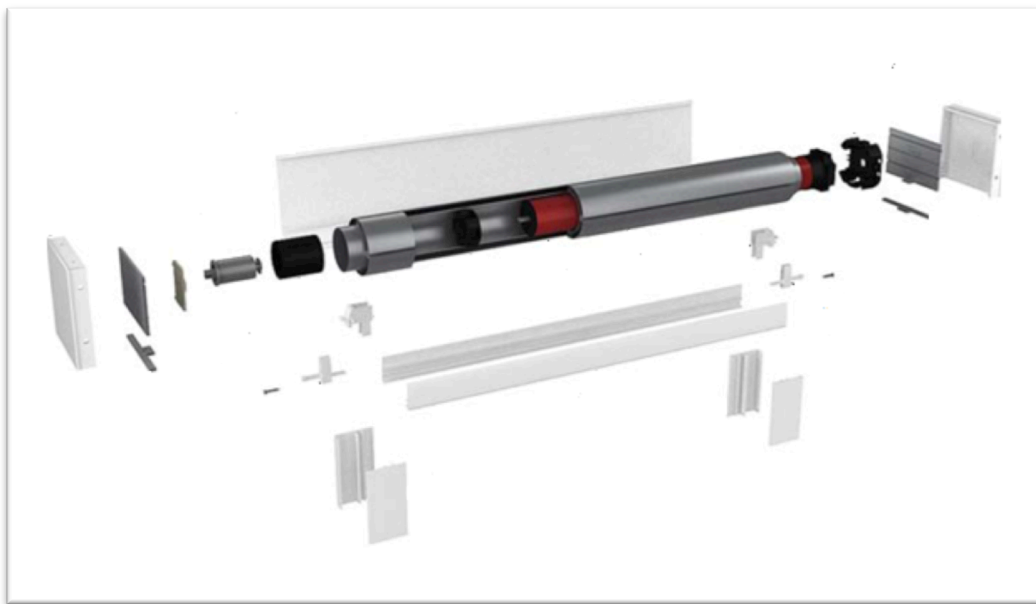


CHALMERS



DEVELOPMENT OF MOTORIZED ROLL DOWN INTERIOR SHADING

Master of Science thesis in Product Development



DEEPAK DIVAKARAN

Department of Product & Production Development
Division of Product Development
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2011

(empty page)

MASTER OF SCIENCE THESIS IN PRODUCT DEVELOPMENT

**DEVELOPMENT OF MOTORIZED ROLL DOWN INTERIOR
SHADING**

DEEPAK DIVAKARAN



Department of Product & Production Development

Division of Product Development
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2011

Development of Motorized Roll down Interior Shading

DEEPAK DIVAKARAN

© DEEPAK DIVAKARAN, 2011

Supervisor & Examiner: Dr. Dag Bergjö, Chalmers University of Technology

Industrial Supervisor: Mr. Christer Kallstrom, CEO, Maestroschild USA Shutter Company

Department of Product & Production Development
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden

Telephone +46 (0)31-772 1000

Chalmers Reproservice

Gothenburg, Sweden 2011

Acknowledgement

This project wouldn't have been successful without the support and encouragement from many other. I would like to take this opportunity to express my gratitude to each one of them directly or indirectly helped me to complete this project.

I would like to thank my Supervisor Dr. Dag Bergjö, PhD, Assistant Professor from Chalmers University of Technology, Sweden for supervising this project. Having given me an opportunity to do my Masters Program, I would like to thank Chalmers University of Technology for raising me higher in knowledge and career.

I am highly grateful to Maestrosshield USA shutter company, and in specific Mr. Christer Kallstrom, CEO, Maestrosshield for his guidance and constant supervision as well as for providing necessary information regarding the project & also for support in completing the project.

I would like express my special gratitude to

Mrs. Marie Kallstrom, *CFO*

Jeff Barkin - *Marketing Director*

Tom Nalbach - *Warehouse Manager/Technical Support*

Brian Thompson - *Purchasing Manager*

Jason Li - *Logistics Manager*

Bob McAllister - *Outside Sales Manager*

Dimitri Ferrone - *Sales Manager*

And all other employees of Maestrosshield for their tremendous support and help and Also making my stay in Naples, Florida a memorable one.

Also my sincere thanks go to Mr. Albin Hasselström, Mr. Oskar Strand, Mr. Ravi Subramanian and all other friends for extending their support.

Finally I would like to thank my family for always being with me with their unlimited support during my thesis and studies at Chalmers University of Technology, Gothenburg, Sweden.

Abstract

Maestroshield is a Shutter Company has its business in Hurricane Protection, Security Protection, Exterior shadings & Tubular motors. They are placed in Naples, Florida. This project was carried out in Maestroshield. Interior shading is a new product line for Maestroshield. Having extensive experience in other areas of window shading, Development of Interior shading became lot more creative and innovative.

Initial development of interior shading took place between Jan 2010 – Feb 2011. Later the developed product was evaluated with customer feedback through outside sales representatives. The results were expressing the challenges in price and certain functionalities of product. This motivated Maestroshield to carry out market analysis and compare the developed product with competitor's products. The results from market analysis showed that many components needed to be relooked and modify to match the requirements.

Based on these results from market analysis some components of the product had to undergo redesign focusing on better quality, functionality and price. Prototypes of all the parts are being manufactured and tested. Since the product configuration involves extreme modularizations. It was necessary to create product selection procedures with better clarity from competitors catalogues.

Knowledge on product development process and methodologies were applied to organize and structure activities involving development. SolidWorks is used as the CAD tool for development.

The final resultant product looks to be more promising both cost wise and total functionality. Customers are now looking forward to see the actual working product soon.

Table of Contents

1	Introduction	1
1.1	Background	1
1.2	Purpose	2
1.3	Objective	2
1.4	Limitations.....	2
2	Literature Survey.....	3
2.1	Product development process	3
2.1.1	Generic Product Development Process.....	3
2.1.2	Spiral Product Development Process	4
2.1.3	Complex System Development Process	4
2.2	PEST Analysis.....	4
2.3	Customer Segment matrix	5
2.4	KANO Model.....	5
2.5	Product/Market Planning and strategy.....	6
2.6	Product development strategies.....	6
2.7	Fact of product development process:	6
2.8	Morphological matrix:.....	7
2.9	Pugh matrix:	8
2.10	Product Modularity	8
2.11	Rapid prototyping:	8
3	Methodology.....	10
3.1	Developed product.....	11
3.2	Feedback	11
3.3	Market analysis	11
3.4	Requirement Specification	11
3.5	Redesign	12
3.6	Manufacturing drawings	12
3.7	Prototyping	12
3.8	Testing.....	12
4	Interior shading product configuration before market analysis	13
4.1	Fascia Assembly.....	13
4.1.1	3"x3" Single Fascia assembly.....	14
4.1.2	4"x4" Single Fascia assembly.....	16

4.1.3	Dual Fascia assembly	16
4.1.4	Triple Fascia assembly	16
4.2	Bracket Assembly	17
4.2.1	90 mm Single Bracket.....	17
4.2.2	140mm Single bracket.....	18
4.2.3	7” Double bracket	19
4.2.4	0 to 90deg connector Idler:.....	19
5	Market Analysis of Motorized roll down interior shading	20
5.1	Methodology for market analysis	20
5.1.1	PEST analysis	21
5.1.2	Customer Segment Matrix	22
5.1.3	Customers & Competitors.....	23
5.1.4	Data Collection	23
5.1.5	Product comparison	24
5.1.6	Data Analysis	24
5.1.6.1	KANO Model.....	24
5.1.6.2	Blue water diagram	25
5.1.7	Brainstorming.....	26
5.1.8	Strategy	26
5.1.9	Action plan	27
6	Selection procedure for motorized roll down interior shading.....	29
6.1	Data for selection procedure	30
6.1.1	Lifting capacity chart	30
6.1.2	Window height.....	30
6.1.3	Window Width	32
6.1.4	Square footage-Height & Width chart:	34
6.1.5	Motor selection chart.....	34
6.2	Selection procedure	35
7	Redesign of Interior shading	36
7.1	Development of 4x4 Connector fascia bracket	36
7.2	Male and Female idler bearing with Housing screw	36
7.3	Connector Idler 0 to 90deg	37
7.4	Provide provision for Fascia on the 90mm bracket.....	37
7.5	Modification of Motor bracket.....	38

8	Prototyping & Testing	39
9	Discussion.....	40
10	Conclusion	42
11	Recommendations	43
	Bibliography	44
	Appendix A: PEST Analysis Template	46
	Appendix B: Customer segment matrix template.....	47
	Appendix C: Product Comparison	48
	Appendix D: Data Analysis	60
	Appendix E: Square footage-Height & Width Chart.....	63
	Appendix F: Motor selection chart.....	65
	Appendix G: Compatibility chart	69
	Appendix H: Requirement specification for 0-90deg Connector idler universal.....	71
	Appendix I: Morphological matrix for 0-90deg Connector idler Universal	72
	Appendix J: Pugh Matrix for 0-90deg Connector idler Universal	73
	Appendix K: Prototypes.....	75

1 Introduction

Interior shadings are used on windows to control light passing into the rooms. Based on the type of fabric used solar energy flowing into room can be controlled. The light controlled fabric can range from transparency to semi opaque to complete black out for room. Thus we can have optimum air condition usage and improve summer time comforts. Transparency is required if you need have view of the landscape from windows and blackout for complete privacy. Interior shadings are manually operated using clutch or motorized with remote control. They can be rolled up on a tube or folded like pleats. There are different types of interior shadings based on their style. Some of them are

- Roller shades: The fabric in roller shades rolls on to tube. They can be spring rolled, clutch operated or motorized with remote control.
- Roman shades: Roman shades pulled up from bottom by a string and folds horizontally. As they are moved down forms flat cover for windows. Shades are made up of either polyester or woven wood.
- Cellular shades: They are also called honey comb shades. The shades are made in honeycomb structure which gives unique feature to these shades. They can trap air inside which enables to absorb light and energy, also can take high stresses from outside and control heat and cold passing through them. They are operated by pulling up and down.
- Pleated shades: The shades are single layer of pleated fabric. They are not as energy efficient like cellular shades. They come with different waves and patterns.

Aesthetics is one of the important requirements within interior shading products. Thus the hardware is equally important with fabric and style. This report is mainly concentrating on motorized roller shades.

Key word:

Light Gap: This is the amount of gap through which light enters the room. This measurement needs to be minimum possible especially in the case of blackout shadings. This gap is usually found at the extreme vertical ends of the fabric.

1.1 Background

USA Shutter Company DBA Maestrosshield is an American company placed in Naples, Florida, develops and supplies high quality, Tubular motors, Electronics, Accessories and innovative window protection systems. Maestrosshield offer complete window safety and security systems as well as extrusion and casting components to enhance other systems. Maestrosshield supplies to more than 500 dealers and manufacturers in 40 states. Also have deliveries to 15 other countries outside United States. The customers are in the areas of

Indoor Shading, Security, Exterior Shading Awning and Hurricane Industry. With the construction industry growing rapidly and people choosing bigger space to live, also people concerned to keep their rooms decorative, Maestrosshield's choice to move into Interior shading is right decision at right time. This project was carried out at R&D Centre in Maestrosshield, Naples, Florida.

1.2 Purpose

Maestrosshield has its own motors and saw the opportunity to sell motors and electronics through interior shadings as new product line. Also its experience with other type of window shadings motivated to have this product line.

Development of Interior shade started extensively from April 2010. The product underwent different stages like concept development, design, prototype and manufacturing drawings creation. The initial design phase was completed by Feb 2011. This product was then introduced into market to study the performance. Even though the interior shadings were not sold as complete assembly, some of the parts could be sold independently. This is possible because the design is modular. The parts were designed in such a way that these could be assembled with competitor's interior shading assembly. For example the brackets designed for Maestrosshield interior shadings could hold common motor tubes of other manufacturers available in the market. From market feedback it was found that price of Maestrosshield product was high and certain functionalities were not competitive with similar products in the market. Thus the purpose of this project is to study the market and find and correct those missing links to bring Maestrosshield's product to one level high compared to competitor's products.

1.3 Objective

Complete the design and development of interior shading as per customer requirements. Also manufacture and test working of the interior shade.

1.4 Limitations

- There are many types of window shadings available. This report is basically focused on motorized roll down shadings only.
- Maestrosshield has business in motors and electronics with hardware. Since we are using our own Motors, the hardware to suite the interior shading requirements were given priority. So this report discuss about the development of hardware.
- Since Maestrosshield doesn't have fabric production, no details on fabrics are included.
- The report is based on the information gathered from interview with employees, outside sales of Maestrosshield, Visit to fabricator & internet sources.

2 Literature Survey

This chapter focuses on the literatures that were referred to support the explanations in this report. Resources like books, Product development course materials and internet were used to prepare this survey.

2.1 Product development process

Based on (Karl T.Ulrich & Steven D.Eppinger, 2012) there are following product development processes.

2.1.1 *Generic Product Development Process*

This process as shown in Figure 1 is suitable for market pull, technological push, platform, process-intensive, customized and high risk products. After each stage of process there is gate to confirm the completion of the stage before moving forward with the process.

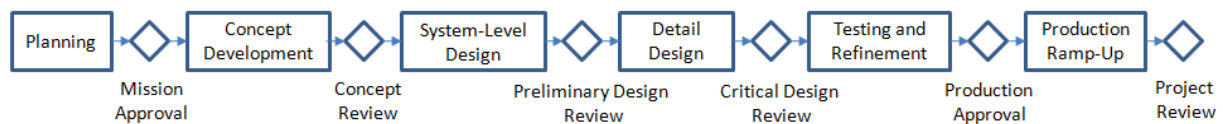


Figure 1: Generic Product Development Process (Karl T.Ulrich & Steven D.Eppinger, 2012)

The phases involved in the process are briefed below

Planning: In this phase market opportunities, strategies for market, investments, financial impact, and production requirements are studied in detail to form framework for new product. The plan goes through review and approved plan will have set of requirements for concept development.

Concept Development: Based on the requirements set at the planning phase, concepts are developed for new product. These concepts are evaluated against requirement and finally a concept is selected. The concepts are reviewed during review meeting.

System-Level Design: Here subsystems and parts of the product are defined. The interface between these systems is also discussed. Output of this phase will have flow chart of the assembly of subsystems and parts. This again undergoes review for approval.

Detail Design: In this phase each and every components are fixed with material and production tolerances to supply to vendors. This includes controlled documents and bill of materials for assemblies. The output will be basically drawings for respective parts and assemblies. All these are checked for layouts and checked against requirements before sending to vendors.

Testing and Refinement: Here the parts developed as per the drawings supplied to vendor are checked for fitment and assembled together. This assembly then undergoes

performance testing, where performance, reliability and life of the product are studied. The results of testing are reviewed before production approval. If there are any changes to be made, these again are updated.

Production Ramp-Up: The product is now in production phase. The products here are actually manufactured with preferred production processes. The products from this phase are sometimes sent to selected customers to identify any more faults. At last project is reviewed to check if the product is meeting the target as planned.

2.1.2 *Spiral Product Development Process*

This process as shown in Figure 2 is suitable for quick build products. This is similar to Generic Product Development process but the difference is that the Design-Build-Test stages carry many iterations. The prototype parts are immediately tested and checked for faults before production. This goes much iteration. After each iteration there is always knowledge gathered and correction are made in next design.

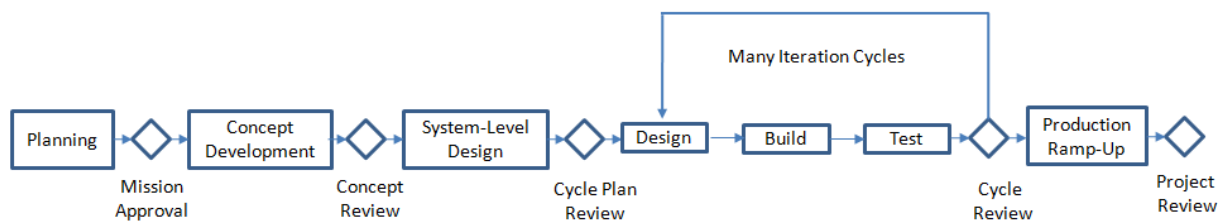


Figure 2: Spiral Product Development Process (Karl T.Ulrich & Steven D.Eppinger, 2012)

2.1.3 *Complex System Development Process*

This as shown in Figure 3 process is suitable for complex systems. Here parallel works are carried out for many systems and components. Here each system is designed and tested independently and finally all these systems are integrated for final product performance test.

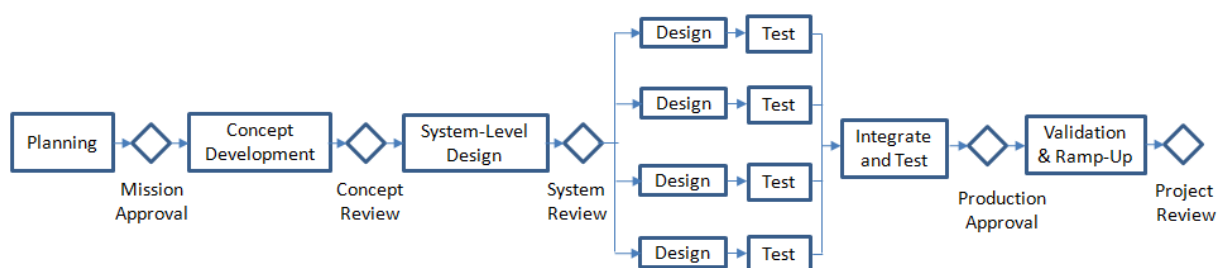


Figure 3: Complex System Development Process (Karl T.Ulrich & Steven D.Eppinger, 2012)

2.2 PEST Analysis

PEST is an acronym for Political, Economic, Social and Technological factors, which are used to assess the market for a business or organizational unit (Businessballs.com, 2011). This tool guide strategic product planning, product development & research reports. PEST Analysis

measures the potential of the market and current situation for the market. Appendix A of this report shows the template for PEST Analysis and the factors belonging to each of these four sectors like Political, Economic, Social and Technological.

2.3 Customer Segment matrix

This is one of the methods adopted for identifying the information sources for market analysis (Karlsson, MA: Customer Segment Matrix, 2009). Here stake holders under this project are listed down under one column and areas on which information is needed is listed in a row. Each stake holder is graded High (H) or Low (L) against these identified areas of information. This gives an idea to search right place for information. This is crucial in identifying right person with right information. The template of Customer segment matrix is show in Appendix B.

2.4 KANO Model

The Kano Model's main objective is to help teams uncover, classify, and integrate 3 categories of customer needs and attributes into the products or services they are developing (Kano Model, 2012). This allows visualization of the product characteristics. Figure 4 shows format of Kano Model.

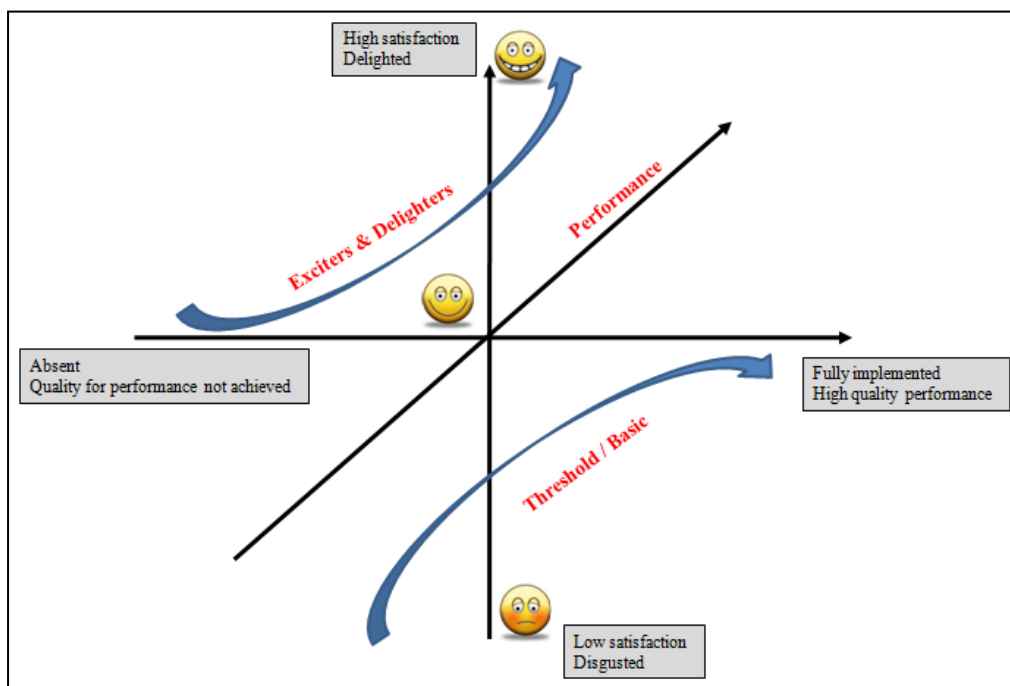


Figure 4: Kano Model basically defines three attributes

- a) Basic: These are the requirements that must be achieved by the product in order to be sold.
- b) Performance: These are functionalities and requirements that bring greater customer satisfaction.

c) Exciters: These are functionalities which customers are not expecting but achieving this can make the customer greatly satisfied. Absence of these on other hand anyways will not affect customer satisfaction.

2.5 Product/Market Planning and strategy

There are 4 four basic questions that are addressed in a Product/Market strategy for a business (Steven C. Wheelwright & Kim B. Clark, 1992). They are

- a) What Product will be offered?
- b) Who will be target customers?
- c) How will products reach those customers?
- d) Why will customers prefer our products to those of competitors?

The firms planning for new business should know their product and the market for their product. Having answer to above questions will allow the firms to make a better decision while planning their strategy for business. The key fact in this strategy is based on number of platform (Core) and derivative (enhanced) products. Some firms would like to have infrequently changing core products and increase the variety of products based on core products.

2.6 Product development strategies

The product development strategies can be grouped as reactive and proactive (Karlsson, MA: Product development Strategies, 2009)

In reactive strategy, the firms deal with pressures as it comes. The strategy is to be defensive by producing new competitive products which are similar to products in market but better. Also this strategy reacts to customer needs purposively.

In proactive strategy, the firms avoid unfavorable situations for their business. Here firms try to be first in market with the product to avoid competition. The firms spend resources in research and development, understanding customer needs very clearly. This strategy includes acquiring or forming alliance with other firms.

2.7 Fact of product development process:

The Figure 5 illustrates that as the product development project progress the freedom to change the design decreases where as the knowledge about the product increases. Therefore it is important to gain and collect as much knowledge as possible in the beginning of product development.

