task. The efficiency of the handles tested would have to be seen as moderate, because of enabling horizontal carrying well. When the product shall be lifted to a height of over 0,5 meter the handles act useless and does not enable any solution for solving the task. Instead the product has to be picked up and lifted from the bottom to allow for a proper grip which enables vertical lifting to a specific height.

The level of satisfaction is connected to the efficiency, however the level of satisfaction varied a lot between the different users. The RRUS 11 handle did perform the task much more satisfactory then the handle of the RRUS 01. None of the handles enabled vertical lifting to a specific height, which has to be regarded as non-satisfactory. One user stated the level of non-satisfaction as high, while another user did not find the aspect of handle not solving the task of lifting to a specific height non-satisfactory at all.

In regard to the valuable data obtained from the usability-tests, the handles have to be seen as in need of improvements and are non-satisfactory to this day.

2.17 Ergonomic aspects

Sr Industrial Designer HW Usability, Ericsson AB, Mats Johansson, with expertise in ergonomics, has been consulted and interviewed to get accurate and valid data on how to optimise ergonomic aspects of the carrying feature. Interviewing an ergonomic expert, based on the ergonomic aspects of the handles of the RRUS 01 and 11 & 12, has provided data which will work as a foundation for improvements within the redesign. There are many important ergonomic aspects to consider when redesigning the carrying feature. As many of Ericsson AB's RRUs are very heavy and hard to handle, it is important that the carrying feature simplifies handling as much as possible as well as provides a good ergonomic work situation. Johansson (2011).

It is recommended that a product which is lifted from the ground is not to hold a weight of more than 25 kg for it to not affect the user negatively regarding to ergonomic aspects. Products with a weight up 10 kg can be handled by 99 % of the population, concerning both men and women. As soon as a product holds a weigh up to about 25 kilo the users capable of lifting it is reduced to 85% of the general population. Products holding a weight over 25 kg are recommended to only be handled by professional personnel under special circumstances, as it can lead to large stress on the user. It is crucial for the users to be well trained and properly instructed to handle a lift of a 25 kg item without causing to large stress on his/her body. Johansson (2011)

As of regulations set, every work situation is to suite everyone within the working population, men and women. This reduces, to some extent, the percentage of the population capable of lifting heavier loads. Johansson (2011).

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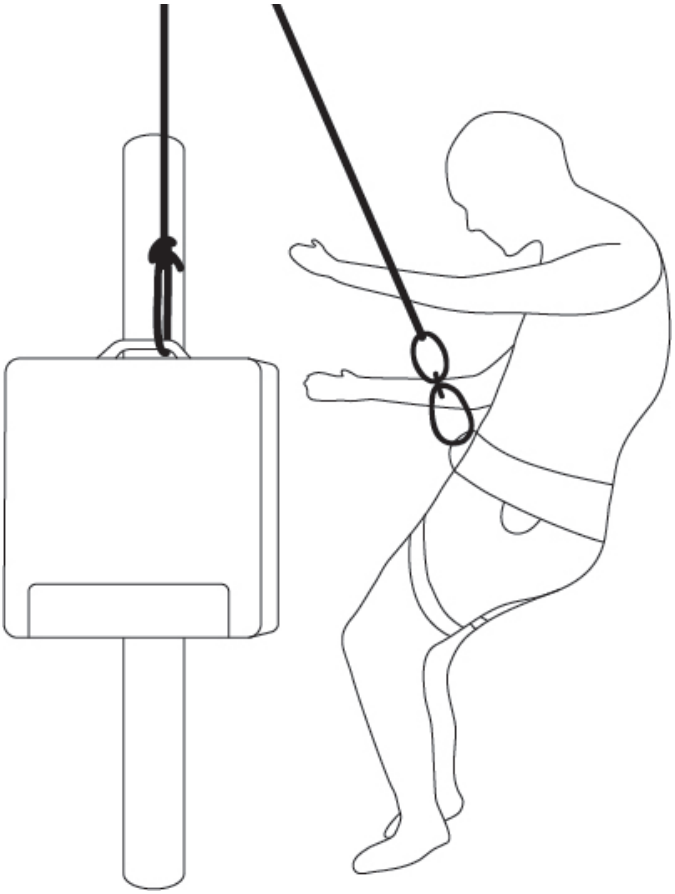
Regarding the lifting sequence, it is always recommended that heavy products are lifted using both hands and arms to balance the load in front of the users body. The load should be lifted and held close to the body to minimise stress. Johansson (2011).

When it comes to hoisting, is it important to minimise the load as much as possible, especially when the load is as heavy as 25-40 kg. It will be hard for the user to handle an item this heavy, as well as it will put unnecessary stress on the user. A tackle or a chain-pulley can be used to minimise the load of the item while hoisting it.

One very interesting aspect when handling a heavy load is that the stress on the user's body is much worse when an item is held statically without support, compared to lifting the item from the ground. The optimal handling situation of a heavy product, about to get mounted is to support the item. A "third hand" solution which enables the user to properly use both his/her hands for installation without supporting the product, is regarded desirable. Johansson (2011). See Picture 2.45 - Third hand solution.

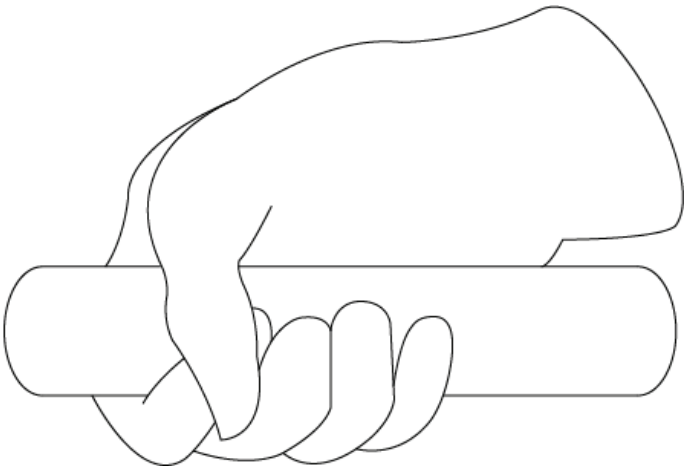


Picture 2.45 - Third hand solution. Regnér (2011)

As the RRUs are heavy and hard to handle, some kind of tool for transporting the product ergonomically to the installation-site is to prefer. Johansson (2011).

There are many different aspects to regard in the design of a handle or a carrying feature. To provide the strongest possible grip, the carrying feature should hold a diameter of 3-4 cm for an adult user. This allows the users thumb to just cover the tip of the index and middle fingers providing a strong and sturdy grip of the handle, a power-grip. Patkin (2001), Johansson (2011).

The power-grip is used to handle heavy items as well as where power goes before precision. A power-grip is what is used by the user when handling a RRU through its handle. The power-grips is described by that all fingers are firmly wrapped around the grabbed object, with the thumb overlapping the fingers or placed along the shaft of the grabbed object. The whole hand of the user wraps around the grabbed object. See Picture 2.46 - Power grip. The power-grip provides good strength in the grip, due to the forearm muscles are shortened through contraction to a position where they provide maximum strength and effectiveness. The main muscles used while carrying or holding an item through the power-grip is the strong muscles in the forearm, upper arm (biceps and triceps) and shoulder. Patkin (2001).



Picture 2.46 - Power grip. Regnér (2011)

The shape of the handle should be cylindrical (to some extent) if possible, to properly fit the palm of the hand. All sharp edges and high spots in the grip area should be avoided to secure fully ergonomic and comfortable handling. Sharp edges and high spots can not only lead to uncomfortable handling it can also impair the security of the grip, as the user is not able to hold the handle as firm as necessary. Patkin (2001), Johansson (2011).

The handle should be designed so that it enables lifting and handling without creating uncomfortable arm separation or placement. To enable ergonomic and easy handling it is important that the user can lift and handle the item in front of him/her, close to the body, without requiring body lean.

The carrying feature should be designed in consideration of the user wearing gloves. RRUs are sometimes handled in very harsh and extreme weather. This means that gloves are needed to perform installation and service. The carrying feature has to be designed to fit to a user wearing gloves, without obstructing easy handling and task performance. Kallin (2011).

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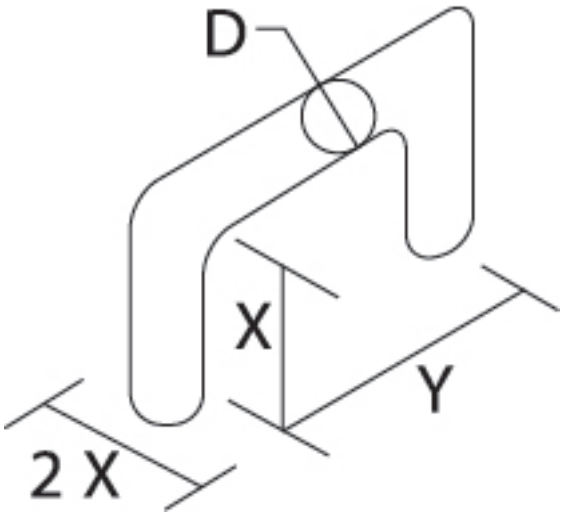
There are standard dimensions and measurements to regard when designing a carrying feature, for it be optimised in regard to ergonomic aspects. For a handle-bar used to carry a product with one hand to be optimised for ergonomic handling, it has to hold a grip area with a length of at least 111 mm. This is for it to suit most kind of hand-types and be possible to use with gloves. The handle has to hold at least 40-48 mm of free space all around it for a hand to properly and untroubled grab and handle it. These measurements are developed by NASA, which means that they are adapted to handle the most demanding situations. Johansson (2011).

The diameter of the handle varies depending on how heavy the product is. It is recommended that a product that is heavier than 18 kg is to hold a circular diameter of at least 25 mm. Johansson (2011). Sr Industrial Designer HW Usability, Ericsson AB, Mats Johansson states that for optimal gripping of heavy products, the handle diameter should be between 25 up to 40 mm. However if the products weight is less, the handle diameter can be made much thinner. A 7 - 18 kg product can hold a diameter varying from 13 - 19 mm. Johansson (2011). See Picture 2.47 - Ergonomic grip dimensions. Regnér (2011).



Picture 2.47 - Ergonomic grip dimensions. Regnér (2011).
D = Diameter, X = Grip-space, Y = Length

For a user to properly get a good grip around a handle to enable lifting of heavy features, the fingers of the gripping hand shall wrap around the handle's edge with a minimum angle of 120°. Johansson (2011).

It is important to synchronise the handle's placement and the CoG of the product for it to enable straight and easy handling. Johansson (2011).

For a flexible carrying feature to fit to the most of Ericsson AB's products it has to be as low and thin as possible. Both in regard to not increase the total volume of the product as well as for the carrying feature to fit within the dimensions of the product when hidden. The products vary some in volume and dimensions and it is desirable that the carrying feature is modular to fit as wide span of Ericsson AB's portable products as possible. Kallin (2011). If the handle is too large it can tend to intrude on the cooling flanges or sun-cover. See Picture 2.48 - Too large handle. Regnér (2011).

Picture 2.48 - Too large handle. Regnér (2011).

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2.18 Sustainability analysis

The aspect of sustainability is becoming a more and more important factor, there is a need to take care of our planet through social responsibility. Financial benefits can be made as well as differentiation from the competitors is possible through sustainable design.

The analysis will be based on information provided by Ericsson regarding material selection, production methods, environmental impact, the modularity and upgradability possibilities and reusability and re-cycling aspects. The data in the sustainability analysis will concern Ericsson AB's RRUs and mainly be based on the reference RRUS 12, being the most recent product. When complied, it will lead to information which shall be easy to regard within future product development. Ericsson AB is a very large company and it is hard to compile data from all different sections working with production, logistics, recycling and research & development. The data has been gathered from competent engineers and designers at Eriksson AB Kista, Sweden. Due to the size of the organisation and the short the time frame of this thesis, it is difficult to compile and conclude every important aspect regarding sustainability. The sustainability analysis has been performed on the data that has been able to get hold of, in the short amount of time, and compiled this into valid and useful sustainability guidelines.

To conclude accurate and valid data on the materials, production methods, upgradability, modularity and recycling, a questionnaire document concerning these topics was compiled. The document was then sent to relevant actors, such as material and mechanical engineers, within Ericsson AB. These actors provided the relevant data which the analysis is based upon together with interviews. See Appendix IV - Questions vital to answer within the sustainability.

2.18.1 Materials

In the sustainability analysis, the materials that will be considered are the ones concerning the sun-cover, internal-body and interaction areas. The materials used in the vital technical parts are too delicate and hard focus on within the time-span of this master thesis, why they will be disregarded. This will have to be considered when reviewing this analysis. However the thesis is concerning sustainable industrial and hardware design, these factors are the main area of focus.

The choice of materials can be crucial for the environmental impact of a product during its life time. There is a great necessity to optimise this to minimise the negative impact. Due to large size of Ericsson AB and the fact that their products are sometimes produced and manufactured at different locations, depending on where the products are to be sold and used, it has been hard to conclude the exact materials and production-sites.

There are very hard restrictions and requirements on the materials of the RRUs, and all of Ericsson AB's products. This makes the possibility of using alternative materials low. One of the most important and restricting requirements, on the choice of materials, is the fire safety requirements. These requirements are set to the highest level so that the products will make minimal damage on the structure it is placed on, if taken on fire. The products are rather to release toxic fumes than rapidly and greatly burn, for it to surely not damage a building or enhance a fire. The hard requirements are mainly due to American legislations. The highest level of fire safety requirements is V0 in the standard of HL94. Pettersson (2011).

In all of the recently produced products as well as the ones underdevelopment, all heavy metals are excluded to as large extent as possible. All materials used shall be possible to reuse or recycle. Rodgers (2012).

Every part of the RRUs is to hold the HL94 requirement of V0 except the sun-cover, which recently has been degraded to level A6. HL94 level A6 holds not as strict fire safety requirements as V0 does. This means that more materials are possible to use to solve the specific task. However none of the reference RRUs have been developed with regard to HL94, but instead with the stricter V0. Pettersson (2011).

When using recycled materials Ericsson AB can minimise the CO2-Emissions by up to 20 times compared to using new material. There are great possibilities in using recycled materials as it can both be beneficial financially and environmentally as well as strengthen the brand. Rodgers (2012).

Sun-cover

The design-values of Ericsson AB's are not yet fully implemented in the Ericsson AB product line. All reference products hold some kind of protective sun-cover which protects the products and its vital technical functions from outer forces. Thelin (2011). This protective sun-cover is the part which material has been degraded to the less strict fire requirement of A6. Pettersson (2011).

The reference product of RRUS 12 holds a sun-cover made from Polycarbonate - PC plastic and/or Acrylonitrile butadiene styrene – ABS plastic, depending of situation and production-sites. Pettersson (2011).

Because of the fire requirements of V0, which has until recently been used, PC and ABS are the only materials which are cheap and safe enough to use as sun-covers. Using a metal cover will be too expensive and unnecessary, as a plastic material solves the task good enough with regards to protection and durability. The requirement of V0, which only enables a few materials to be used, means that

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any kind of method to apply protective paint and lacquer is not possible. PC and ABS plastics are not possible to colour within the production process. The paint has to be added after the plastic has been moulded into shape, using the method of wet-coating. This method of lacquering is very expensive and holds a very negative environmental impact, due to many toxic solvents being used. Pettersson (2011).

The use of wet-coating also holds a negative effect with regard to the production cost of the product. The production cost of wet-coating stands for almost 50 % of the total production cost of the sun-covers. Due to the high fire restriction level, the materials possible to use are lowered drastically. Pettersson (2011).

Internal-body (design-values)

Under the protective sun-cover is the solid internal-body of the RRUs. It houses all the vital technical features and cables-connections inside. The internal-body also houses the cooling flanges which work through cooling the technical features, generating large amounts of heat. All of the reference RRUs has an internal-body made from die-casted aluminium. The internal-body has to be solid, strong and durable as well as enable good cooling. Isolating to disable radiation and signals between the internal technical features is another important aspect. If the internal-body does not disable radiation, the signals transmitted between radio units and antennas might be disturbed which will result in poor telecommunication possibilities and mobile signals.

Ericsson AB's products are manufactured and produced at different locations depending on product and area where they shall to be used. Due to this fact, the materials used differ some. For example are the products produced and manufacturer in Europe made mainly from recycled aluminium, while products produced in Asia consist of mainly newly broken aluminium. Pettersson (2011).

When recycled aluminium is used, it is not uncommon that small amounts other metals can be found in the aluminium. It is hard to fully exclude other unwanted materials within the recycled aluminium. However Ericsson AB controls every batch to secure as pure aluminium as possible. Pettersson (2011). When aluminium contains other materials it can lead to corrosion within the material, which makes the lifespan much shorter. For this reason Ericsson AB has set up guidelines which states the maximum amount of, for example, copper that is allowed within the aluminium. The level of aluminium is very important to regard. If the level of copper is increased, the risk of corrosion within the aluminium is far greater. This means that it will be hard for Ericsson AB to provide products with a minimum lifespan of 10 years. For example, if the amount of copper is doubled, the lifespan of the part is decreased by up to 4 times, due to corrosion. This indicates that a product that is intended to last for 10 years only will last for 2,5 years. Pettersson (2011).

Corrosion is most likely to appear on products which are placed outdoors. Aluminium is used due to its relatively low weight and price as well as it fulfils all of Ericsson AB's requirements of radiation isolation and protection from outer forces. Pettersson (2011).

Why for example steel is not used, is because of it being heavier than aluminium as well as when steel corrodes it is much more obvious from a spectator point of view. Rust and corrosion on steel is much less socially accepted than corrosion on aluminium, which is only portrayed as whitish powdery areas. This aspect is another very important aspect why Ericsson AB is using die-casted aluminium within the internal-bodies of their RRUs. Pettersson (2011).

Overlays (Interface-areas)

The interface features of the RRUs are areas which are closely interacted with, by installation and service personnel. The areas show indications and symbols how the products are to be used, which feature do what and what features are in use. The most important aspect of the material used for the interface areas, is that it is to be transparent. The interface areas are, by Ericsson AB, defined as Overlays, a sticker-like surface which is attached to the internal-body of the RRUs. The overlay is transparent so that the colour of the internal-body is to visible trough it. Today almost all overlays are made from thin transparent Polycarbonate - PC plastics. Why Polycarbonate is used is due the fact that it is relatively strong and durable as well as is not ripped in two, if pealed of the internal-body. It is very important for the overlay not to break if it shall be changed or replaced. The part shall last for at least 10 years and be strong enough to withstand the force of being pealed off from the internal-body, pealing of the glue. V0 restriction shall be regarded within this part. Pettersson (2011).

Carrying feature

The carrying features have to be made from a durable strong material which shall withstand the heavy load of the RRUs as well as a "fall and stop" situation while hoisted. Due to these requirements, the handles on the reference products are made from high strength die-casted aluminium on the RRUS 11 & 12 and stainless steel on the RRUS 01. As it is common for RRUs to be placed outdoors where it is exposed to harsh weather and strong sun-light, the material shall withstand these forces without being negatively affected. It is extra important that the material is not to broken down by UV-light/rays. The material has to be adapted towards resisting these impacts. The die-casted aluminium carrying features on the RRUS 11 & 12 are of the same material as the internal-body making it easy to recycle and produce. The carrying features hold the same requirements on the quality and pureness of aluminium, to minimise risk of corrosion and shortening of the lifespan of the material,1 as the internal-body. Pettersson (2011).

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Screw-joints

All screws and joint-items have to be very hard and be able to withstand the forces of the product being handled as well as the outer forces the product is exposed to. The material used is stainless steel classification A4, due to the materials extremely good capacity to withstand corrosion in almost any situation. When a RRUs is placed indoors the necessity of having A4 stainless steel screws is not as big. However stainless steel is still used in all these features. Pettersson (2011).

Paint - colouring

Colouring of different parts and features of Ericsson AB's RRUs are crucial. Both in the aspect of protection but also the aspect of the semantic expression. Colouring by powder-coating together with corrosion resistant solvents is a very important combination. This is to assure that the die-casted aluminium does not corrode, which shortens the products lifespan.

The colouring methods used depend on the material, however there are two methods that are commonly used to colour the internal-body and the sun-cover of the RRUs. The internal-body and the sun-cover are the parts mainly being coloured, as these two are the ones mostly exposed to the outer weather forces. When colouring the internal-body, also concerning the carrying features and product feet as these are made from die-casted aluminium as well, powder-coating is used. The method of powder-coating works by applying a negative loaded coloured powder to a positive loaded item. The item is then put into an oven where the powder is evenly melted onto the item, creating a very strong and nice coloured finish. The binder used during powder-coating is mainly Polyethylene, while earlier Ericsson AB used epoxy. The use of Epoxy as a binder was cancelled due to the high risk of allergic reactions when handling the substance. Polyethylene is less toxic however it takes on a yellowish colour after some time. The yellowing process is also speeded up by the exposure to light and heat. Pettersson (2011).

Wet-coating is used on the sun-cover due to the fact that the Polycarbonate and ABS granulates cannot be coloured when produced. Instead the end-product has to be wet-coated to colour the part as desired for protection and visual appearance. Pettersson (2011).

Ericsson AB is today using Dupont and Akzo Nobel as deliverers in colouring of their products, including the RRUs. Pettersson (2011).

The chemicals used within the actual paint depend on the actual colour itself. For example when white paint is applied it is derived from titanium-oxide. Pettersson (2011).

Control of Materials

Ericsson AB tries, in the best possible way, to control where the materials used in their products originates from. However, Ericsson AB can only control as far back as to their subcontractors, where and how the products are produced. This makes it impossible for Ericsson AB to know exactly how and where the materials used in their products are mined and originates from. Ericsson AB has to trust their subcontractor to act ethically and work with human and environmental aspects is regard. Pettersson (2011).

For the subcontractor to know what is required of them in regard to environmental and humane aspects, Ericsson AB has concluded regulations and requirements which are to be followed. Ericsson AB does continuously follow up and control if these regulations and requirements are followed by their subcontractors. If the subcontractor prove to not follow these requirements and regulation, as promised, Ericsson AB confront or even sue the subcontractor. Pettersson (2011).

Due to the regulations and requirements, which also concerns standards on materials, Ericsson AB can control that the materials used are fulfilling the necessary aspects, to some extent. Trankell (2012).

Every material used by Ericsson AB in their products is declared, to be able to control the materials and understand how and if they are affecting its environment. A software by the name of Eliza, is used to declare and clear materials which shall be used. However it is not always that the materials are cleared to use. If the materials are not cleared, they do not fulfil the requirements concerning durability, surface-finish, cooling and environmental aspects, which is notified by Eliza. Trankell (2012).

Ericsson AB is striving to use as environmental friendly materials as possible. However it is sometimes very hard to control this, as it is controlled by sub-contractors all over the world. For example is recycled aluminium used within the aluminium parts produced I Europe. Recycled aluminium is cheaper than new aluminium in Europe, why it is preferred within production to minimise the costs. Pettersson (2011). In Asia and foremost China on the other hand, newly mined aluminium is much cheaper than recycled aluminium which means that this is used exclusively. The use of new aluminium holds a much larger impact on the environment than recycled aluminium. Ericsson AB is unable to affect the use of new aluminium in China as this is the common occurrence, as well as the production being based on price. Pettersson (2011).

Within the EU, recycled aluminium is approximately 10 % cheaper than newly mined aluminium. This provides some indication that the production-sites within Europe holds less negative environmental impact compared to the Asian factories. However there are other factors which have to be regarded as well. Pettersson (2011).

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2.18.2 Production

The production methods used to produce Ericsson AB's RRUs will be analysed and portrayed in the best possible way. This will later be compiled and provide data which shall be regarded in the future R&D process. There are many interesting sustainability aspects concerning environmental impact as well as welfare issues before, during and after production.

The production of Ericsson AB's RRUs varies depending on model, place it is being sold at and the material differences. Depending on where the product is being sold and used, the productions-site varies. For example is it common for products being sold and used in Asia to be produced in China. While many products for the European market are made in Eastern Europe. Ericsson AB has an unwritten policy which they try to follow to as large extent as possible; to use suppliers of materials and parts as close to the production-site as possible. By doing this Ericsson AB works with minimising the transportation of goods, which holds a large environmental impact. Pettersson (2011).

Ericsson AB subcontracts major production-sites in many parts of the world, however Asia and Europe are the major areas. This means that parts are and can be produced close to the assembly-sites, which can minimise the transportation of parts. Pettersson (2011).

Almost exclusively all parts within Ericsson AB's products are produced at different locations and productions-sites. This is mainly due to the fact of one factory often only dealing with one type of production. Pettersson (2011).

Ericsson AB uses aluminium die-casting production subcontractors in Europe, Asia and South America. In Brazil for example, Ericsson has started up production at subcontractors, focusing on the Brazilian market. This is due to the fact of high import taxes of products to Brazil. It is cheaper for Ericsson AB to produce certain parts locally than to import them. This is also a good aspect when it comes to environmental impact as less parts has to be transported. The product can be produced and assembled locally and then sold on the national market. Other major Swedish corporations acting on the Brazilian market are Scania and Volvo Trucks to minimise the importing taxes. Pettersson (2011), Scania Group (2012), Volvo Trucks Global (2012).

Depending on where in the world the products are produced there are different legislations controlling the quality and environmental impact of the production-process. As these legislations differ a lot between different parts of the world, Ericsson AB has chosen to regard only the toughest requirement legislations. This means that the best possible production methods will be used to secure high quality and minimise the environmental impact. By only regarding the toughest legislations Ericsson AB holds the possibility of producing goods all over the world, retain quality and minimise the environmental impact. All products shall be possible to produce anywhere in the world and still be just as good. Rodgers (2012), Pettersson (2011).

Aluminium

All aluminium parts such as the internal-body and the carrying feature are made through die-casting.

The internal-body and the carrying feature of the RRUS 11 & 12 are produced by die-casting. Melted aluminium is poured into a metal mould and is then cooled down to solidify in the specific shape of the mould. The moulding tool is made from a metal material and cost around 50 000 Euro produce. The tool can make around 50 000 moulds before it has to be discarded and replaced. Pettersson (2011).

The aluminium used to produce the European made products consists mainly of recycled aluminium. New aluminium is mixed with recycled aluminium to produce a strong, clean and more environmentally friendly material, fulfilling the purification requirements of Ericsson AB.

Ericsson AB has at least seven major aluminium production subcontractors placed on the Chinese east coast. The major production-site being TATFOOK, who has been producing die-casted aluminium products with very good quality over a long period of time. They work out of the Shenzhen and Anhui regions of China. Other die-casted aluminium productions-sites used by Ericsson AB are located in the eastern regions of Europe, foremost Rumania and Czech Republic. Pettersson (2011), Tatfook (2012).

Plastic details

Almost exclusively, all plastic details which are used within the Ericsson AB's products are injection-moulded. This way of production is relatively cheap and enables large batches of identical products.

The sun-covers which are made from Polycarbonate or ABS plastic are injection-moulded to get the desired shapes. Plastic granulates melted and injected into the mould, where it is later cooled off and solidified to the specific shapes. The injection-mould cost approximately 50 000 Euros, however can produced around 1 000 000 copies of the desired shapes. Pettersson (2011).

Rubber parts such as cable-connection caps are usually made from some kind of rubber or rubbery plastic. The method used as well as the specific material has been hard to conclude however, Ericsson AB's material engineers indicates that sand-casting is the most likely method to be used to produce these small parts. The environmental impact of these parts is small due to the little material used as well as not being a major part of the RRUs as a whole. Pettersson (2011).

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Other productions-sites used by Ericsson in Europe are for example a large one in Tallinn Estonia, mainly producing radio filters. The production-site in Tallinn is close to Sweden and Europe, one of Ericsson AB's largest markets, which means that the transportation can be minimised. The production costs in Tallinn are fairly low while the quality is still high, making it a good choice to hold production in the European region. Pettersson (2011).

Due to Ericsson AB starting up production in areas like Brazil, their subcontractors are starting up in these areas as well. When the subcontractors are starting up business in these regions, it indicates that there are big possibilities of delivering large amounts of products to these areas. The production in Brazil, as well as India, which is fast growing, can enable more locally produced products to the South American and Central Asian region. Kallin (2011).

Assembly

Assembly of Ericsson AB's products are always performed by Ericsson AB at local assembly offices. This provides the safety of Ericsson AB being the only actor who knows how the products work and are assembled. By not letting subcontractors handle assembly, Ericsson AB can to a much higher level control that minimum valuable and secret information is leaking to competitors. Kallin (2011).

One of the major assembly-sites in Europe is in Kumla, Sweden. Here many of the products for the European market are assembled. The individual parts are collected in Kumla, assembled and sent to customers. If the materials used to assemble the products in Kumla are foemost produced in Europe, has not been concluded as information about this has been hard to get hold of. Kallin (2011).

Even things like the circuit boards are produced locally in Kumla from lose components, shipped from all over the world. Due to the high level of secrecy, it is important for Ericsson AB to control the assembly. The assembly-site in Kumla is Ericsson AB's head assembly-site in Europe. However when the batches are becoming too large, the assembly is moved to Tallinn This site can handle larger quantities. Tallinn holds both production of specific parts as well as assembly for the European market due to its location, quality provided and price efficiency. Pettersson (2011).

Other major assembly-sites are foremost in China, where the products are aimed for and sold on the Asian market. As parts are supplied by different producers it is crucial during the assembly-phase that the products are checked so that they hold the same quality and colour scheme. There is a risk of differentiation, which does not correspond to Ericsson AB's requirements. It is therefore extremely important to follow up production during the assembly-phase. Pettersson (2011).

As of recently, Ericsson AB has started up major assembly-sites in India as well as in Brazil, just as the production-sites. Kallin (2011). The assembly-site in Brazil will work closely with locally produced components. Together these sites can help Ericsson AB to minimise the importing taxes that comes with importing complete products to the country. The assembly-site in Brazil will together with large production-sites in Mexico work as the main supplier of Ericsson AB products to the South American market. Pettersson (2011).

Part information

Due to the time-span of this master thesis, as well as the possibility of getting hold of important information, the sustainability analysis will overall be general. The information about parts is only concerning the major parts of the RRUs. In this case the RRUS 12 has been used as a reference product. From a product database software, PIwin - R20, data has been collected of the weight and sizes of the parts of the reference RRU. Andersson (2012).

The internal-body and the sun-cover of the reference product are made in two parts each, one front- and one back-piece. This enables easier assembly and service of the product. The total weight the individual parts will only be regarded in this analysis. Andersson (2012).

- Internal-body - 14,6 KG
- Sun-cover - 1,98 KG
- Overlay, labels and interface markings - 0,116 KG
- Carrying feature - 0,098 KG
- Feet (A pair of two) - 0,027 KG
- Screws - 0,21 KG (Total weight)
- Packaging material - 14 Kg
- Total weight of RRUS 12 - 25 Kg

Total weight including packaging materials 39 Kg. Andersson (2012).

The weights of the products are of significance when applying data into a life cycle assessment software, to conclude the environmental impact of a product over its whole life cycle.

Packaging materials

Packaging materials are essential to most products when it comes to transportation of the goods from manufacturing and assembly to retailer. The packaging material protects the products during transportation and handling before it reaches the end-user. The environmental impact of the packaging material is important to regard as this is usually a one-time use element. Often the packaging materials

are used during transportation and when the product reaches the end-user, the packaging material is discarded. Rosdgers (2012).

The packaging material which is used for Ericsson RRUS 12 holds a total weight of 14 Kg, which makes the total weight of the product to approximately 39 Kg. The main parts of the packaging material is a wooden pallet with a weight of approximately 3,9 Kg. The pallet makes out the base of the packaging material, where the RRUs is placed on top of it. Next after the pallet are the fitments, a softer material frame which the product is placed inside for protection and shock absorption. These fitments are made from expanded Polyethylene which is non-conductive. Buzsaky Johansson (2012). The fitments consist of a bottom-fitment of 4,06 Kg and two top-fitments of 1,93 Kg. Surrounding the fitments is a frame made from corrugated board with a weight of 1,05 Kg and a Plywood lid of 2,6 Kg protecting the RRUs from outer forces. Huele (2012).

Holding all the packaging material together is a 3,6 meter long package strip made from polyester. The packaging strips are wrapped around the corrugated frame, lid and pallet enabling a steady and durable package, possible to transport trans-continental. Huele (2012).

2.18.3 Modularity

By analysing the RRUs modularity within the product family, the usage of the product and its features can through this be optimised. By letting features and parts be modular and adapted to fit many of the products within the product family, less parts and features has to be developed, produced and discarded. It prolongs the lifespan of Ericsson AB's products as well as being a possibility for the company the save money on expensive R&D. None of the reference products are modular in a way that it or its parts can be used in a different way or situation. However there are possibilities of using a few parts from one product on another. Kallin (2011).

The RRUS 12 is a Swedish further developed version of the Chinese developed RRUS 11. The handles on the RRUS 11 & 12 are very similar, however the one fitted on the RRUS 12 is slightly longer and has other dimensions for the fittings. The dimensions of the internal-bodies are slightly different between the RRUS 11 & 12 which means that the sun-covers are not modular between the two products. Due to the difference in efficiency of the radio unit placed inside the internal-body, the internal-body has been custom designed to fit the cooling properties to that specific product. The size and number of radio units placed within the internal-body differs between the different models as well. This means that none of the present internal-bodies are modular to be used with another RRUs radio unit. However in one sequence there is some modularity within the internal-bodies. The RRUS 02 and 12 uses the same die-casted aluminium internal-body. The RRUS 02 is a one-signal version of the two-signalled RRUS 12. The area for the second amplifier unit is taken out and not replaced with anything. This indicates that the internal-body for the RRUS 02 is slightly over-dimensioned as there is unused space inside. The products are identical but with a slight difference in performance. Kallin (2011).

As the RRUS 01 is totally differently designed in regard to shape, size and the way the carrying feature is placed, the product's parts are not modular to any other Ericsson AB product. The major problem with modularity within Ericsson AB's products is the fast development of new technology. For example did the NMT-system last for approximately 20 years, GSM for 10 years, 3G for 5 years and now 4G which will be up to date for an estimated 2,5 years before a new technology takes over. This fast development of new technology means that a product can be outdated very fast. This will only increase as the recent technology is being overrun in a faster pace all the time. Kallin (2011).

With a new generation of technology, the effect and efficiency of the products demands better and more efficient cooling. This means that every new product has to be customised to fit these needs for the product to work as desired. Due to this customisation of the parts within each Ericsson AB product, there are very few details which are fully modular between the products.

Within the RRUS 12, a smart and modular feature has been developed for the internal-body. Depending on where the product is to be used, the frequency of the signals varies. This means that modifications and rearrangements of the internal parts has to be done. Usually this indicates that the internal structure of the internal-body has to be redesigned to fit each of the different internal features. On the RRUS 12 the engineers and designers at Ericsson AB have developed a system where the internal structure can be change without further development or customisation. Earlier the internal structure was divided by walls made during the die-casting process, which separated the internal technical parts. However, these walls are now modular and not moulded into the design. They are instead made from silicone rubber and are fully movable within the structure. This allows for rearrangement of components to allow different frequencies without redesigning the internal-body. This kind of feature is new and improves the modularity of the products a lot. Work concerning adaptation and customisation can due to this be minimised. Kallin (2011).

No data on if the screws are modular and fit the reference products have been obtained, however there is great possibility that this is the case.

The cable-connections are made from brass and are to some extent modular to fit many different products. There are many cable-connections that are standardised connections all over the world, which means that they are uniform between the products. However, the mounts of the cable-connection within the RRUs do have to be adapted to fit each internal-body and circuit-board. The cable-connections are to some extent modular between the

products, but usually do minor changes in design have to be done for the connection-area to fit the specific product. When a cable-connection is to be placed on a different product it is often slightly different in size and shape which demands changes in design. This means that not even the cable-connections are fully modular. Kallin (2011).

The overlays are similar in layout but each of these items has to be adapted to fit the representative RRUs. If one overlay is used on a product which it is not intended for, it can provide misleading information.

The modularity of Ericsson AB's RRUs and its parts are, as of today, not adapted to be modular and this can be seen throughout the design and dimensions of the products.

Some of the other products developed by Ericsson AB, such as cabinet-housings, containing radio and transmission units, are made much more modular. Usually these cabinets are much larger and placed on the ground, not like the portable and "radio tower mast-mounted" RRUs. The cabinets are made modular in a way that many different radio and transmission units can be place inside. The way of modularity makes it easy to change and upgrade the technical features and performance of the products. However, large areas inside the product are open with unused space. This enables good cooling but at the same time makes the product larger in volume. The mobile RRUs are not designed and engineered in the same way. Pettersson (2011).

There are steps taken to make the Ericsson AB's products within a specific product family more modular. This can be financially and environmentally beneficial. The implementation of the design-values is a step in the right direction as this unifies the products and makes it easier to adapt them towards modularity.

When the semantic expression is uniform, it is easier to try to make other parts more modular. However, the modularity of for example the internal-body and the sun-cover might be hard to make fully modular. The shape of the product tells the difference between the products within that specific product family. Other, not as substantial, parts are both easier and more suitable to make modular, such as carrying features, feet, cable-connections and mounting brackets.

2.18.4 Upgradability

The aspect of upgradability is one area where a product can prolong its life and fulfil the requirements with improved performance. For example would this indicate that a RRUs can exchange and upgrade the vital technical parts inside, allowing better performance and usage without changing the exterior parts. One place where upgradability is common within technical items is computers. A computers performance can easily be enhanced by upgrading the random access memory, RAM. The computer is then substantially upgraded with regard to performance without it being a new computer.

The fast changes and demands for better performance within telecommunication makes the development of new products constant. This indicates that even if a product has a physical lifespan of at least ten years, it will not surely be up to date concerning the technical performance.

As describe previously in Chapter 2.18.3 - Modularity there is a fast change taking place, constant development and upgrading of the telecom-systems. Nowadays, a new generation is outdating the current one in only a few years. This makes upgradability of Ericsson AB's products very difficult. As new technology holds different and higher demands on cooling for example, as it produces more heat, it is not possible to fit a new and updated radio unit inside and old RRU internal-body. The cooling system and flanges are not adapted to be able to properly cool a radio unit not designed for that specific internal-body. This is why new hardware has to be developed as soon as more efficient or new systems are developed. Kallin (2011), Pettersson (2011).

Ericsson AB's products are not designed for upgradability, as each new and better performance part demands different requirements on cooling and dimensions. The RRUS 12 for example holds four transmitters while the RRUS 11 only holds two. This means that the cooling system on the RRUS 12 has to be adapted to be able to properly cool the system for it to not fail through overheating. Kallin (2011).

The constant demand on better performance within the products under development leads to new systems and more features to be fitted inside the internal-body. When more receivers and transmitters are to be placed within the RRUs, the internal-body and its dimensions has to be adapted. For this reason it is hard to upgrade a present RRUs. Instead the product has to be replaced to fulfil the new requirements with higher demands.

The exterior parts of the RRUs are can theoretically be changed and replaced to allow upgradability. However no upgradable parts are available as of today. To this day there are no possibilities of face-lifts for any product within the Ericsson AB product family. For example, a RRUS 11 cannot be updated to a RRUS 12 visually, by fitting a RRUS 12 sun-cover onto the internal-body of the RRUS 11. The sun-cover of the RRUS 12 does not fit onto the internal-body of the RRUS 11. Kallin (2011).

The issue of the constant changes and demand for faster and more reliable mobile communication shortens the lifespan of Ericsson AB's RRUs as well as other products. The products get outdated even though they physically can last much longer. Some of Ericsson AB's requirements are that the products shall last for up to 20 years. However, as the launching of new generations of telecommunication systems occurs much faster nowadays, the lifespan of products has been downgraded to 10 years. If not adapted to last for 10

years instead of 20, the products get outdated to fast and would be overdesigned in regard to quality. Kallin (2011).

As a whole, it can be concluded that the upgradability of Ericsson AB's products are almost exclusively non-existent. Instead new products are launched.

2.18.5 Reuse & Recycling

Reuse

The reuse and recycling aspect of sustainability is very important. If a product is still good and works, there is a possibility for it to be further used in a different situation or place. The possibility lies within selling outdated products from one part of the world to other parts where this technology is still up to date. There is a theoretical possibility of reuse, but this is something that Ericsson AB, as of today, is not using. Rodgers (2012). A second-hand market is occurring outside the hands of Ericsson AB where former users sell their products instead of returning them to Ericsson AB for recycling. The products then exchange users and can be provided with a new life. However, this is something that is not desirable for Ericsson AB. A second hand market makes it impossible for the company to control the level of secrecy of their products. Possibly the middle men dealing and selling Ericsson AB's products to operators buy back the old equipment from the operator and resell it to another operator. Rodgers (2012). Other occurrences is that the former users recycles the product "themselves" instead of letting Ericsson AB perform this through their controlled recycling partners. Rodgers (2012). This means that the quality of the recycling cannot be controlled. When products are sold and not recycled properly, which occurs when Ericsson AB do not have the possibility to control the process, there is a great risk of bad publicity and negative environmental impact. Rodgers (2012).

The issue of reuse is a topic which splits Ericsson AB. Some parts of the company are in favour and trying to implement a system of reuse of products. The other parts, mainly R&D, states that reuse is not favourable as less effort is used to develop new more energy efficient products than to further use old energy inefficient products. Rodgers (2012).

Some reuse occurs when a product breaks down. The product is swapped with a new or a repaired, fully working product. The broken product is taken to reparation stations, where it is fixed and all broken and dysfunctional parts are replaced. When the product is repaired and refurbished, it is used to replace other broken products at site. It is then considered as "new". Rodgers (2012).

This also indicates that there is a kind of second hand market for the products. The products are repaired, refurbished and reused as long as they are in good condition and the specific telecom generation is still used. Thelin (2011).

Where the broken down products are repaired and refurbished has not been concluded, as it has not been possible to find data within the topic. Relevant actors at Ericsson AB have not been found. This means that it is not possible to conclude if this is done locally or at a centralized facility. Neither has it been concluded if it is performed by Ericsson AB, middlemen or sub-contractors.

Recycling

Ericsson AB is using reused aluminium in as large extent as possible. However the need to minimise other metals present within the reused aluminium means that it has to be diluted with new pure aluminium, otherwise is the risk of corrosion is too great. Pettersson (2011).

After Ericsson AB's products are taken out of service, Ericsson AB collects and recycle them for reuse of materials, through sub-contractors. Why the products are taken back to Ericsson AB also has to do with the control of the products due to the level of secrecy and espionage. When the products are taken back by Ericsson AB, it is also easier for the company to control the recycling process so that it corresponds with the company's Code-of-Conduct. Ericsson AB can control that the products are properly recycled and not just seen as waste and put into land fill. Ericsson AB does not handle the recycling themselves as this is a complicated process. However they coordinate the collection of old products and monitor the recycling process to ensure the highest quality of recycling. Rodgers (2012). Since the mid of 1990's Ericsson AB has been one of the leading companies on recycling. Still to this day considered one of the role-modelling companies in ensuring good and proper recycling of electronic goods. Rodgers (2012).

Many of the materials in Ericsson AB's RRUs are possible to recycle. This is an area where the company can save money from excluding new production and buying of newly mined materials. Nowadays there are extremely large amounts of money that can be saved by recycling material and reusing them within the production. The common occurrence is a break-even result from the recycling process within Ericsson AB. However, there has been years when the process of recycling old products has proven to be financially very beneficial for the company. Rodgers (2012).

There are European Union legislations stating that electronic manufacturers selling and distributing goods within the EU are to recollect the products when taken out of service. Ericsson AB shall collect the product from the customer without charge and recycle it. More and more parts of the world are stating legislations such as the ones the EU is using. However the EU still holds the strictest and most advanced ones to this date. This is something that is strictly regarded within Ericsson AB and the company applies these legislations within the whole company, even though many products are sold and distributed outside the EU. Rodgers (2012).

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Ericsson AB would like to collect all used products from users, as this would enable the company to better control the End-of-Life process. The company is however having trouble to collect all used products, as the users sees an opportunity in recycling the products themselves and at the same time make profit from it. This is a major problem for Ericsson AB in regard to recycling. Today only about 5-7 % of used products, taken out of service, are returned to Ericsson AB. Rodgers (2012).

The recycling rate of the products collected is extremely good, over 98 % is recycled of the 5-7 % collected. The 2 % not possible to recycle are non-toxic materials which are land-filled. None of the materials used within Ericsson AB's newer products as well as products under development uses any hazarders or toxic materials, not possible to recycle. For example are all lead-welds replaced with a less toxic weld, making the product more environmental friendly and easier to recycle. Rodgers (2012).

New EU legislations demands that electronic manufactures selling products on the European market are to collect at least 45 % of their used products, starting by 2016. This means that Ericsson AB would raise their quote of recycled materials quite some. This will make it possible for the company to further develop this area of business. Rodgers (2012).

Due to the complexity of recycling as well as recycling not being the main focus area of Ericsson AB, sub-contractors are used to perform the recycling process. Ericsson AB in their turn coordinates and monitors the process. Rodgers (2012).

There are only a handful of actors on the world market today, who can manage to properly and fully recycle complex electronic products. Ericsson AB is using the "top of the line" recycling companies to secure that the recycling process is the best that it can be. By using these actors and their facilities, Ericsson AB can easily control that the recycling process fulfils all requirements set. Rodgers (2012).

The major actors that Ericsson AB are using when recycling their products are five world leading companies acting all over the globe. One large actor on the Asian market is the Chinese company of FORTUNE. FORTUNE is working out of the Chinese east-coast and mainly the Nanjing district. Not having any recycling facilities themselves, other recycling companies are sub-contracted to perform the procedure. Due to the fact of Ericsson AB using major recycling-companies, the quality of process can be well controlled, even though the sub-contractors are contracting other sub-contractors. As companies like FORTUNE rely on being a world leading company on recycling, it is crucial for them to control the process for maximum quality. This means that Ericsson AB can, to some extent, rely on the process fulfilling their requirements. At least once a year Ericsson AB is pursuing controls of each sub-contractor dealing with recycling to conclude that their Code-of-Conducts are fulfilled and that the highest quality is used in the recycling procedure. Other ways which Ericsson AB controls the recycling process is to check all the packing-lists of incoming goods to the recycling-sites, with the packing-lists of outgoing goods. The lists are to correspond with each other and all materials recycled are to be declared. Managing recycling is by Ericsson AB considered to be much more complicated than managing production and R&D. This is also showing how far the recycling aspects have come in regard to R&D and optimisation in production. Rodgers (2012).

When using the five major recycling companies, Ericsson AB gets worldwide coverage on recycling. This means that recycling products from any part of the world is possible to coordinate and perform. Local recycling is also possible to some extent. As there are so few facilities which holds the possibility of recycling and refining electronic parts, the recycling do not always occur locally. Sometime it is necessary and financially more profitable to perform recycling abroad, why this is a common occurrence. The local Ericsson AB offices are the ones coordinating and collecting all used products. The products are transported to appropriate recycling facilities by the local office. The actual transportation is mainly managed by the sub-contractors, securing fast and effective transportation. Rodgers (2012).

Local recycling facilities are mostly processing simpler materials and parts. When recycling circuit-boards and other more complex electronic parts, they are sent to a centralised recycling facility. More advanced recycling facilities have the possibility of proper recycling for best result and quality. Rodgers (2012).

Which recycling facility and sub-contractor that is used to recycle used is commonly based on which one is most geographically suitable. However the aspect of cost is just as important, why the geographical aspect is overridden and the products are transported to another part of the world for recycling. Rodgers (2012).

The Asian recycling actors and market are by Ericsson AB regarded as one of the best in the world in regard to recycling rate and dealing with different materials. Rodgers (2012).

Other recycling sub-contractors which are in partnership with Ericsson AB are SIMS, TESS-AMM, DATEC, AER and partly BELMONT SIPI. SIMS is an Australian worldwide recycling company, global leader in recycling, working in the Netherlands, Sweden, United Stated of America, South Africa, India and many more places. SIMS are not holding any recycling and refining facilities themselves, however sub-contracting other actors to perform recycling after demands. One large facility that is used by SIMS is a UMICORE in Belgium. UMICORE uses pyrotechnical methods to recycle different electronic components. Rodgers (2012).

TESS-AMM is a Singapore based recycling company dealing with recycling of the major parts of the Asian

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market. They are large actors on the Chinese and Indian market and one of the few who can and do use a chemical recycling process to recycle complicated electronic features. There work in China is regarded as very good and do fulfil the Code-of-Conduct of recycling with high quality and little environmental impact set up by Ericsson AB. Rodgers (2012).

DATEC is yet another recycling sub-contractor used by Ericsson AB. Mainly working on the North and South American market. Rodgers (2012).

Another major actor on the North and South American market is BELMON SIPI who holds their own recycling facility in the Chicago area. It is possible that some of the products initially recycled in Europe end up at BENMON SIPI's facility in Chicago. This commonly happens when more complex parts and materials shall be recycled through a chemical recycling process. Initially products used in, for example, Sweden are recycled in Scotland and further recycled at BELMONT SIPI's facility. Rodgers (2012).

BOLIDEN in Sweden is sometimes used to recycle some of Ericsson AB's products. They are mainly locally in Scandinavia and Europe. However BOLIDEN hold requirements on only taking on extremely large quantities when recycling. This is not always possible from Ericsson AB's point of view. Due to this fact BOLIDEN is not always possible to use even though it is geographically suitable. BOLIDEN uses pyrotechnics to recycle electronic parts and features. Rodgers (2012).

Finally AER, an USA based recycling sub-contractor is used by Ericsson AB to deal with recycling of the North and South American market as well as Asian market, for example locally in Malaysia. AER do not hold any facilities themselves instead sub-contracting other recycling facilities suitable for the specific recycling task. Rodgers (2012).

All these major actors use by Ericsson cooperate with each other in one way or another, with regard to recycling processes and facilities. Rodgers (2012).

As of today recycling and reuse of packaging material is not present within Ericsson AB. The packaging is collected by Ericsson AB if this is a demand from the government or the customers, a very uncommon occurrence. Ericsson AB means that there are no plans of implementing a system of recycling or reuse of packaging materials. It is not financially beneficial and the transport of packaging materials to recycling facilities can hold larger environmental impact than not recycling the material. Rodgers (2012).

2.18.6 Design for disassembly - DfD

The aspect of design for disassembly is important from an environmental point of view, as this can ease the possibility of reuse and recycling. For example, is it important to DfD when a product shall be serviced. Each part will then be easier to disassemble from the product without breaking. If the sun-cover shall be removed, which is a common occurrence, it is preferably to be very easy without any risk of breaking. Kallin (2012). If the sun-cover is attached to the internal-body by snap-buckles, the sun-cover will be hard to remove and there is an obvious risk of breaking the snap-buckles. If this was to happen, the sun-cover would have to be replaced. The production of sun-covers would increase. Design for disassembly can drastically improve a products impact on the environment through being easier to recycle. Engineering Design Projects. It can also be a step towards minimising the use of many different materials. This can be beneficial in regard both to the economic as well as the environmental aspect. Rodgers (2012).

There are guidelines which enable better DfD, for example ; the variation of materials used shall be minimised in the best possibly way. Instead shall the same material/materials be used to as large extent as possible. Dowie (1994). Similar elements and parts shall be combined in a group. Dowie (1994). If one element holds different materials, it shall be designed so that these materials can easily be separated. All materials are to, in the best possible way, be clearly marked for easy identification, separation and disassembly. Dowie (1994). The use of fasteners, such as screws and snap-buckles, are to be minimised for faster and easier disassembly. Engineering Design Projects. The fasteners shall be easy accessible as well as being of the same type and size. Mital (2007), Engineering Design Projects, Dowie (1994).

Through the data gathered at Ericsson AB, it has not been possible to conclude if DfD is used with regard to recycling and reuse. What has been concluded is that Ericsson AB design and develop their products to be easy to service and repair parts. Kallin (2012). This can be seen as a kind of DfD.

The products shall be easy to disassemble so that each part and feature can be removed and replaced at site without taking down the product. Kallin (2012). Parts and features are designed and developed as modular, in as large extent as possible, so that they easily can be replaced with new functioning parts. By minimising the integrated parts it is easier to replace these parts without having to replace a major part of the product. Engineering Design Projects. Now, all external features are mounted onto the internal-body of the RRU, such as handle, feet and sun-cover. Most external parts are mounted with screws for easy assembly and disassembly. However snap-buckles occur on some of the smaller products, within the product family of portable products. Nykänen (2012).

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One aspect of good assembly and disassembly is to minimise the different types of screw-joints and only use one kind and size. Engineering Design Projects. When analysing the reference products as well as other portable telecom products of Ericsson AB, it can be concluded that different types and sizes of screws are used. Screws of different sizes are used to join and mount different parts together. The screw-size depends on the type of part that is mounted. Snap-buckles are also sometimes used together with screw-joints, which is not optimal in regard to assembly and disassembly guidelines. Nykänen (2012). This is not only poor in a sustainable aspect, it is also poor in regard to costs as it will take longer to assemble and disassemble the product. Engineering Design Projects.

Due to the relatively new industrial design department at Ericsson AB, new ways of designing and developing products are implemented in the company's way of product development. Thelin (2012).

As of today the Industrial design department is the only actor at Ericsson AB working to implement Design for Disassembly. When designing and developing a product, it is important to regard environmental impact within the design process. It is possible to affect the outcome towards sustainable products when adapting the design process towards DfD. Due to the industrial design department being relatively young and the process of implementing new ideas is somewhat slow, the DfD-process is yet only in the initial stages. Thelin (2012).

Work is continually being done to further develop the implementation of sustainable and responsible design within the design-process. This is closely connected to the development of Ericsson AB's uniform design-values as well as ONE Ericsson. ONE Ericsson is a future strategy of the visual identity of Ericsson AB, in regard to everything from products to graphics, hand-outs and so forth. Cevenell (2012).

2.18.7 Cradle-to-Cradle

One aspect of sustainability for Ericsson AB to regard is Cradle-to-Cradle, C2C. This method is an obvious and good way to achieve better sustainability and less environmental impact from their products. By implementing C2C to the development process of hardware, Ericsson AB can differentiate themselves from the competitors. This can be done through providing high quality products that has been developed in regard to sustainability.

As of today it has not been concluded if Ericsson AB uses the method of C2C within their R&D process. However it is an interesting aspect that they want to regard for future hardware development. Thelin (2012). There are initiations taken to close the loop of the company's products. This is to secure higher quality and minimising the environmental impact. Ericsson AB's role as a world leading electronic company will be further developed in regard to environmental management. Rodgers (2012).

If Ericsson was to implement more of a C2C way of performing hardware development, their products would be given a longer lifespan. They would be given a further life after it has played out its role of providing telecom solutions. Adapting the hardware design towards C2C can be done by designing the products to be reusable and possible to put back into the industrial production process. By doing this the Waste Output can be minimised drastically. Vagga till Vagga (2012). Materials which have good recycling abilities or is possible to break down organically are possible ways to conducts C2C design. This way of adapting design would also be an opening for Ericsson AB to save money on easier and better recycling. It will also result in less use of adding newly produced materials to their products.

By minimising the need to produce new materials from mining etc, which stands for up to 75 % of the environmental impact and energy used when producing a product, Ericsson AB can produce much more environmentally sustainable products. The Worldwatch Institute (2008).

2.18.8 Transportation

The transportation of goods between and during the production, assembly and selling phase holds large environmental impact.

By producing and assemble products as close as possible to the area the product is being sold and used, Ericsson AB can minimise the cost and impact of transportation. Transportation data has been hard to get hold of, however some data has been compiled concerning the transportation of goods delivered to the operator.

Between factories who produce goods and assembly, it is unsure exactly how the goods are transported. However it has been concluded that the transportation method is both connected to the time as well as cost aspect. Ericsson AB's products are commonly developed after demands from a customer. From the time a new product is initiated till it is delivered to the customer, there is a time shortage to develop, test, produce, assemble and deliver the finished product. The aspect of producing products after the demands of the customers, affect the choice of transportation. The most efficient transportation is not always optional, due to the time aspect. Pettersson (2011).

Because of the relative short lifespan of the products, constantly new developed technology and the high level of espionage, it is important to deliver the products fast. If the transportation takes too long from the release, there might be a case of a competitor realising a similar product before delivery of Ericsson AB's product. This means that if a product is released and then shipped by boat-cargo,

which takes up to six months, there is a risk of the product not being delivered in time. It might then be somewhat outdated in comparison to the competitor's. Pettersson (2011).

The issue of time in regard to transportation results that air-cargo is commonly used by Ericsson AB to deliver the first batches of products to the customer. Air-cargo is fast, however it is very costly and holds a higher negative impact on the environment compared boat-cargo. With boat-cargo larger amounts of goods can be transported at the same time. Pettersson (2011).

Ericsson AB states that air-cargo almost always has to be used in the initial stages of delivery and implementation a new product. If the product arrives late or too slow due to the transportation, large financial sums can be lost. It can also lead to the fact that the customer will instead buy a competitor's products.

When looking at the transportation of goods which are to be recycled, Ericsson AB has set up requirements of not using air-cargo at all, if possible. When transporting goods from remote islands, air-cargo might occur. However this is extremely rare. Boat- and train-cargo is as widely used to minimise the environmental impact of transportation of used goods to the recycling facilities. Ericsson AB also has as a part of the Code-of-Conduct a requirement of always and only transporting full loads for optimum transportation. Transportation is only possible if the cargo can fill up the space of the transportation vehicle, to as large extent as possible. This is to minimise the possibility of transporting goods in unfilled transportation spaces. Unnecessary transports can then be controlled and minimised. The environmental aspects of transportation are overlooked for time and cost efficiency. Rodgers (2012).

Ericsson AB is working to maximise the use of surface freight as much as possible and minimise the use of air-freight. This means that boat-, train- and possibly lorry-freight are intended to be the main ways of transportation. Trankell (2012).

2.18.9 Quality

The question of quality is always relevant when regarding the environmental impact. By providing products of very good quality the lifespan will be prolonged and new products do not have to be developed and produced. However, is this closely related to upgradability and modularity as the changes and improvements on the telecom market happens so rapidly. If a product holds good quality and works over a long time, this does not mean that it will be used the time will to last. It will be outdated long before it breaks down. There is not always a need to make the product of absolute best quality. The environment the product is placed in does not always demand top quality. Kallin (2012).

To minimise the environmental impact, the quality of the production and assembly can be optimised. By reusing and recycling materials, the quality of the process and impact on the environment can be improved. Rodgers (2012).

By optimising the production, spill and production mishaps can be minimised which means that the material usage will be optimised. No unnecessary materials have to be used within production, such as over-usage during die-casting and moulding. It can also mean that the spill from failed production can be minimised. The design team can, by designing in regard to the environmental impact just as the semantic aspects, optimise production. This will minimise the environmental impact as well as over time be financially beneficial. Optimisation of the process of producing and assembling the product raises the environmental quality. Pettersson (2012). This can be seen in production of some parts where large amounts of toxic chemicals are used to secure the finish quality of the product for it to fulfil Ericsson AB's requirements. If the process is instead optimised to fulfil the quality requirements properly or if the quality requirements can be adapted, the usage of toxic chemicals can be either minimised or dropped fully. Pettersson (2012).

Ericsson AB's role in the environmental impact is crucial and by challenging their subcontractors to produce in a more sustainably way. Their products will be charged with a social responsibility compared to their competitors.

The R&D department within Ericsson AB can also provide a substantial impact regarding the environmental impact of their products. By designing a product which is easier and better to produce, both costs and spill can be minimised. Pettersson (2012).

2.18.10 Usage

The aspect of the actual impact of a product during its life cycle also concerns what and how the product consumes either goods or power. In the case of Ericsson AB's products, the RRUs, electric energy is used to power the system allowing worldwide telecommunication.

The usage-level of electricity depends on where in the world the product is placed, what frequency it operates within as well as the climate and temperature it is placed. The maximum capacity of the RRUs operates at is 600 - 720 Watts depending on frequency. This is the maximum level and is uncommon. A mean value of power usage with regard to climate, frequency and location is approximately 400 Watts. It can be assumed that the product is being used every day during its lifespan over 10 years. This give an yearly consumption of about 3,5 MWh and a consumption over 10 years of 35 MWh of electricity. Nääs (2011).

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400 W = 0,4 kW

0,4 kW used during 1 hour - 0,4 kWh

24 * 0,4 = 9,6 kWh a day

365 * 9,5 = 3504 kWh = 3,5 MWh a year

3,5 * 10 = 35 MWh over a lifetime of 10 years for one single RRUS.

Normally three RRUs as well as other telecom equipment such as antennas, transmission units and Radio Based Stations-RBS work together on a telecom site. The consumption of power is therefore much greater for a whole site. Kallin (2011).

If the power consumption of the RRUs, which is fairly large, compared to antennas and transmission units can be optimised, the environmental impact of the products can be lowered. Nääs (2011).

2.18.11 Ericsson AB - Design for Environment, DfE

Within Ericsson AB's large organisation, one department works with establishing and implementing environmental guidelines and requirements. These requirements and guidelines are based on the toughest environmental laws worldwide. Due to Ericsson AB's large organisation, the DfE department has had problems to implement their work. Since the initiation of the DfE when the first generic requirements were stated in 1998, Ericsson AB has been in the front-line of electronic manufactures to work with sustainability issues. Trankell (2012).

The guidelines and requirements which regard sustainability and the environmental impact are based on laws from the markets which Ericsson AB's products are sold and used at. The market with the toughest demands and laws are the one regarded when implemented into Ericsson AB. As the company wants to be world leader not only on producing top quality telecom products but just as well sustainability, it is important to work with the highest demands and requirements. The EU is the market with the toughest requirements. Therefore these laws often work as the foundation for Ericsson's DfE work. Trankell (2012).

The environmental requirements set up by the DfE department, are set as mandatory requirements in the list of requirements. The requirements are regarded as any other requirements. However there is a possibility from the product developing department to apply not to fulfil the environmental requirements, if these are regarded as not possible to fulfil. It is important that all requirements fulfil the laws worldwide, and are the same at each market. Trankell (2012).

To implement the DfE requirements within the organisation, each department is notified with the environmental requirement data. The DfE department is never personally active in the implementation of the demands at the R&D level. As of today the DfE department has managed to get their requirements into the generic requirements of Ericsson AB's product projects. However it is strived for to implement these requirements and demands into the total list of requirements of the company. If and when this is done, the impact of the DfE requirements will be more substantial and make the products better adapted towards sustainability. Trankell (2012).

A natural way to get good results from implementation of the demands would be to actively participate within the process of setting up projects. The DfE department is aware of the benefits of this. However it is not to this day used, due to financial aspects. By using the knowledge within the DfE department better, the environmental impact and sustainability aspects of Ericsson AB's products can be drastically improved. Trankell (2012).

The industrial design department and parts of the mechanical engineering department did not even know of the presence of DfE. Certainly not how they work alongside R&D. As the different departments who work with related topics do not interact and work together, it indicates that the products can certainly be improved regarding sustainability and environmental impact. These departments should work hand in hand to achieve optimised environmental design. This would improve the environmental work of Ericsson AB and further strengthen this aspect towards their competitors.

Environmental Prod Mgmt, Techn prg supp at Ericsson AB, Richard Trankell states that it is hard to reach out to other departments within the organisation with the information and requirements of sustainability. Due to the large size of the organisation and the limited financial possibilities, the outreach is sometimes lacking. Trankell (2012).

Together with the environmental requirements set, the department of DfE has also set up a list of banned materials and processes. These materials and processes are not to be used at all when developing new products. This list of banned materials and processes is distributed to all departments active within R&D. It has not been possible to obtain information if the developers, except for higher management, are aware of the list and the impact it holds. Trankell (2012).

Every material used by Ericsson AB is compiled into a material database, Focal Point, where the products are "checked" during development. This secures that a product is not developed with any of the materials and processes from the banned list. This is one of the ways which interaction between the R&D departments and DfE occurs. Over time, DfE affects the material selection and initiates the work of phasing out materials holding to great negative environmental impact. Trankell (2012).

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There are no demands or requirements concerning DfE which states that minimum amount of different materials shall be used to minimise the environmental impact. Trankell (2012).

