UNIVERSITY OF TWENTE.

INTERNSHIP REPORT

Design of a Modular Display Trolley

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2 Acknowledgement

This design report is the result of the internship which took place at Siemens Healthcare GmbH, Forchheim, Germany on a design assignment. This report gives an overview of designing a Modular Display Trolley which was part of new-look/refresh project at the X-ray Products division of the company.

I am very grateful to Uwe Ringel for giving me the opportunity to work on this assignment and for extending his full support in helping with my transfer activities to Germany and making my stay there a pleasant and memorable one. I would also like to thank Andreas Limmer, the team leader for Customized Solutions, of which I was part of for three months. Working with him was thoroughly enjoyable and challenging for the most part. His approach to always question every part of the design is something I would want to apply in my professional career in the future.

As for my colleagues, Oezcan Karsak, Bernd Malter, Martin Streit and Michael Satler; I am sincerely grateful to all your help and support whenever I needed it, not just at work but also making it a lot nicer to settle down in a new country temporarily.

I hope the solution that I developed during the course of my internship is implemented in the coming months and helps deliver the necessary requirements to the customer.

My time spent at Siemens was one of the most memorable times I have spent, and I hope to use all my knowledge and experience that I gained there in my future endeavors.

Aniruddh Lotlikar

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3 Abstract

The topic for the assignment was initiated by the company as a result of an ageing display trolley in its existing product portfolio. The X-ray Products (XP) division of Siemens Healthcare GmbH use these display trolleys in their current portfolio as an accessory to their Fluoroscopy systems. Since there was no refresh activity carried out on this module of the system, the display trolley remained outdated in terms of its design and functionality with the current trends of the market today and as desired by the customer.

The X-ray products division at Siemens Healthcare values the quality and reliability in the products that they have been delivering for many years. With that being said, the company is also very sensitive towards its profit margin on products being sold. The objective of the assignment was to develop a modular display trolley to fit all the products in the XP product portfolio. The goal was to have minimum interchangeable parts depending on the variant being ordered. Additionally, there were two more features that were expected to be included in the new design of the trolley as compared to the existing one. A cost reduction of 25% and assembly time minimization was also targeted on the make up of the parts used to make up the display trolley. With this being said, all Siemens Healthcare products need to comply to the necessary compliance (IEC 60601-1) and safety norms to get the required certification for sale in most countries around the world. So, the design was obligated to fulfil certain criteria in terms of tests that are mentioned in these standards.

The first part of the report explains the research that was carried out after studying the requirements drafted for the new display trolley. This includes making a basic concept using the Siemens product style guide as a reference. The aim was to get a general idea about the look and feel of the trolley and review it with the stakeholders. After the stakeholders decided their preference for the most desirable concept, further improvements and detailing was carried out.

The next part of the report describes the market research that was carried out in search of modules that would meet the requirement for the two new functions that were added in the requirement specifications. The next step was to design the rest of the components and analyzing manufacturing possibilities. After this structural analysis was carried out on the indigenized components. The last part of the detailed design included calculating the stability calculations on the entire structure for all the variants. Based on the results of this analysis, further optimization was carried out on some of the components like the driving frame of the trolley and placement components within the assembly.

During the final review, the cabling feasibility and serviceability is discussed in detailed.

Keywords: Modular design; display trolley; COTS; stability

4 Introduction

4.1 Background of the company

Siemens Healthineers (Siemens Healthcare GmbH) is a medical technology company and is headquartered in Erlangen, Germany. The company dates its early beginnings in 1847 to a small family business in Berlin, co-founded by Werner von Siemens. Siemens Healthineers is connected to the larger corporation, Siemens AG. The name Siemens Medical Solutions was adopted in 2001, and the change to Siemens Healthcare was made in 2008. In 2015, Siemens named Bernd Montag as its new global CEO. In May 2016, Siemens Healthcare was rebranded "Siemens Healthineers" [1].

At Siemens Healthineers, the purpose is to enable healthcare providers to increase value by empowering them on their journey towards expanding precision medicine, transforming care delivery, and improving patient experience, all enabled by digitalizing healthcare.

An estimated five million patients globally everyday benefit from their innovative technologies and services in the areas of **diagnostic** and **therapeutic imaging**, **laboratory diagnostics** and **molecular medicine**, as well as **digital health** and **enterprise services**.

They are one of the world's leading medical technology companies with over 170 years of experience and 18,000 patents globally with about 50,000 dedicated colleagues in over 70 countries [2].

FIGURE 1: SIEMENS HEALTHCARE GMBH BRAND LOGO

The **X-ray products** division of Siemens Healthineers where this internship took place, focuses on diagnostic imaging specifically in the region of women's health, radiography and fluoroscopy. They are the market leaders in the X-ray business with over **3,000** employees, in excess of **600** patent families, **21** products across **6** segments and with a manufacturing footprint in **5** countries. It is estimated that **4,500,000** X-ray images are generated using Siemens systems [2].

FIGURE 2: X-RAY IMAGING SYSTEMS

4.2 Problem Definition

The current display trolley in the existing product portfolio has been in existence for over 10 years without any change activities been carried out on its design. Its features and designs in terms of ease of usability and ergonomics remain outdated when compared to the needs and requirements of today's market trends. Additionally, since there was no DtC (Design to cost) activity carried out on this product in the recent past, the manufacturing cost remains too high for its current state. The assembly time required for the display trolley was also judged to be on the higher side.

Besides the main reasons identified in the paragraph above, other drawbacks included:

- Manufacturability of components
- Ergonomics of design
- Serviceability of the trolley
- Cabling aspects
- Ease of usability

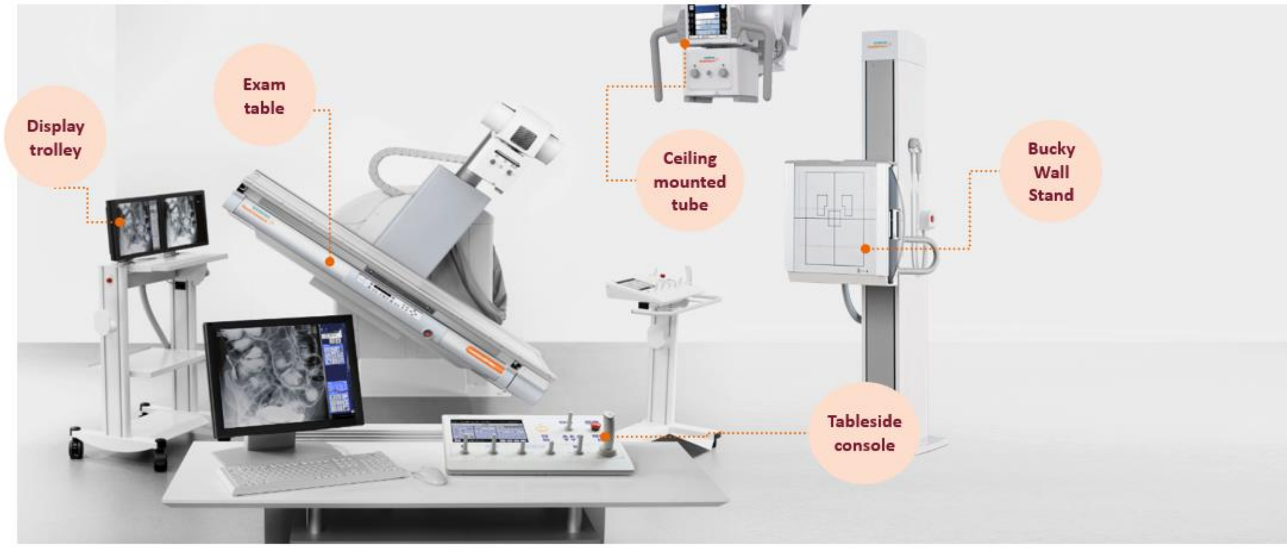


FIGURE 3: AN EXAMPLE OF THE ELEMENTS OF A FLUOROSCOPY SYSTEM

4.3 Scope of the assignment

Taking into account the factors mentioned in the Section 4.2, the X-ray products division of Siemens Healthineers decided it was time to carry out a "refresh" activity on the display trolley for its fluoroscopy systems. The objective of the assignment is to create a design concept for a modular display trolley with minimum interchangeable parts based on the variant of the trolley that was ordered by the customer. The goal was to have a new, "fresh" looking design that was in line with the current Siemens product style guidelines. The requirements for the design of the trolley is included in the **Appendix** and was used as a reference during the design and development phase.

The following points summarize the target of the activity that was carried out:

- Improve the ergonomics of the design
- Improve the general usability of the system
- Take into account the integration of two additional features to the trolley as compared to the existing one; vertical height adjustment of the displays and central braking of the castor wheels
- Improve serviceability and cabling aspects of the trolley
- Reduce manufacturing costs by 25%
- Reduce assembly time
- Ensure ease of manufacturability of components

The 4 variants of the display trolley as shown in Figure 4 are as follows:

1. Trolley with 1 display
2. Trolley with 2 displays
3. Trolley with 1 display and 1 Touch User Interface (TUI)
4. Trolley with 1 display and 1 Touch User Interface (TUI)

FIGURE 4: TROLLEY VARIANTS FOR FLUOROSCOPY SYSTEMS

5 Conceptual design

5.1 Objective of a modular design

Modularity has been defined as the relationship between a product's functional and physical structures such that (1) there is a one-to-one correspondence between the functional and physical structures and (2) unintended interactions between modules are minimized [3].

Modular design is basically to decompose complex systems into simple modules in order to more efficiently organize complex designs and processes. The concept was first introduced by (Starr 1965), in which the use of modular product in production was proposed as a new concept to develop variety. It makes possible to modify specific modules for a new requirement without influencing the main infrastructure, so that the complex problems can be decomposed in to several small ones. Modular design concept has been employed in many fields of design and manufacturing [3].

The basic modules in the structure of the monitor trolley are shown in Figure 5.

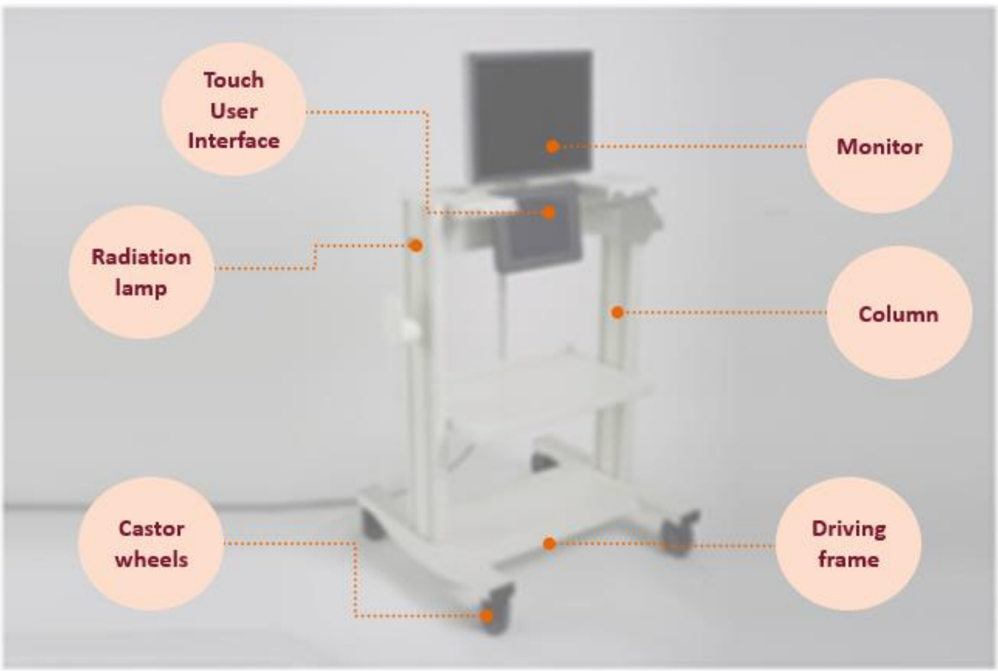


FIGURE 5: BASIC MODULES OF A DISPLAY TROLLEY

For the purpose of this design it was decided that the same configuration as that of the existing trolley be maintained. For the new updated design, the common components would be the **driving frame**, **castor wheels** and the **column**. The interchangeable parts would include the components used to mount the monitor and the touch user interface.

5.2 Design Approach

The main objective while making the design approach was "Exploring future-proof solutions". Figure 6 shows the design approach that was followed while creating the concepts for discussions with the stakeholders.

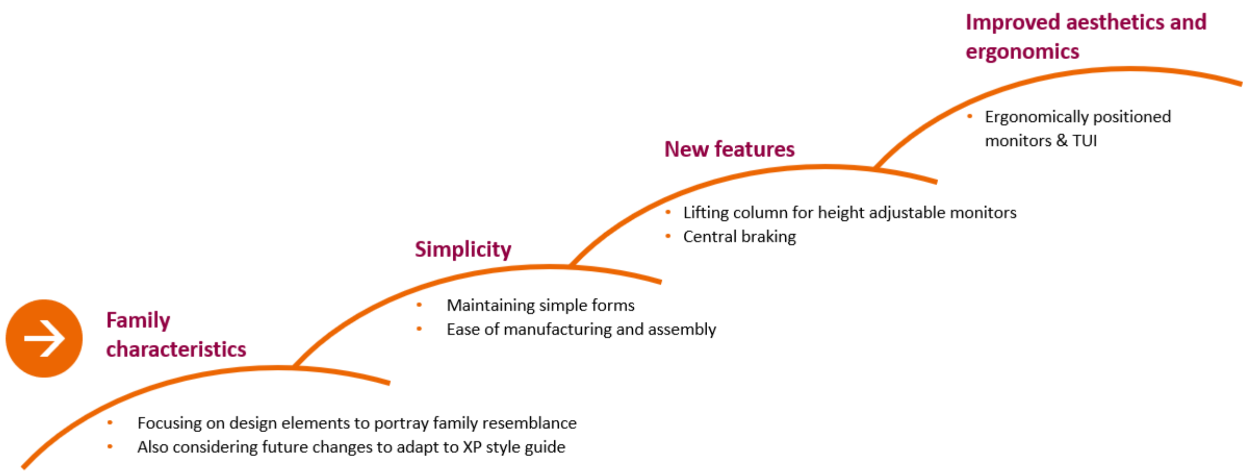


FIGURE 6: DESIGN APPROACH FOR NEW CONCEPT

- **Family characteristics**: The main focus of this step of the design process is to extract features that resemble from the systems that the display trolley is used as an accessory to. The reason behind this is so that the display trolley fits into the product family and does not look like a random accessory.
  While creating the concept, the key and mandatory elements from the product style guide and design specifications are also adhered to.
  In a design process context, it is also necessary to have a model that states the goals for the design process, i.e. the design specification. The specification and the structures are linked by causal relations: the process determines the functions, the functions are created by the organs, and the organs are materialized by the components [3].

- **Simplicity**: Maintaining simple forms are key if the main product requirements of ease of manufacturing & assembly and meeting the specified material cost targets. Complex forms are more difficult to manufacture, and tooling costs are generally higher.

- **New features**: Implementing the two additional features to the new concept is also included in the design process. It had to be ensured that these new sub-systems would integrate well into the design.

- **Improved aesthetics and ergonomics**: The main focus of this step is to improve on the flaws of the earlier model and ensure that aesthetics (which is also focused on in the step "Family characteristics") and ergonomics is taken care of while making the new concept.

5.3 Ideation

The first step was to sketch basic forms for the concepts before making 3D models and subsequently renders. While executing this step, the main points from the design approach are followed and used as a guideline. Figure 7 shows the drafts for the initial sketches that were made before making the 3D model for the basic concepts.

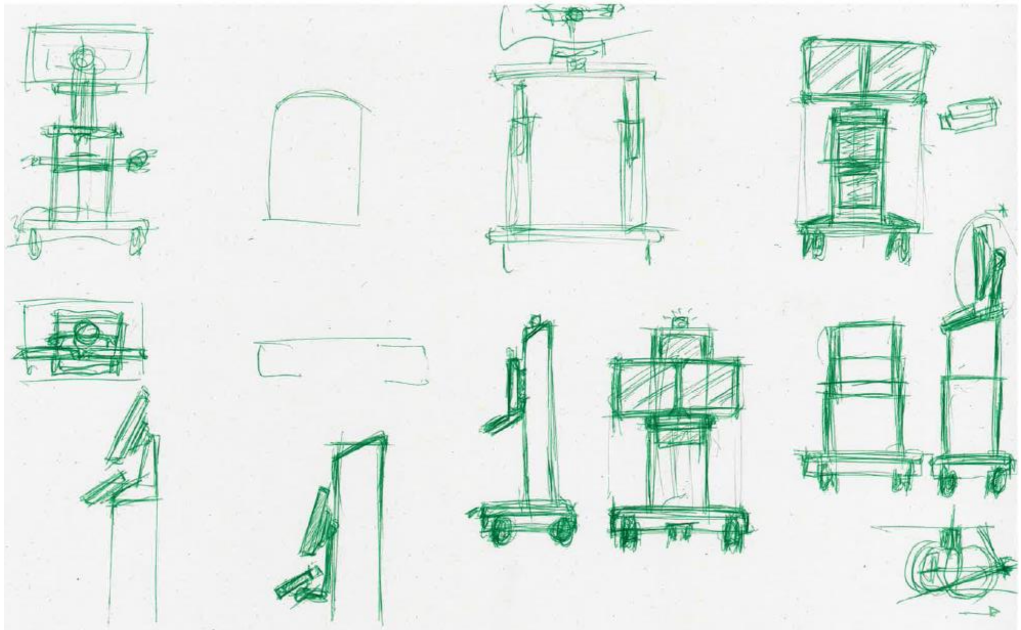


FIGURE 7: INITIAL DRAFTS OF SKETCHES FOR IDEATING LOOK AND FEEL OF THE DISPLAY TROLLEY.

5.4 Initial concept designs

The next step was to create basic 3D models using the sketches. These 3D models are just basic forms and were not detailed. The purpose of creating these models was to initiate a discussion with the stakeholders and provoke thoughts regarding the general look, feel and usability of the product.

5.4.1 Concept A

FIGURE 8: CONCEPT A

Concept A as shown in Figure 8 incorporates a tubular structure at the top which would house the height adjustment component similar to that utilized in the Luminos dRF max system.

5.4.2 Concept B

FIGURE 9: CONCEPT B

Concept B as shown in Figure 9 incorporates the telescopic rails which would house the lifting column similar to the one adopted in the examination table of the Ysio Max system.