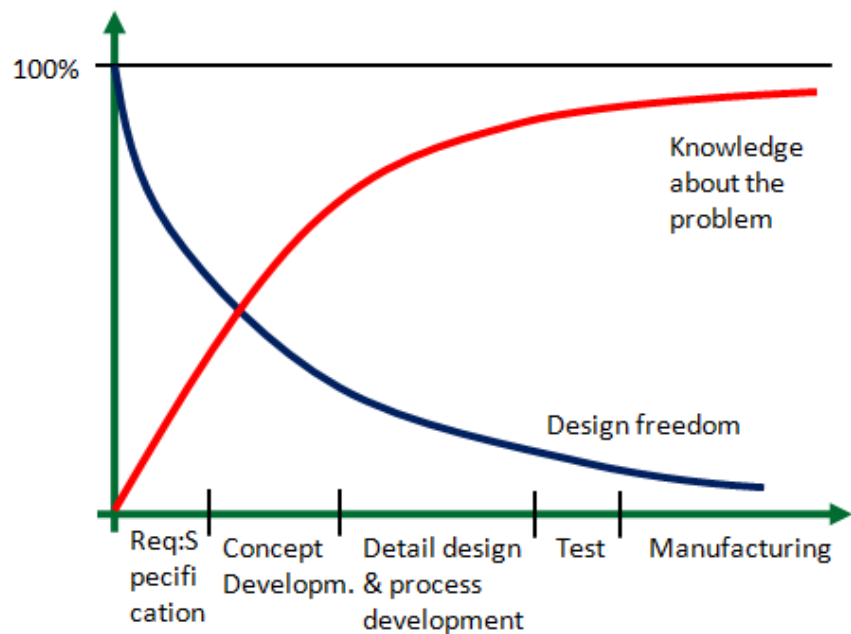


Figure 5: Fact of product development process (Lars Almfelt: The Product Development Process, 2009)

2.8 Morphological matrix:

Morphological matrix is one of the methods for concept synthesis. Using a morphological matrix, essentially, bottom-up approach for synthesis (Lars Almfelt: Concept Synthesis, 2009). This matrix has left hand column defining the design parameters that are required for design and for each of these parameters there are ideas with illustrations showing various ways to achieve respective parameter. Using this matrix we can generate different concepts just by linking the ideas of each parameter with each other in a possible way. The Figure 6 shows sample Morphological matrix.

Functions	Solutions							
	1	2	3	4	5	6	7	8
Attach to Frame	Bolts	Welds	Cables	Glue	Plastic Bolts	Locks	Rivets	Magnets
Secure Tank	Belt	Bracket	Net	Bag	Weld	Clips	Sliders	Magnets
Transfer load	Bracket	Bolts	Hooks	Beams	Bars	Linkages	Clamps	Chains
Avoid vibrations	Rubber	Foam	Air cushion	Springs	Dampers	Impact gel	Bearings	Anti-vibration System (AVS)

Figure 6: Sample Morphological Matrix (Erik Bjärkby & team, 2010)

2.9 Pugh matrix:

Pugh is one of the tools used to select the concept. This matrix has requirements/desires defined in the left column and concepts are mentioned on the top rows. The matrix is then run by selecting any concept as datum and comparing other concepts with the datum against each requirement. “+” sign is used if the requirement is better than datum and “-”, if is not better. And “S or 0” sign is used if they are same value. After running this matrix, All “+”, “-” & “S” are calculated. Based on the total each concept is ranked. And the concept that stands last in rank is eliminated. And again this matrix is repeated with elimination process to reach the final concept. The Figure 7 shows sample Pugh Matrix.

Criteria \ Koncept	1	3	5	7	8	Ref9	10
Cost	0	-	0	0	+	0	0
Lifelength	-	0	0	-	0	0	0
Ice and dirt resistance	-	+	-	-	0	0	+
Idiot safe to handle	-	+	-	-	0	0	-
Fit in existing fuel tank	0	-	0	0	0	0	-
Fit existing external can	0	-	0	0	0	0	0
Ergonomic	0	+	-	-	0	0	-
Easy to understand handling	0	0	-	-	0	0	-
Not opened by mistake	0	+	0	0	0	0	+
Allow alternative refueling	0	-	0	0	0	0	-
Glove handling	-	0	-	0	0	0	0
Spillage and fumes	0	+	0	0	-	0	+
Overall protection	0	+	0	0	-	0	0
Sa: +	0	6	0	0	1	0	3
Sa: -	4	5	5	5	2	0	5
Sa: 0	9	3	8	8	10	13	5
Netto	-4	2	-5	-5	-1	0	-2
Rank	5	1	6	6	3	2	4
Of to further development	Yes	Yes	No	No	Yes	Yes	Yes

Figure 7: Sample Pugh Matrix (Lars Trygg: Pugh Concept Selection, 2009)

2.10 Product Modularity

Product Modularity is defined as “Decomposition of a product into building blocks (modules) with specified interfaces, driven by company- specific strategies” (Lean Directions, 2011). Two companies may have same products but in the end they will have different modularized product structures based on their strategies. This is not same as subassemblies. Subassemblies are made to facilitate the assembly planning. The advantages of modularization are high flexibility in changing products to suit the market, fewer inventories, reduce lead time, easy service & reduce cost.

2.11 Rapid prototyping:

“Rapid Prototyping (RP) refers to the layer-by-layer fabrication of three-dimensional physical models directly from a computer-aided design (CAD)”, (Cooper, K.G, 2001). RP plays important role in product development process. Making a physical model in actual

manufacturing processes is costly, thus RP enables the company to rapidly produce prototypes at very low cost. There are few intricate models that are nearly impossible by conventional manufacturing methods. RP makes it easy to produce such parts. This reduces lead time for product development. The raw materials used can be liquid, solid or powder. RP parts are mainly used to test functionality. But in some cases they are directly used in operation.

3 Methodology

According to literature there are different product development processes, Namely Generic Product Development Process, Spiral Product Development Process & Complex System Development Process (Karl T.Ulrich & Steven D.Eppinger, 2012). In all these conventional development processes, a detailed market study is asked to carry out as first step in developing a product. The market study is to understand and map the requirements of the customer clearly. Then the prototypes are made to validate product against the requirements.

In case of this project work the process followed has deviation from conventional development process. Here the realization for detailed market study rose only after finding out the prototypes were not meeting the requirements of the customers. The steps followed for this project is explained in Figure 8.

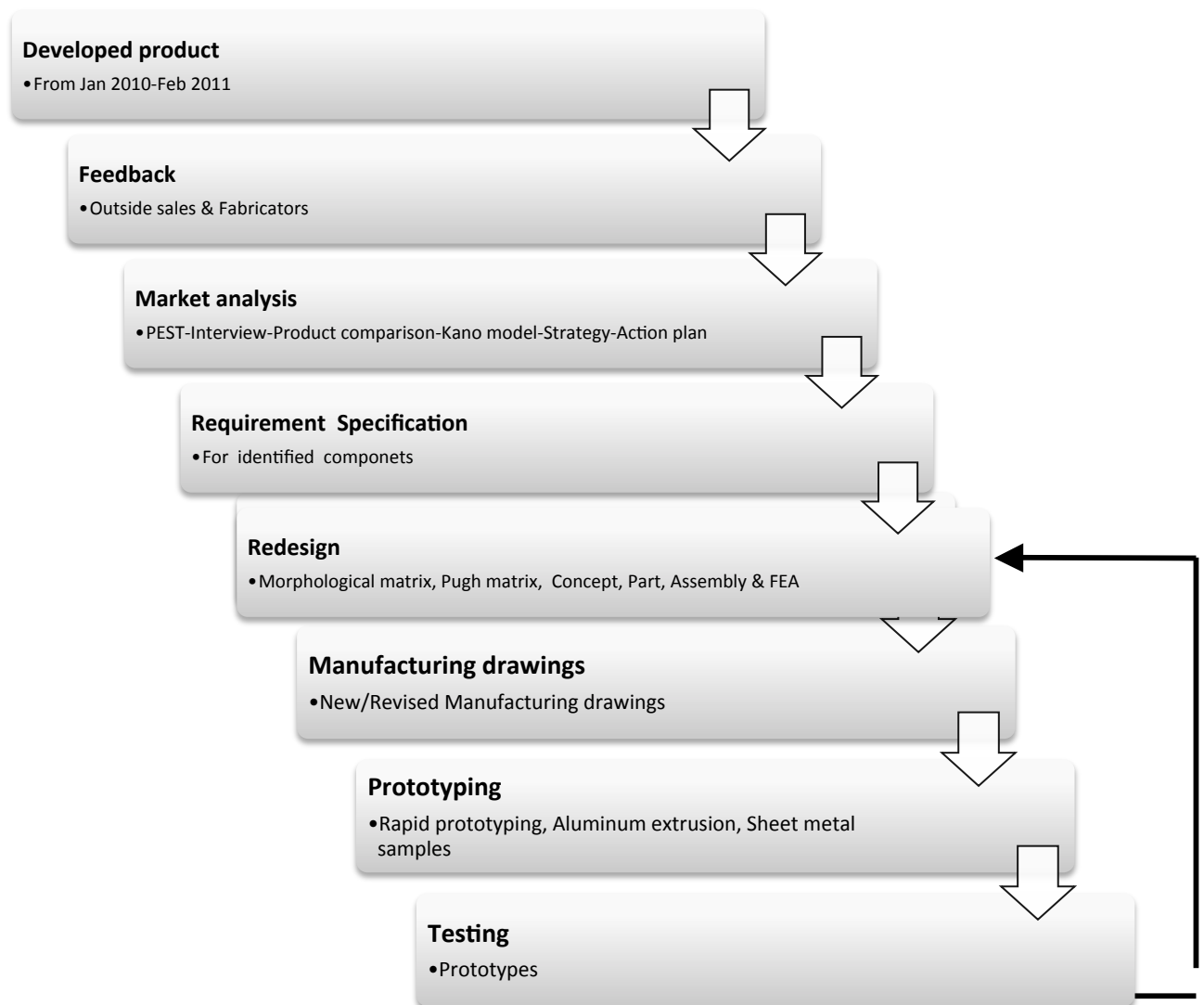


Figure 8: Methodology adopted in this project

3.1 Developed product

When this thesis work started in Feb 2011, there was already prototype of interior shadings available and some of the components were already selling to customers. Development activities of this prototype were carried out between Jan 2010 & Feb 2011. Very soon Maestrosshield had realized that the supplied product is not meeting customer expectations. Even though there was market study carried by Maestrosshield prior to prototype, but was not sufficient. Hence there was need to carry out market analysis in detail and relook into the product developed. Thus Figure 8 shows Market analysis stage after Developed product stage.

3.2 Feedback

To understand the requirements of customers very well, the prototypes of product was provided to outside sales and fabricators for their feedback. The results came up with needs to improve product to be competitive in the market. The challenge was to make the product unique with better quality and performance at a competitive price. To support the further actions to be taken, Market analysis was required to collect information on the developed product and other equivalent product already existing in the market.

3.3 Market analysis

The market analysis started with PEST analysis to understand market and factors that are influencing the market. This was followed by interviews with stake holders to know their real time experience with the products. Also data was collected through internet and websites of competitors. The data collected were then compared with developed product to find the advantage, disadvantages within Maestrosshield product over the competitor's products. Also could find the future business opportunities for Maestrosshield.

3.4 Requirement Specification

The information gathered was analyzed with Kano model (Kano Model, 2012) to understand the spread of requirements over Basic, Performance & Exciters. This allowed to better map requirements that which are basic needs or the needs that can be moved to performance margin in order to produce a high performance product. Extensive brainstorming sessions were carried out to come up with strategies to handle the situation. Later action plan was developed to identify component that needs to undergo changes and the components that can be obsolete. Now these requirements became the basis for checking the performance measurements of the final product.

3.5 Redesign

Using the action plan and requirements specifications only few parts were redesigned and some needed new design. Product development methodologies like Morphological matrix & Pugh matrix were applied to create & select concepts. Designs were verified using CAD & FEA tools.

3.6 Manufacturing drawings

Drawings for redesigned parts were revised and new parts with drawings were provided to vendor for prototyping.

3.7 Prototyping

Prototyping methods like rapid prototyping were used to quickly produce parts to check the functionalities of the parts. Some parts were fabricated by the vendor and supplied to Maestrosshield. Many of these were aluminum extrusions and sheet metal formed parts. All these parts were assembled in house to check for performance measurements.

3.8 Testing

The parts were tested and checked against requirement specification to finalize the design. The basic purpose of tests can be classified into following

- To check the fitment of parts together
- If the parts can be easily assembled and disassembled
- If the parts meet the dimensions in the drawings.

Final technical performance measurements like life of the product, rigidity and reliability has not yet confirmed. This requires extensive testing and Maestrosshield needs to carry out these tests.

Based on assembly and fitment testing, the parts with undesired quality were redesigned and corrected to achieve complete working product.

The methodology of this project can be said very similar to Spiral Product Development Process as explained in literature survey. In Spiral Product Development process Design and Build stages are repeated for quick development of the product. Similarly in this project the prototyping and redesign had several iterations to arrive at desired design.

4 Interior shading product configuration before market analysis

As explained in section 3.1 of chapter 3, there was already a prototype developed by Maestrosshield that was selling in market. And chapter 4 focuses on explaining this prototype. Feedback from customers on these prototypes leads to a detailed market analysis. Subsequent chapters would cover the details of market analysis and changes to this prototypes based on the reports from market analysis. The scope this chapter is to introduce various product configurations and associated parts under interior shading prior to market analysis. Maestrosshield interior shading product configuration is shown in the Figure 9.

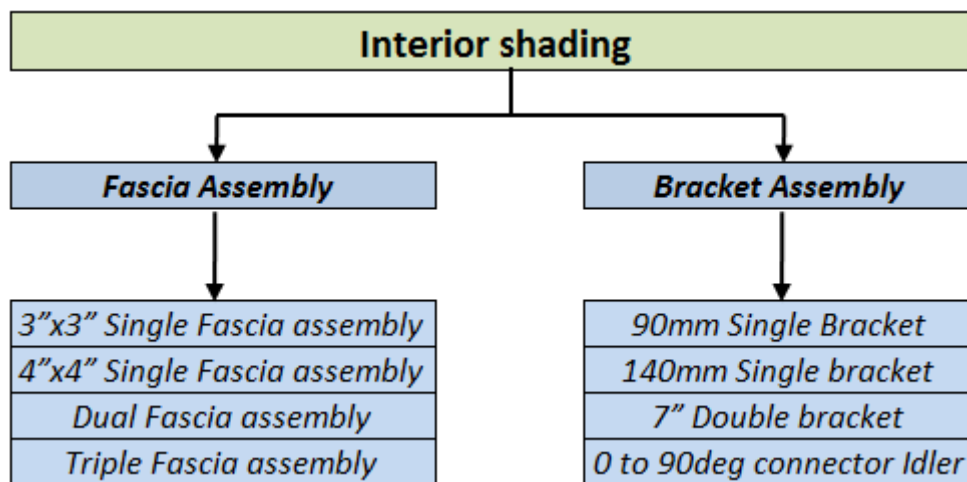


Figure 9: Interior shading product configuration

The basic configuration of Maestrosshield Interior shading can be sub classified into 2 groups. They are **Fascia Assembly** and **Bracket Assembly**

4.1 Fascia Assembly

Fascia assembly has Fascia side caps on which other parts are supported. They are Aluminum die cast. The uniqueness of this from others in market is that, the entire assembly can be adjusted vertically and horizontally. This adjustment is important with respect to installations because no window comes with straight edges or faces. So it is extremely important to keep the shading straight for Aesthetic purpose as well as minimizing light gaps. Maestrosshield is the only company with this innovative product. Fascia assembly is further classified based on size of the side caps and number of rolls/tubes it can take on same side caps. They are **3"x3" Single Fascia assembly**, **4"x4" Single Fascia assembly**, **Dual Fascia assembly** and **Triple Fascia assembly**

4.1.1 3"x3" Single Fascia assembly

It is so called because the size of the side cap is 3inch x 3inch. The Figure 10 shows the complete assembly.

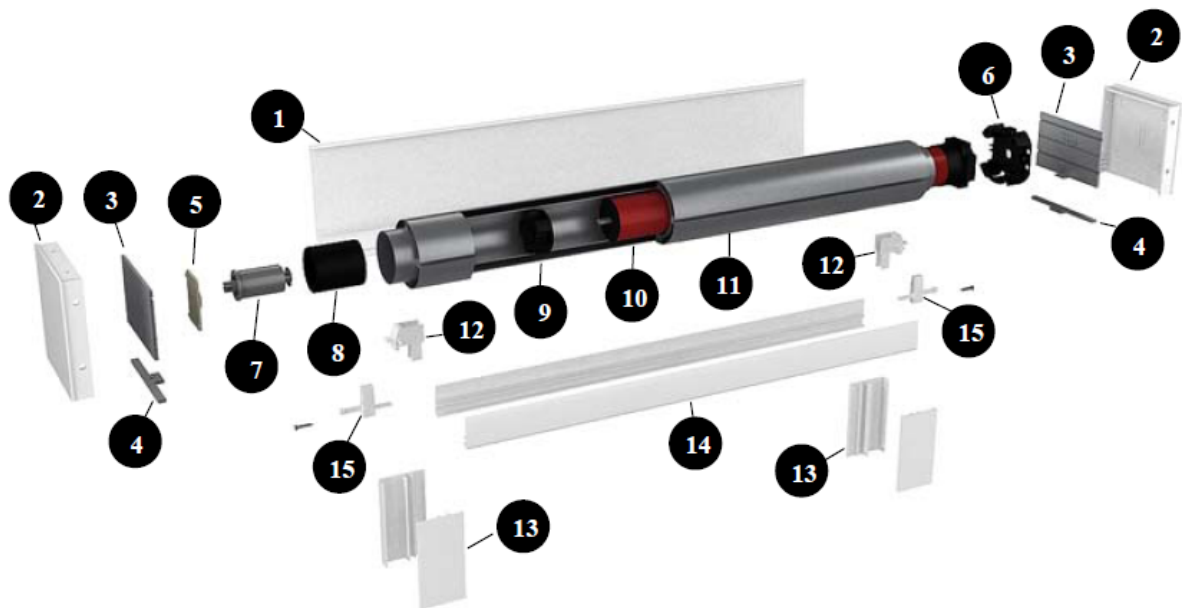


Figure 10: 3x3 Fascia assembly

Single Roll Assembly Component Key			
#	Component	#	Component
1	Single Fascia	9	Drive Gear
2	Single Fascia Brackets	10	Motor
3	Slide Plate	11	Motor Tube
4	Slide Plate Stop Bar	12	Black Out Guide (4x4 only)
5	Idler Bracket	13	Black Out Track (4x4 only)
6	Motor Bracket	14	Bottom Bar
7	Idler Bearing	15	Bottom Bar End Cap (4x4 only)
8	Idler Insert		

Only those components that are focused in this report have been briefed below. Component names are referenced with item number as show in the Figure 10 for quick reference.

- Fascia (1): This is an Aluminum extruded part which can be easily snapped on to fascia side caps/brackets (2). This covers the inner components.
- Fascia side cap/bracket (2): Holds the slide plate (3), Idler and motor brackets (5 & 6), Slide plate stop bar (4). Fascia side caps are used on both ends, one holding the idler bracket at one end and motor bracket at other end of the shading.
- Idler bracket (5): Idler bracket is made of Nylon 66 with no glass fiber. This supports Idler bearing shaft (7). This is one of the support end points of whole shading assembly. Idler bearing shaft rotates inside this bracket.

- Motor Bracket (6): This is also made of Nylon 66 without glass fiber. This is used snap motor into side caps. This bracket forms the other end of the shading assembly.
- Idler bearing (7): Idler bearing comes with male and female shafts. Idler bearing can be used for connecting two shades as well as just bearing. To function as connector/torque transmitter, Pin is inserted which passes through Housing and shaft thus locking each other. Idler bearing is in-turn assembled into motor tube (11). When tube rotates the torque is transmitted into shaft and shaft then rotates the other shade through male and female shafts. By changing the position of pin to lock light gaps can be adjusted. The Figure 11 shows Idler bearing without pin, this configuration is used as bearing. To function as bearing the pin is removed and shaft moves independently from its housing thus act as bearing. The Figure 12 shows male and female idler bearings locked each other to connect two shades together.

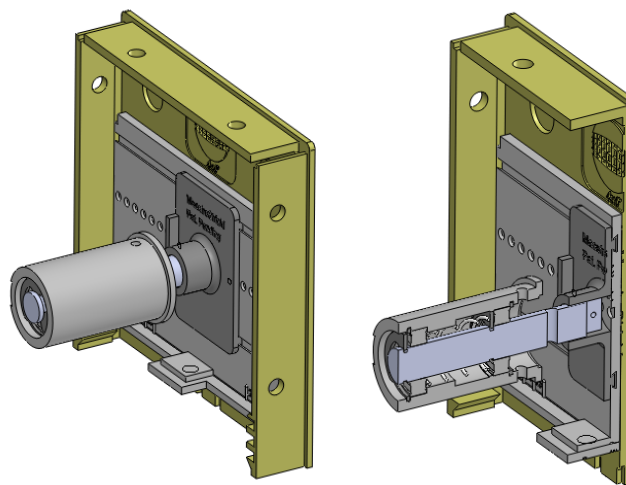


Figure 11: Idler bearing as bearing

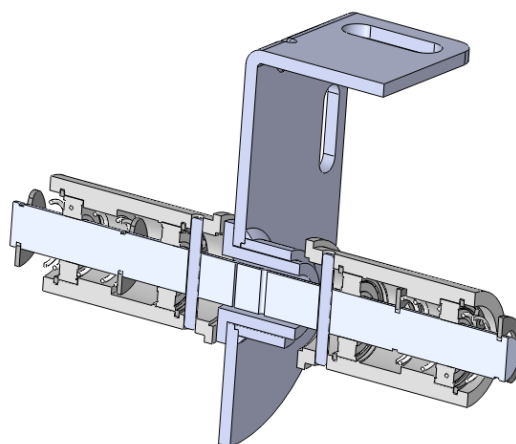


Figure 12: Idler bearing locked with pin to connect two shades

- Motor (10): This is the driving force in interior shading. The different motors available for interior shading are 0.7Nm, 1Nm, 3Nm, 6Nm and 8Nm

- Motor tube (11): This is Aluminum extruded having different sizes and profiles. They are already available in the market. Fabric is rolled on this.