Environmental Prod Mgmt, Techn prg supp at Ericsson AB, Richard Trankell states that the consumption of energy holds exclusively the largest environmental impact during any of Ericsson AB's products life cycle. Due to this reason, energy consumption is the topic in highest need of improvement to minimise the environmental impact of the products. This is also one aspect which is of focus by the department of DfE, and requirements are set around maximum product efficiency and power. The energy consumption and power output of the products are controlled through a market standardised energy efficiency measurement. This enables easier control and management of energy consumption. Trankell (2012).

Design for Environment consists of a wide variety of different topics and issues of environmental impact. For example, better recycling is one issue where demands are made on material declaration, material indication and easy disassembly as well as that no specialised tools shall be needed to disassemble the product for recycling. Trankell (2012).

As the topic of environmental impact is such a large and broad topic, it is not possible for the DfE department to control all subjects regarding this. For example is the issue of usage of different solvent when colouring and painting products excluded. This also goes for packaging materials which is only regulated by the laws of the EU and other governments. The issues and topics which are focused and regarded by the DfE department are mainly affected by financial aspects and interests of the company. Trankell (2012).

Together with the demands and requirements, DfE also sets up a number recommendations regarding sustainable design. These recommendations are for the R&D to interpret and apply, if they are seen as beneficial for the product and the company. It is concluded that these recommendations do not tend to impact the R&D, to further develop their products in regard to sustainability. Trankell (2012).

The requirements of DfE are nowadays regarded as any other requirement when producing new products. This is something that Environmental Prod Mgmt, Techn prg supp at Ericsson AB, Richard Trankell finds important. Improvements can be made in reaching out with the information of DfE within Ericsson AB. Some departments are better than others when regarding the environmental requirements. Ericsson AB's intranet is the major outreach portal for DfE today. This is something DfE further develops, to better reach out within the organisation. Being present within the process of R&D and initiation of projects by DfE would probably further improve the work of the department. This is something that Environmental Prod Mgmt, Techn prg supp at Ericsson AB, Richard Trankell is aware of. However this means further financial aid and time, which are the major issues why this is not already more commonly used. Trankell (2012).

2.18.12 Map of materials

To summarise and compile the data gathered on the materials used in Ericsson AB's Present RRUS 11 & 12, a material map was made. The map shows what materials are used at the specific parts analysed in the sustainability analysis. The map provides easy access and knowledge to the materials used. It helps in understanding how to further develop the parts and products in regard to improved material choices. The map can be substantial when performing optimised design from a sustainability point of view. However it can also be of importance when regarding production and price. An updated Map of materials will be shown in the result, Capter 4.2 - Map of materials - Updated. The updated Map of materials has compiled the data gathered on possible substitute materials which can, foremost, improve the product from a sustainability point of view.

The Map of materials shows the materials used in the sun-cover, internal-body, overlays, product feet, handle and screw-joints. See Picture 2.49 - Map of materials, Initial.

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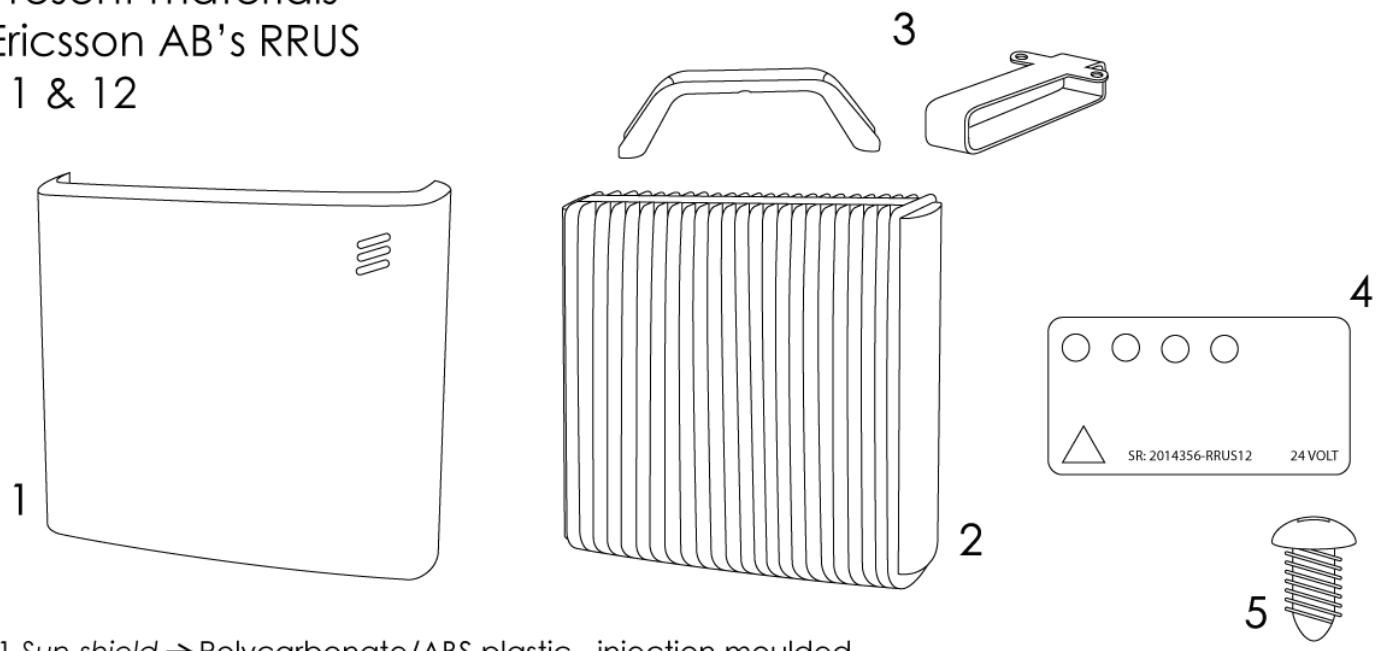
Present materials Ericsson AB's RRUS 11 & 12



1 *Sun-shield* → Polycarbonate/ABS plastic - injection moulded
2 *Internal-body* → Aluminiu er - Die casted
3 *Carrying feature* & Feet→Aluminium, - Die casted
4 *Overlay (interface)* → Polycarbonate plastic, transparent
5 *Screws* → A4, Stainless steel

Picture 2.49 - Map of materials, Initial. Regnér (2012).

Footnote - Pre-study

A request from the one of the heads of product management as well as the mechanics department at Ericsson Kista was that the carrying feature shall be flexible and removable from the product. The carrying feature should be modular in a way so that it can be taken of the product as soon as it is not needed. It is to be a part of the toolbox that installation and mounting specialist uses while installing the product. If designed well, the installation workers will always have a carrying feature present when needing it. However the tool does not interfere with the product's semantic expression when not used. Kallin (2011).

This statement was soon after discarded. The use a removable handle was seen as less plausible. Thelin (2011).

It has come to attention that an integrated handle can add to the total volume of products as the handle, feet and sun-cover are not regarded in the measurements of volume in a product. Integrating a subtle handle can add to the total volume, as more volume has to be added to fit the carrying feature due to the low free space. When measuring the volume of a product, industry standard, it is measured by the most outer parts in every direction. Thelin (2011). This means that even if just a small part of the handle is visible over the rest of the volume, the total volume added will be much greater. This means that large parts of the total volume can be "thin air", not even a physical part of the product. If this measurement of volume can be change, possibly through Ericsson AB's big influence on the world's telecom-market, the actual or visual volume of the product can be measured. If this would become reality, then the products can be better adapted to house integrated features without adding to the total volume as much, such as handles.

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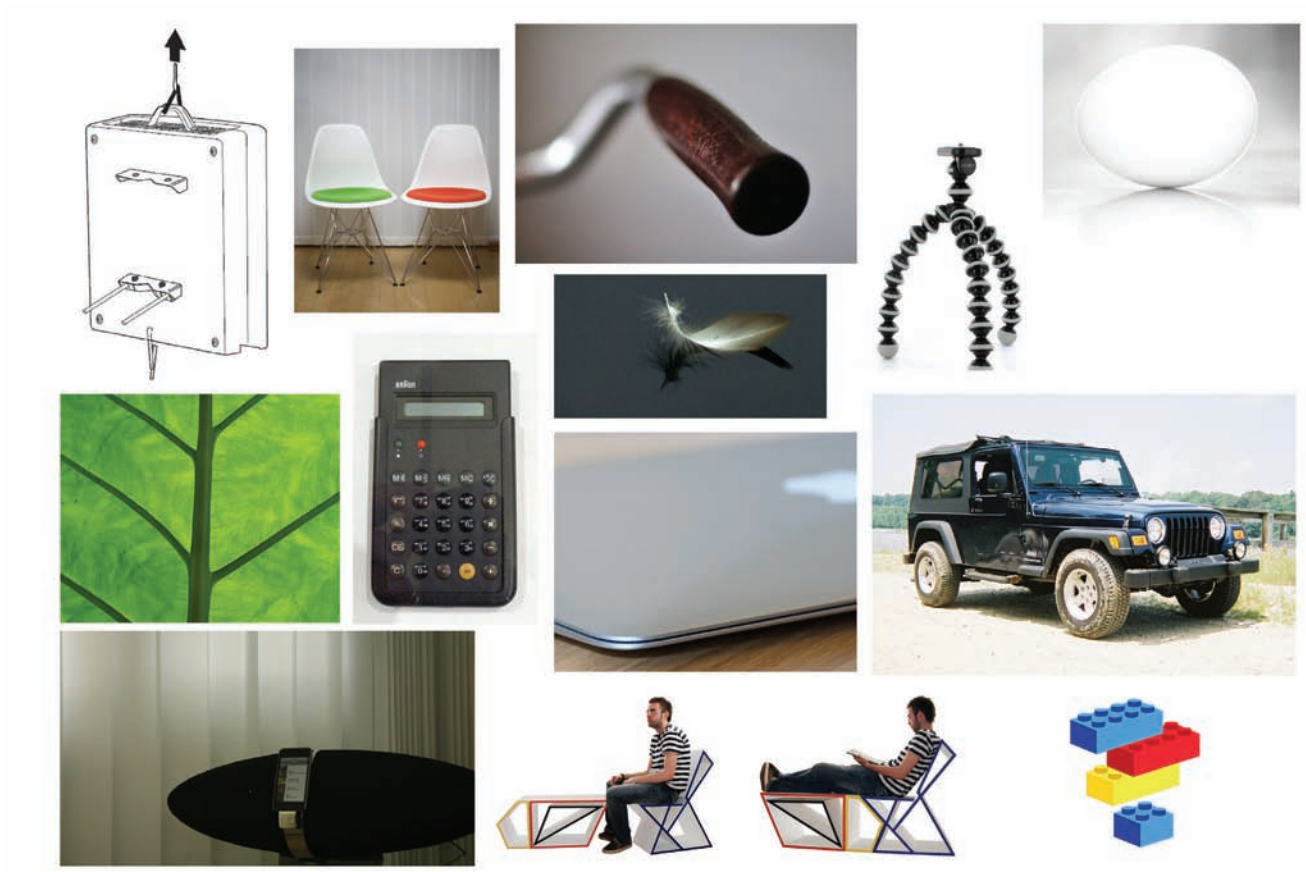
3.1 Expression board

To conclude what the final product shall represent, it is important, at an early stage, to portray this through a visual expression. The expression board will indicate what to strive for and regard in the redesign; design guidelines. See Picture 3.1 - Expression Board.

The expression board, just as the impression board compiled in the pre-study, concludes a new set of "Words of value". The "Words of value" will help to indicate what shall be fulfilled and regarded in the redesign. The generated concepts and especially the final concept shall fulfil the "Words of value" as good as possible. This will mean that the products have been designed with regard of the pre-study, to optimally fit the need for the users, buyers and Ericsson AB.



Picture 3.1 - Expression board. Image References see Reference list

"Words of value":

Comfortable - The carrying feature shall be comfortable to enable easy handling

Easy/Light - The carrying feature shall be light and do not add any unnecessary volume

Flexible - The carrying feature shall be flexible, hidden when not needed and easy accessible when needed

Smooth - Smooth edges and surfaces for comfortable handling

Discrete/subtle - The carrying feature shall be discreet and fit into the total semantic expression of the RRUs.

Graceful - Provide a sleek and graceful semantic expression. Add to the total semantic expression without being intrusive

Robust/strong - The carrying feature shall be strong and durable, withstanding large forces of a heavy RRUs being carried and hoisted

Ergonomic - The carrying feature shall be ergonomically adapted to optimally fit the user. Minimise the stress obtained during handling of heavy loads

Modular - The carrying feature shall be modular and fit many different products as well as being easy to replace

Integrated - The carrying feature shall be integrated into the RRUs and be designed as an additional part without adding unnecessary volume

Straight handling - The carrying feature shall enable straight and easy handling, CoG

Sustainable - The carrying feature shall be as sustainable adapted as possible, in regard to the sustainability analysis performed in the pre-study

3. IDEATION

3.2 Ideation - Initial process

The ideation process involves different methods of generating ideas and concept solutions for what was concluded in the pre-study. The ideation will include brainstorming and sketching sessions. This means that many different ideas and concept of solving the task of carrying the RRUs will be created. These ideas will then be evaluated and three of them will be chosen for further development. The three concepts will be further developed with regard to design and technical solution, to better fulfil all the required aspects.

All ideation methods will be regarded together when the three concepts are to be further developed. They all provide different ideas and solutions.

3.2.1 Mind-mapping

To generate ideas and possible solutions for a modular foldable carrying feature, a mind-map was created. The mind-map focuses on the carrying feature and how it shall optimally solve what was concluded in the pre-study.

The mind-mapping is done as the initial ideation process to generate and conclude ideas which are relevant for the task of redesigning a carrying feature.

The mind-map is divided into sub-groups of *fixed, flexible* and *detachable carrying feature* as well as *body carrying*. All the generated solutions might not be qualified in regard to the requirements, however quantity is set before quality as all ideas are worth evaluating.

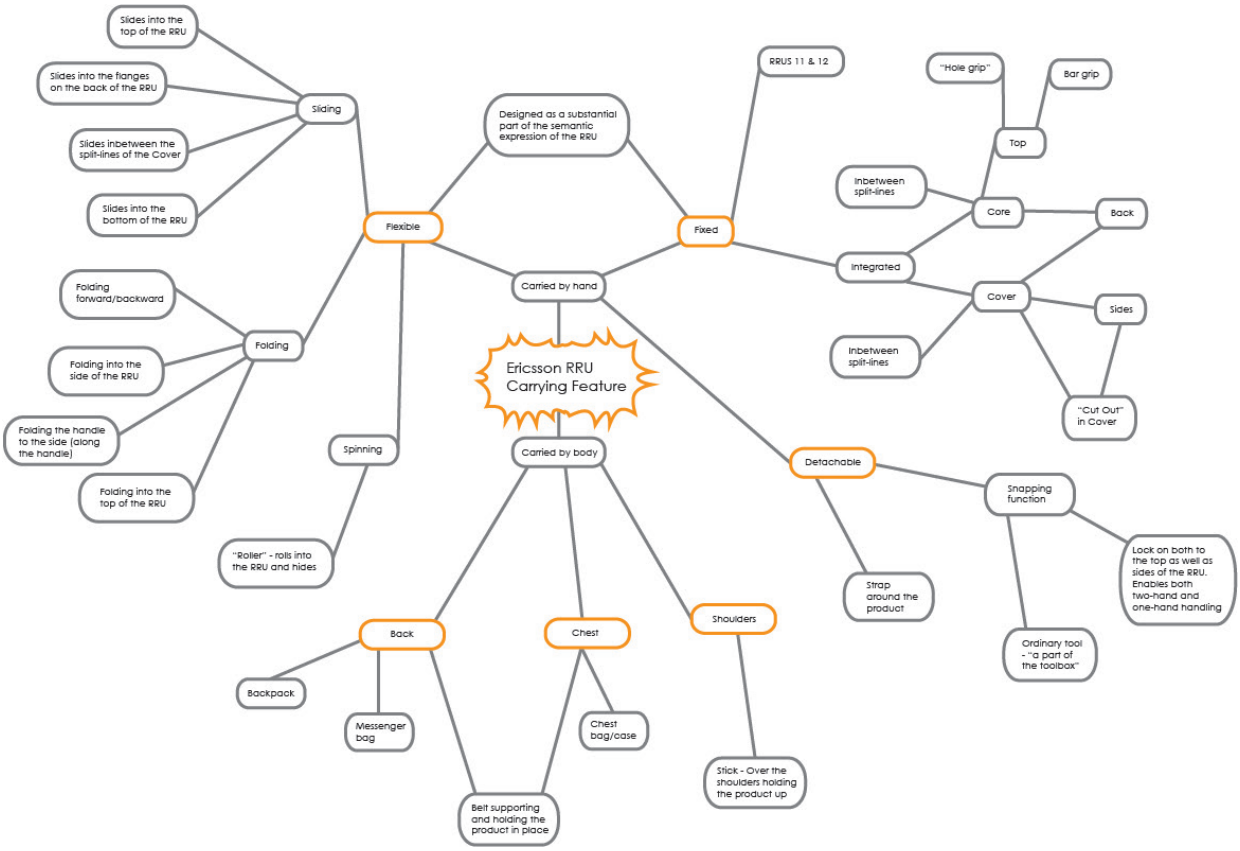
The mind-map is an iterative process and it is updated during the redesign process due to the fact of a single participant. The method has brought up new and "out of the box" solutions. These solutions will be evaluated on how well they fulfil the stated requirements. See Appendix II - List of requirements.

For concepts generated from the mind-mapping session, See Picture 3.2 - Mind-mapping.

3.2.2 Brainstorming

As this master thesis is done by a single student and a brainstorming session shall be performed by at least two or more participants, the method hasl been customised to fit the environment. The brainstorming sessions has been performed exclusively by the author. However, have they been performed in several shorter sessions complementing each other to get maximum input. To get further input, the brainstorming result has been consulted with Ericsson AB.

For concepts generated from the brainstorming session, See Picture 3.3 - Brainstorming.



Picture 3.2 - Mind-mapping. Regnér (2012).

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Hook	Shackle – enabling easier carrying of heavy items	Integrated in the spilt-lines
Sliding handle	Integrated – Screwdriver case	Camera case handle - Drawer handles
Top-mounted handle	- Biomimicry – Gecko-grip enabling handling through the material - Gloves enabling carrying	"Bus roof strap"
Folding handle – Barcelona 2011	Spinning handle	"STRAP-A-HANDLE"
Fixed handle – RRUS 11 & 12 Possibility to immerse the handle in the core-body, to minimise the intrusion on the RRUs semantic expression	Double centred cooling flanges – two handles sliding in-between the cooling flanges, placed on each side of the midsection of the centre top of the RRU	Integrated loops allowing external handle/ropes to enable carrying
Sliding/folding from the bottom	Handling through the feet of the RRU	Integrated in "Cover"
Harness	Collapse band	No handle – carrying in the product as a whole (Today's situation)
Sewing machine case – folds to the side on top of the RRU Possibility to integrate this handle in-between the split-lines as well	"Camera-case" handle	Tool-box tool to enable carrying of the RRU, Polygrip plier
Harness – Backpack Connected to gear/clothes (like a backpack) to enable lifting and handling	Single – Double; Two handles (separated enables two hand gripping on the sides of the RRU) used together on the top (enabling one-hand carrying)	Suitcase puller handles – can be hidden between the cooling flanges or on between the Cover and Core on the side of the RRU
Sliding and folding on top of the RRU. Two handles which enables both one- and two-handed handling. Mounted on rails to the top of the RRU	Two in one – The box. Two handles mounted in a box, allows both one- and two-handed handling	Double fold – a handle that folds down onto the top of the RRU in two stages. Double hinges/axis
Top slider – A handle which slides down into two rails which allows a subtle and flexible handling	Connectable bar – on top of the RRU/product are two base-plate brackets mounted, these base-plate brackets allow a handle bar to be connected	The J – a J-shaped handle which is connectable to the top of the RRU/product
Telescope – handle made from different dimensioned rods, allowing it slide down "into itself" like a telescope		

Picture 3.3 - Brainstroming. Regnér (2012).

3.3 Concepts

From the ideation process, three major categories of solving the problem of enabling carrying of heavy RRUs were concluded. Throughout the process, many different concepts were derived, later arrange into one of the three categories. The concept development and evaluation will be regarded from the three categories set.

The three categories consist of; Integrated carrying features, Flexible carrying features and Detachable carrying features. Within each category, many different ideas of solving the task in the specific way was generated and designed.

All concepts are modular in that way that they are not moulded into the product. The carrying features are easy to replace and change if broken or in need of replacement.

3.3.1 Integrated

The first category is a common way to enabling carrying of heavy products, an integrated carrying feature which is incorporated in the actual product. The carrying feature is either incorporated in the design of the product or the carrying is enabled through the material and shapes.

RRUS 11 & 12 Concept

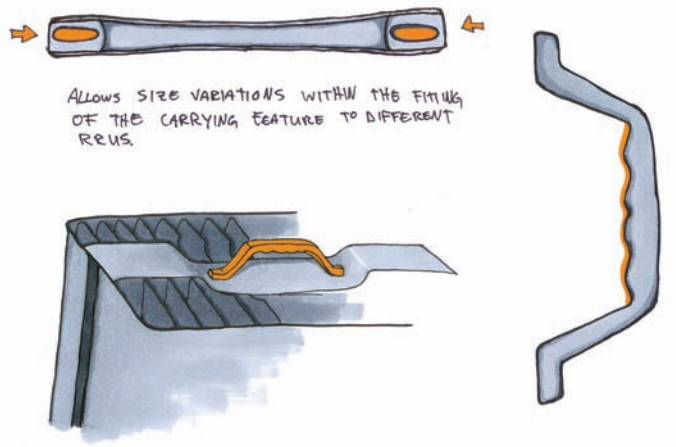
This idea is based on the already present carrying features of the reference products RRUS 11 & 12. The idea is not concerning any innovative redesign of the carrying feature. It is about adapting a fixed handle which is modular, to fit most of Ericsson AB's portable products as well as being subtle.

Designing a carrying feature which is as simple and easy to handle as the present handles of the reference products. This will mean minimum redesigning costs as well as being

3. IDEATION

cheap and easy to produce. The present handles fulfil the task of enabling carrying and handling of the RRUs rather well. By implementing minor changes there is a great possibility to improve these handles to be even better as well as more subtle.

Size-wise the present handles are not fully adapted towards the ergonomic recommendations. Johansson (2011). However, there are possibilities of slimming down the handles to be much more subtle, still provide even better ergonomic qualities. For example, it is possible to make a groove in the internal-body of the two of the RRUs. This will allow the handle to stand lower from the top of the RRUs. This will make it less visible from sight. See Picture 3.4 - RRUS 11 & 12 Concept Handle.



Picture 3.4 - RRUS 11 & 12 Concept Handle. Regnér (2012).

There is the obvious possibility of making the carrying feature more adapted to allow a more comfortable and ergonomic grip. This can be done by adding a different material which is more comfortable and provides better grip-friction. Adding of an extra material was one aspect wished for by the test-persons of the usability-test. However Ericsson has previously tried this and it was too expensive to produce, why it might not be a suitable solution.

One aspect of the present handles, is that they do not allow any kind lifting when the product shall be placed or mounted to a height of over 0,5 meters. This was concluded in the usability-tests. See Chapter 2.15 Usability- & user-test & Interviews. The users have to lift the product from its sun-cover or the base of the RRUs.

Material grip Concept

The idea of a material grip is derived from the theory of Biomimicry, using the innovations of nature. By allowing the user to steadily and firmly grip the product and enable carrying and lifting only through the material, there will be no need for a physical carrying feature.

The idea consists of using a material on the RRUs sun-cover which enables the user's bare or glove-covered hands to grab around the product and enable a firm steady grip. This can be seen in for example Gecko-lizards, who have microscopic straws on the bottom of there feet. The straws form Van der Vaal bonds between the material and the straws, which can withstand large forces and enables the lizard to climb upside-down without falling. There are current studies being made where scientists are trying to develop a material containing microscopic straws, just like the ones on gecko-feet. This will provide great adhesive abilities. Griggs (2008).

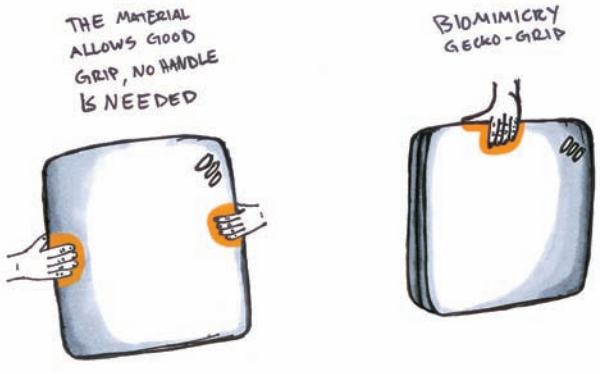
One of the requirements of Ericsson AB is for the carrying feature to be subtle and non visible when not in use. An adhesive material which is non-sticky can be used on the sun-cover of the RRUs to allow good handling without attaching a handle. The idea is not yet fully possible as the studies on "gecko-grip" adhesive materials are still not fully done. The concept will probably not be a possibility the next five yeas to come.

Other very good aspects of using a fully adhesive material which is non-sticky, is that the user can grab the product in the most comfortable way and get a good grip. The product enables carrying and lifting from any angle. The user does not have to worry about grabbing a handle and switching grip to allow a different type of lift. See Picture 3.5 - Material grip Concept.

One aspect of the material grip is that it is hard to indicate how the product shall be handled. As the product can be handled at any surface and position of the sun-cover, it will be hard to indicate handling with symbols and colours. There is also the possibility of the product not being very intuitive. This means that the users might have a hard time understanding how the products shall be handled. As no type of non-sticky adhesive material is not yet commonly know, as of today, the use of the carrying feature will not speak for it self.

The idea is extremely innovative and will possibly be something to regard for future carrying features.

Footnote - This idea can also be considered as a detachable carrying feature. The user would instead wear, for example, a pair of gloves which enables adhesive "gecko-grip". The surface of Ericsson AB's RRUs sun-cover can be of any kind of suitable material. The user still gets to grip the product only through the material, due to the non-sticky adhesive gloves.



Picture 3.5 - Material grip Concept. Regnér (2012).

3. IDEATION

Carrying features in the product's feet Concept

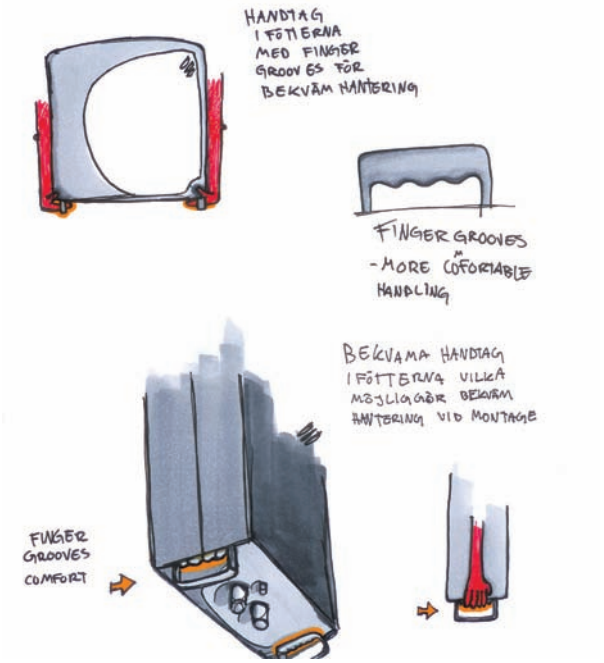
The Ericsson AB RRUS 12 holds feet on the bottom of the product. These enable the product to stand steadily on the ground, house cables connected to the RRUs as well as function as support-handles. The feet are designed as loops which enable the user's hands to grab the product for further handling and lifting. See Picture 2.15 - Product feet RRUS 12.

One idea is to further develop these handles to enable better handling and allow easy lifting of the RRU to a specific height of over 0,5 meters. This will enable easier and more ergonomic mounting and installation of the product to a wall. See Picture 3.6 - Product feet Concept.

By redesigning the feet to enable better handling and gripping, they can be a substantial part of the lifting feature of the RRUs. As of today these feet are sharp and uncomfortable to grab. They mostly work as support handles, enabling easier handling in some situations and hoisting. Due to their shape they shall not be used regularly for handling.

If the feet were redesigned to be more comfortable and use the material better, they can be very useful. The handles are to house finger-grooves so that they suitably fit the user's hands. They shall also to be thicker and not hold as sharp edges.

Very little redesigning has to be done to optimise these handles to enable a much better and more ergonomic carrying and lifting situation.



Picture 3.6 - Product feet Concept. Regnér (2012).

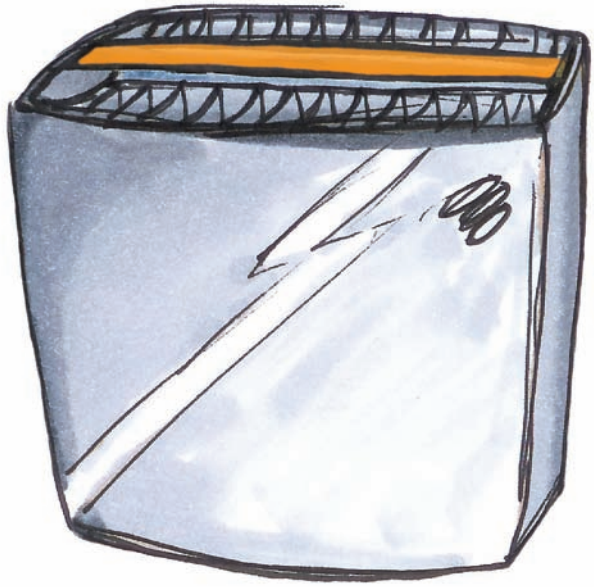
Minor adaptations to the already developed support-handles of the RRUS 12 can be done which will mean, minimum redesigning, costs as well as they will suit the RRUS 12.

Integrated in the RRU Concept (Screwdriver case)

There many ways a carrying feature can be integrated in the RRUs. An integrated carrying feature is possible to make non-visible, yet still enable easy and good lifting and carrying. The carrying feature can be integrated on the top of the RRUs internal-body. Another possibility is to make it a part of the sun-cover fitted within the split-lines or in the back of the product. The integrated carrying features will not in any way be flexible yet hidden from sight.

Integrated handles can be found in products such as heavy cases and screw-driver cases. They enable good carrying possibilities without being too intrusive on the semantic expression. See Picture 2.23 - Screwdriver case.

Good aspects with the integrated carrying features are that they are containing minimum lose parts. There is the possibility of integrated handles in the sun-cover will intrude on the semantic expression. Due to this they have to be carefully designed not to intrude. If a handle is integrated into the back of the RRUs, like the one fitted on the RRUS 01, it has to be carefully designed. This is to allow CoG lifting as well as not obstruct mounting and installing through the bracket mount in the back of the RRUs. See Picture 3.7 - Screwdriver case Concept.



Picture 3.7 - Screwdriver case Concept. Regnér (2012).

3.3.2 Flexible

The second category of concepts concerns all kinds of flexible carrying features. The requirement of Ericsson B as well as what was concluded in the pre-study showed that the carrying feature shall be present when needed and hidden otherwise. The flexible concepts all enable carrying when needed. Through a mechanical feature it is possible to hide when not needed. This is done through gliding, folding, spinning and so forth.

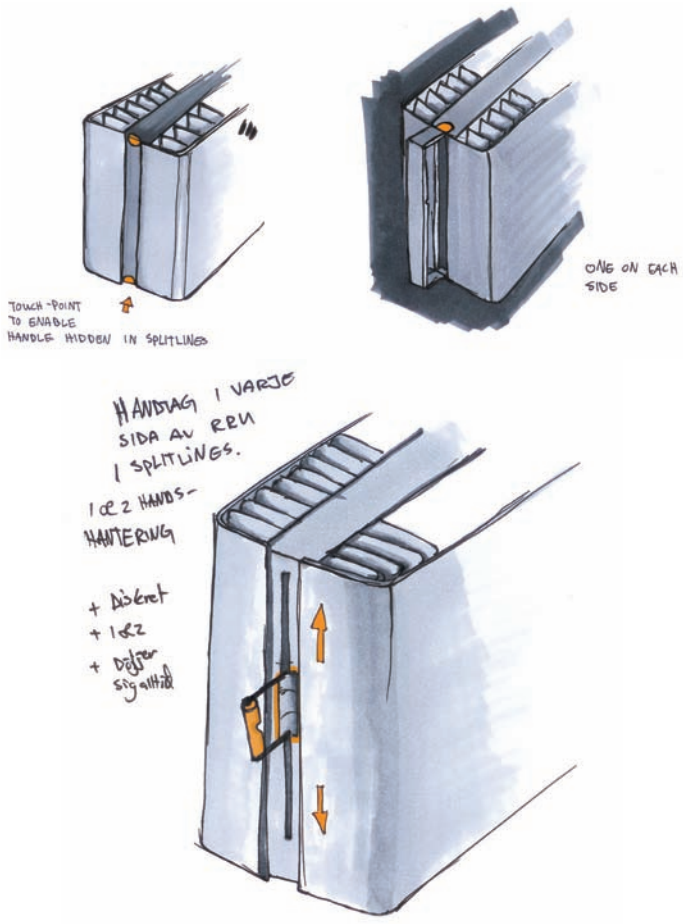
3. IDEATION

Split-line handles Concept

There are many ways to integrate carrying features into the RRUs without making them intrusive on the semantic expression. Ericsson AB's design-values states that it is preferable to let the product have clear visible split-lines, as long as the internal-body is visible beneath as a solid sleek surface. ERICSSON AB - Design-Values (2011). This minimises the risk of clutterness within the semantic expression.

One way of integrating carrying features in a subtle way is to place them as a part of the split-lines between the sun-cover surfaces. By placing the carrying features within the split-lines, they will be non-visible when not used. When needed they will be possible to fold out to perform carrying and lifting. By developing a simple folding, sliding mechanism, the carrying features can fold/slide out from the internal-body between the split-lines to enable carrying and lifting. See Picture 2.39 - Sliding handle.

One handle can be placed on each side of the RRUs to enable good two-hand handling when lifting vertically for mounting and installing. If the product is tilted 90° to the side, the handles enables CoG one-hand carrying and hoisting. See Picture 3.8 - Split-line Concept Handles, See Picture 3.9 Split-line Concept Handles Mock-ups.



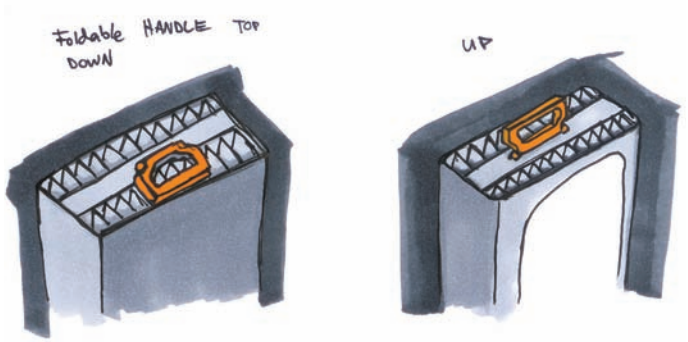
Picture 3.8 - Split-line Concept Handles. Regnér (2012).

Picture 3.9 - Split-line Concept Handles Mock-ups. Regnér (2012).

Foldable handle – Barcelona 11 & 12 Concept

Ericsson AB has previously developed concept handles which are foldable and enables carrying as well as folding down to a subtle position. See Chapter 2.12 - Concept RRUS handle design by Ericsson AB.

One easy way to develop a foldable handle is to use the already present handle of the RRUS 11 & 12. These can be adapted to enable folding. This would demands minimum redesigning and the handle will be lower than the previous developed foldable concept handle, making it easier to fit to the present RRUs. See Picture 3.10 - Foldable handle – Barcelona 11 & 12 Concept, See Picture 3.11 - Foldable handle – Barcelona 11 & 12 Concept Mock-ups.



Picture 3.10 - Foldable handle – Barcelona 11 & 12 Concept. Regnér (2012).

Picture 3.11 - Foldable handle – Barcelona 11 & 12 Concept Mock-ups. Regnér (2012).

3. IDEATION

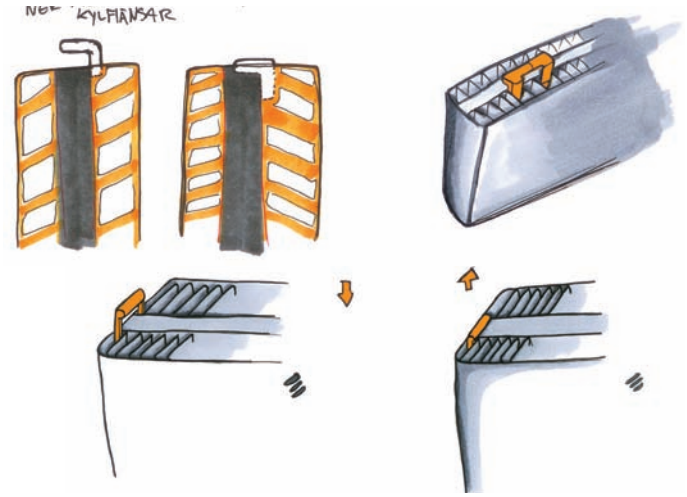
Sliding handle – hidden in the cooling flanges Concept

One concept of a flexible carrying feature slides in-between the cooling flanges to hide when not needed. The handle is pulled upwards to enable handling and lifting. It is a very easy and subtle way to hide a handle which still allows steady and good handling.

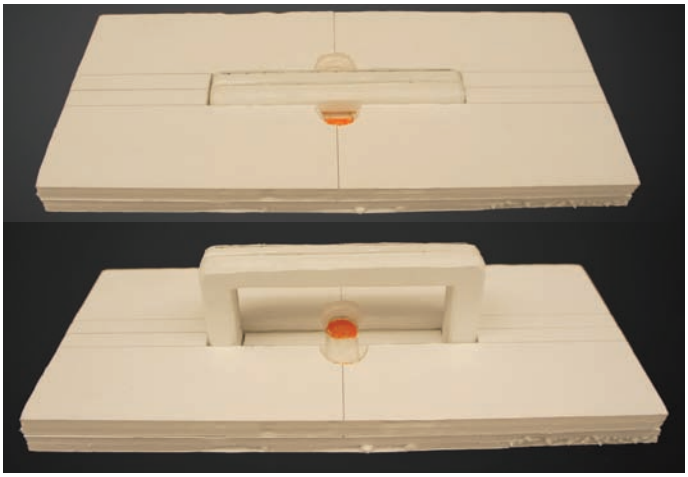
One aspect to regard when developing a sliding handle, placed in-between the cooling flanges, is that it shall be designed so that it does not affect the performance of the cooling system. There is a risk of the handle affecting the cooling as it takes up area from the cooling flanges. However this negative affect can be minimised if designed well.

The carrying feature is possible to make very simple in its design. This will minimise the need of mechanical features.

The concept can also be designed as two sliding handles, like the ones found on a rolling suitcase, placed on the side of the RRUs. This enables two-handed carrying and lifting. See Picture 3.12 - Sliding handle – hidden in the cooling flanges Concept, See Picture 3.13 - Sliding handle – hidden in the cooling flanges Concept Mock-ups



Picture 3.12 - Sliding handle – hidden in the cooling flanges Concept. Regnér (2012).



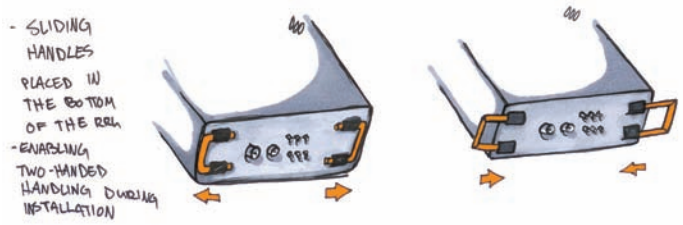
Picture 3.13 - Sliding handle – hidden in the cooling flanges Concept Mock-ups. Regnér (2012).

Slides from the bottom Concept

In the bottom of the RRUs, mainly cable-connections, feet and overlays are placed. There are surface areas here which are not used. A carrying feature placed in the bottom of the RRUs does not interfere with the products height and semantic expression. They would also enable easy flexibility and possible to make non-visible when not needed.

One concept of sliding handles placed on the bottom of the RRUs is two loops which slide to the side of the RRUs to enable two-handed handling. This kind of carrying provides a steady grip. The product can be carried close to the user's torso, an ergonomic requirement. Johansson (2011).

The handles are shaped like two open loops which slides into the base of the RRUs. They hide to become totally non-visible when not needed. When the handles are to be used, they can slide to the side, enabling two-handed carrying. No mechanical features adding to the risk of failure has to be added. See Picture 3.14 - Slides from the bottom Concept.



Picture 3.14 - Slides from the bottom Concept. Regnér (2012).

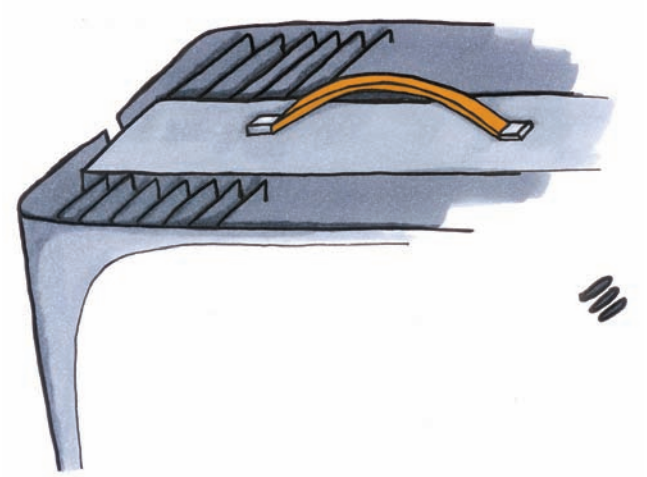
This concept does not allow one-handed handling. There is the possibility of hoisting the product from the handles. It would be recommended to design a hoisting feature in the top of the RRUs in combination with the sliding handles.

Collapse-band Concept

Collapse-bands are common carrying features on heavy products, such as heavy cases and music amplifiers. The concept of a collapse-band is an already well-designed and tested solution which works very well. It allows good carrying and lifting when needed as well as slides back into the subtle "0-position" when not used. See Picture 3.15 - Collapse-band Concept, See Picture 3.16 - Collapse-band Concept Mock-ups.

There is the possibility of placing different collapse-bands both on the top of the RRUs as well as in-between the split-lines on the side, which will mean absolute subtlety. There is a great possibility developing a collapse-band made from textile or other innovative materials. Sr Industrial Designer HW Usability – Ericsson AB, Mats Johansson is not keen on the idea of using collapse-bands from an ergonomic point of view. He states that they will not provide good ergonomic properties when carrying heavy products over 18 kg. Johansson (2011).

3. IDEATION



Picture 3.15 - Collapse-band Concept. Regnér (2012).

Picture 3.16 - Collapse-band Concept Mock-ups. Regnér (2012).

Sliding and folding along the top Concept

Another concept that allows two-handed handling through foldable handles, is an idea where two handles slides along a path on top of the RRUs. This solution allows the handles to slide out maximum to the side, allowing handling when mounting and installing. The handles can also slide to a CoG upright position in of the top of the RRUs. This enables one-handed handling. When the handles are not in use they fold down flat onto the top of the RRUs. From here they are non-visible and do not interfere with the semantic expression. See Picture 3.17 - Sliding and folding along the top Concept.

Picture 3.17 - Sliding and folding along the top Concept. Regnér (2012).

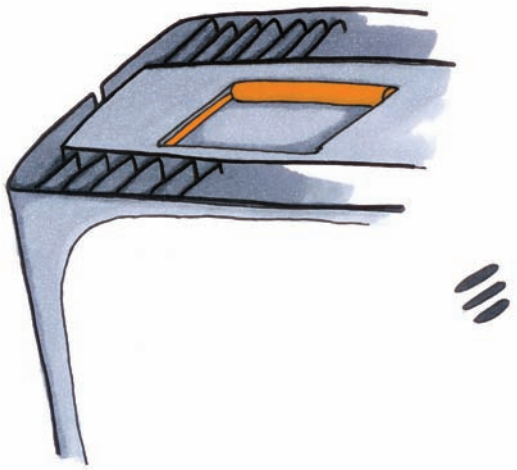
This concept is technically a little bit more advanced than some other concepts. It has to be well-designed not to fail during usage.

Camera-case handle Concept

During the pre-study, other types of durable handles enabling carrying of heavy loads where concluded. One of these carrying features was the foldable metal handles, commonly used on heavy protective camera cases. See Picture 2.25 - Bent steel handle The handle is a well designed and tested product. It is easy to modulate to fit the different Ericsson AB's RRUs.

The basic idea is similar to the concept of the Foldable handle – Barcelona 11 & 12, described above Chapter 3.3.2. The major difference is that this concept is ought to be integrated into the internal-body of the RRUs, as well as being slimmer and more subtle. See Picture 3.18 - Camera-case handle Concept.

It can be placed in the top of the RRUs to allow one -handed handling as well as on the bottom to allow both one- and two-handed handling when mounting and installing.



Picture 3.18 - Camera-case handle Concept. Regnér (2012).

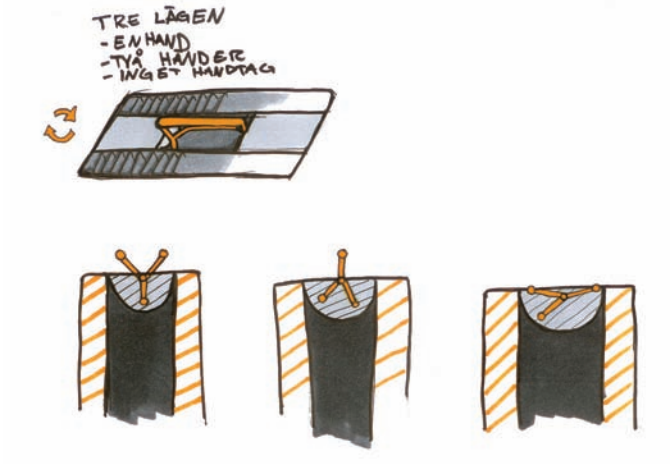
Spinning handle Concept

One concept that differs a lot from the other ideas, is a flexible handle which allows both one- and two-handed handling through one single carrying feature. This concept is portrayed as a spinning handle working by spinning to different positions to allow different types of grips as well as non-visibility.

The spinning handle is immersed into the top of the internal-body of the RRUs. It can be totally hidden when not in use.

The technical features of the handle are not very complicated. It is only containing a handle and an axle which allows it to spin. The handle is designed so that it always takes on the non-visible "0-position" when not in use. See Picture 3.19 - Spinning handle concept.

3. IDEATION

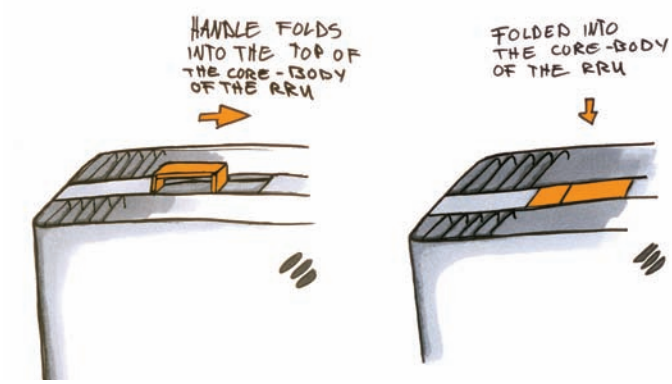


Picture 3.19 - Spinning handle Concept. Regnér (2012).

Sewing-machine foldable handle Concept

This concept is derived from a sewing-machine case, where the handle folds onto the top of the case. The handle folds to the side, on top of itself allowing a thin and sleek look. The technical mechanism of folding to the side means that the handle has to be flat on all sides as it is to lies flat on top of itself on the top of the RRUs. See Picture 3.20 - Sewing-machine foldable handle Concept.

The concept allows one-handled handling when placed on top of the RRUs. If the handles are placed on the side, possibly in-between the split-lines, two-handed lifting and handling can be enabled.



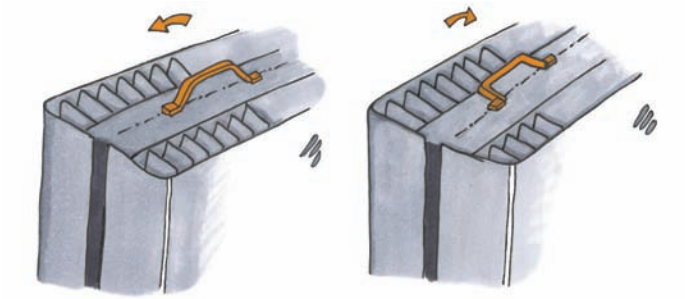
Picture 3.20 - Sewing-machine foldable handle Concept. Regnér (2012).

Foldable handle – RRUS 11 & 12 Concept

The concept is a foldable handle portrayed as the present RRUS 11 & 12 handles. By developing a foldable version of the already developed handle, minimum redesigning will be needed. It means that the foldable handle can be made lower than the Barcelona 2011 & 2012 version. It will not be raised further because of the base-plate. This makes a sleeker look but still provides just as good ergonomic aspects.

By just implementing minor changes to the end-area of the present handles, it can be adapted to enable folding over an axis. The base-plate which enables folding can be fitted to the already fabricated mounting holes on the top of the RRUs.

See Picture 3.21 - Foldable handle - RRUS 11 & 12 Concept, See Picture 3.22 - Foldable handle - RRUS 11 & 12 Concept Mock-ups.



Picture 3.21 - Foldable handle – RRUS 11 & 12 Concept. Regnér (2012).

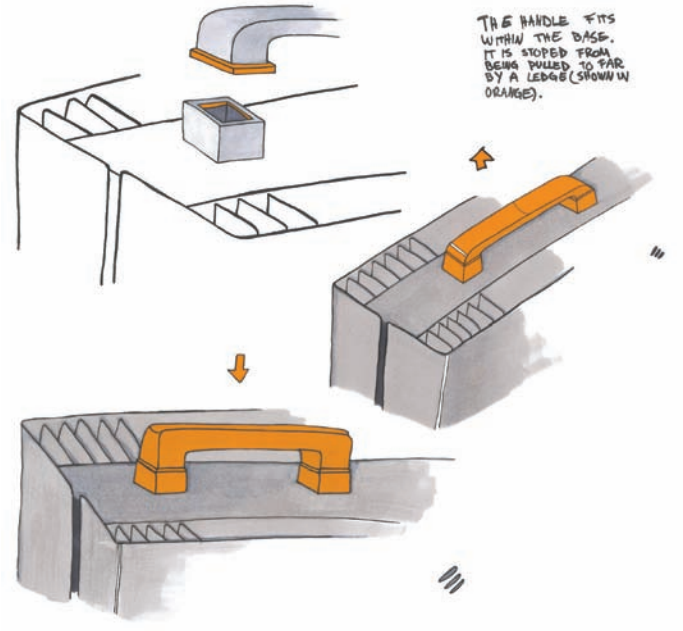
Picture 3.22 - Foldable handle – RRUS 11 & 12 Concept Mock-ups. Regnér (2012).

Telescope Concept

A sliding mechanism is another way to make a handle flexible. One way of doing this is a vertical handle sliding within itself. This concept lets the handle slide up to enable handling and lifting when needed. When not needed it slide down into itself once again. The solution of enable flexibility is very simple and does not involve any unnecessary mechanical features in risk of failing. It consists of a fairly standard ergonomically adapted handle which enables power-gripping. The handle is made from tubing and the base-plate from the same kind of tubing, with a larger diameter. This enables the handle to slide into the base, to be more subtle than the present fixed handles of the RRUS 11 & 12.

There is the possibility of making the handle even more subtle and flexible by designing it in more levels. More tubes of different dimensions allowing the handle to slide within itself, denoting less semantic intrusion of the RRUs. However the more levels of tubing, indicates either a thinner handle or a larger base-plate. More mechanical mechanism can mean a greater risk of failure. This will probably not be a problem and is something that has to be regarded if further developed. See Picture 3.23 - Telescope Concept.

3. IDEATION



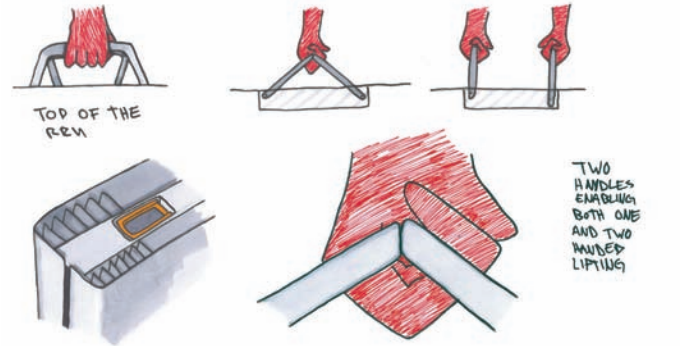
Picture 3.23 - Telescope Concept Mock-ups. Regnér (2012).

Two-in-One Concept

The concept of two in one is a single carrying feature which enables both one- and two-handed handling from two handles. The carrying feature can either be placed as integrated into the top of the RRUs or within a box, mounted onto the top of the RRUs. The concept is very modular can easily be adapted to fit many different products. It also holds the possibility of being used on the present RRUS 11 & 12. One handle is placed on each side of the box it is being house within. The handles are also connected at different height which enables the handles to fold over each other. This means that the carrying feature can be made very subtle to not interfere on the whole semantic expression of the RRUs.

The handle can be designed to allow a good power-grip,, be very steady and durable as well as at the same time be very subtle. The handles are connected to the base-box with a simple axle-mechanism allowing folding.

If the handles, each are folded upward to a 90° angle towards the top of the RRUs, two-handle carrying is enabled. If instead the handles are met at the middle a 45-60° angle towards the top of the RRUs, one-handed carrying is enabled. See Picture 3.24 - Two-in-One Concept.

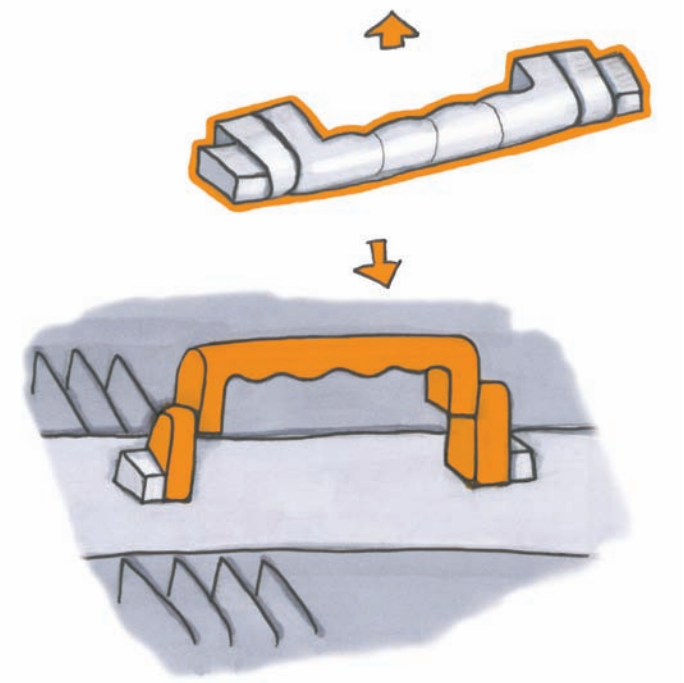


Picture 3.24 - Two-in-One Concept. Regnér (2012).

Double Fold Concept

The Double Fold handle is a simple handle, much like the present RRUS 11 & 12 handle. It is made foldable through integrating a doubled-axis folding mechanism. The mechanism is simple and the handle can be made very subtle, yet durable by letting it fold twice. The folding mechanism is possible through connecting the handle to two smaller side-sections by an axle-mechanism. These side sections are connected to each-other, allowing the handle to fold as well as provide a good steady handle for horizontal carrying. The handle is robust and is possible to make ergonomically adapted for better carrying. See Picture 3.25 - Double fold Concept.

The design of the handle enables it to be modular to many of Ericsson's different mobile products as well as usable to the present products available at the telecommunication market. The present handle of the RRUS 11 & 12 can be used and made minor adjustments to for it work properly.



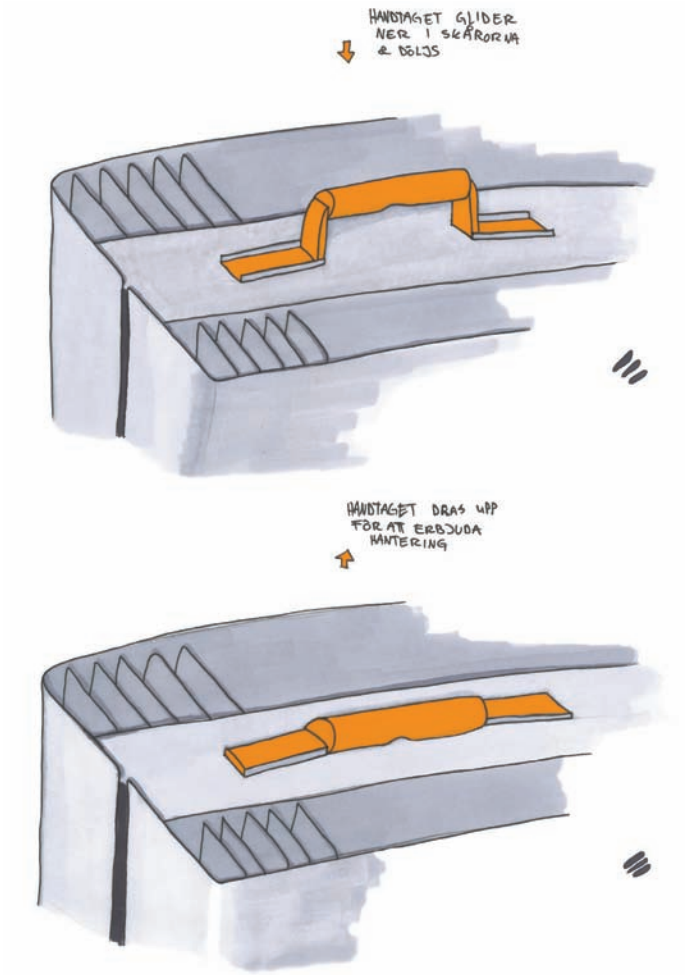
Picture 3.25 - Double fold Concept. Regnér (2012).

Top Slider Concept

The top slider concept is a fairly common type of handle use in suitcases and other types of large bags. It is subtle yet still very flexible. The construction is designed as a rounded handle, enabling comfortable and steady handling. It is connected to one bar on each side by and axle-connection. The side-bars are in the other end connected to a "box" on each side of the handle. In their turn connected to the top of the RRUs. The side-bars slides within the "box" enabling the handle to slide down and be subtle when not needed. The handle is then easily pulled upwards and the side-bars slide to the centre of the RRUs to enable carrying and handling.

3. IDEATION

Fairly simple in its construction the handle holds some hinges and axles which enable it to be flexible. The "boxes" are mounted to the top of the RRUs and can be designed to be modular to many different mobile products as well as fit the present RRUs. See Picture 3.26 - Top slider Concept, See Picture 3.9 - Split-line Concept Handles Mock-ups.



Picture 3.26 - Top slider Concept. Regnér (2012).

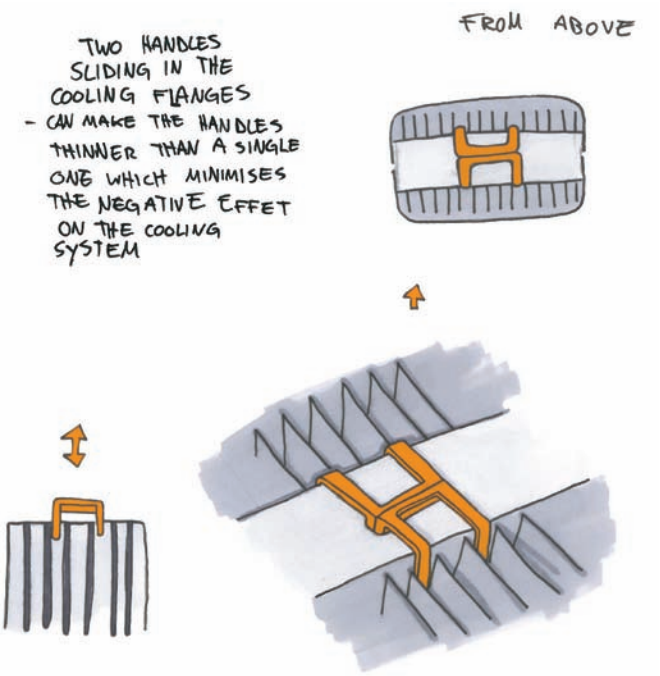
Double Centred Cooling Flanges Concept

When a flexible handle shall slide in-between the cooling flanges, there is the possibility of negatively affecting the efficiency of the cooling system. For a single handle to slide in-between the cooling flanges, it has to be strong and durable. This means that it will have to be fairly thick. If the handle instead is split in to into two handles, one on each side of the centre of the internal-body, they can meet in the middle. The handles can be made thinner and lighter and still allow the same strength and durability.

The handle slides up and down in-between the cooling flanges on each side of the centre of the internal-body, enabling one-handed CoG carrying and lifting. See Picture 3.27 - Double Centred Cooling Flanges Concept.

This concept is somewhat difficult to make fully modular as each RRUs and Ericsson AB product differs in design and shape. Some of the products do not even hold cooling flanges on two sides of the internal-body.

The concept is a derived version of the sliding handle hidden in-between the cooling flanges.



Picture 3.27 - Double Centred Cooling Flanges Concept. Regnér (2012).

3.3.3 Detachable

The detachable carrying feature concepts consists of ideas how to enable handling with a feature that is easy to remove when not needed. The generated concepts allow the user to handle the product comfortably and easy through a carrying feature. The carrying feature is attached to the product when it shall be handled or carried. When not needed the carrying feature is easily detached from the product. The carrying feature does not intrude on the products total semantic expression through this mechanism.

Hook Concept

This concept is derived from the idea of using a hook connected to the user's wrists. It will allow extra strength when carrying and lifting heavy loads. The concept is commonly used within the fitness and heavy weight lifting industry. Such hooks can be found where a person is doing the exercise of "hang ups". The person is hanging upside down from a bar, which his/her feet is connected to via hooks, performing upside down sit ups with greater success.

The hooks are connected to the user's wrist like a kind of glove, where the hook runs down the palm of the user's hand. The hooks are then hooked on to special base-plate brackets on the RRUs. This enables lifting and carrying of the product. See Picture 3.28 - Hook Concept.

The hook can be connected to the top of the RRUs, which enables CoG one-handed handling. There is a possibility to place more base-plate brackets on the side of the RRUs in-between the split-lines. By doing so there is a possibility of two-handed handling for mounting and installation.

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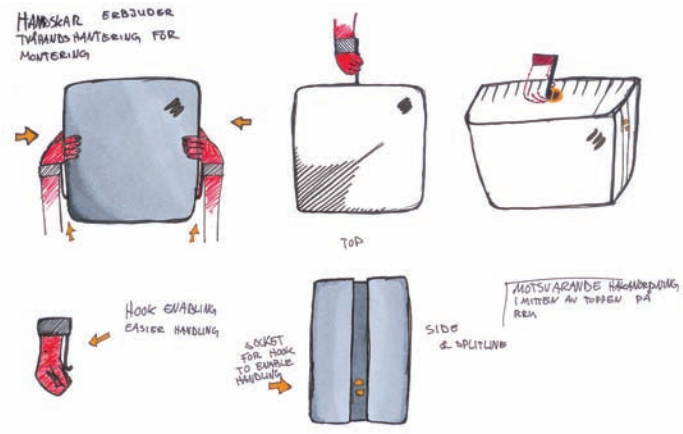
The user can either use a hook on one hand or two hooks on both hands, depending of the purpose of the carrying situation and the personal usage situation.