5.4.3 Concept C

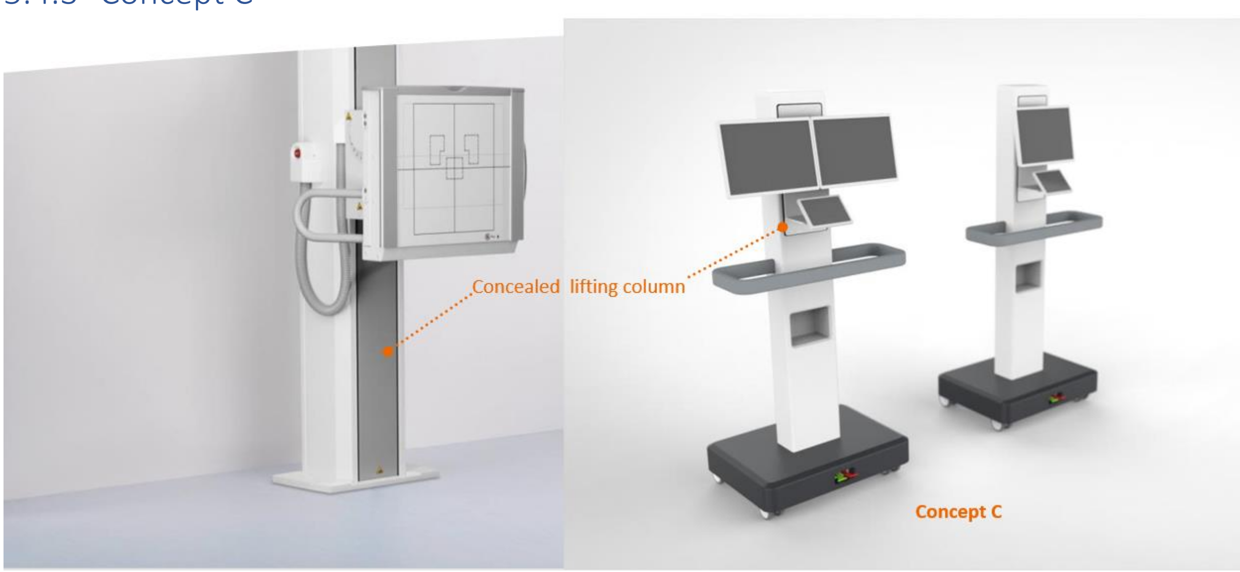


FIGURE 10: CONCEPT C

Concept C as shown in Figure 10 incorporates the concealed lifting mechanism using a front cover similar to the one adopted in the Bucky Wall stands of the Ysio family of systems.

5.5 Feedback

The next step was to discuss the three concepts with all the stakeholders (technical, design and usability, and marketing). Different aspects of the concept were discussed separately with stakeholders from different departments.

The stakeholders unanimously favored **Concept C**. Hence, further discussions were held only with regards to this concept. The various feedback received from the stakeholders about the different elements of the design is summarized in Figure 11.

FIGURE 11: SUMMARY OF FEEDBACK

- **Base or driving frame**: The design of the base or driving frame was thought to be a little too bulky and made the overall appearance of the trolley feel too heavy. The design and usability team also identified a few usability issues with regards to access to the displays when standing in front of them because they felt that distance should be minimized so the user could come as close to it as possible.

- **Column**: The design of the column was appreciated, and the overall consensus was that it fit the design well and only needed minor tweaking. The storage space provided in the column though was deemed unnecessary and asked to be removed.

- **Handles**: The design of the handles was thought to be ok although the technical team identified some issues with regards to manufacturability of the handles.

- **Design**: The general design of the concept was liked by all stakeholders. With the necessary modifications requested from the industrial design team, the concept was good to go ahead with for the detail design.

- **Display**: The position of the display was thought to be ok and the stakeholders didn't see any problem with it.

- **Cost**: As this was one of the most important and key factors, every element of the design was scrutinized with regards to whether the concept would be able to achieve the targeted material cost.

5.6 Final Industrial design concept

After the feedback discussion with the stakeholders, improvements on *Concept C* with respect to the industrial design was taken up. This activity was carried out along with the industrial designer of the Design and Usability team. The detailing that was added to the initial concept was based on improvements suggested by the stakeholders, updates in on-going projects and basic changes to correct the usability of the concept.

During this phase, scale models in the form of 3D printed prototypes were also used to check the overall scale of the components with respect to each other.

Some of the sketches and prototypes that were used are as shown in Figure 12.

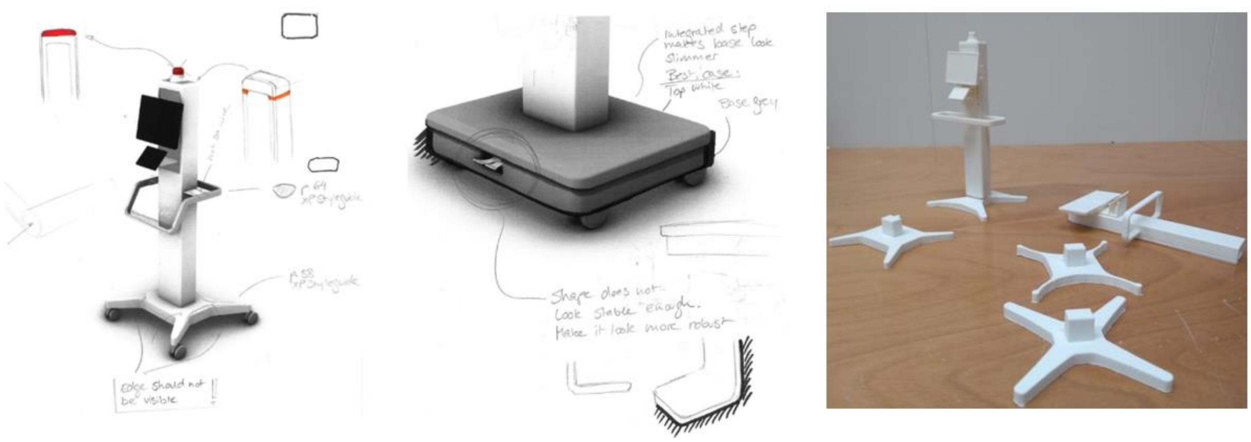


FIGURE 12: INDUSTRIAL DESIGNERS SKETCHES AND PROTOTYPES

6 Preliminary design

6.1 Commercial of-the-shelf (COTS) components

As the basic configuration of the system is available, decisions must be made on how best to meet the need in selecting a specific approach in responding to an equipment need.

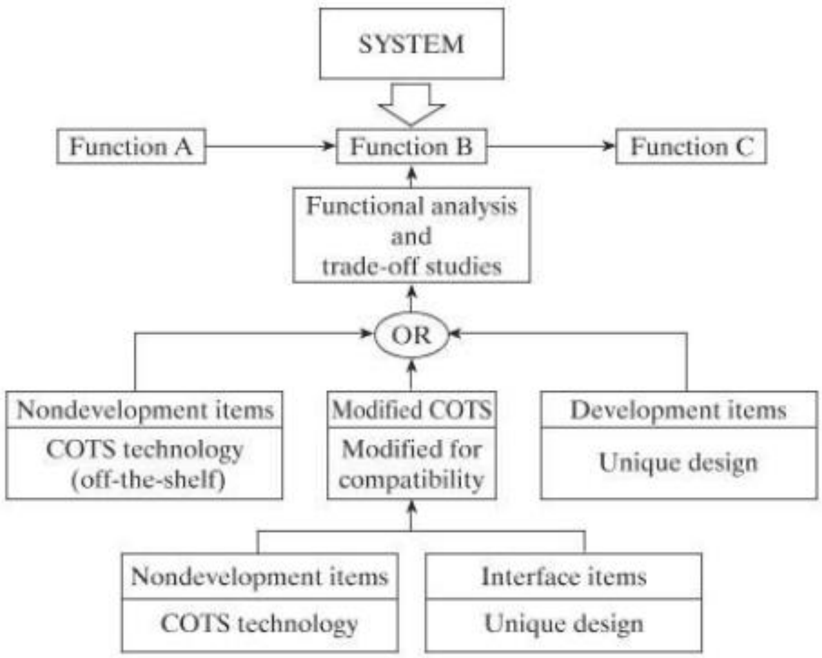


FIGURE 13: ALTERNATIVE APPROACHES IN SELECTION OF RESOURCES [4]

As illustrated in Figure 13, the following steps as explained in [4] are taken to arrive at a satisfactory result:

- Select a standard component that is commercially available and for which there are a number of viable suppliers; for example, a commercial off-the-shelf (COTS) item, or equivalent. The objective is, to gain the advantage of competition (at reduced cost) and to provide the assurance that the appropriate maintenance and support will be readily available in the future and throughout the system life cycle when required, or;
- Modify an existing commercially available off-the-shelf item by providing a mounting for the purposes of installation, adding an adapter cable for the purposes of compatibility, providing a software interface module, and so on. Care must be taken to ensure that the proposed modification is relatively simple and inexpensive and doesn't result in the introduction of a lot of additional problems in the process or;
- Design and develop a new and unique component to meet a specific functional requirement. This approach will require that the component selected be properly integrated into the overall system design and development process in a timely and effective manner.

For the purpose of this assignment, the option of having modified commercial off-the-shelf (COTS) components is highly favorable. The reason behind this option is that selection of commercial off-the-shelf (COTS) components gives an added advantage when it comes to the cost of procurement, lead time in procuring these components and since the technology is already proven in the field.

It was decided to explore COTS components in the market for meeting the two new requirements for the product which are:

- Vertical height adjustment of the displays
- Central braking of the castor wheels

The following section of the report details the market research of the COTS solutions that was done in order to meet the requirement for the features mentioned previously.

6.2 Selection of COTS components

A careful online search was carried out in search of standard subsystems that would meet the requirements for the vertical height adjustment of the monitors and for centrally braking the castor wheels. A summary of the components that were explored among different vendors is shown in Figure 14.

FIGURE 14: SUMMARY OF ALL VENDORS

6.2.1 Vertical height adjustment solutions

For the *vertical height adjustment* solutions, several vendors were explored. The vendors were invited for discussions to the company's office premises. Two different types of solutions were explored; mechanical and electrical.

Mechanical solutions were mostly comprised of a system that is designed to counterbalance a load range with the use of gas springs or a torsion spring; *Electrical solutions* generally comprised of motor with relatively high torque attached to a spindle with the use of a gear box mechanism.

A weighting chart between the mechanical and electrical solutions for the vertical height adjustment components is shown in Table 1.

TABLE 1: COMPARISON BETWEEN MECHANICAL AND ELECTRICAL VERTICAL HEIGHT ADJUSTMENT SOLUTIONS

	Weightage	Mechanical	Electrical
Ease of integration	3	4(12)	3(9)
Closeness to Siemens requirement specification	3	4(12)	4(12)
Reliability	4	3(12)	4(16)
Cost	5	2(10)	4(20)
Total		**(46)**	**(57)**

From the weighting chart electrical solutions were the more favorable option.

From the list of available solutions, the lifting column from LINAK, with model number DL17 from the Deskline was selected to aid the vertical height adjustment of the displays.

FIGURE 15: DESKLIFT DL17 FROM LINAK

Along with the lifting column, the other components that were included were a control box that served as the power source/regulator and logical controller for the lifting column itself, a control switch to adjust the height of the lifting column and a 1-meter cable that connects the control switch to the control box. All these components together made up the entire solution for the vertical height adjustment.

FIGURE 16: LIFTING COLUMN CONTROL BOX (LEFT) & CONTROL SWITCH (RIGHT)

6.2.2 Central Braking Solution

For the purpose of centrally braking the castor wheels, only one supplier- Steinco had a ready to integrate sub-system available. This solution was available in two options; with flexible links and with rigid links.

FIGURE 17: CENTRAL BRAKING SOLUTION FROM STEINCO

After receiving the quotations from the supplier for both the solutions and doing an initial cost analysis, it was decided to avoid this option completely and to remove this feature from the requirements. This decision was taken after the initial cost analysis showed that introduction of this feature significantly increased the material cost more than it was expected. But this option remains open for a future upgrade of the trolley and the driving frame is designed to suit the same.

6.3 Material selection

6.3.1 Driving frame

The material selection for the driving frame was the subject of much discussion. Table 2 gives a comparison of the materials that were considered for manufacturing the driving frame.

TABLE 2: MATERIAL COMPARISON (DRIVING FRAME)

	Steel (and its alloys)	**Aluminum (casting alloys)**	**Thermoplastics (HDPE)**
Density	7700 kg/m^3	2700 kg/m^3	952 kg/m^3
Brinnel Hardness	121	95	
Tensile strength, Ultimate	720 MPa	310 MPa	22 MPa
Tensile strength, Yield	460 MPa	276 MPa	
Modulus of elasticity	210 Gpa	69 Gpa	1070 MPa
Machinability	70 %	50%	
Shear modulus	80 GPa	26 Gpa	377 MPa

It was decided to proceed with *Aluminum* as the material of choice for the driving frame since a light weight material was preferred which would also lower the overall cost of the component. Although HDPE is the lightest of the three materials that were considered, it was decided to proceed with

Aluminum since it would have caused problems for the stability testing and the cost for compensating this with counterweights would have negated the benefits for the cost of the component.

6.3.2 Column

Table 3 gives a comparison of the materials that were considered for manufacturing the column.

TABLE 3: MATERIAL COMPARISON (COLUMN)

	Aluminum (extrusion alloys)	**Polycarbonate**
Density	2700 kg/m^3	960 - 1020 kg/m^3
Tensile strength, Ultimate	241 MPa	93 MPa
Tensile strength, Yield	214 MPa	
Modulus of elasticity	69 Gpa	1860 MPa
Machinability	50%	
Shear modulus	26 Gpa	377 MPa

It was decided to proceed with *Aluminum* as the material of choice for the Column since a relatively stiff and light weight material was preferred. Extruded aluminum would provide a good cost benefit since the quantities would be high enough which was an important factor while making the material selection.

6.3.3 Other parts

A summary of the materials for the miscellaneous parts is shown in Table 4.

TABLE 4: SUMMARY OF MATERIALS FOR OTHER PARTS

Description	**Material**
Column top cover	Thermoplastic
Cable holder	Thermoplastic
TUI mounting holder	Steel
Lifting column controller mounting bracket	Steel
Lifting column stand	Steel
Monitor mounting bracket	Steel
Lifting column_monitor mounting bracket assembly	Steel
Colum front cover	Steel
TUI holder mounting bracket assembly	Steel
Terminal block mounting rail	Steel
Handles	Aluminum

6.4 Stability Calculations

One of the most important design considerations for a medical device, especially for devices that are mobile, are the stability requirements as specified in the IEC 60601-1 standard. The standard lists multiple requirements pertinent to stability. During the preliminary design phase, three requirements are taken into consideration to be analyzed numerically while the rest could be achieved with testing during the development phase of the initial prototypes. The three requirements in consideration are highlighted in document titled “Brief specification trolley platform” which is included in the Appendix.

The following steps are carried out for all 4 variants of the display trolley as defined in the problem definition. The methodology for the calculation is as explained in the sub sections below.

6.4.1 Calculating center of mass

The center of mass for each component is derived from the modelling software (NX-Unigraphix 11). This is done by applying the correct material properties to the component for the software to calculate where its center of mass lies. Then using the center of mass of the entire structure is calculated using the following equations:

$$center\ of\ mass_x = \frac{\sum_{i=1}^{n} m_i x_i}{\sum_{i=1}^{n} m_i}$$

$$center\ of\ mass_y = \frac{\sum_{i=1}^{n} m_i y_i}{\sum_{i=1}^{n} m_i}$$

$$center\ of\ mass_z = \frac{\sum_{i=1}^{n} m_i z_i}{\sum_{i=1}^{n} m_i}$$

Once the center of mass is derived, the following steps can be carried out.

6.4.2 Calculating instability in transport position

This requirement is basically put in place to ensure the stability of the device during daily transportation i.e when the device is transported within the hospital or clinic floor space. Usually, medical device manufacturers, define a transportation position. This usually means that if the structure has any moving parts, it must be brought to the starting position in the longitudinal and transverse axis to avoid instability. For the purpose of this calculation, we consider the weight of the displays to be at the highest possible point in its travel range to assume the worst-case scenario. Although this is not necessary, we want to ensure that the structure is stable in all possible scenarios.

To test the requirement the display trolley is to be placed on a 10° ramp and the castor wheels braked. We calculate to check if the applied moment about A due to the trolley's weight is enough to topple it over. If the counter moment about the same point is greater, then the trolley is considered stable in such a position.

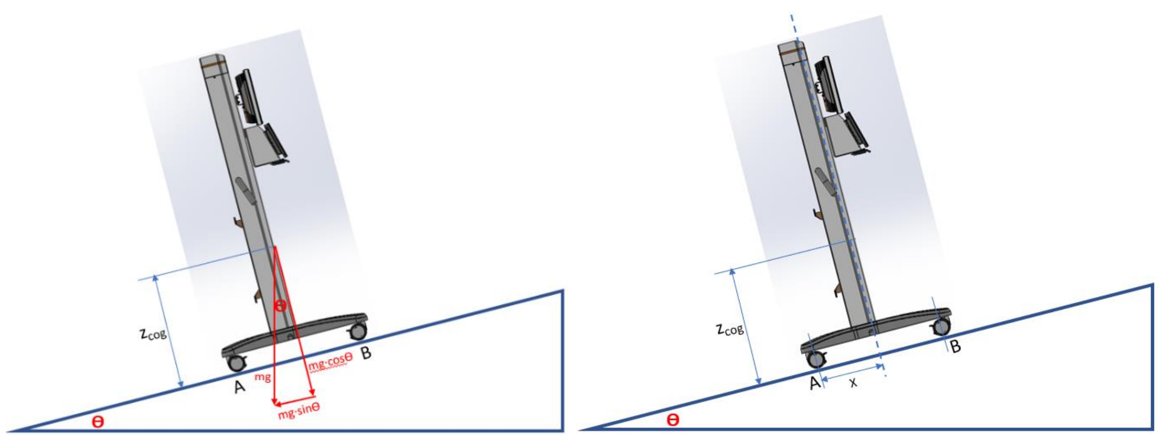


FIGURE 18: STABILITY TEST ON AN INCLINE

$$applied\ moment = mg \cdot sin\theta \cdot z_{cog}$$

$$counter\ moment = mg \cdot cos\theta \cdot (x - ecc.of\ wheel)$$

Where:
m is the mass of the trolley & m = $\sum_{i=1}^{n} m_i$;
g is the acceleration due to gravity and g = 9.81 m/s^2
Ɵ is the angle of the slope & Ɵ=10^o
z_{cog} is the distance where the center of mass lies in the z axis
x is the distance of point A till the center of mass in the horizontal plane
ecc. of wheel = 31.2 mm

6.4.3 Calculating instability excluding transport position

This requirement is put in place to ensure the stability of the device during its daily transportation within the area intended for its use. If the device has any moving parts, it must be brought to its extreme position in both the longitudinal and transverse axis. For the purpose of this calculation, we consider the weight of the displays to be at the highest possible point in its travel range to as this is the worst-case scenario.