4.1.2 [4"x4" Single Fascia assembly](#)

It is so called because the size of the side cap is 4inch x 4inch. The parts are similar to that explained for 3"x3" assembly

4.1.3 [Dual Fascia assembly](#)

The parts used are similar to 3"x3" assembly. The uniqueness is that this can accommodate two rolls of fabric. This provides the customers with their choice of fabric to be used on the rolls. The Figure 13 shows the Dual Fascia assembly

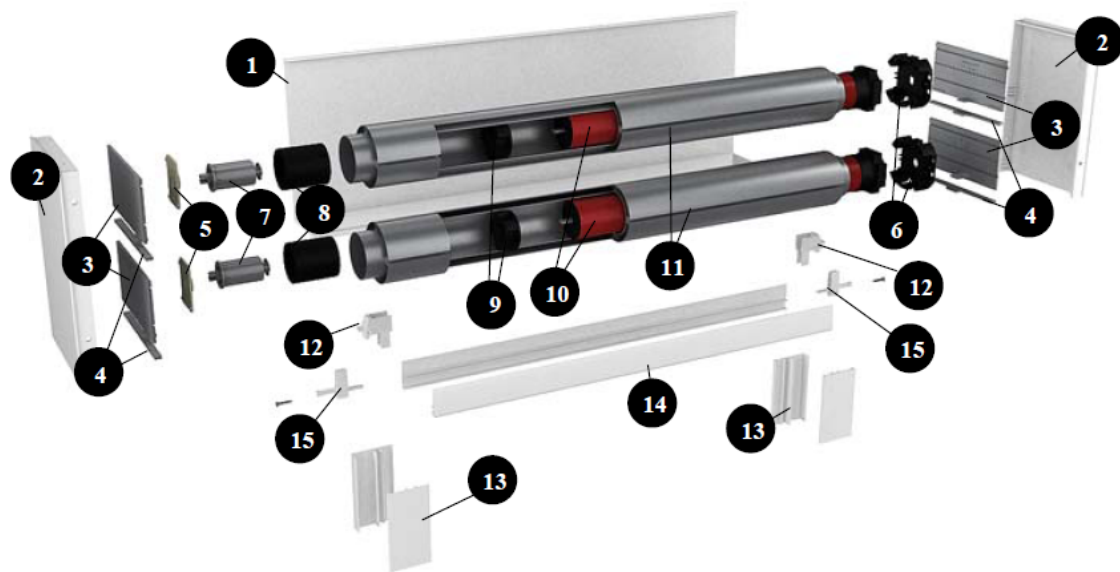


Figure 13: Dual Fascia assembly

4.1.4 [Triple Fascia assembly](#)

The parts used are similar to 3"x3" assembly. The uniqueness is that this can accommodate three rolls of fabric. This provides the customers with their choice of fabric to be used on the rolls. Maestrosshield is the only company that holds this design. The Figure 14 shows Triple Fascia Bracket

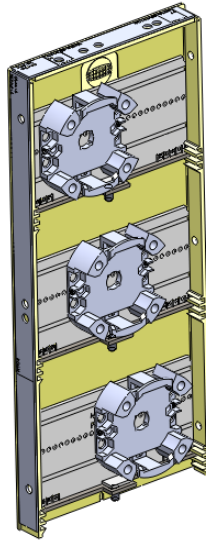


Figure 14: Triple Fascia Bracket

4.2 Bracket Assembly

Bracket assembly has stamped sheet metal brackets on which other parts are supported. The important function of this is that, the entire assembly can be adjusted vertically. This adjustment is important with respect to installations because no window comes with straight edges or faces. So it is extremely important to keep the shading straight for aesthetic purpose as well as minimizing light gaps. This is the most common product in the market. Bracket assembly is further classified based on size of the bracket and number of rolls/tubes it can take on same bracket. They are **90mm Single Bracket, 140mm Single bracket, 7" Double bracket** and **0 to 90deg connector Idler**.

4.2.1 90 mm Single Bracket

The height of this bracket is 90mm having only vertical adjustment. The parts associated with these are similar to Fascia assembly. The difference is that this uses Idler bearing holder instead of Idler bracket and are screw mounted. Also another difference is that there are no slide plates. The motor brackets are mounted using screws.

Uniqueness in this is that same bracket and Idler bearing holder can be used as connector brackets to hold two shades together. When used as connector brackets. The male and female idler bearing assemblies each inside the idler bearing holder on this connector bracket. The Figure 15 shows 90mm Single bracket assembly. Figure 16 shows the Idler bearing holder. Figure 17 Shows Motor bracket and Idler bearing holder mountings on the 90mm bracket.



Figure 15: 90mm Single bracket assembly

Bracket Assembly Component Key			
#	Component	#	Component
1	Single or Double Bracket	5	Connector Idler
2	Motor Bracket	6	Idler Bracket
3	Motor Tube	7	Adjustment Screw
4	Connector Bracket		

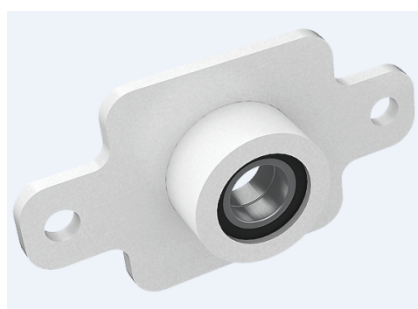


Figure 16: Idler bearing holder

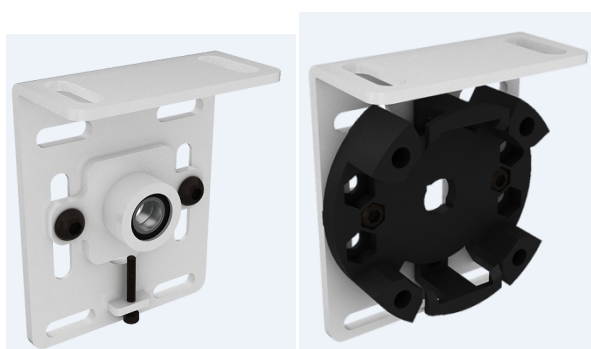


Figure 17: Motor bracket & Idler bearing holder- 90mm bracket

4.2.2 140mm Single bracket

This is similar to 90mm Single bracket. The only difference is that the size of bracket is 140mm in height. They can be used as connector brackets as well.

4.2.3 7" Double bracket

The parts are same as explained in 90mm single bracket. But this can take two rolls of fabric and height of the bracket is 7". They can be used as connector brackets as well. Figure 18 shows this 7" Double bracket.

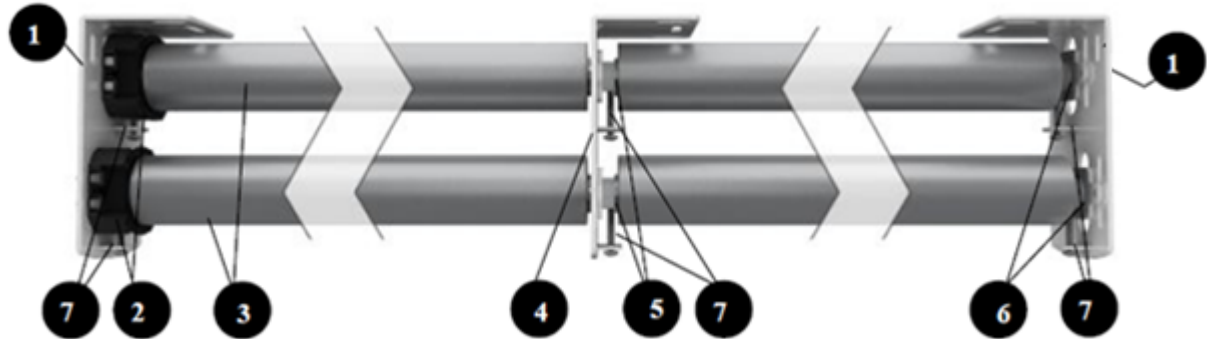


Figure 18: 7"double bracket assembly

4.2.4 0 to 90deg connector Idler:

Some buildings and rooms have their windows curved. They may not be straight. In this case using 90mm or 140mm single brackets as connecting brackets is impossible because the male & female Idler bearing needs to be connected in a way such that they can transfer torque each other. At the same time the connector must be able to adjust to any angle from 0 to 90 degree. This means that this bracket can be used for curved windows anything between 0 to 90degrees. The Figure 19 shows 0-90deg connector idler. This uses universal joint to transmit torque from one shaft to other.

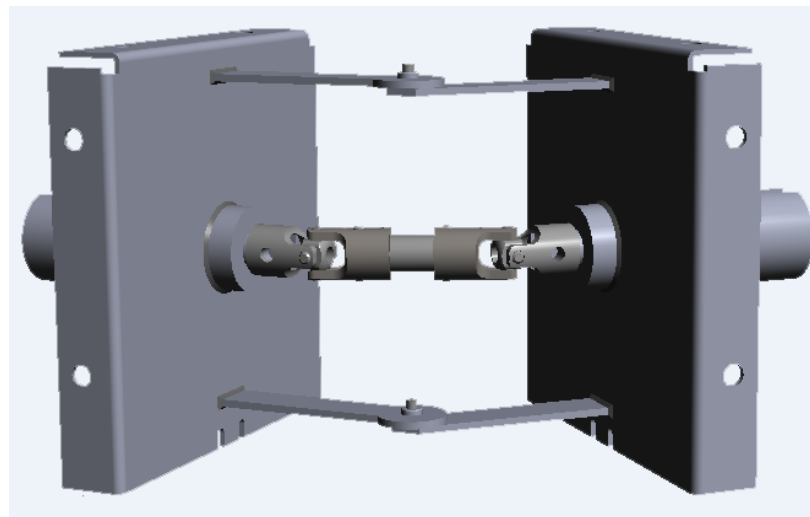


Figure 19: 0-90deg connector idler

5 Market Analysis of Motorized roll down interior shading

As explained in purpose of this project, the interior shading that was developed had to face challenges from other competitor's product in cost and certain functionalities. This motivated to study the market once again and compare the developed product with similar products available in the market. This chapter explains the methodologies followed for market analysis, and how the data collected from market analysis were analyzed. Finally chapter ends with the developed strategies and list of action plans taken to redesign the product based on the outcome of market analysis.

5.1 Methodology for market analysis

The methodology adopted for market analysis is illustrated by Figure 20. Each step followed is explained in the following sections.



Figure 20: Methodology adopted for Market analysis

5.1.1 PEST analysis

PEST analysis is an important tool for companies to understand the environmental factors related to their product. This can be considered as first step in market research. PEST analysis was also conducted for interior shading as first step to describe framework for strategies and action plans to be taken in redesigning the product. The brief points on the PEST Analysis are show in the below chart.

Political	Economical
<ul style="list-style-type: none"> * Fascia & Tube material standards: Painted Powder coating, Anodized Aluminum, Extruded Aluminum tube 6063-T5, ASTM = B221, FEDERAL = QQ-A-2009, AMSE = SB221, AMS = 4156 * Tubes Sizes: 1.25", 1.5", 1.75", 2", 2.5", 2.7", 3.25" * Warranty: Life time Clutch warranty Life time guarantee 8yrs & 10yrs limited warranty * Safety Standard: Child safety Std 2010 WCMA * Quality: Green guard quality standard. * Noise standards & Lifting capacity chart of motors 	<ul style="list-style-type: none"> * Cost: Inexpensive * Hardware adaptability with leading industry motors * Affordable to any home windows * Distribution: As a Component supplier * Distribution with fabric suppliers * Modularization * Services: Customized designs for special req. Assembly and associated component diagrams, Individual components and spec. sheet, Installation sheets Tube deduction diagram Online warranty registration Contact information of dealers Product work book (Adding to basket) 24X7 customer care
Social	Technological
<ul style="list-style-type: none"> * Fascia: White, Alabaster, Brown, Vanilla, Bronze, Black, Anodized. * Brackets: Generally white & black Alabaster, bronze and anodized * Bottom bar: White, black and anodized * Plastic bracket cover: Black, Apo grey, Barley, Sandstone * Aesthetics: Fascia: Round and Square Bottom bar: Flat and Oval 	<ul style="list-style-type: none"> * Easy to use * Easy to install * Motor: Automatic limit adjustments, Easy to program the motors. Less noisy-silent in operation Infrared and radio technology * Adaptability to harsh environment * Minimum light gap: 0.75inch per side

a) Political: The main factors under this section were standards & warranty that are followed in this business. The standards are both technical and safety related. Technical standards include specifications of the material used in the components, as well as sizes and specifications of the product. Child safety standard called 2101 WCMA (Window Covering Manufacturers Association) is moving as an important standard for interior shadings. Regarding the warranties it is based on the business strategy of the firm to decide.

b) Economical: One of the key success factors in this business is cost of the product. Firms are making products cheaper and with high quality. Also companies like ZMC (ZMC, 2011) are making their hardware adaptable to leading motor manufacturers like Somphy. Keeping the product modular gives an advantage for fewer inventories and less cost as discussed in literature survey. With a good product it is also important to have good and strategic distribution channels to meet business targets. Looking for key routes of distribution channel with an aim to reach maximum customers has become trend in this business. Also companies are providing excellent services to their customers by giving them with clear information also making these available to them easily and quick.

c) Social: Since interior shading is kind of product line where aesthetics plays very important role. The customers are very choosy in buying good looking products. Therefore companies working hard to create the product with good aesthetics and ergonomics. Also the interior shading products especially motorized roll down shadings has motor which enables them move up and down, the customers demand the product to be silent during operation.

d) Technological: The technological advancements are made in the motors and electronics part of interior shading. The whole system is being made more intelligent and sophisticated. The competitor like Lutron (Lutron, 2010) has technology to automatically adjust shades based on the sun light directions. Also these shades are integrated with other advanced technologies of Lutron to adjust the shades depending on the room activities like Lunch, Dinner, cleaning etc (Lutron Electronics Co., 2011). There are infrared and radio technologies. Also Lutron has a technology that can synchronize all motors shades thus avoiding shades misalignment across the windows.

5.1.2 [Customer Segment Matrix](#)

Customer segment matrix for this project is shown below Table 1. Here H-Stands for higher knowledge on product characteristics and L-stands for Low knowledge. From the Table 1 it is clear that the Management (CEO)/Designer & outside sales of the Maestrosshield have overall information regarding motorized interior shading. Fabricators & Distributors knows the product very well because they handle products of different companies. They can provide actual requirements that can make difference in the market. Our sources of information are these stake holders. Also Internet is also an important source of information.

Characteristics Stake Holders	Business Benefits	Product knowledge	Product handling	Purchase decision / Marketing	Product Issues
Management / Designer	H	H	L	H	H
Inside Sales	H	L	H	H	L
Outside sales	H	H	H	H	H
Suppliers	L	L	H	H	L
Shop Manager	L	H	L	L	H
Manufacturer	L	L	H	L	L
Fabricators	L	H	H	L	H
Distributors	H	L	H	L	H
Dealers	H	H	H	L	L
Installers	L	H	L	L	H

Table 1: Customer segment matrix for Motorized Roll down interior shading

5.1.3 Customers & Competitors

Once we have information about the market and stakeholders. We must know who are our customers and competitors to gather right data and make product a sellable one. From above said sources of information mentioned customer segment matrix the following conclusions we achieved.

Customers: Distributors, Installers, Suppliers, Dealers, Fabricators

Competitors: Competitors are again classified into 2 groups as Hardwares and Motors. Because firms focused on hardwares, design their hardwares suitable to leading motor manufactures like Somphy and Lutron.

Hardware: ZMC, Rollease, Acmeda, Hunter Douglas, Mitjavila

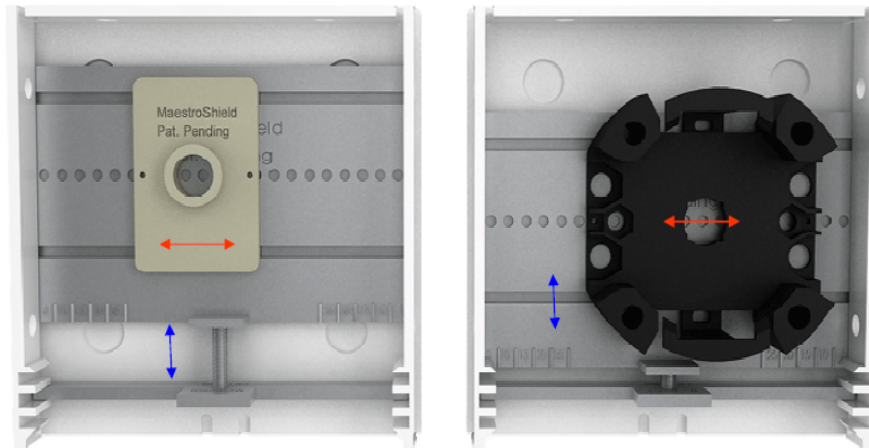
Motors: Somphy, Lutron

5.1.4 Data Collection

The data collection methods followed was personal Interview, fabricator visit & internet. Personal interview was conducted with CEO, CFO, Sales Manager, Shop floor Manager, and Purchasing Manager of the Maestrosshield. Also with Outside sales Manager who is always in contact with Fabricator and Distributors. CEO and Outside sales Manager is working on the sales from last 1 year constantly. They were a great source of information. Also there was one Fabricator visit; it was right place to see competitor's products as well. This enabled to compare Maestrosshield initially developed product with competitor's product. Also could learn common installation problems and trends in this market. Finally internet is common source to surf websites to gathers data on motorized roll down shadings.

5.1.5 Product comparison

In this section already developed MaestroShield product was compared with competitor's product considering the data collected from interviews and internet. Each part under product was compared with similar products in the market. The results were tabulated into advantages and disadvantages of MaestroShield product with others parts in the market. Also there were recommendations made on opportunities for improvements on these parts to make it better. An example is shown in Table 2. The part is identified with MaestroShield part number. The rest of the comparisons can be found Under Appendix C.



Part no:	Description	Advantages	Disadvantages	Selling package
IS1533	Fascia bracket 3x3	<ol style="list-style-type: none"> 1. Vertical & Horizontal adjustment 2. Snap for Fascia bracket 3. Provides Entry guide support 4. Can be used Left and Right ends 5. Covers end of interior shading 6. Can be mounted on wall or ceiling 7. Looks strong 8. Color: White, Brown, Anodized, Black and Mill finish 9. Warranty powder coating: 1 year 	<ol style="list-style-type: none"> 1. Need spacer to flush with wall or ceiling 2. Difficult to access motor bracket & Adjustment plate in assembly 3. Heavy 4. Expensive 5. Need bracket for harmonic series 0.7Nm & 1Nm motors 	<ol style="list-style-type: none"> 1. Left and right Fascia 2. Adjustment plate pair 3. Adjustment Stop bar pair 4. Idler brackets 5. Motor bracket

Table 2: 3x3 Single Fascia Bracket product comparisons

5.1.6 Data Analysis

Product comparison gave greater insight on the actual requirements of the customer and the areas that needs to be improved to be competitive player in the market. The tools like KANO Model and Blue water diagram were used for data analysis.

5.1.6.1 KANO Model

To better understand the requirements, the data was spread on KANO Model. This gave more clarity on the basic requirements that are needed for the product to function as desired and the requirements that gives better customer satisfaction. Also found that some of the features in MaestroShield products belong to excitors region. Achieving these

requirements basically excite the customers. The Figure 21 shown below represent example for KANO Model. KANO Models for rest of the parts can be found under Appendix D.

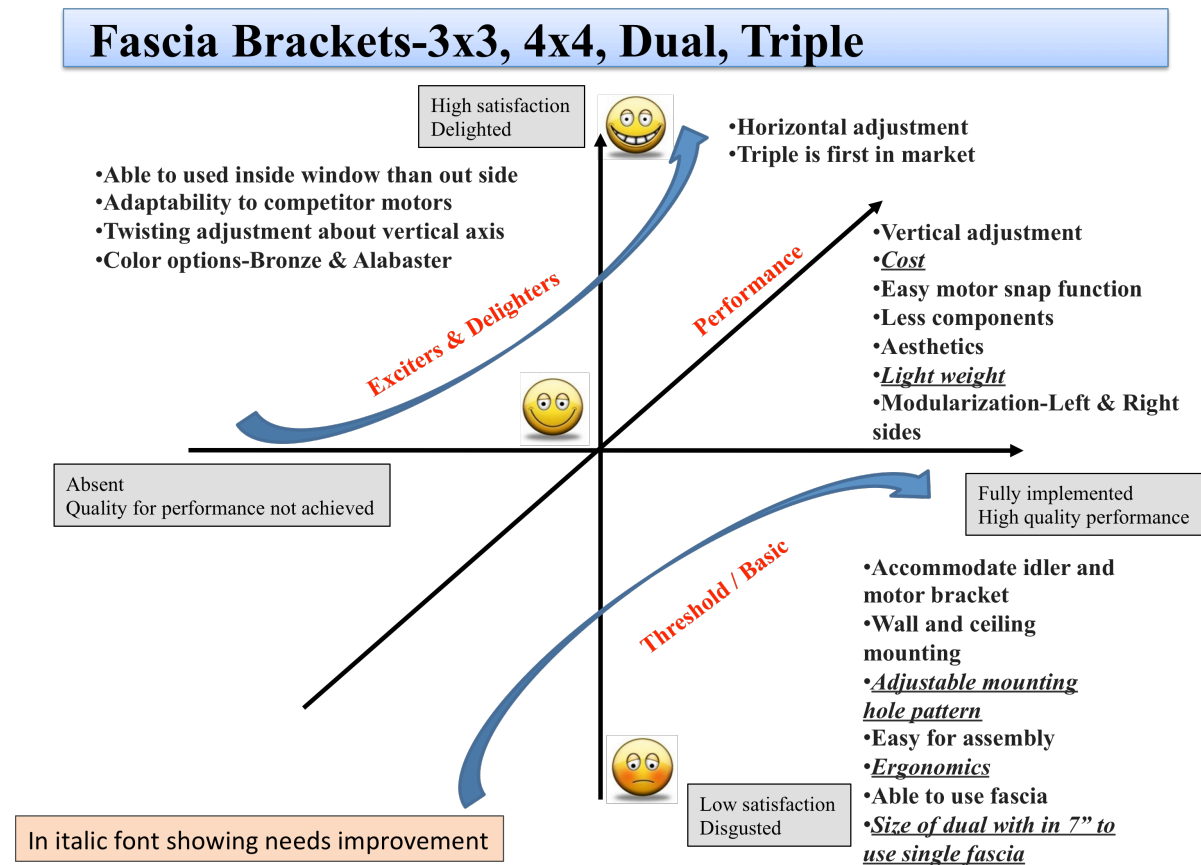


Figure 21: KANO Model for Fascia Brackets

5.1.6.2 Blue water diagram

In order to understand the way the competitors are behaving in the market and the position of Maestrosshield with others, Blue Water Diagram was plotted. To create this, the properties that influence the market of motorized roll down shadings are identified and each competitor is graded 1-10 scale against each property. Where 1 is bad and 10 is best. The matrix is run and the result is plotted as a graph as show below. It should be noted that all the grading are based on the information from websites of individual competitors by considering their performance, popularity, and looking at the pictures of product. For accurate result this needs to be practically tested and more research time must be spend.