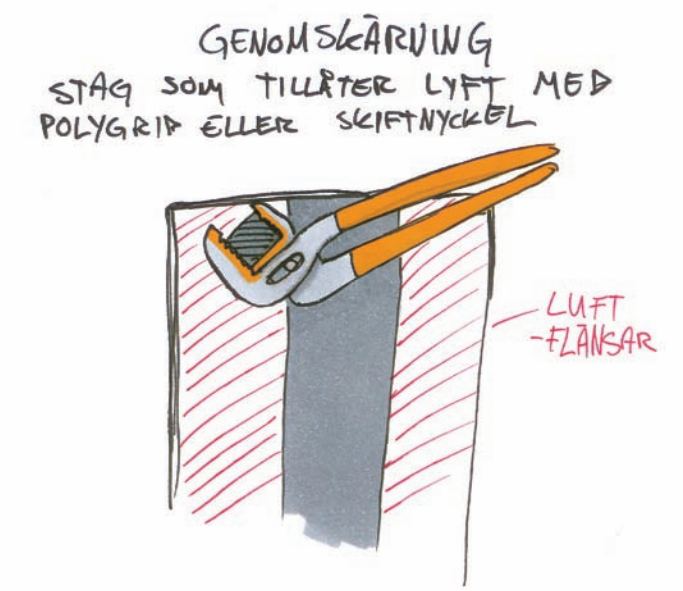


Picture 3.28 - Hook Concept. Regnér (2012).

Toolbox tool Concept

This concept is thought to enable carrying by using a common tool. A tool which is "always" present during installation or any situation when installing/servicing a product. As the RRUs has to be mounted to a radio tower mast or a wall, using large bolts, they have to be tightened to secure the installation. The idea is to develop a mount or some kind of gripping-area on the product where a tool, such as a wrench or a pair of polygrip-pliers, can grip around to become the carrying feature itself. See Picture 3.29 - Toolbox tool Concept.

The common tool will take on a different purpose when used in combination with the gripping area. Through this concept it is the possibility to minimise the visual intrusion of the handle as well as to only allow a handle if one such is desired.



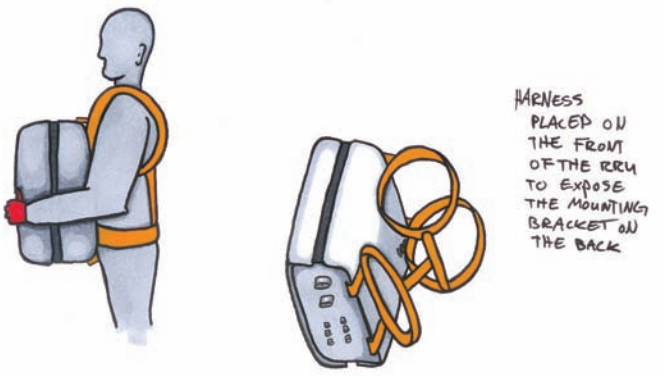
Picture 3.29 - Toolbox tool Concept. Regnér (2012).

Harness Concept

The carrying feature does not have to be a common handle. It can be any kind of feature which enables a solution for lifting and carrying. Harnesses are commonly used when carrying heavy products, such as pianos and safes.

The concept of using a harness is to minimise the heavy load of the RRUs when carried by hand. The product is instead intended to be carried with the entire body of the user. The ergonomic recommendations state that loads over 18 kg are not to be carried regularly. It tends to put large stress upon the person carrying. Johansson (2011). The user shall carry the product at chest-height and hold it close to the torso to minimise the body stress. By connecting the RRUs to a harness, which is worn by the user, the product might be easier to carry and handle during installation. The RRUs can be connected to either the back or the chest of the user, depending of what is best out of ergonomic as well as comfort aspects. See Picture 3.30 - Harness Concept.

The harness shall be placed on the front of the RRUs, exposing the back and the mounting bracket to enable installation.



Picture 3.30 - Harness Concept. Regnér (2012).

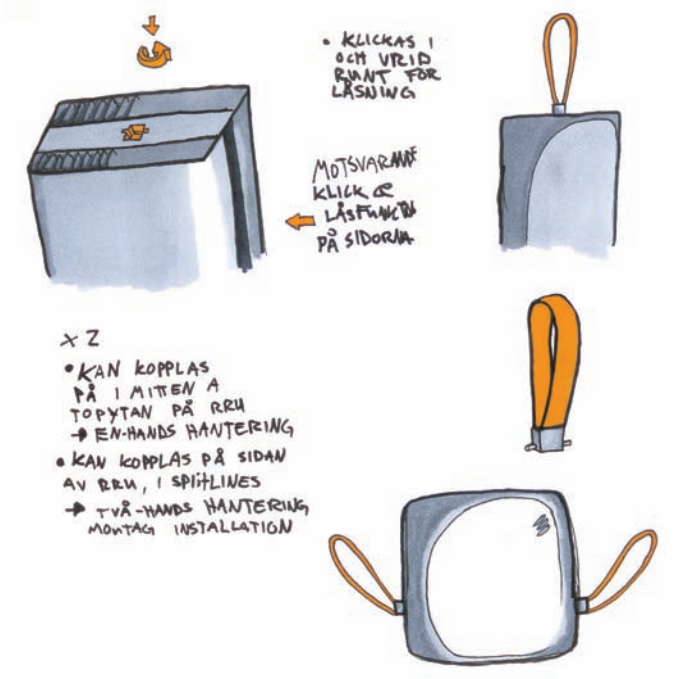
Bus ceiling strap Concept

In many buses, there are plastic or leather straps hanging from the rails in the ceiling of the bus. These straps enable the passengers to get a good and steady grip which helps to provide a more comfortable and safe bus ride. When a bus ride is bumpy the ceiling straps can provide stabilisation.

The "ceiling straps" are thought to be connected to the RRUs to enable one- and two-handed carrying. The detachable handles can be attached to the top for one-handed carrying and hoisting. There is also the possibility to attache them to the sides, in-between the split-lines, to enable two-handed handling for installation and lifting.

The "ceiling straps" are connected to the RRUs through locking base-plate brackets which enable the carrying feature to lock to the product when lifting. See Picture 3.31 - Bus ceiling strap Concept.

3. IDEATION



Picture 3.31 - Bus ceiling strap Concept. Regnér (2012).

Handle strap Concept

The product STRAP-A-HANDLE is already a consumer product on the market. STRAP-A-HANDLE (2011). However, there is a possibility to design and develop a similar product which can be intended for carrying and lifting of Ericsson AB's portable products.

The concept is a handle and strap, all-in-one, which wraps around the product to enable carrying and handling. It is fully removable when not needed and easy to attach when carrying is needed. The carrying feature can be made so that it is usable in other common installation and mounting situations when dealing with Ericsson AB's products. The carrying feature strap can be designed so that it enables easier hoisting for example. See Picture 3.32 - Handle strap Concept.

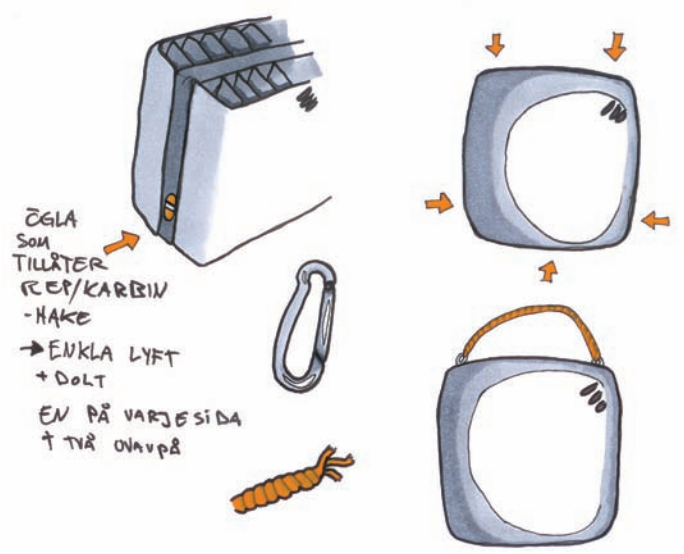
Picture 3.32 - Handle strap Concept. Regnér (2012).

Loops Concept

When dealing with the concepts of a detachable carrying feature, there is not always a need to design the carrying feature itself.

The concept named "Loops" consists of designing and developing a base-plate bracket which enables any kind of rope or shackle to be connected to enable carrying and lifting. The basic idea is that the base-plate brackets, possibly shaped like loops, are placed in-between the split-line and on top of the RRUs. They allow the user to attach any kind of available tool. See Picture 3.33 - Loops Concept.

The focus is to design and develop a base-plate bracket which is optimally designed to be subtle but at the same time enable easy attachment of possible tools to enable carrying.



Picture 3.33 - Loops Concept. Regnér (2012).

Single-Double Concept

The concept of single-double is two classic handles which are attachable and detachable to the RRUs at different positions. The handles form, if placed on top of the RRUs, a single handle which enables CoG one-handed handling. Much like the present RRUS 11 & 12 handles. The handles can be split apart and attached in-between the spilt-lines of the RRUs sides to allow two-handed handling for lifting and installation. See Picture 3.34 - Single-Double.

When the handles are not needed they are easy to detach so that he user can take them with him/her. Another possibility is to hide the handles in the bottom of the product. See Picture 3.35 - Placement in the bottom. This means that they do not interfere on the semantic expression of the RRUs, when mounted to a radio tower mast or a wall/facade.

The concept enables many different solutions of lifting and hoisting through the same handles which are very easy to attach and detach.

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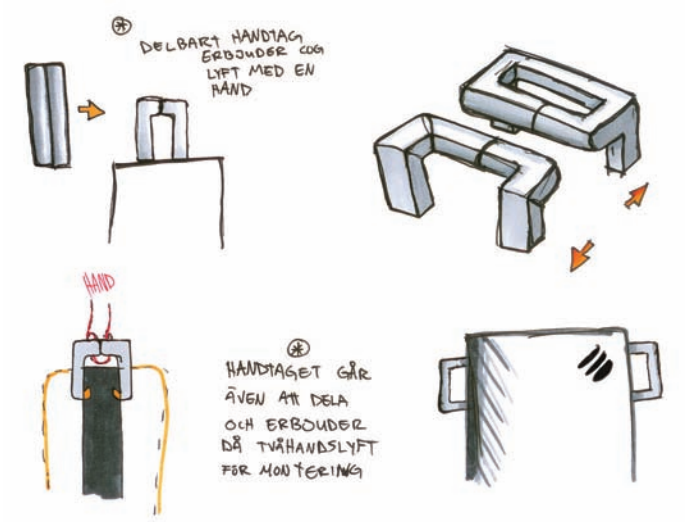
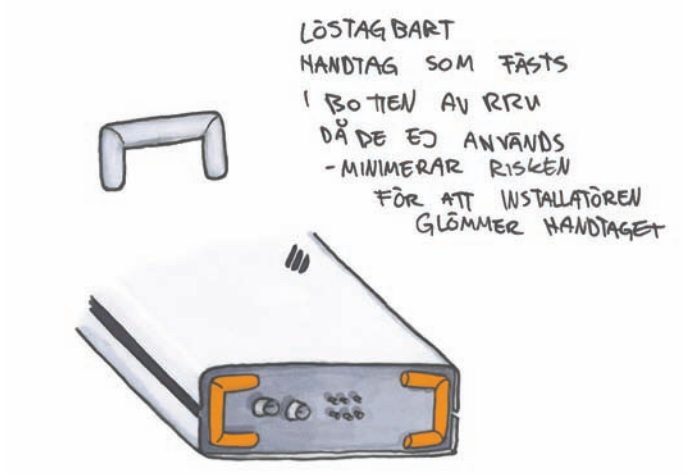


Picture 3.34 - Single-Double Concept. Regnér (2012).



Picture 3.35 - Placement in the bottom. Regnér (2012).

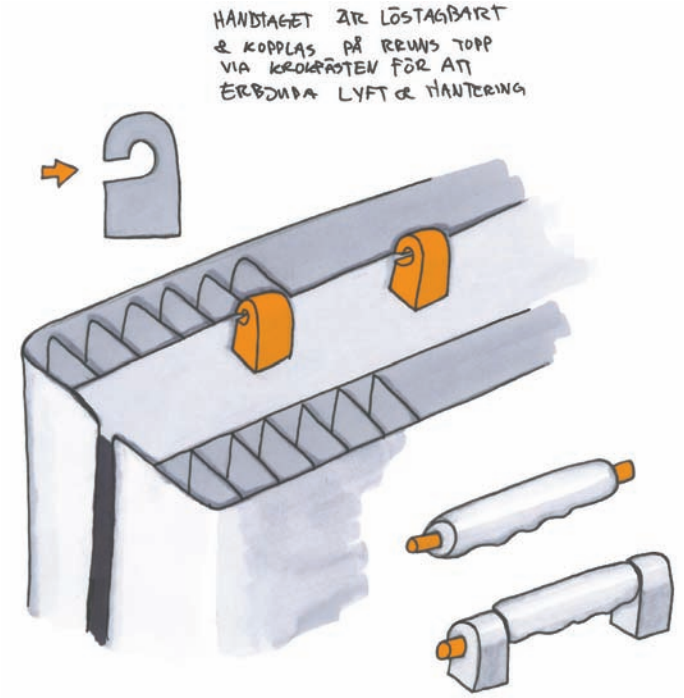
Connectable Bar Concept

The concept of the connectable bar is a detachable handle which is connected to the top of the RRUs. Two base-plate brackets are mounted to the RRUs which the handle then is connected to. The base-plate brackets can be shaped like up-side-down "Js" which the handle slides into and locks when pulled upwards.

The handle itself is shaped like a rounded bar with groves for better fitting of the fingers. The end pieces are of thinner rods which are to be connected to the base-plate brackets. See Picture 3.36 - Connectable Bar Concept.

The handle can be detached when not needed and placed in the bottom of the RRUs to enable carrying the next time it is needed. The base-plate bracket can be placed on other areas of the RRUs to enable different kind of handling and lifting. See Picture 3.35 - Placement in the bottom.

There are no mechanical mechanisms involved in this concept. This means that there is a minimal risk of failing.

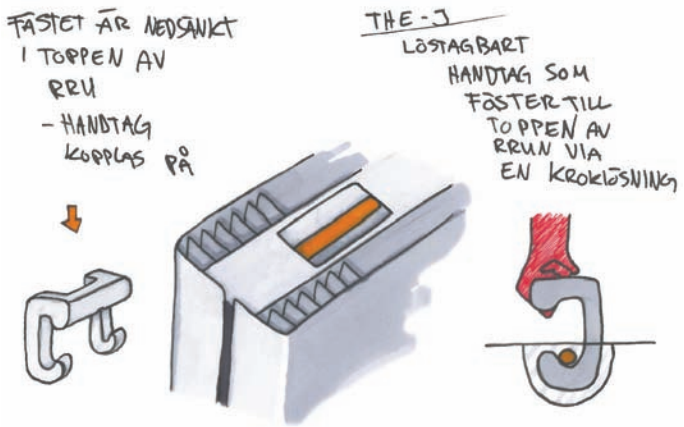


Picture 3.36 - Connectable Bar Concept. Regnér (2012).

The-J Concept

The J is similar to the connectable bar concept however it is done in the opposite way. The base-plate bracket is made as a bar fitted onto the top of the RRUs and the handle is J-shaped to easily and steadily connect to the RRUs. See Picture 3.37 - The-J Concept. The handle is detachable and can be placed in the bottom of the RRUs when not needed. See Picture 3.35 - Placement in the bottom.

The concept is a steady, durable handle which is easily detachable. It is not as subtle and neat as some of the other generated concepts.



Picture 3.37 - The-J Concept. Regnér (2012).

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3.4 Concept evaluation, initial

A good way to conclude which of the generated concepts that is best suited for the purpose was to use a Pugh-matrix. In the Pugh-matrix the concepts were evaluated towards the requirements set in the List of requirements as well as the data compiled and concluded in the pre-study. See Appendix II - List of Requirements.

The concept evaluation shows which concepts that fulfil the requirements the best. The final decision will however be done after a consultation with Ericsson AB. A unanimous decision on which concepts shall be further developed to reach a finalized product will be stated after this consultation.

When compiling the data from the Pugh-matrix, valuable data about which concepts are most suitable for solving the task in regard to the requirements was concluded. Many concepts could be excluded from further development. The result was a good indication of what concepts to continue develop and pitch during the concept evaluation meeting at Ericsson AB.

The concepts fulfilling the task in the best way, as concluded in the Pugh-matrix, were two integrated, three flexible and three detachable concepts. See Appendix V - PUGH-matrix. The integrated concepts of an *immersed version of the present RRUS 11 & 12 handles* as well as integrating a handle in the *products feet* were the most suitable. The flexible concepts consisted of the *foldable version of the present RRUS 11 & 12 handles*, the *two-in-one* as well as the *top slider*. One concept enables both one- and two-handed handling, another one being very simple and true to the present handles and the third one holding a mechanical flexible solution which is yet untried within carrying features at Ericsson AB. One of the detachable concepts most suitable is the *hook* concept. The other two concepts were the *loops* and finally the *single double*.

After the Pugh-matrix had been compiled and the most suitable concepts had been pin-pointed, an evaluation meeting with Ericsson AB took place. The meeting, 11th January 2012 involved the author, Manager, Industrial Design Mikael Thelin and Industrial designer Jens Kallin. It was concluded after some discussion that the detachable concepts were not to be further developed. Even if they were to be further developed and evaluated, these concepts were decided by Ericsson AB, after discussion, not fulfilling the requirements of being present when needed. Ericsson AB stated that there is a too great risk of the user forgetting to bring or lose the handle/handles. This means that handling and carrying will not be possible. There is a major risk of failure if this occurs, something that Ericsson AB state is common from previous experience.

This conclusion led to a continuation of three different concepts, which was unanimously decided at the concept evaluation meeting. The Pugh-matrix made a very good overview how well the concepts where to work and fulfil the requirements. However in the end it was the decision of Ericsson AB that is significant for the further and final development.

Ericsson AB wanted to further develop the concept of using a fixed handle which shall be integrated and subtle in its design. The concepts *Integrated Screwdriver* and the *Present RRUS 11 & 12* handle shall be further developed , optimised for a second evaluation meeting before selecting the final concept.

The second carrying feature which shall be further developed is a concept of a flexible handle which folds. The concepts of F*oldable RRUS 11 & 12, Camera Case, Barcelona 11 & 12, Two-in-One* and *Double Fold* shall be combined to one optimised foldable handle concept. The concept shall be subtle and flexible, yet robust and durable to enable carrying of a heavy product.

The third concept is also flexible carrying feature holding a sliding mechanism. The concepts of *Top slider, Split-line handles, Sewing machine, Sliding along the top* shall be combined for further development.

The three concept-groups will be further developed through ideation, sketches and mock-ups. Finally one concept in each category will be evaluated against the requirements, the reference handles as well as Ericsson AB's opinion. This will lead to a final concept which shall be finalised and optimised to fulfil the requirements.

3.5 Ideation - Second process

After consultation with Ericsson AB, during the concept evaluation meeting, narrower requirements for the carrying feature have appeared. Ericsson AB's response was very good. However, they wanted to pin-point and focus the product development to a top placed CoG carrying feature enabling one-handed lifting through a power-grip.

As the final product concept of this master thesis might be realised in the future, Ericsson AB's demands are extremely crucial to regard. Due to this fact a further ideation process regarding the chosen concepts has taken place. This means further development for more optimised and better concepts, specific regard to the new important requirements.

The further development will try to optimise the solution of a subtle non-intrusive fixed handle, a foldable handle and a sliding handle. The process focused on how these concepts can be made more integrated and how they are to function technically. The concepts was, in consultation with Ericsson AB, evaluated and finally one concept and solution was chosen for final development.

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The methods used to further generate ideas how to solve integration as well as technical mechanisms of flexibility are as previous ideation process; brainstorming and sketching sessions. These methods have also been combined with visual studies of the placement of the handles of the present RRUS. By doing so it was easier to understand how and where the redesigned carrying feature can be optimally integrated.

3.5.1 Placement of the carrying feature

Surrounding the internal-body of RRUS 11, and many other portable Ericsson products, in the centre of the die-cast is an elevated spline. This spline is not present on the RRUS 12, which holds a different solution of joining the two internal-body parts. This spline is used to house a gasket, which secure water-resistance of the product as well as enables screws to join the two halves of the internal-body. The handle of the RRUS 11 is placed on top of the spline. The handle stand above the sun-cover, making it fully visible. This placement of the handle is common on many of Ericsson AB portable products except the RRUS 12. The spline varies some in height depending on the products. On most of the products studied, the spline sits about 10-15 mm above the rest of the internal-body. See Picture 3.38 - RRUS 11 Spline. The spline itself does not stick out above the sun-cover and is not visible for a by-passer. The thickness of the material of the internal-body is usually not more than approximately 6 mm. Näss (2012). The material is not thick enough to withstand the forces when handling the product through the handle. The screws are approximately 6 mm wide and the depth of the screw-holes has to be at least twice of the width of the screw. Vallin (2012). This means that it is not possible to place a handle elsewhere than on the spline. This is especially important when the steel screws are being used together with die-casted aluminium. This enables the screws and die-casted aluminium to withstand the forces of lifting and handling the product through its handle.

Picture 3.38 - RRUS 11 Spline. Regnér (2012).

After consultation with mechanical engineers at Ericsson AB, it appeared that there is the possibility of lowering or removing the spline in specific areas. This means a redesign of the internal-body of the RRUs with adaptation to the water-sealing gasket and screw joints. Andersson (2012). If the spline can be removed in an area where the handle shall be placed or at least in the area of where the hand is grabbing around the handle, the handle itself can be made lower and more subtle. See Picture 3.39 - Integrated handle in the spline, Mock-up.

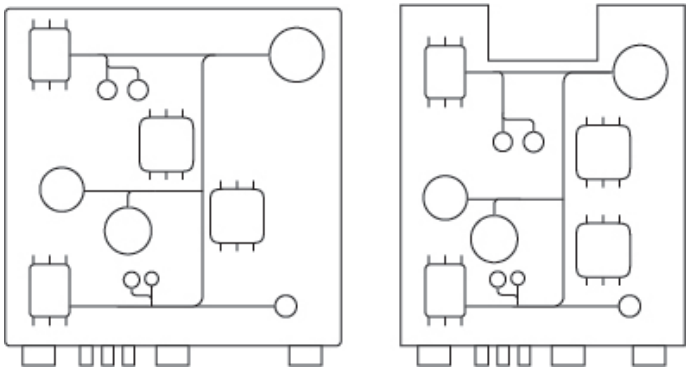
Picture 3.39 - Integrated handle in the spline, Mock-up. Regnér (2012).

By designing a handle which is as low as possible and still not interfered by the spline would indicate optimal design. The handle can be connected to the Spline but hang to one side, enabling good gripping-space. However as the spline is centred, at least on the RRUS 11, it will be hard enabling CoG handling and at the same time not interfere with the spline in regard to grip-space. See Picture 3.44 - D-Shaped Handle Concept.

There is the possibility to raise the total volume of the internal-body so that the handle can be easily integrated without risking intrusion and rearranging of the internal parts. This would however affect the total volume of the product, something that is undesired.

An integrated handle can be die-casted into the actual internal-body, a possibility with a fixed handle. Other possibilities with adding material to the internal-body is a possibility of making a lowered section in the middle of the top-area of the RRUs which will allow a handle and the needed grip-space. See Picture 3.4 - RRUS 11 & 12 Concept Handle.

The shape of the internal-body and the circuit-board can be challenged. The easiest and most effective way to make a circuit-board is to make it square with the cable-connections in the bottom. Thelin (2012). If some redesign was to be made to the circuit-board, the internal-body would be possible to reshape. This would mean that it is better suited to house integrated features such as a handle. See Picure 3.40 - Circuit-board adaptation.



Picture 3.40 - Circuit-board adaptation. Regnér (2012).

A third solution to better integrate the handle and make it more subtle is to add some material to the sun-cover. By adding material to the sun-cover, it can be made a little bit longer. This means that it will cover more of the

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handle making it more subtle. This adaptation will still add to the total volume of the product as well as a small weight increase.

3.5.2 Fixed handle

The idea of using a fixed handle is the most previously tested way of integrating a handle to a portable product within Ericsson AB. The concept enables a strong and heavy-duty handle which allows lifting and carrying of the product to site. The durable and rigid construction of the previously designed fixed handles, RRUS 11 & 12, has been tested to withstand both handling as well as hoisting without failing over a lifespan of ten years.

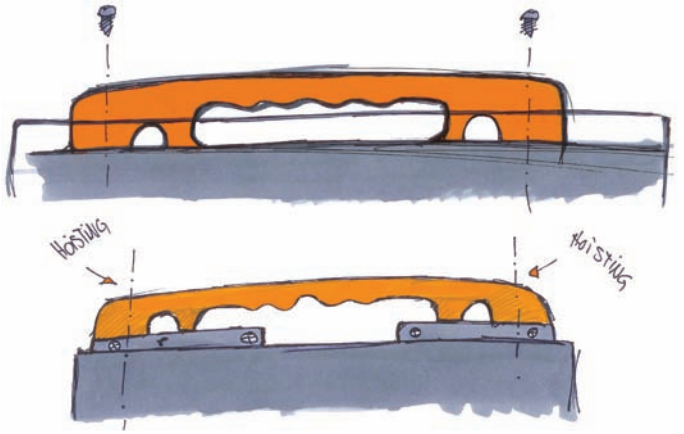
The major problem with the present fixed handles is that they are not subtle and interfere with the semantic expression of the RRUs as a whole.

If further design would be applied to the internal-body as well as the carrying feature, the handle could potentially be much more subtle. The handle cannot be made "too" integrated as it is not to interfere on the circuit-board and the radio unit housed inside the internal-body.

With the previous fixed handles of the RRUS 11 & 12 in mind, the grip space is between 41 - 43 mm. See Picture 2.17 - Dimensions Handle RRUS 11, See Picture 2.18 - Dimensions Handle RRUS 12. This is well adapted with regard to the ergonomic aspects. By minimising and compromising the grip-space needed the handle can, with the ergonomic aspects in mind, be made more subtle.

Long bolted on Handle Concept

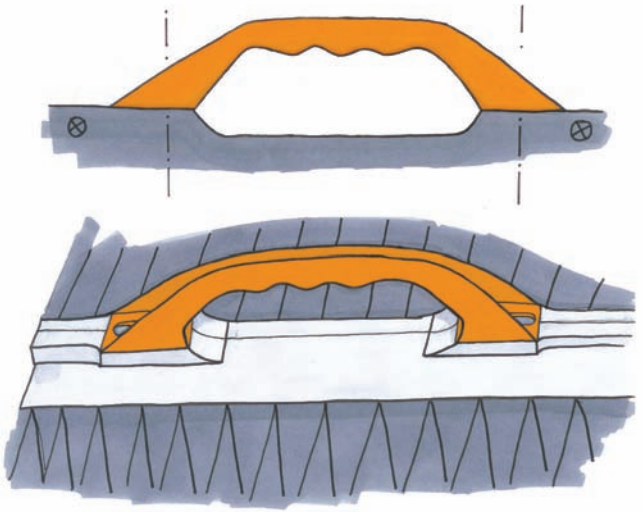
One possible solution is a long steady fixed handle mounted onto the top of the RRUs. It can be placed on both present products as well as to future developed products. It will be even more subtle due to the grip-space being integrated as a "cut-out" of for example in the top-spline. The handle shall be almost as long as the product is wide. This means that the handle will be more uniform to the product and will look like a part of the spline. The handle will be more subtle to the total semantic expression of the product as a whole. By making a long the handle, a good ergonomic grip with a grip-area of at least 110 mm including comfortable finger-grooves can be accomplished. As the finger-grooves are integrated in the handle, the centre groove will be a downward tip. This means that if finger-grooves shall be integrated and CoG carrying is desired, a crease for CoG hoisting will not be possible to integrate in the middle of the handle. One possibility is to use one crease to the side of the centre tip of the finger-grooves as a hoisting crease. These creases to each side of the centre tip are close enough to the centre of the handle to provide almost CoG hoisting. Another solution to the problem is to design two loops in each end of the handle to enable steady CoG hoisting. Loops are incorporated in this concept and enable a rope to be connected in an easy way. The handle is bolted onto the top on the RRUs, in the spline or other suitable areas. The handle provides a loop-like shape inside as well as a humble yet steady semantic expression. See Picture 3.41 - Long bolted on Handle Concept.



Picture 3.41 - Long bolted on Handle Concept. Regnér (2012).

Slimmed-Regular Concept

A different but yet similar solution is to use a present Ericsson AB handle and redesign it to be more subtle and modular to many products. If the handle can be integrated so that the grip-space is "interfering" on the spline, the handle can be lowered. This means a sleeker and more subtle look. The base of the handle can be made a little longer with the possibility of having an oval-shaped hole for screw attachment. This means that the handle will be more suitable and modular for many products. The fittings and screw-holes vary in distance between the different portable products within Ericsson AB's product family. The handle can be designed to integrate finger-grooves for a more comfortable grip. There is the possibility of designing in loops to the side of the handle to enable hoisting through. See Picture 3.42 Slimmed-Regular Concept.



Picture 3.42 - Slimmed-Regular Concept. Regnér (2012).

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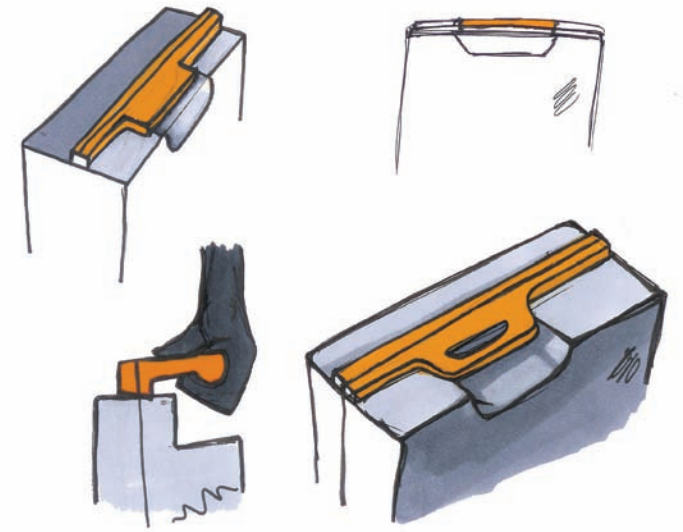
Cut-out Off-centre Concept

If there is the possibility to remove material to the internal-body to allow a lowered section in the centre of the top area, it would be possible to integrate a handle which is much more subtle. If the spline can be moved over towards one side, a handle which "hangs" over the immersed area of the internal-body can be fitted. The handle will be non-visible, fixed and allowing CoG handling and hoisting. As the handle is not placed right above the area where it is connected to the product, the arms of it will have to be made very strong and durable to withstand lifting and hoisting. If not designed well, there is a great risk of the handle breaking. This means it has to be replaced and do not fulfil the requirements of having a lifespan of at least 10 years. Finger-grooves and hoisting possibilities is possible to integrate, just as the previous solutions of fixed integrated handles.

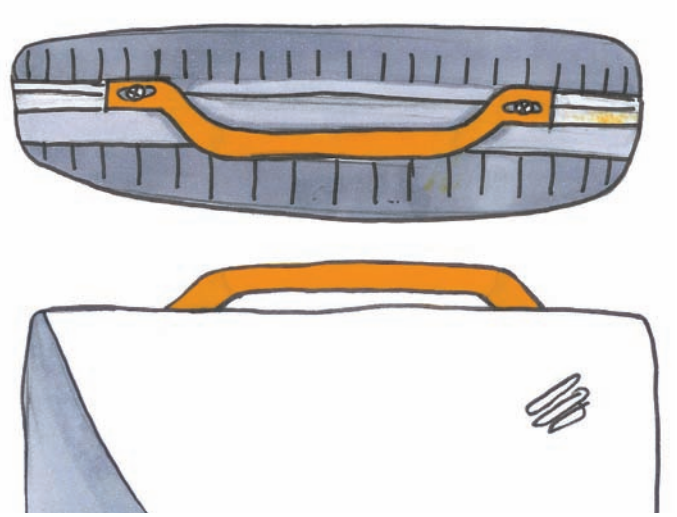


Picture 3.43 - Cut-out Off-centre Concept. Regnér (2012).

A fully integrate handle which is moulded into the die-cast is not possible to make modular. It will have to be redesigned to some extent, every time it shall be fitted on a new or different product. See Picture 3.43 - Cut-out Off-centre Concept.

D-Shaped Handle Concept

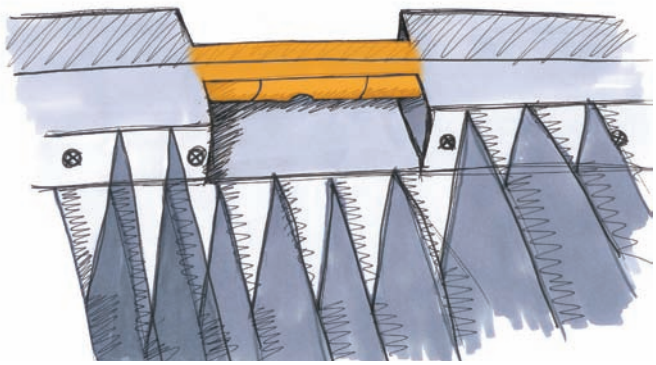
Like the previous described concept there is a possibility of making an "over-hanging" handle which shall be mounted onto the top of the RRUs. This will make the handle a little bit less subtle. However, still very discrete and almost non-visible for by-passers observing the RRUs when placed in a public environment. The benefits of having the handle mounted onto the product instead of mounting it into the die-cast is that it is easy to replace as well as being modular and fit many products. See Picture 3.44 - D-Shaped Handle Concept.



Picture 3.44 - D-Shaoed Handle Concept. Regnér (2012).

Material-add integration Concept

One way of integrating a handle is to add material to the internal-body. If this is done a handle can be integrated into the internal-body itself. The sealing and fastener spline can be removed and the area of the added material will work as sealer as well as holding a handle. By adding material, it is also easier to make "cut-outs" to enable a more integrated and subtle look of a handle. Material can be stripped so that a handle is shaped out of the internal-body. This solution demands redesign of the whole product, is not modular in any way as well as un-replaceable if broken. It is a very sleek and durable way to fully integrate a handle which is easy and comfortable to use. It does not negatively interfere on the semantic expression of the product. See Picture 3.45 - Material-add integration.

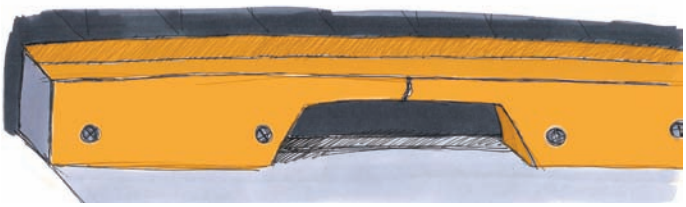


Picture 3.45 - Material-add integration Concept. Regnér (2012).

Raised integrated spline Concept

Other possible ways which does not include a large redesign is to add material to the sealing and fastener spline. If material is added, it will mean a larger and higher spline which the handle can be die-casted into as a part of the product. The handle will be fully integrated, be strong and comfortable as well as providing good ergonomic griping possibilities. This solution would need a fairly large amount of material adding to the spline, a raise of up to 35-40 mm. This can be problematic in regard to semantic

intrusion. The handle will not be modular or possible to exchange, but as the previous concept very integrated. See picture 3.46 Raised integrated spline Concept.



Picture 3.46 - Raised integrated spline Concept. Regnér (2012).

Raised spline-centre handle Concept

The final way of making a subtle integrated fixed handle is somewhat similar to the solution of the Raised integrated spline Concept. The handle is integrated into the spline, however the spline is only raised in the area where the where the actual handle is placed. This means less adding of material but still demands a redesign of the internal-body and the spline. The sealing gasket and fastener possibilities are placed within the spline and the handle. The water resistance should be just as good. The handle can be designed to look sleek and subtle fitted to the semantic expression of the product. There is a possibility of the handle being somewhat similar to the present RRUS 11 & 12 handle but without the possibility of modularity and "replaceability". See Picture 3.47 - Raised spline-centre handle Concept.

Picture 3.47 - Raised spline-centre handle Concept. Regnér (2012).

3.5.3 Folding handle

A folding handle is not previously experienced and used in any launched products, as fixed handles has been used. There is a great possibility of using a steady and durable handle which can be made very subtle and not interfere on the total semantic expression of the whole RRUs.

Ericsson has previously developed concepts of a foldable handle. These concepts have been made for the Mobile World Congress in Barcelona of 2011 and 2012, as well as a concept product. None of the concepts has been further developed and implemented in their finished products. With a foldable handle the risk of failure is raised, due to mechanical details and parts in risk of failure over time. If designed well with proper and appropriate materials and mechanical solution selection, the risk can be controlled and minimised.

Folding handles are possible to design to suit the present Ericsson RRUs. How the handle shall be designed and what mechanical solution to be used, will be established when selecting a concept to finalise.

The folding handles shall be integrated in the same extent as the fixed handles, with exception of being die-casted into the internal-body. If the foldable handle shall be integrated through minimising the sealing and fastener spline, the handle would have to be extra subtle. It shall not be visible at all when folded down, and still enable satisfactory handling with good ergonomic aspects in regard.

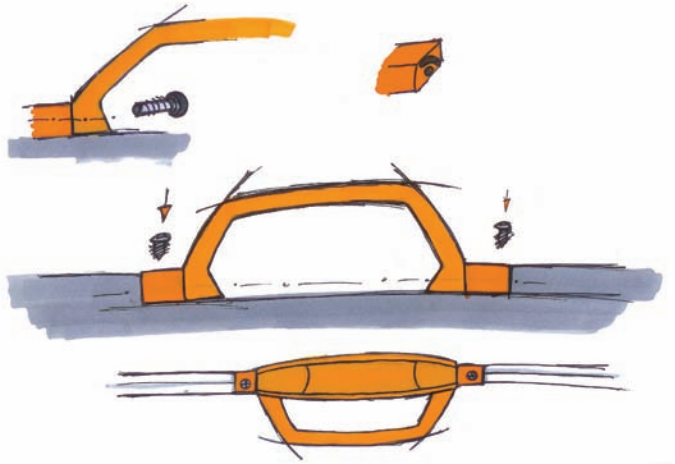
Foldable RRUS 11 & 12 Concept

One possible solution of enabling a folding handle is to use the present RRUS 11 & 12 handle as a foundation. These handles are durable as well as steady and with minor redesign can be made more subtle and foldable. The area of the handle which is attached to the top of the RRUs is to be redesigned be replaced with a base-plate bracket. This will enable the handle to fold over an axle. The base-plate brackets housing the folding mechanism will be attached to the top of the RRUs.

The handle can either be shaped as it is today, updated with integrated finger-grooves or possibly designed to be uniform to the 2012 Mobile World Congress in Barcelona concept handle.

The concept will be modular and possible to fit onto different portable products. Indicating that it can replace many of the present handles used. The handle can be placed on present products, mounted on top of the sealing and fastener spline. There will also be the possibility of fitting it to future products, where the internal-body has been adapted to better and more subtly integrate the handle.

The folding sequence will work through an axle which runs from the handle into the base-plates brackets. See Picture 3.48 - Foldable RRUS 11 & 12 Concept.



Picture 3.48 - Foldable RRUS 11 & 12 Concept. Regnér (2012).

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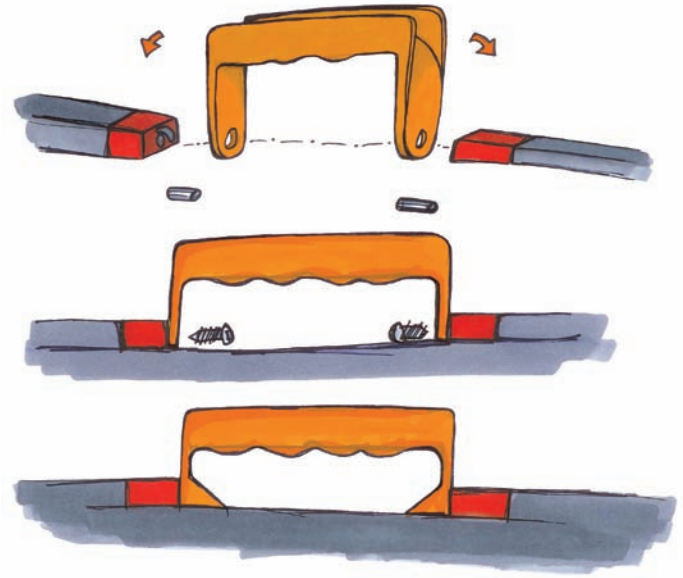
Barcelona 12 without centre Concept

During the end of 2011 Ericsson developed a foldable concept handle for the 2012 Mobile World Congress in Barcelona. It holds the folding mechanism underneath and inside the base-plate of the handle. Another way of doing a handle just like 2012 Mobile World Congress in Barcelona is to make the folding mechanism outside the handle. By putting the folding mechanism on the outside instead of the inside of the handle, the handle can be made somewhat lower. This is due to the fact that the base-plate of the 2012 Mobile World Congress in Barcelona handle uses necessary grip-space within the handle. Making it stand a little bit higher over of the top of the RRUs.

The handle will be fully modular between many of Ericsson AB's portable products and will be able to fit to both present and future products. Integration is possible through for example a lowering of the spline. Little redesign, mostly concerning the folding mechanism and moving it to the outside instead of the inside. See Picture 3.49 - Barcelona 12 without centre Concept.



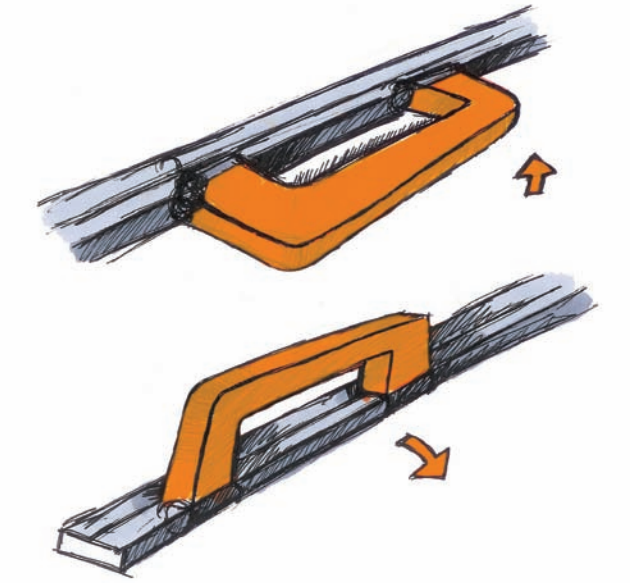
Picture 3.49 - Barcelona 12 without centre Concept. Regnér (2012).

Spline hinge fold Concept

Another concept is to develop a handle which holds the folding sequence inside the spline. Hinges are placed inside the spline which allows the handle to fold. This enables handling when the handle is needed and being subtle when not needed. When the handle is folded down, it will be sleek and almost as low as the spline itself. This makes the handle non-visible from a straight onward look of the product. The sun-cover covers the sight of the handle when folded down.

This concept is dependent of there being a sealing and fastener spline present on the product where the handle is placed.

The handle shall be connected to the hinges, this means that the handle is replaceable. The hinges are also attached in a lowered section of the spline, which makes it modular. Some adaptation of the internal-body is needed for this concept to work, indicating that it will not be possible to use on any present products. See Picture 3.50 - Spline hinge fold Concept.

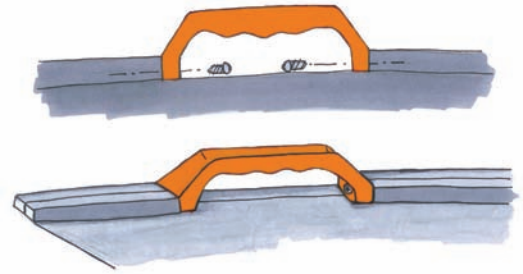


Picture 3.50 - Spline hinge fold Concept. Regnér (2012).

Fold within the spline Concept

To minimise the need for a total redesign, one possibility is to use one of the present Ericsson AB handles and adapt it to be fully foldable. One concept which is dependent of the product having a sealing and fastener spline with a lowered section uses the present RRUS 11 & 12 handle. It folds over an axle between the handle and the product. The handle is placed within the lowered section of the spline and is fastened to the spline trough two screws. These screws do not only work as fasteners but also as the axles over which the handle folds.

The concepts demands minor adaptation to the present handle, however also demands a redesign of the internal-body of the product. It will enable the handle to be very subtle and blend into the products as a whole. There is a possibility of making the handle modular if future products will be developed to fit the handle. There will not be a possibility of fitting the handle to any present RRUs or Ericsson AB's portable products. See Picture 3.51 - Fold within the spline Concept.



Picture 3.51 - Fold within the spline Concept. Regnér (2012).

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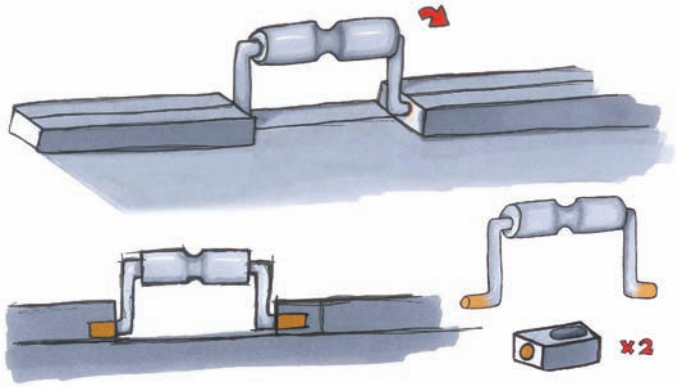
Integrated Camera case handle Concept

Using a bent rod with a thicker section as the grip-area is a common type of handle of heavier products, such as camera cases. See Picture 2.25 - Bent steel handle. This type of handles have also been used by the design-guru Dieter Rams in some innovative products of the past. The concept of a bent rod as a handle has been proved flexible, reliable and aesthetically appealable. The handle is thought to be integrated into the sealing and fastener spline of the RRUs. It shall be placed within holes in a lowered section of the spline. This is a simple way of enabling folding as well as making the handle very easy to replace. Together with developing a handle which is integrated into the RRUs, parts in which the handle can be placed can be developed. This would enable the handle to also be modular and able to fit onto present RRUs. If the handle is only developed to fit within the spline it will not be modular and possible to use without redesigning the internal-body of the RRUs.

The grip-area can house finger-grooves and easily be made from a material which is raising the level of comfortable handling.

The solution of using a camera case type of handle will make the handle very subtle as well as provide Ericsson AB's products with a distinct semantic appealable design. See Picture 3.52 - Integrated Camera case handle Concept.

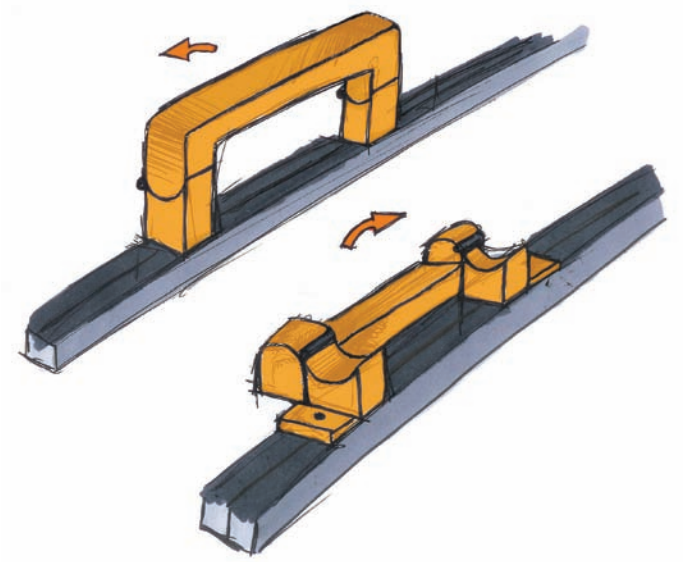


Picture 3.52 - Integrated Camera case handle Concept. Regnér (2012).

Mid-fold Concept

A fairly simple concept of enabling a foldable handle is to make the handle itself fold. The handle shall be bolted onto the top of the product at a suitable place, much like the present RRUS 11 & 12 handles. The handle is made from two parts which are connected through hinges, allowing the handle to split and fold over itself. When the handle is "up", it locks through simple locking mechanism so that it is not to fold when carrying the product. When the handle is not needed it folds back, making it less visible.

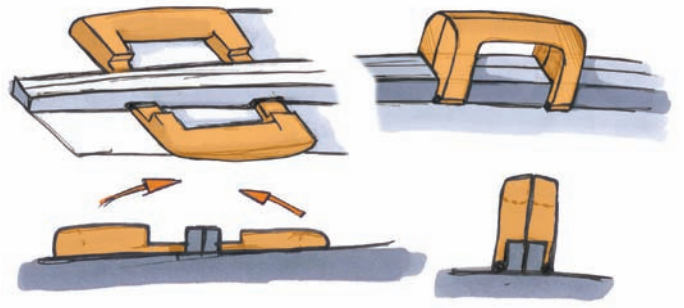
The solution of a foldable handle can be modular and adapted to fit both present and future Ericsson products. There is a need to carefully design the mechanical mechanism of the folding as well as material selection for the handle to be trustworthy and durable. See Picture 3.53 - Mid-fold Concept.



Picture 3.53 - Mid-fold Concept. Regnér (2012).

Two-part fold Concept

The solution consists of a handle being slit in the middle. Each half folding to one side through a hinge placed in the bottom of each part. When the handle is needed for handling, the two halves are folded upwards and meet to become one steady and comfortable handle. The concept can be made so that it is modular and fits to both present and future products. It can also be made so that it fits onto and to the side of a sealing and fastener spline, if one is present. The handle shall be attached to the top of the RRUs by bolts which provides a good mount and allows the handle to withstand the large forces of carrying and handling the heavy products. See Picture 3.54 - Two-part fold Concept.



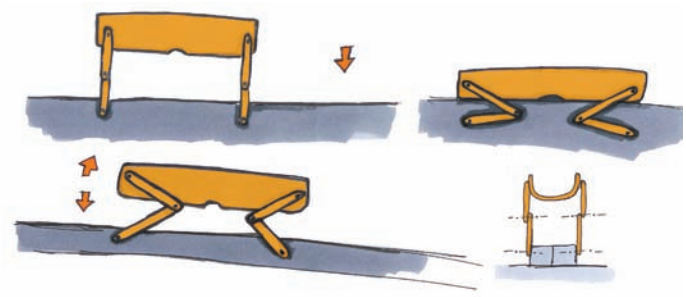
Picture 3.54 - Two-part fold Concept. Regnér (2012).

Downward Two-leg Concept

A foldable handle does not have to fold to the side, even though this is the most obvious way of enabling folding. One way of enabling the handle to fold is to fold it downwards to make it more subtle. The concept is thought to work through a grip-area which is connected to four arms, one on the outside of each corner of the handle. The arms are connected to the handle by and axles which enables the rod to rotate towards the grip-area. The arms

are the connected, in the same way through axles, to next four arms. These arms are in their turn connected to the top of the RRUs. This mechanical mechanism allows the grip-area to subtly fold downwards and lay flat on-top of the RRUs. The arms folds inwards towards the centre of the grip-area when the handle is folded downwards. The solution houses a few more mechanical mechanisms than an ordinary "side" folding handle. Due to this it has to be designed to be durable and minimise risk of failure.

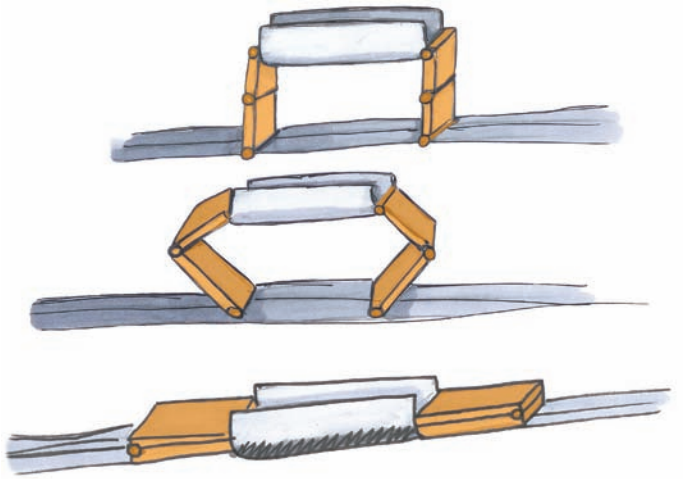
The concept shall be placed onto the sides of the senaling and fastener spline. This means that there has to be one present, otherwise would the handle not work. If base-plate brackets are developed, the handle can be made modular. The solution of fitting it to the spline makes the handle very subtle and discrete, not intruding on the semantic expression of the RRUs. See Picture 3.55 - Downward Two-leg Concept.



Picture 3.55 - Downward Two-leg Concept. Regnér (2012).

Outward fold Concept

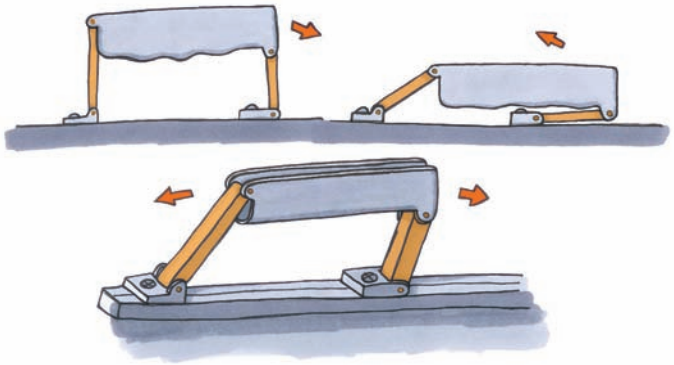
This solution is similar to the one described above, Downward Two-leg Concept, however the folding arms are instead placed inside the grip-area. This enables the arms to be four instead of eight. They can also be made more steady which can mean a stronger and more durable construction. It folds in a similar way but shall be placed on-top of the sealing and fastener spline. In contrary to the previous solution of Downward Two-leg Concept, the arms fold outwards to allow the handle to be more subtle when folded. See Picture 3.56 - Outward fold Concept.



Picture 3.56 - Outward fold Concept. Regnér (2012).

Along spline fold Concept

The last solution generated to solve the folding mechanism enables the handle fold to the side along the sealing and fastener spline. This solution differs from the other folding solutions due to the angle it folds to, as well as it folds "over" itself. As many of the previous solutions, it consists of a grip-area which is connected to the RRUs via two arms enabling the folding mechanism. The arms are connected to the grip-area by axles which allow the arms to swing. The same type of connection is occurring between the arms and the base-plate brackets which are bolted on the top of the RRUs by two screws. The handle folds to the side on-top of one of the arms. The arms are of different length and attached to the grip-area in different places at each end. This is so that the handle can enable CoG and straight lifting and carrying of the RRUs. See Picture 3.57 - Along spline fold Concept.



Picture 3.57 - Along spline fold Concept. Regnér (2012).

3.5.4 Sliding handle

A sliding handle is another way to make a handle flexible and subtle but still steady and durable. This way of technically solving flexibility has not previously been tested or used by Ericsson AB. This indicates that there are possibilities of bringing something new and innovative to their products.

The design and function of a sliding handle is somewhat more complicated than a folding handle. It consists of more joints and pivot-points which have to both be flexible and smooth as well as steady and durable. More mechanical feature means an increased risk of failure over time. The sliding mechanism can either work through the handle, the base-plates connected to the RRUs, the internal-body or two of the solutions combined.

Box-sliding arms Concept

One way of enabling a handle to slide to a subtle position, is to mount two arms to a grip-area by two axles. This allows the arms to swing towards the grip-area. The arms are then connected to a base-plate bracket which is mounted to the RRUs by bolts. The arms are connected to the base plate by an axle each, allowing it to slide within two slots of the sides of the base-plates. When the axles of the arms

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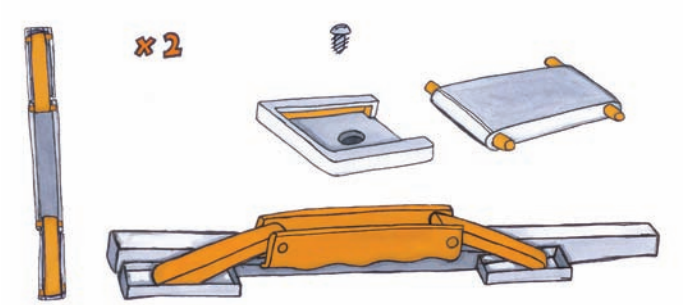
are allowed to slide within the slots of the base-plate, the handle can slide into a subtle discrete position or when needed for lifting and carrying to an upward position.

The handle can be mounted either to the top of the sealing and fastener spline or to the internal-body of the RRUs. The solution of this kind of sliding mechanism enables the handle to be fully modular and fit onto many different products both present and future. See Picture 3.58 - Box-sliding arms Concept.

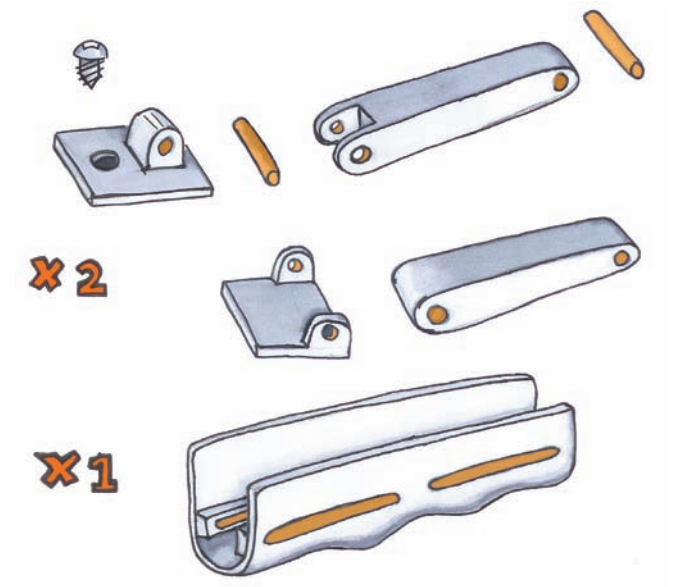


Picture 3.58 - Box-sliding arms Concept. Regnér (2012).

Inverted Handle slide Concept

A similar but yet reverse solution is to let two arms, connected between two base-plates and the grip-area, slide within the grip-area. The handle holds slots inside which the arms are allowed to slide within. The two arms are connected in one end to a base-plate by an axle and in the other end to the grip-area by a similar axle. The base-plates are bolted onto the RRUs with a bolt each, much like the present RRUS 11 & 12 handles. The solution is very simple and all the mechanical mechanism is fitted inside the handle.

The handle is easy to replace and modular to many different products both present and future. The grip area can be designed to house both a CoG hoisting and/or finger-grooves. See Picture 3.59 - Inverted Handle slide Concept.

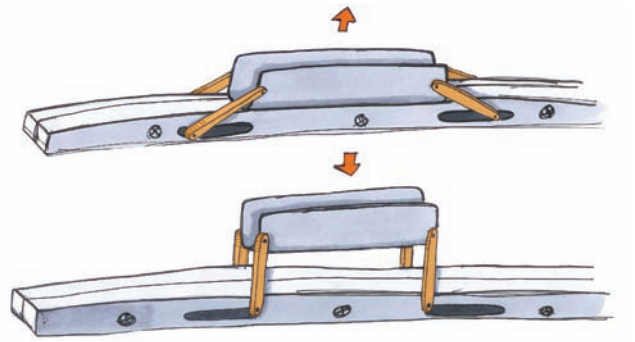


Picture 3.59 - Inverted Handle slide Concept. Regnér (2012).

Integrated spline slide Concept

Another way to enable a sliding handle is similar to a folding solution. It consists of four arms attached to the outside of the grip-area and the sealing and fastener spline. The arms are connected to each end of the handle by axles as well as two slots placed in the outside of the spline. The axles slide within the slots and enable the handle to take on different positions.

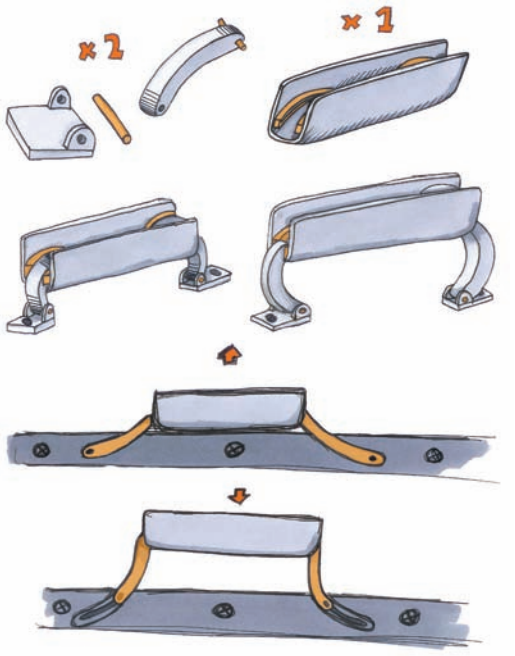
The concept of enable sliding through this solution demands there being a sealing and fastener spline present, for it to work. The solution is subtle and well integrated into the internal-body. It demands a minor redesign of the product for the handle to properly work. See Picture 3.60 - Integrated spline slide Concept.



Picture 3.60 - Integrated spline slide Concept. Regnér (2012).

Bent integrated Handle Concept

Yet another sliding solution, similar to the previously described solutions work in the same way only using bent arms instead. This is to be more subtle and less visible when the handle is folded down. The strength and durability of bent arms in comparison to straight ones has to be analyzed to conclude if it is a better or worse solution. See Picture 3.61 - Bent integrated Handle Concept.



Picture 3.61 - Bent integrated Handle Concept. Regnér (2012).

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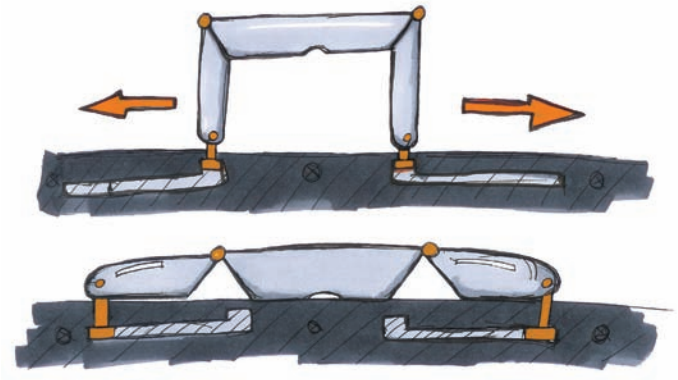
Three piece slide Concept

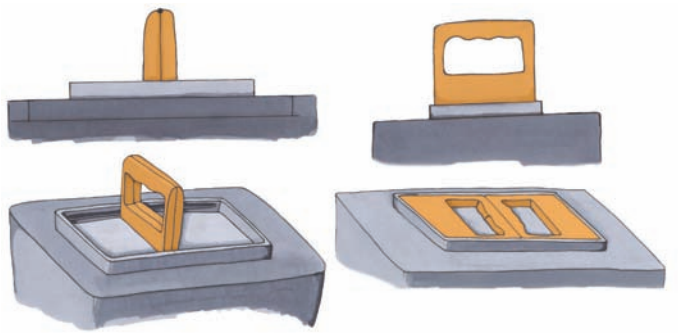
A more complex and solution of enabling sliding is to divide the handle into three parts all connected together by hinges in the corners. The grip-area is connected to the side arms by hinges. The bottom of the arms is connected to the spline or internal-body by a hinged axle sliding within a slot. The handle can slide within the slots to different positions and the handle will follow. The handle demands some mechanical mechanisms which are in risk of failing over time. It can be fitted to two base-plates enabling modularity and attachment onto many different products. This will however raise the total height of the handle making it less subtle. Otherwise it is possible to integrate it into the internal-body. See Picture 3.62 - Three piece slide Concept.