To test the requirement the display trolley is to be placed on a 5^o ramp and the castor wheels braked. We calculate to check if the applied moment about A due to the trolley's weight is enough to topple it over. If the counter moment about the same point is greater, then the trolley is considered stable in such a position.

$$applied\ moment = mg \cdot sin\theta \cdot z_{cog}$$

$$counter\ moment = mg \cdot cos\theta \cdot (x - ecc.of\ wheel)$$

Where:
m is the mass of the trolley & m = $\sum_{i=1}^{n} m_i$;
g is the acceleration due to gravity and g = 9.81 m/s^2
Ɵ is the angle of the slope & Ɵ=5^o
z_{cog} is the distance where the center of mass lies in the z axis
x is the distance of point A till the center of mass in the horizontal plane
ecc. of wheel = 31.2 mm

6.4.4 Calculating instability from horizontal and vertical forces

This requirement is put in place to ensure the stability of the device during its daily use within the area intended for its use. To test this requirement the display trolley is pulled with a force of 25% of the total weight of the trolley at a height of 1500 mm from the floor. As shown in fig X, the stability is checked by applying a pull force on the trolley from 4 sides. The requirement is considered passed if the counter moment about point A is greater than the applied moment.

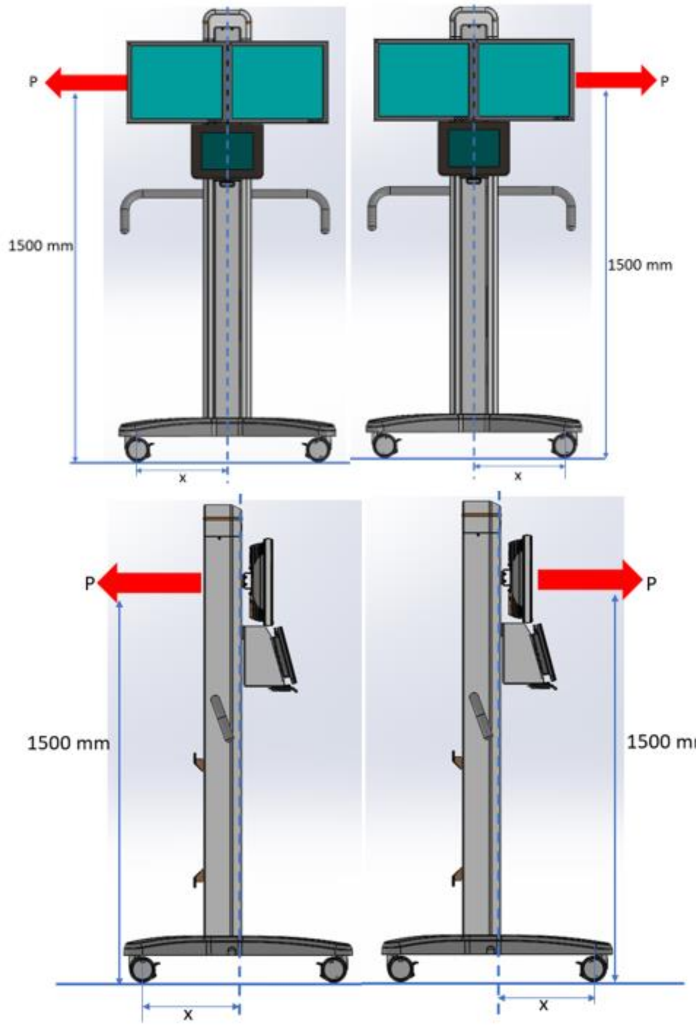


FIGURE 19: TEST CASES FOR CHECKING INSTABILITY DUE TO HORIZONTAL FORCES

$$applied\ moment = 0.25 \cdot m \cdot g \cdot pull\ height$$

$$counter\ moment = \ m \cdot g \cdot (x - ecc.of\ wheel)$$

Where:
m is the mass of the trolley & m = $\sum_{i=1}^{n} m_i$;
g is the acceleration due to gravity and g = 9.81 m/s^2
pull height = 1500 mm
x is the distance of point A till the center of mass in the horizontal plane
ecc. of wheel = 31.2 mm

Note: The pull force considered here is 25% of the total weight of the trolley even though in edition 3.1 of the IEC 60601-1 standard it has been amended to 15% of the total weight of the trolley. This is because, for sale of medical devices in China, it is mandated that the previous edition of the standard be followed.

6.5 Optimization

Once the results of the stability calculations are available, we have a better idea about the placement of the components and particularly, the size of the driving frame. The goal of the assignment was to have a modular design for the trolley, hence the size of the driving frame is key in achieving this.

After multiple iterations, the wheel to wheel distance of the driving frame was finalized at *820 mm x 820* mm. The size is measured from the mounting position of the castor wheels.

The position of the column is also an important factor, since it plays a major role in where the center of mass lies. After all the iterations were carried out, an optimum position for the column was also finalized and the design of the driving frame was also modified to suit the same.

Since the total mass of all four variants differ from one another, the center of mass shifts slightly which results in instability while checking some of the requirements as specified in the section above. Hence, counterweights are required to compensate for the same. The position of the counterweights remains the same, but the masses differ based on the variant.

7 Detailed Design

7.1 Manufacturing process

The decisions for the manufacturing process for all the parts that comprise the mechanical assembly are discussed in this section

7.1.1 Driving frame

A comparison for the three possible methods for manufacturing the driving frame for the display trolley is shown in Table 5.

TABLE 5: COMPARISON OF MANUFACTURING PROCESSES

Parameters	Sand Casting	Gravity die casting	Pressure die casting
Minimum wall thickness	5 mm	4 mm	2 mm
Tolerances on dimensions	±0.75 mm	±0.5 mm	±0.2 mm
Surface finish	Rough	Good	Very Good
Complex Machinery	Not required	Not required	Required
Production capacity	Low	High	Very High
Investment for setup	Low	Medium	Very High
Molten metal flow	By Gravity	By Gravity	By high pressure through machines

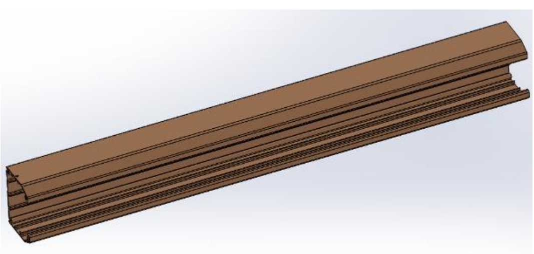
FIGURE 20: DRIVING FRAME (LEFT) & GRAVITY DIE CASTING PROCESS [5] (RIGHT)

Based on the size and complexity of design, it was decided to proceed with *Gravity die casting* as the manufacturing process and the alloy chosen was *EN AW-6061-T6*. The post processing steps for this component include:

- **Milling**: This process is critical so that the mounting surfaces remain flat and parallel to one another to avoid any issues during assembly.
- **Drilling**: Holes are required for mounting the wheels and column.
- **Anodising & Powder coating**: As a method of surface treatment.

7.1.2 Column

It was decided to proceed with *Extrusion* as the method of manufacturing for the column; the alloy chosen was *EN AW-6063-T6*. The decision was taken based on the ease of manufacturing as the extruded column quantities in terms of meters produced would provide a cost benefit. The precision from the extrusion process is sufficient as the column serves more or less just as a cover to the internal components, although during the design of this component, other factors such as possibility of integration in new products was also taken care of. A manufacturing guideline [6], was used while designing the profile for the extruded part.



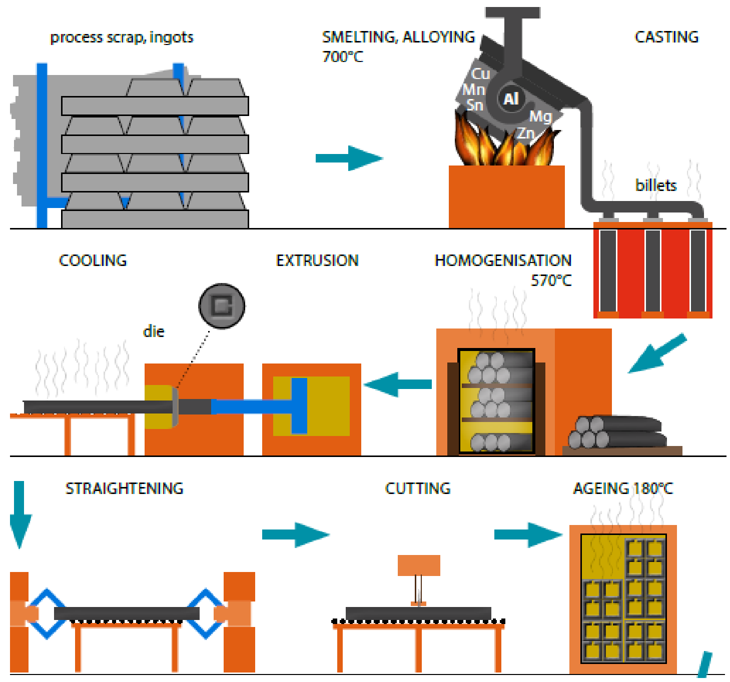


FIGURE 21: EXTRUDED COLUMN (LEFT) & EXTRUSION PROCESS [6] (RIGHT)

The post processing steps for this component include:

- **Drilling**: For the mounting of the covers and cable holder
- **Anodising & Powder coating**: As a method of surface treatment.

7.1.3 Column top cover

It was decided to manufacture the column top cover by means of *Injection Molding* as this was the cheapest and easiest way to manufacture this par. *ABS* was the most suitable option for developing this part. This manufacturing option is most suitable for this component based on its size and complexity. When the design of this part was discussed amongst the technical team, it was decided that that the X-ray indication lamp should be integrated within the column top cover using an LED band. This decision was taken as a cost saving initiative and at an industrial design level as part of the new style of products to be introduced within the X-ray products portfolio.

Although, the form of the part was designed during the course of the internship, the development of an integrated part along with the LED band that served as X-ray indication was not done due to time constraints. It was decided amongst the members of the technical team that the development of such an integrated part would be done at a later stage with minor modifications to the already designed component.

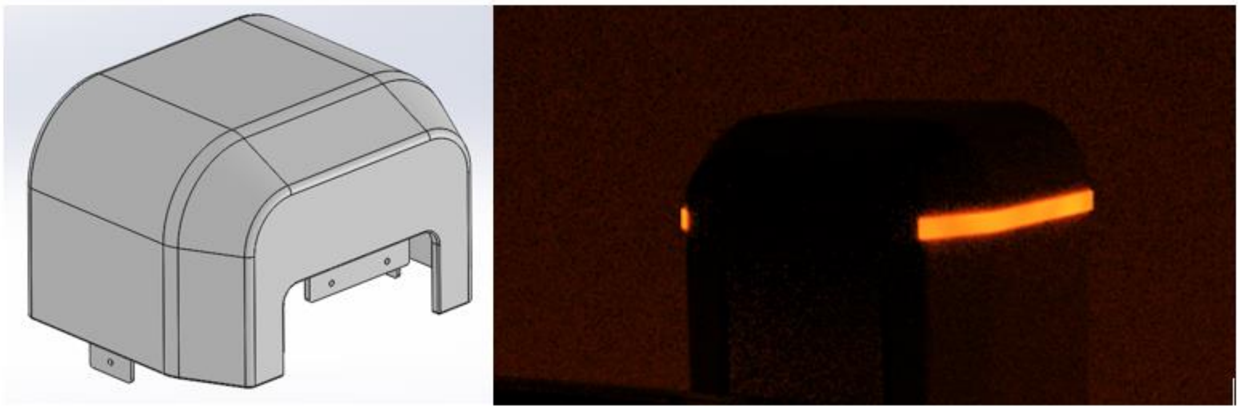


FIGURE 22: COLUMN TOP COVER CONCEPT WITH INTEGRATED LED STRIP

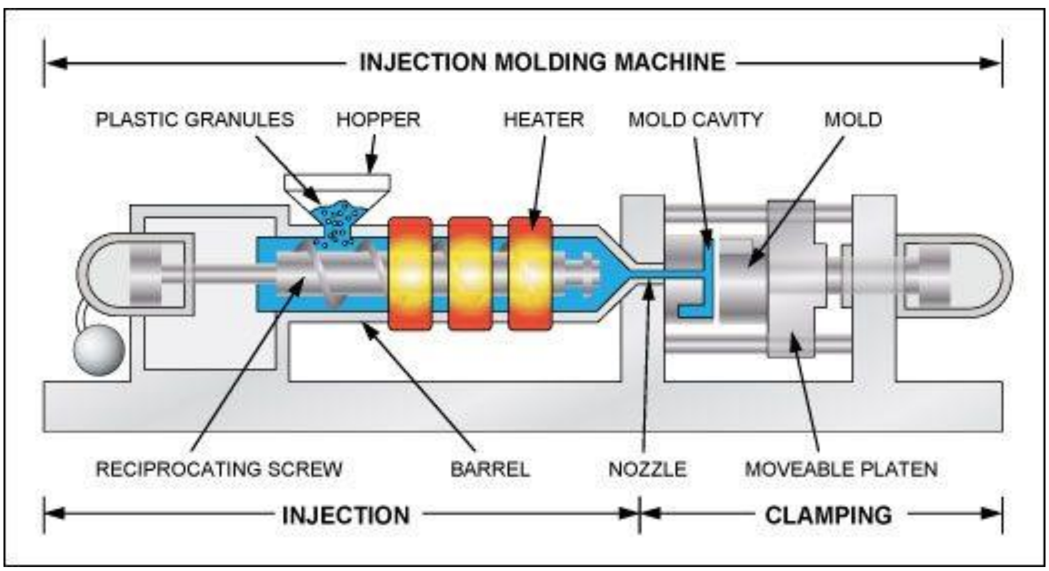
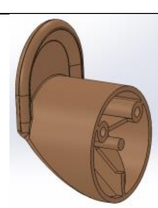


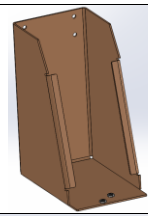
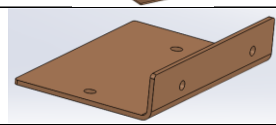
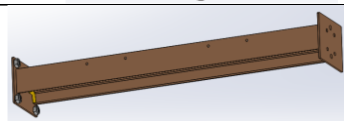
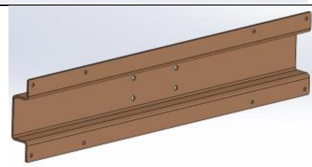
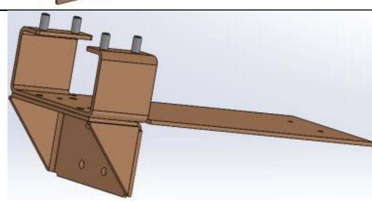
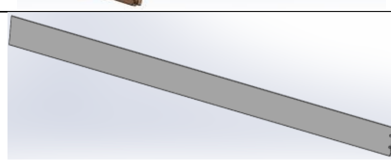
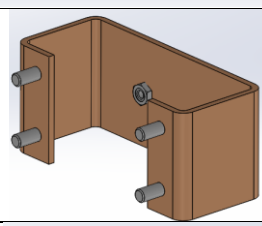
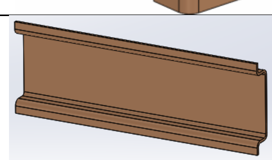
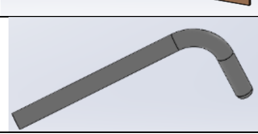
FIGURE 23: INJECTION MOLDING PROCESS [7]

7.1.4 Other parts

A summary of the manufacturing processes and the specific material used is shown in Table 6.

TABLE 6: SUMMARY OF MANUFACTURING PROCESSES AND MATERIALS

Description		Manufacturing process	Material
Cable holder		Injection molding	ABS

TUI mounting holder		Laser cutting + Sheet metal bending	S215G DIN 1623
Lifting column controller mounting bracket		Laser cutting + Sheet metal bending	S215G DIN 1623
Lifting column stand		Laser cutting + welding	S215G DIN 1623
Monitor mounting bracket		Laser cutting + Sheet metal bending	S215G DIN 1623
Lifting column_monitor mounting bracket assembly		Laser cutting + Sheet metal bending + welding	S215G DIN 1623
Colum front cover		Sheet metal bending	S215G DIN 1623
TUI holder mounting bracket assembly		Laser cutting + Sheet metal bending	S215G DIN 1623
Terminal block mounting rail		Sheet metal bending	S215G DIN 1623
Handles		Rolling	EN AW-6063

7.2 Finite Element Analysis

In order to ensure the structural integrity of all the major load bearing components, finite element analysis was done using the *ANSYS* tool to simulate the actual loading conditions.

7.2.1 Driving Frame

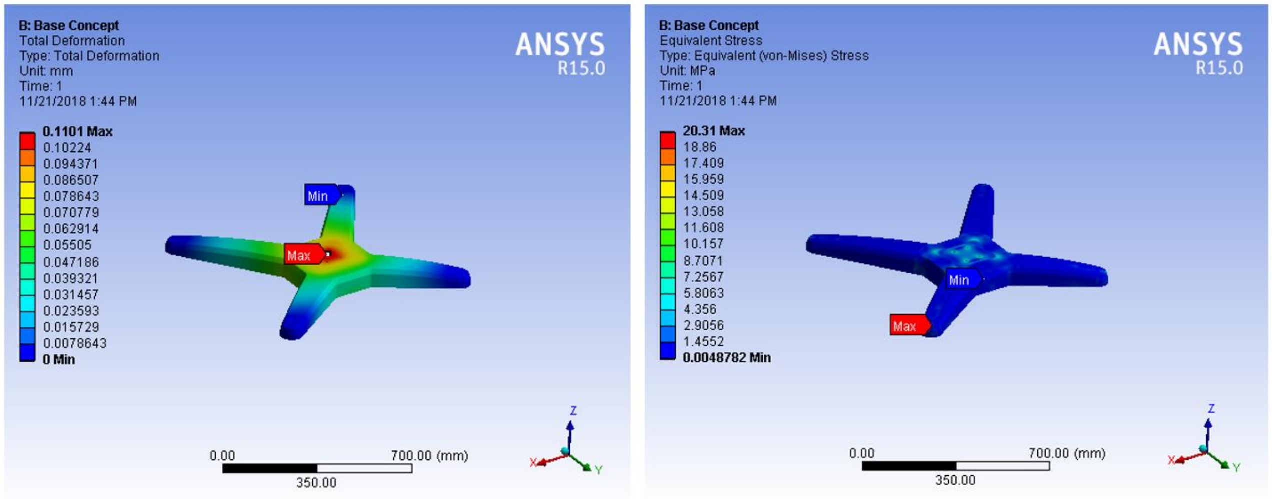


FIGURE 24: FEM SIMULATION OF DRIVING FRAME

Results:

- Max. Equivalent stress = 20.31 MPa
- Max Deformation = 0.11 mm
- Tensile Strength = 276 MPa
- Safety Factor = 13.58

The driving frame is designed to be stiff and strong enough to sustain the actual loading conditions and to meet the required safety requirement as specified in the IEC 60601-1 standard.