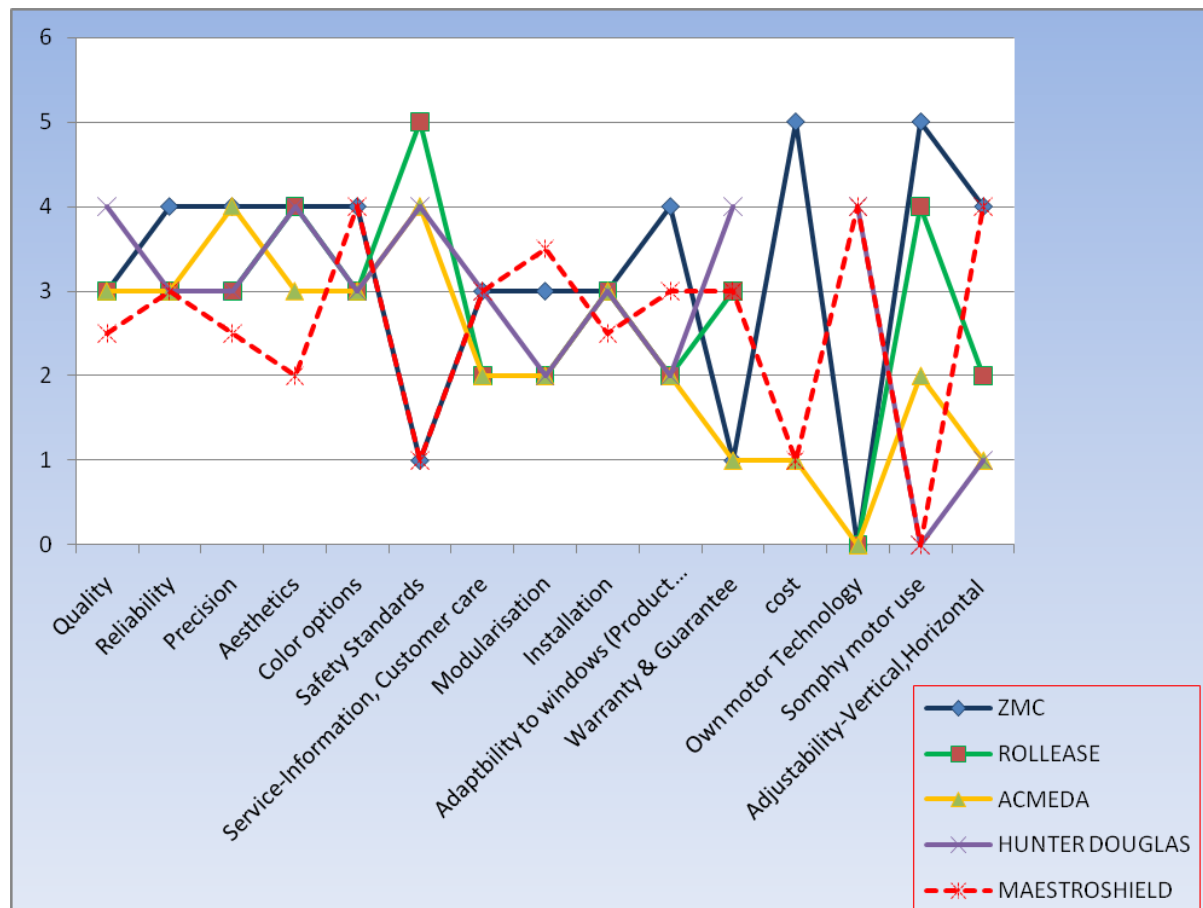


Figure 22: Blue water diagram for Motorized roll down interior shading

Looking at Figure 22, at point “Own motor Technology” one can see that all the competitors doesn’t use own motors, while they are adapting their hardware to suit major motor manufacturing companies like LUTRON & SOMPHY. This may be reason they are keeping their hardware cost low to compete in the market. However Maestrosshield has its own motor technology. There by behaving unique in the market, this is good. But looking at other features, Maestrosshield needs to improve to be best in the market and raise the curve above competitors. Also they need improve motor technology as well. Since the graph is plotted before product testing, this in future can change after product testing.

5.1.7 Brainstorming

After collecting all above information and data, the points were discussed extensively in group discussion. The participants for the discussion were CEO, CFO, Sales Manager, outside sales Manager, Designer & Shop Manger. There were around 4 meetings carried out point by point and came up with strategy to handle the situation. The meetings resulted with action plan and deadline to complete the project. The resulted action plan has been discussed in section 5.10.

5.1.8 Strategy

From market analysis it was found that the developed product is expensive for certain parts. On the other hand certain features of product are new in the market. So the cost can be

compensated with the feature of the product. Since the time is less to redesign from the scratch. The strategy is to move the product forward with correcting only the features that are absolutely necessary and are feasible in short period of time and then monitor the performance of the product. If needed in future products can be revised.

5.1.9 Action plan

After brainstorming session and based on the strategy, following action plan was created.

- I. Selection procedure for motorized interior shading: When there was discussion on selection of the product configurations, there was realization that interior shading product configuration is modular and there is a need for structured procedure for selection of product. This helps to choose optimized product for the customers, thus reducing time and effort over confusion in selection. Understanding the amount of details involved in this action, chapter 6 is worked out to get deeper insight into selection of interior shading.
- II. Development of 4x4 Connector fascia bracket: The fascia bracket at present when used is suitable for single window. If there is need to connect 2 or more shades these fascia brackets cannot be used, because the fascia brackets are closed at ends. The bracket forms center support for 2 shades, such that one motor can be used to run 2 shades together or can also use two different motors to operate the shades independent to each other.
- III. Male and Female idler bearing with screw operated light gap adjustment: The current design is using pin to lock the position. The disadvantage is that this pin is difficult to insert during the installation of shade. As well as it now gives only 4 desired positions whereas the screw method like the once ZMC has, can handle any positions. The Figure 23 shows the current design with pin to lock shaft and housing.

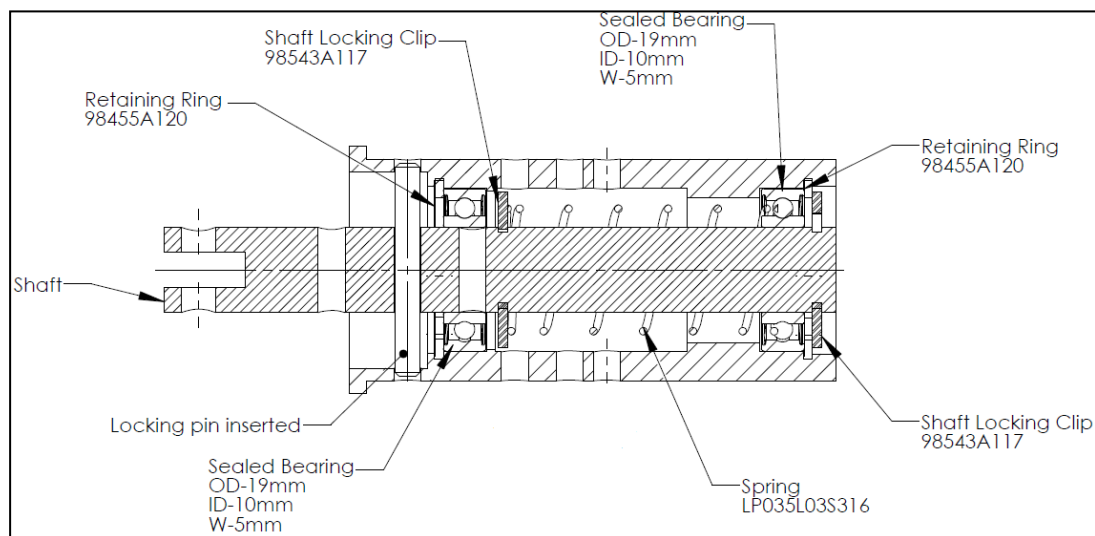


Figure 23: Female Idler bearing with pin lock

- IV. 0 to 90deg connector Idler: Find a solution to 0 to 90deg connector Idler brackets. Current design uses universal joint which is expensive and doesn't allow light gap adjustment.
- V. Provide provision on Fascia to be used on the 90mm bracket.
- VI. Modify 0.7Nm, 1Nm DC & 3Nm AC Series motor bracket to suit 3Nm & 6Nm AC& DC harmonic series motors.
- VII. Create Fascia for 7" Double Bracket and use the same Fascia on Dual Fascia bracket: Currently there is no available fascia for 7" double Bracket because of it size. The task is to make one for it and try to use it on the Dual Fascia bracket assembly.
- VIII. Manufacture prototypes for all the available designs and test it for functionalities.
- IX. Triple Fascia bracket is dropped from development for the moment.
- X. Extrude fascia for 16ft only instead of 21ft. As this is the standard length. Also 21ft is difficult to carry into the room especially through lifts and elevators.

6 Selection procedure for motorized roll down interior shading

The motivation behind creating selection procedure can be understood from below Figure 24. The customer input is only height and width of the window and kind of bracket system needed for their requirement. But the product list of Maestroshield is highly modularized. Components are designed with suitable interfaces to make different product configurations. Thus a structured selection procedure is necessary to deliver correct and optimized product configuration to customers. This chapter explains the inputs required for selection and how to process these inputs to select optimized product configuration against customer requirements.

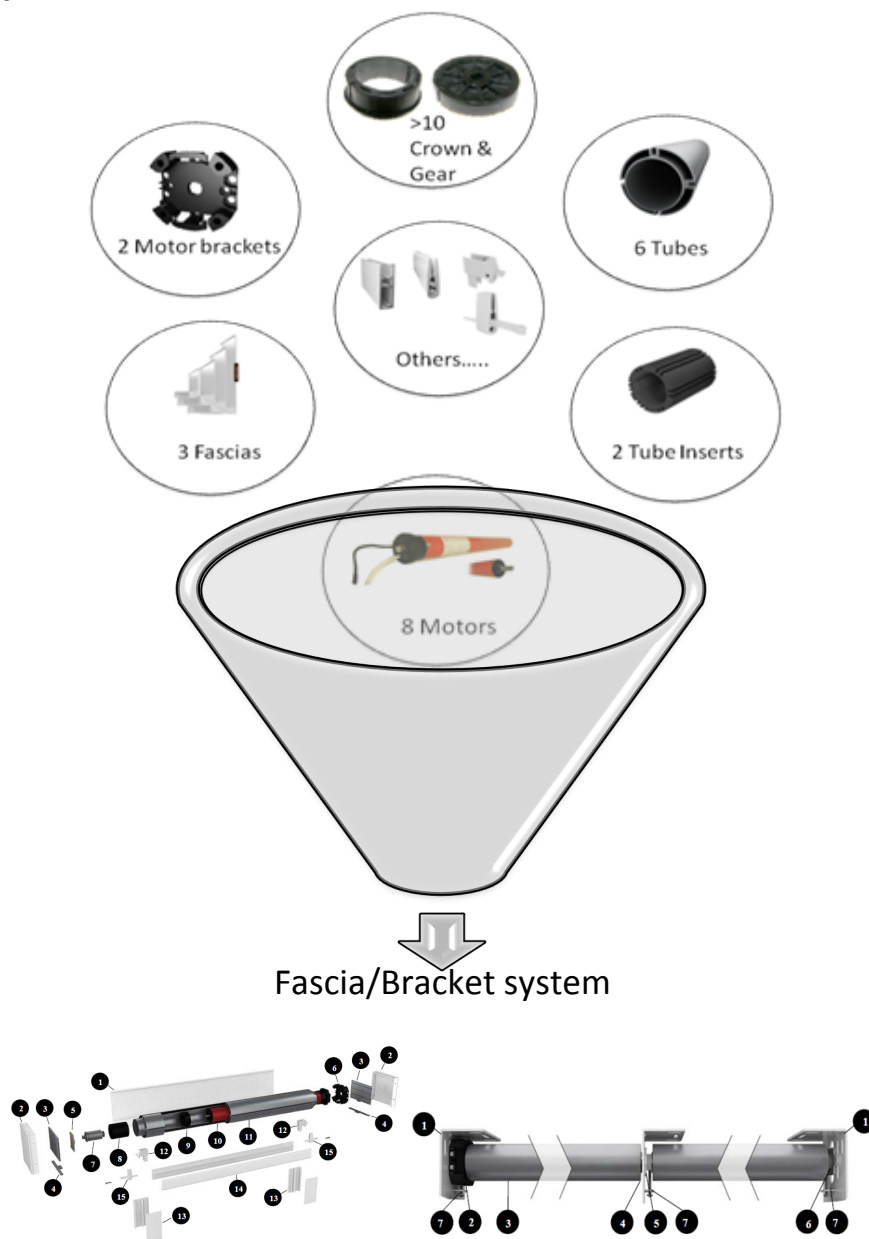


Figure 24: Showing need for selection procedure

6.1 Data for selection procedure

The data required for selection procedure are

- Lifting capacity chart
- Window Height
- Window width
- Square footage-Height & Width chart
- Motor selection chart

6.1.1 [Lifting capacity chart](#)

Lifting capacity of tube for the respective motor is shown by Table 3.

LIFTING CAPACITY CHART				
Tubes	1"	1.5"	2"	2.7"
OD (mm)	33.4	39.5	50.5	68.6
Motors (Nm)	Load (lbs)			
0.7	7.05	5.96		
1	10.07	8.52		
3		25.55	19.98	14.71
6		51.10	39.97	29.42
8			53.29	39.23

Table 3: Lifting Capacity chart

The load or lifting capacity is calculated by basic Torque formula

Torque=Radius of tube x Load

Therefore, Load (lbs) = Torque/Radius of tube

Deduct 25% from calculated load for factor of safety

Note: All the cells left empty doesn't count because of limitation of supporting parts for assembly

6.1.2 [Window height](#)

Window height corresponds to amount fabric that can be rolled on the tube or number of turns of fabric on the tube. This in turn depends on the whether it is Fascia or Bracket system. The calculation was carried using Arithmetic Progression (AP).

Calculation example shown below

Example: To start with we need to select the tube size. Let the tube size be 50mm in diameter and thickness of fabric be 0.9mm and amount of fabric rolled be 15ft=4572mm

Now using AP

$$S_n = a + (a+d) + (a+2d) + (a+3d) + \dots + a + (n-1)d$$

$$4572 = \pi \times 50 + [\pi(50+1.8)] + [\pi(50+2 \times 1.8)] + \dots$$

$$= \pi[50 + (50+1.8) + (50+2 \times 1.8) + \dots]$$

$$a = \pi \times 50$$

$$d = \pi \times 1.8$$

$$S_n = n/2 [2a + (n-1)d]$$

$$4572 = n/2 [2 \pi \times 50 + (n-1) \pi \times 1.8]$$

Calculated $n=21.31$ which is number of turns on the tube of 50mm diameter with fabric of 15ft long.

To find roll diameter at 21.31turn

$$T_n = a + (n-1)d$$

$$T_{21.32} = \pi \times 50 + (21.31-1) \pi \times 1.8 = 271.92$$

We have $\pi \times d = 271.92$, therefore diameter is $d = \mathbf{86.55mm}$.

This entire calculation is automated in Excel sheet, So that the dynamic calculation can be performed.

Now let us take example with actual values. If we are calculating height of fabric for 3X3 Fascia assembly with 1" tube, First find through CAD what diameter of the roll can be achieved maximum inside the bracket. This is show by Figure 25.

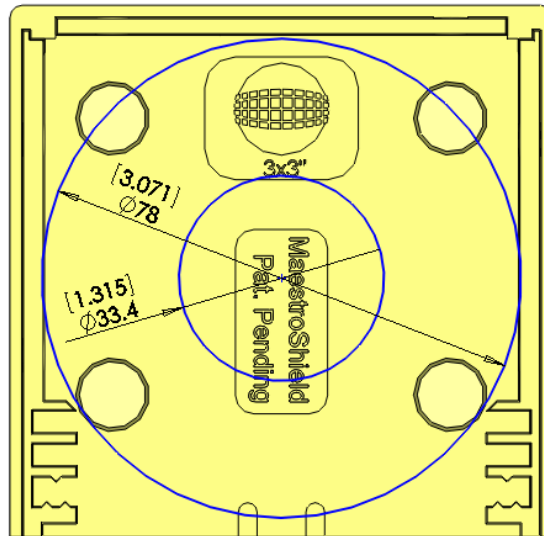


Figure 25: Max diameter of fabric inside the 3x3 Fascia bracket

Now use these values in the roll calculation excel sheet. For calculation, the thickness of fabric considered is 0.03inches. This is the thickness of the fabric commonly used. In the excel sheet as shown in Figure 26, the cells marked with yellow are for inputs and fabric length is changed until value of max diameter after rolling doesn't exceed the max roll diameter calculated above. This fixes the height of the window and fabric height.

	Dia of tube	33.4	mm
	Thickness of Fabric (0.03")	0.762	mm
CASE 1: 3x3 Fascia Bracket			1.524 mm
		feet	mm
	Fabric length	16.5	5029.2
	$S_n = a + (a+d) + (a+2d) + \dots + (a+(n-1)d)$		
	a	104.9291946	
	d	4.787787204	
	$S_n = n/2 * (2a + (n-1)d)$		
	Coefficeient of n2 (A)	1.524	
	Coefficeient of n (B)	65.276	
	Constant ©	3201.688159	
	Number of turns : n	29.17539939	
	$T_n = a + (n-1)d$		
	Circumference of nth term T_n	239.8270113	
	Maximum diameter after rolling	76.33930867	77.86331 mm
	Max roll dia 78mm		

Figure 26: Fabric height/Window height for 3x3 Fascia bracket using Roll calc excel sheet

6.1.3 Window Width

Window width is directly proportional to deflection on the tube. The tube when installed on the brackets acts like a beam supported at ends. If the tube deflects then it produces wrinkles on the fabric and doesn't look good when the shades are down. The allowed deflection for the tube is 6mm. using this constrain, Finite Element Analysis (FEA) was

carried out on all tubes for all maximum load cases as shown in lifting capacity chart. The results are tabulated in Square footage-Height & Width chart shown in Appendix E.

FEA of tube was carried out with following stages

a) Material Properties: 6063 T5

Property	Value	Units	Temp Dependency
Elastic modulus	6.9639e+010	N/m ²	Constant
Poisson's ratio	0.33	NA	Constant
Shear modulus	2.58e+010	N/m ²	Constant
Mass density	2700	kg/m ³	Constant
Tensile strength	186000000	N/m ²	Constant
Compressive strength		N/m ²	Constant
Yield strength	145000000	N/m ²	Constant
Thermal expansion coefficient	2.4e-005	/Kelvin	Constant
Thermal conductivity	209	W/(m.K)	Constant
Specific heat	900	J/(kg.K)	Constant
Material damping ratio		NA	Constant

b) Constraints and load: Fixed at ends, Applied Load as per the lifting capacity chart also added gravity due to self weight of the tube. Figure 27 shows the loading and constraints applied on the tube.

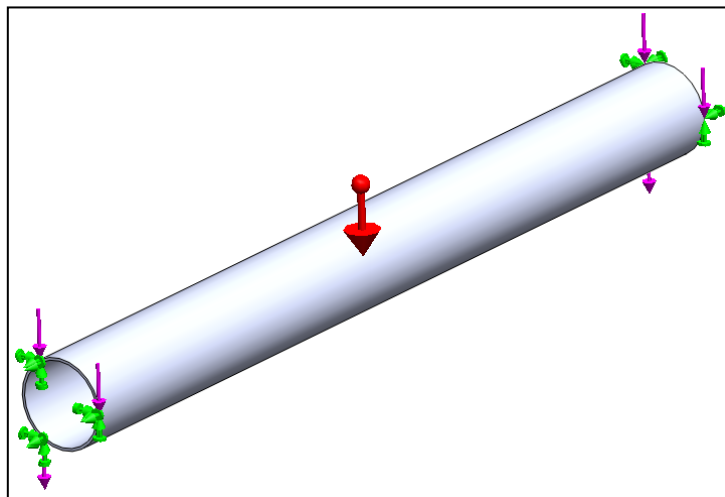


Figure 27: Constraints and loading on tube

c) Results: As an example the deflection of 2" tube is shown below Figure 28.

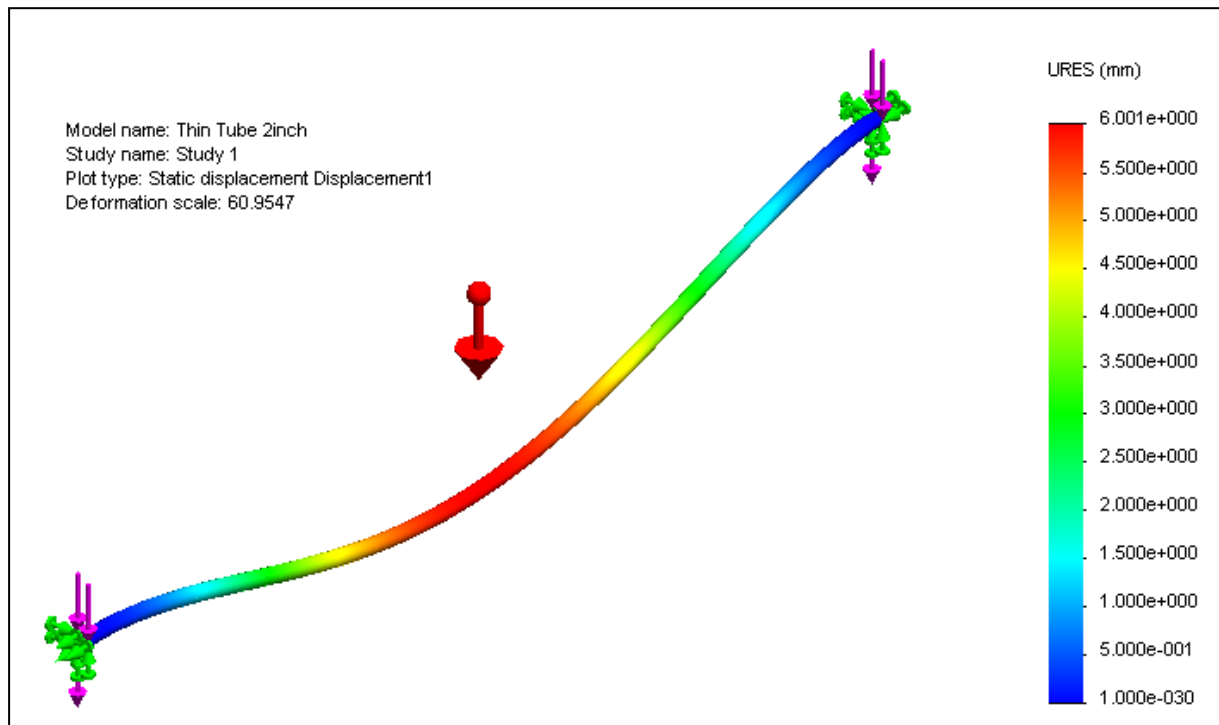


Figure 28: Deflection of 2" tube

6.1.4 Square footage-Height & Width chart:

This is required to calculate maximum square footage of area that can be covered by each of the product configurations. The chart can be found under Appendix E.