Picture 3.62 - Three piece slide Concept. Regnér (2012).

Sliding within a Box Concept

When making a sliding handle modular, it is important that it can be attached to many different products, both present and future. One possible way of doing this is to make a handle which is placed inside a box which shall be attached to the top of the RRUs. The handle is designed as two separate parts which are connected in the top of the two handle-parts by a hinge. The bottom of each handle is connected to the box by axles which slide within slots on the sides of the base-plate box. The box is attached to the top of the RRUs by screws and is possible to fit onto most present and future RRUS. The box can be adapted to fit over the sealing and fastener spline with minor redesigning. See Picture 3.63 - Sliding within a Box Concept.



Picture 3.63 - liding within a Box Concept. Regnér (2012).

3.6 Concept evaluation, Second - Leading to the final concept

The three concepts, which have been further developed, have been evaluated and one concept selected to finalise. On the 31st of January 2012, an evaluation meeting was held with Mikael Thelin - Manager, Industrial design at Ericsson AB.

After discussion and decision from Ericsson AB, all fixed handles were excluded. These has already been developed and tested over a long time. Ericsson AB wants to further develop the possibility of developing and using a flexible, subtle handle. This means a focus on the two solutions of folding and sliding for the final concept. The sliding concept of "Sliding within a box" was discarded due to it being too bulky and big, taking up to much space.

Some foldable concepts where also discarded as they did not go with Ericsson AB's design-values. They were also considered too complex without being subtle enough to answer for the complex design. The foldable solution which were discarded were the concepts of "Two-part fold", "Mid-fold" and "Spline hinge fold". During the evaluation meeting it was concluded that all mechanical features shall be housed inside the handle or base-plate brackets. They shall not be placed or integrated into the internal-body or spline. If these the splines were to fail, it would mean replacement of the whole internal-body.

During the evaluation meeting it was concluded that there is no need to reuse the present handles of the RRUS 11 & 12. Instead focus should be aimed at redesigning and better adapt a similar handle, if a solution like that is chosen for further development.

To state what concepts to finalise and once again further develop, a decision was made to conclude an evaluation workshop. At the evaluation workshop relevant actors with knowledge in the subject participated and stated their opinion of how to optimally solve the task.

From the second evaluation process, two major concepts involving similar solutions was chosen to further evaluate in the evaluation workshop. The tow major concepts which has been further evaluated with regard to visual design, ergonomics, user-friendliness and mechanical engineering is a combination of sliding and foldable concepts using jointed "arms" to enable flexibility. The solutions which has been further evaluated in the workshop are; "Along spline fold", "Downward two-leg", "Outward fold", "Inverted handle slide", "Bent Integrated handle", "Box-sliding arms", "Bent Integrated spline", Integrated spline slide" and "Three piece slide".

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The second solution, of enabling flexibility within the handle, which was decided to further evaluate in the workshop was a concept which will lead to further development and adaptation of the previously designed handle for the 2012 Mobile World Congress in Barcelona. See Chapter 2.12.4 Final concept. The foldable handle solutions which has been evaluated at the workshop are the "Foldable RRU 11 & 12", "Fold within the spline", "Barcelona 12 without centre" and "Integrated camera case handle".

The evaluation workshop will be a third step in deciding which solution that fulfils the requirements of Ericsson AB the best.

Participants at workshop was the master thesis author as well as Mikael Thelin (Manager, Industrial design), Jens Kallin (Industrial desiger), Andreas Säfström (Senior Industrial Design Specialist), Tom Andersson (Designer-Mechanics), Mats Johansson (Senior Industrial Designer HW Usability) and Ulf Williamsson (Site Solution I&V Tester). The workshop took place on the 9th of February 2012 at Ericsson AB in Kista Sweden.

3.6.1 Evaluation Workshop

On the 9th of February 2012, the workshop was held with Jens Kallin, Tom Andersson and Ulf Williamsson. Michael Thelin, Andreas Säfström and Mats Johansson did not have the possibility of joining the workshop. Discussions about the handle design were held with them at a later date.

First workshop

During the workshop, the background to the project, ideation process and the two final solutions on how to enable a flexible handle was presented. The final two solutions was discussed on how well they fulfil the requirements set in the beginning of the project.

Both handles was considered fulfilling the task of enable lifting and hoisting as well as being subtle and flexible. However some aspects were better adapted by the different solutions.

After discussions on which handle would be most suitable to finalise as a concept with a working realistic mock-up, it was concluded that the solution of using folding/sliding arms was favourable. Unanimous opinions were provided with what solution would be most suitable to further develop and finalise.

Aspects talking in favour of the solution of sliding/folding arms were that it can house all mechanical features inside the handle/grip-area. It provides a new and innovative approach to modular handle design within Ericsson AB. It is a very modular concept and easy to adapt to fit many of company's products. One aspect that was frequently stated is that a handle which hold all mechanical features within the grip-area can minimise assembly at the assembly-sites. This means that the handle will be somewhat cheap to produce. The mechanical parts can be produced inside the grip-area after production or possibly assembled at the production-site to low cost. The sliding mechanism was also undoubtedly preferred due to the subtleness the handle can portray if designed well. The handle does not have to hold any kind of stop function for it to not fold to one side where it might affect the effect of the cooling flanges. It will neither interfere on the sun-cover nor affect the semantic expression of the product.

The possibility of developing a smart, slim and innovative handle which can hold significant impact on modularising parts of Ericsson AB's products was seen as an argument to further develop a handle using sliding/folding arms.

The aspect of a folding handle, like the 2011 & 2012 Mobile World Congress in Barcelona concept handles, being to large for many upcoming products was seen as a negative aspect. As the folding handle might have to be adapted to only fold one way as well as being in risk of intruding on the semantic expression and cooling effect, it was regarded too negative to further develop this concept at this stage.

Factors to regard when finalising the design – derived from the workshop:

- As cost-effective as possible through minimising the mechanical features as well as adapting material to cost. Possibility of producing the handle from reinforced plastics which is extremely durable, cheap to produce and holds the possibility of producing mechanical features integrated inside the grip-area
- Not more than 25 SEK/handle to produce, possible with simple design or large batches (No possibility to conclude the cost of the final redesigned concept. However it is an indication, to focus on a simple solution)
- The handle has to function in all kinds of environments
- Should function just as well even though it has been mired with dirt and filth
- Integrate mechanical features within the grip-area for optimised assembly at Ericsson AB's assembly-sites
- Hoisting through the handle, no loops. Many functions integrated raises the possibility of the handle being realised
- 3-4 mm of material thickness would be enough to allow the handle to be strong enough to be both lifted and hoisted through

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- Over-dimensioning the handle for it to be durability
- Use the present C-C measurements of the RRUS 12 handle, 160 mm

Second workshop

As Mikael Thelin, Andreas Säfström and Mats Johansson did not have the possibility of joining the initial workshop, a second one was set up. For this occasion only Andreas Säfström was available. Mikael Thelin was busy with management and Mats Johansson ill. As of the short time-span of the project the two non-present actors will be informed through mail-communication. Mikael Thelin has been present at all previous evaluation processes which means that he has a good view of the final concepts.

As of Mikael Thelin role at the industrial design department, he holds the final decision of which handle to finalise. He has been informed about the results from the workshops. From this data he has chosen the direction Ericsson AB is aiming for this flexible carrying feature.

During the second workshop Andreas Säfström was informed about the whole product development process. He was also informed about the result from the previous workshop with Jens Kallin, Tom Andersson and Ulf Williamsson.

Andrea Säfström stated that the concept of enabling flexibility through using sliding/folding arms would provide a new dimension of handles for Ericsson AB. He also felt that this concept was braver and more exciting compared to the already developed and tested 2011 & 2012 Mobile World Congress in Barcelona concept handles. The 2011 & 2012 Mobile World Congress in Barcelona concept handles was regarded as overdesigned for the purpose they shall fulfil. These handles look good and work fine, however are regarded as not relevant for the purpose.

3.6.2 Final decision

With regard to the data gathered from the workshops and final opinion from Mikael Thelin, it was concluded that the 2011 & 2012 Mobile World Congress in Barcelona concept handles will not be further developed. Instead focus will be on optimising the solutions of using sliding/folding arms to enable the handle to take on different positions. The aspect of integrating all mechanical features within the grip-area excludes the folding arm solution as well as enabling sliding arms in the base-plate of the handle.

This means that the solution to finalise is a handle using sliding arms to enable flexibility, holding all mechanical features integrated into the grip-area. The handle shall fulfil all ergonomic requirements as well as be as slim, smart, subtle and innovative as possible.

The concepts of "Inverted handle slide" and "Bent Integrated handle" will be further designed in regard to mechanics and durability to enable an strong, long lasting and fully flexible handle.

3.7 Finalise of design

When the final concept of how to enable flexibility within the handle has been chosen, the product development process was continued with finalising of the design. When finalising the design, the mechanical solution of how to enable folding through sliding in regard to minimum mechanic parts, strength and durability as well as visual design was concluded. To conclude the best possible solution, concept solutions was derived and tested to see how well they fulfilled the requirements. Mechanical and material engineers at Ericsson AB was consulted to conclude what solution is possible and suitable to use in the specific situation. The final concept has been adapted to be optimal in regard to the requirements as well as be semantically suitable for Ericsson AB. The handle has been portrayed by sketches as well as renderings performed from CAD tools. In the end of the product development process, the CAD-model has been customised and manufactured by Ericsson AB's mechanics lab as a mock-up. The mock-up shows the handle portrayed as a real hardware 3D-handle.

The concept has been designed in regard to all the requirements stated previously in the List of Requirements as well as from the pre-study. See Appendix II - List of Requirements. The concepts has been derived from studying of different sliding mechanisms as well as common everyday solutions of enabling flexibility through mechanical features.

Together with Designer - Mechanics, Ericsson AB, Anders Jahge possible solutions were generated which was later consulted and discussed with Designer - Mechanics, Ericsson AB, Tom Andersson on how suitable the solutions are. This meant that the best, most suitable solution was selected to be used within the final handle design.

Late in the product development process information about the actual dimensioning to the handles was obtained. On most of Ericsson AB's products there are requirements of the handle being able to withstand forces 4-times as great force than the total weight of the product. Andersson (2012). This means that the final handle shall withstand a weight up to 160 kg for a 40 kg product. The requirement gives little room for possible mechanical solutions possible to use and narrows down the design possibilities quite some. The final solution and concept shall withstand these forces without breaking or wearing out. The mechanical solution shall be designed and selected with this in regard.

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Due to the fact of 4-times the products total weight as a safety limit, the issues of using loops instead of hoisting through the handle has to be revived. If loops are integrated, the handle does not have to be as strong as the safety limit states. If hoisting loops are used, they shall be designed in regard of lifting the product from cranes up into the air.

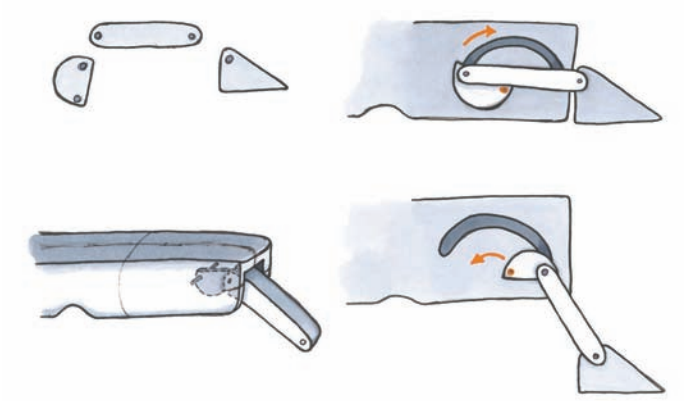
Every solution where the force is transmitted straight along the Z-axis provides shearing-stress, tearing on the connection-areas. This means that the parts have to be stronger and over-dimensioned not to fail. Andersson (2012)

3.7.1 Further developed Concepts

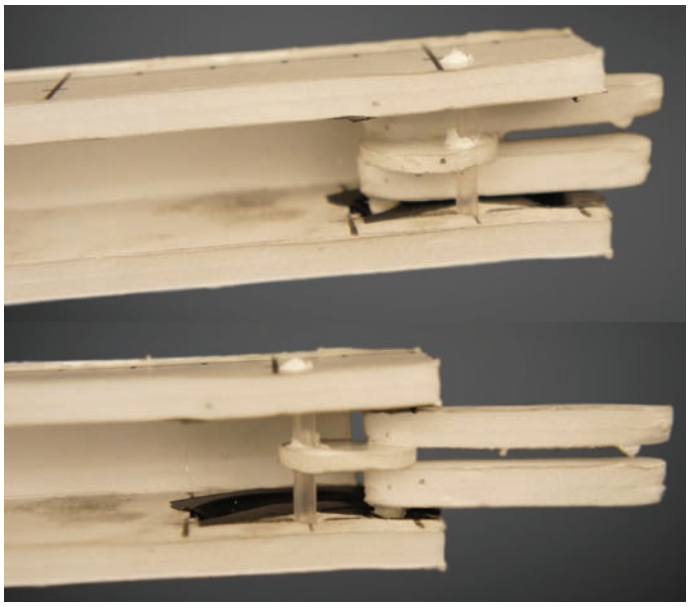
"Off-centred disk spin"

The solution of allowing the arms to be flexible through connecting them to a disk which can spin within the handle, enables the forces put on the handle to be concentrated to a fixed area. The forces which are derived from lifting the products are all centred to the axle which the off-centred disk is connected to. This axle has to be dimensioned to be able to withstand the forces. However the forces will always be centred to one area. This will not be the situation if sliding axles are used. Jahge (2012). The axle on which the forces are put is connected to the off-centre to the disk. This allows the plate to spin over a larger area. The arms of the handle are in their turn connected to the opposite end of the disk allowing large movements. This will make the handle take on one position when handled and a more subtle one when not interacted with. The arms and the axle which connects them to the disk are controlled through sliding along a slot, providing a smooth transition. The off-centred disk can be weighted to allow the handle to slide back into a subtle "0-position" when released from integration. See Picture 3.64 - Off-centred disk spin, See Picture 3.65 - Off-centred disk spin Mock-ups. This means that no springs have to be used to enable a auto-retraction function.

The solution demands many different parts to be integrated into the flexible mechanism. This raises the risk of failure and all axles have to be dimensioned to withstand the large forces put upon them when lifting the product. One issue would also be to fit all the parts within the grip-area of a slim and subtle handle



Picture 3.64 - Off-centred disk spin Mock-ups. Regnér (2012).



Picture 3.65 - Off-centred disk spin Mock-ups. Regnér (2012).

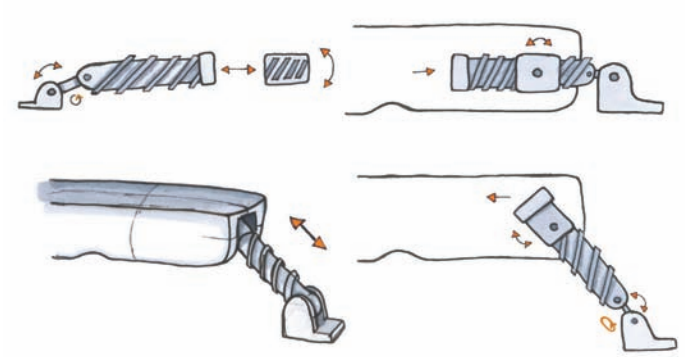
"Threaded arms – screwed into the handle"

One way of allowing the arms to smoothly slide into the grip-area of the handle, is to use an old and well proven method of threaded arms and casings. By allowing a threaded arm to screw into a threaded casing placed inside the grip-area, the arm can smoothly screw into the grip-area. The casing is mounted onto an axle which allows it to rotate for the arm to fit within the grip-area. The forces of lifting the products are centred to the fixed axis on which the threaded casing is allowed to rotate around. The threaded arm or the casing has to rotate in regard to the z-axis, indication that one of the axles has to be "double-jointed". The axle which connects the arm to the base-plate of the RRUs can be "double-jointed" or possibly made as a ball-joint which can rotate along the Z-axis and over the Y-axis. See Picture 3.66 - Threaded arms - screwed into the handle, See Picture 3.67 - Threaded arms - screwed into the handle Mock-ups.

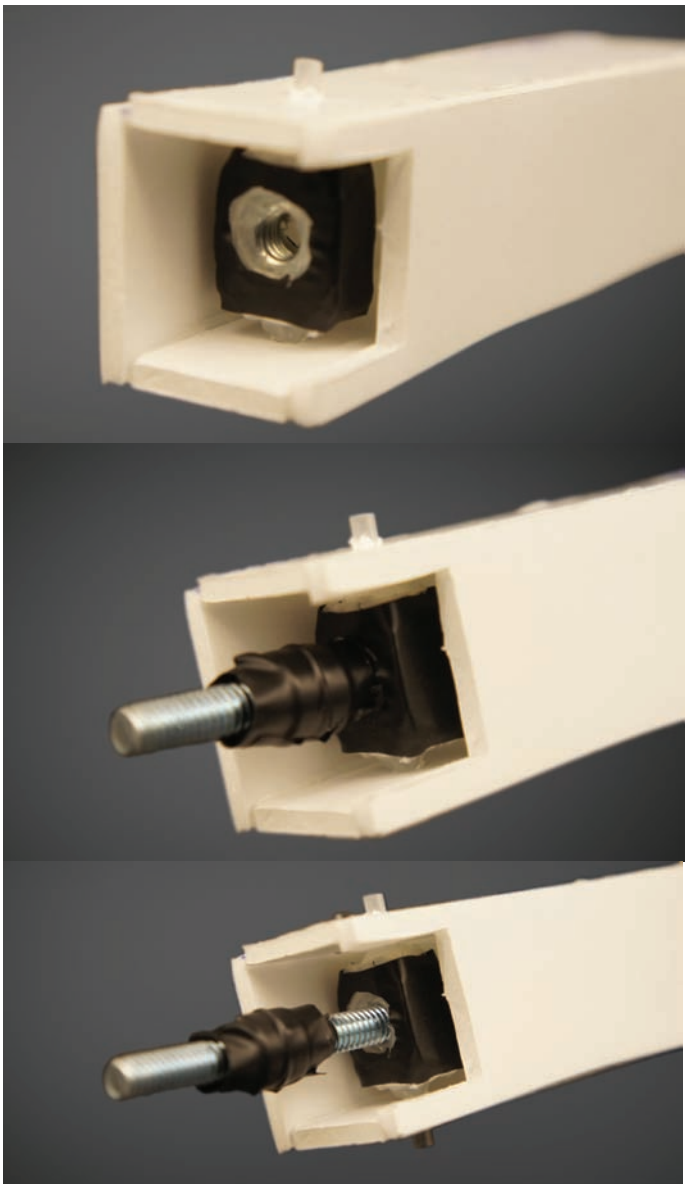
If the threads are made thick and with a large pitch, the transition between the different positions would be both smooth and fast. A large pitch would also mean that the handle would "thread itself back", when released from interaction into a subtle "0-position". No springs would be

necessary to enable this, auto-retraction. The mechanical parts are fewer than the solution of the "Off-centred disk spin" however needs "double-jointed" axes to work.

Using the old and proven technique of threads are a well tested and proven to be both strong and durable. This is something to regard when selecting the final solution.



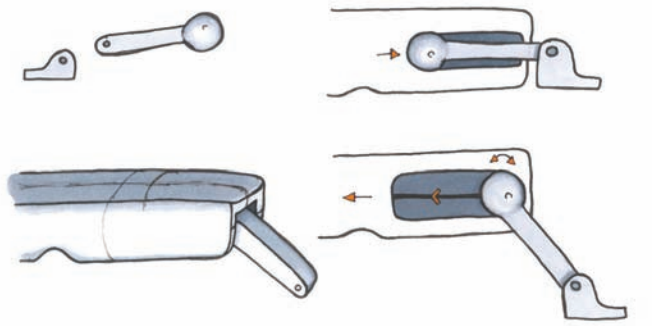
Picture 3.66 - Threaded arms – screwed into the handle. Regnér (2012).



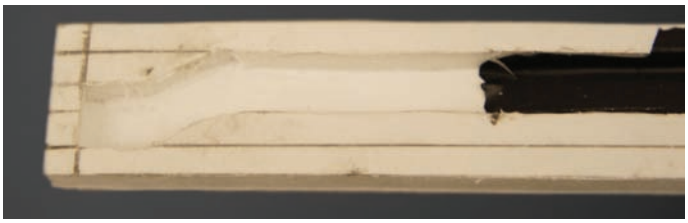
Picture 3.67 - Threaded arms – screwed into the handle Mock-ups. Regnér (2012).

"Arms sliding back and forth within a slot"

This solution is the easiest one, holding minimum loose parts. The solutions consists of an arm which is allowed to slide within the handle through designing a sliding function with low friction. Axles can tend to not be strong enough if not over-dimensioned, why one possibility is to use ball-joint which can slide within a slot inside the handle. The ball-joints can be locked to only be allowed to rotate in one direction, around the Y-axis. Where the arm is connected to the base-plate, the joint can either be made as an axle or as a ball-joint locked to only allow rotation around the Y-axis. As the solution holds few mechanical parts, there is a low risk of failure. One possibility is for dirt to stick or corrosion occuring within the slots. This would add friction in the sliding mechanism and worsen the smoothness of this function. The slots can be designed with a slope, which would mean that the handle can slide downwards to a "0-position" by itself, due to gravity. To secure that the handle always goes back to the "0-position" when not used, a spring could be connected between the arms pulling them inwards. As this solution can be designed without axles, the arm and ball-joints can be dimensioned to withstand large forces without taking up too much space within the grip-area. See Picture 3.68 - Arms sliding back and forth within a slot, See Picture 3.69 - Slot Mock-up.



Picture 3.68 - Arms sliding back and forth within a slot. Regnér (2012).



Picture 3.69 - Slot Mock-up. Regnér (2012).

3.7.2 Shear Stress Calculations of the joints

To conclude what forces are possible to apply to the joints used to enable sliding and rotation, simpler mechanical equations have been used. The force is applied along the arms of the handle and through shearing on the axles or joints. The shearing stress can negatively affect the axles and lead to fatigue and breakage, if too large forces are

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applied. The handle shall at least be able to deal with forces 4-times greater than the total weight of the whole product, up to approximately 1600 Newton.

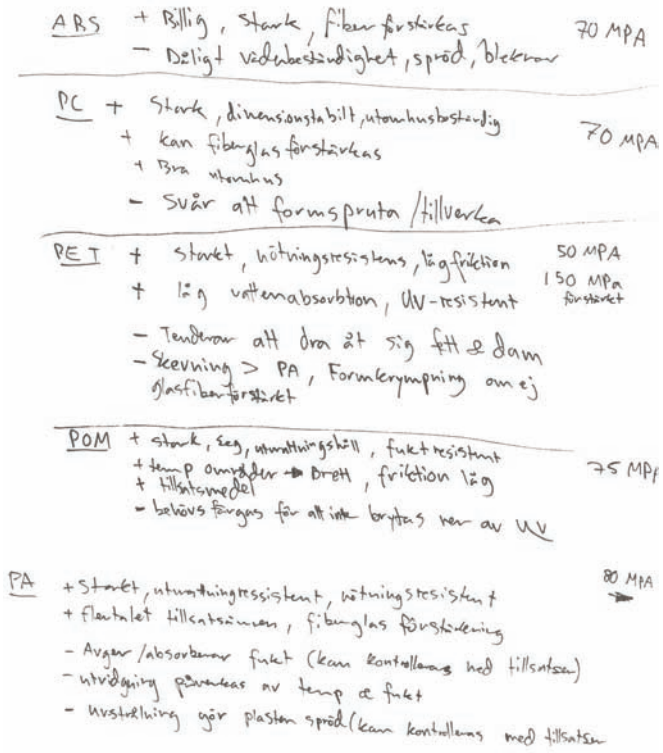
The axles are initially calculated in regard to being made from tough stainless steel holding a tensile strength of 360 MPa. Mattsson (2003). By looking at a 4 mm thick axle, it can be concluded that it would be possible to withstand forces of up to 5400 Newton without failing from shear stress. A 3 mm thick steel axle would be possible to withstand forces up to 3000 Newton. The dimension of the axles can be made thin yet still be very strong and durable, if a stainless steel is used. See Appendix 6 - Shear Stress Calculations.

When looking at plastic materials, they are not as strong when put under large forces and the shearing stress can easily lead to fatigue and breakage of the material. Mattsson (2003). ABS is previously used by Ericsson AB on many of their products, why this is and obvious material to consider. ABS plastic has a tendency to withstand outer forces such as UV-light well. The plastic has a tensile strength limit at around 80 MPa. To be extra safe the force is set to 6-times the total weight of the product when calculating the minimum diameter of plastic axles. Ericsson AB has stated that a strength security limit of 6-times shall be strived for. This gives a force of 40*6*9,81 which is approximately 2350 N. The minimum axle diameter possible to use with ABS-plastic is 5,6 mm, which means that it would withstand large forces of both lifting and hoisting the product. When using Polyamide plastics the minimum axle diameter possible can be reduced to 5 mm. Polyamide is also used within some parts of Ericsson AB's products. It is very strong yet brittle so the design has to be adapted to be suitable to use Polyamide. Andersson (2012). The calculations are based on material data at a temperature of 20° C. Mattsson (2003)

For more precise data on durability, more advanced calculation has to be made. However for this concept handle these indicative calculations are considered good enough. If the handle is to be realised it has to be further developed and calculated to withstand forces I many directions. Andersson (2012).

3.7.3 Suitable Plastic materials

Other possible plastic materials that would solve the task of being strong and durable, apart from Polyamide and ABS, are Polycarbonate, PET (Polyethylene Terephthalate) and POM (Polyoxymethylene). Pettersson (2012). All these plastic materials fit the requirements and are suitable to use for a handle which will withstand heavy loads. See Picture 3.70 - Material data sheet. One aspect that would be recommended when using a plastic material is to reinforce it with fibres. This would strengthen the material and make it more durable in the direction of which the force is applied. Not all plastic materials are possible to reinforce with fibres. Pettersson (2012). The material which will be used will be the one most suitable to produce, commonly used by Ericsson AB and fit the design of the handle.



Picture 3.70 - Material data sheet. Regnér (2012).

As all these materials are thermoplastics, denoting that they can be moulded or casted to the desired shape. The handle shall be both cheap and easy to produce. The axles allowing sliding or spinning within the slots can be moulded into the arms, casings or disks.

Plastic materials are cheaper to produce in comparison to aluminium. Another aspect of using a plastic material is that metal materials tend to negatively affect the radio signals transmitted by the products. A plastic material would not affect the signals transmitted and would therefore be suitable for a wider range of products. Kallin (2012). This aspect appeared late in the product development process and have not been possible to regard at an earlier stage. However it is necessary to regard the effect of the product which indicates that a plastic material can fulfil the requirements.

One possibility is to use metal axles on plastic arms. This would mean a strong and durable construction. However a mix of different materials is something to exclude if possible, due to assembly and disassembly costs as well as environmental impact from recycling.

When discussing the issue of material selection with Nordbergs Tekniska, supplier of plastic materials to Ericsson AB's mechanical workshop, a PET plastic is advised to use. This PET is possible to get in a variety of colours, is weather and UV resistant, possible to reinforce and holds a primary tensile strength of 90 MPa. It is also possible to use in production of large quantities. Patrik (2012).

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3.7.4 Decision of mechanical solution

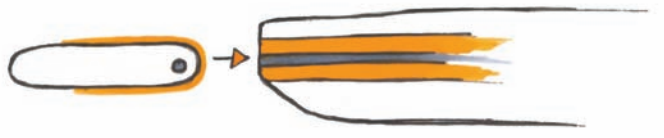
When studying and discussing the three concept solutions of enabling flexibility with mechanical engineers at Ericsson AB, it is concluded that minimum loose parts as well as few mechanical features are favourable. This means that the concepts of "Off-centred disk spin" and "Threaded arms - screwed into the handle" are regarded to be too complex, too expensive to produce, in too large risk of failure and holding too many loose parts. These two concepts would work well, however over a lifespan of ten years in to great risk of failing. They would also have to involve different materials and complex mechanical feature such as "double-joints".

So with recommendations from Designer-Mechanics, Ericsson AB, Tom Andersson and Manager, Industrial Design Mikael Thelin it has been decided to further optimize and work with the concept of "Arms sliding back and forth within a slot". This concept holds few loose parts and mechanical features which are in risk of failing. The concept can still be made very smooth and strong. If dimensioned well in regard to a suitable material, the handle would work over a long time.

3.7.5 Assembly of sliding arms

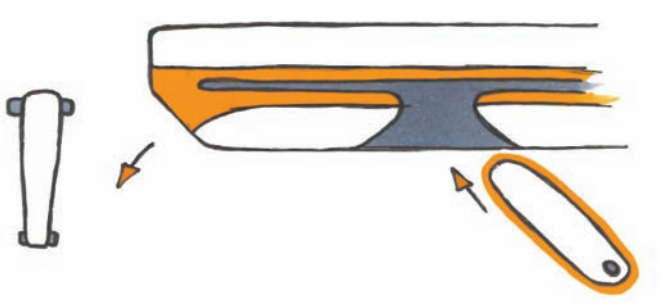
Due to final selected concept holding loose mechanically sliding parts, it has to be assembled after production to work as desired. The two sliding arms have to be integrated into the inside of the grip-area for the handle work. One possible thought was that the arms can be moulded into the grip-area of the handle during the injection-moulding process, co-injection moulding. However this will probably not be possible when the arms have to be flexible within the grip-area. The different parts will instead have to be assembled after production. Andersson (2012).

The arms can be assembled by inserting them into the ends of the grip-area. See Picture 3.71 - Arms inserted from the ends.. This would mean that this opening would have to be shut close in someway after assembly. Otherwise would the arms not have any stop-position, stopping them from sliding out of the grip-area when lifting the product. A screw screwed in from the side into each end of the handle could work as the stop function. This would however mean more assembly as well as more loose parts. Aspects which should be excluded if possible.



Picture 3.71 - Arms inserted from the ends. Regnér (2012).

Another possibility of assembly is to insert the sliding arms into a hole in the handle. A hole can be made in the bottom of the grip-area where the arms can be inserted. See Picture 3.72 - Arms Inserted from the bottom, See Picture 3.73 - Arms Inserted from the bottom Mock-ups.



Picture 3.72 - Arms Inserted from the bottom, Regnér (2012).

Picture 3.73 - Arms Inserted from the bottom Mock-ups, Regnér (2012).

A hole in the underside of the grip-area would be possible as it would not interfere when handling the handle as well as not let any dirt into internal slots. One arm at a time will be inserted into the hole and slided to the intended side. See Picture 3.72 - Arms Inserted from the bottom, See Picture 3.73 - Arms Inserted from the bottom Mock-ups. They would be connected by a spring which would hold them together, enabled auto-retraction and enable a smooth handling experience. One aspect which has to be regarded for this kind of assembly to work is that the axle on the other side of the arm has to be somewhat smaller than the one fitted inside the grip-area. If not, the arm would not be possible to slide through the end opening of the grip-area.

By using a solution of assembling the handle by inserting the arms, the grip-area can be moulded as one piece excluding any joining areas or splices.

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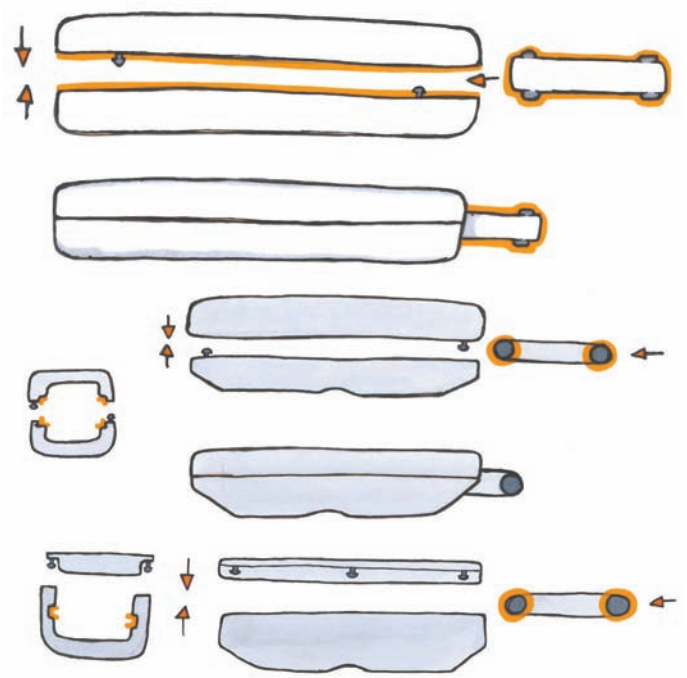
When discussion the issue of assembly with Designer - Mechanics, Ericsson AB, Tom Andersson, the possibility of making the grip-area as two parts, assembled with snap-buckles was considered to be more appropriate. This solution would enable easier assembly and would not affect the performance of the handle. Using snap-buckles would be possible if the handle is made from a plastic material. These features can be moulded into the handle during production. As the handle will be replaced if broken and not repaired, snap-buckles would be a suitable option. See Picture 3.74 - Grip-area made as two parts.

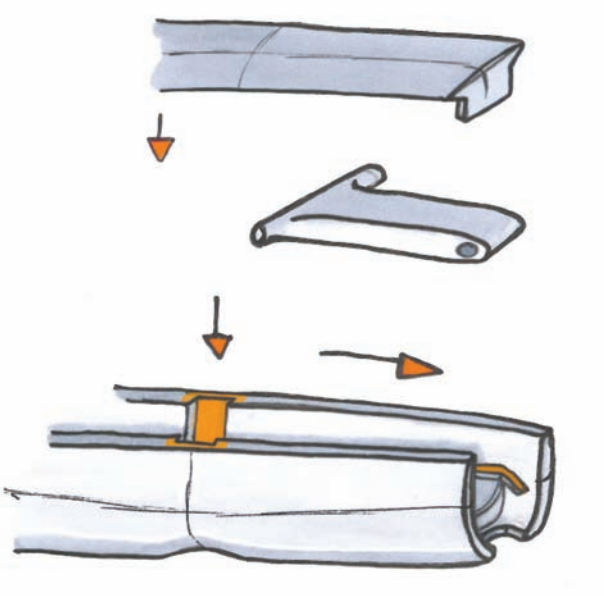


Picture 3.74 - Grip-area made as two parts. Regnér (2012).

Joining of the two parts of the handle can be done in different ways, two parts vertically, two parts horizontally or as a major part which is joined with a lid placed on top.

When considering the options, assembly shall be as easy as possible. The method of designing the grip-area of the handle as two separate parts along the middle, joining them by snap-buckles would be preferable. Due to this fact as well as the advantages it will bring without affecting the performance of the handle, this is a preferable solution. When deciding how it shall be done, it shall be as sturdy and strong as possible as well as being ergonomic and comfortable to handle. This indicated that any split-lines interfering with the users palm when interacting with the handle is something to avoid.

In consultation with Designer - Mechanics, Ericsson AB, Tom Andersson a decision has been made of focusing on working with a u-shaped extruded part assembled with a lid. This solution will provide the necessary strength as well as enable easy assembly of the arms within the grip-area. The handle is "closed" by snapping on a lid to the U-shaped body. When making the handle as two parts, one bottom piece and one lid. The split-lines between the parts will be placed in an area where it will not affect the ergonomic performance. The arms can be inserted into the grip-area from the top and slided into position before the lid is snapped on. See Picture 3.75 - Arms inserted from the top, ee Picture 3.76 - Arms inserted from the top Mock-up.



Picture 3.75 - Arms inserted from the top. Regnér (2012).

Picture 3.76 - Arms inserted from the top. Regnér (2012).

3.7.6 Dimensions

When dimensioning the handle regards have been taken to fulfil the durability requirements as well as being as slim and subtle as possible. The grip-area has to be at least 110 mm where the hand grips around it in regard to the ergonomic aspects. It shall house all the mechanical features, be strong and durable but yet be as slim as possible, not to interfere with the semantic expression of the whole product.

If a plastic material with a tensile stress limit of preferably 100 MPa shall be used, the axles which slide within the slots inside the handle can be dimensioned to hold a cross-sectional area of 5 mm. This would provide a security of 6-times the total weight of the reference product. The axles would be able to withstand forces of up to 2350 N. This is well over the market based standard of 4-times the total weight. Axles with a diameter of 5 mm enables the rest of the design to be very slim and still provide enough room inside the grip-area to house the arms. An appropriate length of the axles would be 4 mm, extended from the rest of the arms. This would allow them to properly fit within the slots to enable sliding. Andersson (2012).

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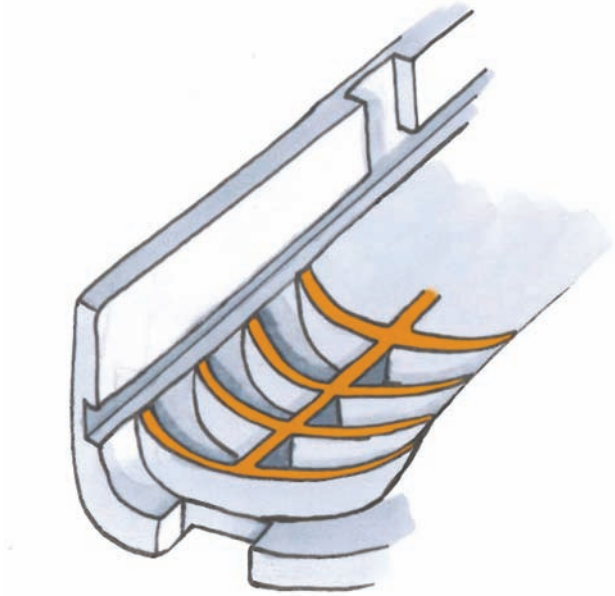
At the end of the handle, the position where the axles of the arm will be placed within the slots when interacted with, can be tilted 45°. This will enable the axles and arms to stay stuck in the desired position when the handle is used, not allowing any translation sideways. See Picture 3.69 - Slot Mock-up.

Within the grip-area of the handle, it has been concluded that there is a need for support with vault shaped slats. Andersson (2012). As the handle is made from a plastic material, this means that the plastic will have to be further supported to withstand the forces put upon it when lifting the product. Only raising the material thickness will not provide enough strength to support the handle, why support-slots needs to be added. These slats will have to run all along the handle and start vertically just under each slot. See Picture 3.77 - Supporting sats. The slats will be rounded to the same diameter as the end of the axles on the arm. This will enable the arms to slide along the slots without being interfered by the supporting slats. In the bottom of the inside of the grip-area, an along-running slat can be placed, crossing the lowest part of each vault-slat.



Picture 3.77 - Supporting slats. Regnér (2012).

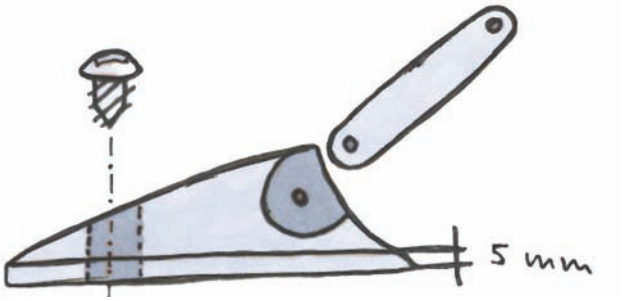
The slats should hold a material thickness of 1-1,2 mm. If dimensioned thicker they can lead to deformations in the material. The most appropriate and strongest design of slats is a zigzag pattern. Andersson (2012).

The thickness of the arms will have to be regarded to making the handle as strong, sturdy and durable as possible. The axles of the arms should hold a minimum diameter of 5 mm and when discussing the issue with Designer - Mechanics, Ericsson AB, Tom Andersson, it was concluded that it will be suitable to make the thickness of the arms the same as the axles. There is also the possibility of strengthening the arms by reinforcing the plastic by adding along-running or disorganised fibres. The width of the arms depend on the other dimensions of the handle, however they will surely be wider than the handle is thick.

In the other end of the arms, the ends shall be connected to the base-plate brackets. This end of the arm might have to be somewhat thicker to house a stainless steel axle connecting them to the base-plate brackets. The steel axles shall hold a cross-section area of minimum 3 mm which means that the end of the arms has to be at least 8 mm surrounding the axle. If made 5 mm as the rest of the arm the material thickness would not be enough to withstand the forces put upon it when lifting the product. Andersson (2012).

3.7.7 Thickness of the base-plate brackets of the carrying feature

On the 2012 Mobile World Congress in Barcelona concept handle the material thickness of the base-plate brackets of the carrying feature is set to 5 mm. These base-plate brackets are made from aluminium and the material thickness is well over-dimensioned for its purpose. Kallin (2012). The thickness was set to 5 mm due to the fact of enabling the M6 bolts to be countersunk. When consulting with Designer - Mechanics, Ericsson AB, Tom Andersson, it was decided that using a material thickness of 5 mm will be well enough to withstand the forces of lifting the product by the handle, even when using a plastic material. This material thickness will work to hold the product firmly towards the top of the RRUs, fitted by one M6 bolt each. See Picture 3.78 - Thickness of the base-plate brackets.



Picture 3.78 - Thickness of the base-plate brackets. Regnér (2012).

3.7.8 Tolerances

For the handle to be of high quality as well as feel the part, it is necessary to hold as fine tolerances as possible but yet allow a smooth sliding for mechanism to work. The tolerances shall allow the arms to slide within the grip-area with a tight fit. A tight fit will enable a good experience when integrating with the handle. It can also provide extra strength. If the tolerances are rough, friction and vibrations will easily occur. This will affect the parts negatively. Fine tolerances will enable the handle to last longer without breaking. Kallin (2012).

The tolerances can depend on how the part is produced and what materials that will be used. However the tolerances

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shall not to be rougher than 0,2 mm, as this would mean the handle to wobble and the parts to fit too loosely. It can also decrease the high quality feeling of the handle as well as its lifespan. Kallin (2012), Andersson (2012).

If the handle shall be made from one material only, for example a Polyamide plastic, the tolerances shall be set to approximately 0,2 mm for the arms to properly slide within the slots smoothly but not hold a too loose fit. Andersson (2012). If however a plastic material which holds an oily surface with less friction is used, such as Polyoxymethylene, the tolerances can possibly be set to almost 0 mm. Kallin (2012). During the production process the tolerances will be set appropriately, with an as tight fit as possible, to the material used.

3.7.9 Spring

For the arms to smoothly slide within the handle and automatically retract back into the grip-area, a spring can be used. The spring would also allow the arms to work simultaneously which means that the handle will be pulled out to an upright position without sloping to one side. This spring will have to be mounted inside the middle of the grip-area for the arms not to slide uncontrollably.

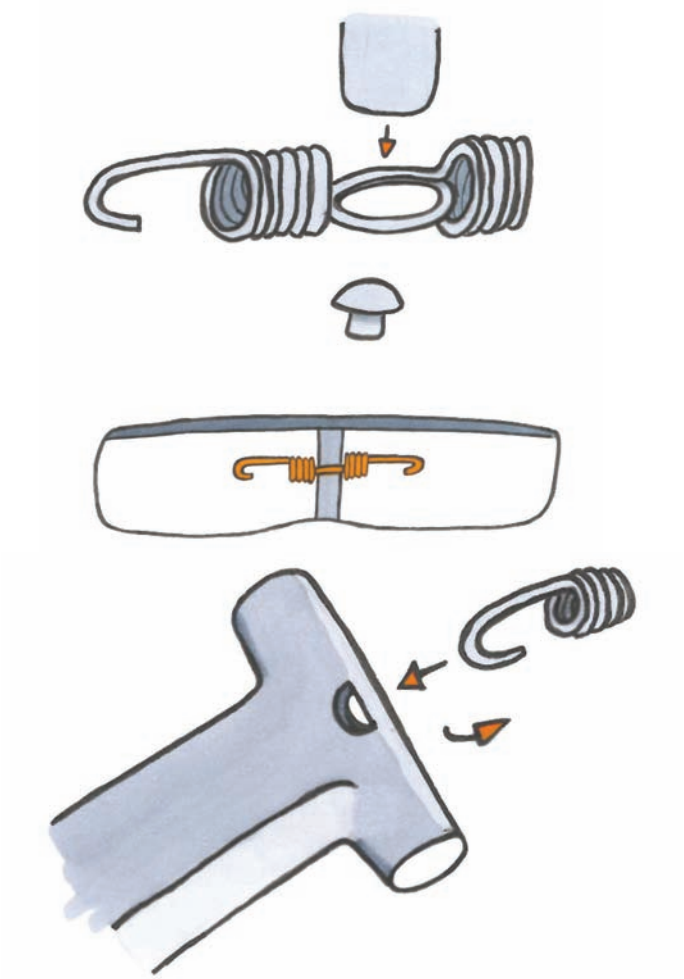
The spring shall preferably be made from a plastic material, if possible. This would minimise the use of many different materials and be better of from a recycling point of view. However if necessary a metal spring will be used to solve the problem. Designer - Mechanics, Ericsson AB, Tom Andersson states it would not be a problem using a spring. Neither would it be a problem in regards to cost as it will be cheap to integrate into the production.

Assembly-wise the spring can be possible to fix when snapping the two halves of the grip-area together. The spring will be fixed by a snap-buckle stopping if from moving in the centre. Yet still enable the spring to flex the necessary distance, enabling flexibility of the arms. The spring will not have to be very strong, only allowing the handle to be pulled up and retract the arms within the handle when released. See Picture 3.79 - Spring connected to the arms and grip-area.

The spring can be connected to the arms by a hook which is connected to a hollowed-out area in the end of the arms. The material thickness of the area in front of the cut-out area can be made as little as 1,5 mm, as no large forces put on this surface. Andersson (2012). The dimension of the hole can be set to 2 mm deep and 3 mm long which means that the hook-end of the spring is allowed to be hooked within the hole. See Picture - 3.79 - Spring connected to the arms and grip-area

The spring shall withstand forces of somewhere between 10-50 N, but has to be further evaluated to find out the most appropriate spring tension. Andersson (2012).

A too strong spring will mean that the handle will be hard to pull up and the handle will be slammed down when released. A too week spring will mean that the downward movement of the handle when released might not be optimal for retraction. Andersson (2012).



Picture 3.79 - Spring connected to the arms and grip-area Regnér (2012).

3.7.10 Semantic expression

The semantic expression of the handle is important, as it shall be as subtle as possible not to interfere on the semantic expression of the product. The handle still has to be unique and tell the story of Ericsson AB through its visual design. The semantic expression will help distinguish the product as being of high quality, durable, subtle and user-friendly.

The main objectives concerning the design of the handle, except from being subtle, is that it shall be performance driven. Performance driven indicates that focus shall be set on durability, sturdiness and strength as well as well ergonomically adapted. Thelin (2012). When the handle has been concluded to be strong, sturdy and durable as well as shaped in regard to ergonomics, the visual expression can be added as fine-tuning. This will regard rounds, split-lines and other exterior design features which will not interfere with the performance.

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3.7.11 Shapes

The shape of the handle has to be made with regard for performance, sturdiness and ergonomics. This means that the visual design has to adapt to how and when the mechanical features has been decided and fitted. When these factors have been decided and concluded, refining visual design will be performed.

When looking at the ergonomic performance, the grip-area has to hold a minimum length of 110 mm to fit 95 % of the users worldwide. Johansson (2011). Desirable, the handle could be made even longer and by this fit an even larger span of users. It is at the same time important to adapt the handle to work with the mounting C-C of 160 mm. This can be an obstructive aspect of prolonging the grip-area. If the mounting of the handle to the C-C of 160 mm can be done underneath the grip-area instead of outside, the length of the grip-area can be prolonged to the extent of the length of the product.

The handle should preferably be rounded to fit the palm of the hand and provide a smooth grip. If possible, it should also be thinner towards the edges and thicker in the middle as this will enable a more centred grip as well as better and easier handling. A minimum grip thickness of 25 mm is required to provide a proper ergonomic power-grip. Johansson (2012). One aspect that was desired from the test-users of the usability-test was to implement finger-grooves to the redesigned handle. However when consulting with Sr Industrial Designer HW Usability – Ericsson AB, Mats Johansson it was concluded that implementing finger-grooves shall be avoided. This feature tends to not fit any users properly. They provide an ergonomic expression but tend to be useless and not provide any improved ergonomic aspects. Due to this fact will finger-grooves be discarded and not integrated in the final handle concept. Johansson (2012).

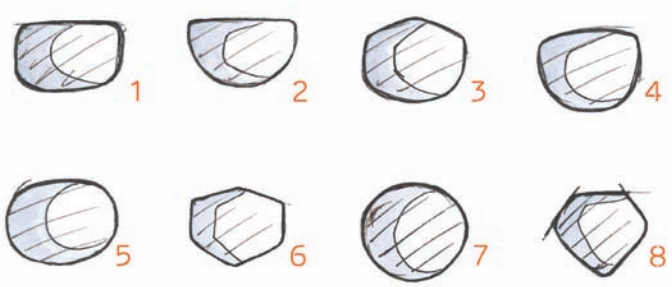
The shape of the handle is important for the ergonomic qualities. It shall lay smooth within the users' hands, yet provide a strong and sturdy power-grip. When consulting Sr Industrial Designer HW Usability – Ericsson AB, Mats Johansson it is concluded that the handle has to hold some kind of rounded shape towards the user's palm. This area is where the force and the interaction between the handle and the user will occur. There is no obvious need for a circular handle. A square one would be fully possible as long as the edges are well rounded to provide the comfort needed.

When regarding the whole shape of the handle it would, from a subtle-design perspective, be preferable if the top of the grip-area could be made flat. This would make the handle lower and interfere less on the total semantic expression. When consulting this issue with Sr Industrial Designer HW Usability – Ericsson AB, Mats Johansson, there seems not to be a major issue in flattening the top of the handle without risk affecting the ergonomic requirements. The product will almost exclusively be carried horizontally with the handle up, on top of the product. Due to this fact there is no need to hold a rounded upside of the handle. This surface will most certainly not be the force-bearing surface. Johansson (2012).

This means that the handle can hold a flatten surface on the top as long as the bottom surface, which interacts with the palm of the user's hand, is well rounded and smooth. Of course will the top surface have to hold smooth rounded edges as well, but there is no obvious need to use a fully rounded surface. Johansson (2012).

To decide what shape is most suitable in regards to comfort ergonomics and strength, discussions were held with Sr Industrial Designer HW Usability – Ericsson AB, Mats Johansson and Desinger – Mechanics, Ericsson AB, Tom Andersson. Together with input from relevant actors, a number of simple mock-ups of different shapes of the handles were made. These could then interacted with to provide valuable data in regard to how the specific shape fulfills the requirements of comfort and ergonomics.

The shapes analysed is a rectangle with rounded corners, a half circle with flat top, a full circle, an ellipse, a half circle with a slight rounded top, a rounded hexagon, a diamond shape (pentagon), a half circle with a triangular top. See Picture 3.80 - Shapes of the handle, See Picture 3.81 - Shapes of the handle Mock-ups. A full circular handle is very comfortable however is too bulky and with the information collected, this kind of solution will be discarded. The handle shapes with pointy edges such as the diamond-shape as well as hexagonal shape are regarded as not comfortable enough when interacting with the mock-up. These solutions will also be discarded. The elliptical shape tends to put stress on the wrong areas of the user's hand, concluded when interacting with the mock-up. This leaves a half circle shape and a rectangular shape with well rounded angles. Both these solutions provide a sturdy comfortable grip and are regarded as ergonomically well adapted. The important aspect is that the handle should hold recommended dimensions. It shall also hold a lean and smooth surface to provide comfortable interaction. Johansson (2012).



Picture 3.80 - Shapes of the handle. Regnér (2012).

The final design will be using the shape of one of these two shapes, with focus on using large rounded surfaces. There is the possibility that a combined shape can be suitable.

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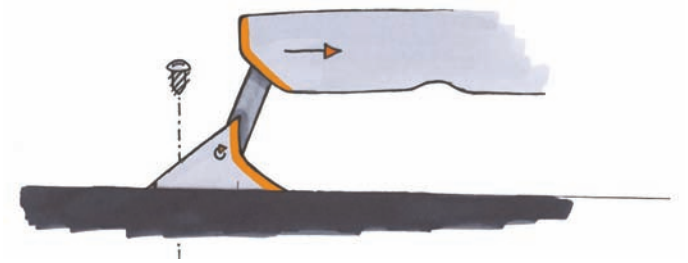
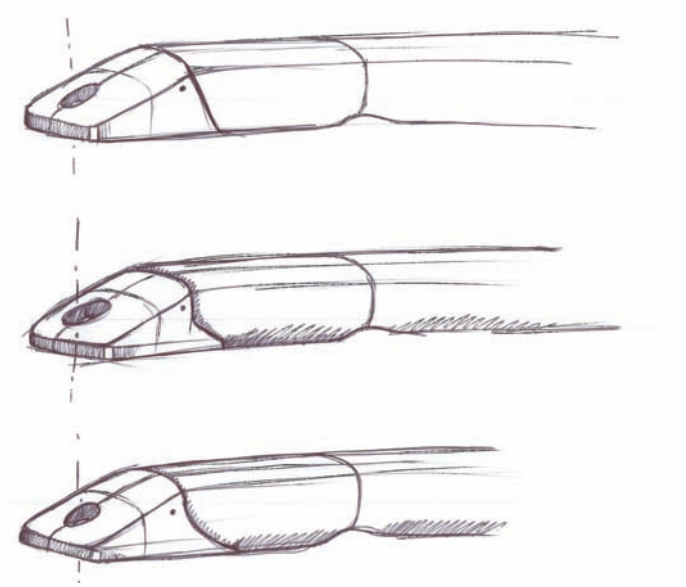
Picture 3.81 - Shapes of the handle Mock-ups. Regnér (2012).

The ends of the grip area will be sloped inwards. The flat top-surface should be approximately 130 mm and the flat bottom surface 110 mm. This will enable easier and smoother downwards retraction. When the spring pulls the arms back into the grip-area, the grip-area will smoothly slide downwards. The slope on the grip-area which is mirrored onto the base-plate bracket enables a good fit between the grip-area and the base-plate bracket. See Picture 3.82 - Split-lines where Grip-area meet base-plate Bracket.



Picture 3.82 - Split-lines where Grip-area meet base-plate Bracket. Regnér (2012).

The split-lines between the grip-area and the base-plate brackets can made in many different ways. The design-values of Ericsson AB states that the split-lines shall rather be big than small, as the materials are allowed to adapt to weather conditions without interfering on the semantic expression. ERICSSON AB - Design-Values (2011). The split-line can be made straight, running in one line from top to bottom. Another design is to make it rounded where the slope holds a rounded shape, like a skateboard ramp. This provides a smoother and softer expression compared to using a straight split-line. The last design is a "broken" split-line which has a steep angle in towards the top but is broken in the middle to a more levelled angle towards the bottom. This is a more complex design however provides a mix of the straight and the rounded split-lines. See Picture 3.83 - Split-lines.



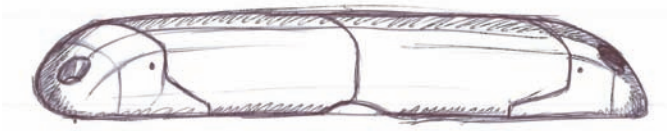
Picture 3.83 - Split-lines. Regnér (2012).

The area of free grip-space between the bottom of the grip-area and the top of the RRUs can be set to as low as 40 mm. This is enough to fulfil the ergonomic aspects well, as well as enable the length of the arms to fit within the grip-area together with the spring.

3.7.12 Base-plate brackets

The base-plate brackets can be designed in numerous ways, either square, rounded sloped, covered open and so forth. Many sketches were made to show and conclude what solution is most suitable for the final concept with regard to Ericsson AB's design-values as well as ergonomics and mechanics. See Picture 3.84 - Smooth sloped base-plate Bracket, See Picture 3.85 - Rounded sloped base-plate Bracket, See Picture 3.86 - Flat sloped base-plate Bracket, See Picture 3.87 - Rounded Box-end base-plate Bracket, Picture 3.88 - Box-end base-plate Bracket, See Picture 3.89 - Open and Semi open base-plate Bracket, See Picture 3.90 - Open and Semi Covered base-plat Bracket.

When discussing the issue with Mikael Thelin and other industrial designers at Ericsson AB, it is decided to focus on an honest and mechanical design, which clearly shows the functionality of the handle and the base-plate brackets.



Picture 3.84 - Smooth sloped base-plate Bracket. Regnér (2012).

Picture 3.85 - Rounded sloped base-plate Bracket. Regnér (2012).

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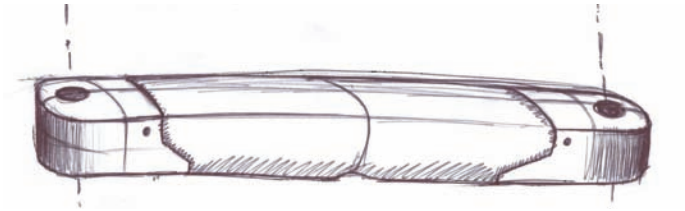
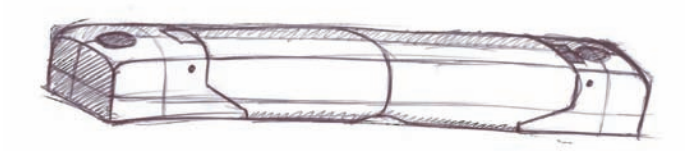
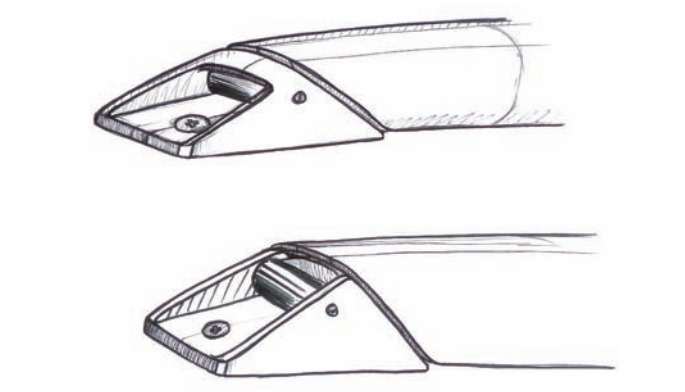
Picture 3.86 - Flat sloped base-plate Bracket. Regnér (2012).



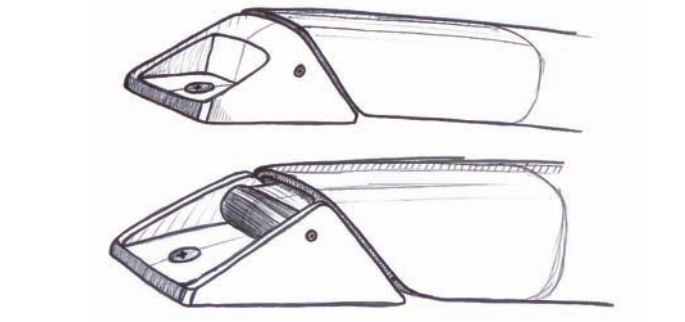
Picture 3.87 - Rounded Box-end base-plate Bracket. Regnér (2012).



Picture 3.88 - Box-end base-plate Bracket. Regnér (2012).



Picture 3.89 - Open and Semi open base-plate Bracket. Regnér (2012).



Picture 3.90 - Open and Semi Covered base-plat Bracket. Regnér (2012).

3.7.13 Touch-points

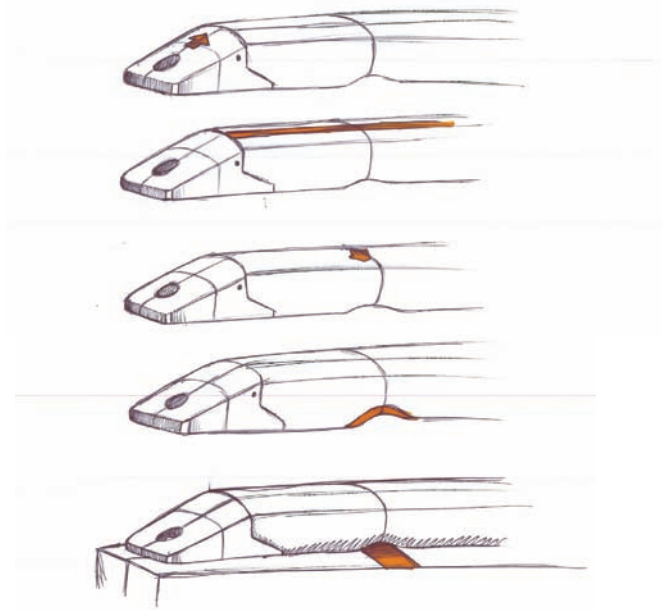
In the Ericsson AB's design-guidelines an accent colour is used to indicate what features shall be interacted with. The orange coloured parts in the sketches indicate a touch-point which aims to ease the understanding of how the products shall be used and interacted with. ERICSSON AB - Design-Values (2011). Touch-points are of interest when designing the new innovative handle. It can help the user understand how the handle shall be used.

The touch-point indication can be placed on the grip-area of the handle, on the base-plate brackets, around the groove enabling hoisting, in the split-lines or on-top of the internal-body. There is an obvious question of how to use the touch-points. The previous touch-points of Ericsson AB's design-values indicates areas which shall be interacted with. This would be a suitable way to go in this case as well. It means that the touch-point indication should portray that the handle shall be interacted with to allow handling and carrying of the product.

The touch-point shall not interfere with the semantic expression of the product which can be the case if placed on top of the handle. Some parts of the handle might visible above of the sun-cover. If the touch-point indication is placed in an area above the sun-cover, there is a risk of making the handle intrusive instead of subtle. See Picture 3.91 - Touch-point indication Concepts.

When studying previous touch-point areas of previous products developed, with Ericsson AB's design-values in regard, the touch-points shall not be visible through the extralnal surfaces of the product. They are instead to be hidden beneath. The previous handles, both fixed and flexible, do not hold any touch-point indications. They are regarded as holding obvious functionality, not in need to be displayed for the user.

When discussion this issue of placement of touch-points within the industrial design group as well as when evaluating the previous touch-point placements, it is concluded and decided that the indication shall be non visible, if the handle is not to be interacted with. The touch-point indication shall indicate where to interact and not indicate differentiation between parts, such as indicating split-lines between base-plate brackets and grip-area. This means that the touch-points shall be placed somewhere where they clearly indicate where the handle is grabbed to enable lifting and carrying.



Picture 3.91 - Touch-point indication Concepts. Regnér (2012).

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4.1 Life Cycle Assessment

The life-cycle assessment will be a tool to confirm the environmental issues with the product. It will also provide important information about further development possibilities in regard to environmental impact ans cost savings.

As the RRUs are advanced high-technology products with circuit-boards holding heavy metals, these high-technology features will not be included in the LCA. The circuit-boards are to complex and delicate to handle within the timspan of the thesis. The LCA focuses on the major external parts, such as sun-cover, internal-body, carrying feature and packaging materials. With regard to not including the internal radio unit and high-technology features, due to secrecy and lack of material data, the LCA will not be fully accurate. The purpose is not to conclude a fully accurate analysis. Instead the LCA shall provide indications of how the products can be improved. The focus of the LCA is concerning the external features, production methods, transportation, usage and End-of-Life.

The tool which is used to perform the LCA, is an online-based LCA-tool. It provides good and accurate data on materials produced, manufactured and disposed in Europe. In regard to the LCA-tool being focused to the European market the product analysed will have to be regarded as produced and used in Europe. This result will differ from a product being produced and used in Asia, as the methods of production and material selection differs. The result will however be a good indication of what parts of the product can be redesign to fulfil the requirements of being designed in regard of sustainability. The tool used is Product Ecology Online which holds an easy clean interface, suitable for this purpose of a lucid life-cycle assessment. Product Ecology Online (2012). The tool measures CO2-Emissions in tonnes CO2 equivalent (t CO2 eq), Water Usage in m3 and Waste Output in kg waste. These units are globally adapted, commonly used worldwide to show the environmental impact within a LCA. Product Ecology bases their results and data on the Ecoinvent database (v2.0). Product Ecology Online (2012).