7.2.2 Lifting Column Stand

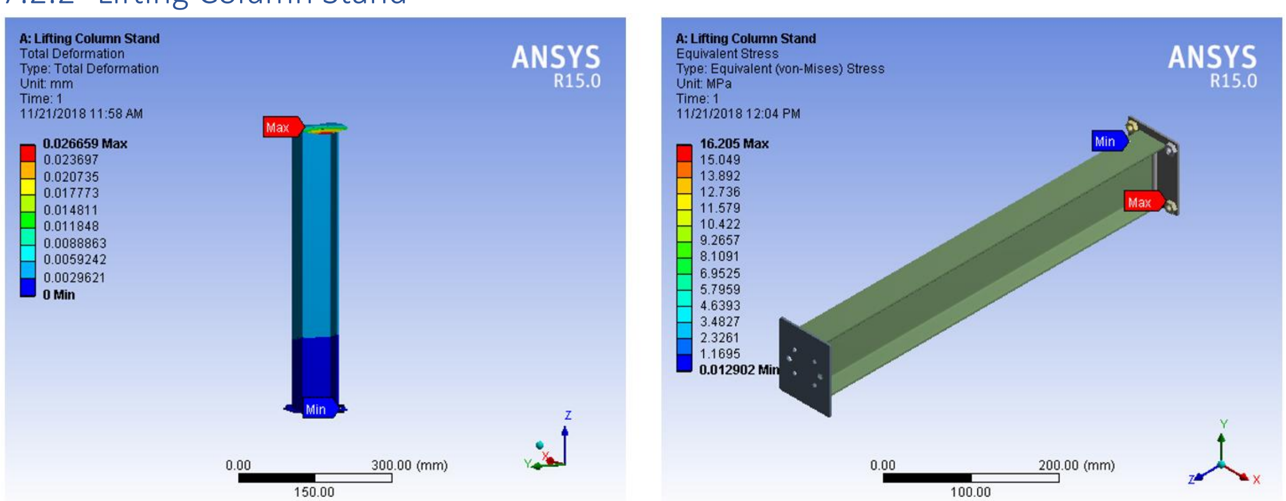


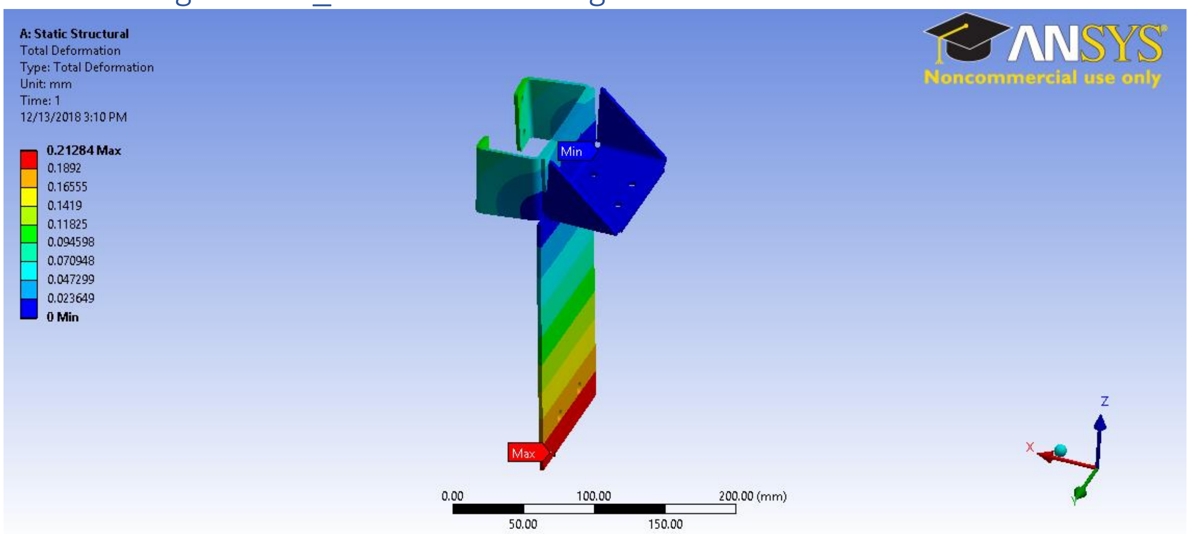
FIGURE 25: FEM SIMULATION OF LIFTING COLUMN STAND

Results:

- Max. Equivalent stress = 16.205 MPa
- Max Deformation = 0.026 mm
- Tensile Strength = 460 MPa
- Safety Factor = 28.38

The Lifting column stand is made of a standard I-beam cross section which is chosen according to DIN 1025-1 (smallest available size) and welded to two 3mm thick sheet metal plates on either side. This design proved to meet the requirements in terms weight, stiffness, and safety.

7.2.3 Lifting column_monitor mounting bracket



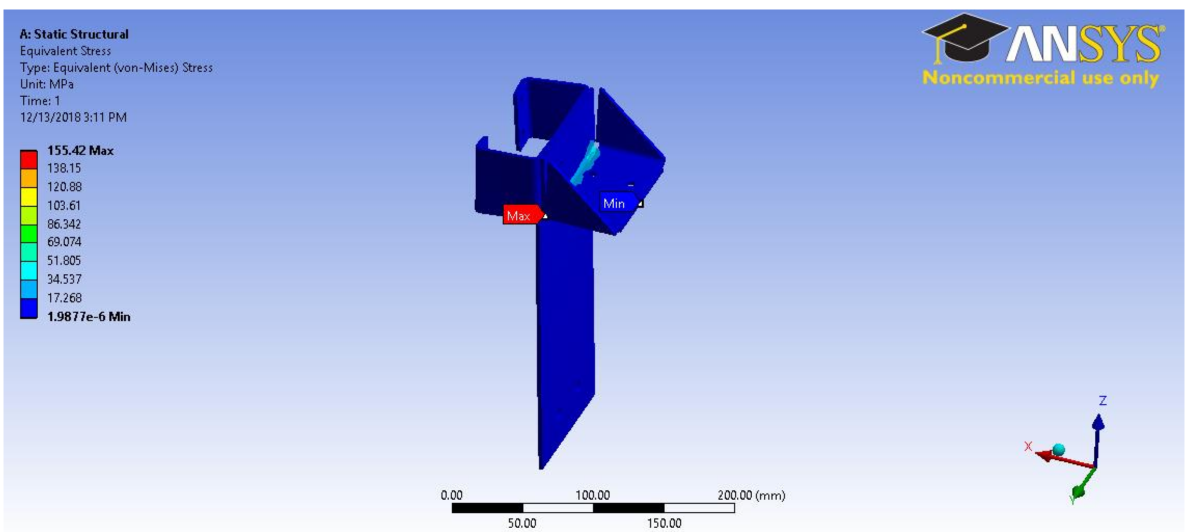


FIGURE 26: FEM SIMULATION OF LIFTING COLUMN_MONITOR MOUNTING BRACKET

Results:

- Max. Equivalent stress = 155.42 MPa

- Max Deformation = 0.214 mm
- Tensile Strength = 460 MPa
- Safety Factor = 2.96

From the results of the simulation, it is decided to weld the corners where the maximum stress occurred. The thickness and design of the part was concluded to be sufficient.

7.2.4 Monitor mounting bracket

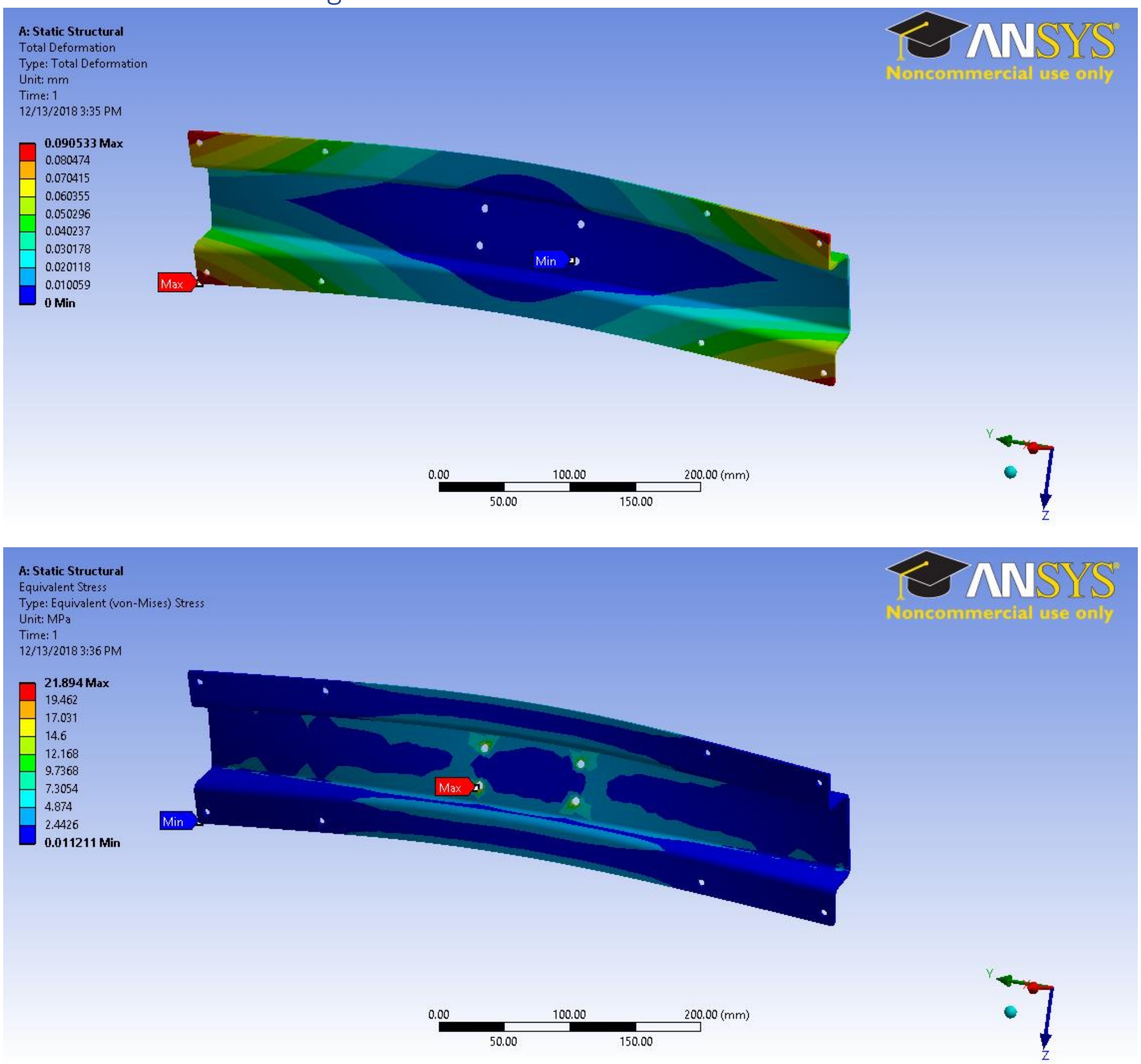


FIGURE 27: FEM SIMULATION OF MONITOR MOUNTING BRACKET

Results:

- Max. Equivalent stress = 21.89 MPa
- Max Deformation = 0.09 mm
- Tensile Strength = 460 MPa
- Safety Factor = 21.01

From the result of the simulation it is concluded that the design proved to meet the requirements in terms weight, stiffness, and safety.

7.3 Assembly and Cabling considerations

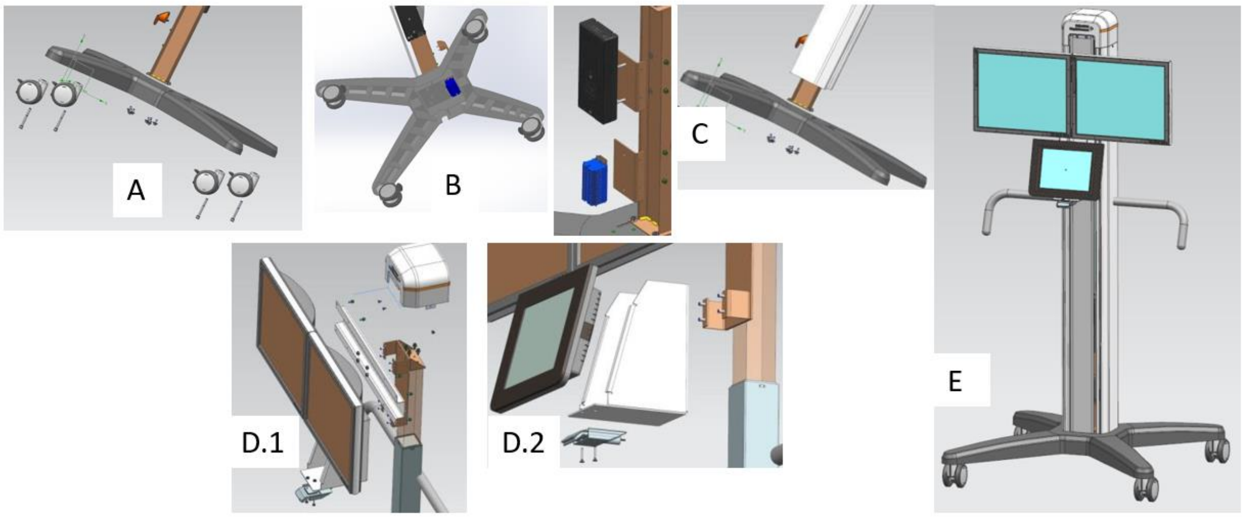


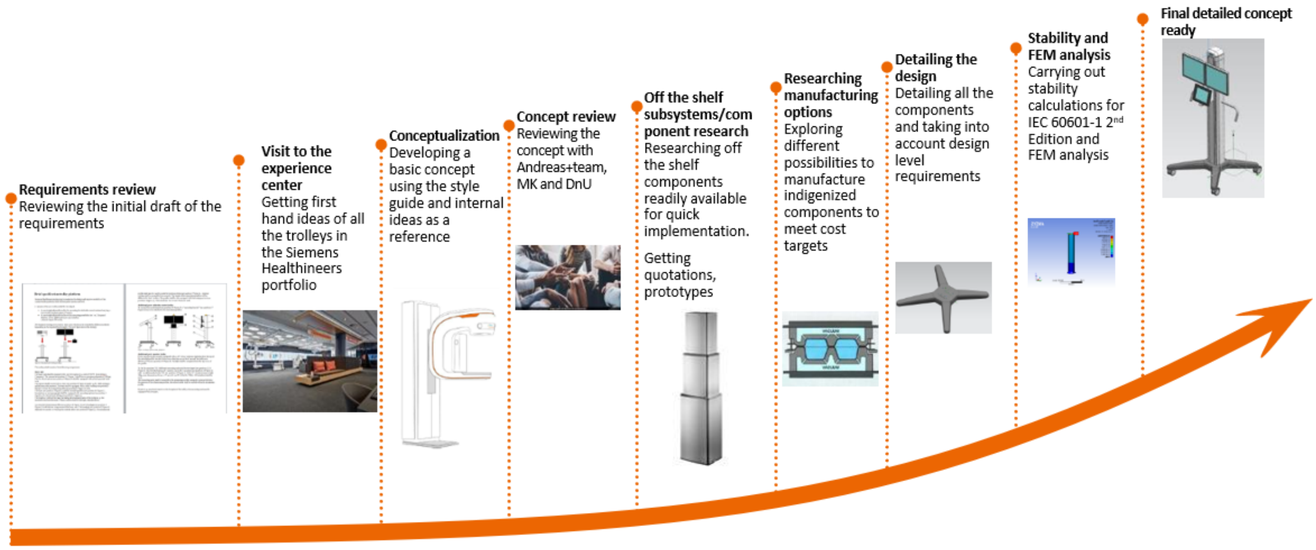
FIGURE 28: SUMMARY OF ASSEMBLY STEPS

An important consideration during the design phase of the display trolley is the assembly procedure. Close attention is paid to ensure only standard hardware is used for mating components and the assembly steps that can be carried out easily. It is also kept in mind that adjustment procedures are kept to the minimum. In the case of this design, the lifting column_monitor mounting bracket needs to be adjusted slightly with respect to the column such that the gap on either side of the front cover of the column remains equal to avoid any interference during the longitudinal travel of the displays.

An explanation of the summary as depicted in Figure 28 can be seen below:

- A : Mounting of wheels to the driving frame; Mounting the lifting column stand to the driving frame
- B : Mounting of the terminal block to the bottom of the driving frame; Mounting the Lifting column controller to the Lifting column stand
- C : Mounting the Column to the driving frame; mounting the cable holders to the column.
- D.1 : Mounting the Lifting column on the lifting column; Mounting the lifting column_monitor mounting bracket to the lifting column; Mounting the monitor mounting bracket; Mounting the displays.
- D.2 : Mounting the TUI holder mounting bracket assembly to the lifting column_monitor mounting bracket; Mounting the TUI holder mounting bracket; Mounitng the Touch User Interface and the lifting column control switch
- E : Final assembly of the mechanical structure is ready.

8 Summary



9 Conclusion

This report discusses the design and development of a display trolley with a modular design. The design of the driving frame of the trolley is the most critical element of the structure. The selection of the commercial off-the-shelf components was carried out for the two additional features as stated in 4.3. After a cost benefit analysis, it was decided not to proceed with the integration of the “central braking of castor wheels” feature.

The size of the driving frame was finalized after carrying out multiple iterations to ensure the stability of the entire trolley structure and also keeping the overall weight light in order to get a cost benefit. An easy to use excel sheet was developed so that it could be easily modified in case of any change in the position or weights of any of the components. The excel sheet aided in carrying out a stability analysis for all 4 variants easily.

The Finite Element Analysis of the showed the design for structurally safe for the real loading conditions. The FEM results for the “Lifting column_monitor mounting bracket” showed that design needed to incorporate welding at the corner joints of the sheet metal bend. [8]

During the final review of the design of the trolley, the assembly and cabling considerations were discussed. After this review, a change in the position of the power distribution was incorporated with its position being changed to within the column to under the driving frame. This modification effectively changed the way the cable would be routed from within the trolley with the cable now being routed from the side of the driving frame and then moving upwards through a slot.

Figure 29 shows the final renderings of all the 4 variants that were designed during the course of this internship assignment.