For example if we were to calculate max Sq.ft for 3x3 Fascia bracket system. Then refer the chart and find the maximum height that is allowed out of all the tubes. The height is 16.5ft for 1" tube. Now find the worst condition for width which is nothing but the least width out of all tubes. The width is 9ft for 1.5" tube with weight 51.1lbs.

Therefore the max Sq.ft for 3x3 Fascia bracket systems is $16.5 \times 9 = 149$ sq.ft

Similarly calculate for other systems.

6.1.5 Motor selection chart

Using above information motor selection chart is created for all tubes sizes. The information about the motor compatibility with tube is already known. Now using the max Height and max Width as well as the Lifting capacity of motors, the charts are made. All these charts are shown in Appendix F. The procedure for creating these charts is as follows

1. Calculate the load for each height, width chosen,
i.e. Load (lbs)= Fabric weight + Bottom bar weight (for chosen height and width)

$$= (\text{Height (ft)} \times \text{Width (ft)} \times \text{Weight Per square foot of fabric (0.19 lbs/ft}^2)) + (\text{Chosen width} \times \text{weight of bottom bar per foot (0.39 lbs/ft)})$$

Where 0.39 lbs/ft, Is the weight of bottom bar

And width for calculating bottom bar weight is the width you choose to calculate the fabric weight

2. Compare this load with lifting capacities of the motors used with the tube chosen

For ex: Say we calculated 5 lbs for particular height and width. We have 7.42lbs and 10.60lbs for 0.7Nm and 1Nm motors as shown in Lifting capacity chart. Now the cell in the chart should be filled with 0.7Nm motor because it's the closest motor that can lift our calculated load for that particular window height and width. Note: Always we need to go for smallest tube with lowest motor. Also it's the motor size needs to be filled in the table, Not load.

3. Similarly loop the code for all the cells. If the load is above either of the lifting capacities then don't fill the cell

6.2 Selection procedure

Having data collected a standard selection procedure was developed for Maestrosshield roll down interior shading. This is shown in Figure 29.

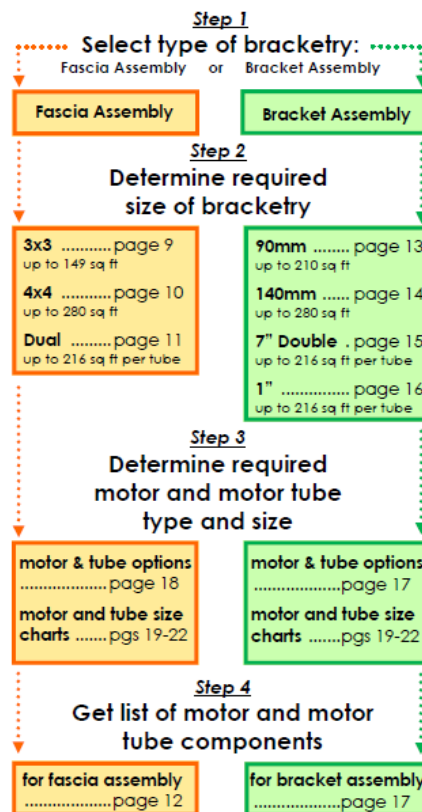


Figure 29: Selection procedure (Maestrosshield, 2011)

The process starts with selection of bracket system. Firstly customer needs to specify with what kind of product from interior shading product line they would like to use. After this, customer has to give size of the window, i.e the maximum sq.ft of the window. This is followed by motor and the tube selection. The motor, tube and window sizes all need to work together. The Motor selection chart is used for this purpose. Based on these selections the other parts that are compatible are selected from compatibility chart. The compatibility chart can be found under Appendix G. For more details the entire selection procedure can be downloaded on request from Maestrosshield website.

7 Redesign of Interior shading

Referring to action plan of chapter 5 (Section 5.1.9), only outcome of design changes are explained in this chapter. The background of each change is discussed briefly in the action plan. For the methods adopted for evolution of new concepts can be observed under annexure H, I, J & K. These changes were based on the action plan that was developed as a result of market analysis. The following are the design changes carried out

7.1 Development of 4x4 Connector fascia bracket

As explained in the action plan, This bracket is required if there is need to connect two or more shades with single motor or using two motors to operate shades independently . Thus a new connector bracket was developed for connecting shades together. The Figure 30 shows the installed position of connector bracket. The connector bracket is in the middle, which can connect two shades together with one fascia running throughout length.

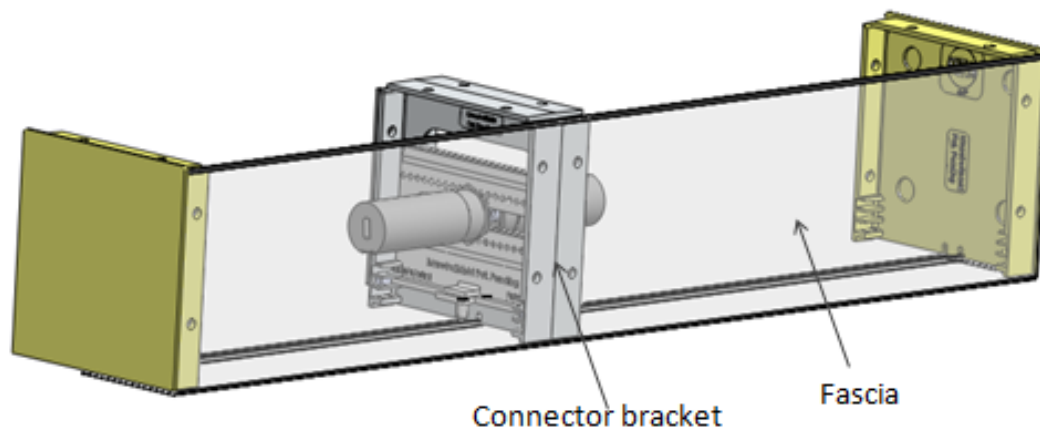


Figure 30: 4x4 Connector fascia bracket

7.2 Male and Female idler bearing with Housing screw

The present design with pin to transfer the torque between the shades is difficult to assemble during installation. The other disadvantage is that this design doesn't give dynamic light gap adjustment. Thus new design was made is shown in Figure 31. This has 2 parts Housing screw and Housing. Housing screw can move in and out of housing adjusting light gaps. Since it is screw design this allows dynamic control over light gaps. The spring loaded shaft inside comes very useful while installation. The shaft can be moved into housing and released into brackets with spring action during installation. This makes it easy for installation. This design demanded high level brainstorming session with designers and management. This design and related drawings were finalized with help of engineers of the case company.

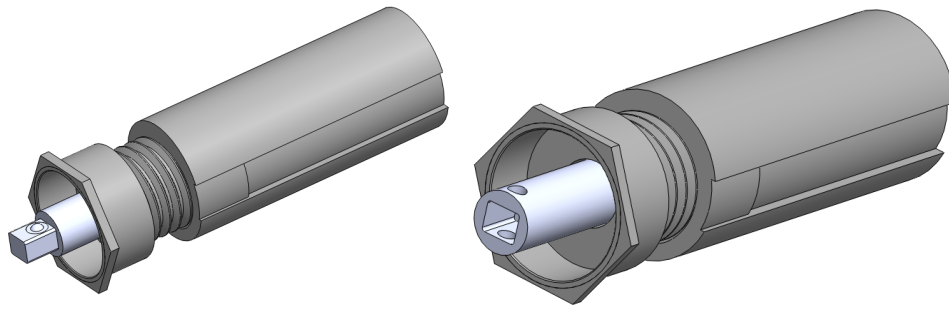


Figure 31: New Male & Female idler bearing

7.3 Connector Idler 0 to 90deg

Current design as explained under section 4.2.4 of chapter 4 uses universal joint which is expensive and doesn't allow light gap adjustment. This needed extensive brainstorming to find a new solution. The design methodology approach was followed. Initially requirement specifications were listed down. This is show in Appendix H. Later Morphological matrix was run to find solutions (Appendix I). The resulted concepts were processed through Pugh method to choose the best suitable solution (Appendix J). The chosen concept is shown in Figure 32 and assembly is show in Figure 33. It was also found that using this flexible shaft solution, 0-45deg can also be achieved by using only one flexible shaft. This shaft can move inside the bearing on the brackets thus light gaps can be adjusted. Using 0-45deg the light gap is reduced to 29.5mm and 0-90deg gives about 53mm. The initial design was having up to 100mm light gap.

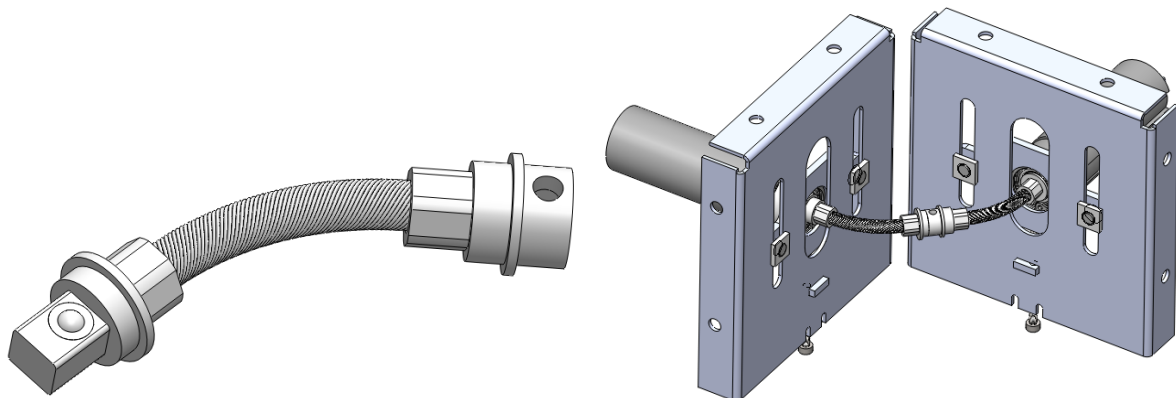


Figure32. Flexible shaft as universal to transfer torque Figure 33. Connector idler 0-90deg

7.4 Provide provision for Fascia on the 90mm bracket

Current bracket doesn't have provision to use fascia, but it will be an exciter need for customers, if we can achieve fascia for 90mm bracket. Also since there is delay in producing existing 3x3 single fascia bracket. This 90mm bracket with fascia can fill up this need. The figure 34 below shows 90mm bracket with fascia.

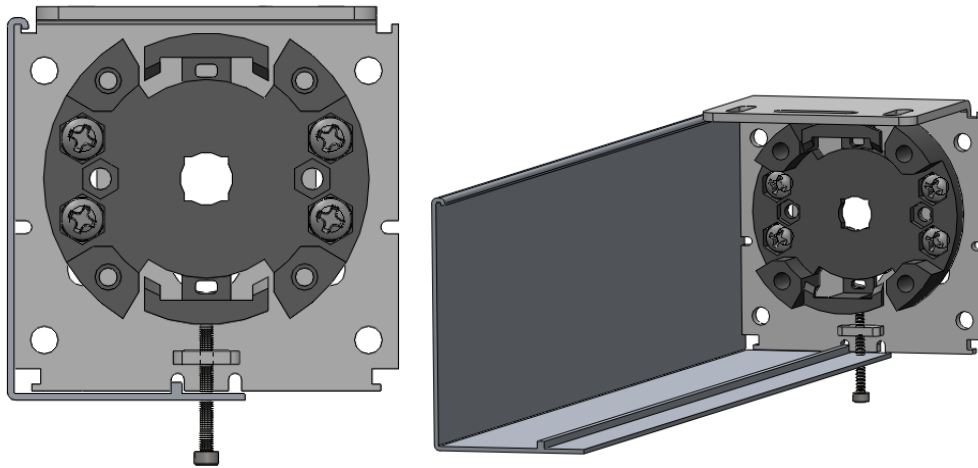


Figure 34: 90mm Bracket with fascia

7.5 Modification of Motor bracket

This activity was to keep modularized product structure and reduce inventory. This resulted in new design. This design consist plastic snap that is used when 3Nm & 6Nm AC& DC harmonic series motors are installed and when 0.7Nm Harmony DC, 1Nm Silent (Smart) series DC & 3 & 6Nm Smart series, AC are used snap is removed. The motor head of these motors are provided with screw that has special head. This customized screw head along with motor can be hooked onto the bracket hole. The bracket has U-shaped hole that can accommodate this screw. This makes assembly faster and easy. Below shown Figure 35 explains the concept. *This design needs to be validated with actual prototype testing. The life of this part is very important to study as the Figure 35 itself shows the cutouts are very close to each other. Thus there are chances of fatigue failure.*

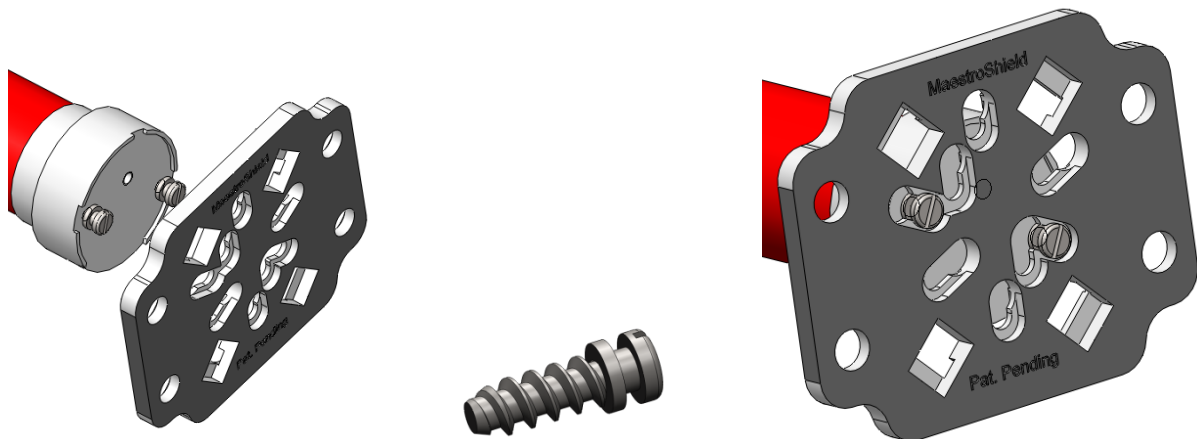


Figure 35: Modified motor bracket with customized screw

8 Prototyping & Testing

Prototyping and testing are very important phases of product development. This is the stage which ultimately proves the design. Rapid prototyping and samples manufacturing were the two methods followed for prototyping & testing.

Initially the plastic parts were made in Injection molding to make samples. This was found to be very expensive to carry out because the samples after testing can have revisions in design. This in turn revises the mould making this a costly procedure. Understanding the capability of rapid prototyping, samples were quickly produced using this technology. Certain questions regarding functionality can be answered through CAD models. So the parts that are necessary to be rapid prototyped were identified and produced.

Rapid Prototyping has its own limitations. The RP components are not always recommended for load testing. Due to these strength limitations of RP part, certain parts cannot be used for testing the working of product assembly. Some parts needed to be extruded & die casted parts. Forecasting revisions on the design after testing, to be on the safer side, the manufacturing processes were studied and tolerances for the parts were fixed in such a way that revision in parts could be easily adjusted in the manufacturing shops.

Parts that were prototyped are shown in Appendix K. Testing of these parts were conducted in Maestrosshield shop. Some of the tests include corrosion testing where the parts are dipped in salt water having 6% salt to check for any corrosion. Functionality tests are based on the function of the individual parts. Deflection test on tubes are measured by rolling fabric on the tube and measuring the deflection and also checking if there are any wrinkles when fabric is rolled down completely. Fitment of parts with each other is done manually by assembling the parts that goes with each other.

Since there are some more parts under prototyping stage, the complete product performance is yet to be measured. The individual components are tested for functionality now. It is also important for Maestrosshield to learn the life of the product and validate the materials selected for the components. A cycle test of the entire assembly must be carried out for this purpose.

9 Discussion

As explained in the purpose of this project work, to carry out detailed market analysis in order to identify and meet those basic needs of the customer that are yet to be implemented in the product, thus make the project successful in market.

Methodology:

It was realized in the beginning of project itself that, a structured development process needs to be followed to map all the requirements and redesign the product. In this context, the methodology followed in the project was to a great extent successful in meeting the purpose. As explained in the methodology, prior to start of this project there was prototype developed by Maestrosshield and this project is to improve this prototype. The methodology started all over again from market analysis through prototype testing.

Even though Maestrosshield had carried out market analysis, a structured development process as adopted in this project work, provided clarity of information and vision for future works. By following structured development process new opportunities were identified for Maestrosshield. One of them is selection procedure for motorized roll down interior shading was identified from this project. This was followed by other competitors as well. But the procedure developed in the project is has lots of calculations behind it and clear for sales and customers to follow. Efforts were made to make sure that the selection very optimized and customers need not pay more by providing over designed product.

Findings:

As per the analysis of results from the market analysis carried out, lots of improvements were identified. Since there is limitation in explaining all those points of improvements, one can refer appendix C and D for details. But if we point out few major changes that was brought to prototype after this project were

- To connect shaded together new concept of connector fascia bracket was introduced. This was one of the outcomes of market analysis; the competitors in interior shading business also have this connector bracket with them.
- Since the existing male and female idler bearing were not performing well, more efficient design was developed as referred to section 7.2 of chapter 7.
- Developed 0-90deg bracket which can be used for angle 0-90deg, where as existing product in the market can hold only less than 90deg. This was achieved by new concept as referred to section 7.3 of chapter 7. Product development methods like Morphological matrix and Pugh method helped in arriving at this concept.
- Regarding the product configuration as explained in chapter 4, decision was made to go with only bracket assembly not fascia assembly, because the fascia system is more expensive as it is made of die casting, where are bracket system is just sheet metal

forming. This decision is based on the market feedback that customers are looking for cheaper products.

Observations:

- There were time and resource constraints in completing the project. The time was only 6 months which included design changes and release of drawings and development of prototype. As well there was short time for releasing the product into market. But in this short span of time, the purpose of this project was met to great extent. The parts under action plan were changed and prototypes were made. But still the reliability of the assembly needs to be evaluated with real test. The plan would be to assemble parts together and run it for calculated cycles to check the performance and life of the product.
- For data collection, the interviews were conducted only with members of Maestrosshield, outside sales and only one fabricator. If there was opportunity to meet more fabricators and dealers, more insight would have been achieved into market requirements.
- Since there are lots of new products being introduced by Maestrosshield and also the products being modular traceability of parts with proper part numbering system is absolutely necessary. Efforts were made while during this project work to introduce such system in the company with running number maintained in an excel sheet. This is not covered in this project work but it's an opportunity for the company to adopt more clear system.
- The cost effectiveness of the changed designs needs to be evaluated as cost is very important factor for customers to choose product.
- This project went through all the phases of product development and faced the problems that are narrated in most of the literatures related to product development. As described in the literature survey about the obvious fact of product development, that as product development progress the knowledge about the product increases but the flexibility to change decreases. This was clearly seen during this project. The market analysis showed opportunities of progress that can be achieved in this product. But it was difficult to implement the changes as the product was almost at the stage of production. So only those changes that was in our scope to change without affecting the time of delivery and cost were taken.

10 Conclusion

Even though development of Interior shading had commenced in the year 2009, the critical part of the work was carried out in the last 6 months. Best efforts were put in this short span of time to satisfy the purpose and meet the objective of this project. Following are conclusions out of this work

- A structured development process was used to study the product and implement the critical changes to the prototypes. This process was supported by design methodologies for collecting information and decision making. Following this process helped in identifying lots of hidden requirements and concepts were developed effectively to meet the requirements of the customer. Maestroshield has been introduced with this process and recommended to further explore this process.
- Through extreme brainstorming sessions with all the departments and with right marketing strategy this task to create a competitive product was up to the mark. The outcome of this meeting is listed down in action plan of this project.
- The selection procedure made for motorized roll down shadings is effective and can avoid lots of confusions in selecting optimized product.
- All design changes including new concept development of connector fascia bracket, male and female idler bearings, connector Idler 0 to 90deg were completed on time. This was due to clear planning between management, engineering and purchase departments.
- Some of the prototypes like male and female idler bearing, bracket assembly are being tested with fabricators who are one of the customers. The prototypes and testing are showing confidence on the product both related to cost and functionality. Management is also receiving positive feedback from outside sales.

The measurement of success of this product can be estimated once the sales start. Thus it can be concluded that there are chances that the developed product may not perform as we intended to be. But having ability to react quickly to market response, with a right strategy and development process, success can be achieved.

11 Recommendations

Based on the experience of this project work, following recommendations are suggested to improve product and process.