Due to no data on the percentage of spill during production, this aspect has been excluded in the analysis. All production material is set to the final weight of the parts. All processes used by Ericsson AB when producing a product is not possible to choose within this LCA-tool. When this occurred, the closest most suitable process was chosen as substitute. Where transportation is regarded, production of aluminium and plastic is set to Romania, as it has been confirmed that production takes place there. Assembly is set to Estonia and the product is set to be sold and used in Sweden. Paint and minor details such as screws and overlays has been set to production in Romania as well, due to not other accurate data on where production is taking place. No data on production of packaging material has been concluded. Production and transportation to assembly of packaging material has therefor been excluded. The LCA-tool holds no data on expanded Polyethylene which is used within the fitments. Polystyrene foam has been selected instead, as this is also commonly used by Ericsson AB in their fitments.

The LCA-analysis is performed on the RRUS 12 exclusively, as this is the most present product.

The LCA provides a good indication on what parts of the product, processes and steps from production to end of life that impacts the environment the most. The result can be used as a guide to know what parts, process and steps during the lifespan of the product that can be improved to lower the environmental impact as well as lower the cost.

4.1.1 Materials & Processes

When studying the materials and processes used to produce the specific parts of; the internal-body, sun-cover, product feet & carrying feature, screw-joints overlays and packaging materials, one major conclusion can be made. The process of producing aluminium parts of the internal-body, but also products feet & handle, holds without doubt the most environmental impact. The CO2-Emmissions, Water Usage and Waste Output are much greater for the aluminium products in regard to any other production of parts and materials. The plastic details in the sun-cover hold the second highest environmental impact, yet less than six-times that of the aluminium parts.

In regard to Water Usage the aluminium material and production still holds the most environmental impact, seven-times as great as the second highest impact factor of the steel-screws.

When analysing the Waste Output from the processes, the production of aluminium is up to ten-times greater than any of the other material processes.

The production of aluminium parts, foremost the internal-body, due to its large weight, holds CO2-Emission of almost 60 t CO2 eq. This is significantly more than the plastic parts which stand for just over 10 t CO2 eq and the packaging materials which stand for approximately 30 t CO2 eq. See Picture 4.1 - Materials & Processes CO2.

When looking at the Water Usage within the material and production process, the production of aluminium parts uses 7,5 m3. While the production of fasteners less than 2 m3 and packaging material about 0,75 m3. See Picture 4.2 - Materials & Processes Water.

The Waste Output, which occurs when processing materials and producing parts, is 0,5 kg of waste from the production of aluminium parts. Approximately 0,03 kg of waste is produced each when producing plastic details for sun-

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covers as well as steel for fasteners while packaging materials consumes up to 0,5 kg waste. See Picture 4.3 - Materials & Processes Waste.

With this in mind, without regarding the internal technical features, it is easy to understand that to minimise the environmental impact during production of the RRUS 12 focus shall be aimed at the aluminium parts. The high environmental impact has to be understood to be greater than the other parts due to its high weight. However the use of aluminium also holds relatively high environmental impact during production and material processing. Especially when new aluminium is used instead of recycled material.

By minimising the weight and changing the material to one which holds less environmental impact during production, Ericsson AB can minimise the environmental impact of their products substantially.

4.1.2 Distribution

The transportation has not been able to fully pin-point which has led to some assumptions being made. One thing that can be concluded is that the use of air-cargo hold a substantial impact on the environment. The transportation from production to assembly is, in this case, thought to be one of the greatest factors of environmental impact. As air-freight is commonly used by Ericsson AB to deliver the initial batches in time, this has been regarded in the LCA. If the products instead would be transported by train- and road-freight the environmental impact would be less. In the all-over impact of the product, production, transportation, consumption and End-of-Life; transportation stands for about 20 % of the total CO2-Emmissions. See Picture 4.7 - Whole impact. Product Ecology Online (2012). However only approximately 1 % of the total Water Usage and 1-2 % of the total Waste Output is due to transportation. Transportation from Romania to Estonia holds an impact of CO2-Emmissions of over 60 t CO2 eq, 0,35 m3 water and 0,1 kg waste. Transportation from Estonia to Sweden holds an impact of CO2-Emmissions of 20 t CO2 eq, 0,01 m3 water and 0,03 kg waste. See Picture 4.4 - Distribution CO2, See Picture 4.5 - Distribution Water, See Picture 4.6 - Distribution Waste.

When the products have been used in Sweden over a lifetime of possibly ten years, it will be transported to recycling-sites for breaking down of components and materials. These recycling-sites are placed at different locations worldwide, depending on where the product has been used and what type of product that is dealt with. When discussing the topic with Director Ecology Affairs – Ericsson AB, Stephen Rodgers, it is concluded that it is not uncommon for a product to be shipped from Sweden to Scotland for an initial recycling process. Rodgers (2012). The transportation of one RRUS 12 unit from Sweden to Scotland by boat-freight holds an impact of CO2-Emmissions of 1 t CO2 eq, 0,001 m3 water and 0,0005 kg waste. See Picture 4.4 - Distribution CO2, See Picture 4.5 - Distribution Water, See Picture 4.6 - Distribution Waste.

When the initial recycling process has been done in Scotland the product is shipped to Chicago in the United States of America for final recycling of the more complex components and material. The transportation from Scotland to USA is also performed by boat-freight. This holds an impact of CO2-Emmissions of 2,5 t CO2 eq, 0,025 m3 water and 0,01 kg waste. See Picture 4.4 - Distribution CO2, See Picture 4.5 - Distribution Water, See Picture 4.6 - Distribution Waste.

As the transportation from usage- to recycling-sites can be secured to boat-freight, the environmental impact is far less than the one where products are transported by air-freight from production. Even though the distance of transportation to recycling-sites can be much greater.

A conclusion of this is that air-freight shall be use as little as possible due to its high level of negative environmental impact.

4.1.3 Consumption

Regarding consumption, a mean value of 400 W is set as the usage-level of one single RRUs at normal conditions, including spill and waste. During a lifespan of 10 years a product holds a significant environmental impact and if this is calculated into the LCA no other impact would be possible to interpret. For this reason of easier interpretation of the LCA, the usage has been set to 1 year which gives a level of usage to 3504 KWh.

Looking at the whole life cycle, the consumption of 1 year stands for 60 % of the total CO2-Emmissions, 60 % of the total Water Use and up to 90 % of the total Waste Output. The CO2-Emmissions from 1 year consumption of electricity is 300 t CO2 eq, Water Usage is 45 m3 water and Waste Output is 16 kg waste. See Picture 4.8 - Consumption CO2 1 Year, See Picture 4.9 - Consumption Water 1 Year, See Picture 4.10 - Consumption Waste 1 Year.

When looking at the usage level over a 10 year perspective the impact of the usage situation in comparison to the total environmental impact rises significantly. The CO2-Emmissions level rises to over 90 %, Water Usage to over 90 % and Waste Output to over 99 %. See Picture 4.11 - Consumption CO2 10 Years, See Picture 4.12 - Consumption Water 10 Years, See Picture 4.13 - Consumption Waste 10 Years.

When analysing the result from the LCA it is easy to conclude the affect the level of consumption holds on the total lifespan of Ericsson AB's RRUS 12. This corresponds well with the data provided by Environmental Prod Mgmt – Techn prg supp – Ericsson AB, Richard Trankell. If there is one aspect that can be further developed and improved,

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it has to be the consumption energy of the product. Production and material processes, distribution and End-of-Life is definitely also to be regarded and further developed. However together these four do not even stand for 40 % of the total CO2-Emmissions, 40 % of the Water Usage and not even 10 % of Waste Output over a one year period. See Picture 4.7 - Whole impact.

By implementing new and better technology, the products can be made more effective. There are also possibilities of implementing renewable energy "absorbers" into the products to obtain much of the energy that the products is exposed to through the wind and the sun.

4.1.4 End-of-Life

The end-of-life of a product's life cycle is substantial for the total environmental impact. All end-of-life processes did not fully correspond to the methods concluded to be used by Ericsson AB, when using the LCA-tool. When this occurred, the closest most suitable option was used to get an as accurate result as possible.

As the internal-body and sun-covers are the largest and heaviest parts of the product, these also hold largest environmental impact in most aspects. When regarding the CO2-Emmissions, the incineration of the plastic details together with process of recycling aluminium stand for the significant part of the environmental impact. The LCA-tool does not have recycling data for aluminium recycling, only data on sanitary landfill. The process of recycling aluminium through landfill uses 1 tonnes CO2 equivalents while the process of incinerating plastic parts about 5 t CO2 eq. Packaging materials stand for the largest impact during recycling through incineration, almost 20 t CO2 eq. See Picture 4.14 - End-of-Life CO2.

When regarding the Water Usage of the end-of-life phase, the land-filling of aluminium before recycling holds almost exclusively all environmental impact with a consumption of about 15 m3 of water. See Picture 4.15 - End-of-Life Water.

End-of-life concerning the aluminium parts holds about two times as high impact as the plastic details in the sun-cover. The most impact on the environment from the end-of-life phase is exclusively made by the process of recycling aluminium and plastic parts. This process stands for approximately 0,0075 kg, when Landfill of aluminium, and only 0,004 kg, when incineration of plastics, of Waste Output. See Picture 4.16 - End-of-Life Waste.

The end-of-life consumables portrays the environmental impact from the consumables used to recycle the aluminium and plastics in sun-cover when producing new material from the recycled material.

The total impact of the end-of-life of the total life-cycle of the reference RRUS 12 is fairly low. Only a 2-3 % when regarding CO2-Emmissions however the Water Usage uses a significant portion of the total life-cycle, up to about 20 %. The total portion of Waste Output from the end-of-life phase is only minimal, not even 1 % of the total Waste Output. See Picture 4.7 - Whole impact.

There is a definite need to regard and optimise the end-of-life phase. However this analysis shall be regarded with understanding of the circumstances, as all data is not fully accurate to the real life situation.

4.1.5 Ecocompare – Product Ecology Online - material and process benchmarking-tool

To know if one alternative material is better suited in an environmental point of view, the chosen LCA-tool provides data by comparing materials and processes. When comparing materials it is easy to state if the alternative material is a possibility to use as a substitute, to minimise the negative environmental impact during production.

When comparing the RRUS 12 internal-body made from aluminium to one made from magnesium, which has been stated to be a possible material to use. Pettersson (2011). The magnesium proved to hold much greater environmental impact. The mass of the internal-body was set to the present weight of 14.8 kg for aluminium however as magnesium has a lower density by 0,64 the weight of the internal-body. If the internal-body would be made from magnesium it would hold a weight of 9,54 kg. (Klason 2008) When regarding CO2-Emissions, magnesium proved to hold over 100-times as great environmental impact as aluminium, 0,664 t CO2 eq compared to 0.00587 t CO2 eq. See Picture 4.17 - Ecocompare AL & MG - CO2. The same goes for the Water Usage and Waste Output; magnesium uses 8,64 m3 of water and produces 3.14 kg waste while aluminium only uses 0,407 m3 water and produces 0.0272 kg waste when producing a 14.8 kg product. See Picture 4.18 - Ecocompare AL & MG - Water, See Picture 4.19 - Ecocompare AL & MG - Waste. The environmental impact from producing magnesium is much greater than aluminium. The product's weight is however lowered by 46 % which means that transportation will be cheaper as well as less environmental impact would come through transportation. These factors will have to be further analysed and tested if magnesium would be considered as a material of choice. However there might be benefits in changing to different materials even if they hold greater environmental impact during production.

Comparing the aluminium internal-body to a internal-body made from Polycarbonate, the weight will be dropped from 14,8 kg to as low as 4,69 kg. (Klason 2008). The environmental impact during production will be somewhat greater however the impact from transportation will be

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much lesser. If a plastic material is possible to use in the internal-body is uncertain. However possible treatments of the material might provide the necessary factors which enables it to fulfil all requirements. 0.0312 t CO2 eq of CO2-Emissions, 0.338 m3 of water and 0.0547 kg waste is produced when producing a polycarbonate product of 4,69 kg. See Picture 4.20 - Ecocompare AL & PC - CO2, See Picture 4.21 - Ecocompare AL & PC - Water, See Picture 4.22 - Ecocompare AL & PC - Waste.

If plastic materials such as Polycarbonate are possible to use within the internal-body, the weight can be minimised by up to 68 % which means that environmental impact from transportation would be minimise to a large extent.

4.1.6 Result of the LCA

To summarise the LCA of the reference product of Ericsson AB's RRUS 12, it can be said that there are numerous of processes, materials and steps that can be improved and further developed to minimise the environmental impact of the product during its life-cycle.

In the all-over impact of the product, production, material processes and production stand for about 20 % of the total CO2-Emmissions. See Picture 4.7 - Whole impact. Approximately 15 % of the total Water Usage and only about 5 % of the total Waste Output is due to material production and processes. See Picture 4.7 - Whole impact. Distribution stands for about 20 % of the total CO2-Emmissions. See Picture 4.7 - Whole impact. Approximately only 1 % of the total Water Usage and about 2 % of the total Waste Output is due to distribution of goods. See Picture 4.7 - Whole impact. Consumption of goods during the products lifetime stands for over 50 % of the total CO2-Emmissions. See Picture 4.7 - Whole impact. Over 60 % of the total Water Usage and over 90 % of the total Waste Output is due to consumption of electricity over 1 year. See Picture 4.7 - Whole impact. End-of-life process stands for about 10 % of the total CO2-Emmissions. See Picture 4.7 - Whole impact. Over 20 % of the total Water Usage however only about 1 % of the total Waste Output is due to end-of-life processes. See Picture 4.7 - Whole impact.

When studying the result it is easy to conclude that the consumption of electricity to power the product during it lifetime holds exclusively the highest environmental impact. However it has to be regarded that the technical internal features of the RRUs has not been included in the LCA. These features hold valuable and environmentally unfriendly materials, which would possibly change the outcome of the result. The impact of material processing and production as well as end-of-life phases would hold a higher impact compared to the current result. Due to the large part of the negative environmental impact comes from electricity usage this would probably still hold the most significant impact, even if all the internal features would be regarded.

Important conclusions from the LCA analysis to regard is that further development and improvements on the product has to be done in all phases of the life-cycle and all parts involved. Even though the usage situation exclusively stood for the highest environmental impact, other phases and parts of the life-cycle shall not to be neglected. Even if a part holds little negative environmental impact compared to other parts or phases, further development and improvements can make a significant difference. This is due to so many products being produced and sold. Every effort possible to minimise the negative environmental impact from production, transportation, usage and end-of-life is worth taking. Over time there is the possibility to make a huge difference to the environmental changes occurring world wide.

The result from the LCA has provided very valuable data on what to regard concerning the products environmental impact. It will work as a foundation together with the rest of the sustainability analysis for the sustainable design guidelines.

For further information See Appendix VII - Life Cycle Assessment

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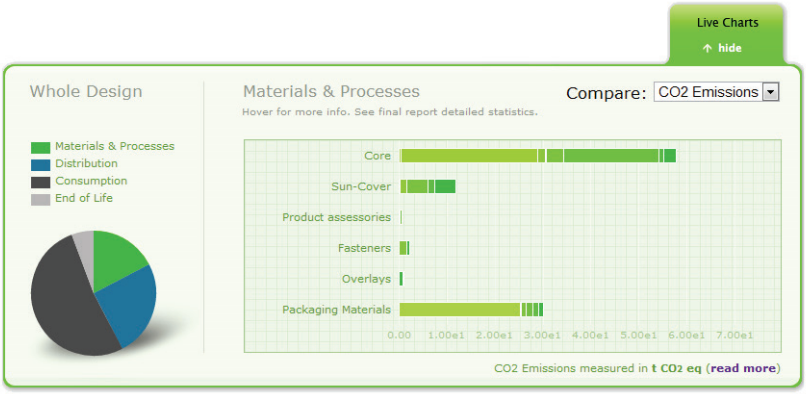

Picture 4.1 - Materials & Processes CO2. Product Ecology Online (2012).

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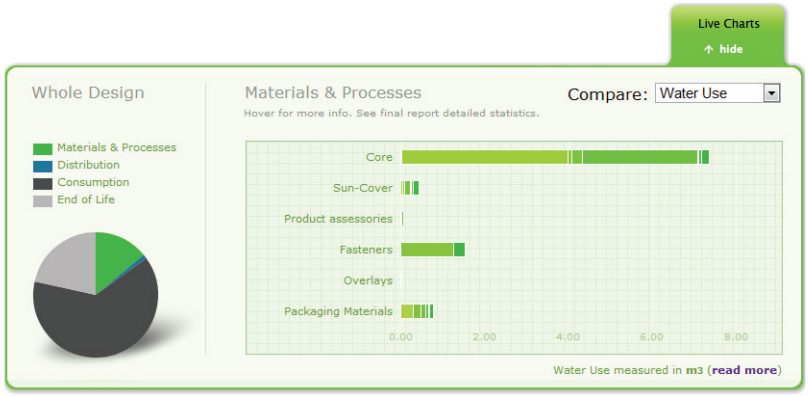
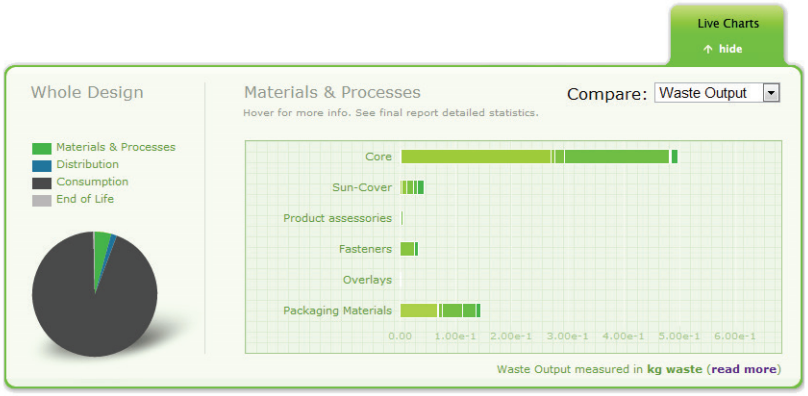
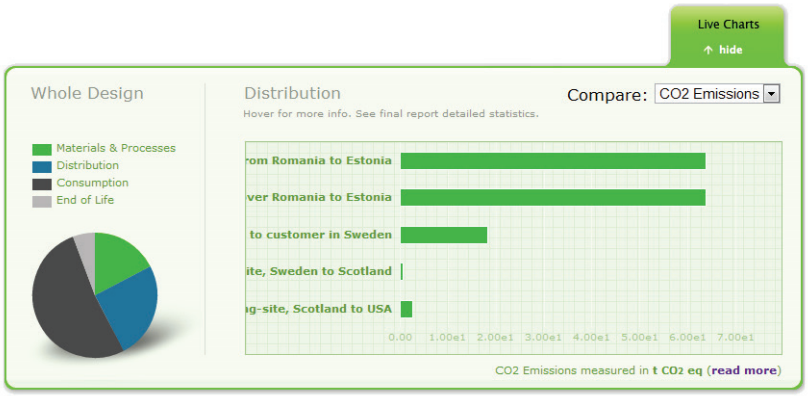


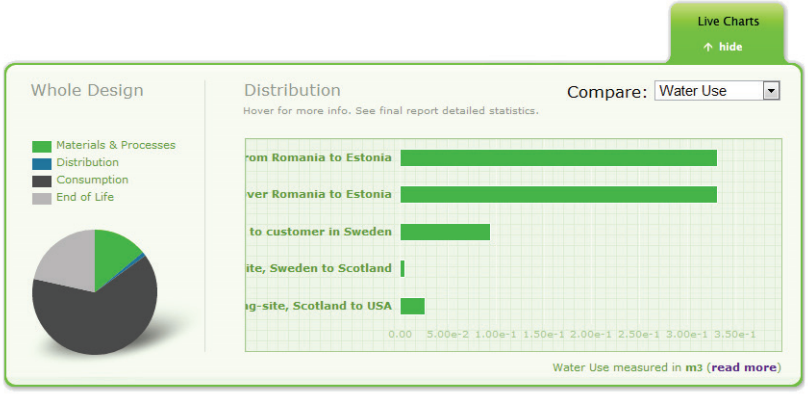
Picture 4.2 - Materials & Processes Water. Product Ecology Online (2012).



Picture 4.3 - Materials & Processes Waste. Product Ecology Online (2012).



Picture 4.4 - Distribution CO2. Product Ecology Online (2012).



Picture 4.5 - Distribution Water. Product Ecology Online (2012).

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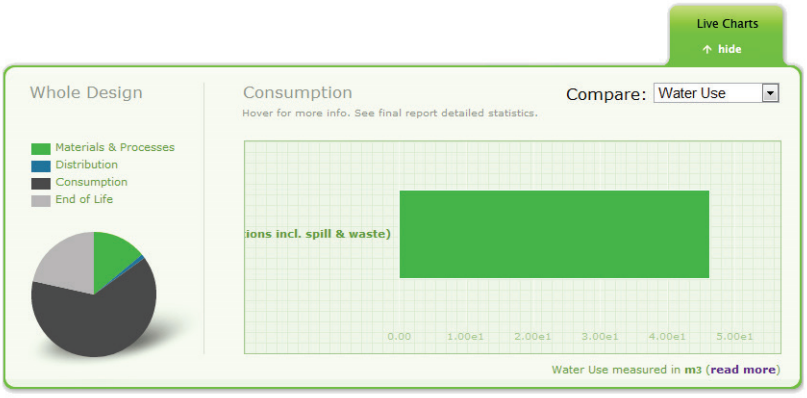
Picture 4.6 - Distribution Waste. Product Ecology Online (2012).

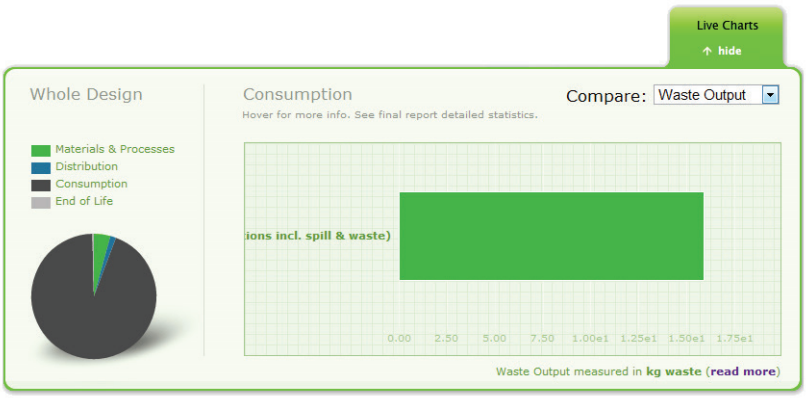
Picture 4.7 - Whole impact. Product Ecology Online (2012).

Picture 4.8 - Consumption CO2 1 Year. Product Ecology Online (2012).

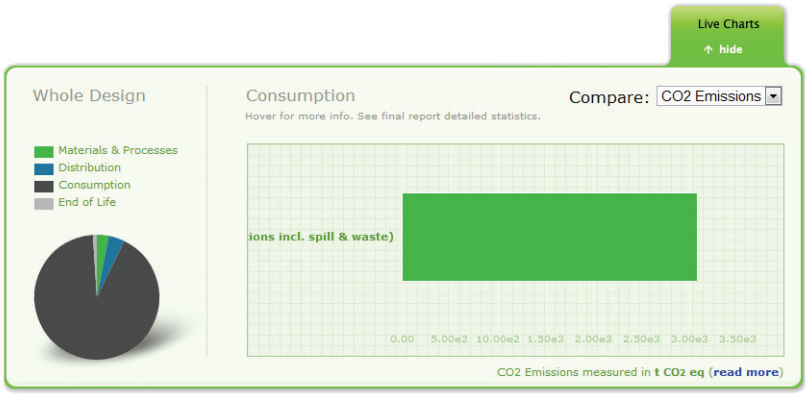


Picture 4.9 - Consumption Water 1 Year. Product Ecology Online (2012).

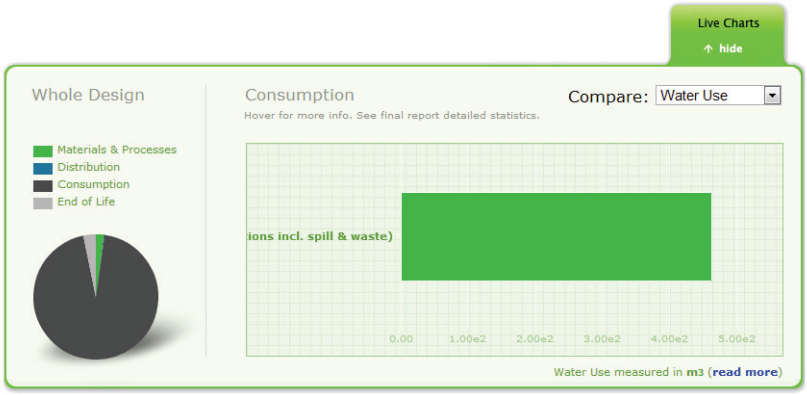
4. RESULT - SUSTAINABILITY



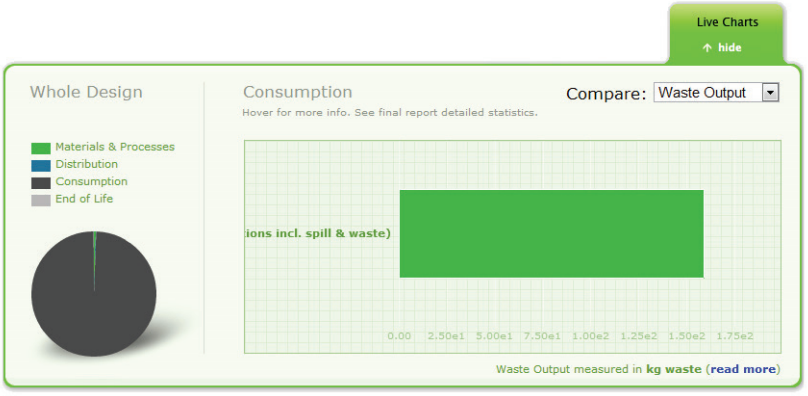
Picture 4.10 - Consumption Waste 1 Year. Product Ecology Online (2012).



Picture 4.11 - Consumption CO2 10 Years. Product Ecology Online (2012).

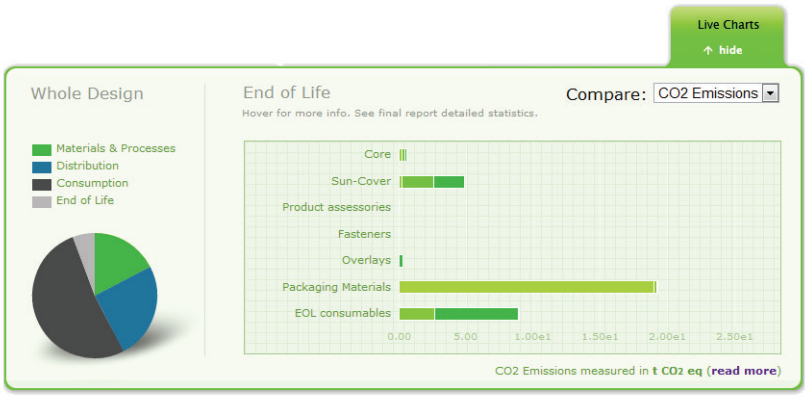


Picture 4.12 - Consumption Water 10 Years. Product Ecology Online (2012).

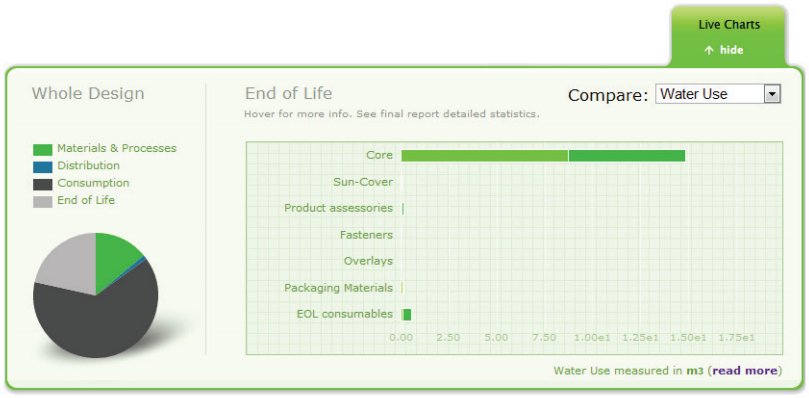


Picture 4.13 - Consumption Waste 10 Years. Product Ecology Online (2012).

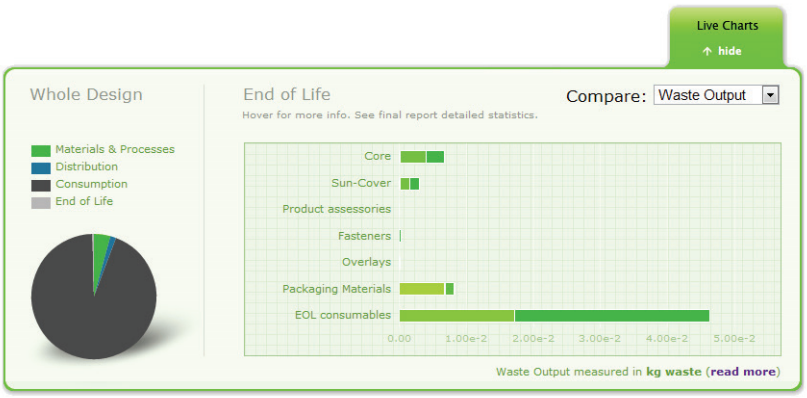
4. RESULT - SUSTAINABILITY



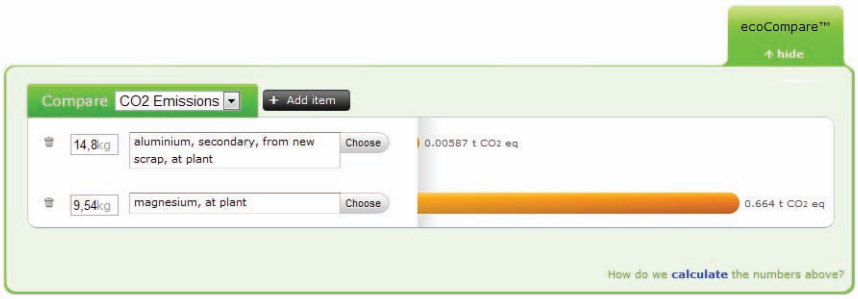
Picture 4.14 - End-of-Life CO2. Product Ecology Online (2012).



Picture 4.15 - End-of-Life Water. Product Ecology Online (2012).

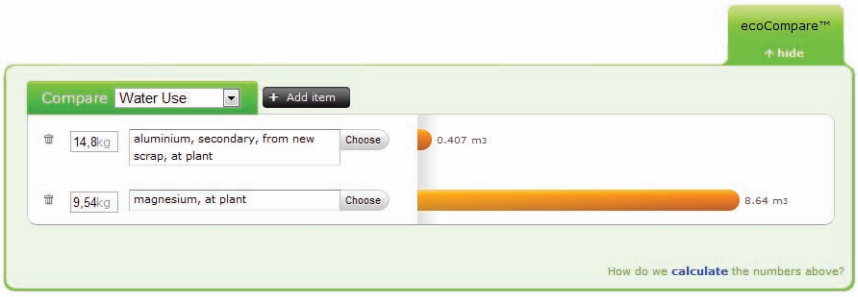


Picture 4.16 - End-of-Life Waste. Product Ecology Online (2012).

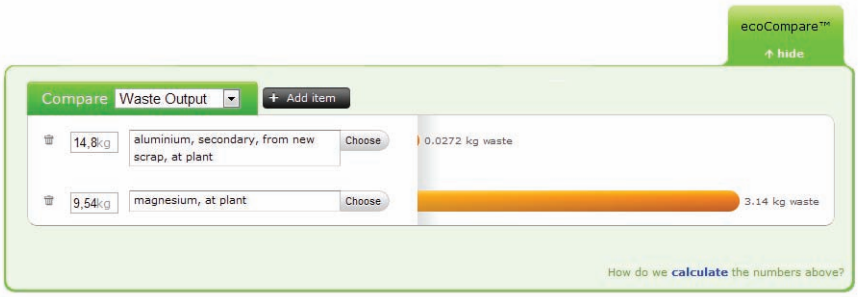


Picture 4.17 - Ecocompare AL & MG - CO2. Product Ecology Online (2012).

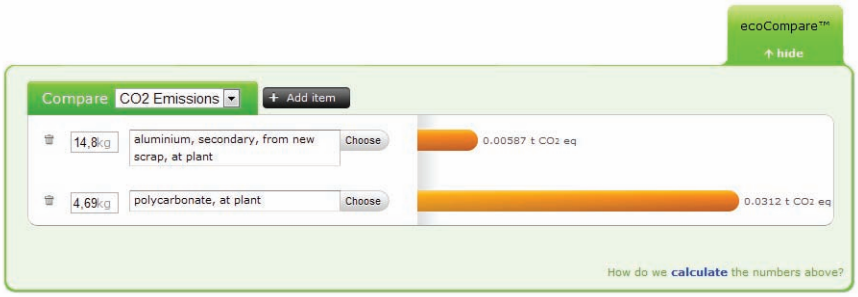
4. RESULT - SUSTAINABILITY



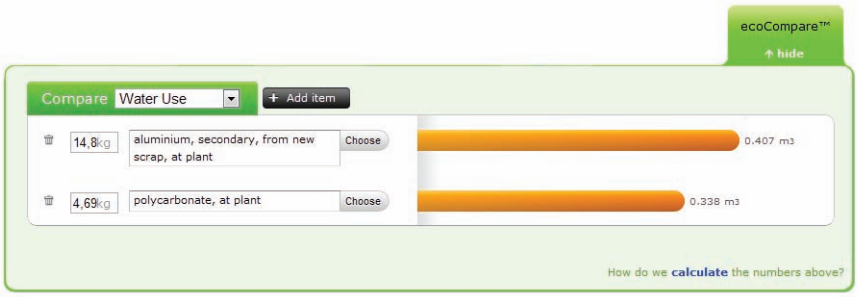
Picture 4.18 - Ecocompare AL & MG - Water. Product Ecology Online (2012).



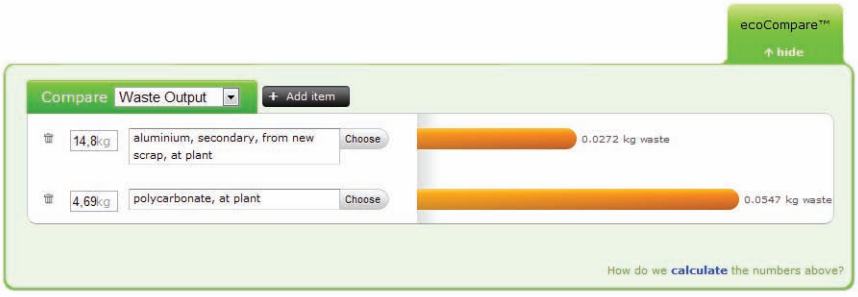
Picture 4.19 - Ecocompare AL & MG - Waste. Product Ecology Online (2012).



Picture 4.20 - Ecocompare AL & PC - CO2. Product Ecology Online (2012).



Picture 4.21 - Ecocompare AL & PC - Water. Product Ecology Online (2012).



Picture 4.22 - Ecocompare AL & PC - Waste. Product Ecology Online (2012).

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4.2 Map of materials - Updated

To conclude what materials are used, a map over the reference RRU 12 was made in Chapter 2. This map hasl in a clear and easy way portrayed the materials used. See Chapter 2.18.12 - Map of materials, See Picture 2.49 - Map of materials, Initial. The map shows the product as an exploded sketch where every part regarded is described by what material it is made from.

As a conclusion of the sustainability analysis, a further developed map of materials was made. This updated map shows materials which shall be regarded when designing new Ericsson AB products. It is made with a focus on sustainability and minimising the negative environmental impact of the product during its life-cycle.

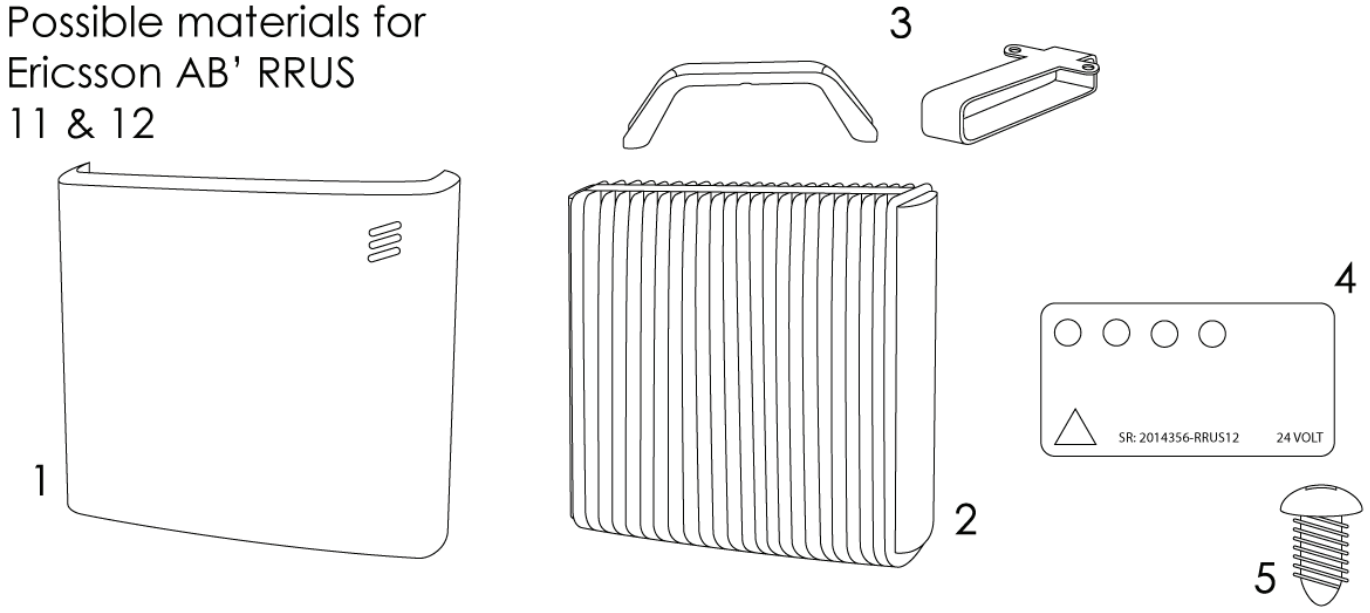
Obviously there are numerous of possible materials to regard. However only materials which have been indicated to be possible to use, have been included within the further developed map of materials. The map is derived from data gathered in the sustainability analysis and indications provided from the life cycle assessment.

A possible alternative material for the sun-cover is to use ASA-plastic. Pettersson (2011). It is a kind of ABS-plastic where the butadiene has been replaced with acrylic rubber, making the material more weather and UV-resistant. It is easier to produce and possible to colour within the process of production, excluding the need wet-coat. Pettersson (2011).

Another solution is to look into the possibility of using a textile material as the sun-cover. This would minimise the weight of the part drastically as well as provide good cooling properties.

Regarding the internal-body magnesium is also a possible material to use, if adapted to withstand being exposed to the air. Through the LCA-process it was concluded that the use of magnesium holds a greater environmental impact during production than aluminium. However it is lighter which means that it will hold lesser environmental impact in regard to transportation, why it should be further analysed as a possible material to use. Only using recycled aluminium would be the easiest and probably most suitable material improvement to minimise the environmental impact.

A third, not fully concluded if it is a possible material to use, would br to use a plastic material as the internal-body. It would lower the weight of the product drastically making the environmental impact from transportation far less.



1 *Sun-shield* → ASA - injection moulded, plastic which excludes the need to wet-coat
→ Textile suncover with a rigid frame, withstanding outer forces → better cooling
2 *Internal-body* → Aluminium, focus on only using recycled aluminium minimise spill
→ Magnesium, lower the weight drastically
→ Plastic material will lower the weight
3 *Carrying feature* & Feet → Aluminium, recycled or plastics such as Polyamide or PET → Lighter
4 *Overlay (interface)* → Organic plastics
→ Inscript the overlay into the core/body → Excluding yet another plastic material
5 *Screws* → Focus on using the same size and type of screws. Minimise the use if possible

Picture 4.23 - Updated Map of materials. Regnér (2012).

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Improving the product feet and carrying feature goes under the same statements as the internal-body. If a plastic material is used the weight will be lowered enabling better transportation.

When looking at the overlays an organic plastic would be preferable, possible to break down during the recycling process. One possible idea is to exclude the overlays and instead mold or mill the indications into the internal-body. This would mean that less material will be used as well as minimising the use of many different materials

The screws are commonly made from a stainless steel. There are not many improvements possible here. However as stated during the sustainability analysis, there is a need to minimise the use of screws. If used they are always to be made from the same material and of the same size if possible, enabling better assembly and disassembly.

The map shall provide ideas on how product can be further developed in regard to materials. The sketch is will not be final decision on materials however provide a different approach to the choice of materials and design. See Picture 4.23 - Updated Map of materials.

4.3 Sustainable Design Guidlines

The result from the sustainability analysis will be summarised as a number of guidelines which can be regarded in the future design process. They are also important to regard by other departments of Ericsson AB, to improve the products' environmental impact during production, transportation, usage and end-of-life.

4.3.1 Materials - Sun-cover

- Adapt the material after the market where it shall be sold and used. In the US where the fire-requirements are high, one material can be used. A product used at a different market can hold materials better adapted to these requirements. More materials are possible to use to solve the specific task, without "over-dimensioning"
- Always use the best, most suitable, and most sustainable material possible
- Chose materials which demands minimum toxic solvents in the process of production and coating. Especially in plastic parts which have to be wet-coated, exclude these materials if possible
- Design and use of materials which are possible to use on many products and parts
- Minimise the use of many different materials in one product, as well as within the product family
- Regard the possibility of using "out-of-the-box" materials and methods such as textile sun-covers and handles
- Use materials which are possible to recycle and reuse, so that the lifecycle of the product can be prolonged (C2C)
- Minimise the use of materials which are dumped as landfill when the product has "fulfilled its services"

4.3.2 Materials - Internal-body

- If aluminium shall be used, use recycled aluminium to as large extent as possible
- More effective cooling can mean that different as well as less materials can be used. For example the new and innovative type of fans which enables a different approach to cooling, can be used to

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minimise the material use. Dyson (2012)

- Look over the possibilities of using alternative materials such as magnesium where corrosion does not occur to the same extent. Minimising the weight of the product means better transportation and handling. Magnesium has to be processed for the material to work for this kind of usage
- Look over the possibilities of using alternative materials such as Polycarbonate or other plastics where corrosion does not occur. Can minimise the weight of the product significantly which means better transportation and handling

4.3.3 Materials - Carrying feature

- Maybe look into different materials which are lighter and in less risk of corroding, especially if mechanical features will be implemented in the handle
- Plastic materials might be a possibility
- Regard the possibility of using textile materials
- Regard the possibility of integrating the handle into the material using for example biomimicry (Gecko-grip) Griggs (2008).
- Use of a stronger material will mean that a less material will have to be used to secure the same strength. Possibly composite materials
- Modular handles, possible to fit to most portable products within Ericsson AB's product family would minimise the environmental impact as well as minimise R&D

4.3.4 Materials - Screw joints

- The screws shall be adapted to only use one material if possible
- Only use one size screws if possible
- Possibility of using one type of screws for indoor-use and another type for outdoor-use. No need for "over-dimensioning" of screws through using to advanced materials or to large screws

4.3.5 Materials - Paint

- Focus on using powder-coating and colouring within the production process to as large extent as possible
- If possible use materials which do not need paint and other coating to withstand outer forces over a 10 year period
- Minimise or exclude the use of wet-coating
- Control the coating process and performer, to secure minimum use of toxic solvents. The latest and best process possible shall be used
- Control the paint and the binding material used. This can affect both the workers applying the paint as well as negatively affect the environment. Choose the best paint and method possible. Polyethylene rather than epoxy as binder when applying powder-coating
- Chose paint that is not affected negatively by outer forces, shortens the visual and physical lifespan of the product
- Wet-coating is very expensive and time-consuming, money can be saved by excluding this process. Stand for up to 50 % of the total production cost of the sun-covers
- Each colour and tone is derived from specific chemicals/metals and methods. Adapt Ericsson AB's design-values and use the most environmentally friendly colour palette possible

4.3.6 Materials - Packaging materials

- Modularise packaging materials, means that less development and adaptation of packaging materials will have to be used. This will also lead less buying of different materials and production-tools. Possibility of reusing packaging materials
- Minimises the use of different materials. This will increase the possibility and ease recycling
- Focus on using recyclable, organic and reusable packaging materials
- Adapt products and hardware design to enable more modular and better packaging materials

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- Minimise the weight of packaging materials for less environmental impact through more effective transportation
- Use present or develop modular, adaptable and reusable packaging straps
- Set up a system for returning of and reusing packaging material. Many of the packaging materials such as loading pallets can be reused many times. Offer a reward if packaging material is recycled, reused or possibly returned to Ericsson AB

4.3.7 Materials - Control of materials

- Try to further control materials and where they originate from. Put pressure on sub-contractors to better declare their methods of work, their sub-contractors and where the material originates from
- Ericsson AB shall further develop the requirements on environmental impact and human rights towards their sub-contractors. It is good that this process is present, however it is an iterative process which has to be continually developed and expanded
- Minimise the use of production-sites of companies who does not regard work- and service-conditions. It provides Ericsson AB with bad publicity and negatively affects both in regard to environment impact as well as human rights
- If possible, use Ericsson AB-owned production-sites where materials, methods used and work-conditions can be better controlled and regulated
- Inform all departments within hardware R&D with material declarations and what productions-sites that can produce certain parts. It will be easier to design in regard to environmental aspects and human rights if the developers at Ericsson AB can adapt design and development to the best possible production-sites
- Put pressure on the Asian market to start using recyclable aluminium extensively. If a large actor like Ericsson AB puts pressure and demands this, other actors might follow and a change will occur much faster. A large part of the corporate responsibility

4.3.8 Production

- Centralise all production to one specific production-site in each continent to as large extent as possible. This will minimise transportation and ease the control of the production-site.
- Today when a production-site is regarded to not follow Ericsson AB's requirements, this production-site should be cancelled and the production moved. Pettersson (2011). This demands a lot of work and costs. If the production-sites instead are controlled better at an earlier stage as well as centralised, Ericsson AB can save money and fulfil the corporate responsibility better
- Hold production and assembly close to each other to minimise unnecessary transportation
- Put up more local production-sites in places like South America and Asia. This will minimises the transportation. Centralises production and assembly is easier to control
- Minimise spill and low quality production, which is detected during assembly. This can be done by better controlling of the production process
- Adapt design to minimise spill and low quality production
- Always use the latest most effective method of production to minimise the negative impact on the environment

4.3.9 Production - Aluminium

- TATFOOK is the major production-site in Asia for aluminium die-casts. They provide good quality products and is by Ericsson AB regarded as a reliable sub-contractor. Centralise all or most production to TATFOOK which would mean better control of production, less transportation and securing good quality to all products produced and sold in Asia/East Asia
- Control quality so that minimum new aluminium is used to obtain the requirements of pure aluminium

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4.3.10 Production - Plastic details

- Use organic plastic details in as large extent as possible.
- Get more out of the production-tools when using plastics instead of metals. 20 times the moulds/die-cast from a tool made for plastics instead of metals. Fewer tools need to be made which means less material discard. Possibility to save money
- More modular parts will mean that less tools for production have to be made and designed. Faster and easier production
- Minimise the use of wet-coating on plastic details
- Integrate colouring of plastic details within the production process if possible, coloured granulates

4.3.11 Production - Assembly & disassembly

- Less parts and modularity enables easier and faster assembly and disassembly
- Use the same type of materials and size on fasteners for faster and easier assembly and disassembly
- Assembly close to the place where the product is being sold. Faster delivery and less transportation

4.3.12 Modularity

- Modularise all loose parts so that they can be used on most or all of Ericsson AB's portable products. Carrying features, product feet and possibly other major parts can be developed to be fully modular
- Adapt the internal-body like the RRUS 02 & 12, where the internal structure is possible to rearrange for modularity of the internal features. Modular walls made from rubber instead of fixed die-casted walls. Provides the product with larger usage possibilities. Less development and adaptation of internal-bodies will be needed when a new product is to be launched
- Possibility of making the cooling system of cooling flanges modular. One type of internal-body can be used with many different products by adding cooling flanges which provides the accurate cooling aspects. The cooling flanges are mounted onto the internal-body. This means that a product can be provided with a longer life. It can be upgraded in regard to telecom generations, performance and cooling
- Use one kind of screws, screw size and fasteners on all products. Better modularity, easier assembly and disassembly
- Modularise the cable-connections for easier adaptation to different products
- Make all products modular like Ericsson AB's cabinet-based products, possibility of swapping the internal parts for easy service and upgradability. This provides better modularity and longer lifespan of the product

4.3.13 Upgradability

- Develop hardware which is upgradable, by modularise the product to as large extent as possible. Provides longer lifespan of the product
- Possibility of face-lifting products, prolongs the visual life of the product

4.3.14 Reuse & Recycle

- Develop the possibility of a 2nd-hand market for Ericsson AB's products and enable selling of used products to other markets where they are still up-to-date. Reuse of the products
- Focus the design to adapt it towards Design for Disassembly for better recycling and servicing of the products
- Minimise the use of different material enables better, cheaper and easier recycling. It is hard to recycle different plastic materials used together. Enable each plastic to be separable from another and clearly mark them if many different plastics are used
- Hold reparation and service stations locally where the products are being used. Enables fast and effective service as well as minimises transportation
- Educate R&D and the entire Ericsson AB organisation how and to what extent recycling is performed. Clearer information and more transparency within the organisation in regard to sustainability and recycling
- Communication between departments such as R&D and sustainability/recycling to achieve optimal

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results in regard to sustainability and recycling adapted hardware design

Reuse & Recycle - Design for Disassembly, DfD

- Use only one type of fastener if possible
- Same size on all fasteners/screws
- Minimise use of complicated snap-buckles
- Minimise the use of fasteners
- Strategic placement of fasteners
- Easy access to all fasteners
- Focus on adapting products to be fast and easy to disassemble, DfD
- Design products to minimise the risk of parts breaking when repairing and servicing the product
- Minimise use of many different materials (See guideline above - Reuse & Recycle)
- Group similar elements and parts of the same material
- Mark all parts and materials for easy identification when disassembling the product
- Focus DfD towards both servicing and recycling (not only servicing, as today)
- Modularise the hardware design to minimise discarding of parts when broken
- Implement DfD for service and recycling into all hardware R&D departments, not only industrial design
- Implement DfD as a major factor within Ericsson AB's design-values as well as ONE-Ericsson. Important to have a guideline and a way of performing DfD within the R&D of new products

Reuse & Recycle - Cradle to Cradle, C2C

- Cradle to Cradle - use organic materials so that the product will have a longer life cycle
- The choice of materials and design shall be adapted to be as reusable and recyclable as possible. This minimises the production of new material and prolongs the total usage of the products.
- Using this philosophy of C2C when designing products, should be the obvious choice in the R&D of new products. Ericsson AB should make a Cradle to Cradle way of working in the R&D process and implement it on every part of their hardware design. By doing so, Ericsson AB will differentiate themselves from their competitors, as well as take their corporate responsibility to another level. C2C can and shall be regarded in all steps of hardware design, from circuit-boards to handles

4.3.15 Transportation

- Hold production, assembly, usage, servicing and end-of-life all close together to minimise transportation. Produce and assemble locally
- Focus transportation on environmental issues as well as cost and time. This can be done through better planning within the R&D, production as well as sales
- Better communication between departments at Ericsson AB can enable different and better transportation methods being used
- Better and lighter products which means easier transportation of heavy goods as well as better usability and handling
- Minimise the use of air-freight
- Focus on using boat- and train-freight
- If air- and road-freight has to be used, control so that the best and cleanest vehicles are used
- Locally production and assemble - faster delivery and less risk of competitors offering their products to the customers before Ericsson AB
- Compromise by delivering first and most important batch by air-freight, if needed, and deliver the rest of the batches by boat- or train-freight
- Subtle design on Ericsson AB's products means that less space is used during transport - more products can be transported at once

4.3.16 Quality

- Adapt quality to the lifespan of the product
- Adapt quality to the customer and their preferences

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- Adapt quality after the rapid development of new technology
- High quality means less breakage, less production of new replacing parts and less transportation
- Minimise and control spill by having high quality on the production and assembly.
- Adapt product quality after the environment the product is being used in. No need for over dimensioning of quality if not needed, required or asked for
- Control production to minimise the use of toxic solvents to achieve specific qualities. Can be done by adapting the quality to purpose, as well as controlling production
- Put pressure on sub-contractor to produce more sustainably and adapt quality to production

4.3.17 Usage

- Develop more energy efficient products by adapting design and materials
- Include or integrate solar-cells or wind-power "absorbents" into the cooling-system to reduce "land-based" energy infusion usage
- Adapt internal parts and features, efficiency-wise, to the environment the product is being placed in

4.3.18 Design for Environment, DfE

- Set up a system of regarding environmental requirements early in the R&D process
- Make sure that one professional actor from the department of DfE and other environmental departments are present throughout the whole R&D process.
- Possibly retain the knowledge of an environmental engineer with design experience within the industrial design department. This would further improve the environmental aspects of the design process. It can also improve the product as a whole
- If the two previous steps are not possible, or in combination of these two steps, include a environmental co-ordinator who can implement all environmental requirements to the extent needed in the R&D process
- Create a closer connection between the departments of DfE and industrial design. These two should work hand in hand to accomplish optimised sustainable product design
- The recommendations set by the DfE department tend to not be regarded in the extent needed. These recommendations shall be better regarded and possibly set up as mandatory requirements together with the law-based requirements
- Base the environmental requirements not only on governmental laws. Other factors shall be regarded to accomplish optimised sustainable design
- Just as the design-values, Ericsson shall develop and implement a unified sustainability language which corresponds to the company's values and sustainability aim. This sustainability language would better adapt all products to a unified sustainable profile. It will also be easier for the designers and engineers to know how to work and what to strive for when developing new products, in regard to environmental impact reduction and sustainability

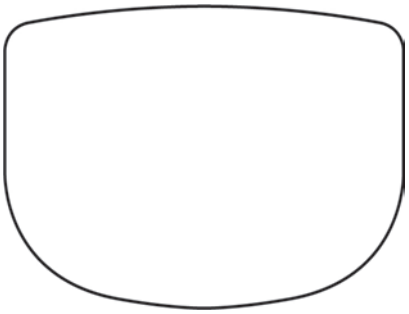
The sustainability design guidelines shall be regarded within all future product development to optimise products in regard to minimise the negative environmental impact during its lifecycle.

5. RESULT - HANDLE REDESIGN

5.1 Design

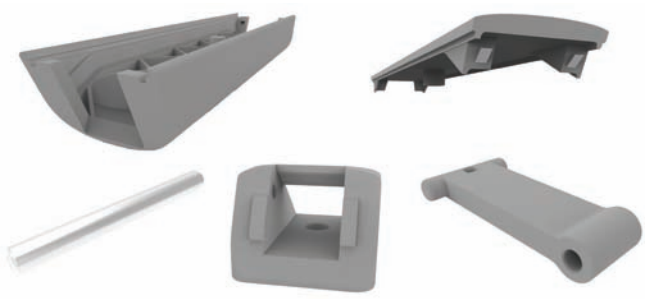
The final concept of the carrying feature is a flexible handle using a sliding function to enable carrying however yet be slim and subtle. It is refined and optimised from the previous carrying features developed and evaluated during the design phase. This concept will act as a carrying feature which Ericsson AB can test, benchmark and further develop to add another innovative product to their product family. The carrying feature is ready to use however needs to be further developed with regards to dimensions, calculations as well as material selection if Ericsson AB wants take it into production.

The design of the final carrying feature concept is a slim subtle handle which enables good and steady handling and carrying. The shape of the carrying feature has after consultation with Sr Industrial Designer HW Usability - Ericsson AB, Mats Johansson, and evaluation of mock-ups been concluded to a rounded bottom shape with a flattened top surface. This provides good ergonomic properties but at the same time allows the carrying feature to be slim and subtle. The flattened top-surface is slightly rounded to be more comfortable. This also gives a more unified and suitable visual expression which is corresponding well with the shape of many of Ericsson AB's products under development, "squarish" shapes with rounded features. See Picture 5.1 - Final shape of the redesigned carrying feature.



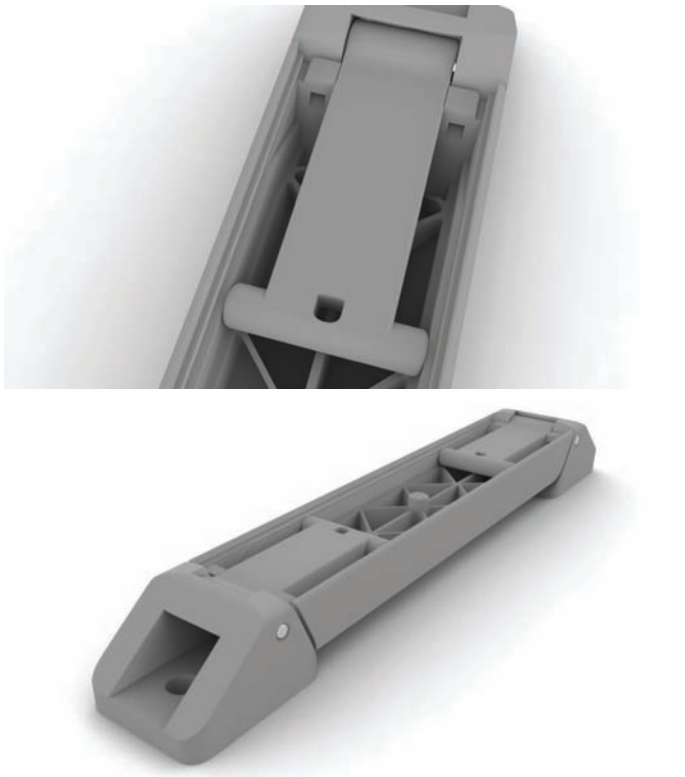
Picture 5.1 - Final shape of the redesigned carrying feature. Regnér (2012).

The carrying feature is designed as four major parts, the grip-area which is consisting of a lid and a solid hollow "body", two arms and two base-plate brackets. To this a spring is added which enables the carrying feature to subtly retract back into the low "0-position" after interacted with. See Picture 5.2 - Parts of the redesigned carrying feature.



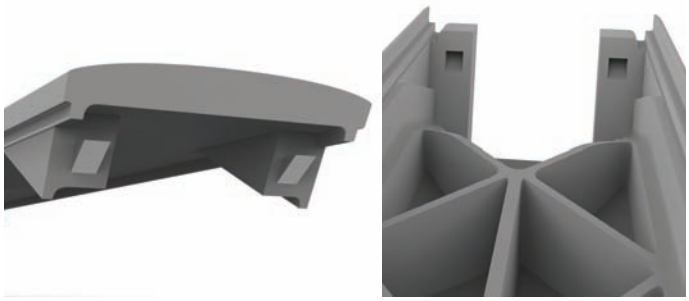
Picture 5.2 - Parts of the redesigned carrying feature. Regnér (2012).

The arms slide within the body of the grip-area, enabling the carrying feature to take on different positions when interacted with and when not used. See Picture 5.3 - Arms fitted inside carrying feature.



Picture 5.3 - Arms fitted inside carrying feature. Regnér (2012).

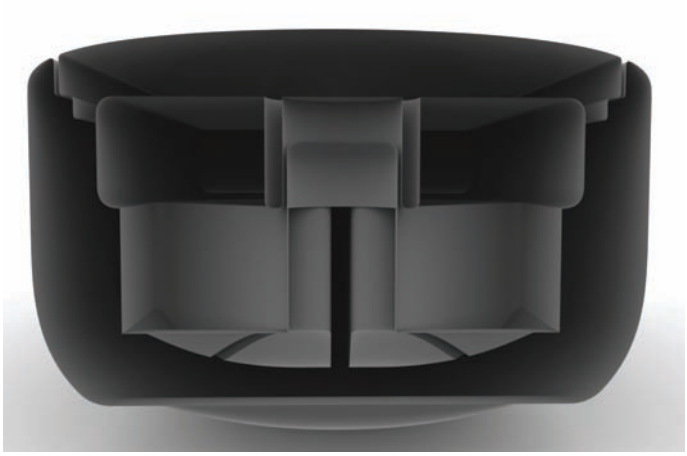
The lid is fitted onto the hollow body of the grip-area, locking the arms into place. The lid is fitted through snap-buckles placed on the inside of the ends of the lid, locking into the end inside the hollow grip-area body. See Picture 5.4 - Snapp-buckles, lid and grip-area body. It is also fitted in the middle by press-fitting of two axles. See Picture 5.5 - Handle as a half. The lid holds a hollow tube which is fitted around a rod sticking up from the inside of the body of the grip-area. This press-fitting enables better locking of the lid and the body however its main function is to enable fitting of the spring. See Chapter 5.9 - Spring.



Picture 5.4 - Snapp-buckles, lid and grip-area body. Regnér (2012).

Between the lid and the grip-area body is a controlled split-line of 0,2 mm on each side. This enables a smooth transition between the parts and secures that no sharp edges are present which will mean uncomfortable handling. See Picture 5.5 - Handle as a half.

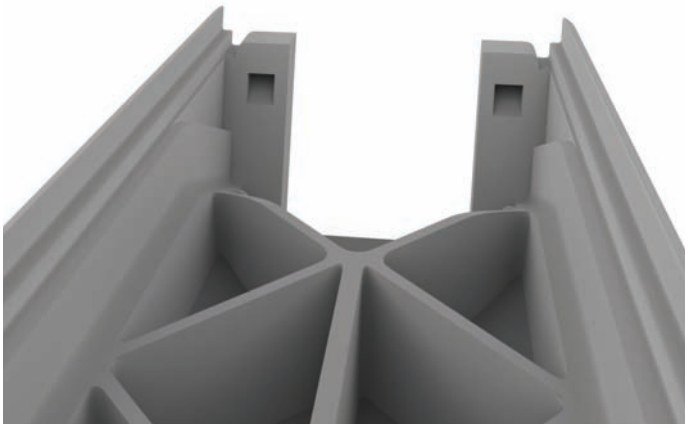
5. RESULT - HANDLE REDESIGN



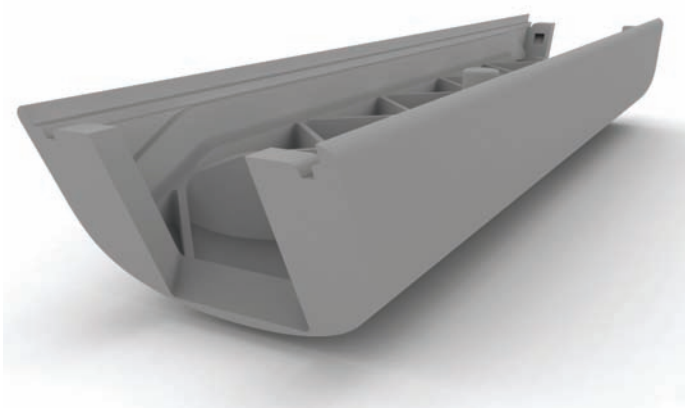
Picture 5.5 - Handle as a half. Regnér (2012).

The slots in which the arms slide, runs along the inside of the grip-area body. They slope 45° towards the ends to enable the arms to better lock into a steady position when the carrying feature is up. See Picture 5.6 - Inside of the grip-area showing the slots and slats, See Picture 5.7 - Perspective veiw of the handle showing the slots.

In each end of the grip-area body where the length of the arms meets the grip-area, a flat surface is placed which lock the arms from swaying back and forth when the carrying feature is interacted with. See Picture 5.7 - Perspective veiw of the handle showing the slots.