FIGURE 29: FINAL RENDER OF ALL 4 VARIANTS OF THE DISPLAY TROLLEY

10 Recommendation

During the course of this assignment, it was seen that the time involved in the design process of the 'driving frame' and the 'column' was considerable compared to the other parts. This was expected, since these are the two most critical components of the design of the modular display trolley in terms of structural integrity and cost of the component. With the advancements of machine learning extended greatly into all fields including design of structures, it would be highly beneficial if **'Generative design'** manufacturing tools could be introduced quickly in the prototyping phase of projects. This would have significantly reduced the time required for developing the driving frame and column.

Generative design is an iterative design process that involves a program that will generate a certain number of outputs that meet certain constraints, and a designer that will fine tune the feasible region by changing minimal and maximal values of an interval in which a variable of the program meets the set of constraints, in order to reduce or augment the number of outputs to choose from [9].

Companies like **Autodesk** offer generative design solutions along with their 3D modelling software that use the power of cloud computing to explore all different possibilities of designing a component according to the parameters set by the designer or the engineer. With new advancements in this technology, the limitations of the earlier versions of this tool have been improved. Parameters like manufacturing and cost constraints are also taken into account by the software's algorithms. An example of how generative design emulates the nature's evolutionary approach to design to come up with an optimum design in terms of strength and weight is shown in …

FIGURE 30: AN EXAMPLE OF A PART PRODUCED AS AN OUTCOME OF THE GENERATIVE DESIGN APPROACH [10]

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APPENDIX

Brief specification trolley platform

Siemens Healthineers is planning to modernise the design and improve usability of the current trolley portfolio while lowering the current cost level.

2 variants of the new trolleys shall be developed:

- A non-height adjustable trolley for mounting the tableside control unit and carrying a foot switch (Annual output 110 units).
- A non-height adjustable trolley with a mounting possibility for 1 or 2 flat panel displays and an additional touch user interface
  (Annual output 250 units)

Development strategy is to create a basic unit, which can be extended by different modules depending on the required functionality. The next figure shows the strategy.

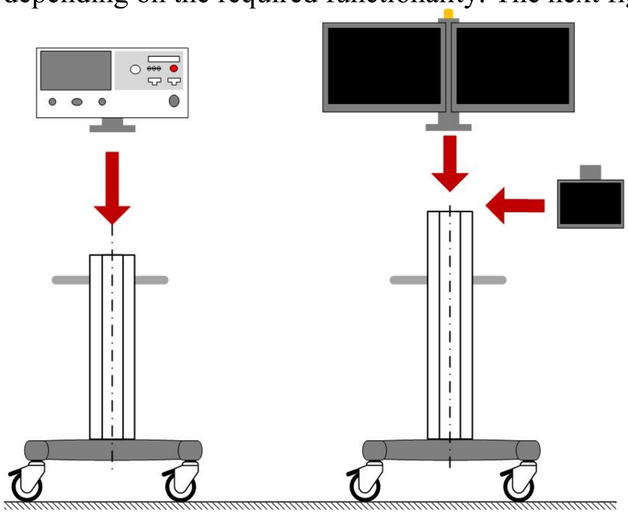


Figure 1: Development strategy trolleys

The trolleys shall consist of the following components:

Basic unit
The basic unit shall be equipped with 4 swivel castors (e.g. series 550/551 from Steinco Company). The castors (see position 1/2 Figure 2) shall have a minimum diameter of 100mm. The two front castors (see position 1 Figure 2) shall be equipped with as foot operated total lock.
The castors shall be screwed to a base (see position 3 Figure 2) made e.g. by chill casting or milled from solid material. The base shall be equipped with a cable bushing (see position 5 Figure 2) where the connecting cable (see position 6 Figure 2) exits.
The base (see position 3 Figure 2) and the extruded profiles (see position 10 Figure 2 – description see next paragraph) shall be equipped with mounting options (see position 4 Figure 2) for the internal cabling (see position 7 Figure 2).
The length or width of the base (including all attachment parts of the trolleys e.g. the monitors) shall not decrease 870mm (trolleys shall fit through a standard door).

An extruded aluminium profile (see position 10 Figure 2) and a handgrip (see position 9 Figure 2) build the last components of the basic unit. The handgrip (see position 9 Figure 2) shall also be useable to wind up the related cables (see position 6 Figure 2). The aluminium profile shall also be used to guide the internal cables (see position 7 Figure 2 - internal cabling shall be accessible but covered). The height of the aluminium profiles will be different for the 2 trolleys. The profile shall be also equipped with fastening grooves (see position 8 Figure 2), which shall also be covered when not used.

Additional parts tableside control trolley

To mount the control panel (see position 16 Figure 2) a “mounting bracket” (see position 17 Figure 2) has to be attached to the aluminium profiles.

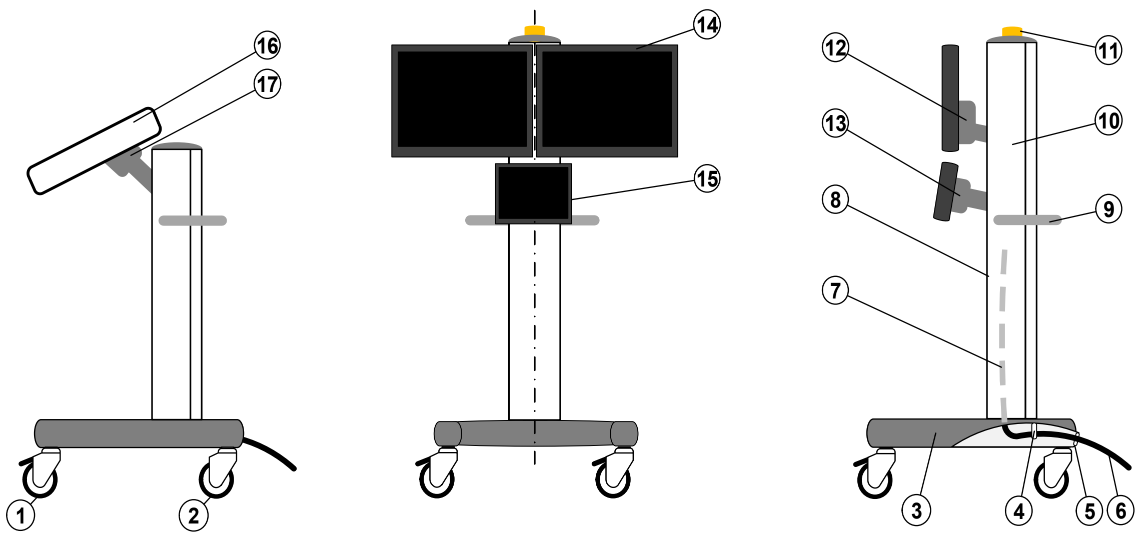


Figure 2: Design of the trolley platform

Additional parts monitor trolley

Every monitor trolley must be equipped with a 24V X-Ray indicator light placed at the top of the extruded profile viewable from every direction on eye level around the trolley at a distance of 5m (see position 11 Figure 2), the light shall be integrated into the top cover of the profile.

To fix the monitors/TUI 3 different mounting units shall be developed (see position 12/13 Figure 2). One for the fixation of 1 monitor, one to fix 2 monitors (see position 14 Figure 2), and 1 to additionally fix the TUI (see position 15 Figure 2). Only 19’’ monitors (max weight 10kg, max. dimensions 42 cm x 47 cm x 21 cm (W x H x D), VESA 100 interface) shall be used.

The mounting units shall be mounted to the aluminium profiles using slot nuts inserted into the grooves of the aluminium profiles, the related cables shall be routed within the aluminium profile.

If parts (e.g. monitors) stand over the footprint of the trolleys the mounting unit must be equipped with a bumper.

When necessary, compliance is checked by connecting the ME EQUIPMENT to a specified SUPPLY MAINS from which the most unfavourable short-circuit current expected can be drawn in the event of a fault in the MAINS PART. Subsequently, a fault in a single insulation in the MAINS PART is simulated so that the fault current is the least favourable. The occurrence of any HAZARDOUS SITUATIONS listed in 13.1.2 constitutes a failure.

9 * Protection against MECHANICAL HAZARDS of ME EQUIPMENT and ME SYSTEMS

9.1 MECHANICAL HAZARDS of ME EQUIPMENT

For general requirements on design and manufacture of ME EQUIPMENT, see Clause 4 and 15.3.

Table 19 identifies the subclauses that address the MECHANICAL HAZARDS.

Table 19 – MECHANICAL HAZARDS covered by this clause

MECHANICAL HAZARD	Covered by subclause
Crushing HAZARD	9.2, 9.4 and 9.8
Shearing HAZARD	9.2 and 9.8
Cutting or severing HAZARD	9.2, 9.3 and 9.8
Entanglement HAZARD	9.2
Trapping HAZARD	9.2
Stabbing or puncturing HAZARD	9.2, 9.3 and 9.8
Friction or abrasion HAZARD	9.2 and 9.3
Expelled parts HAZARD	9.5
High pressure fluid ejection HAZARD	9.7
Falling HAZARD	9.8
Instability HAZARD	9.4
Impact HAZARD	9.2 and 9.8
Moving and positioning of PATIENT	9.2 and 9.4
Vibration and noise	9.6

9.2 * MECHANICAL HAZARDS associated with moving parts

9.2.1 * General

ME EQUIPMENT with moving parts shall be designed, built and laid out so that, when PROPERLY INSTALLED and used as indicated in the ACCOMPANYING DOCUMENTS or under reasonably foreseeable misuse, the RISKS associated with those moving parts are reduced to an acceptable level.

The RISK from contact with the moving parts shall be reduced to an acceptable level by use of ~~protective~~ RISK CONTROL measures, bearing in mind the ease of access, the ME EQUIPMENT'S function, the shape of the parts, the energy and speed of the motion and the benefits to the PATIENT.

The RESIDUAL RISK associated with moving parts is considered acceptable if exposure is needed for the ME EQUIPMENT to perform its intended function~~. If after all reasonable protective measures have been implemented HAZARDS persist, warnings shall be marked on the ME EQUIPMENT or given in the instructions for use.~~, and RISK CONTROL measures have been implemented (e.g. warnings).

NOTE 1 Requirements for parts subject to wear are found in 15.2.

NOTE 2 See ISO 14971:2007, subclauses 6.2 and 6.5.

9.2.2 TRAPPING ZONE

9.2.2.1 General

Where feasible, ME EQUIPMENT with a TRAPPING ZONE shall comply with the requirements of one or more of the following:

– gaps as specified in 9.2.2.2; or
– safe distances as specified in 9.2.2.3; or
– GUARDS and ~~protective~~ other RISK CONTROL measures as specified in 9.2.2.4; or
– continuous activation as specified in 9.2.2.5.

If implementation of the above ~~protective~~ RISK CONTROL measures would be inconsistent with the INTENDED USE of the ME EQUIPMENT or the ME SYSTEM, control of the relevant motion shall comply with 9.2.2.6.

9.2.2.2 Gaps

A TRAPPING ZONE is considered not to present a MECHANICAL HAZARD if the gaps of the TRAPPING ZONE comply with the dimensions specified in Table 20.

NOTE In general the values for adults should be used. However, in the case of devices specifically designed for use with children, the dimensions given for children should be applied.

9.2.2.3 Safe distances

A TRAPPING ZONE is considered not to present a MECHANICAL HAZARD if the distances separating the OPERATOR, PATIENT and other persons from the TRAPPING ZONES exceed the values specified in ~~ISO 13852~~ ISO:13857:2008. The distances are measured from the expected positions of the OPERATOR, PATIENT and other persons near the ME EQUIPMENT in NORMAL USE or under reasonably foreseeable misuse.

9.2.2.4 * GUARDS and ~~protective~~ other RISK CONTROL measures

9.2.2.4.1 Access to TRAPPING ZONES

A TRAPPING ZONE is considered not to present a MECHANICAL HAZARD if GUARDS ~~and protective~~ or other RISK CONTROL measures (e.g. electro-mechanical):

– are of robust construction;
– are not easy to bypass or render non-operational;
– do not introduce any additional unacceptable RISK.

NOTE RISK CONTROL measures (e.g. electro-mechanical) addressed by this subclause are intended to include collision detection or collision avoidance systems, such as those employing light barrier(s) and similar feedback control(s).

Compliance is checked by the applicable tests of 15.3 for ENCLOSURES.

9.2.2.4.2 FIXED GUARDS

FIXED GUARDS shall be securely held in place by systems that cannot be dismantled without the use of a TOOL.

Compliance is checked by inspection.

DESKLIFT™ DL17

Die DL17 Hubsäule setzt den Standard für Inlinesäulen. Die kompakte, quadratische Hubsäule wurde entwickelt, um die Marktanforderungen für ein kleines Einbaumaß bei einer gleichzeitig großen Hublänge zu erfüllen. Durch ihre sehr kleinen Abstände zwischen den Profilen und ihren unsichtbaren Gleitern ermöglicht die DL17 ein modernes Tisch-Design. Die Hubsäule wurde für Tische ohne Quertraverse entwickelt, welches eine größere Beinfreiheit und mehr Design-Möglichkeiten bietet. Standardmäßig enthält die DL17 die PIEZO™ Funktion – ein integrierter Sensor, der das Risiko von Materialschäden am Tisch minimiert, die durch Einklemmen oder Blockierung durch ein Hindernis verursacht werden können. Die DL17 wird ohne die Verwendung von PVC produziert, was einen umweltfreundlichen Vorteil darstellt. Die Säule wird standardmäßig mit Profilen in den Farben Tiefschwarz, Weißaluminium oder Verkehrsweiß geliefert oder ganz einfach auch in einer kundenspezifischen Farbe (optional).

Die DL17 ist kompatibel mit allen DESKLINE® Steuereinheiten und Bedienelementen – ganz einfach durch Plug & Play™.

Merkmale:
- 3-teilige Inline Hubsäule
- Quadratisches Profil, Außenprofil 70 x 70 mm
- Kraft: bis zu 700 N pro Bein
- Geschwindigkeit: bis zu 38 mm/s
- Standard Einbaumaß: 518 mm oder 545 mm
- Standard Hublänge: 660 mm
- Gewicht: 8,0 kg per Säule (DL17000B0E660545)
- Farbe: alle Teile Tiefschwarz (RAL 9005), alle Teile Weißaluminium (RAL 9006) oder alle Teile Verkehrsweiß (RAL 9016)
- Unsichtbare Gleiter für ein optimiertes Design
- Geringer Abstand zwischen den Profilen für ein optimiertes Design
- PIEZO™ minimiert das Risiko von Schäden am und um den Tisch
- PVC-freie (PVC-free™) Hubsäule für ein umweltfreundliches Produkt
- Niedriges Geräuschniveau
- Gleichlauf des mittleren Profils
- Separate Motorkabel
- Biegemoment: My = max. 150 Nm dynamisch
- Bench-Beschlag für Bench-Lösungen

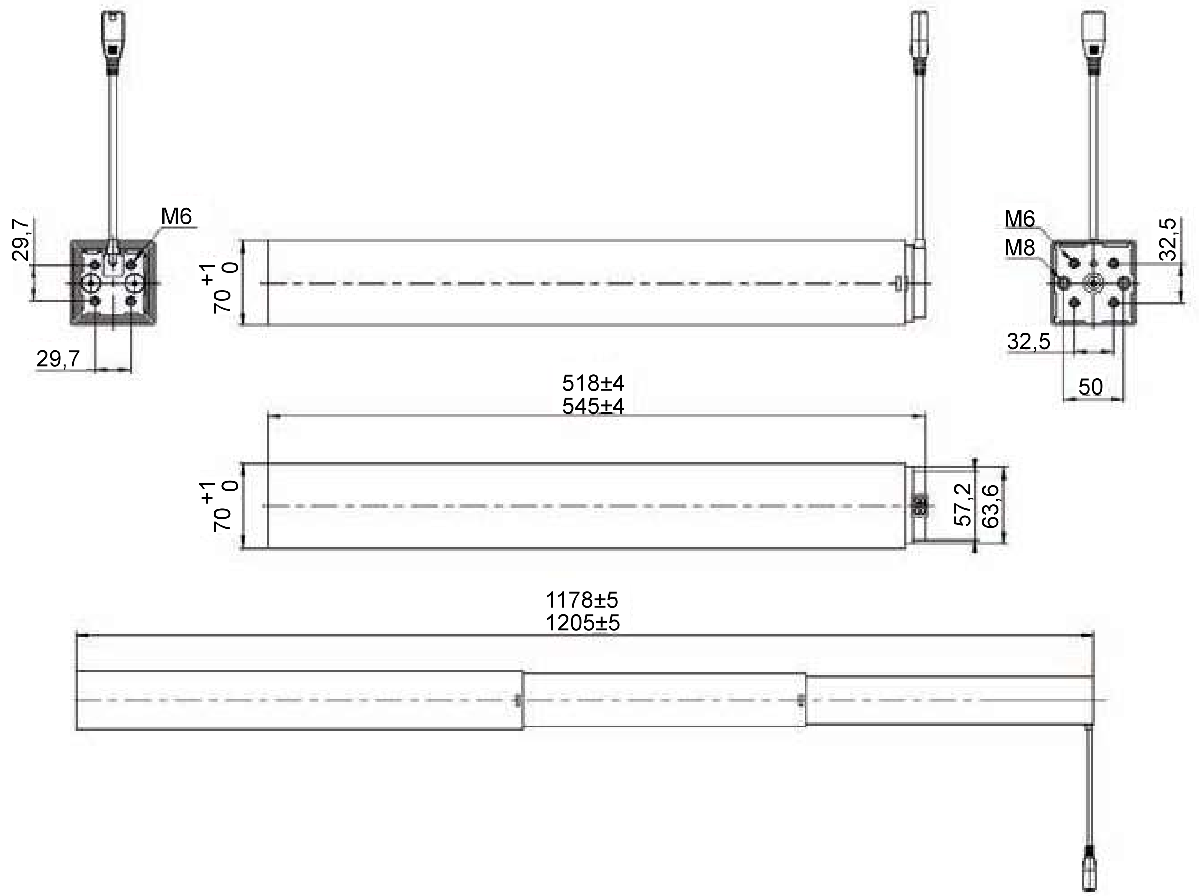
Optionen:
- Kundenspezifische Farben
- Beschlag für Quertraverse (kundenspezifische Version)
- Adapter für Motorgehäuse montiert oder als eine separate Einheit. Immer schwarz.