- The development process followed in this project work can be said to be premature. And at a high level. But was effective compared with available time for this project work. There are more opportunities to complete this development process to micro level. Recommendation is to include gate review systems and define the inputs, outputs, checklists under each gate reviews that must be met to move to next gate level.
- Looking at the Maestrosshield product there are opportunities for improving the product. Even though bracket assembly configuration is currently chosen to go forward with production, recommend Maestrosshield to explore fascia assemblies also and make it cost effective. This fascia has lots of advantages compared to bracket assembly. Only target is to make this less expensive. There are many ways to do this. The product can be made even cheaper and functionally better by changes material, material thickness, changing manufacturing process etc. Value engineering is one such methodology that can be followed.
- The selection procedure explained in this project still needs manual effort for choosing optimized product. This can be automated which can save data processing time also making process more efficient. Going further automated software can be made online or stand alone license can be created and supplied to customers and dealers. This makes life easy for sales to interact with customers.
- As explained in discussion the developed interior shading product is highly modularized and parts are revised several times, traceability of these parts and its revisions are an issue now. The recommendation to Maestrosshield is to pass these parts and related file through automated systems like Product Lifecycle Management (PLM) and Product Data Management (PDM). These systems can handle these issues very effectively. This will help not only this project but also can migrate all other products of Maestrosshield into this system. These systems are globally accessible too.
- The parts that are prototyped needs to assemble together and test the reliability and life of this product. This is yet to be done. The performance of the product is very important to be tested. Currently only prototypes are just developed in prototyping materials. This has not been tested with actual material and assembled to check the fitment of all parts together.
- For students, recommendation will be that Maestrosshield has lots of other products related to shadings, above mentioned improvements can be adopted into those products as well. Also there are possibilities to improve this interior shading product with better aesthetics. Also develop other interior shading product lines.

Bibliography

1. Acmeda. (2011). *Acmeda*. Retrieved May 03, 2011, from www.acmeda.com: <http://www.acmeda.com/>
2. Businessballs.com. (2011). *PEST Market Analysis tool*. Retrieved August 24, 2011, from Businessballs.com: <http://www.businessballs.com/pestanalysisfreetemplate.htm>
3. Cooper, K.G. (2001). *Rapid Prototyping: Principles and applications*. Singapore: World Scientific Publishing Co. Pte. Ltd.
4. Erik Bjärkby & team. (2010). *Fuel tank bracket, Product Development project*. Gothenburg: Chalmers University of Technology.
5. HUNTERDOUGLAS. (03 May 2011). *HUNTERDOUGLAS*. Retrieved May 03, 2011, from www.hunterdouglas.com: <http://www.hunterdouglas.com/product-option.jsp?id=147>
6. Kano Model. (2012). *Kano Model*. Retrieved October 21, 2012, from kanomodel.com: <http://kanomodel.com/>
7. Karl T.Ulrich & Steven D.Eppinger. (2012). *Product Design & Development, 5th Edition*. McGraw Hill.
8. Karlsson, MA: Customer Segment Matrix. (2009). *Product Planning and Market Analysis, Lecture 23.11.2009*. Gothenburg: Chalmers University of Technology.
9. Karlsson, MA: Product development Strategies. (2009). *Product Planning and Market Analysis, Lecture 02.11.2009*. Gothenburg: Chalmers University of Technology.
10. Lars Almefelt: Concept Synthesis. (2009). *Introduction to Design Methodology, Lecture 24.11.2009*. Gothenburg: Chalmers University of Technology.
11. Lars Almefelt: The Product Development Process. (2009). *Introduction to Design Methodology, Lecture 27.10.2009*. Gothenburg: Chalmers University of Technology.
12. Lars Trygg: Pugh Concept Selection. (2009). *Product Development Management, Lecture 05.10.2009*. Chalmers University of Technology: Gothenburg.
13. Lean Directions. (2011, August 24). *Product Modularity, The e-newsletter of Lean Manufacturing*. Retrieved August 24, 2011, from [sme.org](http://www.sme.org/cgi-bin/get-newsletter.pl?LEAN&20060509&3&): <http://www.sme.org/cgi-bin/get-newsletter.pl?LEAN&20060509&3&>

14. Lutron Electronics Co. (2011, May 03). *Grafik Eye QS*. Retrieved May 02, 2011, from lutron.com:
<http://www.lutron.com/Products/SingleRoomControls/GrafikEyeQS/Pages/Overview.aspx>
15. Lutron. (2010). *Lutron*. Retrieved May 03, 2011, from Lutron Product guide: Lutron.com
16. Maestrosshield. (2011). *maestrosshield.com*. Retrieved July 15, 2011, from maestrosshield.com: www.maestrosshield.com
17. MITJAVILA. (2011). *Mitjavila*. Retrieved May 03, 2011, from www.mitjavila.com:
<http://www.mitjavila.com/>
18. Rollease. (2011). *Rollease*. Retrieved May 03, 2011, from www.rollease.com:
<http://www.rollease.com>
19. *Saturn Resource Management*. (2011). Retrieved June 23, 2011, from srmi.biz:
http://srmi.biz/page/resources/tips/low-cost-cooling/interior-shades?/Tips.Low_Cost_Cooling.Interior_shades.htm
20. Steven C. Wheelwright & Kim B. Clark. (1992). *Revolutionizing Product Development*. Free Press.
21. Window Blind Ratings. (2011). *Window Blind Ratings*. Retrieved June 23, 2011, from windowblindratings.com: <http://windowblindratings.com/cellular-shades.php>
22. ZMC. (2011). *ZMC*. Retrieved May 03, 2011, from [zmc.ca](http://www.zmc.ca): <http://www.zmc.ca/>

Appendix A: PEST Analysis Template

PEST analysis (political, economical, social, and technological) assesses a market, including competitors, from the standpoint of a particular proposition or a business.

criteria examples ecological/environmental current legislation future legislation international legislation regulatory bodies and processes government policies government term and change trading policies funding, grants and initiatives home market pressure-groups international pressure-groups wars and conflicts	political	economical	criteria examples home economy economy trends overseas economies general taxation taxation specific to product/services seasonality issues market/trade cycles specific industry factors market routes trends distribution trends customer/end-user drivers interest/ exchange rates international trade and monetary issues
criteria examples lifestyle trends demographics consumer attitudes and opinions media views law changes affecting social factors brand, company, technology image consumer buying patterns fashion and role models major events and influences buying access and trends ethnic/religious factors advertising and publicity ethical issues	social	technological	criteria examples competing technology development research funding associated/dependent technologies replacement technology/solutions maturity of technology manufacturing maturity and capacity information and communications consumer buying mechanisms/technology technology legislation innovation potential technology access, licencing, patents intellectual property issues global communications

(Businessballs.com, 2011)

Appendix B: Customer segment matrix template

Customer Segment Matrix			
Stakeholders	Characteristics		
	purchase decision	use experience
a ...	L	H	H
b...	L	L	L
c...	H	L	L
d...	H	H	H

©M A Karlsson

Customer segment matrix (Karlsson, MA: Customer Segment Matrix, 2009)

Appendix C: Product Comparison

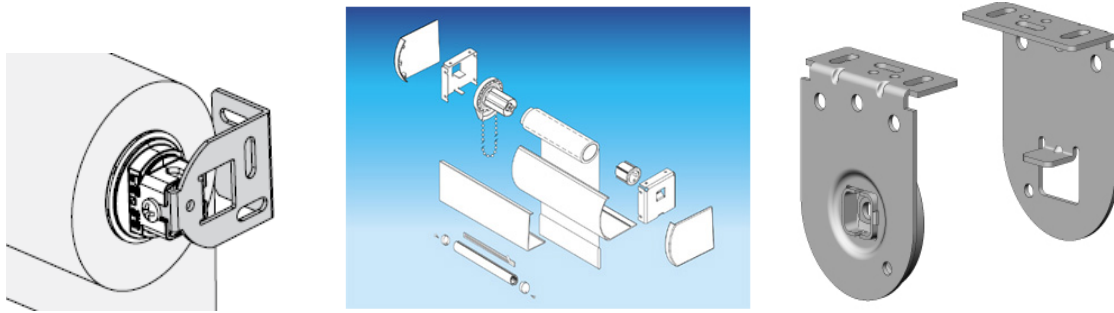
a) 4x4 Single Fascia Bracket

Part no:	Description	Advantages	Disadvantages	Selling package
IS1501	Fascia bracket 4x4	<ol style="list-style-type: none"> 1. Vertical & Horizontal adjustment 2. Snap for Fascia bracket 3. Provides Entry guide support 4. Can be used Left and Right ends 5. Covers end of interior shading 6. Can be mounted on wall or ceiling 7. Looks strong 8. Color: White, Brown, Anodized, Black and Mill finish 9. Warranty powder coating: 1 year 	<ol style="list-style-type: none"> 1. Need spacer to flush with wall or ceiling 2. Difficult to access motor bracket & Adjustment plate horizontal adjustment screws in assembly 3. Heavy 4. Expensive 5. Need bracket for harmonic series 0.7Nm & 1Nm motors 	<ol style="list-style-type: none"> 1. Left and right Fascia 2. Adjustment plate pair 3. Adjustment Stop bar pair 4. Idler brackets 5. Motor bracket

Competitor's product Similar to 3x3 & 4x4 Single Fascia Brackets



ZMC: (ZMC, 2011)



LUTRON: (Lutron, 2010) **ROLLEASE:** (Rollease, 2011) **ACMEDA:** (Acmeda, 2011)

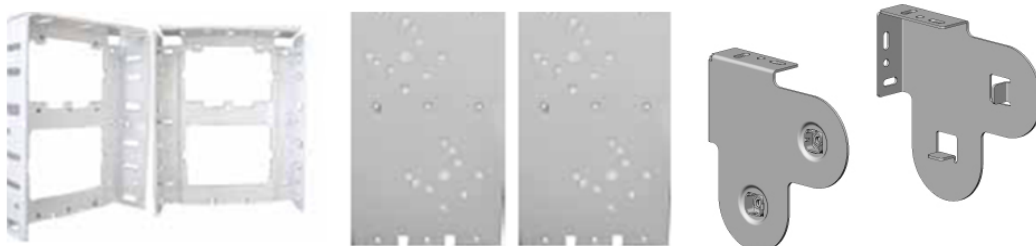
Opportunities for Maestrosshield

1. Make in sheet metal to reduce cost and light weight.
2. Design new sliding plate with predrilled holes to adapt to Somphy motors
3. Idler plate with ball joint
3. Colors: Bronze and Alabaster

b) Dual Fascia Bracket

Part no:	Description	Advantages	Disadvantages	Selling package
IS1502	Fascia bracket Dual	1. Vertical & Horizontal adjustment 2. Snap for Fascia bracket 3. Provides Entry guide support 4. Can be used Left and Right ends 5. Covers end of interior shading 6. Can be mounted on wall or ceiling 7. Looks strong 8. Color: White, Brown, Anodized, Black and Mill finish	1. Need spacer to flush with wall or ceiling 2. Difficult to access motor bracket & Adjustment plate in assembly 3. Heavy 4. Expensive 5. Need bracket for harmonic series 0.7Nm & 1Nm motors 6. Need bracket for harmonic series 0.7Nm & 1Nm motors	1. Left and right Fascia 2. Adjustment plate pair 3. Adjustment Stop bar pair 4. Idler brackets 5. Motor bracket

Competitor's product Similar to Dual Fascia Brackets



ZMC: (ZMC, 2011)

ACMEDA: (Acmeda, 2011)

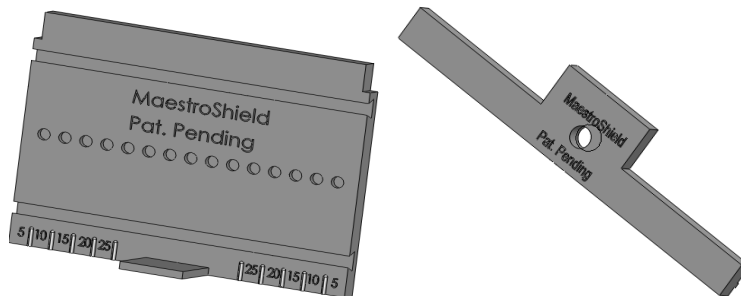
Opportunities for MaestroShield

1. Make in sheet metal to reduce cost and light weight.
2. Design new sliding plate with predrilled holes to adapt to somphy motors
3. Colors: Bronze and Alabaster

c) Triple Fascia Bracket

Part no:	Description	Advantages	Disadvantages	Selling package
IS1501	Fascia bracket Tripple	1. Vertical & Horizontal adjustment 2. Snap for Fascia bracket 3. Provides Entry guide support 4. Can be used Left and Right ends 5. Covers end of interior shading 6. Can be mounted on wall or ceiling 7. Looks strong 8. Color: White, Brown, Anodized, Black and Mill finish 9. Warranty powder coating: 1 year 10. New in market	1. Need spacer to flush with wall or ceiling 2. Difficult to access motor bracket & Adjustment plate 3. Heavy 4. Expensive 5. Need bracket for harmonic series 0.7Nm & 1Nm motors	1. Left and right Fascia pair 2. Adjustment plate pair 3. Adjustment Stop bar pair 4. Idler brackets 5. Motor bracket

d) Adjustment plate & Adjustment stop bar for Fascia assembly



Part no:	Description	Advantages	Disadvantages	Selling package
	Adjustment plate for Fascia bracket	1. Easy to slide horizontally 2. Easy to assemble on the fascia		
	Adjustment Stop bar for Fascia bracket	1. Easy to assemble on the fascia	1. Needs to be die casted because of the locking stop provided on the stop bar	

e) 3x3 Snap on motor bracket for Fascia assembly & Bracket Assembly



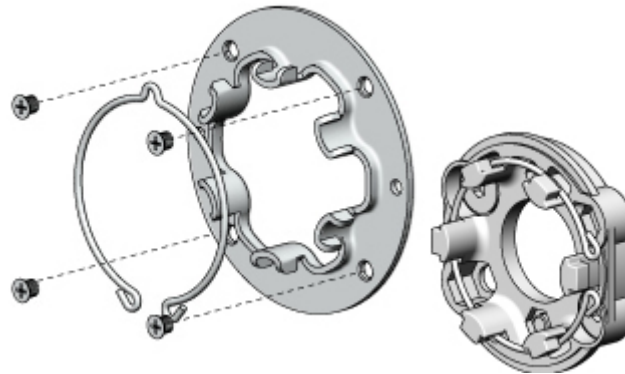
Part no:	Description	Advantages	Disadvantages	Selling package
IS1019	3x3 Snap on motor bracket	1. Easy snap function for motors 2. Compatible with 0.7Nm-0.8Nm DC motors 3. Easy to assemble on the fascia	1. Difficult to access horizontal adjustment screw in assembly 2. Can not be used with harmonic series 0.7Nm & 1Nm motors	

f) Snap on motor bracket for Fascia Assembly & Bracket assembly- Silent motors



Part no:	Description	Advantages	Disadvantages	Selling package
IS1018	Snap on motor bracket for Silent series	1. Easy snap function for motors 2. Compatible with Silent series motors	1. Mounting screws are difficult to access	

Competitor's product Similar to Motor Brackets



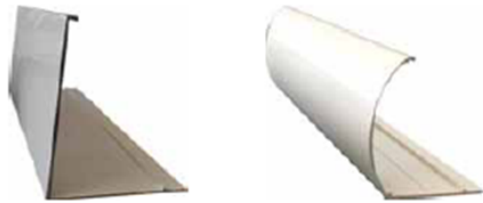
ACMEDA: (Acmeda, 2011)

g) Fascia

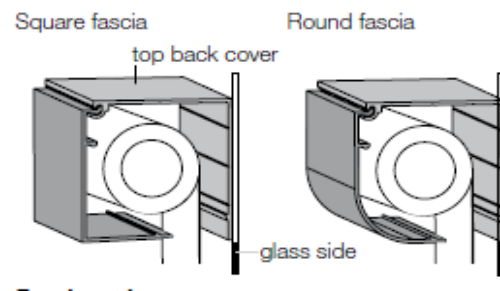


Part no:	Description	Advantages	Disadvantages	Selling package
IS-H131 IS-H101 IS-H102 IS-H103	Fascia 3x3 4x4 Dual Triple	1. Easy to assemble 2. Extruded 3. Available in Mill and powder coating 4. Sold in 21 foot length 5. Warranty powder coating: 1 year 6. Color: White, Brown, Anodized, Black and Mill finish 7. No need to use <u>platic</u> end caps for fascia bracket	1. Dual & Triple fascia needs to be split into 2 from front because of the limitation of die size	

Competitor's product Similar to Fascia



ZMC: (ZMC, 2011)

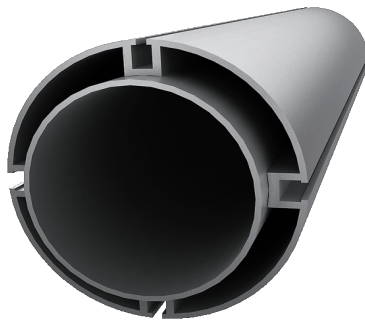


LUTRON: (Lutron, 2010)

Opportunities for Maestrosshield

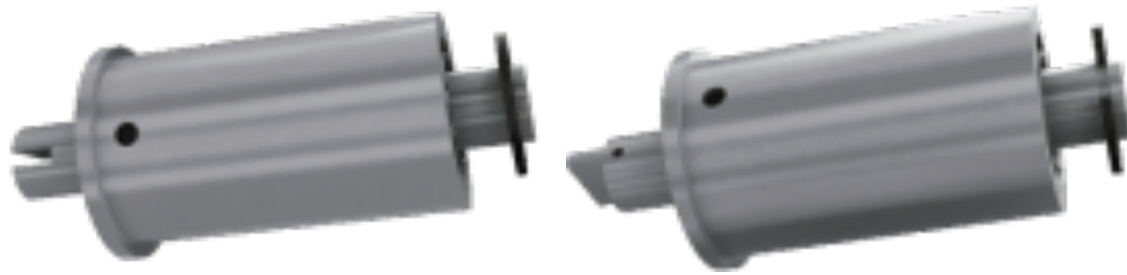
1. Use of round fascia for aesthetics
2. Colors: Bronze and Alabaster

h) Tube 2.7"



Part no:	Description	Advantages	Disadvantages	Selling package
IS 1525	Motor Tube 2.7" (68.6MM)	<ol style="list-style-type: none"> 1. Used for complete blackout 2. Zipper goes along the roll size at the ends when rolled up 3. Fabric can be attached to tube by zipper or Rubber 	<ol style="list-style-type: none"> 1. Large in size 	

i) Male & Female Idler bearing With Connector

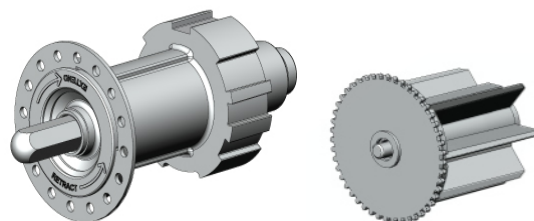


Part no:	Description	Advantages	Disadvantages	Selling package
IS1006M	Idler bearing with Male connector	<ol style="list-style-type: none"> 1. Axial Adjustment with 4 different lock positions to reduce light gaps 2. Used to transfer of torque with female connector 3. Can be used with 1.25", 1.5" and 2" Tubes. 4. Use same shaft size for different application 	<ol style="list-style-type: none"> 1. Difficult to adjust the axial position with pin during installation 2. Axle is 10mm in dia where as the market identifies with axle size and has 12mm axle connectors 3. Fitment of male and female connector is loose 4. The tongue extension is small, needs to be long for better engagement 	
IS1006F	Idler bearing with Female connector	<ol style="list-style-type: none"> 1. Axial Adjustment with 4 different lock positions to reduce light gaps 2. Used to transfer of torque with female connector 3. Can be used with 1.25", 1.5" and 2" Tubes. 4. Use same shaft size for different application 	<ol style="list-style-type: none"> 1. Difficult to adjust the axial position with pin during installation 2. Axle is 10mm in dia where as the market identifies with axle size and has 12mm axle connectors 3. Fitment of male and female connector is loose 	

Competitor's product Similar to Male & Female Idler bearing



ZMC: (ZMC, 2011)



ACMEDA: (Acmeda, 2011)

j) Idler inserts 1.5" & 2" tubes



Part no:	Description	Advantages	Disadvantages	Selling package
IS1016	1.5" Idler Insert	1. Goes with 3 different 1.5" profiled tubes and male & female idler bearing 2. Saves inventory and cost 3. Used with common tubes available in market		
IS1017	2" Idler Insert	1. Goes with 3 different 2" profiled tubes and male & female idler bearing 2. Saves inventory and cost 3. Used with common tubes available in market		

k) Single bracket 90 & 140 Bracket assembly



Part no:	Description	Advantages	Disadvantages	Selling package
IS1007 IS1008	90mm & 140mm Single Bracket	1. Used with snap on bracket for Silent series and harmonic series motors 2. Looks strong 3. Color: white 4. Easy to snap motor	1. Bracket vertical movement is difficult because the screw is difficult to access with bracket 2. Aluminum extrusion	1. Pair-Ball bearing Idler and motor bracket 2. Adjustment plate and adjustment bars

Competitor's product Similar 90 & 140 Bracket assembly



ZMC: (ZMC, 2011)



ACMEDA: (Acmeda, 2011)

I) 7" Double bracket assembly



Part no:	Description	Advantages	Disadvantages	Selling package
IS1028	7" Double Bracket	1. Used with snap on bracket for Silent series and harmonic series motors 2. Can use double rolls 3. Looks strong 4. Color: white 5. Use Less space in width	1. Bracket vertical movement is difficult because the screw is difficult to access with bracket 2. Aluminum extrusion	1. Pair-Ball bearing Idler and motor bracket 2. Adjustment plate and adjustment bars

Competitor's product similar to 7" Double Bracket assembly



ZMC: (ZMC, 2011)



ACMEDA: (Acmeda, 2011)

m) Connector bracket 90, 140 & 7" Double Bracket assembly



Part no:	Description	Advantages	Disadvantages	Selling package
IS1020 IS1030 IS1022	90mm, 140mm & 7" Double Connector	1. Couple two windows 2. Vertical adjustment of mm 3. Color: white	1. Ball bearing is not press fit so creates noise 2. Aluminum extrusion	1. Idler bearing -2 2. Ball bearing Idler 3. Screws

Opportunities for Maestrosshield

1. Use of sheet metal to reduce cost
2. Providing simple tools
3. Zinc plated for cheaper corrosion protection

n) Connector idler 0-90deg



Part no:	Description	Advantages	Disadvantages	Selling package
IS1005	Connector Idler	1. Used to transfer torque 2. Used from 0 to 90deg. window locations 3. Graduated scale to read the angle 4. Can be used with Fascia 5. Size is 4.33x4.33" 6. Sheet metal	1. Mounting holes needs to be adjustable pattern 2. Non adjustable with vertical movement 3. Not suitable to curved windows	1. Idler bearing -2 2. Brackets 3. Universal 0-90deg