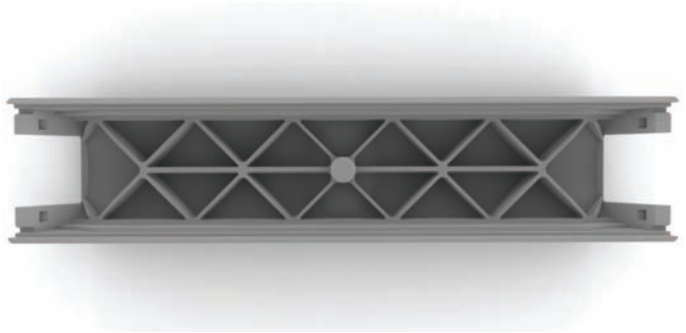


Picture 5.6 - Inside of the grip-area showing the slots and slats. Regnér (2012).



Picture 5.7 - Perspective veiw of the handle showing the slots. Regnér (2012).

The hollow body of the grip-area holds a material thickness of approximately 3 mm all over. See Picture 5.5 - Handle as a half. To strengthen the design further a diamond-shaped pattern of support-slats are placed inside. See Picture 5.8 - Grip-area from above with diamond shape slats. The slats provide good strength which means that the grip-area can withstand all the forces put upon it when interacted with. A hoisting groove is placed in the centre of the bottom of the carrying feature, which enables better CoG hoisting. See Picture 5.9 - Handle from the side with hoisting groove. The slats provides extra strength here, as this is otherwise a weaker section. The slats are made 1 mm thick, which is preferable. This provides enough strength as well as minimising the risk of sink-marks in the plastic. Andersson (2012). In the middle of the diamond-shaped slats an along running slat is splitting the diamond shape. See Picture 5.8 - Grip-area from above with diamond shape slats. This along running slat secures that the spring can slide smoothly and freely within the grip-area without getting stuck on the other slats. The middle-slat also provides extra strength to the carrying feature.

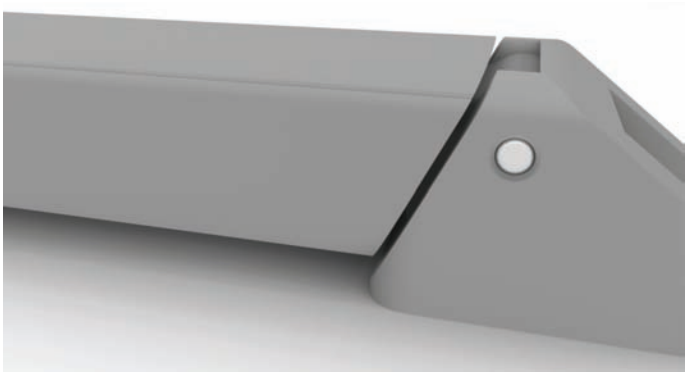


Picture 5.8 - Grip-area from above with diamond shape slats. Regnér (2012).

Picture 5.9 - Handle from the side with hoisting groove. Regnér (2012).

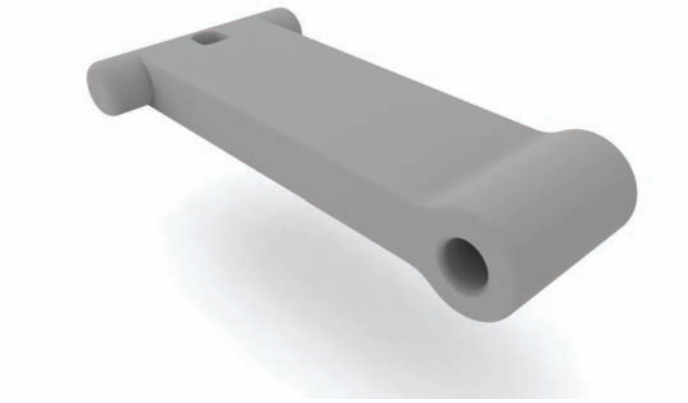
Between the grip-area and base-plate brackets is a split-line of 1 mm. See Picture 5.10 - Split-line between Grip-area and brackets. This split-line distinguishes the different parts and indicates that interaction can be possible. It is also designed to the specific distance as this enables a controlled split between the parts. It allows some differentiation of the materials depending on weather without disturbing the semantic expression. The split is made honest and distinguished by having a controlled straight split-line. This provides a more raw, mechanical and honest expression coinciding well with the semantic expression of Ericsson AB's design-values. ERICSSON AB - Design-Values (2011).

5. RESULT - HANDLE REDESIGN



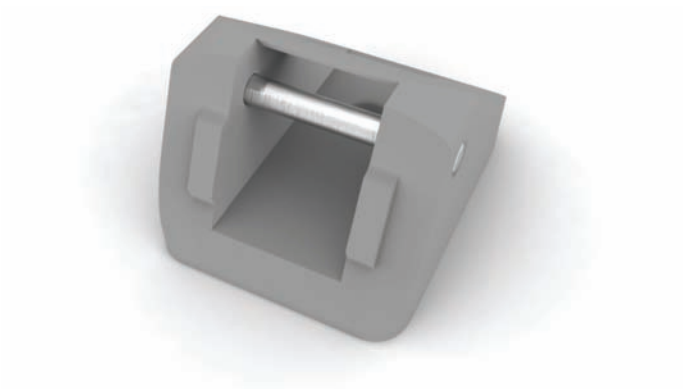
Picture 5.10 - Split-line between Grip-area and brackets. Regnér (2012).

The arms hold an axle diameter of 5 mm with a length of 44 mm. This allows the arms to slide within the slots of the grip-area body. See Picture 5.11 - Arm. The dimensions are well enough to withstand the forces of lifting products up to 240 kg, 6-times the maximum weight of any product contemplated to hold this concept carrying feature. The thickness of the arm is set to 5 mm, just as the inside sliding axles. The end part of the arms fitted to the base-plate brackets are made somewhat thicker. See Picture 5.11 - Arm. Instead of axles sticking out from this end of the arm, a 3 mm steel axle is fitted and screwed through the base-plate bracket running inside the end of the arm. See Picture 5.12 - Axle. As a 3 mm axle is fitted through the end of the arm, this end has to be widened to 8 mm instead of the 5 mm. Widening the end of the arms with 3 mm, provides enough material to withstand the forces of lifting a heavy product. Andersson (2012). See Picture 5.13 - Axle fitted to the bracket, See Picture 5.10 - Split-line between Grip-area and brackets. The end of the arm is still slim enough to fit within the base-plate bracket and enable a screw to be fitted, to secure the base-plate brackets and carrying feature to the top of the product. The arm holds a length of 44 mm which is enough to allow the carrying feature to stand 40 mm above the top of the RRU. This is well adapted to the necessary ergonomic aspect which allows the user to properly and comfortable interact with the carrying feature. Johansson (2012).



Picture 5.11 - Arm. Regnér (2012).

Picture 5.12 - Axle. Regnér (2012).



Picture 5.13 - Axle fitted to the bracket. Regnér (2012).

The carrying feature is designed to work well on products of up to 40 kg, however it works just as well on lighter products. The only limitation is that the C-C measurement of 160 mm has to correspond with the product's C-C measurement. The carrying feature also has to fit within the length of the internal-body. See Picture 5.14 - Redesigned carrying feature fitted to Ericsson AB RRUS 12. This means that the carrying feature can be fitted to many of Ericsson AB's portable products, except from some of the older products where the C-C measurement is not corresponding.

Picture 5.14 - Redesigned carrying feature fitted to Ericsson AB RRUS 12. Regnér (2012).

5. RESULT - HANDLE REDESIGN

The carrying feature will be visible above the sun-cover when looked straight at, by only a few millimetres. However as of its slim and subtle design, when the product is looked at from a slight upward-angle, the carrying feature will be fully hidden not intruding on the semantic expression. See Picture 5.15 - Carrying feature seen front on fitted to RRUS 12., See Picture 5.16 - RRUS 12 fitted with the redesigned carrying feature seen slightly from below.

Picture 5.15 - Carrying feature seen front on fitted to RRUS 12. Regnér (2012).

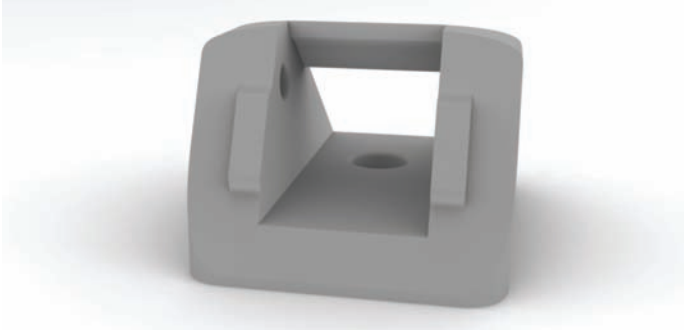
Picture 5.16 - RRUS 12 fitted with the redesigned carrying feature seen slightly from below. Regnér (2012).

5.2 Appurtenant

The carrying feature is designed as being a part of the internal-body holding these semantic and colour values. The carrying feature is made from the same greyish tone, subtly coinciding with the rest of the rougher internal-body. It will be partly visible just above the upper sun-cover edge, however not interfering with the semantic expression. Ericsson AB's design-vlues allows for the internal-body surfaces to show in the cut-outs of the sun-cover. ERICSSON AB - Design-Values (2011).

5.3 Base-plate brackets

The base-plate brackets were made open and "honest", just as discussed in the final design evaluation. Raw straight lines and open in the middle to show the mechanical features of the swinging arm and the screw, fastening the base-plate brackets and carrying feature to the top of the RRUs. See Picture 5.17 - Base-plate bracket. All screws and axles are fully visible and not hidden from sight. This mechanical expression provides a quality experience as well as indicates that the carrying feature holds technical functions. The top of the base-plate brackets follows the shape of the grip-area with a curvature transition. This transition is broken off by the intended split-line between the base-plate brackets and the grip-area of the handle. See Picture 5.10 - Split-line between Grip-area and brackets. The edges and slopes are made with minor rounds to indicate a rougher and steadier appearance. This also corresponds with Ericsson AB's design-values where the carrying feature is seen as a part of the rougher internal-body. ERICSSON AB - Design-Values (2011). The carrying feature is slim and subtle yet hold a semantic expression which distinguishes it as an individual part in the Ericsson AB product family. The base-plate brackets hold the height of the grip-area, 20 mm, and slopes backwards. This provides a slimmer and more subtle look. The base of the base-plate brackets is made 5 mm thick. This enables the material to withstand the forces put upon the carrying feature during interaction. The bas-plate brackets are screwed through the base onto the top of the RRUs by M6 bolts. Andersson (2012). See Picture 5.17 - Base-plate bracket.



Picture 5.17 - Base-plate bracket. Regnér (2012).

5. RESULT - HANDLE REDESIGN

The base-plate brackets hold the same width as the grip-area, 28 mm. They are however not slimmed down in the bottom. Instead are rounded bottom corners applied to visually portray a slimmed down base-plate bracket corresponding with the grip-area. See Picture 5.10 - Split-line between Grip-area and brackets, See Picture 5.13 - Axle fitted to the bracket, See Picture 5.18 - Width of the carrying feature. The base-plate bracket holds the same width at the bottom as the top, due the fact that it has to stand firmly when mounted onto a product.

Picture 5.18 - Width of the carrying feature. Regnér (2012).

Connecting the arms to the base-plate brackets is done through inserting two axles through the ends of the arms and the base-plate bracket locking the arms and base-plate brackets together. See Picture 5.13 - Axle fitted to the bracket. The hole in the arm and the base-plate brackets are made with 0,2 mm tolerance to allow the arms to smoothly and freely, yet with a tight fit, swing around the axles. The axles are screwed into the base-plate brackets to secure them.

The part of the base-plate brackets which meets the grip-area when the handle is in its "0-position" hold a small area sticking out. The part sticks out 1 mm and secures the split-line between the parts to the set distance. See Picture 5.13 - Axle fitted to the bracket, See Picture 5.17 - Base-plate bracket, See Picture 5.19 - Part securing split-line between Grip-area and brackets.

Picture 5.19 - Part securing split-line between Grip-area and brackets. Regnér (2012).

5.4 Function

The carrying feature works as previous evaluated concepts of enabling flexibility through two arms which slides within the body of the grip-area. See Picture 5.3 - Arms fitted inside carrying feature.

The arms are pulled inwards inside the grip-area which pulls the grip-area down till the arms are hidden inside. At this stage the grip-area has been pulled down till it meets the base-plate brackets and the small area securing the set split-line of 1 mm. See Picture 5.20 - Carrying feature fully assembled, perspectiv & above.

Picture 5.20 - Carrying feature fully assembled, perspectiv & above. Regnér (2012).

What controls this descend of the grip-area is both gravity, but mainly a spring placed inside the carrying feature connected to the inner end of each arm. See Picture 5.28 - Single spring. The spring retracts the arms which pulls the grip-area down to a subtle position in a controlled way.

The mechanical solution is simple; a sliding function in one end and a rotating function in the other end of the arms. As the parts, enabling flexibility, are the parts which are in risk of failing through fatigue, these have been designed in regard to withstanding the forces of up to 2400 N. This is possible through using a strong reinforced plastic material.

The sliding arms controlled by the spring which secures that the carrying feature always takes on a subtle "0-position" when not used. The spring also controls a smooth and comfortable handling when pulling the grip-area upwards to enable handling of the product.

5. RESULT - HANDLE REDESIGN

5.5 Ergonomics

The shape of the carrying feature is designed in regard of being comfortable to handle and provide good ergonomic aspects. The grip-area holds the necessary dimensions to provide a good power-grip when interacted with. It is 28 mm wide and 20 mm high, which gives an approximate diameter of 28 mm, regarding that the carrying feature is semi circular. See Picture 5.1 - Final shape of the redesigned carrying feature.

The ergonomic requirements are 25-40 mm in diameter for products heavier than 18 kg. Johansson (2012). The RRUs 12 weighs 25 kg so the set diameter of 28 mm is well within the requirements of good ergonomic dimensions.

The recommendations from Sr Industrial Designer HW Usability – Ericsson AB, Mats Johansson of good ergonomic aspects regarding handling heavy products, states that 40 mm of free space is needed around the carrying feature, in all directions. The redesigned carrying feature concept stands 40 mm above the top of the RRUs which corresponds well with the recommendations. See Picture 5.21 - Carrying feature up, grip-space, See Picture 5.22 - Carrying feature up fitted to Ericsson AB RRUS 12.

Picture 5.21 - Carrying feature up, grip-space. Regnér (2012).

Picture 5.22 - Carrying feature up fitted to Ericsson AB RRUS 12. Regnér (2012).

The hoisting groove placed in the centre of the carrying feature enables the user to more easily grab the handle. It provides a kind of indication of the carrying feature being possible to interact with. This improves the cognitive ergonomic aspect of interacting with the carrying feature. See Picture 5.9 - Handle from the side with hoisting groove.

5.6 Material

For the final concept a plastic material is chosen, just as suggested and discussed in the finalisation of the carrying feature design. The concept is thought to be produced from PA-66, a Polyamide plastic which is suitable for heavy-duty products, or possibly a PET plastic which also fulfils the demands and requirements. The plastic can be injection-moulded into the desired shape of the individual parts of the carrying feature. Both materials hold a very high tensile strength and are weather resistance. To strengthen the material further, the plastic shall be fibre reinforced which provides extra strength in the direction of the tension. Pettersson (2012).

Other good aspects of using one of these two material is that they can be coloured within the production phase. This means that any after-production colour treatment can be excluded. The colour of internal-body can be controlled to precise accuracy when producing the parts. Pettersson (2012).

Both materials are regarded as fully possible to use within a future production, as the fire requirements are lowered. They are both safe to use as well as minimises the environmental impact due to no need of after-production colouring.

What material to finally select is a decision of Ericsson AB, however one of these two materials is recommended to use due their good qualities and fulfilment of the companies requirements.

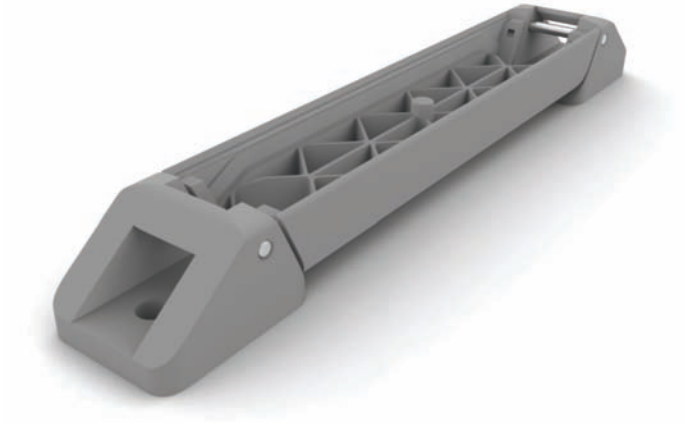
The tensile strength and durability of the material is seen as equal, this also goes for weather resistance and production methods. PET plastics are commonly used, why using this material can indicate easy access of recycled plastics. This would embrace the sustainability aspect. However, Polyamide is commonly used as a construction plastic, why its performance can be concluded as reliable. Polyamide is also easy to reinforce by adding fibres during production. Pettersson (2012).

Which material that is most suited to be used in this carrying feature can be established by checking what production-sites are previously used by Ericsson AB and what material is preferred there. Cost and availability are other aspects which will help to establish what material shall be used. Which of the two materials that is most suitable is left open for Ericsson AB to decide when and if the carrying feature is taken into production.

5. RESULT - HANDLE REDESIGN

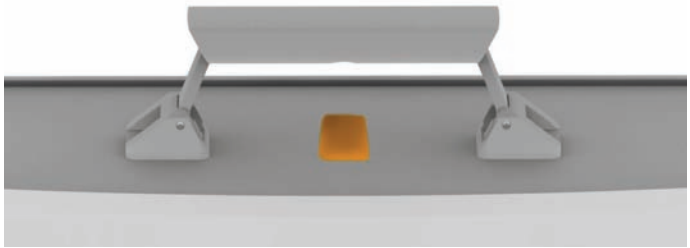
5.7 Assembly

The carrying feature consists of nine different parts, two arms, two base-plate brackets, two axles, one grip-area body, one grip-area lid and one spring. The carrying feature shall be assembled at the production- or assembly-site. The arms are connected to the spring and placed inside the grip-area where the lid locks the arms and spring inside the grip-area. See Picture 5.3 - Arms fitted inside carrying feature, See Picture 5.23 - Carrying feature without arms and lid. This is done easily and quickly by the snap-buckles locking the lid onto the grip-area body. When these parts are assembled the arms are connected to the base-plate brackets by the steel axles securing and finalising the assembly of the whole carrying feature. See Picture 5.20 - Carrying feature fully assembled, perspectiv & above.



Picture 5.23 - Carrying feature without arms and lid. Regnér (2012).

The carrying feature is then shipped to final assembly-sites where it shall be mounted onto the product by two M6 bolts. This assembly shall be as quick and easy as possible why the screw-holes has been designed to be easy to access. See Picture 5.14 - Redesigned carrying feature fitted to Ericsson AB RRUS 12, See Picture 5.15 - Carrying feature seen front on fitted to RRUS 12., See Picture 5.16 - RRUS 12 fitted with the redesigned carrying feature seen slightly from below, See Picture 5.24 - Carrying feature up fitted to Ericsson AB RRUS 12., See Picture 5.25 - Carrying feature fitted to Ericsson AB RRUS 12 from above, See Picture 5.26 - Carrying feature up fitted to Ericsson AB RRUS 12 front on, See Picture 5.27 - Carrying feature fitted to Ericsson AB RRUS 12 zoom.



Picture 5.24 - Carrying feature up fitted to Ericsson AB RRUS 12. Regnér (2012).

Picture 5.25 - Carrying feature fitted to Ericsson AB RRUS 12 from above. Regnér (2012).

Picture 5.26 - Carrying feature up fitted to Ericsson AB RRUS 12 front on. Regnér (2012).

Picture 5.27 - Carrying feature fitted to Ericsson AB RRUS 12 zoom. Regnér (2012).

5.8. Production

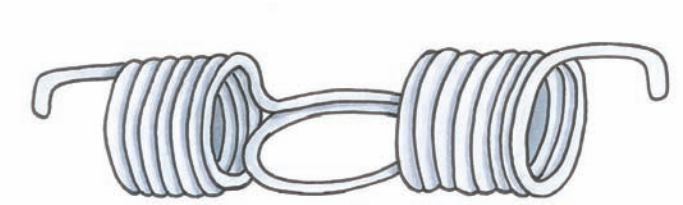
The carrying feature shall be injection-moulded, which enables cheap and fast production. By injection-moulding the plastic parts, very large batches can be accomplished which means low production costs. Moulding the carrying feature by injecting plastic enables a controlled production.

Minor adjustments will have to be made to the design to enable the product to be production worthy. Applying an angle of release is needed to all surfaces for the parts ro smoothly and easily be released from the mould.

5. RESULT - HANDLE REDESIGN

5.9 Spring

The spring secures and enables the carrying feature to smoothly retract into a subtle "0-position" when released from interaction and handling. It shall be made from a stainless steel, which means that it will withstand the outer forces partly exposed to during its lifetime of ten years. See Picture 5.28 - Single spring.



Picture 5.28 - Single spring. Regnér (2012).

After the finished handle was sent for rapid prototype-production, the company making the spring mock-up stated that the desired dimensions on the spring was not possible. The redesigned handle was then already sent away for rapid prototype-production which made things somewhat complicated. The timeframe did not allow any further adaptation within the redesign. The spring was intended to be made as one piece however when discussing it with the mock-up producer, it was concluded that this would be too hard to produce. See Picture 5.28 - Single spring. The spring will instead will be made as two springs. It will perform and look like the single spring however split in the middle as this was easier to produce the mock-up this way. The spring was also initially intended to hold an outer diameter of 4.8 mm wide. However sometime after sending away blueprints of the spring to the mock-up producers, they returned saying that the dimensions was not possible to make. The 5 mm outer diameter had to be change to 10.8 mm which means that minor changes will have to be done to the handle rapid prototype-mock-up. See Picture 5.47 - Spring Mock-up.

The specific spring-tension was initially to be concluded after trying out a number of springs in the span of 10 – 50 N. However, the late issue with the production of the spring mock-up meant that it was only possible to make one spring which holds the dimensions required. The spring-tension will be approximately 28.5, N which is somewhere in-between the recommended span. Andersson (2012). The springs are flattened in the ends which are connected to the press-fitting inside the grip area. See Picture 5.47 - Spring Mock-up. The other outer end of the springs are connected to the inner end of the arms by a hook. See Picture 5.29 - Hole in the arms for connection of springs, See Picture 5.47 - Spring Mock-up. The minimum length of the springs, as two, in the subtle "0-position" of the carrying feature is a total length of 29 mm. When the carrying feature is pulled out the springs are extended to a full length of 114 mm for the two. The maximum length to which the spring can be pulled is set to 68,5 mm each making the it 127 mm for the two.

Picture 5.29 - Hole in the arms for connection of springs. Regnér (2012).

For final spring dimensions See Appendix VIII - Spring dimensions.

If the handle shall be further developed and taken into production, Ericsson AB will have to adapt the handle to fit the new dimensions of the springs. This adaptation is minor and would have been possible if it would have been indicated before the last week of this project.

5.10 Indications, Touch-points

Indications are sometimes used by Ericsson AB to show how and where a part of product is to be interacted with, orange accent coloured touch-point areas. None of the previous Ericsson AB carrying features analysed has been indicated as touch-points, they are regarded as "self-defining" of function by its design. The redesigned carrying feature concept differentiates a lot from Ericsson AB's previous handles. It is much more subtle, and not as "self-defining" in its subtle "0-position".

Due to this fact there is a reason, in one way or another, to indicate that interaction is possible, portraying that this is a carrying feature enabling lifting and carrying. The split-lines between the grip-area and the base-plate brackets together with the hoisting groove in the grip-area can indicate that interaction is possible. Indicating these areas as a touch-point will have both advantages and disadvantages.

The touch-point indication shall not interfere with the semantic expression of neither the carrying feature nor the product as a whole. This led to the decision to not place an orange accent indication on the carrying feature itself. Instead it is portrayed as a line on top of the RRUs internal-body, placed just underneath the grip-area of the carrying feature. This means that the touch-point is not visible from any angle accept from above. This makes the touch-point indication non-intrusive to the semantic expression, yet clearly indicating a possibility of interaction. See Picture 5.14 - Redesigned carrying feature fitted to Ericsson AB RRUS 12, See Picture 5.22 - Carrying feature up fitted to Ericsson AB RRUS 12, See Picture 5.24 - Carrying feature up

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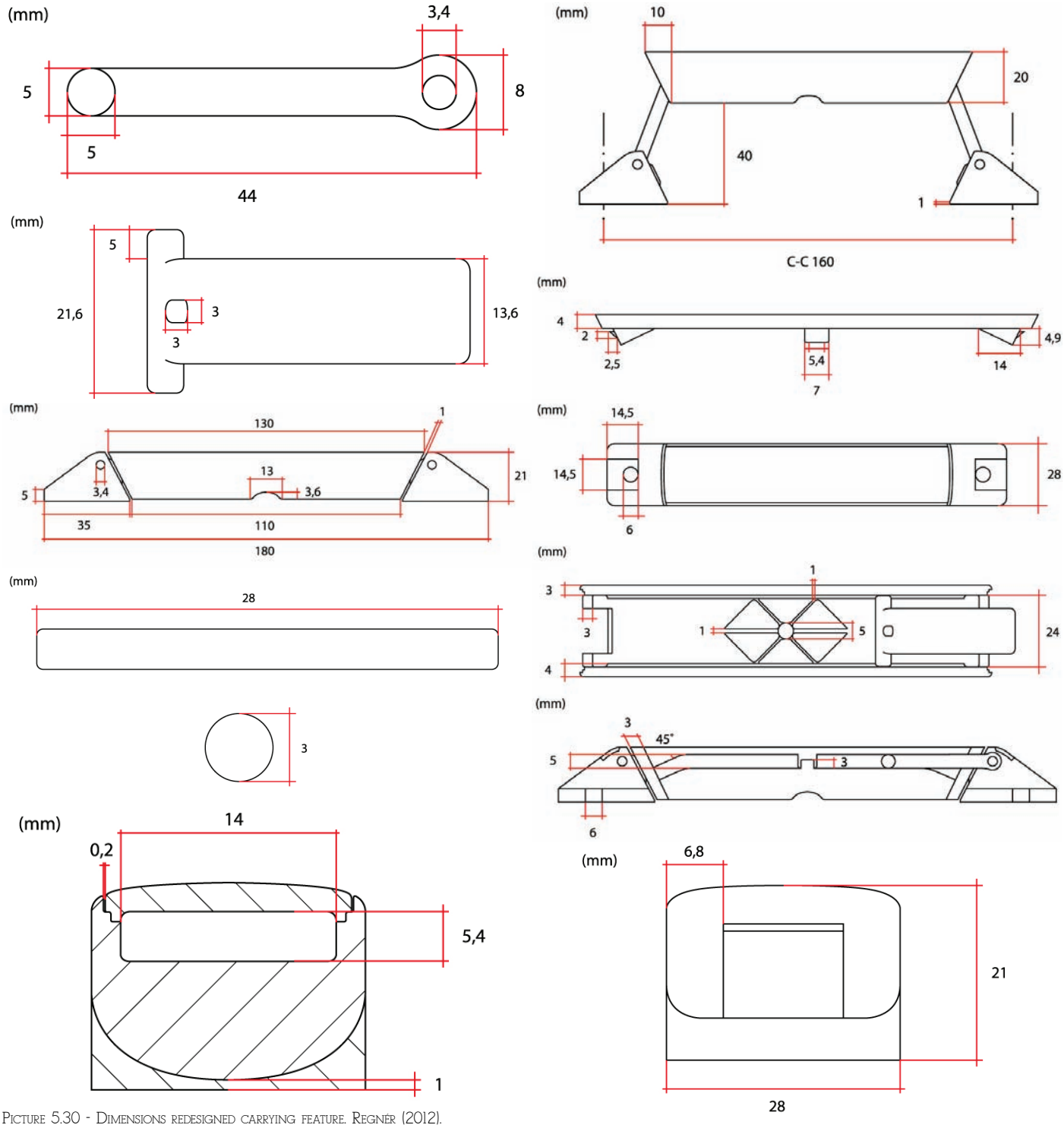
fitted to Ericsson AB RRUS 12., See Picture 5.25 - Carrying feature fitted to Ericsson AB RRUS 12 from above, See Picture 5.27 - Carrying feature fitted to Ericsson AB RRUS 12 zoom.

The indication can either be applied to the internal-body as a layer of paint/powder-coat or as a strip of orange coloured overlay. If not regarded as desirable by the customer it would be easy to exclude if using an overlay-indication.

5.11 Dimensions

The carrying feature is designed to be durable, steady as well as ergonomic. The grip-area holds a total length of 130 mm. However as it slopes in the ends, the area to which the palm grabs is 110 mm. This corresponds to the ergonomic requirements provided by Sr Industrial Designer HW Usability - Ericsson AB, Mats Johansson. The total length of the product including the grip-area and the base-plate brackets is 180 mm. See Picture 5.30 - Dimensions redesigned carrying feature.



Picture 5.30 - Dimensions redesigned carrying feature. Regnér (2012).

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The total height of the carrying feature is 21 mm where the grip-area is 20 mm high. This due to a 1 mm gap between the bottom of the grip-area towards the top of the RRUs. This gap secures deviations in the materials, depending on weather conditions as well as indicates and enables easy interaction. See Picture 5.30 - Dimensions redesigned carrying feature.

5.12 Advantages

There are great possibilities with the redesigned concept carrying feature. It is both very subtle yet provides good ergonomic and handling/lifting possibilities. As the carrying feature is long and low in its design, it will not interfere with the performance of the product. This is a possible problem for the 2011 & 2012 Mobile World Congress in Barcelona concept handles as they can tend to intrude on the semantic expression of the sun-cover and cooling flanges on slimmer products. See Picture 2.48 - Too large handle. This will not be a problem with the new redesigned carrying feature as it will never interfere on the cooling flanges nor the sun-cover. It runs along the width of the product, not the depth as other folding handles does. See Picture 5.14 - Redesigned carrying feature fitted to Ericsson AB RRUS 12., See Picture 5.22 - Carrying feature up fitted to Ericsson AB RRUS 12, See Picture 5.25 - Carrying feature fitted to Ericsson AB RRUS 12 from above.

As Ericsson AB's products in the future will tend to be even slimmer and slimmer, the advantages with this carrying feature increases. Andersson (2012). It will be easy to fit onto the products without neither affecting the performance nor the semantic expression.

As the carrying feature is so slim and subtle, there is the possibility of placing and applying it to many different products and at different places on these products. If a product is very heavy and designed in regard to the redesigned carrying feature there is a possibility of placing two carrying features, one on each side of the product in-between the split-lines. This would enable better and steadier handling. The user can carry the product using two hands providing even better ergonomic aspects.

A very important aspect of this carrying feature is that it is modular and possible to use on many different products. This means a standardisation of handles. It can be placed on both present and future products in need of a flexible subtle carrying feature. The modularity of the carrying feature also improves the sustainability aspect and lowers the environmental impact from the product.

Due to the use of a plastic material, the transmission of radio-waves will not be negatively affected to the same extent as if a metal handle had been used. The carrying feature will provide good handling without either disturbing the cooling, semantic expression nor the transmission of radio-waves.

If the future products are adapted to better house the carrying feature, it will intrude even less on the semantic expression. For example can this be done by a lowering of the sealing and fastener spline, if one is present. Or raising of the sun-cover disguising the carrying feature when in a "0-position".

The carrying feature hold a unique design which can be seen as an advantage as it adds to the semantic expression and helps the products being recognised as Ericsson AB.

5.13 Consistency with "Words of value" - Expression Board

To understand what the redesigned carrying feature shall fulfil to be more suitable, an Expression board was made. See Chapter 3.1 - Expression board. The Expression board led to a number of "Words of value" which the redesigned carrying feature shalk visually and functionally represent.

The new redesigned flexible carrying feature corresponds well with the "Words of value" as it is more comfortable to handle and better ergonomically adapted than the previous reference handles.

The new carrying feature is lighter as it is made from a different lighter plastic material. It is also more subtle and does not add any unnecessary volume or weight to the product. The carrying feature takes on a low "0-position" when not needed, only visible when being interacted with. The feature has been designed to be strong and durable, withstanding the forces of lifting heavy products. However it is still graceful and sleek in its design when in "0-position". Modularity and sustainability has been of major concern when designing the carrying feature as this is both an important aspect within Ericsson AB as well as this thesis.

The redesigned carrying feature can clearly be said to fulfil both the requirements as well as the Expression board "Words of value" very well.

5.14 Sustainability

The sustainability aspects of the redesigned carrying feature are very important, partly due to the thorough sustainability analysis performed during this master thesis. The carrying feature shall correspond to the environmental requirements of Ericsson AB as well as with the conclusions of the sustainability analysis and the environmental guidelines set.

The modularity aspect of this carrying feature means that it can be used on many different products as well as being possible to reuse on a different product later in its life time. Modularity is very important in a sustainability point of

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view, as the product can be provided with a longer life. Less different products will have to be produced, reuse of parts as well as production of large quantities will be possible. Less production impact will occur.

As the carrying feature mainly will be produced from a plastic PET or PA, it means that it will be much lighter than a metal handle. This indicates that the transportation costs and impact is lowered drastically. A plastic PET or PA material is many times lighter than die-casted aluminium, which is the material used in all other handles produced by Ericsson AB.

An Ecocompare session, performed with Product Ecology Online, on the final handle showed that aluminium uses less water, emits less CO2 and leaves less waste during production. See Picture 5.31 - Ecocompare Carrying feature CO2, See Picture 5.32 - Ecocompare Carrying feature Water, See Picture 5.33 - Ecocompare Carrying feature Waste. This can indicate that the material to use from a sustainability aspect shall be aluminium. Due to the issue of external metal parts, interfering with the transmission performance of the product, a plastic material should be used. The plastic materials also hold a much lower weight which means less impact during transportation. The issue of Ericsson AB producing many of their products in China indicates that the aluminium used will not be reused material. Instead newly mined aluminium will be used, holding 20 times greater environmental impact. Rodgers (2012).

The Ecocompare was calculated on a carrying feature with the estimated weight of 115 gram PA, 140 gram PET and 270 gram Aluminium. The spring and the steel axles were not included. See Picture 5.31 - Ecocompare Carrying feature CO2, See Picture 5.32 - Ecocompare Carrying feature Water, See Picture 5.33 - Ecocompare Carrying feature Waste.

To minimize the use of different materials is important, this will indicate easier recycling of the parts. Almost all parts of the carrying feature are made from one type of plastic. They will be easy to recycle, and the metal spring and the pins connecting the arms to the base-plat brackets can easily be separated to recycle these with the accurate metals.

If the PA or PET plastic can fulfil all requirements, without adding fibre reinforcement or adding of chemicals to achieve this, the negative environmental impact of the carrying feature can be further minimised.

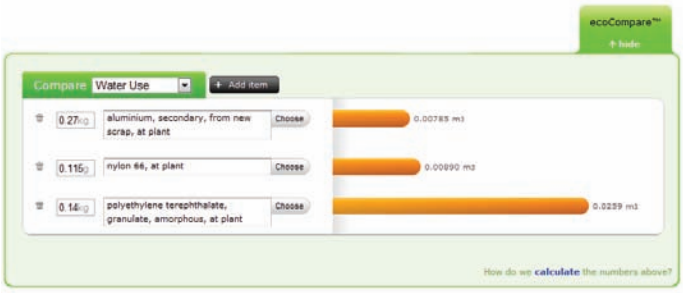
The carrying feature is durable and calculated to withstand six-times the maximum weight of the product it shall carry. The material of PET and PA is also selected due to its strength and resistance to outer weather- and sunray-forces.

One major environmental advantage by using a PET or PA plastic material instead of any other plastic or die-casted aluminium is that no wet-coating or powder-coating will occur. The product will be coloured to the right tone within the production process. The use of toxic and hazardous solvents and adhesive materials used during wet-coating and powder-coating can be excluded.

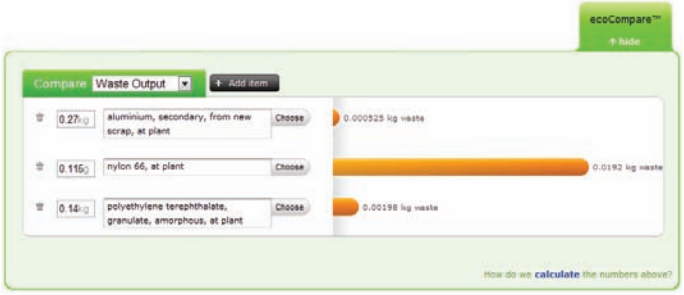
Disassembly is one aspect which can affect the recycling process to a large extent. DfD proved, from the sustainability analysis, to be an aspect to focus on to achieve as little negative environmental impact as possible from the product during its life-cycle. The carrying feature uses snap-buckles which tend to not be "disassembly-friendly". However these are so small that it will be easy to take the carrying feature apart for recycling. The snap-buckles are steady enough to lock the carrying feature in place, yet small enough enabling easy disassembly. All parts are loose and easy to disassemble from the grip-area, loose arms and spring. The major disassembly hurdle is to unscrew the pins from the base-plate brackets separating the arms, brackets and pins. However this is still an easy and quick procedure. Using a screw instead of snap-buckles securing the lid to the grip-area body would have added yet another material why it was discarded as a possibility.

Due to the few and large parts, the aspect of disassembly will have to be regarded as good. The carrying feature will be easy to disassemble. All plastic parts will hold indications of material which further indicates easier disassembly and recycling.

Picture 5.31 - Ecocompare Carrying feature CO2. Regnér (2012).



Picture 5.32 - Ecocompare Carrying feature Water. Regnér (2012).



Picture 5.33 - Ecocompare Carrying feature Waste. Regnér (2012).

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5.15 Production costs

Discussing the final concept and mock-up with Designer - Mechanics, Ericsson AB - Tom Anderson, it is estimated that the redesigned carrying feature would hold an estimated production cost of 15 SEK per product. This includes injection moulding of all parts as well as the pin and the springs. Because of plastic being much cheaper to produce and possible to produce in larger batches, the price will be fairly low. The present fixed handles of RRUS 11 & 12 hold an estimated production coast of 15 - 18 SEK. This means that the redesigned flexible carrying feature would be just as cheap or possibly cheaper than the present handles, making it even more suitable for Ericsson AB.

5.16 Model

The mock-up of the redesigned handle and all its parts was produced by the method of laser sintering. A plastic material is sintered in thin layers into the desired shape of the CAD-model. The material used to laser sinter the mock-up was a Polyamide, PA due to the high strength and durability of the material. By using a PA-plastic the handle is very realistic to the intended material used when taken into production. The mock-up was painted dark grey by the producer. This led to some parts fitting somewhat to tight. Minor adjustments had to be done to make the parts fit as intended. Paternoster (2012).

Images of the carrying feature Mock-up. See images 5.34 -Arm side Mock-up to 5.56 - Ericsson AB product handled and fitted with redesigned handle Mock-up.

Picture 5.34 - Arm side Mock-up. Regnér (2012).

Picture 5.35 - Arm perspective Mock-up. Regnér (2012).

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Picture 5.36 - Bracket perspective back Mock-up. Regnér (2012).

Picture 5.37 - Bracket perspective front Mock-up. Regnér (2012).

Picture 5.38 - Bracket and pin Mock-up. Regnér (2012).

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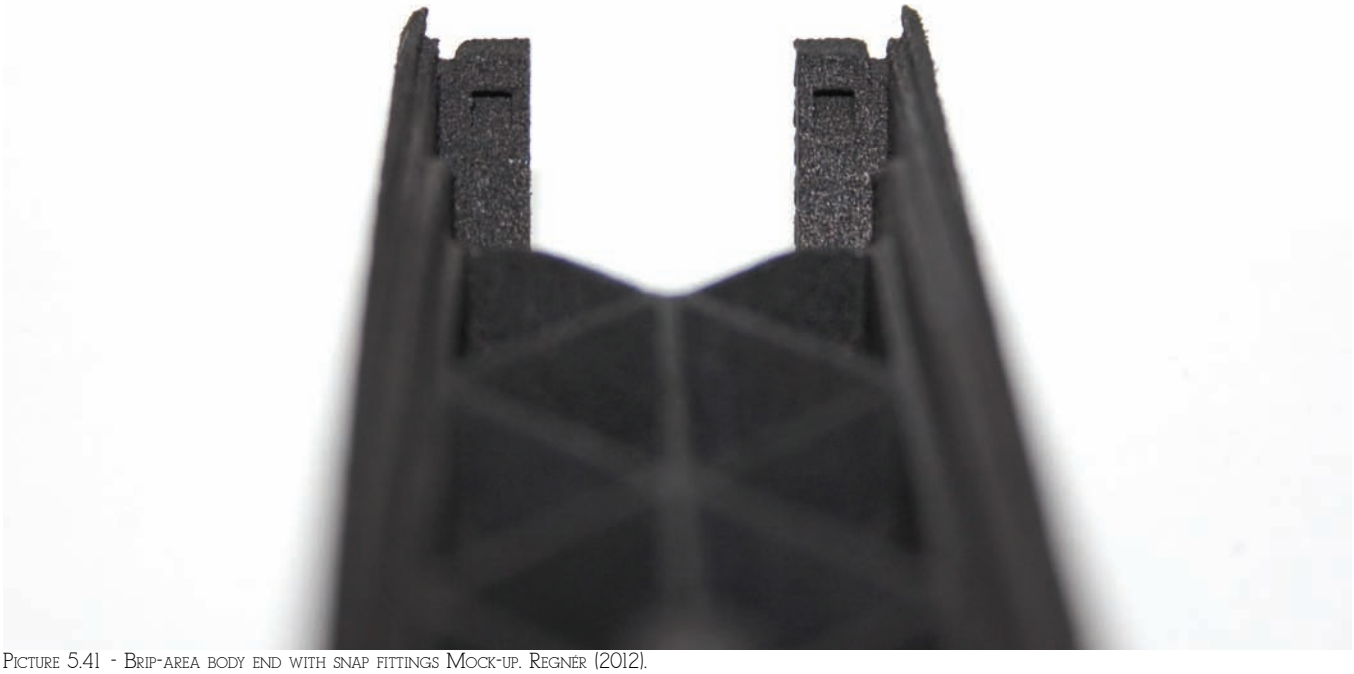
Picture 5.39 - Arm mounted to bracket Mock-up. Regnér (2012).

Picture 5.40 - Grip-area body Mock-up. Regnér (2012).



Picture 5.41 - Grip-area body end with snap fittings Mock-up. Regnér (2012).

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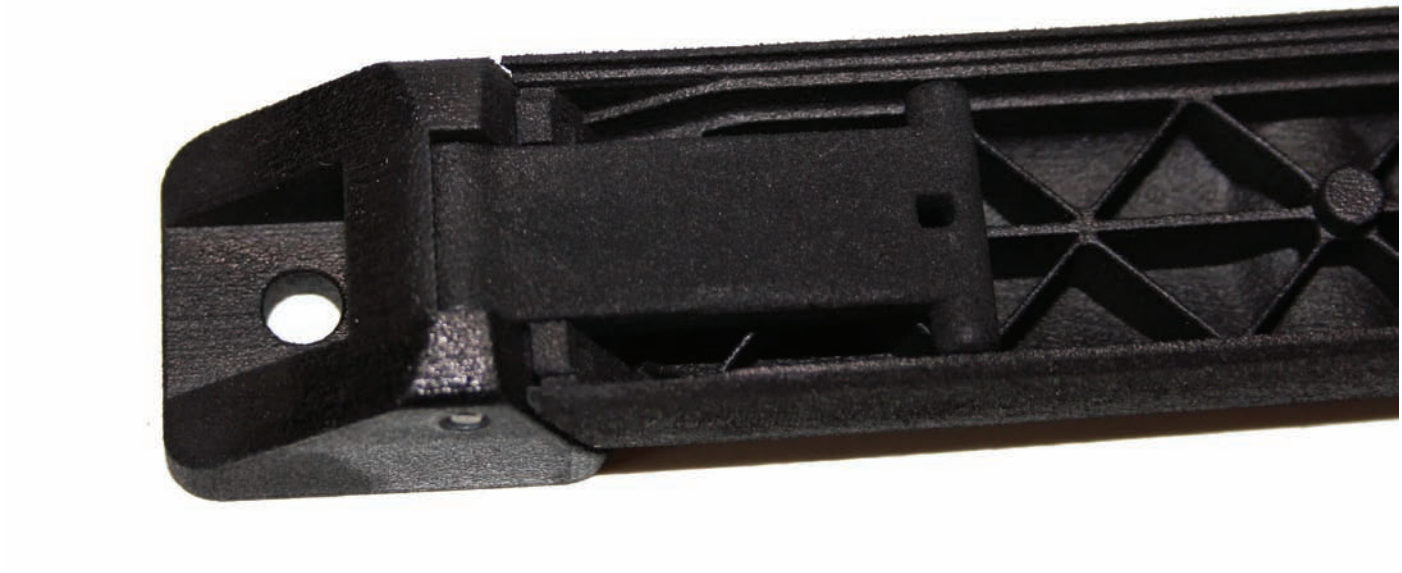
Picture 5.42 - Lid side Mock-up. Regnér (2012).

Picture 5.43 - Lid snap-buckle Mock-up. Regnér (2012).



Picture 5.44 - Arm fitted to grip-area Mock-up. Regnér (2012).

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Picture 5.45 - Handle assembled without liid Mock-up. Regnér (2012).

Picture 5.46 - Handle assembled without liid side Mock-up. Regnér (2012).

Picture 5.47 - Spring Mock-up. Regnér (2012).

Picture 5.48 - Sring assembled to the lid and arm Mock-up. Regnér (2012).

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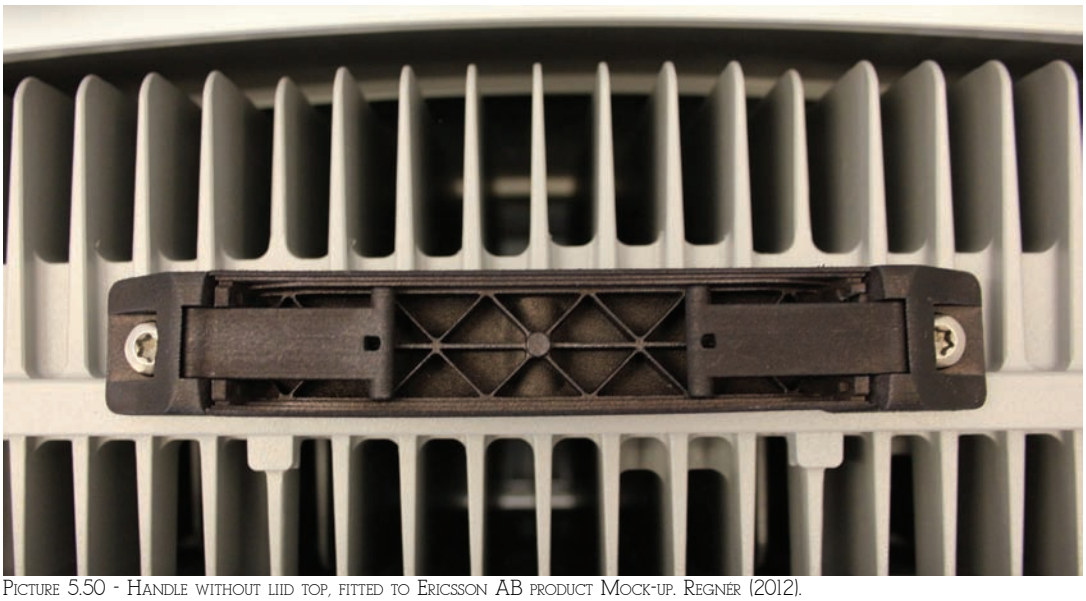
Picture 5.49 - Handle adaptation to fit spring Mock-up. Regnér (2012).



Picture 5.50 - Handle without liid top, fitted to Ericsson AB product Mock-up. Regnér (2012).

Picture 5.51 - Handle assembled side Fitted to Ericsson AB product Mock-up. Regnér (2012).

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Picture 5.52 - Handle fitted to Ericsson AB product down Mock-up. Regnér (2012).

Picture 5.53 - Handle fitted to Ericsson AB product up Mock-up. Regnér (2012).

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Picture 5.54 - Handle fitted to Ericsson AB product up, from side, Mock-up. Regnér (2012).

Picture 5.55 - Handle fitted to Ericsson AB product up, perspective, Mock-up. Regnér (2012).

Picture 5.56 - Ericsson AB product handled and fitted with redesigned handle Mock-up. Regnér (2012).

5. RESULT - HANDLE REDESIGN

5.17 Placement on the product

The redesigned carrying feature fits well onto Ericsson AB's portable products. When mounting the mock-up carrying feature to one of Ericsson AB's portable products, ODW, it is placed subtly on-top on the sealing spline by two M6 bolts. See Picture 5.51 - Handle assembled side Fitted to Ericsson AB product Mock-up. The handle is low when not interacted with and is visible with around 15-20 mm above the sun-cover. Picture 5.52 - Handle fitted to Ericsson AB product down Mock-up. This means that it intrudes very little on the semantic expression. The design of the carrying feature corresponds well with Ericsson AB's design-values. The handle suits the semantic expression, yet still provides a unique design.

When the handle is interacted with it enables good ergonomic handling through its design. The mock-up works fine lifting the portable product. It withstands the forces of lifting the product without problems. See Picture 5.56 - Ericsson AB product handled and fitted with redesigned handle Mock-up.

5.18 Ericsson AB Patent

On the 17th of April 2013, Ericsson AB filed a patent application for a further developed version of the carrying feature developed during this master thesis. Egrelius (2012). Manager, Industrial Design Mikael Thelin and Industrial designer Jens Kallin was managing the further development of the master thesis carrying feature and together with the author of this master thesis, Hampus Regnér, they were all set as patent inventors. Espacenet (2014). See Appendix IX - Patent approval Ireland, See Appendix X - Patent approval Russia, See Appendix XI - Patent approval Spain.

The patent is applied for a ten year period and has been filed in Argentina, China, Spain, Russia, South Korea, Ireland, Italy and Turkey. By the 12th of December 2013 the patent had been approved in Russia, Spain, China and Ireland. Egrelius (2013). See Appendix IX - Patent approval Ireland, See Appendix X - Patent approval Russia, See Appendix XI - Patent approval Spain. The patent is planned to get approved in the remaining countries within the next six months. Egrelius (2013)

Minor adjustments has been made in comparison to the carrying feature developed during this master thesis. It has been adapted for mass production and minor redesign elements has been made to make it work a bit easier. The slots for the sliding arms have been adapted to slide more easily, similar to what was discussed in the Bent integrated Handle Concept in Chapter 3.5.4 Sliding handle. Screws have been added instead of the snap-buckles holding the lid to the grip-area. Kallin (2013). See Picture 5.57 - Patented handled, explosion view. - Picture 5.59 - Patented handled interacted with, placed on Ericsson AB product. See Appendix IX - Patent approval Ireland, See Appendix X - Patent approval Russia, See Appendix XI - Patent approval Spain.

Picture 5.57 - Patented handled, explosion view. Kallin (2013).

Picture 5.58 - Patented handled "0-position", placed on Ericsson AB product. Kallin (2013).

Picture 5.59 - Patented handled interacted with, placed on Ericsson AB product. Kallin (2013).

6. DISCUSSION

6.1 Sustainability analysis

Ericsson AB is on the forefront of sustainable development and works very hard to minimise the environmental impact of their products. A lot of effort has been put into this work. Many different departments within the organisation works on adapting choice of materials, production, recycling and transportation in order to minimise the environmental impact.

Due to the fact of Ericsson AB being such a large company, there has been difficulties getting hold of information and appropriate actors dealing with these factors. When looking for accurate data on the company's environmental work, different and partly un-coinciding answers has sometimes been provided. The data had to be very thoroughly analysed and controlled to conclude the accurate answer. This partly un-coinciding information is thought to be a result of somewhat insufficient communication and information between different departures within the company. This has also been concluded during the analysis, as the departments working with environmental and sustainability does not actively participate in the R&D process and vice versa. The department of Design for Environment stated that the communication and collaboration with R&D departments could be improved. They estimate that the result from their work could be better implemented if so. Trankell (2012).

The sustainability analysis was set to be compiled and concluded by the end of 2011. Due to the difficulties with getting hold of accurate information and the right actors, the analysis was further worked on till the end of February 2012. Initially, maybe a little naively, it was thought that the information was going to be collected fairly efficiently. However due to the "road bumps", the analysis had to be spread over a wider time-span. The prolonged time span of the sustainability analysis is regarded as something positive, when everything has been performed. It enabled a better and more thorough analysis and possibility of finding out more important data. Prolonging the sustainability analysis did not negatively affect the project as a whole.

Due to the limited time-span of the whole project, the sustainability analysis provides indications of how the sustainability work can be improved. Even though the limited time and difficulties in obtaining material the result is considered very good. It proves that there are many great possibilities that can and has to be made to improve the sustainability work. If Ericsson AB wants to keep on being one of the world leading electronic producing companies on the field of sustainability, better communication between the departments has to be done. The work with choice of materials and production methods are relatively advanced and thoroughly worked through by the company. However the work of the environmental departments such as recycling and DfD, can get wider recognition within the organisation. Not only the requirements and demands of DfD shall be recognised but just as well their recommendations.

Modularity is partly used by Ericsson AB, however can be further developed. This is an important part of the sustainability work to improve and minimise the environmental impact of the products. The parts and features are not modular between different products. This provides the products with a shorter lifespan and disables the possibility of reuse of parts and products.

The issue of secrecy has made it harder to obtain accurate data on delicate parts and features. The level of secrecy is also one aspect which disables the possibility of reuse, a possibility to minimising the environmental impact. Ericsson AB sees no financial benefit in "reselling" used products to a different market when they have played out their part in one part of the world. Rodgers (2012). Information provided stated that old products holds greater impact as they uses more energy during its life-time than new more effective products. This is definitely discussable as the environmental impact of producing new goods, especially in Asia where new material is used instead of recycled to an exclusive extent, is great. The energy used to produce new goods and transportation of these would definitely hold a very large environmental impact and if the reuse of older products hold as high or even higher impact on the environment is hard to tell. However the major environmental impact of the products comes from consumption of energy and this is constantly improved in new products, why older products possibly affect the environment more negatively.

During the thesis information occurred that it is not uncommon that a product is replaced, due to outdated technology after just a few years. Even though its physical lifespan is well over ten years in many cases. Ericsson AB develops products of high quality which demands more complex materials and processes. These materials and processes hold great impact on the environment, especially when the products or consumers commonly not demand such a high quality. Looking into the possibility of adapting quality towards the place and for how long the product will be used, will minimise the environmental impact from production of "too" high quality goods.

To strengthen the result of the sustainability analysis, confirm data provided from the different actors and state what and how different parts of the reference product impacts the environment, a life cycle assessment was made. The LCA had to be restricted to the physical exterior features of the RRUs. This was both due to the fact of the aim of the thesis, but mainly because of all the complex internal electronic parts. These parts are very hard to obtain information about, due to the level of secrecy. The information gathered did not always correspond to other information, why it had to be further evaluated before it could be used. The data also varied depending on who the data source was. This led to some minor difficulties in concluding the analysis and the result of the LCA. After intensive work with establishing and evaluating the data, as much creditable information needed was finally complied. The result of the LCA and the sustainability analysis proved to show possibilities in the sustainability work of Ericsson AB. Due to the fact of

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minor lacking information about specific parts, processes, transportation and recycling, the LCA is not fully accurate. However it provides a very good indication on which parts and processes of the products and R&D are in need of improvement to achieve better sustainable design. The data gathering is regarded as very successful. Everyone involved in providing information and helping out with contacts, has been very kind and helpful throughout the whole analysis.

The LCA tool used, did not hold data on all processes and materials. This means that the result is lacking some credibility. However as stated above, provides very sufficient improvement indications possibilities. The LCA was not intended to be the major part of the sustainability analysis. It is a complement to pin-point important aspect, why fully accurate results is not affecting the results of the sustainability analysis as a whole. The LCA tool of Product Ecology Online is based on data from mainly the European Union. This means that the result is not accurate for any product produced outside Europe such as Asia. The database used by Product Ecology Online is the creditable database of ecoinvent. Product Ecology Online (2012). In the end, the LCA became a substantial part of the analysis and the data provided proved very valuable.

When discussing the issue of sustainability and recycling with the mechanical engineers and designers of Ericsson AB, it was initially stated that recycling was performed by Ericsson AB. However when talking to other departments dealing with recycling of products, the information was just the opposite, Ericsson AB subcontracts all of this work. The issue of varying information indicated that this is one area which can be improved to better fulfil the requirements and environmental values of the company.

Initially the envitonmental guidelines were aimed towards the industrial design department and their work with physical design exclusively. However after compiling the data collected throughout the sustainability analysis, the guidelines came to encapsulate possibilities and recommendations for the company as a whole. Not only focusing on the industrial design aspects. All aspects and departures are closely related, why the guidelines aimed at one area almost automatically concerns other areas, and in the end the whole organisation.

The Map of Materials was initially intended to provide alternative materials to use when designing future products. During the sustainability analysis it was concluded that the materials used in the reference products are suitable for its purpose and that only minor changes can be made to improve the environmental impact. Due to this fact the Map of Materials did not become as prominent as intended in the beginning. It still provides some indication and thoughts of how to work with new and different materials. The sustainability analysis proved that the major impact and possibilities in improving the environmental work lies mainly in other areas than material selection.

The final result and the work with the sustainability analysis has proved to be very useful and a large amount of knowledge concerning the sustainability work of major physical product producing companies has been obtained.

The project was presented to Ericsson AB 10.00 am the 13th of April 2012 at Ericsson AB in Kista Stockholm. The result of the sustainability analysis was regarded as very good and useful. Ericsson AB was so happy with the result and what it will provide them, that I was assigned to write the sustainable-design guidelines for the industrial design lead-document. The sustainable-design guidelines will be written in excess of and not be a part of this thesis. The analysis and sustainable-guidelines will provide information how they can improve their sustainable design. It will also be an indicator for higher management that this is an important area to improve and focus on.

6.2 Redesign

The redesign part of the thesis has been, as intended in the start of the project, somewhat larger than the sustainability analysis. However the sustainability analysis has in the end, almost taken up just as large part of the thesis as the design part.

The redesign has gone well and during the process many good and valuable concepts have been generated. They have been tested to properly fulfil the requirements of the thesis work and Ericsson AB.

During the redesign and the ideation process, many innovative, useful and possible carrying feature concepts were derived. Many of them enabling handling and lifting well, as well as providing ergonomic benefits compared to the reference handles. This was mainly done through providing the user with the possibility of carrying the products in a less harmful and hazardous way. The requirements and demands of Ericsson AB and their customers, led to that many of these concepts was discarded early in the product development process.

Information gathered from the usability-tests showed that the ergonomic aspect of lifting and handling heavy products can be improved to further simplify these tasks. The test-users had problems lifting and handling the product when it is placed on the ground. There was a need for a more ergonomic carrying feature enabling two handed handling. This was one aspect that was closely regarded for the ideation process. Most concepts enabling two handed lifting and carrying as well as body-supported lifting was discarded due to the focus on one-handed carrying features. One-handed carrying and a subtle design was regarded more relevant by Ericsson AB for this redesigned carrying feature. To fit the design-values, a subtle one-handed carrying feature was sought.

6. DISCUSSION

The final handle design is well adapted to provides good ergonomic handling for one-handed usage. However as the carrying feature does not provide two-handed handling it does not fully fulfil the needs and requirements of the service installation users. The final carrying feature concept selected was not possible to include two-handed handling. If the handle will be possible to fit onto the sides of future products, it will be possible to enable two-handed handling by fitting two handles, one on each side.

Other carrying features which enable two handed handling and at the same time are fully flexile by being detachable, was discarded early on. These concepts had large potential in being both flexibly as well as ergonomically well adapted. However by Ericsson AB regarded as not satisfactory to the requirements. This was mainly concerning the risk of the carrying feature not being present when needed. Ericsson AB stated that previous knowledge of using detachable handles proved that when needed, they tend to be lost or forgotten. If one of these generated concepts had been selected for further development the result could have been different and just as good, providing a new innovative solution for carrying and lifting.

The final design is now a fully functional and working carrying feature possible for Ericsson AB, to by just minor refinements, put into production. The redesigned handle from this thesis is the first modular, flexible and sliding handle developed at Ericsson AB. The final carrying feature is based on a thorough design analysis and has regarded the requirements of Ericsson AB well. It also provides good ergonomic user aspects as well as being modular and adaptable to many of the company's portable products. The handle also brings a new dimension to the company's product family. It is slim, ergonomic and flexible but does not affect the products performance or semantic expression negatively.

As the Ericsson AB's products are getting thinner and thinner with the advancing technology, the handles has to follow this development. They shall do so without being intrusive or affect the effect of the products. The slimmed design which houses the flexibility functions inside the grip-area does not have to fold to any side, inflicting on the cooling flanges or the sun-cover.

Preferable would have been to earlier in the design-process develop a number of rapid prototyping-models to try the mechanical function of the final design. However the limited time, jog of the memory in using of the CAD-tool, as well as adapting the CAD-model for rapid prototyping-machining, affected the possibility of producing many rapid prototyping models early in the design process. The concepts had to be tested by paper-board models instead. This worked just fine, providing very good indications and data. The paperboard models did portray the function of the concept well, however did not show how the tolerances would enable good flexibility.

The carrying feature design did get a little bit slowed down by the fact that the designers and engineers consulted for assistance, throughout the thesis, was overwhelmed with other projects. In some cases a little bit of further assistance could have been helpful. The work had to keep flowing, why decisions and the design had to be made with the knowledge possible to obtain. This is however not considered to have any major impact on the work of the thesis. The result is considered well and fulfils the requirements set at the beginning. Due to time spent trying to get hold of information and assistance, the final visualisation and exterior design work had to be somewhat compressed to fit everything into the time-frame. The result of the design of the handle is still considered good and well adapted to the design-values. The handle provides Ericsson AB with a good and fully working handle which can be used on the RRUS 12 about to be launched as well as to future products. Compiling and concluding the sustainability analysis also took up a little bit of time and efforts from the design work. However both parts of the thesis is regarded as very well performed.

The redesigned carrying feature is ergonomic, safe, durable and designed with regard to environmental impact. The requirement that can be discussed how well the carrying feature fulfils is the issue of minimising the risk of failure. The product holds some mechanical parts and features which over time, with heavy usage, can be a risk concerning failing and breaking down. The aim was to minimise this risk through minimising the technical features and loose parts. If the handle shall be flexible, which is one of the most important requirements, mechanical features and loose parts has to be used. The way they are used and designed, minimises the risk of failure and the carrying feature has been calculated to withstand 6-times the forces of the total weight of the product.

The handle is considered to be well adapted in regard to the different users. It is ergonomically adapted towards the installation workers, still subtle to not interfere on the semantic expression of the product, the part that the telecommunication users see. It is of high quality and finesse to be well suited for the buyer of the product. All and all it is regarded to have fulfilled the requirements of all user groups very well.

The integration of the carrying feature to the products is considered well, by the Ericsson AB design department, as it is non-intrusive and does not negatively affect the semantic expression of the product as a whole. Ericsson AB is, to this date, calculating the volume of the product by all exterior parts sticking out of the product, not taking away the areas which are only air, in-between the cooling flanges for example. If the way of measuring the products volume is reworked and only the "actual volume" would be measured, the products volume would be lowered compared to today. This would mean that the sun-cover of the products could be raised ten to twenty millimetres without adding to the total volume of today. If the sun-cover can be raised it would mean that the handle would be made even more

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subtle and hidden from the observers. Today the handle is slightly visible above the upper sun-cover edge. This edge of sun-cover would cover the carrying feature if raised.