Verwendung:
- Einzeln oder 2-, 3- und 4-parallel
- Einschaltdauer: 10 % ~ 6 Minuten pro Stunde oder 2 Minuten Dauerbetrieb bei Volllast
- Umgebungstemperatur: +10° bis +40 °C
- Kompatibel mit DESKLINE® Steuereinheiten und DESKLINE® Bedienelementen
- Zugelassen entsprechend EN 60335-1
- Zugelassen entsprechend UL 962 mit CBD6S
- Lager- und Transporttemperatur: -10 °C bis +70 °C
- Kompatibel mit DESKLIFT™ Feet

Technische Spezifikationen:

Typ/ Anwendung	Max. Kraft pro DL [N]	Selbstsperrkraft pro DL [N]	Geschwindigkeit ohne Last [mm/s]	Einschaltdauer [%]	Spindelsteigung [mm]	Hublänge [mm]	Einbaumaß [mm]
DL17	700	700	38	10	20	660	518/545

Abmessungen DL17 ohne Beschlag



CBD6S 200W und 300 W (SMPS)

Die DESKLINE® Steuereinheit CBD6S (SMPS) ist die optimale Wahl für unterschiedliche Möbelapplikationen. Die CBD6S ist ideal, wenn Sie eine kleine und kompakte Steuereinheit benötigen, die auf kleinstem Raum montiert werden kann. Die CBD6S bringt die Reihe der intelligenten DESKLINE Steuereinheiten auf eine neue Ebene. Sie kombiniert das Beste aus der Vergangenheit mit neuen Features. Sie ist die kompakteste und leichteste Steuereinheit der DESKLINE Serie. Sie verfügt über die gleiche Breite wie das Motorgehäuse der DESKLINE Säulen. Dadurch wir gewährleistet, dass sie in einen Tischrahmen passt – sie ist nur 38 mm hoch. Die CBD6S ist eine intuitive Steuereinheit. An beiden Enden der Steuerung befinden sich Anschlüsse für Säulen. Über Kabelführungen im Gehäuseboden können die Motorkabel ganz einfach von einer Seite des Tisches zur anderen geführt bzw. verborgen werden. Zur besseren Erkennung unter dem Tisch sind die Anschlussbuchsen weiß.

Die CBD6S ist in 2 Hauptversionen erhältlich: eine 2-Kanal Version (200 W) und eine 2, 3 oder 4-Kanal Version mit mehr Leistung (300 W). Die CBD6S 300 W verfügt über einen Weitbereichseingang, der sich an die länderspezifische Spannung anpasst. Die Steuereinheiten CBD6S sind kompatibel mit dem DESKLINE Produktprogramm. Sie sorgt für ein gleichmäßiges Verfahren sowie Soft-Start/Stopp der angeschlossenen Beine. Weitere Merkmale sind die automatische Erkennung des Antriebstyps und die Erkennung der Anzahl der angeschlossenen Beine. Dadurch kann die CBD6S sehr intuitiv in einem Tisch eingesetzt werden.

Die CBD6S ist eine umweltfreundliche Steuereinheit, die einen extrem niedrigen Stromverbrauch von nur 0,1 W im Standby-Modus hat und PVC-frei™ ist.

Merkmale CBD6S 200 W:
- An die CBD6S können ein oder zwei DESKLINE® Antriebe/Säulen angeschlossen werden
- Netzspannung: 230 V AC, 50Hz oder 120 V AC, 60 Hz
- Äußerst kompakt: nur 210 mm lang
- Leichte Steuereinheit mit einem Gewicht von nur ca. 400 g

Merkmale CBD6S 300 W:
- An die CBD6S können 1, 2, 3 oder 4 DESKLINE® Antriebe/Säulen angeschlossen werden
- Netzspannung: 100 - 240 V AC, 50 Hz - 60 Hz (universal)
- Äußerst kompakt: nur 265 mm lang
- Leichte Steuereinheit mit einem Gewicht von nur ca. 500 g

Allgemeine Merkmale für CBD6S (200 W und 300 W):
- Niedrige Höhe: 38 mm
- Kompaktes Hochleistungsschaltnetzteil (SMPS)
- Farbe: Schwarz
- Überlastschutz (EOP) durch individuelle Strombegrenzung
- Soft-Start/Stopp Funktion
- Automatische Erkennung der Anzahl der angeschlossenen Antriebe/Säulen
- Automatische Erkennung des angeschlossenen Bein-/Säulentyps
- Kabelführungen am Boden für ein optimales Kabelmanagement
- Leicht erkennbare weiße Stecker zur Montage/Demontage
- PVC-frei™ als Standard
- Der Stromverbrauch im Standby-Modus beträgt nur 0,1 W (ZERO™ Technologie)
- Austauschbares Standard Netzkabel

Optionen:
- Anti-Kollision™ (nur für 3-stufige Säulen)
- Multiparallel Software ist für beide Versionen erhältlich
- Kompatibel mit der Akkubox BA001 (ab CBD6 mit sw 1.37 und neuer)
- Die CBD6S hat standardmäßig eine Multiparallel-Software (ab sw 1.37 und neuer)
- Kompatibel mit CBDSLS

...Fortsetzung

Fortsetzung

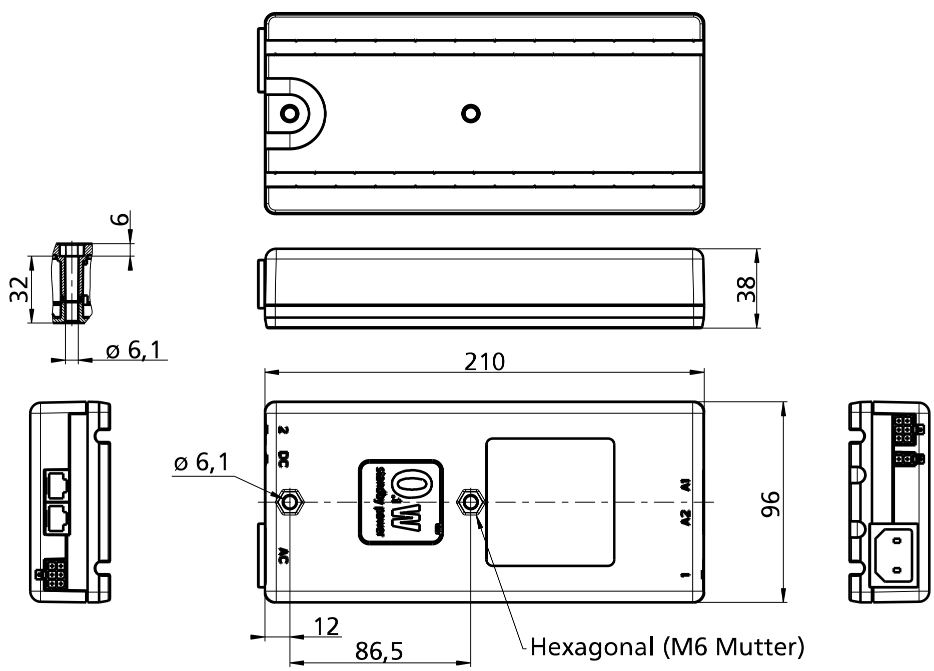
Verwendung:

- Einschaltdauer: max. 10 % ~ 6 Minuten pro Stunde oder 2 Minuten Dauerbetrieb bei Volllast
- Die Steuerung ist mit allen DESKLINE-Säulen und eingebauten Aktuatoren und DESKLINE Bedienelementen komptatibel.
- Für LA23, LA31, DL1A, DL2 und DL61 1200 N ohne PIEZO™ und BL1 ist eine spezielle Konfiguration erforderlich (CBD6S Konfigurator)
- Die CBD6S 200 W (230 V) ist geprüft gemäß EN 60335-1, EN 13849-1 und UL 962
- Die CBD6S 200 W (120 V) ist geprüft gemäß UL 962
- Die CBD6S 300 W ist geprüft gemäß EN 60335-1, EN 13849-1 und UL 962

Anmerkung:

230 V Version	Für die Europäischen und Australischen Märkte
120 V Version	Für die US und Japanischen Märkte
Universal	Die 300 W Steuereinheit ist allgemein gehalten und kann weltweit verwendet werden

CBD6S (200 W) Abmessungen [mm]:



DPG1K

Das Desk Panel DPG1K ist ein intuitives Desk Panel mit den Grundfunktionen eines Bedienelementes: Auf- und Abfahren eines Bürotisches.

Das DPG wird durch Neigen des Desk Panels in die gleiche Richtung, in die der Tisch verfahren werden soll, aktiviert. Dadurch ist es ein intuitives Bedienelement. Die Form des DPG ermöglicht es, den Schreibtisch zu verfahren, ohne auf das Desk Panel zu schauen. Auf diese Weise kann sich der Anwender weiterhin auf seine Arbeit konzentrieren, während er die Position ändert.

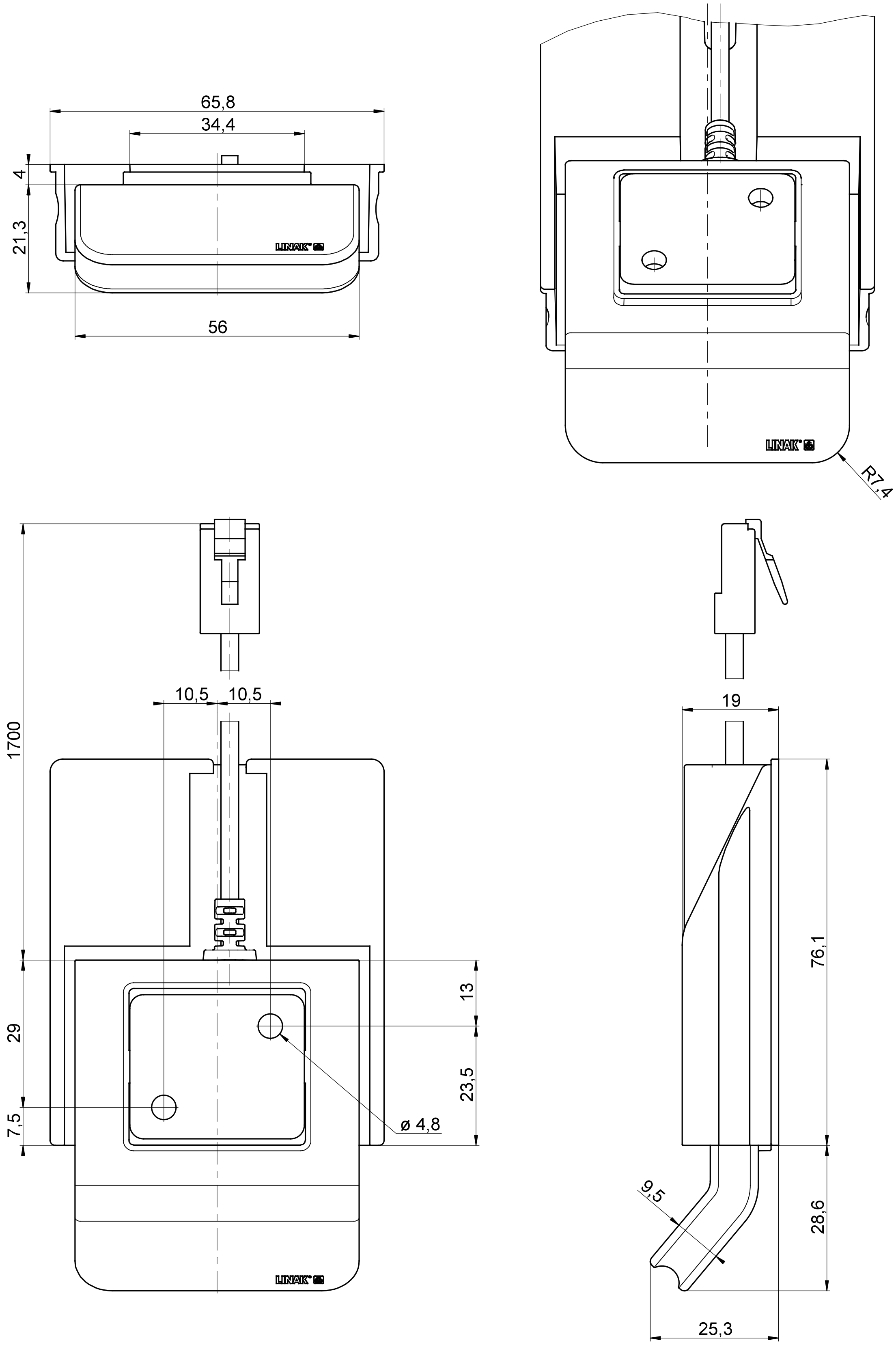
Das DPG1K ist klein und einfach, verfügt über ein modernes Design und passt zu allen Arten von Tischen.

Merkmale:
- Intuitives Desk Panel für einfaches Auf-/Ab-Verfahren
- Farbe: Tiefschwarz (RAL 9005)
- Schwarzes Kabel mit modularem Jack-Stecker, 1.700 mm gerade
- PVC-Frei™
- Mit ZERO™-Funktion: sehr niedriger Stromverbrauch im Standby-Modus

Optionen:
- Kundenspezifisches Logo auf der Vorderseite

Verwendung:
- Umgebungstemperatur: +5 °C bis +40 °C
- Kompatibel mit DESKLINE® Steuereinheiten oder DL IC Systemen
- Geprüft gemäß EN 60335-1
- Zugelassen gemäß UL962

Abmessungen [mm]:

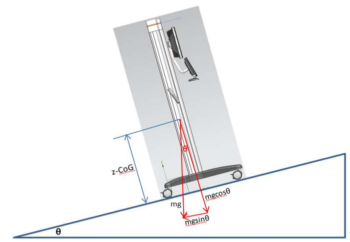


Calculation sheet-1

Component	x	y	z	m(kg)	mx	my	mz
Base	381.108	-0.014	155.321	9.279	3536.301	-0.12991	1441.224
Column front cover	423.095	0	997.11	2.381	1007.389	0	2374.119
Column	333.68	-0.002	974.296	10.33	3446.914	-0.02066	10064.48
Lifting column bracket	383.181	0	1525.272	1.099	421.1159	0	1676.274
TUI holder mounting bracket	402.931	0	1384.672	0.264	106.3738	0	365.5534
Monitor mounting bracket	447.434	0	1589.177	1.729	773.6134	0	2747.687
Plastic top cover	340.212	-0.002	1838.625	0.483	164.3224	-0.00097	888.0559
TUI mounting assm+LC switch	491.168	0	1263.46	2.29	1124.775	0	2893.323
Display 1	515	210	1585	5.7	2935.5	1197	9034.5
Display 2	515	-210	1585	5.7	2935.5	-1197	9034.5
TUI	592	0	1385	2.16	1278.72	0	2991.6
Handle 1	333.46	-190	1285	1.2	400.152	-228	1542
Handle 2	333.46	190	1285	1.2	400.152	228	1542
Lifting column	353.78	0	1148	7.25	2564.905	0	8323
I beam	353.782	-0.008	463.39	3.63	1284.229	-0.02904	1682.106
LC controller mounting bracket	343.365	19.956	569.007	0.234	80.34741	4.669704	133.1476
LC controller mounting bracket	343.365	19.956	347.007	0.234	80.34741	4.669704	81.19964
LC controller - CBD6S	354.278	42.75	610.873	0.4	141.7112	17.1	244.3492
Terminal block+rail	354.278	42.75	344.76	0.4	141.7112	17.1	137.904
Kabelhalter	250.44	0	871.102	0.188	47.08272	0	163.7672
Kabelhalter	250.44	0	413.947	0.188	47.08272	0	77.82204
wheel 1	0	410	50	0.8	0	328	40
wheel 2	0	-410	50	0.8	0	-328	40
wheel 3	820	-410	50	0.8	656	-328	40
wheel 4	820	410	50	0.8	656	328	40
				59.539	**24230.25**	**43.35884**	**57598.61**

CoG	
x	**406.9643**
y	**0.728243**
z	**967.4098**

Sideways			Forward			Back		
slope test			**slope test**			**slope test**		
Angle 'θ'	10	deg	Angle 'θ'	10	deg	Angle 'θ'	10	deg
Cog Height from ground	967.4098	mm	Cog Height from ground	967.4098	mm	Cog Height from ground	967.4098	mm
topple moment	98118.58	N-mm	topple moment	98118.58	N-mm	topple moment	98118.58	N-mm
Counter Moment	217468.4	N-mm	Counter Moment	216141.2	N-mm	Counter Moment	219633.5	N-mm
Stable			Stable			Stable		



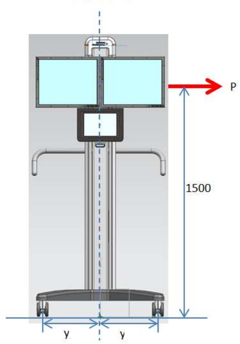
Case 1			
Pull force 'P'	146.0194		
pull height 'x'	1500		
y	378.0718		
Applied moment	219029.1	N-mm	
Counter moment	220823.2	N-mm	Stable

Case 2			
Pull force 'P'	146.0194		
pull height 'x'	1500		
y	379.5282		
Applied moment	219029.1	N-mm	
Counter moment	221673.9	N-mm	Stable

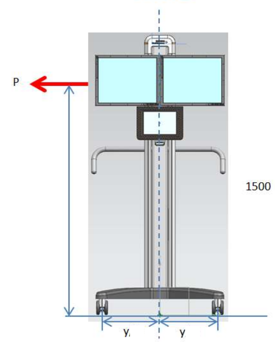
Case 3			
Pull force 'P'	146.0194		
pull height 'x'	1500		
xCOG	375.7643		
Applied moment	219029.1	N-mm	
Counter moment	219475.5	N-mm	Stable

Case 4			
Pull force 'P'	146.0194		
pull height	1500		
410 - xCOG	381.8357		
Applied moment	219029.1	N-mm	
Counter moment	223021.7	N-mm	Stable