Competitor's product similar to Connector idler 0-90deg

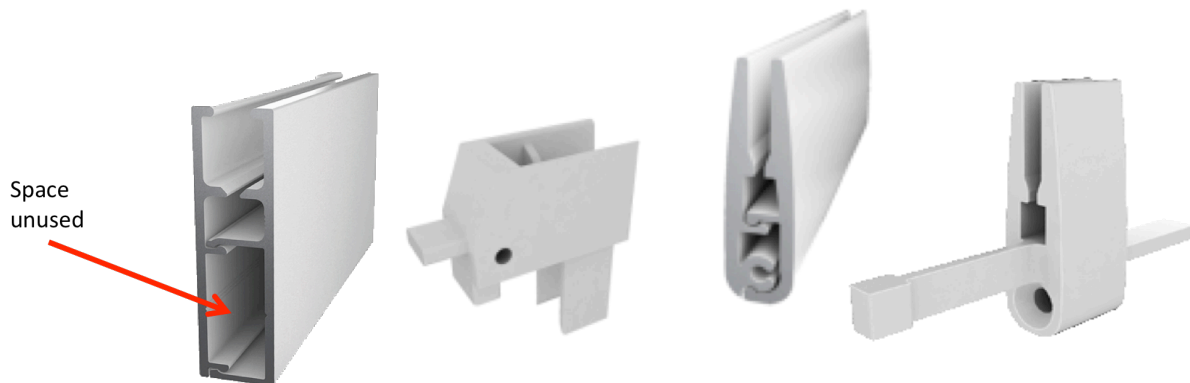


ZMC: (ZMC, 2011)



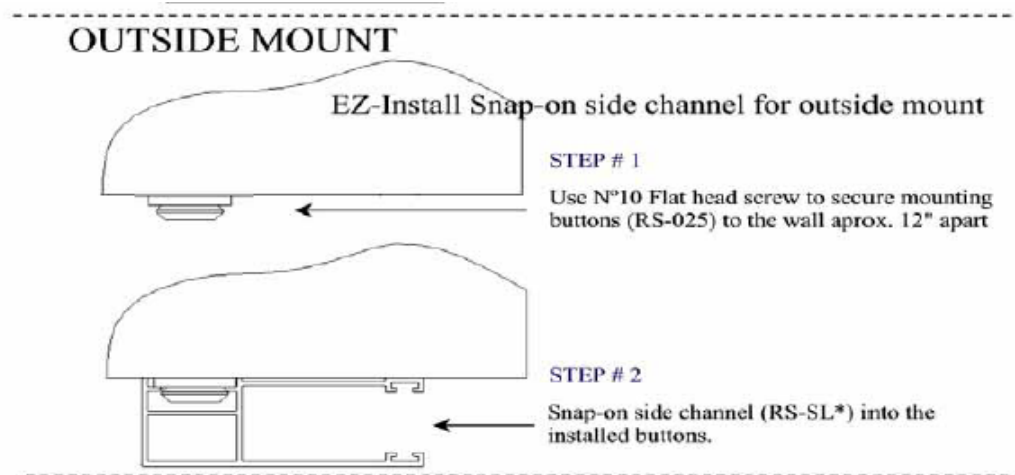
LUTRON: (Lutron, 2010)

o) Blackout

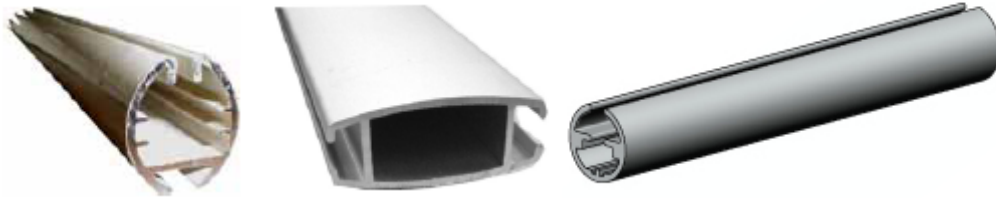


Part no:	Description	Advantages	Disadvantages	Selling package
IS1550	Blackout track	1. Side mounted and wall mounted 2. Snap fit and no need of buttons 3. Color: White, Bronze, Anodized, Black & Mill finish 4. Slim,		Sold in 21 feet
IS1551	Entry guide	1. Used both and left and right 2. Used with double roll 3. Zipper guide 4. Color : White	1. Need to cut the round stem off while using left and right sides	
IS1555	Bottom bar	1. Snap lock 2. Used with or with out track 3. Weight bar can be added 4. Color: White, Bronze, Anodized, Black & Mill finish		Sold in 21 feet
IS1552	Bottom bar end cap	1. Used with side track 2. Follow zipper guide 3. Color : White		

Similar Competitor's product



ZMC: (ZMC, 2011)

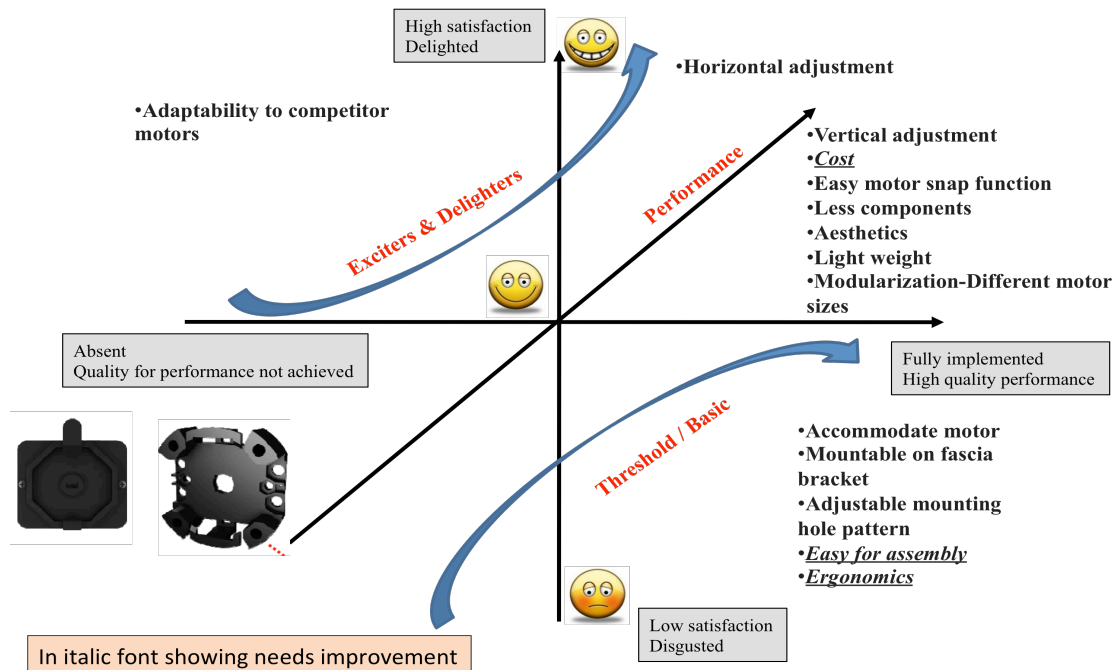


ZMC: (ZMC, 2011)

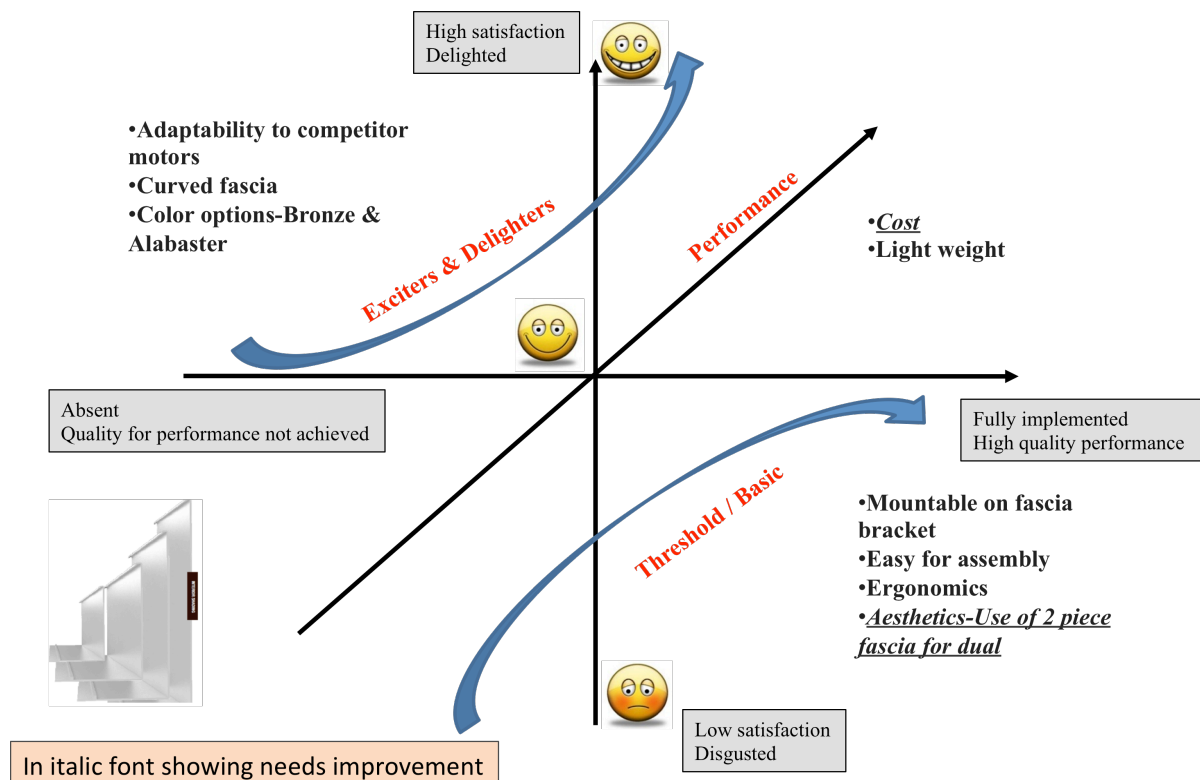
ACMEDA: (Acmeda, 2011)

Appendix D: Data Analysis

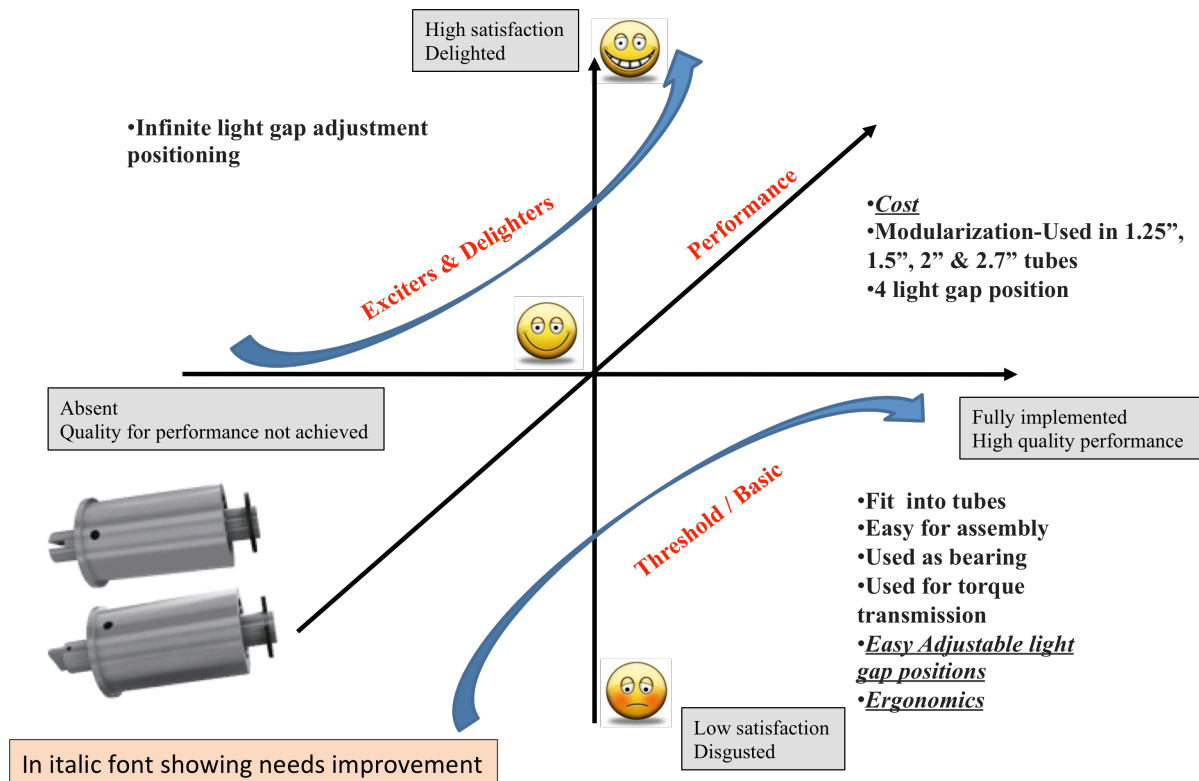
Motor Brackets – Fascia & Bracket assemblies



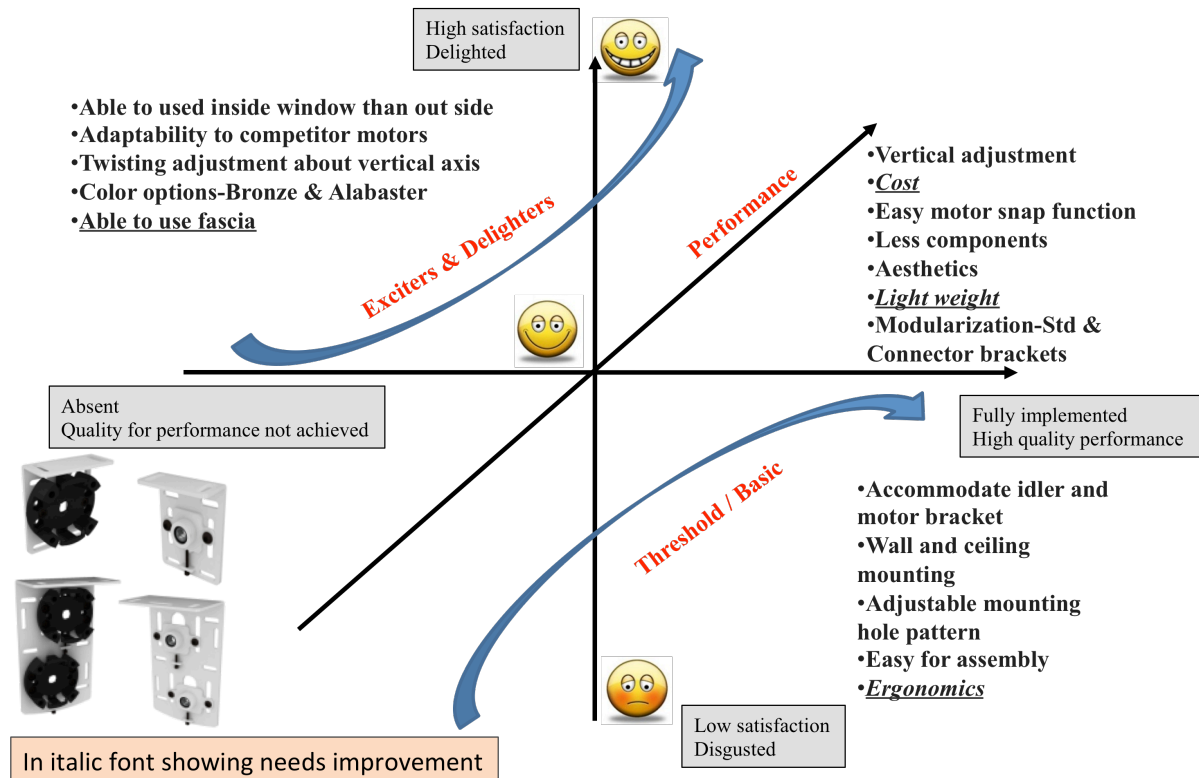
Fascia-3x3, 4x4, Dual



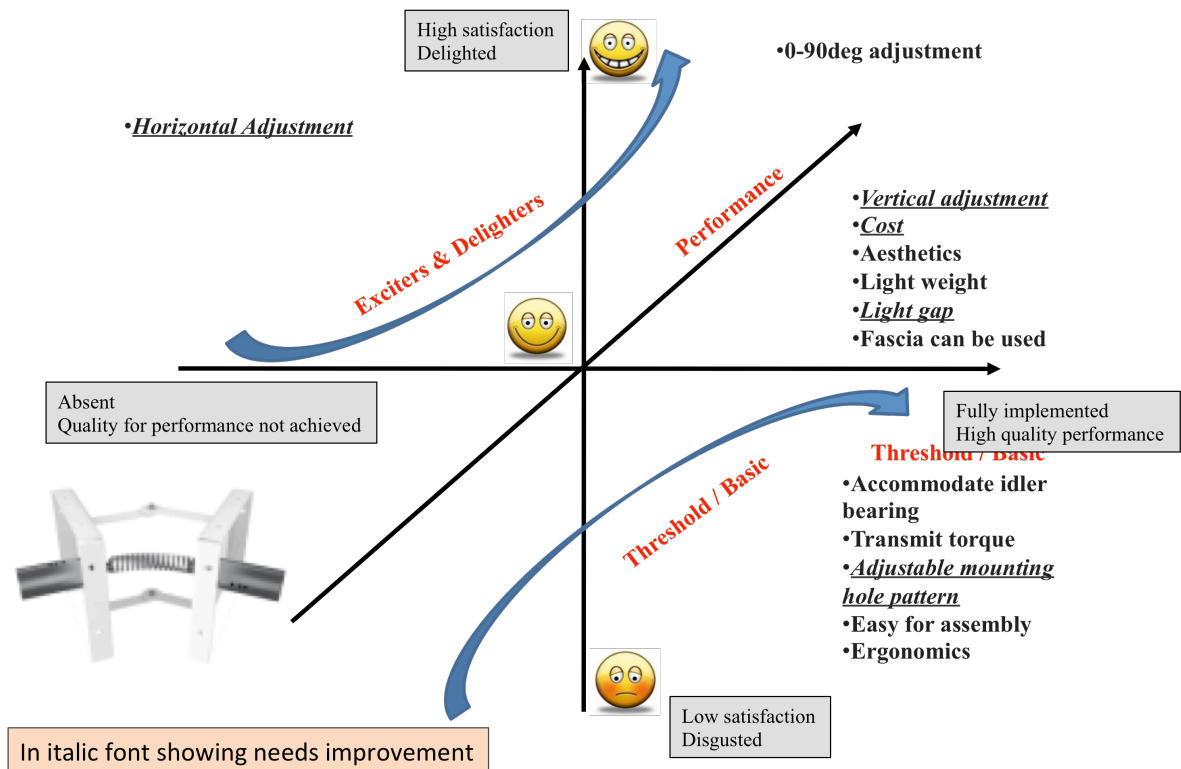
Idler Bearing-Male & Female



Standard Brackets & Connector bracket



Connector Idler 0-90deg



Appendix E: Square footage-Height & Width Chart

SQUARE FOOTAGE-HEIGHT & WIDTH CHART						Deflection (mm) at intermediate widths (ft)				
Tube	Application	Motor (Nm)	Lifting capacity (lbs)	Area (ft2)	Max Height (ft)	10.07 lbs				
1"	3x3 Facia Assembly	0.7	7.05	37.10589444	16.5	0.047	0.41	1.5	6	
		1	10.07	53.00842063	16.5					
	4x4 Facia Assembly	0.7	7.05	37.10589444	32.5					
		1	10.07	53.00842063	32.5					
	Dual Facia Assembly	0.7	7.05	37.10589444	25.5					
		1	10.07	53.00842063	25.5					
	90mm Single Bracket Assembly	0.7	7.05	37.10589444	22					
		1	10.07	53.00842063	22					
	90mm Single Bracket With Fascia	0.7	7.05	37.10589444	18					
		1	10.07	53.00842063	18					
	140mm Single Bracket Assembly	0.7	7.05	37.10589444	29.5					
		1	10.07	53.00842063	29.5					
	7" Double Bracket Assembly	0.7	7.05	37.10589444	22.5					
		1	10.07	53.00842063	22.5					
	1" Bracket Assembly	0.7	7.05	37.10589444	20.5					
		1	10.07	53.00842063	20.5					
1.25"	3x3 Facia Assembly	0.7	7.42	39.03423226	16.5	0.064	0.52	1.84	5.96	
		1	10.60	55.76318894	16.5					
	4x4 Facia Assembly	0.7	7.42	39.03423226	32.5					
		1	10.60	55.76318894	32.5					
	Dual Facia Assembly	0.7	7.42	39.03423226	26					
		1	10.60	55.76318894	26					
	90mm Single Bracket Assembly	0.7	7.42	39.03423226	22.5					
		1	10.60	55.76318894	22.5					
	90mm Single Bracket With Fascia	0.7	7.42	39.03423226	18.5					
		1	10.60	55.76318894	18.5					
	140mm Single Bracket Assembly	0.7	7.42	39.03423226	30					
		1	10.60	55.76318894	30					
	7" Double Bracket Assembly	0.7	7.42	39.03423226	23					
		1	10.60	55.76318894	23					
	1" Bracket Assembly	0.7	7.42	39.03423226	21					
		1	10.60	55.76318894	21					
1.5"	3x3 Facia Assembly	0.7	5.96	31.37561707	14.5	51.10 lbs				
		1	8.52	44.8223101	14.5	3	6	9		
		3	25.55	134.4669303	14.5					
		6	51.10	268.9338606	14.5					
	4x4 Facia Assembly	0.7	5.96	31.37561707	30.5					
		1	8.52	44.8223101	30.5					
		3	25.55	134.4669303	30.5					
		6	51.10	268.9338606	30.5					
	Dual Facia Assembly	0.7	5.96	31.37561707	24	0.23	1.84	6.25		
		1	8.52	44.8223101	24					
		3	25.55	134.4669303	24					
		6	51.10	268.9338606	24					
	90mm Single Bracket Assembly	0.7	5.96	31.37561707	20					
		1	8.52	44.8223101	20					
		3	25.55	134.4669303	20					
		6	51.10	268.9338606	20					
	90mm Single Bracket With Fascia	0.7	5.96	31.37561707	17					
		1	8.52	44.8223101	17					
		3	25.55	134.4669303	17					
		6	51.10	268.9338606	17					
	140mm Single Bracket Assembly	0.7	5.96	31.37561707	28					
		1	8.52	44.8223101	28					
		3	25.55	134.4669303	28					
		6	51.10	268.9338606	28					
	7" Double Bracket Assembly	0.7	5.96	31.37561707	21					
		1	8.52	44.8223101	21					
		3	25.55	134.4669303	21					
		6	51.10	268.9338606	21					
	2"	3x3 Facia Assembly	3	19.98	105.1771039	11.5	40 lbs			
			6	39.97	210.3542078	11.5	3	6	9	13
			8	53.29	280.4722771	11.5				
		4x4 Facia Assembly	3	19.98	105.1771039	27.5				
			6	39.97	210.3542078	27.5				
			8	53.29	280.4722771	27.5				
		Dual Facia Assembly	3	19.98	105.1771039	21				
			6	39.97	210.3542078	21				
			8	53.29	280.4722771	21				
		90mm Single Bracket Assembly	3	19.98	105.1771039	17				
			6	39.97	210.3542078	17				
			8	53.29	280.4722771	17				
90mm Single Bracket With Fascia		3	19.98	105.1771039	13.5					
		6	39.97	210.3542078	13.5					
		8	53.29	280.4722771	13.5					
140mm Single Bracket Assembly		3	19.98	105.1771039	25					
	6	39.97	210.3542078	25						
	8	53.29	280.4722771	25						
7" Double Bracket Assembly	3	19.98	105.1771039	18						
	6	39.97	210.3542078	18						
	8	53.29	280.4722771	18						

2.7"	4x4 Facia Assembly	3	14.71	77.42629369	20.5	29.5 lbs			
		6	29.42	154.8525874	20.5	4	8	12	17.5
		8	39.23	206.4701165	20.5				
	Dual Facia Assembly	3	14.71	77.42629369	13.5	0.0508	0.8396	2.4572	6.034675
		6	29.42	154.8525874	13.5				
		8	39.23	206.4701165	13.5				
	140mm Single Bracket Assembly	3	14.71	77.42629369	18				
		6	29.42	154.8525874	18				
		8	39.23	206.4701165	18				
	7" Double Bracket Assembly	3	14.71	77.42629369	10.5				
		6	29.42	154.8525874	10.5				
		8	39.23	206.4701165	10.5				

Appendix F: Motor selection chart

Window Width and Height Configurations and Required Motor Size (Nm) for 1" Motor Tube

Motor requirements based on fabric thickness of 0.03" weighing 0.19 lbs per sq ft. Adjust for heavier fabric.