The spring can be seen as a part which raises the risk of failure. However after consultation with mechanical engineers at Ericsson AB, the possibility of the spring being as risk has been discarded. Without the spring it would not either be possible to smoothly control the arms as well and secure a smooth and safe auto-retraction after interaction.

When ordering the mock-up of the redesigned carrying feature and the spring, minor mishaps occurred. About 10 days after they had been sent for production the CAD-files were returned, stated to be insufficient. This was fixed over an afternoon and sent back to the manufacturer. After the second try the mock-up of the parts of the handle was done in only a few days with great result. Only minor refinements had to be done, close the mesh in the CAD-file, for the mock-up to be able to be produced.

Due to the first delay, the project was pushed forward a few extra days. After the handle had been sent to production, the spring mock-up producer called and stated the spring measurements not being possible to make. This was almost 14 days after the order was placed. This delayed the production yet another week. The adaptation of the spring, for it to be possible to make, resulted that it no longer fitted inside of the grip-area. The spring had to be split in two and the outer diameter had to be increased from 4.8 mm to 10.8 mm. Due to this late change and the handle already in production, it had to be adapted manually by the thesis writer when the springs arrived. Some material of the diamond-shaped supporting slats had to be cut out to fit the spring. However this did not affect the performance of the handle. If this would have been indicated earlier, the handle could have easily been adapted. However due to the shortage of time, this was not possible. It has been a great indication of the problems which can and will occur during production. The issue with the spring made it impossible to produce a number of spring in the tension span of 10-50 N. Only one spring with the desired dimensions was possible to make.

The custom-made springs for the auto-retraction, had to be changed late in the production process. When testing the springs they were not produced as ordered. They where to strong, short and the attachment ends were not as intended. This resulted that they had manually adapted to fit the construction. However due to the springs not being as intended and holding too high tension, they did not fully work. If springs shall be used, they had to be slightly redesigned. Initially was plastic springs intended to be used, however due to hardship in finding suitable spring this was discarded. This should possibly be revised if the handle will be furthered developed. Another possibility would be to look into using some kind of rubber or silicone band to enable auto-retraction instead of springs. The redesigned carrying feature was tested with using rubber band and the result was very good. If there is a rubber or silicone band which does not break down over a time span of 10 years, this might be a suitable solution.

The handle fits well to the design-values, being both subtle and unified to the expression of the internal-body. As the mock-up was made from polyamide just as intended for the final handle, it withstood lifting and handling the product without any problems. It is strong and durable enough to easily hold the weight of the heavier of Ericsson AB's portable products. The grip-area is smooth which means that the carrying feature is comfortable to grab and handle while lifting the heavy products.

The carrying feature regarded the results from the sustainability to as large extent as possible. It is regarded to have fulfilled the requirements and guidelines very well. It minimises the use of many different materials, in need of few toxic solvents to produce and enables good recycling as well as modularity which indicates a prolonged lifespan. The use of metal in combination with plastics means that two different materials mix. However due to the few materials used and the small size of the product, is this not something of concern. Discussions were made to attach the grip-area lid to the grip-area body by a screw. However the thought was discarded due to more loose and unnecessary parts. The snap-buckles can be seen as not adapted for good DfD, they where however decided to be used. No extra parts or materials were needed to secure the lid to the body by using snap-buckles. The snap-buckles were made thin, as they are not put under any large forces. They will enable easy disassemble. The materials used holds fairly low environmental impact and the plastic can be recycled and reused in other products. This enables a longer life cycle for the carrying feature. The choice of a plastic material also means a much lower weight of the product, compared to the use a metal. This means that less environmental impact will occur during transportation.

The redesigned carrying feature was very appreciated and regarded as fully suitable for the need and requirements. Ericsson AB has started yet another process of developing another flexible handle for the portable products. At the presentation of this master thesis at Ericsson AB, on the 13th April 2012, engineers and project coordinators participated to get indications of how this redesigned carrying feature can be further developed. The CAD model of the handle was immediately further worked on to optimise the function and design. Ericsson AB sees great potential in the redesigned handle. The fact that it right away became the reference product for designing a final flexible carrying feature is a great indication that the project has been successful and that it provided the company with something useful.

In the spring of 2013 Ericsson AB patented the master thesis carrying feature after some minor adjustments. This is a proof that the master thesis accomplished something substantial for Ericsson AB. The carrying feature developed is regarded as well performed as Ericsson AB chosed to continue to further developed the product. The patented

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product is basically just a refined version of the carrying feature developed during the master thesis. Only minor adjustment had to be made to make it production worthy.

6.3 Thesis

The project has gone well, being both very challenging as well as fun, designing a fully functional and usable carrying feature filling the gap of a subtle flexible handle.

The very first aim of the project was designing and stift the semantic expression of an Ericsson AB product. When starting up the analysis phase, in agreement with Ericsson AB, the project was instead more narrowly aimed at developing a fully functional carrying feature which would be durable, flexible and enabling good ergonomic handling. The change towards carrying feature redesign did not affect the work process drastically due to a change at such an early stage of the project. Carrying feature redesign had been discussed as a possible aim before starting up the project. However the final aim was left open for changes. To know where the project was going it had to be started up. It was necessary to start working on finding an area in which improvements could be applied and after talking and initiating the project at Ericsson AB, it was concluded that a redesigned flexible carrying feature was needed. This was also a project of the right size as it was to be combined with a thorough sustainability analysis.

Now when the project is finished, it was a good decision to focus the redesign to a smaller technical part to be able to perform the sustainability analysis to the extent it has been performed. A large semantic redesign of a whole product would have led to a less thorough sustainability analysis. The sustainability part of the project was seen as of big significance for Ericsson AB, Chalmers University of Technology as well as the thesis writer.

The fact that the thesis was performed by a single student as well as most of the project carried out at Ericsson AB's office in Kista Sweden, the result is much influenced by what the company was aiming for. It has been somewhat hard as a single performer to carry out all the ideas and solutions as well as sometimes getting them realised and implemented within such a large organisation.

If the work would have been performed outside Ericsson AB's office, say for example, at Chalmers University of Technology's facilities, yet with continuous contact with the company, the final result would vary a lot. The result would probably be much more conceptual and the final design would not be as mechanically finalised. The result would possibly have provided Ericsson AB with more innovative conceptual concepts. However would these concepts not be as thorough and possible to realise as the final concept in this thesis. The final design is possible to use and by applying minor refinements it is no possible to take into production.

The project has gone smoothly and has followed the schedule set up in the initiation phase well. See Appendix I - GANTT-Chart. The sustainability analysis was set to be done in the end of 2011, as described above in Chapter 6.1 - Discussion Sustainability analysis, however had to be prolonged due to difficulties in getting hold of information. The ideation and design work has followed the time schedule well however the end of these parts did get somewhat tight with time, in order to get done as scheduled. When the model was to be prepared for rapid prototyping-manufacturing, by the use of an engineering software, Ericsson AB did not have the time or man-power to enable this help as indicated initially. This led to that the thesis performer had to prepare the CAD-model which took up some time. Preparation of a CAD-model for rapid prototyping-manufacturing was within the knowledge of the performer. However had not been tried out for several years, why the work was initially struggling and took some time. This was also the reason for the mock-up of the handle to not work fully initially. However by a little bit of persistence, it all worked out fine, everything managed and performed by the thesis writer. The rapid prototyping preparation worked out just fine and it is fully respected and understood that Ericsson AB did not have the possibility of enabling this help. By performing this myself instead of being helped out, this knowledge was further developed and updated. Time wise it would have been very good to been provided assistance in adapting the CAD-model for rapid prototyping, however the knowledge of performing the task would never have been obtained. I widened my knowledge and therefore happy to have performed the task myself, even though it felt somewhat hard in the beginning.

The issue with preparing the CAD-model for rapid prototyping-manufacturing resulted that angles of release, needed for injection-moulding, had to be disregarded. There was not enough time to regard this. This has now been regarded and fixed by Ericsson AB in the further development of the patentet carrying feature.

The mishap with the spring could have been excluded if the producer would have notified the dimensioning problems right away. It could also have been excluded if the producer would have been consulted before dimensioning and designing the spring. This would probably have been the best and easiest solution. It would have meant that the handle could have been designed, interior wise, in regard to the specific spring dimensions. A good aspect which has been a valuable lesson, something that I will regard in future product development processes.

As the designers and engineers consulted were overwhelmed with work, it is fully understandable and respected that it has not always been possible to provide assistance. The design and the work has been adapted to the assistance possible to obtain within Ericsson AB. This was mainly due to limited knowledge within specific areas from the thesis writer. This has however not affected the work or the result negatively in any way.

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If there would have been two persons performing this thesis, the result might possibly have varied some. It would have been easier to perform parallel work, when in the look-out for valuable and appropriate information. It would probably also have been easier to implement the ideas within the Ericsson AB, if two or more performers stating the benefits of the design.

One issue that has made the work somewhat confusing during the thesis work, is that initially the RRUS 01, 11 and partly 12 was set as the reference products. However the further the work went on, the reference product of RRUS 12 did tend to be the most prominent and useful as a reference product. This is the latest and most suitable reference product for the handle developed. The RRUS 12 was for a long time non-present and not possible to get hold of due to it still being under development. The case with the reference products has complicated the connection between the pre-study and the product development phase some. However this has not affected the results in any way. The issue with secrecy within Ericsson AB and their products has also led to complications when designing the product. Information and other products has been hard to get hold of.

During the project, new and different requirements appeared regularly. Right after the detachable handles had been discarded during the evaluation process, word about the product managers being interested in developing a detachable carrying feature appeared. This led to some further work with these concepts even though they had already been discarded. Another few days later did new information appear that the detachable carrying features were once again to be discarded. The unclear information did somewhat affect the process as it was hard to know if the selected concepts did fulfil the requirements properly. The requirements were changed back and forth every now and then. It is fully understandable and respected that the requirements changed during the project. However this was something that was new and which has not previously been experienced during any University-based projects, to the same extent. An aspect that now has been experienced and possible to better deal with in future situations as an industrial design engineer.

Except from the minor bumps on the road, the project has gone smoothly and the result fulfils the aim and requirements well. The thesis has led to new knowledge within mechanical and industrial design as well as what needs to be applied to concept design for it to become a finalised product.

Performing a full product development project as a single performer has to a large extent been very challenging. Initiating, pursuing, researching, designing, developing, writing, modelling, operating and organising has been hard and at times the work has felt somewhat overwhelming. However it has been very good and worthwhile performing the thesis as a single person, challenging my knowledge and driving force.

The work with following the time schedule has felt very important to always keep on track and know what to do in order to propel the project forward all the time. One way to always keep on track and propel the project forward, has been to set up lists every week on what has to be done and ticking each finished part off. By doing this it has been easier to achieve the goals and finishing the project in time.

The pre-study provided very good information for the further development of the handle. It could be concluded what aspect that should be improved for the redesigned handle to better fulfil the requirements. However it was very hard to find accurate information throughout the competitor analysis. This mainly has to do with the level of secrecy that is present on the market of telecom electronics. Just like Ericsson AB, their major competitors are very careful with exposing vital information or any of their products. This led to difficulties in finding information and images on these products. The information gathered had to be interpreted and as closely as possibly inspected. Most of the information gathered was concerning the visual appearance of the competitors' products. The images studied were often of low quality, if even possible to get hold of any, leading to assumptions being made.

When initiating the project, user- and field-studies were intended to be performed to get a good understanding of the usage situation. Due to the high level of secrecy, field-studies were not able to perform. If they would have been able to be performed they would probably have provided valuable data during the pre-study. However the result is not considered to be lacking anything due to not performing any field-studies.

The usability-test proved very valuable, however the usability lab at Ericsson AB has to be said to be unsatisfactory. It was still under construction and missing vital instruments. The formulary set up for the usability-test had a good structure and proved to work well. In some cases did the test-users have so good knowledge of the reference products that the formulary almost became unnecessary. The usability-test almost become a dialog, where the test-user was monitored in how he handled the product by its carrying feature. This was not initially planned. The usability-test was set to be more structured and formal. However during the performance of the tests, it was adapted towards the knowledge and performance of the test-users.

The sustainability analysis has proved what areas are in need to further development for Ericsson AB to improve their sustainable design work. Knowledge within sustainability, collaboration within the organisation and how to compile this into comprehensible and accessible data has been gained through-out the thesis work.

One major aspect which has led to further knowledge is how it is to work in and with a multinational company. The necessity in being persistent to achieve the goals set has been obtained. It has also been experienced how hard

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it can be to get hold of necessary information and get your thoughts implemented. This is something that has not been experienced during any previous university-based projects. It has been good and instructive to understand how hard it can be to get the word out within a large organisation. For example, how two related departments of Industrial Design and Design for Environment did not have any kind of functional collaboration.

The master thesis has been very fun and valuable knowledge have been obtained both on a personal as well as on a professional level. Many thanks and a great appreciation is the result of being able to perform this master thesis at the world leading company of Ericsson AB.

7. CONCLUSION

7.1 Sustainable profile

The sustainability analysis proved to show a much wider and different result from what was initially thought. The materials used within the reference products did not prove to impact the environment as much as other areas, for example the use of energy over a products lifetime. The major improvements on environmental impact have to be aimed at minimising the energy consumption of the products. The material and production process can be improved to minimise the environmental impact. If the material in the plastic parts of the sun-cover can be change to a plastic which can be coloured within the production process, the use of wet-coating can be excluded. This will minimise the environmental impact during production to a large extent.

The major conclusion from the sustainability analysis is the cooperation between departments and how Ericsson AB works to achieve better sustainable design. The cooperation and teamwork between the R&D departments of Industrial design, mechanical design, material design and the environmental departments of DfE and recycling is lacking to some extent. To achieve better sustainable design, different actors within the organisation have to work closer together and interact for a greater understanding of what is needed to improve this area.

If a closer collaboration and cooperation can be established between the different actors, Ericsson AB will further strengthen their position on the world electronic production market as the world leader on sustainable design and environmental work.

Ericsson has come far in their environmental work however there are still major improvements which can be implemented. By changing their transportation methods, focus on modularity and develop the recycling of products, money can be save and credibility will be raised.

7.2 Redesign

The redesign of a flexible carrying feature for Ericsson AB's portable radio tower based products has become a well functioning flexible handle. It is well suited to the Ericsson AB design-values.

The handle is accurately designed in regards to ergonomic aspects and provides a good power-grip for the user to be able to properly lift and handle heavy products. The thorough pre-study provided the necessary data which proved what parts and features that were to be improved for the redesigned flexible handle to fulfil the needs and requirements of Ericsson AB.

By providing Ericsson AB with a new flexible carrying feature which holds a subtle semantic expression, their future products can be designed to be even slimmer without the handle intruding on neither the visual appearance nor the performance of the product.

The function selected to enable flexibility is simple and secures a low risk in failure. The material is specifically selected to be strong and durable and at the same time not negatively affect the performance of the transmitter of the RRUs. The handles works well and with minor adjustments and further evaluation it is possible to make ready to take into production.

An innovative and new breed of flexible handle to Ericsson AB's product family has been developed by analysing previous handles, usage situations and suitable solutions.

As a final proof of the benefits of the new flexible carrying feature for Ericsson AB, it was patented in the spring of 2013.

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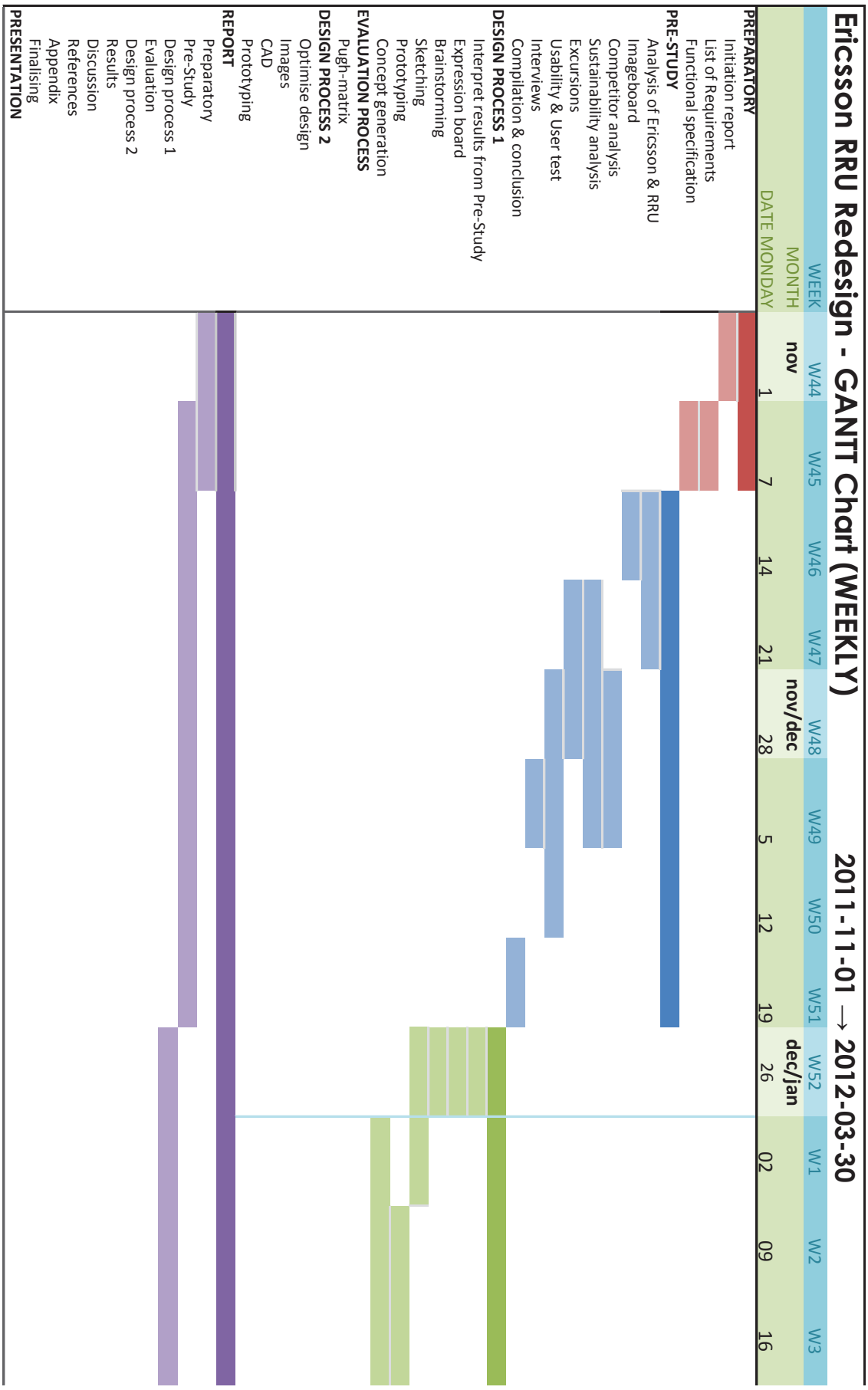
APPENDIX

I - GANTT-CHART



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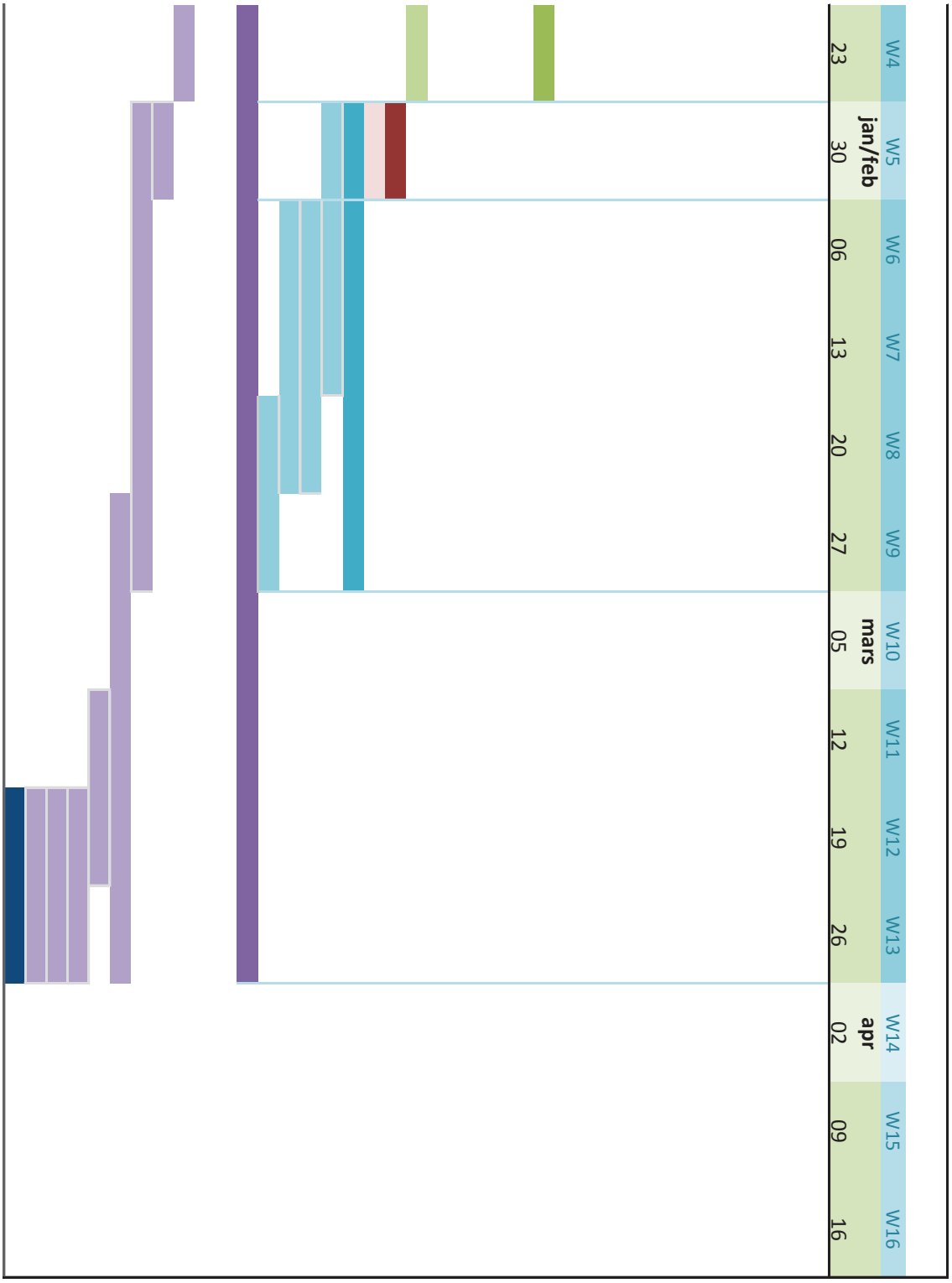
I - GANTT-CHART



APPENDIX

II - List of requirements

Features	***Description***	***Requirement (R)/Desirable (D)***
Technical function		
Carrying	**Main function (MF)** - allow easy handling and carrying of the RRU both horizontally as well as vertically.	**MF**
Flexible use	The "carrying feature" shall both work for optimised handling as well as it being invisible when not in use.	**R**
Modularity	The "carrying feature" shall be modular and in some way fit and work with many products within the product family.	**R**
Weather & climate safe	The "carrying feature" shall be designed so the product is weather and climate proof in any environment. From - 40ºC to + 50 ºC	**R**
Suit	The "carrying feature" shall work for both light products of 5 kg up to heavy product of 40 kg.	**D**
Centred hoisting	The "carrying device" shall enable hoisting as well as performing this through centring of the product while hoisted. Enable use of lines and safety hooks.	**R**
Exchangeable	The "carrying feature" has to be exchangeable for easy replacement if broken.	**R**
Integration	The "carrying feature" is not to be a solid part of the cast metal, however can smaller parts of it possibly be a part of the cast metal of the Core.	**R**
Minimise fail	The product shall in the best possible way minimise the risk of failing while in use. Minimise the use of buttons etc. Preferably two main positions; one hidden and one while in use.	**D**
Technical specifications		
Low weight	The "carrying feature" shall be of low weight.	**D**
Durability/Strength	Provide a strong, tough and durable product which can handle heave loads of up to 40 kg.	**R**
Falling	The "carrying feature" shall be able to withstand drops as well as withstand a drop and stop situation while being hoist.	**R**
Choice of materials	The choice of materials shall be made in consideration of optimising the technical specifications of the product, strength, low weight, production methods, weather resistant...	**R**
Material Use	Preferably shall only one material be used in the "carrying feature", if there is not a need for the use of multiple materials.	**D**
Dimensions	Should be designed after the approximate dimensions of previous "carrying features" - 40 mm of space for knuckles, with of 120	**D**

APPENDIX

II - List of requirements

	mm and a radii of 10 mm.	
Ergonomic aim	The "carrying feature" shall foremost aim for optimised ergonomics & strength and secondly on performance/price.	**D**
Design Aspects		
Ericsson profile	The redesign shall hold the core values and clearly provide an Ericsson profile as well as fit the design language of the product family.	**R**
Core & Cover	The "carrying feature" shall be designed and follow guidelines of Core Touch Points or possibly Core Structure.	**R**
Blend with the product	The "carrying feature" shall blend to the product it is being used with to look uniform and not "stick out" from the design language.	**R**
Fit the environment	The design shall be adapted to the fit the environment the product is being used in; antenna masts and on the wall of houses.	**D**
Aesthetically appealable	The design shall be aesthetically appealing, modern and simple.	**D**
Choice of materials	The choice of materials shall be made in consideration of being uniform with Ericsson's values and design guidelines.	**R**
Choice of colours	The choice of colours should fit the design requirements of the Core Structure or Core Tough Points.	**R**
Intuitive	The "carrying feature" shall be intuitive and easy to understand how to use. Both when "hidden away" and while in use.	**R**
Usability/User Design		
Usability	The redesigned "carrying feature" shall be analysed on usability and optimise the user's needs in the finished design.	**R**
Ergonomic	The redesign shall be ergonomically designed to ease use and handling. Handle placed in the CoG of the product. Enable at least 40 mm of free space around the handle and from the body of the product to the underside of the grip area.	**R**
Ergonomic grip	The "carrying feature" shall hold a ergonomically designed gripping feature, not to slippery and not provide high friction. At least 110 mm long grip area and a grip diameter of 25-40 mm for product heavier than 18 kg.	**R**
Enable ergonomic lifting	The "carrying feature" shall enable one person to ergonomically lift the product, a load of up to 40 kg, with one hand if possible.	**R**
Enable ergonomic vertical lifting	The "carrying feature" shall enable one person to ergonomically lift the product, a load of up to 40 kg, to a height of 1,5 meter to enable installation and mounting.	**D**
Enable ergonomic	The "carrying feature" shall enable one	**R**

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II - List of requirements

hoisting	person to ergonomically hoist of a load up 40 kg.	
Comfort	The "carrying feature" shall, in the best possible way, be comfortable to use.	**R**
Intuitive	The "carrying feature" shall be intuitive and easy to understand how to use. Both when "hidden away" and while in use.	**R**
Minimise load	The "carrying feature" shall in the best possible way help to minimize the load carried.	**D**
Choice of materials	The choice of materials shall be made in consideration of ergonomic and user aspects.	**D**
Environmental		
Quality	The redesign shall be of high quality for long lasting life as well as unnecessary waste.	**D**
Upgradability	The redesign shall include maximum upgradability possibilities for optimised sustainability.	**D**
Choice of material	The choice of material shall be done in consideration of sustainability aspects so that the product holds minimum impact on the environment.	**D**
Production method	The method of production of the "carrying feature" shall be done in consideration of sustainability aspects to minimise the environmental impact during production.	**D**
Upgradability	The "carrying feature" shall be upgradable, if possible, for optimised use of the tool and to minimise waste.	**D**
Modularity	The "carrying feature" shall be modular and fit many of Ericsson's products, to minimise the use of redesign, new production. Modularity also enables further use of the handle as it can be switched to another product which minimises waste.	**R**
Quality	The "carrying feature" shall be of high quality so that it holds a long life which minimises waste and new production.	**R**
Disassembly	The "carrying feature" shall enable easy disassembly and recycling for optimised environmental impact.	**D**
Theft	The "carrying feature" shall be designed to minimise the risk of theft, which will denote that a new "carrying feature" has to be produced and once again applied to the RRU.	**D**
Transport	The "carrying feature" shall be designed so that it optimises the use of space during transportation to minimise the environmental impact. The feature should not be too bulky.	**D**
Production		
Easy to produce	The product shall be easy to produce using ordinary methods.	**R**

APPENDIX

II - List of requirements

Choice of materials	The materials shall be chosen to fit production possibilities.	**R**
Production ready	*The finished redesigned concept shall has acknowledged the possibilities of production.*	*D*
Safety		
Usage	The redesigned product shall be safe to use.	**R**
Product	The "carrying feature" shall be designed so that the product is safe to lift and hoist, to minimise risk of injury of the user (and bypassers).	**R**
Cost		
Transport	*The product shall be designed so that it optimises space during transport.*	**D**
Choice of materials	The choice of materials shall be optimised to minimise cost.	**D**
Theft	The choice of materials shall be made so that it minimises risk of theft.	**D**

APPENDIX

III - Usability test

Usability test - Carrying feature Ericsson, RRUS 01 & 11 - 12

The usability test will be performed by preferably three different users, all with previous knowledge about the RRUs and how they are handled.

First the user will be told how the test will be performed and what he/she is to try in order to provide data for the redesign of the carrying feature. The test user is to try to handle and install the RRUs in a realistic recreated situation, through using the products carrying feature in the best possible way.

The usability test will be observed by the thesis writer trough observations, (video), photos and pen & paper.

As the level of secrecy of RRUs, it will be impossible to perform the usability test in the products real environment. Instead will the usability test be performed a suitable room at Ericsson where the test user can perform the test without any distractions.

Before, during and after the usability tests, the user will be interviewed about the usage of the RRU and its carrying feature.

Scenario 1 - Lifting and Installing

Scenario - 1 *Do two identical tests using both the RRUS 01 and 11*

1. **Part 1 - Lifting from the ground** - The user is to lift the RRU from the ground, in the most obvious and comfortable way.
2. **Part 2 - Lift to a height** - Lift the RRU to a height of approximately 1,5 meters into the air using one hand if possible.
3. **Part 3 - Placement** - Place the product towards the wall as the user were to install/mount it to an actual bracket (Use one hand if possible).
4. **Part 4 - Installation/mounting** - Hold the product in place while trying to install/mount it to its bracket, preferably using one hand (the scenario of installing a RRU while hanging in a radio tower mast).
5. **Part 5 - Displacement** - *(When installed/mounted let the user to the reverse procedure as if the product was to be taken down/replaced.)*

Observation Scenario - 1

- Measure the time used to perform **Scenario 1** - mounting of the RRU (and possibly also dismounting the product).
- Observe the users way to perform the task - does it seem easy to use/handle, ergonomically used, understanding of how the carrying feature is to be used.
- Measure the amounts of faults/mistakes by the user during **Scenario 1**
- Is the task performed in a satisfactory way/is the task finalised.
- Ergonomic aspects of usage - hard to handle, lifting angle, one hand handling etc.
- Rectified mistakes, time this takes if mistakes/faults occur.
- Intuitively - is the task easy to understand/is the usage of the carrying feature intuitive.

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III - Usability test

Scenario 2 - hoisting and Installing

Scenario - 2 *Do two identical tests using both the RRUS 01 and 11*

1. **Part 1 - Prepare for hoisting** - The user is to prepare the equipment to enable hoisting of the RRUs from the ground, it the most obvious and comfortable way. Preferably from the carrying feature. (Provide the user with proper equipment - rope & safety hook).
2. **Part 2 - Hoist to a height** - The RRU is to be hoisted to a height of approximately 1,5 meters into the air using one hand if possible.
3. **Part 3 - Placement** - Place the product towards the wall as the user were to install/mount it to an actual bracket.
4. **Part 4 - Installation/mounting** - Hold the product in place while trying to install/mount it to its bracket, preferably using one hand (the scenario of installing a RRU while hanging in a radio tower mast).
5. **Part 5 - Displacement** - *(When installed/mounted let the user to the reverse procedure as if the product was to be taken down/replaced.)*

Observe Scenario - 2

- Measure the time used to perform **Scenario 2** - mounting of the RRU (and possibly also dismounting the product).
- Observe the users way to perform the task - does it seem easy to use/handle, ergonomically used, understanding of how the carrying feature is to be used.
- Measure the amounts of faults/mistakes by the user during **Scenario 2**
- Is the task performed in a satisfactory way/is the task finalised.
- Ergonomic aspects of usage - hard to handle, lifting angle, one hand handling etc.
- Rectified mistakes, time this takes if mistakes/faults occur.
- Intuitively - is the task easy to understand/is the usage of the carrying feature intuitive.

APPENDIX

III - USABILITY TEST

Interview - questions additional to the usability test (Perform one interview per scenario)

Scenario 1 - Lifting and Installing

Initial questions - answered before the usability test is performed

***Question 1A**: How do you predict the handling/usage of the RRU and its carrying feature will be?*

Grade the usage prediction on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 2A: On the scale from 1 to 6, how easy/problematic do you predict the two RRUs, RRUS 01 or 11, are to handle?

Grade the easy of usage prediction on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Part 1 - Lifting from the ground

Task finalised: **Y** / **N**

Time used to understand how the RRU is to be lifted using its carrying feature: _____ SEC

Time used to perform the task: _____ SEC

Question 3A: On the scale from 1 to 6, how easy/problematic was it to lift each of the two RRUs, RRUS 01 or 11, using its carrying feature?

Grade how easy/problematic the lift of each RRU, using its carrying feature, was on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

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III - USABILITY TEST

Question 4A: On the scale from 1 to 6, how intuitive was the carrying feature on each of the two RRUs, RRUS 01 or 11?

Grade how intuitive the carrying feature was on a scale from 1 to 6 where 1 is not intuitive at all and 6 is very intuitive.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Part 2 - Lift to a height

Task finalised: **Y** / **N**

Number of faults/mistakes to finalise the task: _____ Faults

Time used to perform the task: _____ SEC

Question 5A: On the scale from 1 to 6, how easy/problematic was it to lift each of the two RRUs, RRUS 01 or 11, to the height of 1,5 meters into the air?

Grade how easy/problematic the lifting of the RRUs, using its carrying feature, was on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Part 3 - Placement

Task finalised: **Y** / **N**

Number of faults/mistakes to finalise the task: _____ Faults

Time used to perform the task: _____ SEC

Question 6A: On the scale from 1 to 6, how easy/problematic was it to place each of the two RRUs, RRUS 01 or 11, to the wall at the height of 1,5 meters?

Grade the easy of usage prediction on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

APPENDIX

III - Usability test

Question 7A: On the scale from 1 to 6, how intuitive was usage of each of the two RRUs carrying features, RRUS 01 or 11, as well as the hand-placement while placing the product onto a wall?

Grade how intuitive the carrying feature was and how they were to be used on a scale from 1 to 6 where 1 is not intuitive at all and 6 is very intuitive.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

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Question 8A: On the scale from 1 to 6, how ergonomically well did you experience the usage of each of the two RRUs, RRUS 01 or 11, carrying features while placing the product onto a wall?

Grade level of proper ergonomic usage on a scale from 1 to 6 where 1 is not ergonomically adapted at all and 6 is very ergonomically.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 9A: On the scale from 1 to 6, how ergonomically well did you experience the usage of each of the two RRUs carrying features, RRUS 01 or 11, while placing the product onto a wall?

Grade the level of proper ergonomic usage on a scale from 1 to 6 where 1 is not ergonomically adapted at all and 6 is very ergonomically.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Part 4 - Installation/mounting

Task finalised: **Y** / **N**

Number of faults/mistakes to finalise the task: _____ Faults

Time used to perform the task: _____ SEC

Question 10A: On the scale from 1 to 6, how easy/problematic was it to hold the product in place while trying to install/mount each of the two RRUs, RRUS 01 or 11, onto a wall?

Grade how easy/problematic holding the product while installing/mounting it on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 11A: On the scale from 1 to 6, how easy/problematic was it to properly use the products carrying feature while trying to install/mount each of the two RRUs, RRUS 01 or 11, onto a wall?

Grade how easy/problematic the usage of the carrying feature was while installing/mounting the product on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

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III - USABILITY TEST

Question 12A: On the scale from 1 to 6, to what extent was it possible to handle the product only using one hand while trying to install/mount each of the two RRUs, RRUS 01 or 11, onto a wall?

Grade the possibility of one hand usage on a scale from 1 to 6 where 1 is problematic to use one hand and 6 is very easy and possible to use one hand.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Part 5 - Displacement

Task finalised: **Y** / **N**

Number of faults/mistakes to finalise the task: _____ Faults

Time used to perform the task: _____ SEC

Question 13A: On the scale from 1 to 6, how easy/problematic was it to take down each of the RRUs, RRUS 01 or 11, already installed/mounted from a wall using its carrying feature?

Grade how easy the usage of the carrying feature was when taking down an already mounted RRU on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Summarising question after Scenario 1 has been performed.

Task (total) finalised: **Y** / **N**

Number of faults/mistakes to finalise the task (total): _____ Faults

Time used to perform the task (total): _____ SEC

Question 14A: On the scale from 1 to 6, how easy/problematic was it to lift and install/mount each of the two RRUs, RRUS 01 or 11, using its carrying feature?

Grade how easy/problematic the lift and installation/mounting of each RRU, using its carrying feature, on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

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Question 15A: On the scale from 1 to 6, how intuitive was the carrying feature and how it was to be used on each of the two RRUs, RRUS 01 or 11?

Grade how intuitive the carrying features on each RRU was on a scale from 1 to 6 where 1 is not intuitive at all and 6 is very intuitive.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 16A: All and all, how well do you rate the level of usability of each of the two RRUs, RRUS 01 or 11, carrying feature?

Grade the level of usability on a scale from 1 to 6 where 1 is not at all easy to use and 6 is very easy to use.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 17A: All and all, how well do you rate the level proper ergonomic usage of each of the two RRUs, RRUS 01 or 11, carrying feature?

Grade the level proper ergonomic usage on a scale from 1 to 6 where 1 is not at all ergonomic and 6 is very ergonomic.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 18A: If there was pain involved during usage of the carrying feature while handling and installation/mounting of the two RRUs, RRUS 01 or 11, rate the level of pain on each of the two carrying features?

Grade the level of pain during usage of each of the two *carrying features on a scale from 1 to 6 where 1 is a lot of pain and 6 is no pain.*

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 19A: How durable/strong did you experience each of the two RRUs, RRUS 01 or 11, carrying features?

Grade the level of durability/strength of each of the two *carrying features on a scale from 1 to 6 where 1 is not durable/weak and 6 very durable/very strong.*

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

APPENDIX

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Question 20A: How comfortable did you experience the usage of each of the two RRUs, RRUS 01 or 11, carrying features was?

Grade the level comfort during usage of each of the two *carrying features on a scale from 1 to 6 where 1 is very uncomfortable and 6 is very comfortable.*

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 21A: If you were to redesign the carrying feature for easy handling and optimised ergonomic usage, how would you design it and where is the handle to be placed on the RRUs? Draw or explain.

APPENDIX

III - USABILITY TEST

Scenario 2 - Hoisting and Installing

Initial questions - answered before the usability test is performed

***Question 1B**: How do you predict the handling/usage of the RRU and its carrying feature through hoisting will be?*

Grade the usage prediction on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 2B: On the scale from 1 to 6, how easy/problematic do you predict the two RRUs, RRUS 01 or 11, are to handle while hoisted?

Grade the easy of usage prediction on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Part 1 - Prepare for hoisting

Task finalised: **Y** / **N**

Time used to understand how the RRU is to be hoisted using its carrying feature: _____ SEC

Time used to perform the task: _____ SEC

Question 3B: On the scale from 1 to 6, how easy/problematic was it to find and connect the equipment to enable hoisting on each of the two RRUs, RRUS 01 or 11, preferably using its carrying feature?

Grade how easy/problematic finding where and how to and connect hoisting equipment on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 4B: On the scale from 1 to 6, how intuitive was it to connect the equipment to enable hoisting on each of the two RRUs, RRUS 01 or 11, preferably using its carrying feature?

Grade how intuitive finding where and how to connect the equipment enabling hoisting on a scale from 1 to 6 where 1 is not intuitive at all and 6 is very intuitive.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

APPENDIX

III - Usability test

Part 2 - Hoist to a height

Task finalised: **Y** / **N**

Number of faults/mistakes to finalise the task: _____ Faults

Time used to perform the task: _____ SEC

Question 5B: On the scale from 1 to 6, how easy/problematic was it to hoist each of the two RRUs, RRUS 01 or 11, to the height of 1,5 meters into the air?

Grade how easy/problematic each of the RRUs was to hoist on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 6B: On the scale from 1 to 6, how well do you think each of the two RRUs, RRUS 01 or 11, handle while being hoisted, for example lift angle ?

Grade how easy/problematic each of the RRUs was to hoist on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Part 3 - Placement

Task finalised: **Y** / **N**

Number of faults/mistakes to finalise the task: _____ Faults

Time used to perform the task: _____ SEC

Question 7B: On the scale from 1 to 6, how easy/problematic was it to place each of the two RRUs, RRUS 01 or 11, to the wall at the height of 1,5 meters while the product is hoisted?

Grade how easy/problematic placement onto a wall while being hoisted was on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

APPENDIX

III - Usability test

Question 8B: On the scale from 1 to 6, how easy/problematic was it to hold each of the two RRUs, RRUS 01 or 11, still/steady in the air while hoisted to enable installation/mounting?

Grade how easy/problematic holding the RRUs in place in the air (hoisting) to enable installation/ on a scale from 1 to 6 where 1 is problematic and 6 is very easy

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6 .*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 9B: On the scale from 1 to 6, how ergonomically well did you experience the usage of the hoisting features of each of the two RRUs, RRUS 01 or 11, while placing the product onto a wall?

Grade the level of proper ergonomic usage while hoisting the RRUs on a scale from 1 to 6 where 1 is not ergonomically adapted at all and 6 is very ergonomically.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Part 4 - Installation/mounting

Task finalised: **Y** / **N**

Number of faults/mistakes to finalise the task: _____ Faults

Time used to perform the task: _____ SEC

Question 10B: On the scale from 1 to 6, how easy/problematic was it to hold the product in place while trying to install/mount each of the two RRUs, RRUS 01 or 11, onto a wall?

Grade the easy of usage prediction on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 11B: On the scale from 1 to 6, how well did the product handle in the air, lift angle and steady handling, while trying to install/mount each of the two RRUs, RRUS 01 or 11, onto a wall?

Grade how well the product handled in the air on a scale from 1 to 6 where 1 not well and 6 is very well.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

APPENDIX

III - USABILITY TEST

Question 12B: On the scale from 1 to 6, to what extent was it possible to handle the product only using one hand while trying to install/mount each of the two RRUs, RRUS 01 or 11, onto a wall?

Grade the possibility of one hand usage on a scale from 1 to 6 where 1 is problematic to use one hand and 6 is very easy and possible to use one hand.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Part 5 - Displacement

Task finalised: **Y** / **N**

Number of faults/mistakes to finalise the task: _____ Faults

Time used to perform the task: _____ SEC

Question 13B: On the scale from 1 to 6, how easy/problematic was it to take down each of the RRUs, RRUS 01 or 11, already installed/mounted from a wall using its carrying feature.?

Grade the easy of usage prediction on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Summarising question after Scenario 1 has been performed.

Task (total) finalised: **Y** / **N**

Number of faults/mistakes to finalise the task (total): _____ Faults

Time used to perform the task (total): _____ SEC

Question 14B: On the scale from 1 to 6, how easy/problematic was it to hoist and install/mount each of the two RRUs, RRUS 01 or 11?

Grade how easy/problematic the hoist and installation/mounting of each RRU, using its carrying feature, on a scale from 1 to 6 where 1 is problematic and 6 is very easy.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

APPENDIX

III - Usability test

Question 15B: On the scale from 1 to 6, how well did the carrying feature enable hoisting in the each of the two RRUs, RRUS 01 or 11?

Grade how well did the carrying feature enable hoisting on a scale from 1 to 6 where 1 is not well and 6 is very well.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 16B: On the scale from 1 to 6, how intuitive was it to find and connect the hosting equipment as well as how it was to be used on each of the two RRUs, RRUS 01 or 11?

Grade how intuitive the feature of hoisting on each RRU was on a scale from 1 to 6 where 1 is not intuitive at all and 6 is very intuitive.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 17B: All and all, how well do you rate the level of usability of each of the two RRUs, RRUS 01 or 11, carrying feature while hoisting the products?

Grade the level of usability on a scale from 1 to 6 where 1 is not at all easy to use and 6 is very easy to use.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 18B: All and all, how well do you rate the level proper ergonomic usage of each of the two RRUs, RRUS 01 or 11, carrying features while hoisting the products?

Grade the level proper ergonomic usage on a scale from 1 to 6 where 1 is not at all ergonomic and 6 is very ergonomic.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 19B: If there was pain involved during usage of the hoisting while handling and installation/mounting of the two RRUs, RRUS 01 or 11, rate the level of pain?

Grade the level of pain during usage on a scale from 1 to 6 where 1 is a lot of pain and 6 is no pain.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

APPENDIX

III - Usability test

Question 20B: How durable/strong did you experience each of the two RRUs, RRUS 01 or 11, carrying features while being hoisted?

Grade the level of durability/strength while hoisting on a scale from 1 to 6 where 1 is not durable/weak and 6 very durable/very strong.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 21B: How comfortable did you experience the usage of each of the two RRUs, RRUS 01 or 11, carrying features while hoisting the products?

Grade the level comfort during hoisting on a scale from 1 to 6 where 1 is very uncomfortable and 6 is very comfortable.

RRUS 01	*1*	*2*	*3*	*4*	*5*	*6*
RRUS 11	*1*	*2*	*3*	*4*	*5*	*6*

Question 22B: If you were to redesign the carrying feature for easy hoisting, handling and optimised ergonomic usage, how would you design it and where is the handle to be placed on the RRUs? Draw or explain.

APPENDIX

IV - Sustainability questions

Questions vital to answer within the sustainability

Materials

What materials are the "Cover" made of:
RRUS 01_____
RRUS 11_____
RRUS 12_____
Alternative materials which_____
still fulfil all the requirements

What materials are the "Core Structure" made of:
RRUS 01_____
RRUS 11_____
RRUS 12_____
Alternative materials which_____
still fulfil all the requirements

What materials are "Core Interface" made of:
RRUS 01_____
RRUS 11_____
RRUS 12_____
Alternative materials which_____
still fulfil all the requirements

What materials are the carrying features made of:
RRUS 01_____
RRUS 11_____
RRUS 12_____
Alternative materials which_____
still fulfil all the requirements

1. What materials are the screws and screws points made of:

   RRUS 01_____
   RRUS 11_____
   RRUS 12_____
   Alternative materials which_____
   still fulfil all the requirements

2. What materials are the cable connections made of:

   RRUS 01_____
   RRUS 11_____
   RRUS 12_____
   Alternative materials which_____
   still fulfil all the requirements

3. What materials are the cable connection caps made of:

APPENDIX

IV - Sustainability questions

RRUS 01_____
RRUS 11_____
RRUS 12_____
Alternative materials which_____
still fulfil all the requirements

What kind of colouring methods and colours are used for colouring the different parts of the RRUS?

Are there alternative colouring methods or can the type of colour be change but still provide the same features of heat resistance and protection?

To what extent is the product in need of having painted layers?

Are there possibilities to change some materials to minimise the products total weight, which will denote smaller transportation costs and emissions?

Do Ericsson have any control on the working conditions at the production sites, where ,the materials used in their products, are mined/broken and how this is done to minimise the environmental impact.

Production

How are each of the RRUs exterior and protective parts part produced?

Where are the RRUs and its parts produced?

APPENDIX

IV - Sustainability questions

Does the production site depend on where the product will be sold?

Is it possible to produce the products and its parts more locally to where will be sold and used?

Do Ericsson control where the materials originates from and where and how they are being mined/broken? - (lik sista frågan på material)

Are there different production and assembly sites to produce and assemble a RRU - where and how do the cooperate?

Does a lot and long transportation of the goods between the different production sites occur?

Is it possible to coordinate all the production to one site to minimise the transportation?

Are there different production sites for different products, within the Ericsson product family?

Modularity

Are any parts modular between the three RRUs?

APPENDIX

IV - Sustainability questions

Are there parts within the three RRUs which would be able to be modular and be used on all three products?

If, any products not really are modular today, why is this?

Upgradability

Are there any kind of upgradability in the parts of the three RRU as of today?

Is it possible to reuse the "shell"/"Core & Cover" of a product by changing/upgrading the vital technical parts within the product?

- provide a longer life of the majority of the product

Is it possible today to update/upgrade a RRU by changing the -handle or cover etc?

Re-Usability & Re-cycling

Is it possible to use the "shell"/"Core & Cover" of the three RRUs with any other of Ericsson's products, or possibly in any other way at all?

Is there a possibility and interest of letting the products hit the second-hand market after certain use?

- From Ericsson's point of view?

- From the market's point of view?

APPENDIX

IV - Sustainability questions

What is the situation of Re-cycling of Ericsson's products (foremost the three reference RRUs 01,11, 12) today?

- Is Ericsson's controlling and monitoring this process or is it handled by the buyer?

To what extent are Ericsson's products (foremost the three reference RRUs 01,11, 12) recycled as of today?

To what extent does recycled material from old Ericsson products go back into the material used within the newly produced products?

What happens with the materials with in Ericsson's products (foremost the three reference RRUs 01,11, 12) which is not recycled?

Quality

In what way can Ericsson raise the quality & life span of their RRUs (and all products) in regard to minimise the environmental impact that goes with production and manufacturing?

APPENDIX

V - Pugh-matrix

CONFIDENTIAL INFORMATION TO 2014-01-01

CONFIDENTIAL INFORMATION TO 2014-01-01

APPENDIX

V - Pugh-matrix

CONFIDENTIAL INFORMATION TO 2014-01-01

CONFIDENTIAL INFORMATION TO 2014-01-01

APPENDIX

VI - Shear stress calculations

$r = 2$ mm

- $\tau = \frac{N}{A}$ $\quad A = \pi \cdot r^2$ $\quad \varnothing$ (however two axles)

$\Rightarrow \tau = \frac{N}{\pi \cdot r^2} \Rightarrow \tau = \frac{N}{2(\pi \cdot r^2)} \Rightarrow 0{,}6 \cdot 360 = \frac{N}{2 \cdot (\pi \cdot 2^2)}$

$\Rightarrow N = 0{,}6 \cdot 360 \cdot 2 \cdot (\pi \cdot 2^2) = 5429\ N$ $\Rightarrow 553$ kg On a 4mm axle

Tensile strength
Machine steel
E 360
360 MPa =
$\tau = 0{,}6 \cdot$ Tensile str

- $r = 1{,}5 \Rightarrow N = 0{,}6 \cdot 360 \cdot 2 \cdot (\pi \cdot 1{,}5^2) = 3054\ N$

Tensil Strength
ABS-Plastic
<80 MPA
PA <100

- $r = ?$, $N = 2$ o (well over the limit 1600 N) $\Rightarrow 311$ kg On a 3 mm axle

$\tau = \frac{N}{2(\pi r^2)} \Rightarrow \pi r^2 = \frac{N}{2\tau} \Rightarrow r^2 = \frac{N}{2\pi\tau}$

- $r^2 = \frac{2350}{2 \cdot \pi \cdot 0{,}6 \cdot 80} = 7{,}79$ mm $\quad r = \pm\sqrt{7{,}79} = \pm 2{,}79$ mm $\Rightarrow \varnothing = 5{,}58$ mm

$\tau = 0{,}6 \cdot 80$

- $r^2 = ?$, $N = 2$ o $\quad (\tau = 0{,}6 \cdot 100)$

$r^2 = \frac{2350}{2 \cdot \pi \cdot 0{,}6 \cdot 100} = 6{,}23 \Rightarrow r = \pm\sqrt{6{,}23} = \pm 2{,}5$ mm $\Rightarrow \varnothing 5$ mm

APPENDIX

VII - Life cycle assessment

produced with product ecology™

Summary

Design **RRUS 12 Life Cycle Assessment**

Product **RRU - Ericsson Radio Remote Unit 12**

Life cycle assessment of Ericsson's RRUS 12 - reference product at the master thesis at Ericsson Industrial Design. Chalmers University of Technology. No technical intenal features will be regarded in this LCA. ABS-plastic is used in the analysis, as it holds less CO2-emissions and ... however more water usage, when analyzing the plastic details such as Sun-Covers. Due to not data on the percentage of spill during production is this neglected in the analysis. All production material is set to the final weight of the parts. All processes used by Ericsson when producing a product is not possible to chose in this LCA-tool, when this occurs closest most suitable process is used. Used In Sweden, transported by train to Scotland for initial recycling and further transported to Chicago USA for final recycling.

Product image

Design Impacts

CO2 Emissions **Water Use** **Waste Output**

	CO2 Emissions (t CO2 eq)	Water Use (m3)	Waste Output (kg waste)
Materials & Processes	1.030e-1	1.017e+1	7.209e-1
Distribution	1.403e-1	7.431e-1	2.404e-1
Consumption	3.082e-1	4.621e+1	1.591e+1
End Of Life	3.391e-2	1.571e+1	6.445e-2

Lifecycle Overview

Product Breakdown and EoL Destination

Component	Part	Material	Process	Amount	EoL Destination
Core					
	Core-Body Front	aluminium, secondary, from new scrap, at plant		6 kg	disposal, aluminium, 0% water, to sanitary landfill
			powder coating, aluminium sheet	0.25 m2	

APPENDIX

VII - Life cycle assessment

			aluminium product manufacturing, average metal working	6 kg	
	Core-Body Back	aluminium, secondary, from new scrap, at plant		8.6 kg	disposal, aluminium, 0% water, to sanitary landfill
			powder coating, aluminium sheet	0.45 m2	
			aluminium product manufacturing, average metal working	8.6 kg	
	Adhesive for binding the tone-powder	adhesive for metals, at plant		0.1 kg	disposal, paint, 0% water, to municipal incineration
Sun-Cover					
	Sun-Cover Front	acrylonitrile-butadiene-styrene copolymer, ABS, at plant		0.988 kg	disposal, plastics, mixture, 15.3% water, to municipal incineration
			injection moulding	0.988 kg	
	Sun-Cover Back	acrylonitrile-butadiene-styrene copolymer, ABS, at plant		0.994 kg	disposal, plastics, mixture, 15.3% water, to municipal incineration
			injection moulding	0.994 kg	
	Sun-Cover Paint	alkyd paint, white, 60% in solvent, at plant		0.1 kg	disposal, paint, 0% water, to municipal incineration
Product assessories					
	Carrying feature	aluminium, secondary, from new scrap, at plant		0.098 kg	disposal, aluminium, 0% water, to sanitary landfill
			powder coating, aluminium sheet	0.001 m2	
			aluminium product manufacturing, average metal working	0.098 kg	
	Product Feet	aluminium, secondary, from new scrap, at plant		0.054 kg	disposal, aluminium, 0% water, to sanitary landfill
			powder coating, aluminium sheet	0.001 m2	
			aluminium product manufacturing, average metal working	0.054 kg	
Fasteners					

APPENDIX

VII - Life cycle assessment

	Screws	chromium steel product manufacturing, average metal working		0.21 kg	disposal, steel, 0% water, to municipal incineration
			milling, chromium steel, small parts	0.21 kg	
Overlays					
	Overlay - Plastics	polycarbonate, at plant		0.11 kg	disposal, plastics, mixture, 15.3% water, to municipal incineration
			extrusion, plastic film	0.11 kg	
	Overlay - Paint	printing colour, offset, 47.5% solvent, at plant		0.006 kg	disposal, paint, 0% water, to municipal incineration
Packaging Materials					
	Pallet	industrial wood, softwood, under bark, u=140%, at forest road		0.1 m3	disposal, wood untreated, 20% water, to municipal incineration
			wood chopping, mobile chopper, in forest	3.9 kg	
	Corrogated Frame, 1.053 KG	packaging, corrugated board, mixed fibre, single wall, at plant		1.053 kg	disposal, packaging cardboard, 19.6% water, to municipal incineration
			folding boxboard, FBB, at plant	1.053 kg	
	Plywood Lid, 2.6 KG	plywood, outdoor use, at plant		0.0015 m3	disposal, wood untreated, 20% water, to municipal incineration
			wood chopping, mobile chopper, in forest	2.6 kg	
	Packaging strap	polypropylene, granulate, at plant		0.09 kg	disposal, polypropylene, 15.9% water, to municipal incineration
			extrusion, plastic film	0.09 kg	
	Fitments	polystyrene foam slab, at plant		6 kg	disposal, polystyrene, 0.2% water, to municipal incineration

End of Life Overview

Description	Process	Amount
Recycling of Aluminium	aluminium, secondary, from new scrap, at plant	14.95 kg
Recycling of Plastic details in Sun-Cover	injection moulding	1.982 kg

Distribution Overview

Description	Transport Mode	Distance

APPENDIX

VII - Life cycle assessment

Transportation Aluminium die-casted Core from Romania to Estonia	transport, aircraft, freight	1400 km
Transportation Plastic details - Sun-Cover Romania to Estonia	transport, aircraft, freight	1400 km
Delivery from assembly in Estonia to customer in Sweden	transport, aircraft, freight	400 km
Transportation to recycling-site, Sweden to Scotland	transport, transoceanic freight ship	1260 km
Transportation to recycling-site, Scotland to USA	transport, transoceanic freight ship	5900 km

Consumables Overview

Description	Consumable	Amount Consumed
Energy usage over 1 at a medium consumption of 400 W (average usage in normal conditions incl. spill & waste)	electricity, medium voltage, at grid	3504 kWh

APPENDIX

VIII - SPRING DIMENSIONS

Program *DF* *Ver110315*
Användare *Larsson Christian*

LESJÖFORS

Kund	**Ericsson AB**	Land	**Sverige**	Ber.datum	**2012-03-28 15:22**
Ritn/ID	**Skiss**	Övrigt			
Kontakt	**Hampus Regnér**				

Material

Sort	EN 10270-3 1.4310 - NS	d_t [mm]	1,00	Efter anlöpning R_m [MPa]	2050
G-modul	74800 MPa	Runt,Draget			
E-modul	190000 MPa				
$R_{m,MIN}$	1900 MPa				

Dimensioner

D_y [mm]	**10,80 ±0,3**	L_0 [mm]	28,50 ±0,9	D_m/d_t	9,80
D_m [mm]	9,80	n_t	16,53	L_k [mm]	17,20
D_i [mm]	8,80			P_0 [mm]	1,01

Ände 1	Specificerad ögla/krok	L_{H1} [mm]	7,00	$n_{v,bidrag}$
Ande 2	Specificerad ögla/krok	L_{H2} [mm]	4,30	$n_{v,bidrag}$

Spalt [mm]	0	*Tätlindad med förspänning*	
Lindningsriktning	Höger		
Trådlängd [mm]	542	Egenfrekvens [Hz]	218,2
Vikt [g]	3,36		

Belastningsdata

R [N/mm]	0,601	Antal cykler	Drifttemperatur [ºC]
F_0 [N]	4,50	motsvarar τ=	5,5% av $R_{m,MIN}$

Läge	Längd [mm]	Fjädring [mm]	Kraft [N]	Energi [J]
1	68,50	40,00	28,54 ±2,2	0,661

Påkänningar

Läge	Längd [mm]	τ [MPa]	τ [% av $R_{m,min}$]	τ_k [MPa]	τ_k [% av $R_{m,MIN}$]
1	68,50	712	34,7%	811	39,5%

Uppdaterad
Kontroll

Belastningskrav

Läge	Längd [mm]	Kraft [N]
Obelastad		
1	68,5	
2		
R [N/mm]		

L_3

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IX - PATENT APPROVAL IRELAND

PATENT SPECIFICATION

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(54) Title: A telecom equipment unit mountable on a support structure

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MIKAEL THELIN

(73) Patent Granted to: TELEFONAKTIEBOLAGE T L M ERICSSON (PUBL), Swedish, SE-164 8
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APPENDIX

IX - PATENT APPROVAL IRELAND

"A telecom equipment unit mountable on a support structure"

Technical field

The invention relates to a telecom equipment unit mountable on a support structure and provided with a handle.

Background

Within the field of telecom a lot of the used equipment is remote telecom equipment that is mounted different support structures, e.g. on masts, on walls, or on roofs. On the mounting site, this remote equipment is often handled more or less manually. It may be carried by hand or hoisted by using a rope or chain or some kind of simple lifting apparatus/equipment. In order to be able to do this handling on site and install the remote equipment at its proper location, some kind of handle is usually attached directly onto the remote equipment. It is common that this type of remote equipment is within the ergonomic concept of "one man carry", indicating that the weight is less than 23 kg and that it can be carried by a single person.

The concerned type of remote equipment must be able to withstand outdoor conditions for in the region of 15-20 years, and so must the handle. It must be able to withstand cold, heat, rain, snow, sun radiation, etc. without decay or deterioration, and with full preservation of its functionalities. Therefore, according to prior art, what has so far been used is a rather sturdy fixed handle, e.g. made of aluminium, which is simply screwed onto the top of the remote equipment. However, the handle makes the telecom equipment bulkier and there is a risk that something may involuntarily get caught up by the protruding handle. Also, when packaging and transporting such remote telecom equipment, consideration has to be taken to the protruding handle resulting in a more bulky package and added volume due to the handle.

Summary

An object of the invention is to obtain a telecom equipment unit mountable on a support structure and provided with an improved handle that makes the telecom equipment unit less bulky and easier to pack and handle.

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IX - PATENT APPROVAL IRELAND

The invention relates to a telecom equipment unit mountable on a support structure and provided with a handle, wherein the handle comprises an elongated handgrip configured to be gripped by a human hand and a lifting device comprising a recess located in a bottom face of the handgrip which recess is configured to receive a lifting equipment. The handle is collapsible and that, when the handle is collapsed, a bottom face of the handgrip is located essentially flush with or adjacent an external surface on the telecom equipment unit.

By making the handle collapsible many advantages are achieved. During transportation of the telecom equipment unit, the handle is collapsed and takes up much less space than the prior art handle. It also takes up less volume for packaging. Further, a collapsed handle that is located essentially flush with or adjacent the external surface of the telecom equipment unit does not risk getting caught up in something to the same extent as a regular fixed handle. In addition, it also confers a more unitary visual expression to the telecom equipment unit.

According to an embodiment of the telecom equipment unit, the handle is automatically collapsible. The handle may also be configured to be able to adopt two positions, a first collapsed position and a second use position. When the handle is not in the use position, i.e. the position where it readily could be gripped by a hand or used for attachment of a lifting equipment, the handle will automatically collapse into its collapsed position. Consequently, there is no need to, for example, push down the handle in order for it to collapse/fold.

In order to make the handle automatically collapsible, the handle advantageously may comprise at least one spring element, which is operative to retract the handgrip of the handle from the second use position to the first collapsed position. The use of a spring element for this purpose is convenient. The spring element may comprise any type of resilient or elastic element that can exercise a pulling force and pull down the handgrip towards the surface of the telecom equipment unit in order to collapse the handle. Examples of suitable spring elements are a helical spring, a rubber band or equivalents thereof.

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The handle may comprise a pair of brackets secured to an attaching wall on the telecom equipment unit, a pair of links of which each link connects a bracket to the handgrip, and each link being pivotably connected to a bracket at a first pivot end of the link and being moveably connected to the handgrip by a second end of the link. Thus by making a handle that comprises several assembled parts, much more flexibility is achieved so as to make the handle collapsible.

The handgrip may comprises a hollow interior, and the handgrip may be provided with spaced apart openings that communicate with the hollow interior, and further said second end of the respective link may be insertable into a respective opening. Moreover, the second end of the respective link may be slideable in said hollow interior such that during the collapsing of the handle, when the handle moves from the second use position to the first collapsed position, the respective link is gradually retracted into the hollow interior of the handgrip. By giving the handle this technical design, a collapsible handle is obtained that is very slim when collapsed and it does not affect the available volume inside the telecom equipment unit, since it is entirely on the outside of the unit, even when collapsed. Consequently, there is neither any adverse effect on the performance of the telecom equipment unit. Another advantage is that all moveable parts are located inside the handgrip in the collapsed position, and they are thus protected during ordinary use of the telecom equipment unit since the handle would then be collapsed.