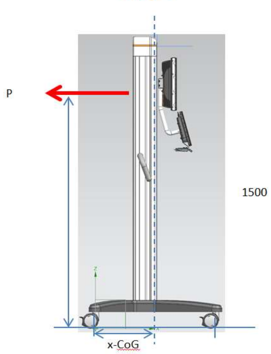
Case 1



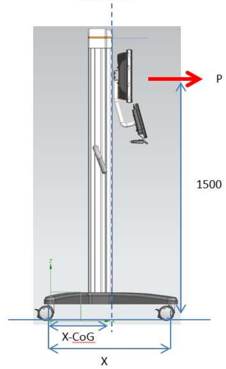
Case 2



Case 3



Case 4

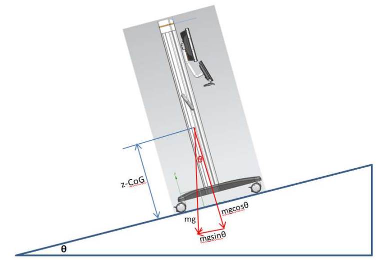


Calculation sheet-2

Component	x	y	z	m(kg)	mx	my	mz
Base	381.108	-0.014	155.321	9.279	3536.301	-0.12991	1441.224
Column front cover	423.095	0	997.11	2.381	1007.389	0	2374.119
Column	333.68	-0.002	974.296	10.33	3446.914	-0.02066	10064.48
Lifting column bracket	383.181	0	1525.272	1.099	421.1159	0	1676.274
TUI holder mounting bracket	402.931	0	1384.672	0.264	106.3738	0	365.5534
Monitor mounting bracket	447.434	0	1589.177	0.8645	386.8067	0	1373.844
Plastic top cover	340.212	-0.002	1838.625	0.483	164.3224	-0.00097	888.0559
TUI mounting assm+LC switch	491.168	0	1263.46	2.29	1124.775	0	2893.323
Display 1	515	0	1585	5.7	2935.5	0	9034.5
Display 2	515	210	1585	0	0	0	0
Counterweight 1	700	-340.64	120	**1.5**	1050	-510.96	180
Counterweight 2	700	340.64	120	**1.5**	1050	510.96	180
TUI	592	0	1385	2.16	1278.72	0	2991.6
Handle 1	333.46	-190	1285	1.2	400.152	-228	1542
Handle 2	333.46	190	1285	1.2	400.152	228	1542
Lifting column	353.78	0	1148	7.25	2564.905	0	8323
I beam	353.782	-0.008	463.39	3.63	1284.229	-0.02904	1682.106
LC controller mounting bracket	343.365	19.956	569.007	0.234	80.34741	4.669704	133.1476
LC controller mounting bracket	343.365	19.956	347.007	0.234	80.34741	4.669704	81.19964
LC controller - CBD6S	354.278	42.75	610.873	0.4	141.7112	17.1	244.3492
Terminal block+rail	354.278	42.75	344.76	0.4	141.7112	17.1	137.904
Kabelhalter	250.44	0	871.102	0.188	47.08272	0	163.7672
Kabelhalter	250.44	0	413.947	0.188	47.08272	0	77.82204
wheel 1	0	410	50	0.8	0	328	40
wheel 2	0	-410	50	0.8	0	-328	40
wheel 3	820	-410	50	0.8	656	-328	40
wheel 4	820	410	50	0.8	656	328	40
				55.9745	**23007.94**	**43.35884**	**47550.27**

CoG	
x	**411.0432**
y	**0.774618**
z	**849.4987**

Sideways			Forward			Back		
slope test			**slope test**			**slope test**		
Angle 'θ'	10	deg	Angle 'θ'	10	deg	Angle 'θ'	10	deg
Cog Height from ground	849.4987	mm	Cog Height from ground	849.4987	mm	Cog Height from ground	849.4987	mm
topple moment	81001.34	N-mm	topple moment	81001.34	N-mm	topple moment	81001.34	N-mm
Counter Moment	204842.8	N-mm	Counter Moment	205406.9	N-mm	Counter Moment	204278.6	N-mm
Stable			Stable			Stable		



Case 1		
Pull force 'P'	137.2775	
pull height 'x'	1500	
y	378.0254	
Applied moment	205916.2	N-mm
Counter moment	207577.5	N-mm

Stable

Case 2		
Pull force 'P'	137.2775	
pull height 'x'	1500	
y	379.5746	
Applied moment	205916.2	N-mm
Counter moment	208428.2	N-mm

Stable

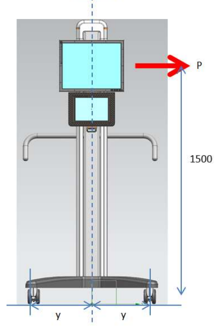
Case 3		
Pull force 'P'	137.2775	
pull height 'x'	1500	
xCOG	379.8432	
Applied moment	205916.2	N-mm
Counter moment	208575.7	N-mm

Stable

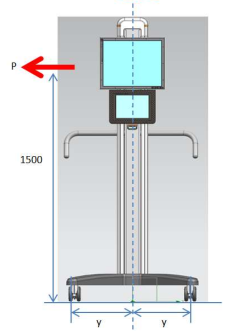
Case 4		
Pull force 'P'	137.2775	
pull height	1500	
410 - xCOG	377.7568	
Applied moment	205916.2	N-mm
Counter moment	207430	N-mm

Stable

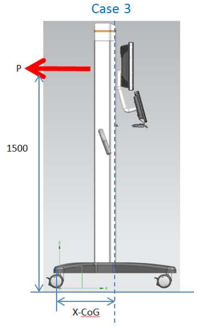
Case 1



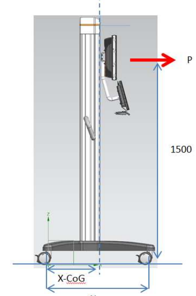
Case 2



Case 3



Case 4

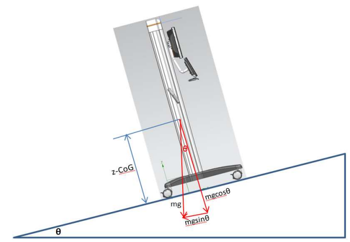


Calculation sheet-3

Component	x	y	z	m(kg)	mx	my	mz
Base	381.108	-0.014	155.321	9.279	3536.301	-0.12991	1441.224
Column front cover	423.095	0	997.11	2.381	1007.389	0	2374.119
Column	333.68	-0.002	974.296	10.33	3446.914	-0.02066	10064.48
Lifting column bracket	383.181	0	1525.272	1.099	421.1159	0	1676.274
TUI holder mounting bracket	402.931	0	1384.672	0	0	0	0
Monitor mounting bracket	447.434	0	1589.177	1.729	773.6134	0	2747.687
Plastic top cover	340.212	-0.002	1838.625	0.483	164.3224	-0.00097	888.0559
TUI mounting assm+LC switch	491.168	0	1263.46	0	0	0	0
Display 1	515	210	1585	5.7	2935.5	1197	9034.5
Display 2	515	-210	1585	5.7	2935.5	-1197	9034.5
TUI	592	0	1385	0	0	0	0
Counterweight 1	700	-340.64	120	**1.25**	875	-425.8	150
Counterweight 2	700	340.64	120	**1.25**	875	425.8	150
Handle 1	333.46	-190	1285	1.2	400.152	-228	1542
Handle 2	333.46	190	1285	1.2	400.152	228	1542
Lifting column	353.78	0	1148	7.25	2564.905	0	8323
I beam	353.782	-0.008	463.39	3.63	1284.229	-0.02904	1682.106
LC controller mounting bracket	343.365	19.956	569.007	0.234	80.34741	4.669704	133.1476
LC controller mounting bracket	343.365	19.956	347.007	0.234	80.34741	4.669704	81.19964
LC controller - CBD6S	354.278	42.75	610.873	0.4	141.7112	17.1	244.3492
Terminal block+rail	354.278	42.75	344.76	0.4	141.7112	17.1	137.904
Kabelhalter	250.44	0	871.102	0.188	47.08272	0	163.7672
Kabelhalter	250.44	0	413.947	0.188	47.08272	0	77.82204
wheel 1	0	410	50	0.8	0	328	40
wheel 2	0	-410	50	0.8	0	-328	40
wheel 3	820	-410	50	0.8	656	-328	40
wheel 4	820	410	50	0.8	656	328	40
				57.325	**23470.38**	**43.35884**	**51648.13**

CoG	
x	**409.4265**
y	**0.756369**
z	**900.9705**

Sideways			Forward			Back		
slope test			**slope test**			**slope test**		
Angle 'θ'	10	deg	Angle 'θ'	10	deg	Angle 'θ'	10	deg
Cog Height from ground	900.9705	mm	Cog Height from ground	900.9705	mm	Cog Height from ground	900.9705	mm
topple moment	87982.01	N-mm	topple moment	87982.01	N-mm	topple moment	87982.01	N-mm
Counter Moment	209785	N-mm	Counter Moment	209467.4	N-mm	Counter Moment	210102.6	N-mm
Stable			Stable			Stable		



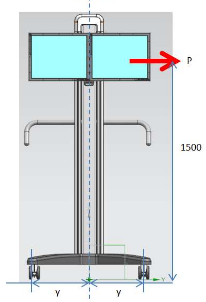
Case 1			
Pull force 'P'	140.5896		
pull height 'x'	1500		
y	378.0436		
Applied moment	210884.3	N-mm	
Counter moment	212596	N-mm	Stable

Case 2			
Pull force 'P'	140.5896		
pull height 'x'	1500		
y	379.5564		
Applied moment	210884.3	N-mm	
Counter moment	213446.7	N-mm	Stable

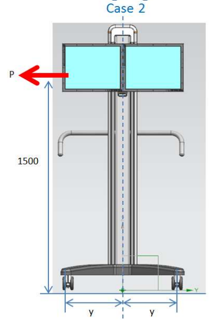
Case 3			
Pull force 'P'	140.5896		
pull height 'x'	1500		
xCOG	378.2265		
Applied moment	210884.3	N-mm	
Counter moment	212698.8	N-mm	Stable

Case 4			
Pull force 'P'	140.5896		
pull height	1500		
410 - xCOG	379.3735		
Applied moment	210884.3	N-mm	
Counter moment	213343.8	N-mm	Stable

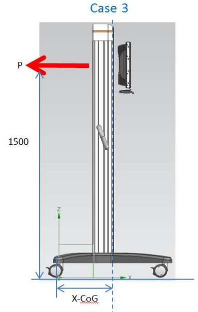
Case 1



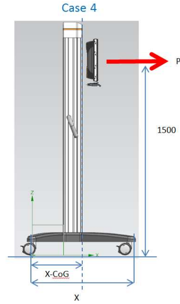
Case 2



Case 3



Case 4



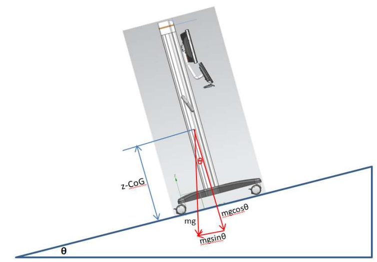
Calculation sheet-4

Component	x	y	z	m(kg)	mx	my	mz
Base	381.108	-0.014	155.321	9.279	3536.301	-0.12991	1441.224
Column front cover	423.095	0	997.11	2.381	1007.389	0	2374.119
Column	333.68	-0.002	974.296	10.33	3446.914	-0.02066	10064.48
Lifting column bracket	383.181	0	1525.272	1.099	421.1159	0	1676.274
TUI holder mounting bracket	402.931	0	1384.672	0	0	0	0
Monitor mounting bracket	447.434	0	1589.177	1.729	773.6134	0	2747.687
Plastic top cover	340.212	-0.002	1838.625	0.483	164.3224	-0.00097	888.0559
TUI mounting assm+LC switch	491.168	0	1263.46	0	0	0	0
Display 1	515	0	1585	5.7	2935.5	0	9034.5
Display 2	515	-210	1585	0	0	0	0
TUI	592	0	1385	0	0	0	0
Counterweight 1	700	-340.64	120	**2.25**	1575	-766.44	270
Counterweight 2	700	340.64	120	**2.25**	1575	766.44	270
Handle 1	333.46	-190	1285	1.2	400.152	-228	1542
Handle 2	333.46	190	1285	1.2	400.152	228	1542
Lifting column	353.78	0	1148	7.25	2564.905	0	8323
I beam	353.782	-0.008	463.39	3.63	1284.229	-0.02904	1682.106
LC controller mounting bracket	343.365	19.956	569.007	0.234	80.34741	4.669704	133.1476
LC controller mounting bracket	343.365	19.956	347.007	0.234	80.34741	4.669704	81.19964
LC controller - CBD6S	354.278	42.75	610.873	0.4	141.7112	17.1	244.3492
Terminal block+rail	354.278	42.75	344.76	0.4	141.7112	17.1	137.904
Kabelhalter	250.44	0	871.102	0.188	47.08272	0	163.7672
Kabelhalter	250.44	0	413.947	0.188	47.08272	0	77.82204
wheel 1	0	410	50	0.8	0	328	40
wheel 2	0	-410	50	0.8	0	-328	40
wheel 3	820	-410	50	0.8	656	-328	40
wheel 4	820	410	50	0.8	656	328	40
				53.625	**21934.88**	**43.35884**	**42853.63**

CoG	
x	**409.042**
y	**0.808556**
z	**799.1353**

40

Sideways			Forward			Back		
slope test			**slope test**			**slope test**		
Angle 'θ'	10	deg	Angle 'θ'	10	deg	Angle 'θ'	10	deg
Cog Height from ground	799.1353	mm	Cog Height from ground	799.1353	mm	Cog Height from ground	799.1353	mm
topple moment	73000.68	N-mm	topple moment	73000.68	N-mm	topple moment	73000.68	N-mm
Counter Moment	196244.6	N-mm	Counter Moment	195748.3	N-mm	Counter Moment	196740.9	N-mm
Stable			Stable			Stable		



Case 1		
Pull force 'P'	131.5153	
pull height 'x'	1500	
y	377.9914	
Applied moment	197273	N-mm
Counter moment	198846.7	N-mm

Stable

Case 2		
Pull force 'P'	131.5153	
pull height 'x'	1500	
y	379.6086	
Applied moment	197273	N-mm
Counter moment	199697.4	N-mm

Stable

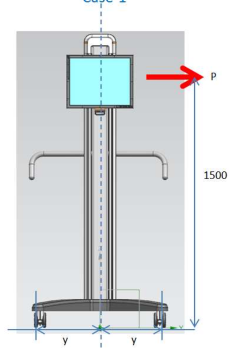
Case 3		
Pull force 'P'	131.5153	
pull height 'x'	1500	
xCOG	377.842	
Applied moment	197273	N-mm
Counter moment	198768	N-mm

Stable

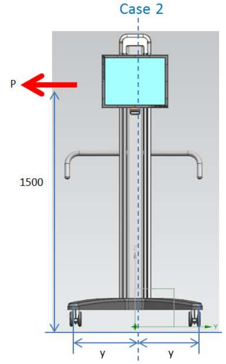
Case 4		
Pull force 'P'	131.5153	
pull height	1500	
410 - xCOG	379.758	
Applied moment	197273	N-mm
Counter moment	199776	N-mm