Width

Feet			1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Inches			12	18	24	30	36	42	48	54	60	66	72	78	84
Feet	Inches	mm	305	457	610	762	914	1067	1219	1372	1524	1676	1829	1981	2134
1	12	305	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
1.5	18	457	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
2	24	610	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
2.5	30	762	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1
3	36	914	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1
3.5	42	1067	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1	1
4	48	1219	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1	1	1
4.5	54	1372	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1		
5	60	1524	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1	1		
5.5	66	1676	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1	1			
6	72	1829	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1				
6.5	78	1981	0.7	0.7	0.7	0.7	0.7	1	1	1					
7	84	2134	0.7	0.7	0.7	0.7	0.7	1	1	1					
7.5	90	2286	0.7	0.7	0.7	0.7	0.7	1	1						
8	96	2438	0.7	0.7	0.7	0.7	1	1	1						
8.5	102	2591	0.7	0.7	0.7	0.7	1	1	1						
9	108	2743	0.7	0.7	0.7	0.7	1	1							
9.5	114	2896	0.7	0.7	0.7	0.7	1	1							
10	120	3048	0.7	0.7	0.7	1	1	1							
10.5	126	3200	0.7	0.7	0.7	1	1								
11	132	3353	0.7	0.7	0.7	1	1								
11.5	138	3505	0.7	0.7	0.7	1	1								
12	144	3658	0.7	0.7	0.7	1	1								
12.5	150	3810	0.7	0.7	0.7	1									
13	156	3962	0.7	0.7	1	1									
13.5	162	4115	0.7	0.7	1	1									
14	168	4267	0.7	0.7	1	1									
14.5	174	4420	0.7	0.7	1	1									
15	180	4572	0.7	0.7	1										
15.5	186	4724	0.7	0.7	1										
16	192	4877	0.7	0.7	1										
16.5	198	5029	0.7	0.7	1										
17	204	5182	0.7	0.7	1										
17.5	210	5334	0.7	0.7	1										
18	216	5486	0.7	1	1										
18.5	222	5639	0.7	1	1										
19	228	5791	0.7	1	1										

Note: For 7" width or less, deflection is less than or equal to 0.6mm for 0.7 and 1 Nm motors

Max. Height for 3x3 Fascia Assembly

Max. Height for 90mm Bracket Assembly with Fascia

Max. Height for 4x4 and Dual Bracket Assembly;
and 1", 90mm w/o fascia, 140mm, and 7" Double Bracket Assembly

(Maestroshield, 2011)

Motor requirements based on fabric thickness of 0.03" weighing 0.19 lbs per sq ft. Adjust for heavier fabric.

Max width per motor size for deflection of less than or equal to 6mm=3

Max. Height For 4x8 Pallet Assembly

66

Motor requirements based on fabric thickness of 0.03" weighing 0.19 lbs per sq ft. Adjust for heavier fabric.

[illegible]

Window Width and Height Configurations and Required Motor Size (Nm) for 2.7" Motor Tube

Motor requirements based on fabric thickness of 0.03" weighing 0.19 lbs per sq ft. Adjust for heavier fabric.

Note: Widths are in inches. See the definition of load factor in the table below.

Width

Note: All widths are in inches.

Feet	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14
Feet	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168
Widths	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264
1	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168
1.5	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174
2	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180
2.5	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186
3	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192
3.5	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198
4	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204
4.5	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210
5	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216
5.5	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222
6	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228
6.5	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234
7	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240
7.5	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246
8	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252
8.5	102	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258
9	108	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264
9.5	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270
10	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276
10.5	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282
11	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288
11.5	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294
12	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300
12.5	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306
13	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312
13.5	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318
14	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324
14.5	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330
15	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336
15.5	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342
16	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348
16.5	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348	354
17	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348	354	360
17.5	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348	354	360	366
18	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348	354	360	366	372
18.5	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348	354	360	366	372	378
19	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348	354	360	366	372	378	384
19.5	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348	354	360	366	372	378	384	390
20	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348	354	360	366	372	378	384	390	396
20.5	246	252	258	264	270	276	282	288	294	300	306	312	318	324	330	336	342	348	354	360	366	372	378	384	390	396	402

Note: Widths for 144-inch Driveway Assembly only (inches)

Note: Widths for 144-inch Driveway Assembly only (inches)

Note: All widths are in inches.

Appendix G: Compatibility chart

Compatible chart
for crown, drive gear, idler bearings, motor plate and idler plate
with MaestroShield Fascia Assemblies

Motor Tube	Motor	Item #	Crown	Drive Gear	Idler Bearing	Idler Insert	Motor Bracket	Idler Bracket
1" Round	0.7 Nm Harmony 12V DC	TMDC-7W/12V	Included w/ motor	Included w/ motor	IS1006F	Not Needed	IS1019	IS1519
	1 Nm Silent 24V DC	SSWR01/30	TMUS-SC458	TMUS-SG472	IS1006F	Not Needed	IS1019	IS1519
1.5" Round	0.7 Nm Harmony 12V DC	TMDC-7W/12V	TMUS-C241	TMUS-G265	IS1006F	IS1016	IS1019	IS1519
	3 Nm Harmony 12V DC	TMDC-3W/12V	Not Needed	TMUS35-35RG	IS1006F	IS1016	IS1019 (with MMS)	IS1519
	6 Nm Harmony 12V DC or 120V AC	TMDC-6W/12V-24 (DC motor) TMUS355-06/33 (AC motor)	Not Needed	TMUS35-35RG	IS1006F	IS1016	IS1019 (with MMS)	IS1519
1.5" Rollease	0.7 Nm Harmony 12V DC	TMDC-7W/12V	TMUS-C241	TMUS-G265	IS1006F	IS1016	IS1019	IS1519
	1 Nm Silent 24V DC	SSWR01/30	TMUS-SC1170	TMUS-SG1171	IS1006F	IS1016	IS1019	IS1519
2" Round	3 Nm Harmony 12V DC	TMDC-3W/12V	TMUS35-46.5RC	TMUS45-46.5RG	IS1006F	IS1017	IS1019 (with MMS)	IS1519
	6 Nm Harmony 12V DC or 120V AC	TMDC-6W/12V-24 (DC motor) TMUS355-06/33 (AC motor)	TMUS35-46.5RC	TMUS45-46.5RG	IS1006F	IS1017	IS1019 (with MMS)	IS1519
	3 Nm Silent 120V AC	SSWR03/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1038	IS1519
	6 Nm Silent 120V AC	SSWR06/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1038	IS1519
	8 Nm Silent 120V AC	SSWR08/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1038	IS1519
2" Rollease	3 Nm Harmony 12V DC	TMDC-3W/12V	TMUS-C118	TMUS-G133	IS1006F	IS1017	IS1019 (with MMS)	IS1519
	6 Nm Harmony 12V DC or 120V AC	TMDC-6W/12V-24 (DC motor) TMUS355-06/33 (AC motor)	TMUS-C118	TMUS-G133	IS1006F	IS1017	IS1019 (with MMS)	IS1519
2.7" Maestro-Shield Tube	3 Nm Harmony 12V DC	TMDC-3W/12V	TMUS35-46.5RC	TMUS45-46.5RG	IS1006F	IS1017	IS1019 (with MMS)	IS1519
	6 Nm Harmony 12V DC or 120V AC	TMDC-6W/12V-24 (DC motor) TMUS355-06/33 (AC motor)	TMUS35-46.5RC	TMUS45-46.5RG	IS1006F	IS1017	IS1019 (with MMS)	IS1519
	3 Nm Silent 120V AC	SSWR03/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1038	IS1519
	6 Nm Silent 120V AC	SSWR06/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1038	IS1519
	8 Nm Silent 120V AC	SSWR08/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1038	IS1519

Compatible chart
for crown, drive gear, idler bearings, motor plate and idler plate
with MaestroShield Bracket Assemblies




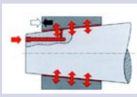
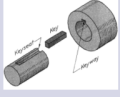
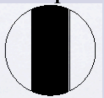

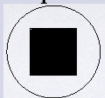














Motor Tube	Motor	Item #	Crown	Drive Gear	Idler Bearing	Idler Insert	Motor Bracket	Idler Bracket
1" Round	0.7 Nm Harmony 12V DC	TMDC-.7W/12V	Included w/ motor	Included w/ motor	IS1006F	Not Needed	AC03-05	Not Needed
	1 Nm Silent 24V DC	SSWR01/30	TMUS-SC458	TMUS-SG472	IS1006F	Not Needed	AC03-05	Not Needed
1.5" Round	0.7 Nm Harmony 12V DC	TMDC-.7W/12V	TMUS-C241	TMUS-G265	IS1006F	IS1016	AC03-05	Not Needed
	3 Nm Harmony 12V DC	TMDC-3W/12V	Not Needed	TMUS35-35RG	IS1006F	IS1016	AC03-05 (with MMS)	Not Needed
	6 Nm Harmony 12V DC or 120V AC	TMDC-6W/12V-24 (DC motor) TMUS355-06/33 (AC motor)	Not Needed	TMUS35-35RG	IS1006F	IS1016	AC03-05 (with MMS)	Not Needed
1.5" Rollease	0.7 Nm Harmony 12V DC	TMDC-.7W/12V	TMUS-C241	TMUS-G265	IS1006F	IS1016	AC03-05	Not Needed
	1 Nm Silent 24V DC	SSWR01/30	TMUS-SC1170	TMUS-SG1171	IS1006F	IS1016	AC03-05	Not Needed
2" Round	3 Nm Harmony 12V DC	TMDC-3W/12V	TMUS35-46.5RC	TMUS45-46.5RG	IS1006F	IS1017	AC03-05 (with MMS)	Not Needed
	6 Nm Harmony 12V DC or 120V AC	TMDC-6W/12V-24 (DC motor) TMUS355-06/33 (AC motor)	TMUS35-46.5RC	TMUS45-46.5RG	IS1006F	IS1017	AC03-05 (with MMS)	Not Needed
	3 Nm Silent 120V AC	SSWR03/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1018	Not Needed
	6 Nm Silent 120V AC	SSWR06/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1018	Not Needed
	8 Nm Silent 120V AC	SSWR08/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1018	Not Needed
2" Rollease	3 Nm Harmony 12V DC	TMDC-3W/12V	TMUS-C118	TMUS-G133	IS1006F	IS1017	AC03-05 (with MMS)	Not Needed
	6 Nm Harmony 12V DC or 120V AC	TMDC-6W/12V-24 (DC motor) TMUS355-06/33 (AC motor)	TMUS-C118	TMUS-G133	IS1006F	IS1017	AC03-05 (with MMS)	Not Needed
2.7" Maestro-Shield Tube	3 Nm Harmony 12V DC	TMDC-3W/12V	TMUS35-46.5RC	TMUS45-46.5RG	IS1006F	IS1017	AC03-05 (with MMS)	Not Needed
	6 Nm Harmony 12V DC or 120V AC	TMDC-6W/12V-24 (DC motor) TMUS355-06/33 (AC motor)	TMUS35-46.5RC	TMUS45-46.5RG	IS1006F	IS1017	AC03-05 (with MMS)	Not Needed
	3 Nm Silent 120V AC	SSWR03/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1018	Not Needed
	6 Nm Silent 120V AC	SSWR06/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1018	Not Needed
	8 Nm Silent 120V AC	SSWR08/28	Not Needed	TMUS-SG197	IS1006F	IS1017	IS1018	Not Needed

(Maestroshield, 2011)

Appendix H: Requirement specification for 0-90deg Connector idler universal

Requirement	Validation	Evaluation/ Verification
R1: Connect (Lock) Idler bearing shafts of 2 shades	Rotate shades with one motor.	CAD verification
R2: Transmit torque up to 8Nm	8Nm is highest motor rating with Maestrosshield	Prototype Testing
R3: Flexible from 0-90deg	To be used for curved and angled windows	Prototype Testing
R4: Rotate weight of 53 lbs	Lifting capacity of 8Nm is 53 lbs	Prototype Testing
R5: Reduce Light gap between the brackets	Market competency	CAD verification
R6: Rotate Clockwise and Anticlockwise	Shades run up and down	Technical papers
R7: Less expensive	Market competency	Design & Process analysis
D1: Able to assemble & disassemble easily	Installation time saving	CAD verification
D2: Able to manufacture easily	Reduce cost and time	CAD verification
D3: Able to access easily	Reduce effort	CAD verification
D4: Look attractive	Minimum market requirement	Customer feedback
D5: Rust and stain proof	Long life of the product	Experimental analysis

Appendix I: Morphological matrix for 0-90deg Connector idler Universal

<div>Solutions</div> <div>Functions</div>	1	2	3	4	5
1. Connect (Lock) Shafts	Leaf spring 	Plunger pin 	Snap 	Taper 	Shaft Key 
2. Move In Bearing	Split 	Symmetric 	Squared 	Plus 	Oval 
3. Rotate Weight	Carbon steel 	Stainless steel 	Spring steel 	Plastic 	Composites 
4. Bend 0-90deg	Flexible shaft 	Cont. VelJoint 	Universal Joint 	Rope 	
5. Adjust Light gap	Telescopic 	Springs 	Metallic Bellows 		

Appendix J: Pugh Matrix for 0-90deg Connector idler Universal

Concept A: S1.1, S2.3, S3.1, S5.3,

Concept B: S1.2, S2.3, S3.1, S4.1

Concept C: S1.4, S2.5, S3.2, S4.2, S5.1

Requirements/ Desire	Concept A <i>Metallic Bellows</i>	Concept B <i>Flexible shaft(REF)</i>	Concept C <i>Telescopic</i>
Connect (Lock) Idler bearing shafts of 2 shades	0	0	0
Transmit torque up to 8Nm	-	0	-
Flexible from 0-90deg	0	0	+
Rotate weight of 53 lbs	-	0	+
Reduce Light gap between the brackets	0	0	-
Rotate Clockwise and Anticlockwise	0	0	0
Cost	-	0	-
Able to assemble & disassemble easily	+	0	-
Able to manufacture easily	+	0	-
Able to access easily	-	0	-
Look attractive	-	0	-
Rust and stain proof	0	0	0
Σ^+	2	0	2
Σ^-	5	0	7
Σ^0	5	12	3
Netto	-3	0	-5
Rank	2	1	3

Table: Pugh Matrix iteration 1, Eliminated Concept C

Requirements/ Desire	Concept A <i>Metallic Bellows(REF)</i>	Concept B <i>Flexible shaft</i>
Connect (Lock) Idler bearing shafts of 2 shades	0	-
Transmit torque up to 8Nm	0	0
Flexible from 0-90deg	0	-
Rotate weight of 53 lbs	0	0
Reduce Light gap between the brackets	0	+
Rotate Clockwise and Anticlockwise	0	0
Cost	0	-
Able to assemble & disassemble easily	0	0
Able to manufacture easily	0	-
Able to access easily	0	0
Look attractive	0	-
Rust and stain proof	0	0
Σ^+	0	1
Σ^-	0	5
Σ^0	12	6
Netto	0	-4
Rank	1	2

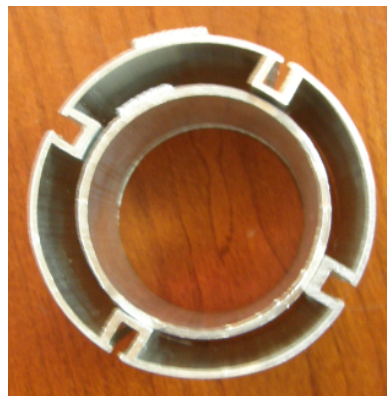
Table: Pugh Matrix iteration 2, Concept B chosen

Appendix K: Prototypes



140mm Single bracket

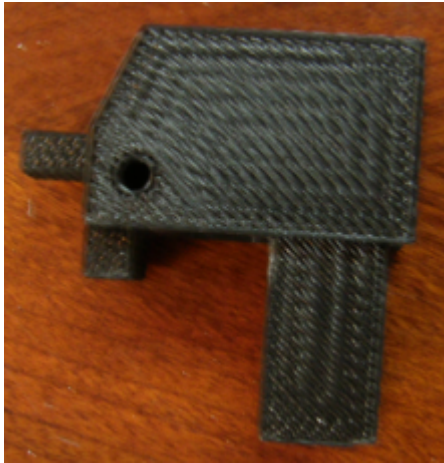
7" double bracket with Ball bearing Idler



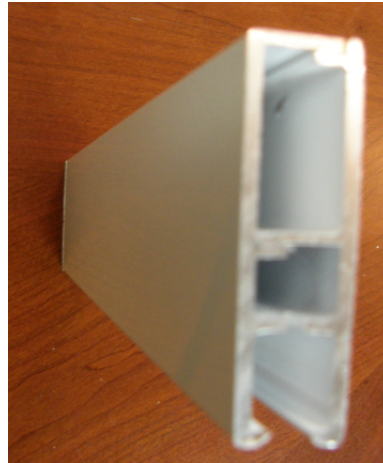
Black out Motor tube



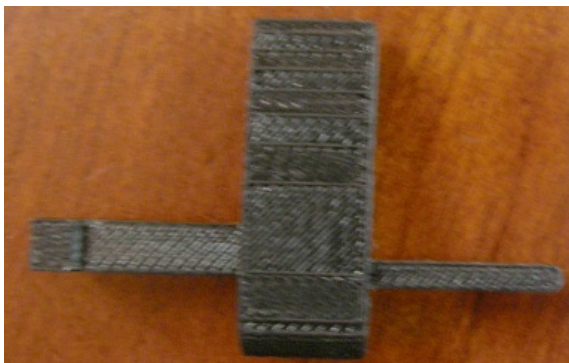
Fascia



Entry Guide



Black out Side track



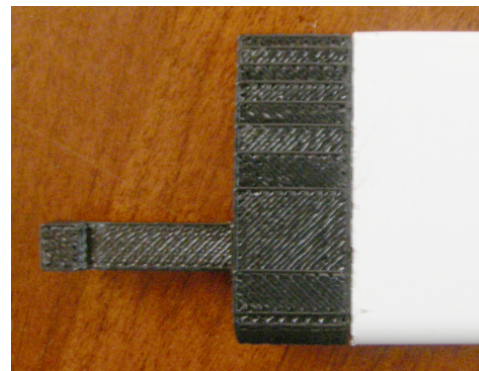
Bottom bar end cap



Bottom bar



Entry guide on Blackout side track



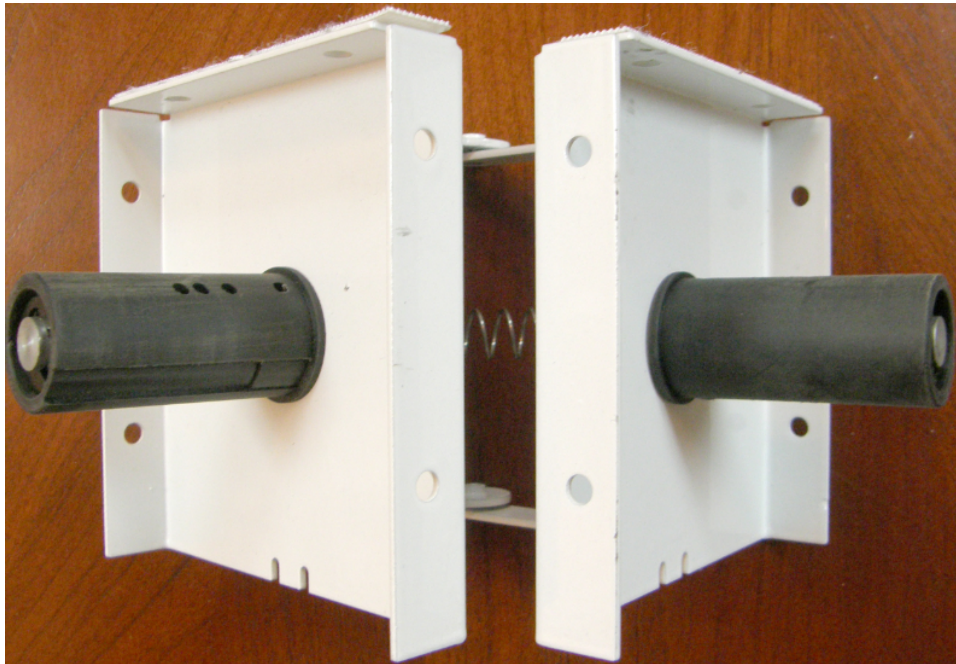
Bottom bar end cap with Bottom bar



Idler Insert



Idler Bearing



0-90deg Connector Idler brackets



Motor Bracket