According to an embodiment, the at least one spring element is located inside the hollow interior of the handgrip, and the respective second ends of the links are provided with a spring support device for connection to the at least one spring element, and further, the at least one spring element is operative to retract the respective link into the hollow interior. Hereby the spring element is also protected inside the handgrip. The at least one spring element can be one spring element attached to the respective second ends of the links, or each link can have its own spring element, in which case such spring element will also need to be attached inside the hollow interior of the handgrip.

According to an aspect of the present disclosure, the links are configured as link arms, each link arm being provided with two laterally protruding pivot pins at its first pivot end and two laterally protruding connection means at its second end for moveable

connection to the handgrip. By making the links as link arms a good durability is obtained.

Since the material of the handle must sustain harsh and variable outdoor conditions for many years, examples of suitable materials are aluminium, glass fibre reinforced plastic or other synthetic materials, and similar. This concerns in particular the exterior parts of the handle.

The above mentioned features and aspects of the telecom equipment unit, according to the present disclosure, may be combined in various possible ways providing additional advantageous embodiments.

Further features and advantages of the embodiments of the invention will also become apparent from the following detailed description of embodiments.

Brief description of the drawings

A detailed description of the present disclosure and embodiments thereof, given as examples only, will now be made with reference to the accompanying drawings, in which:

Fig. 1 shows a schematic perspective view of a telecom equipment unit mountable on a support structure according to the present disclosure, with a handle in a collapsed position;

Fig. 2 shows a schematic perspective view of a telecom equipment unit according to the present disclosure, with a handle in a use position;

Fig. 3 is a perspective view showing the details of the handle, in a use position;

Fig. 4 is a perspective view showing the details of the handle, in a collapsed position;

Fig. 5 is a perspective, exploded view showing the details of the handle,

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Fig. 6 is a perspective, exploded view showing a variant of the handle in Fig. 5;

Fig. 7 is a side view, in cross section along A-A in Fig. 8, and showing the handle in a use position;

Fig. 8 shows a top view of the handle according to the disclosure; and

Fig. 9 is a side view, in cross section along A-A in Fig. 8, and showing the handle in a collapsed position.

Detailed description

Fig. 1 shows schematically an embodiment of a telecom equipment unit 1 mountable on a support structure, according to the invention. The telecom equipment unit is provided with a handle 3 that is collapsible. By collapsible is meant that the handle can be collapsed, or folded down, as shown in Fig. 1. The collapsed position would be the normal position of the handle when it is not used, e.g. for carrying the telecom equipment unit 1. The schematically illustrated telecom equipment unit may be any type of telecom equipment that needs to be carried or lifted and therefore requires an appropriate handle. Examples of such a telecom equipment unit 1 are remote telecom equipment units, e.g.: Remote Radio Unit (RRU), Remote Radio Base Station (RBS), Remote Digital Unit (OD), Access Points (WiFi), Mini-link mast products, and Antenna Integrated Radio (AIR), which are intended for mounting on some kind of support structure such as a mast, a wall , a roof or similar. The telecom equipment unit is therefore also provided with a mounting device (not shown) for mounting the telecom equipment unit on a mast, a wall, a roof or similar, such as an arrangement with bracket and screws.

The handle of the telecom equipment unit 1 comprises an elongated handgrip 5 configured to be gripped by a human hand and a lifting device comprising a recess 7 located in a bottom face 35 of the handgrip 5. The recess is configured to receive lifting equipment, such as a rope or a chain. As mentioned, the handle is collapsible and when the handle is collapsed, the bottom face 35 of the handgrip 5 is located essentially flush with or adjacent an external surface 40 on the telecom equipment unit. This can also be seen in more detail in Fig. 9. Only a very narrow gap, in the order of 1-4 mm, is needed

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between the handgrip and said external surface in order to make it possible for a person to more feasibly insert the fingers under the handgrip or grip the handgrip adjacent the bottom face 35 and pull up the handgrip.

The handle on the telecom equipment unit is configured to be able to adopt two positions, a first collapsed position and a second use position unit. In Fig. 2 is schematically shown the same telecom equipment unit 1 as in Fig. 1, but with the handle in the second use position, which is an uplifted position, a ready to use position. In this position, there will be enough space between the handle 3 and the surface of the telecom equipment unit 1, to which the handle is attached, in order for a hand to be inserted between said surface and the handle, to grip the handle and lift the telecom equipment unit. There will also be enough space to apply a rope or chain. From this position, the handle is collapsible, and in one embodiment configured to automatically collapse, into the collapsed position shown in Fig. 1, as soon as there is no lifting force exerted on the handle, as will be further explained below.

In the illustrated telecom equipment unit of Figs. 1 and 2, the unit is only provided with one handle, but naturally such a unit could also be provided with two or more handles if required. This may for example be the case if the telecom equipment unit is very long or extra heavy.

The handle 3, of which the different aspects are shown in more detail in Figs. 3-9, comprises the elongated handgrip 5, first and second links 13, 15, and first and second brackets 9, 11. The links 13, 15 connect the handgrip 5 with the brackets 9, 11. The brackets are used to attach the handle to an attaching wall 10 on the telecom equipment unit, as shown in Figs. 1, 2, 8 and 9, for example by screws. A first end 13a of the first link 13 connects a first end 14 of the handgrip 5 with the first bracket 9, and a first end 15a the second link 15 connects a second end 16 of the handgrip with a second bracket 11. The first ends 13a, 15a of the links are pivotably connected to the respective brackets. A second end 13b of the first link 13 connects the first link with a first end 14 of the handgrip, and a second end 15b of the second link 15 connects the second link with a second end 16 of the handgrip.

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The handgrip has a hollow interior 20, which may be one continuous hollow interior or it may be divided in several hollow parts, see Figs. 5-7 and 9. Access to the hollow interior is provided by an opening 19, 21 at each end 14, 16 of the handgrip. Through these openings, the second ends 13b, 15b of the respective links 13, 15 can be inserted and the respective link can then be retracted into the hollow interior 20 of the handgrip, and thus making the handle collapse, as illustrated in Fig. 9. In order to make the handle collapse automatically, i.e. to collapse as soon as there is no lifting force applied on the handgrip, the retractable links are connected to a retracting spring element 30. This spring element may for example be a rubber band, a helical spring or any other suitable resilient or elastic member that would automatically pull the link inside the hollow interior as soon as there is no lifting force that pulls on the handgrip and the spring element. Examples of different embodiments of the spring element are shown in Figs. 5 and 6. The spring element can be one and the same attached to both links 13, 15 or each link can have its own spring element, in which case the spring elements would be attached to a fixed support inside the handgrip.

The spring element 30 is mounted on the links 13, 15 by means of a spring support device 31, 32 at the respective second ends 13b, 15b of the links. Further, these ends of the links should be designed with connection means such that they can both provide a reliable connection with the handgrip 5 that is strong enough to sustain the stress when the telecom equipment unit 1 is lifted by the handle 3, and at the same time they should be designed to slide easily inside the handgrip 5 when the spring element 30 pull at the links during collapse of the handle. As an example, they can be provided with two laterally protruding connection means 42, e.g. lugs, that engage in a corresponding recess 47 in the handgrip, just inside the opening 19, 21, and which further have a shape such that they can slideably be guided inside the hollow interior 20 of the handgrip.

As mentioned, the first ends 13a, 15a of the links are pivotably connected to the respective brackets. In order to perform the pivot function, the first ends 13a, 15a are provided with pivot pins 41 and the bracket is provided with corresponding recesses 45 in which the pivot pins are journalled. Alternative pivot or articulated arrangements can also be foreseen. Also in this case it is important that the first ends 13a, 15a both provide a reliable connection with the brackets 9, 11 that is strong enough to sustain the

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stress when the telecom equipment unit 1 is lifted by the handle 3, and at the same time they should be designed to pivot easily when the handle is collapsed.

The links 13, 15 are in the illustrated embodiment configured as solid link arms. However, other types of links can be foreseen such as a square frame link or two part links.

The handgrip is preferably made in two parts that are assembled together, after assembly of the different components such as the spring element and the ends of links inside the handgrip.

The disclosure shall not be considered limited to the illustrated embodiments, but can be modified and altered in many ways, as realised by a person skilled in the art, without departing from the scope defined in the appended claims.

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Claims

1. A telecom equipment unit (1) mountable on a support structure and provided with a handle (3), wherein the handle comprises an elongated handgrip (5) configured to be gripped by a human hand and a lifting device comprising a recess (7) located in a bottom face (35) of the handgrip (5), which recess is configured to receive a lifting equipment, characterized in that,
the handle is collapsible and that, when the handle is collapsed, the bottom face (35) of the handgrip (5) is located essentially flush with or adjacent an external surface (40) on the telecom equipment unit (1).

2. The telecom equipment unit according to claim 1, characterized in that the handle is automatically collapsible.

3. The telecom equipment unit according to any one of the preceding claims, characterized in that the handle (3) is configured to be able to adopt two positions, a first collapsed position and a second use position.

4. The telecom equipment unit according to claim 3, characterized in that the handle comprises at least one spring element (30), which is operative to retract the handgrip of the handle from the second use position to the first collapsed position.

5. The telecom equipment unit according to claim 4, characterized in that the handle (3) comprises a pair of brackets (9, 11) secured to an attaching wall (10) on the telecom equipment unit (1), a pair of links (13, 15) of which each link connects a bracket (9, 11) to the handgrip (5), and each link being pivotably connected to a bracket at a first pivot end (13a, 15a) of the link and being moveably connected to the handgrip by a second end (13b, 15b) of the link.

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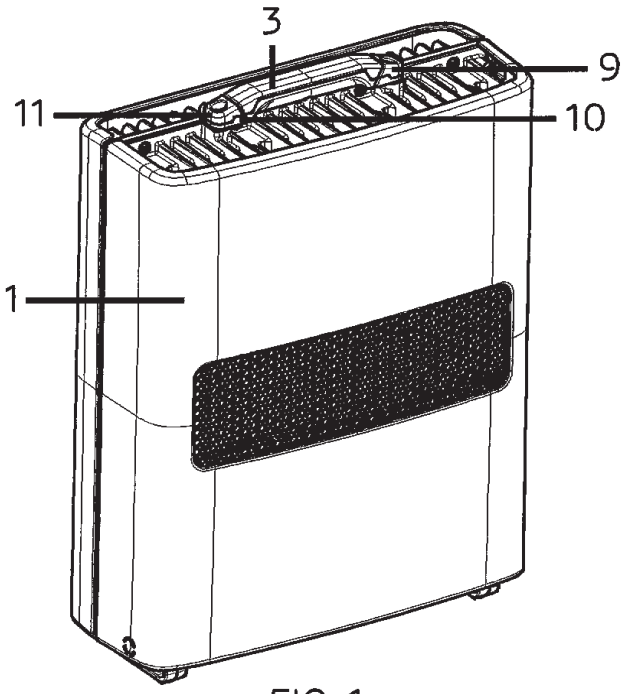

FIG. 1

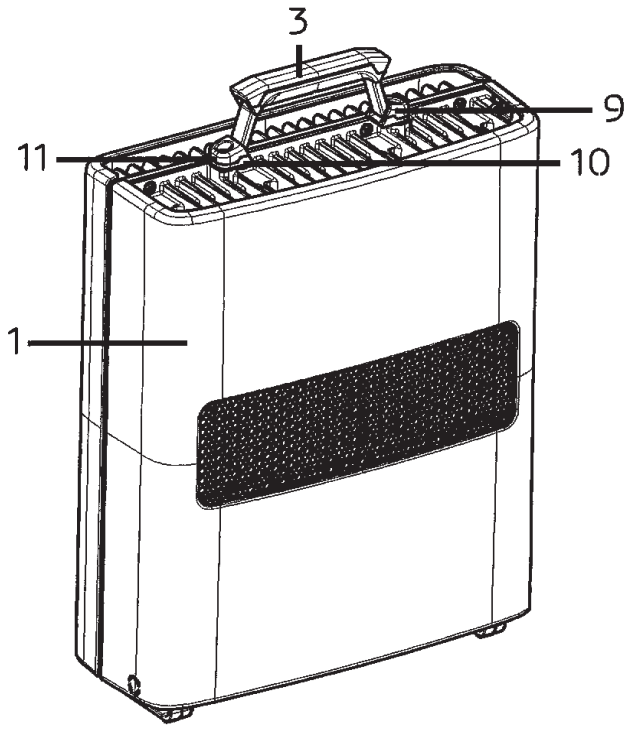

FIG. 2

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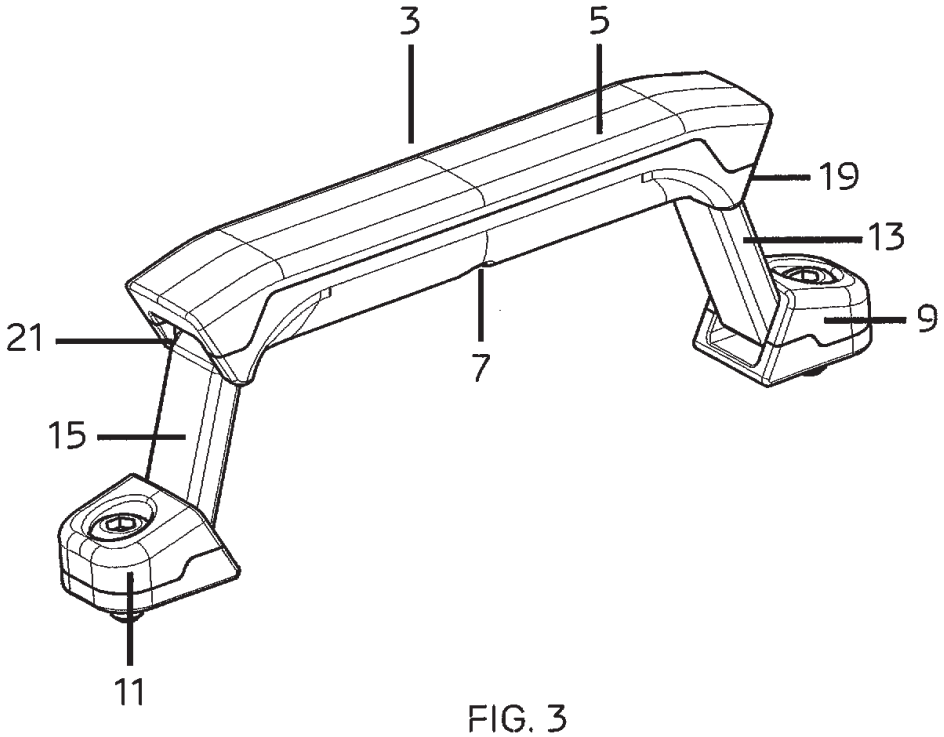

FIG. 3

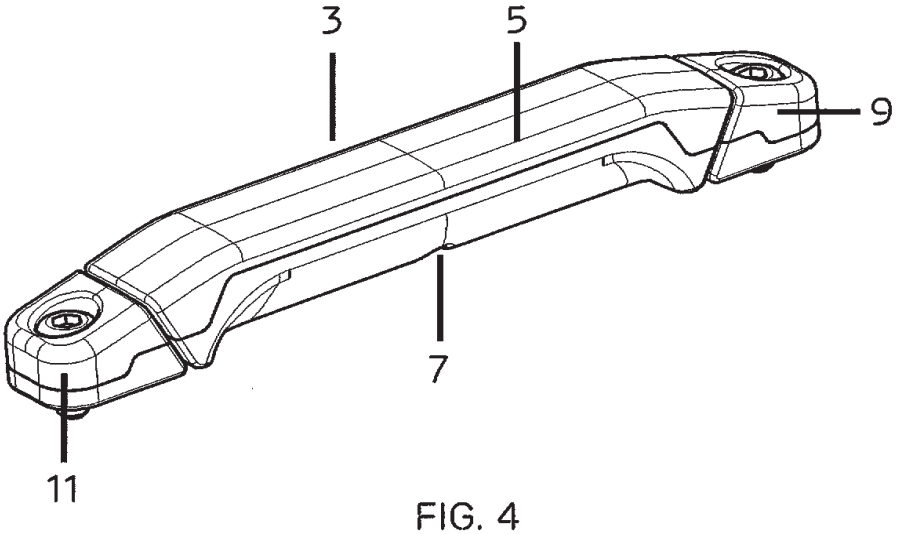

FIG. 4

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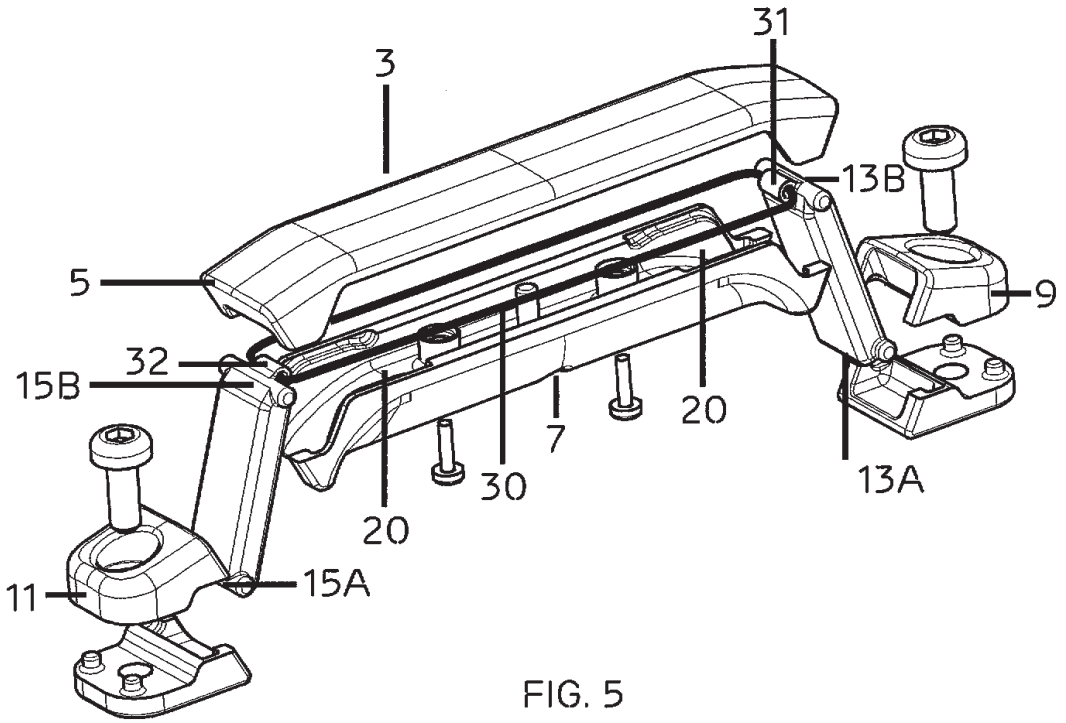

FIG. 5

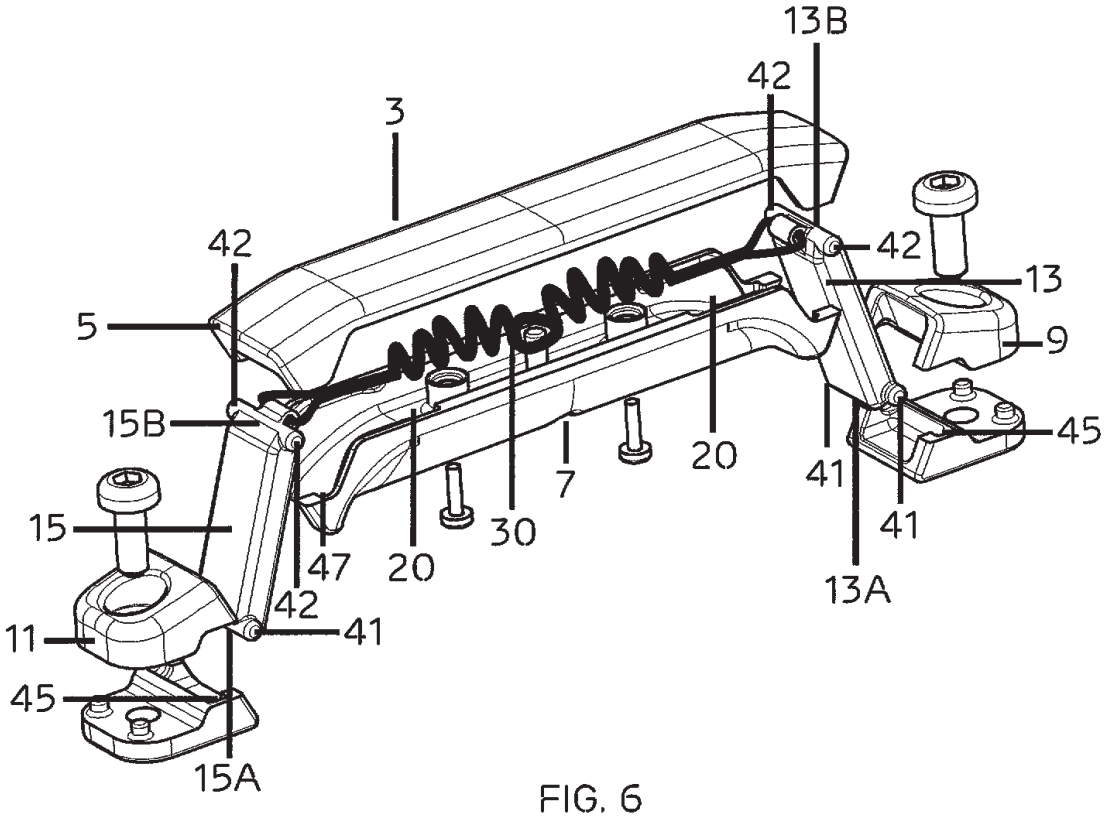

FIG. 6

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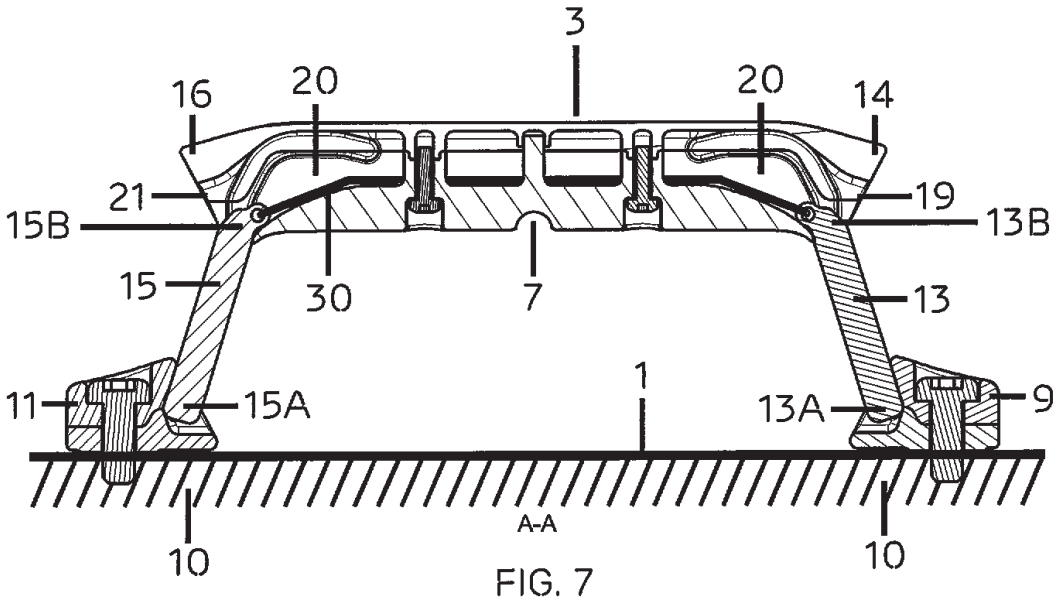

FIG. 7

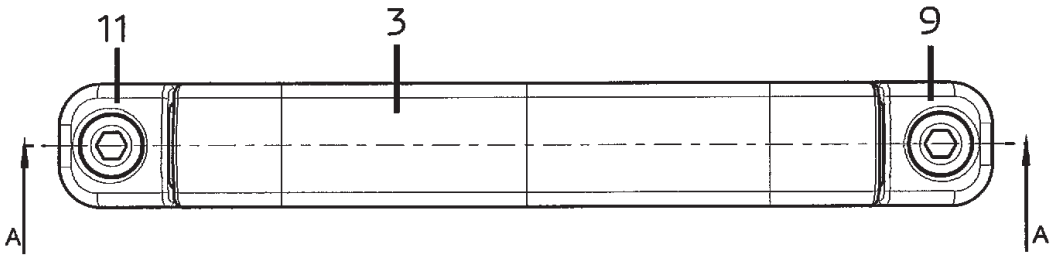

FIG. 8

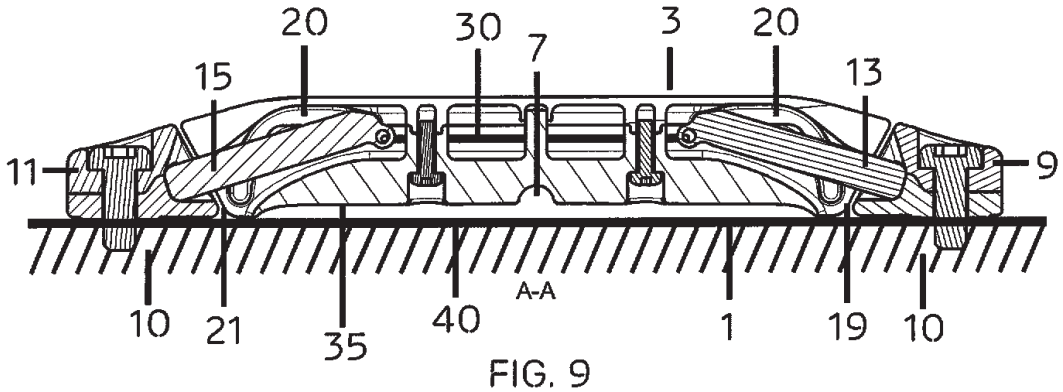

FIG. 9

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РОССИЙСКАЯ ФЕДЕРАЦИЯ

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(54) **БЛОК ТЕЛЕКОММУНИКАЦИОННОГО ОБОРУДОВАНИЯ, УСТАНАВЛИВАЕМЫЙ НА ОПОРНУЮ КОНСТРУКЦИЮ**

(57) Формула полезной модели

1. Блок (1) телекоммуникационного оборудования, устанавливаемый на опорную конструкцию и обеспеченный рукояткой (3), в котором рукоятка содержит вытянутую ручку (5), выполненную с возможностью захвата рукой человека и подъемным устройством, содержащую углубление (7), расположенное на нижней поверхности (35) ручки (5), это углубление выполнено с возможностью приема подъемного оборудования, отличающийся тем, что рукоятка является складной и что, когда рукоятка сложена, нижняя поверхность (35) ручки (5) расположена, по существу, вровень или прилегающей к наружной поверхности (40) блока (1) телекоммуникационного оборудования.

2. Блок телекоммуникационного оборудования по п.1, отличающийся тем, что рукоятка является автоматически складываемой.

3. Блок телекоммуникационного оборудования по любому из предшествующих пунктов, отличающийся тем, что рукоятка (3) выполнена с возможностью занимать два положения, первое сложенное положение и второе рабочее положение.

4. Блок телекоммуникационного оборудования по п.3, отличающийся тем, что рукоятка содержит по меньшей мере один пружинный элемент (30), который функционирует с возможностью отведения ручки рукоятки от второго рабочего положения к первому сложенному положению.

5. Блок телекоммуникационного оборудования по п.4, отличающийся тем, что рукоятка (3) содержит пару скоб (9, 11), прикрепленных к соединительной стенке (10) блока (1) телекоммуникационного оборудования, пару звеньев (13, 15), из которых

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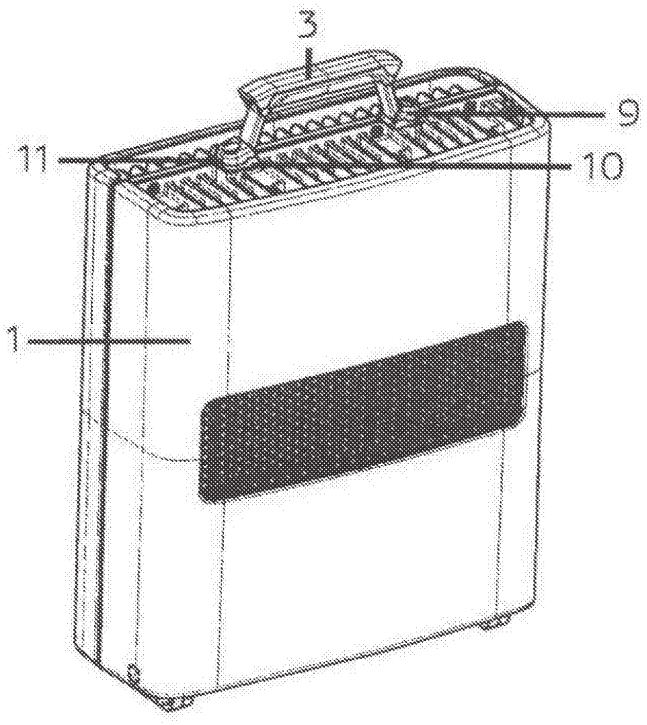
каждое звено соединяет скобу (9, 11) с ручкой (5), и каждое звено шарнирно соединено со скобой на первом шарнирном конце (13a, 15a) звена и подвижно соединено с ручкой при помощи второго конца (13b, 15b) звена.

6. Блок телекоммуникационного оборудования по п.5, отличающийся тем, что ручка содержит полую внутреннюю часть (20), ручка обеспечена разнесенными отверстиями (19, 21), сообщающимися с полой внутренней частью, упомянутый второй конец (13b, 15b) соответствующего звена (13, 15) является вставляемым в соответствующее отверстие (19, 21).

7. Блок телекоммуникационного оборудования по п.6, отличающийся тем, что второй конец (13b, 15b) соответствующего звена (13, 15) может скользить в упомянутую полую внутреннюю часть (20), так, что в ходе складывания рукоятки (3), когда рукоятка перемещается от второго рабочего положения к первому сложенному положению, соответствующее звено (13, 15) постепенно отводится внутрь полой внутренней части (20) ручки (5).

8. Блок телекоммуникационного оборудования по п.6, отличающийся тем, что по меньшей мере один пружинный элемент (30) расположен внутри полой внутренней части (20) ручки (5), тем что соответствующие вторые концы (13b, 15b) звеньев обеспечены пружинным опорным устройством (31, 32) для соединения с по меньшей мере одним пружинным элементом (30), и тем, что по меньшей мере один пружинный элемент работает с возможностью отведения соответствующего звена (13, 15) в полую внутреннюю часть (20).

9. Блок телекоммуникационного оборудования по п.5, отличающийся тем, что звенья (13, 15) выполнены как соединительные тяги, при этом каждая соединительная тяга обеспечена двумя простирающимся в боковом направлении шарнирными пальцами (41) на своем первом шарнирном конце (13a, 15a) и двумя простирающимися в боковом направлении соединительными средствами (42) на своих вторых концах (13b, 15b) для подвижного соединения с ручкой (5).



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(54) Título: **Unidad de equipo de telecomunicaciones montable sobre una estructura de soporte**

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DESCRIPCIÓN

Unidad de equipo de telecomunicaciones montable sobre una estructura de soporte

Campo técnico

La presente invención se refiere a una unidad de equipo de telecomunicaciones montable sobre una estructura de soporte con un mango.

Antecedentes

En el campo de las telecomunicaciones, muchos de los equipos usados son equipos de telecomunicaciones remotos que están montados en diferentes estructuras de soporte, por ejemplo, en mástiles, paredes o tejados. En el sitio de montaje, frecuentemente, este equipo remoto es manipulado más o menos manualmente. Puede ser transportado a mano o puede ser elevado usando una cuerda o cadena o algún tipo de aparato/equipo de elevación simple. Con el fin de ser capaz de realizar esta manipulación en el sitio e instalar el equipo remoto en su ubicación apropiada, normalmente, algún tipo de mango es fijado directamente al equipo remoto. Es común que este tipo de equipo remoto esté incluido dentro del concepto ergonómico "transporte por una persona", que indica que el peso es menor de 23 kg y que puede ser transportado por una única persona".

El tipo de equipo remoto de interés debe ser capaz de resistir las condiciones exteriores durante un intervalo de 15-20 años, y lo mismo se aplica al mango. Debe ser capaz de resistir el frío, el calor, la lluvia, la nieve, la radiación solar, etc., sin decaer o deteriorarse, y conservando completamente sus funcionalidades. Por lo tanto, según la técnica anterior, lo que se ha usado hasta la fecha es un mango fijo, bastante robusto, por ejemplo, realizado en aluminio, que es atornillado simplemente sobre la parte superior del equipo remoto. Sin embargo, el mango hace al equipo más voluminoso y existe un riesgo de que alguna parte se enganche involuntariamente debido al mango sobresaliente. También, al empaquetar y transportar dicho equipo remoto de telecomunicaciones, debe tenerse en cuenta que el mango sobresaliente resulta en un paquete más voluminoso y en un volumen añadido debido al mango.

Compendio

Un objeto de la invención es obtener una unidad de equipo de telecomunicaciones montable sobre una estructura de soporte y provista de un mango mejorado que hace que la unidad de equipo de telecomunicaciones sea menos voluminosa y más fácil de empaquetar y manipular.

La invención se refiere a una unidad de equipo de telecomunicaciones montable sobre una estructura de soporte y provista de un mango, en la que el mango comprende un asidero alargado configurado para ser agarrado por una mano humana y un dispositivo de elevación que comprende un hueco situado en una cara inferior del asidero, cuyo hueco está configurado para recibir un equipo de elevación. El mango es plegable y, cuando el mango está plegado, una cara inferior del asidero está situada esencialmente enrasada con o contigua a una superficie exterior en la unidad de equipo de telecomunicaciones.

Al hacer que el mango sea plegable, se consiguen muchas ventajas. Durante el transporte de la unidad de equipo de telecomunicaciones, el mango está plegado y ocupa mucho menos espacio que el mango de la técnica anterior. También ocupa menos volumen para empaquetar. Además, un mango plegable que está situado esencialmente enrasado con o contiguo a la superficie exterior de la unidad de equipo de telecomunicaciones no tiene el mismo nivel de riesgo de resultar enganchado en cualquier sitio que un mango fijo regular. Además, el mango plegable confiere una expresión visual más unitaria a la unidad de equipo de telecomunicaciones.

Según una realización de la unidad de equipo de telecomunicaciones, el mango puede plegarse automáticamente. El mango puede estar configurado también para que sea capaz de adoptar dos posiciones, una primera posición plegada y una segunda posición de uso. Cuando el mango no está en la posición de uso, es decir, la posición en la que puede ser agarrado fácilmente por una mano o puede ser usado para la fijación de un equipo de elevación, el mango se plegará automáticamente a su posición plegada. Consiguientemente, no hay necesidad, por ejemplo, de empujar hacia abajo el mango para que el mismo se pliegue.

Con el propósito de hacer que el mango sea plegable automáticamente, el mango puede comprender, de manera ventajosa, al menos un elemento muelle, que está operativo para retraer el asidero del mango desde la segunda posición de uso a la primera posición plegada. El uso de un elemento de muelle para este propósito es conveniente. El elemento de muelle puede comprender cualquier tipo de elemento elástico que pueda ejercer una fuerza de empuje y empujar hacia abajo el asidero hacia la superficie de la unidad de equipo de telecomunicaciones con el propósito de plegar el mango. Los ejemplos de elementos de muelle adecuados son un muelle helicoidal, una goma elástica o sus equivalentes.

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El mango puede comprender un par de soportes asegurados a una pared de fijación sobre la unidad de equipo de telecomunicaciones, un par de elementos de acoplamiento, cada uno de los cuales conecta un soporte al asidero, y estando conectado cada elemento de acoplamiento, de manera pivotante, a un primer extremo de pivote del elemento de acoplamiento y estando conectado, de manera móvil, al asidero mediante un segundo extremo del elemento de acoplamiento. De esta manera, al fabricar un mango que comprende varias partes ensambladas, se consigue mucha más flexibilidad con el fin de hacer que el mango sea plegable.

El asidero puede comprender un interior hueco, y el asidero puede estar provisto de aberturas separadas que se comunican con el interior hueco, y además dicho segundo extremo del elemento de acoplamiento respectivo puede ser insertable en la abertura respectiva.

Además, el segundo extremo del elemento de acoplamiento respectivo puede ser deslizable en dicho interior hueco de manera que durante el colapso del mango, cuando el mango se mueve desde la segunda posición de uso a la primera posición plegada, el elemento de acoplamiento respectivo es retraído gradualmente al interior hueco del asidero. Al proporcionar al mango este diseño técnico, se obtiene un mango plegable que es muy delgado cuando está plegado y no afecta al volumen disponible en el interior de la unidad de equipo de telecomunicaciones, ya que está totalmente en el exterior de la unidad, incluso cuando está plegado. Consiguientemente, tampoco hay ningún efecto adverso sobre el rendimiento de la unidad de equipo de telecomunicaciones. Otra ventaja es que todas las partes móviles están situadas en el interior del asidero en la posición plegada y, de esta manera, están protegidas durante el uso ordinario de la unidad de equipo de telecomunicaciones ya que el mango estaría, entonces, plegado.

Según una realización, el al menos un elemento de muelle está situado en el interior del interior hueco del asidero, y los segundos extremos respectivos de los elementos de acoplamiento están provistos de un dispositivo de soporte de muelle para la conexión a el al menos un elemento de muelle, y además, el al menos un elemento de muelle está operativo para retraer el elemento de acoplamiento respectivo al interior hueco. De esta manera, el elemento de muelle está protegido también en el interior del asidero. El al menos un elemento de muelle puede ser un elemento de muelle fijado a los segundos extremos respectivos de los elementos de acoplamiento, o cada elemento de acoplamiento puede tener su propio elemento de muelle, en cuyo caso dicho elemento de muelle deberá estar fijado también dentro del interior hueco del asidero.

Según un aspecto de la presente descripción, los elementos de acoplamiento están configurados como brazos de elemento de acoplamiento, estando provisto cada brazo de elemento de acoplamiento de dos pernos de pivote que sobresalen lateralmente en su primer extremo de pivote y dos medios de conexión que sobresalen lateralmente en su segundo extremo para una conexión móvil al asidero. Al fabricar los elementos de acoplamiento como brazos de elemento de acoplamiento, se obtiene una buena durabilidad.

Debido a que el material del mango debe resistir condiciones exteriores duras y variables durante muchos años, los ejemplos de materiales adecuados son aluminio, plástico reforzado con fibra de vidrio u otros materiales sintéticos, y similares. Esto concierne, en particular, a las partes exteriores del mango.

Las características y los aspectos indicados anteriormente de la unidad de equipo de telecomunicaciones, según la presente descripción, pueden combinarse en varias maneras posibles, proporcionando realizaciones ventajosas adicionales.

Las características y ventajas adicionales de las realizaciones de la invención serán también evidentes a partir de la descripción detallada siguiente de las realizaciones.

Breve descripción de los dibujos

A continuación, se proporcionará una descripción detallada de la presente descripción y sus realizaciones, proporcionada solamente como ejemplos, con referencia a los dibujos adjuntos, en los que:

La Fig. 1 muestra una vista esquemática, en perspectiva, de una unidad de equipo de telecomunicaciones montable sobre una estructura de soporte según la presente descripción, con un mango es una posición plegada;

La Fig.2 muestra una vista esquemática, en perspectiva, de una unidad de equipo de telecomunicaciones según la presente descripción, con un mango en una posición de uso;

La Fig. 3 es una vista en perspectiva que muestra los detalles del mango, en una posición de uso;

La Fig. 4 es una vista en perspectiva que muestra los detalles del mango, en una posición plegada;

La Fig. 5 es una vista de despiece, en perspectiva, que muestra los detalles del mango;

La Fig. 6 es una vista de despiece, en perspectiva, que muestra una variante del mango en la Fig. 5.

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La Fig. 7 muestra una vista superior del mango según la descripción;

La Fig. 8 es una vista lateral, en sección transversal a lo largo de A-A en la Fig. 7, y que muestra el mango en una posición de uso; y

La Fig. 9 es una vista lateral, en sección transversal a lo largo de A-A en la Fig. 7, y que muestra el mango en una posición plegada.

Descripción detallada

La Fig. 1 muestra esquemáticamente una realización de una unidad 1 de equipo de telecomunicaciones montable sobre una estructura de soporte, según la invención. La unidad de equipo de telecomunicaciones está provista de un mango 3 que es plegable. Plegable significa que el mango puede ser colapsado, o plegado, tal como se muestra en la Fig. 1. La posición plegada sería la posición normal del mango cuando no está siendo usado, por ejemplo, para transportar la unidad 1 de equipo de telecomunicaciones. La unidad de equipo de telecomunicaciones, ilustrada esquemáticamente, puede ser cualquier tipo de equipo de telecomunicaciones que necesita ser transportado o elevado y, por lo tanto, requiere un mango apropiado. Los ejemplos de dicha una unidad 1 de equipo de telecomunicaciones son unidades remotas de equipo de telecomunicaciones, por ejemplo, unidad de radio remota (Remote Radio Unit, RRU), estación base de radio remota (Remote Radio Base Station, RBS), unidad digital remota (Remote Digital Unit, OD), puntos de acceso (Access Points, WiFi), productos Mini-link para mástiles y radio con antena integrada (Antenna Integrated Radio, AIR), que están destinados a ser montados en algún tipo de estructura de soporte, tal como un mástil, una pared, un tejado o similar. Por lo tanto, la unidad de equipo de telecomunicaciones está provista también de un dispositivo de montaje (no mostrado) para montar la unidad de equipo de telecomunicaciones en un mástil, una pared, un tejado o similar, tal como una configuración con soporte y tornillos.

El mango de la unidad 1 de equipo de telecomunicaciones comprende un asidero 5 alargado configurado para ser agarrado por una mano humana y un dispositivo de elevación que comprende un hueco 7 situado en una cara 35 inferior del asidero 5. El hueco está configurado para recibir un equipo de elevación, tal como una cuerda o una cadena. Tal como se ha indicado, el mango es plegable y cuando el mango está plegado, la cara 35 inferior del asidero 5 está situada esencialmente enrasada con o contigua a una superficie 40 exterior en la unidad de equipo de telecomunicaciones. Esto puede verse también más detalladamente en la Fig. 9. Solo se necesita un hueco muy estrecho, del orden de 1-4 mm, entre el asidero y dicha superficie exterior con el propósito de posibilitar que una persona inserte, de manera más factible, los dedos bajo el asidero o agarre el asidero contiguo a la cara 35 inferior y empuje hacia arriba el asidero.

El mango en la unidad de equipo de telecomunicaciones está configurado para ser capaz de adoptar dos posiciones, una primera posición plegada y una segunda posición de uso. En la Fig. 2 se muestra, esquemáticamente, la misma unidad 1 de equipo de telecomunicaciones, pero con el mango en la segunda posición de uso, que es una posición elevada, una posición preparada para el uso. En esta posición, habrá sitio suficiente entre el mango 3 y la superficie de la unidad 1 de equipo de telecomunicaciones, a la cual está fijado el mango, con el propósito de que se inserte una mano entre dicha superficie y el mango, para agarrar el mango y elevar la unidad de equipo de telecomunicaciones. También habrá espacio suficiente para aplicar una cuerda o una cadena. Desde esta posición, el mango es plegable y, en una realización está configurado para plegarse automáticamente, a la posición plegada en la Fig. 1, en cuanto no haya ninguna fuerza de elevación ejercida sobre el mango, tal como se explicará adicionalmente más adelante.

En la unidad de equipo de telecomunicaciones ilustrada en las Figs. 1 y 2, la unidad está provista solo de un mango pero, naturalmente, dicha una unidad podría estar provista también de dos o más mangos, si es necesario. Este puede ser, por ejemplo, el caso si la unidad de equipo de telecomunicaciones es muy larga o muy pesada.

El mango 3, cuyos diferentes aspectos se muestran más detalladamente en las Figs. 3-9, comprende el asidero 5 alargado, el primer elemento 13 de acoplamiento y el segundo elemento 15 de acoplamiento, el primer soporte 9 y el segundo soporte 11. Los elementos 13, 15 de acoplamiento conectan el asidero 5 con los soportes 9, 11. Los soportes se usan para fijar el mango a una pared 10 de fijación sobre la unidad de equipo de telecomunicaciones, tal como se muestra en las Figs. 1, 2, 8 y 9, por ejemplo, mediante tornillos. Un primer extremo 13a del primer elemento 13 de acoplamiento conecta un primer extremo 14 del asidero 5 con el primer soporte 9, y un primer extremo 15a del segundo elemento 15 de acoplamiento conecta un segundo extremo 16 del asidero con un segundo soporte 11. Los primeros extremos 13a, 15a de los elementos de acoplamiento están conectados, de manera pivotante, a los soportes respectivos. Un segundo extremo 13b del primer elemento 13 de acoplamiento conecta el primer elemento de acoplamiento con un primer extremo 14 del asidero, y un segundo extremo 15b del segundo elemento 15 de acoplamiento conecta el segundo elemento de acoplamiento con un segundo extremo 16 del asidero.

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El asidero tiene un interior 20 hueco, que puede ser un interior hueco continuo o puede estar dividido en diversas partes huecas, véase las Figs. 5-7 y 8. El acceso al interior hueco se proporciona mediante una abertura 19, 21 en cada extremo 14, 16 del asidero. A través de estas aberturas, los segundos extremos 13b, 15b de los elementos 13, 15 de acoplamiento respectivos pueden ser insertados y, a continuación, el elemento de acoplamiento respectivo puede ser retraído al interior 20 hueco del asidero y, de esta manera, hacer que el mango se pliegue, tal como se ilustra en las Figs. 7 y 9. Con el propósito de hacer que el mango se colapse automáticamente, es decir, se colapse tan pronto como no haya ninguna fuerza de elevación aplicada sobre el asidero, los elementos de acoplamiento retráctiles se conectan a un elemento 30 de muelle de retracción. Este elemento de muelle puede ser, por ejemplo, una goma elástica, un muelle helicoidal o cualquier otro elemento elástico que empuje automáticamente el elemento de acoplamiento dentro del interior hueco tan pronto como no haya ninguna fuerza que empuje sobre el asidero y el elemento de muelle. Los ejemplos de realizaciones diferentes del elemento de muelle se muestran en las Figs. 5 y 6. El elemento de muelle puede ser el mismo, fijado a ambos elementos 13, 15 de acoplamiento ó cada elemento de acoplamiento puede tener su propio elemento de muelle, en cuyo caso los elementos de muelle estarían fijados a un soporte fijo dentro del asidero.

El elemento 30 de muelle está montado en los elementos 13, 15 de acoplamiento por medio de un dispositivo 31, 32 de soporte de muelle en los segundos extremos 13b, 15b respectivos de los elementos de acoplamiento. Además, estos extremos de los elementos de acoplamiento deberían estar diseñados con medios de conexión, de manera que puedan proporcionar una conexión fiable con el asidero 5 que sea suficientemente fuerte para resistir el estrés cuando la unidad 1 de equipo de telecomunicaciones es elevada por el mango 3 y, al mismo tiempo, deberían estar diseñados para deslizarse fácilmente dentro del asidero 5 cuando el elemento 30 de muelle empuja los elementos de acoplamiento durante el plegado del mango. Como un ejemplo, pueden estar provistos de dos medios 42 de conexión que sobresalen lateralmente, por ejemplo, pernos, que se enganchan en un hueco 47 correspondiente en el asidero, justo dentro de la abertura 19, 21, y que además tienen una forma tal que pueden ser guiados, de manera deslizante, dentro del interior 20 hueco del asidero.

Tal como se ha indicado, los primeros extremos 13a, 15a de los elementos de acoplamiento están conectados, de manera pivotante, a los soportes respectivos. Con el propósito de realizar la función de pivote, los primeros extremos 13a, 15a están provistos de pernos 41 de pivote y el soporte está provisto de huecos 45 correspondientes en los que los pernos de pivote son ajustados. Pueden idearse también configuraciones pivotantes o articuladas alternativas. También en este caso, es importante que ambos primeros extremos 13a, 15a proporcionen una conexión fiable con los soportes 9, 11 que sea suficientemente fuerte para resistir el estrés cuando la unidad 1 de equipo de telecomunicaciones es elevada por el mango 3 y, al mismo tiempo, deberían ser diseñados para pivotar fácilmente cuando el mango es plegado.

En la realización ilustrada, los elementos 13, 15 de acoplamiento están configurados como brazos de elemento de acoplamiento sólidos. Sin embargo, pueden idearse otros tipos de elemento de acoplamiento, tal como un elemento de acoplamiento de estructura cuadrada o elementos de acoplamiento de dos partes.

Preferentemente, el asidero está realizado en dos partes que están ensambladas entre sí, después del ensamblado de los diferentes componentes, tales como el elemento de muelle y los extremos de los elementos de acoplamiento en el interior del asidero.

La descripción no debe considerarse limitada a las realizaciones ilustradas, sino que puede modificarse o alterarse de muchas maneras, tal como comprenderá una persona con conocimientos en la materia, sin alejarse del alcance definido en las reivindicaciones adjuntas.

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REIVINDICACIONES

1. Unidad (1) de equipo de telecomunicaciones montable sobre una estructura de soporte y provista de un mango (3), en el que el mango comprende un asidero (5) alargado configurado para ser agarrado por una mano humana y un dispositivo de elevación que comprende un hueco (7) situado en una cara (35) inferior del asidero (5), cuyo hueco está configurado para recibir un equipo de elevación, **caracterizada por que** el mango es plegable y por que, cuando el mango está plegado, la cara (35) inferior del asidero (5) está situada esencialmente enrasada con o contigua a una superficie (40) exterior en la unidad (1) de equipo de telecomunicaciones.

2. Unidad de equipo de telecomunicaciones según la reivindicación 1, **caracterizada por que** el mango es plegable de manera automática.

3. Unidad de equipo de telecomunicaciones según una cualquiera de las reivindicaciones anteriores, **caracterizada por que** el mango (3) está configurado para poder adoptar dos posiciones, una primera posición plegada y una segunda posición de uso.

4. Unidad de equipo de telecomunicaciones según la reivindicación 3, **caracterizada por que** el mango comprende al menos un elemento (30) de muelle, que está operativo para retraer el asidero del mango desde la segunda posición de uso a la primera posición plegada.

5. Unidad de equipo de telecomunicaciones según la reivindicación 4, **caracterizada por que** el mango (3) comprende un par de soportes (9, 11) asegurados a una pared (10) de fijación sobre la unidad (1) de equipo de telecomunicaciones, un par de elementos (13, 15) de acoplamiento cada uno de cuyos elementos de acoplamiento conecta un soporte (9, 11) al asidero (5), y estando conectado cada elemento de acoplamiento, de manera pivotable, a un soporte en un primer extremo (13a, 15a) de pivote del elemento de acoplamiento y estando conectado, de manera móvil, al asidero mediante un segundo extremo (13b, 15b) del elemento de acoplamiento.

6. Unidad de equipo de telecomunicaciones según la reivindicación 5, **caracterizada por que** el asidero (5) comprende un interior (20) hueco, por que el asidero está provisto de aberturas (19, 21) separadas que se comunican con el interior hueco, por que dicho segundo extremo (13b, 15b) del elemento (13, 15) de acoplamiento respectivo es insertable en una abertura (19, 21) respectiva.

7. Unidad de equipo de telecomunicaciones según la reivindicación 6, **caracterizada por que** el segundo extremo (13b, 15b) del elemento (13, 15) de acoplamiento respectivo es deslizable en dicho interior (20) hueco de manera que durante el plegado del mango (3), cuando el mango se mueve desde la segunda posición de uso a la primera posición plegada, el elemento (13, 15) de acoplamiento respectivo es retraído gradualmente al interior (20) hueco del asidero (5).

8. Unidad de equipo de telecomunicaciones según la reivindicación 6 o la reivindicación 7, **caracterizada por que** el al menos un elemento (30) de muelle está situado dentro del interior (20) hueco del asidero (5), por que los segundos extremos (13b, 15b) respectivos de los elementos de acoplamiento está provistos de un dispositivo (31, 32) de soporte de muelle para su conexión a el al menos un elemento (30) de muelle, y por que el al menos un elemento de muelle está operativo para retraer el elemento (13, 15) de acoplamiento respectivo dentro del interior (20) hueco.

9. Unidad de equipo de telecomunicaciones según una cualquiera de las reivindicaciones 5-9, **caracterizada por que** los elementos (13, 15) de acoplamiento están configurados como brazos de elemento de acoplamiento, estando provisto cada brazo de elemento de acoplamiento de dos pernos (41) de pivote, que sobresalen lateralmente, en su primer extremo (13a, 15a) de pivote y dos medios (42) de conexión, que sobresalen lateralmente, en su segundo extremo (13b, 15b) para una conexión móvil al asidero (5).

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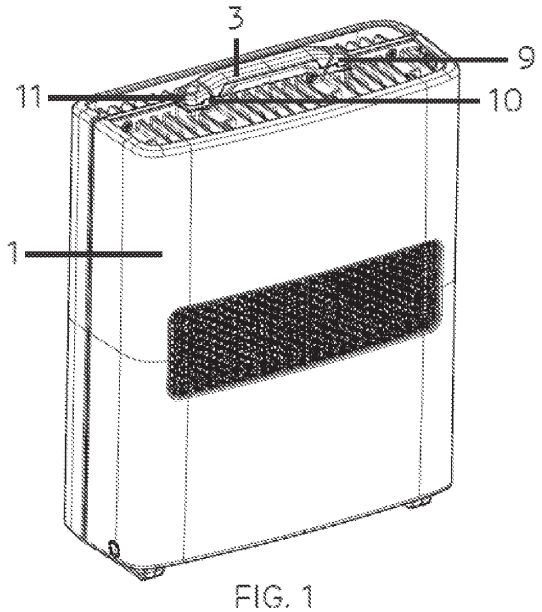

FIG. 1

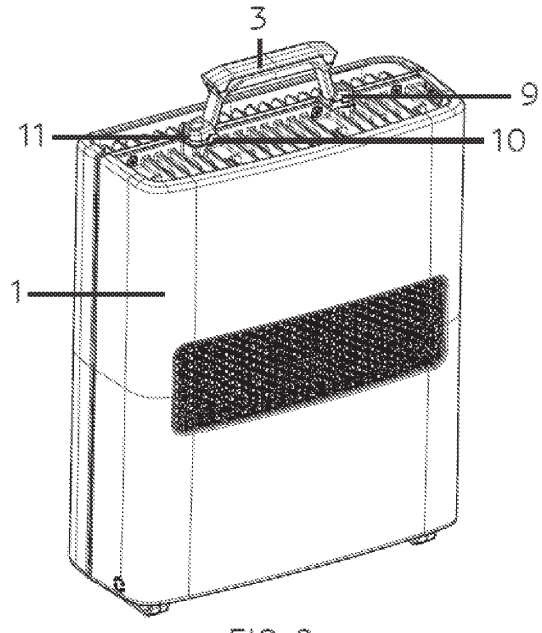

FIG. 2

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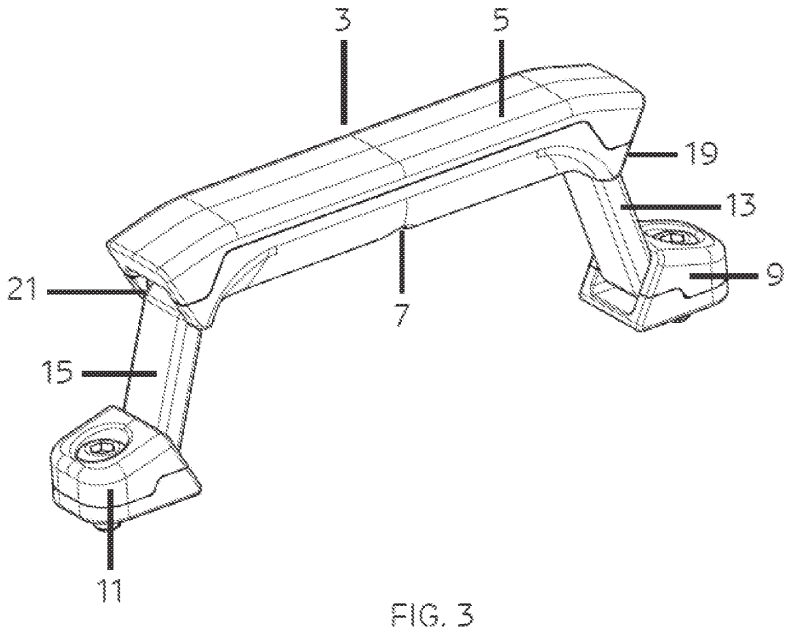

FIG. 3

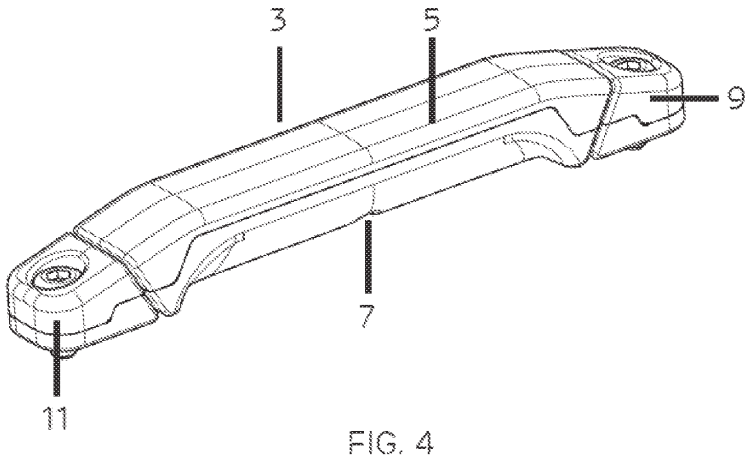

FIG. 4

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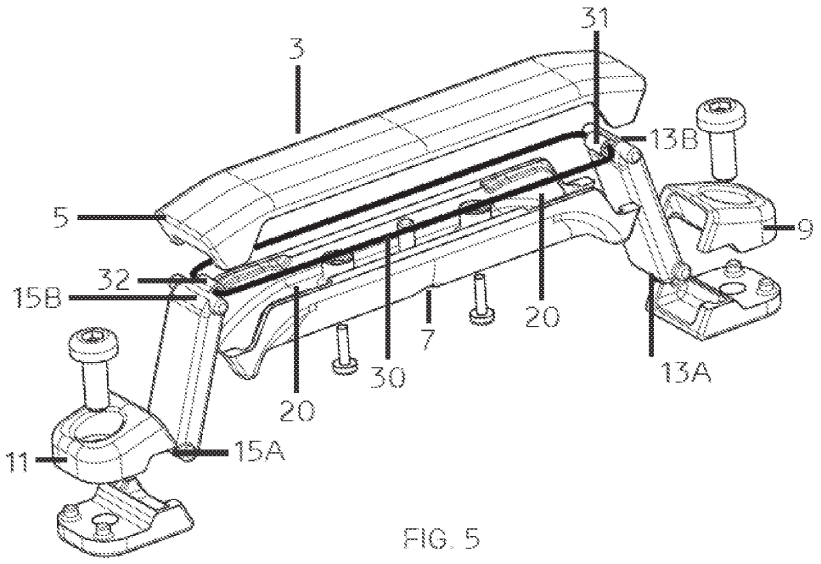

FIG. 5

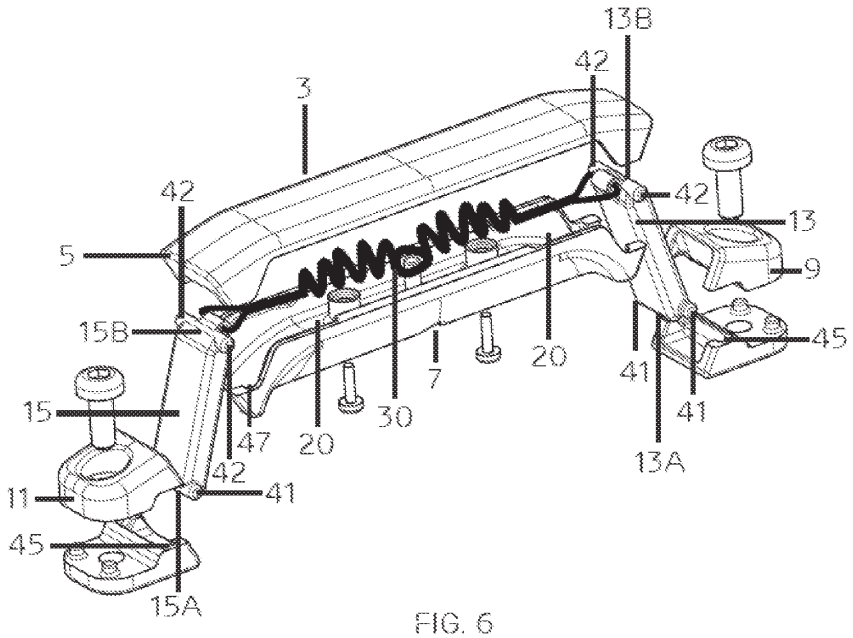

FIG. 6

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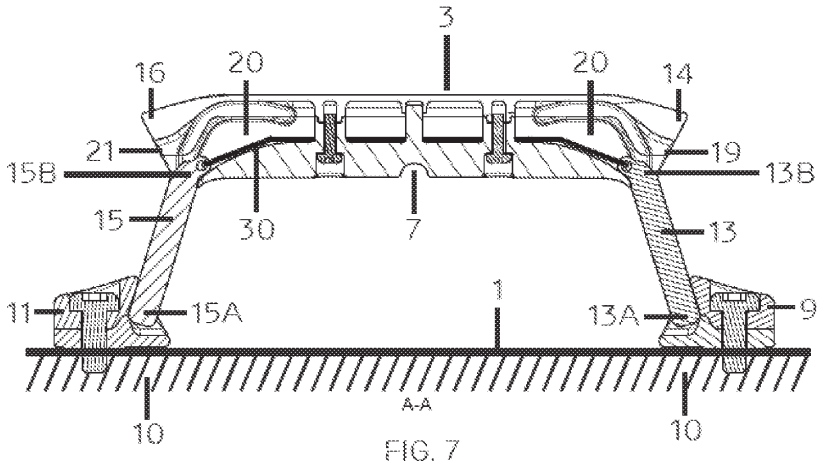

FIG. 7

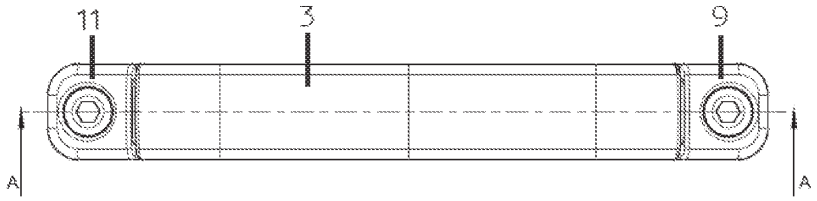

FIG. 8

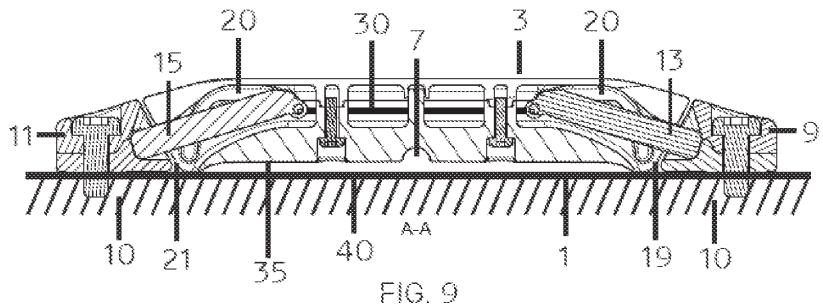

FIG. 9