Stable

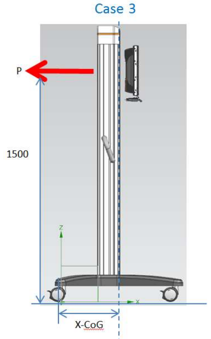
Case 1



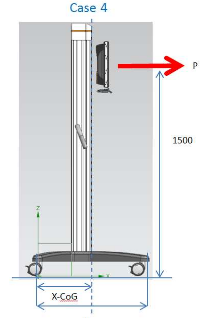
Case 2

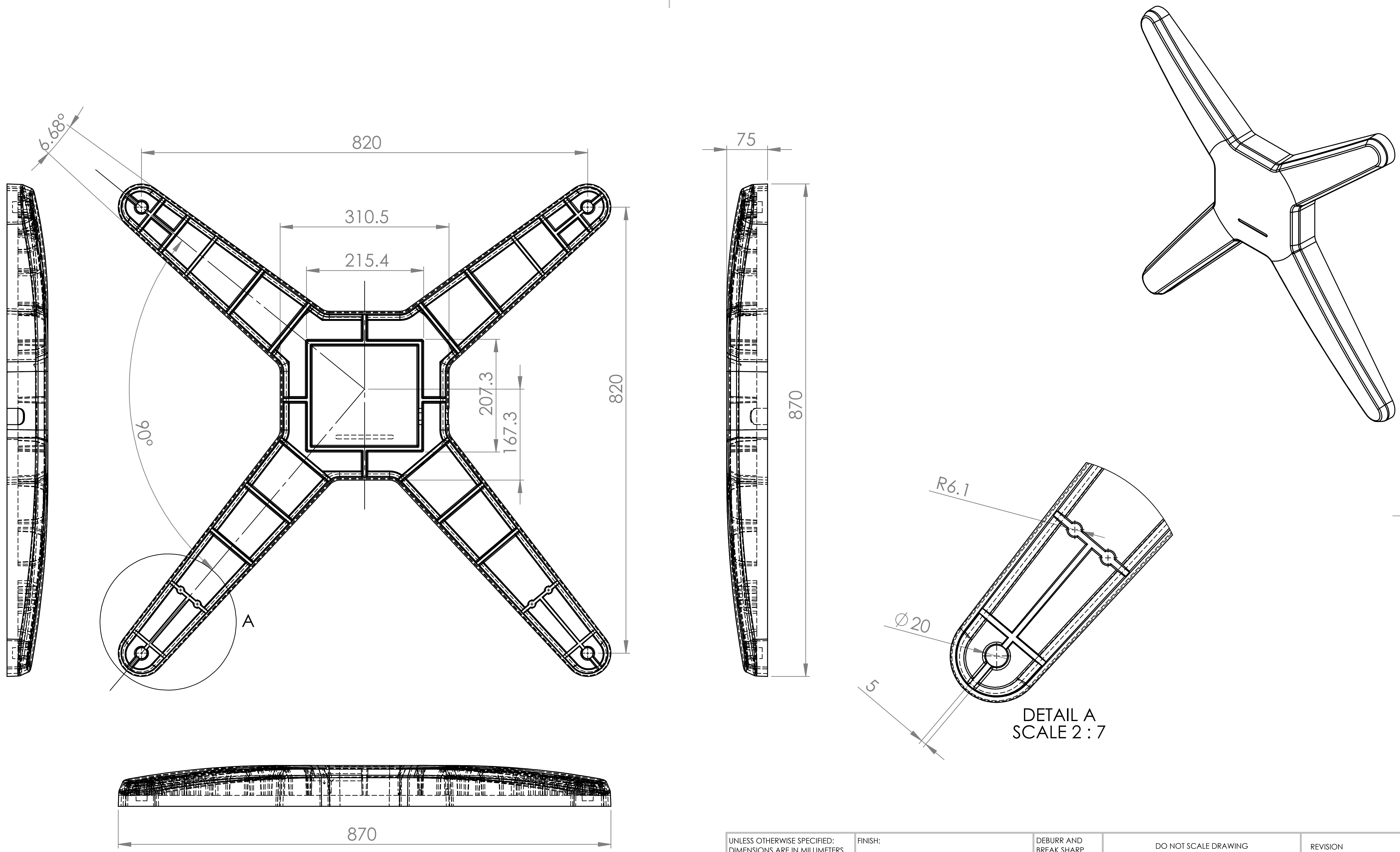


Case 3



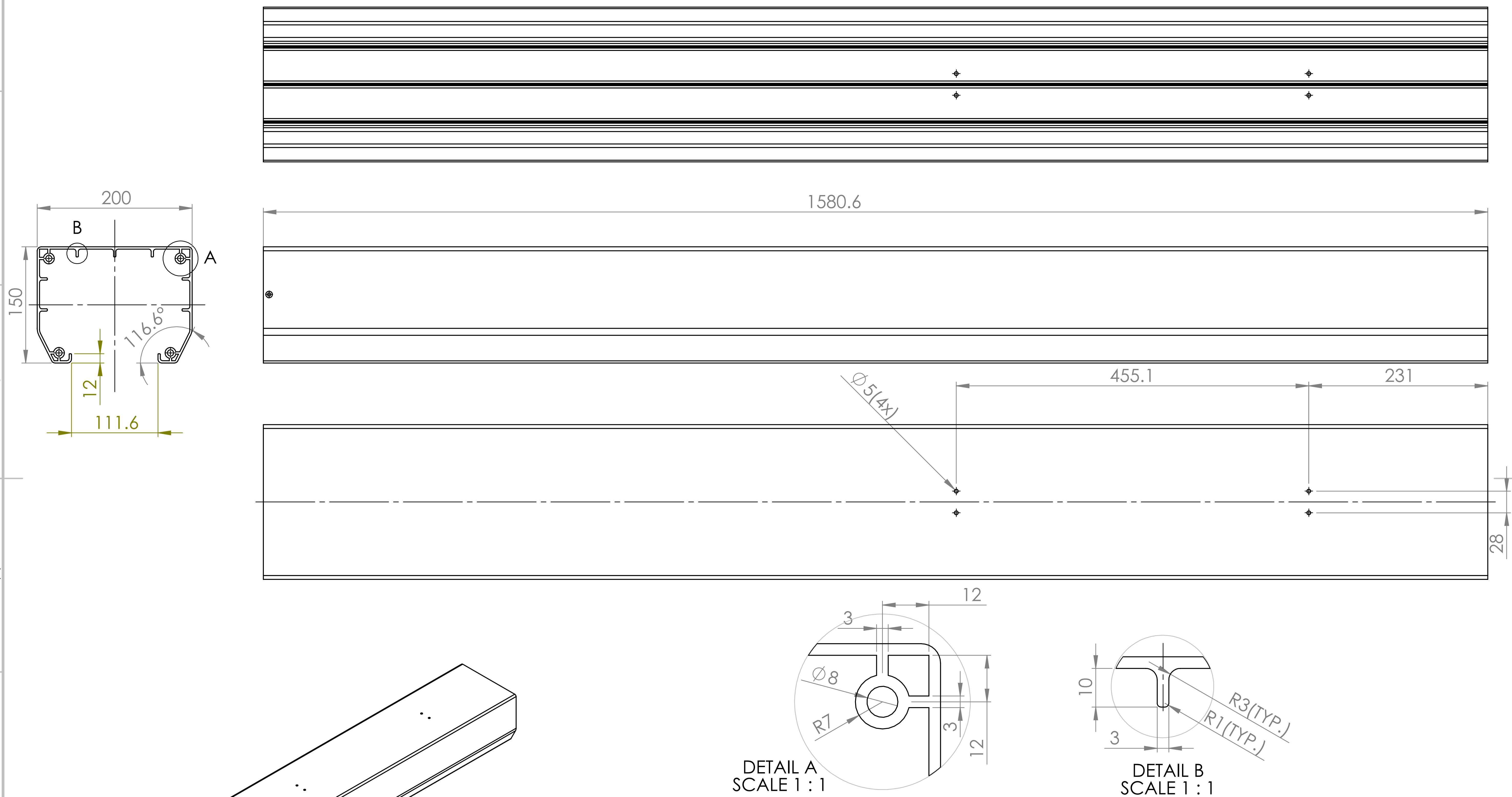
Case 4

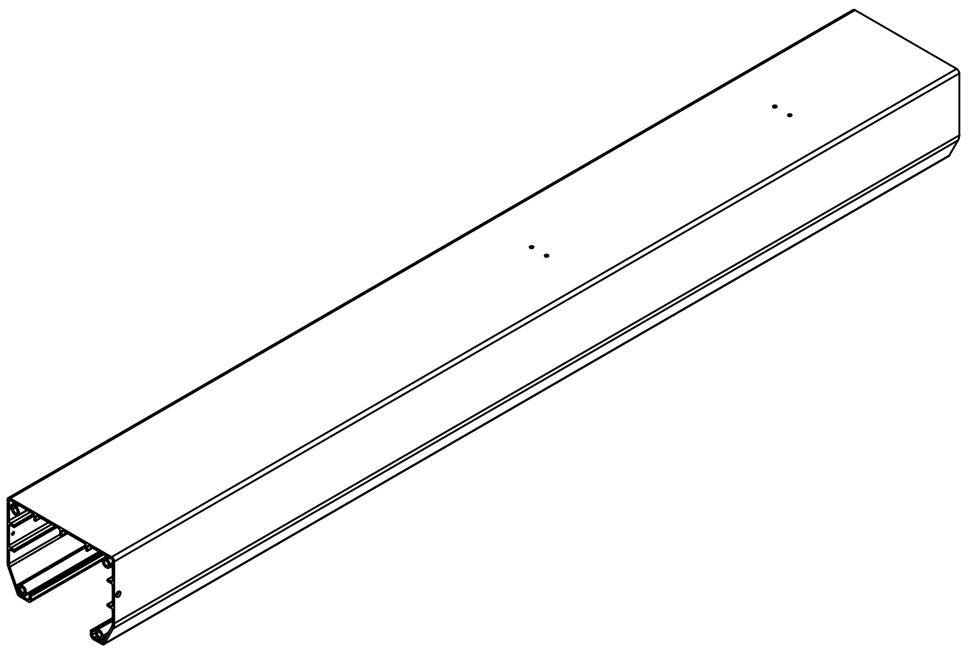




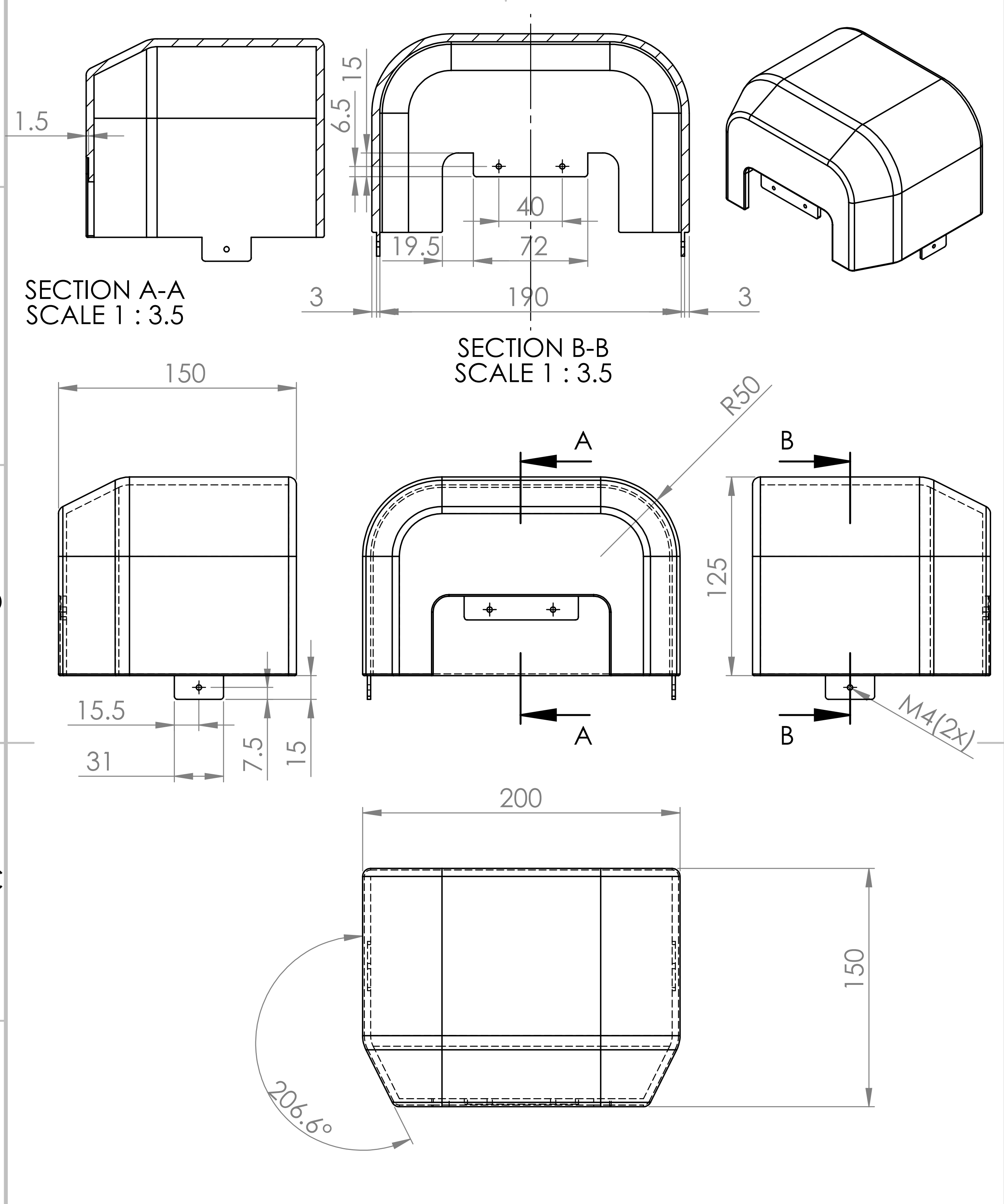
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: ISO 2768-mK LINEAR: ANGULAR:	FINISH:	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION

	NAME	SIGNATURE	DATE	
DRAWN	Aniruddh L.			TITLE: Driving frame
CHK'D				
APPV'D				
MFG				
Q.A				MATERIAL: EN AW-6061-T6
				DWG NO. A3
				WEIGHT: SCALE:1:10 SHEET 1 OF 1





UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: ISO 2768-mk LINEAR: ANGULAR:	FINISH:	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION	
	NAME	SIGNATURE	DATE	TITLE:	Extruded column
DRAWN	Aniruddh L.				
CHK'D					
APPV'D					
MFG					
Q.A			MATERIAL: EN AW-6063-T6	DWG NO.	A3
			WEIGHT:	SCALE:1:20	SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES: ISO 2768-mk
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	Aniruddh L.		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

Extruded_Column_top_cover

MATERIAL: ABS

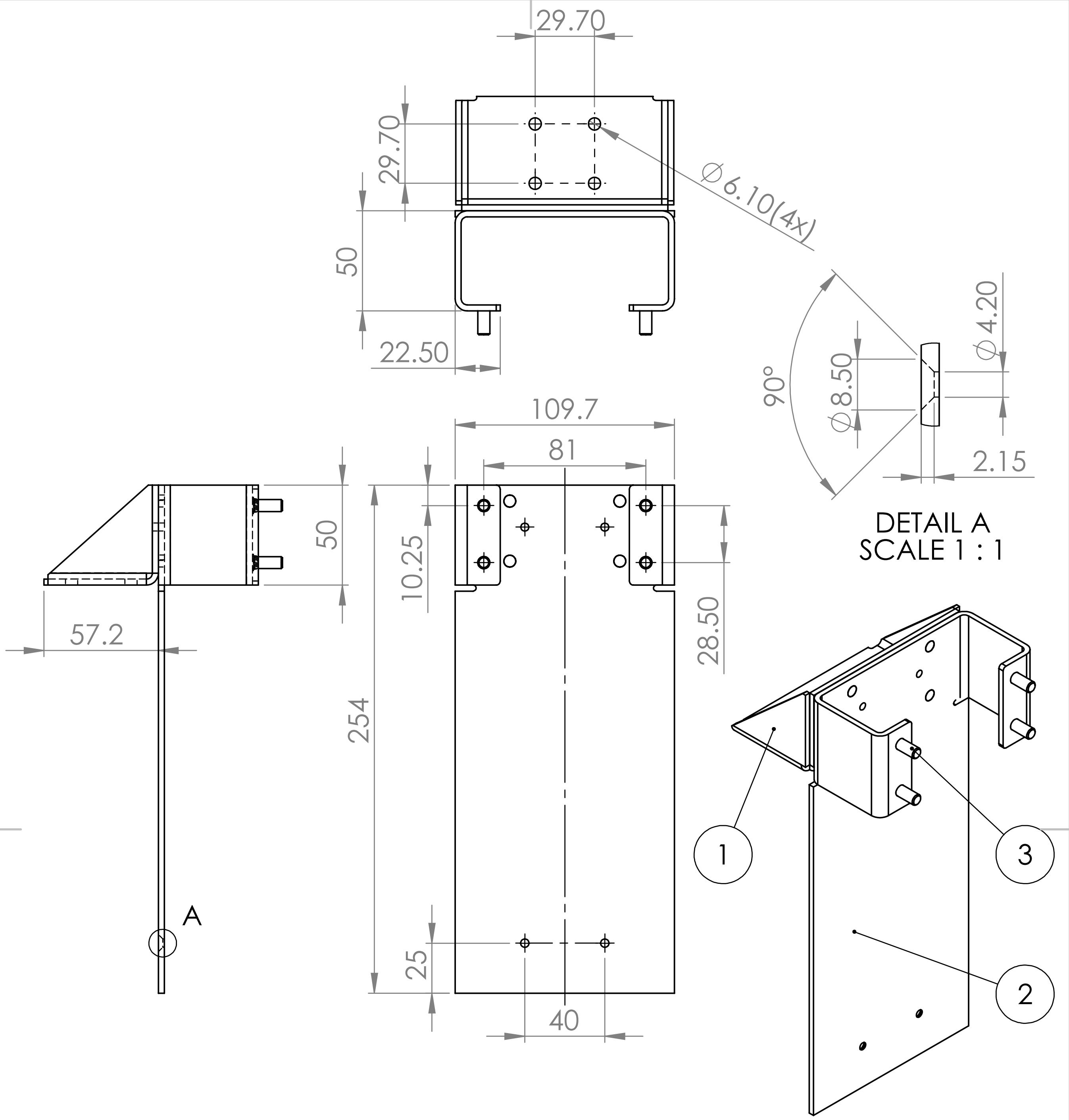
DWG NO.

A4

WEIGHT:

SCALE:1:5

SHEET 1 OF 1



ITEM NO.	DESCRIPTION	MATERIAL	QTY.
1	BRACKET_1	S215G DIN1623 3MM THICK	1
2	BRACKET_2	S215G DIN1623 3MM THICK	1
3	PRESS STUD. M6X12	STAINLESS STEEL	4

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	Aniruddh L.		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

LC_monitor mtng. bracket_asm

MATERIAL:
SEE BILL OF MATERIAL

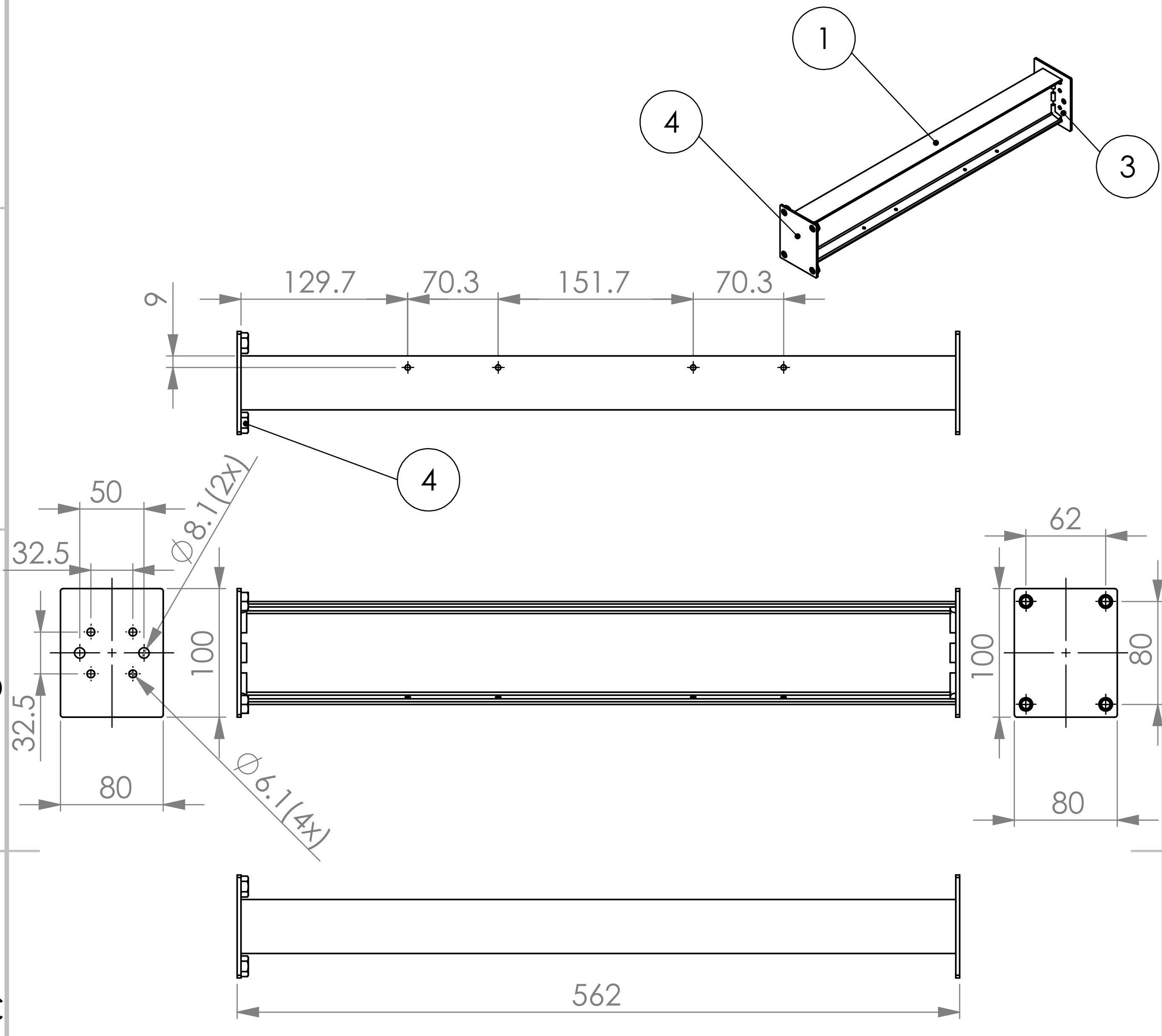
DWG NO.

A4

WEIGHT:

SCALE:1:5

SHEET 1 OF 1



ITEM NO.	DESCRIPTION	MATERIAL	QTY.
1	SH0002160688_00001	DIN 1025-1 80X42 MM HOT ROLLED STEEL	1
2	LIFTING COLUMN MNTG. PLATE	S215G DIN1623 3MM THICK	1
3	BASE MNTG. PLATE	S215G DIN1623 3MM THICK	1
4	WELD NUT M8	STAINLESS STEEL	4

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	Aniruddh L.		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

Lifting column stand

MATERIAL:
SEE BILL OF MATERIAL

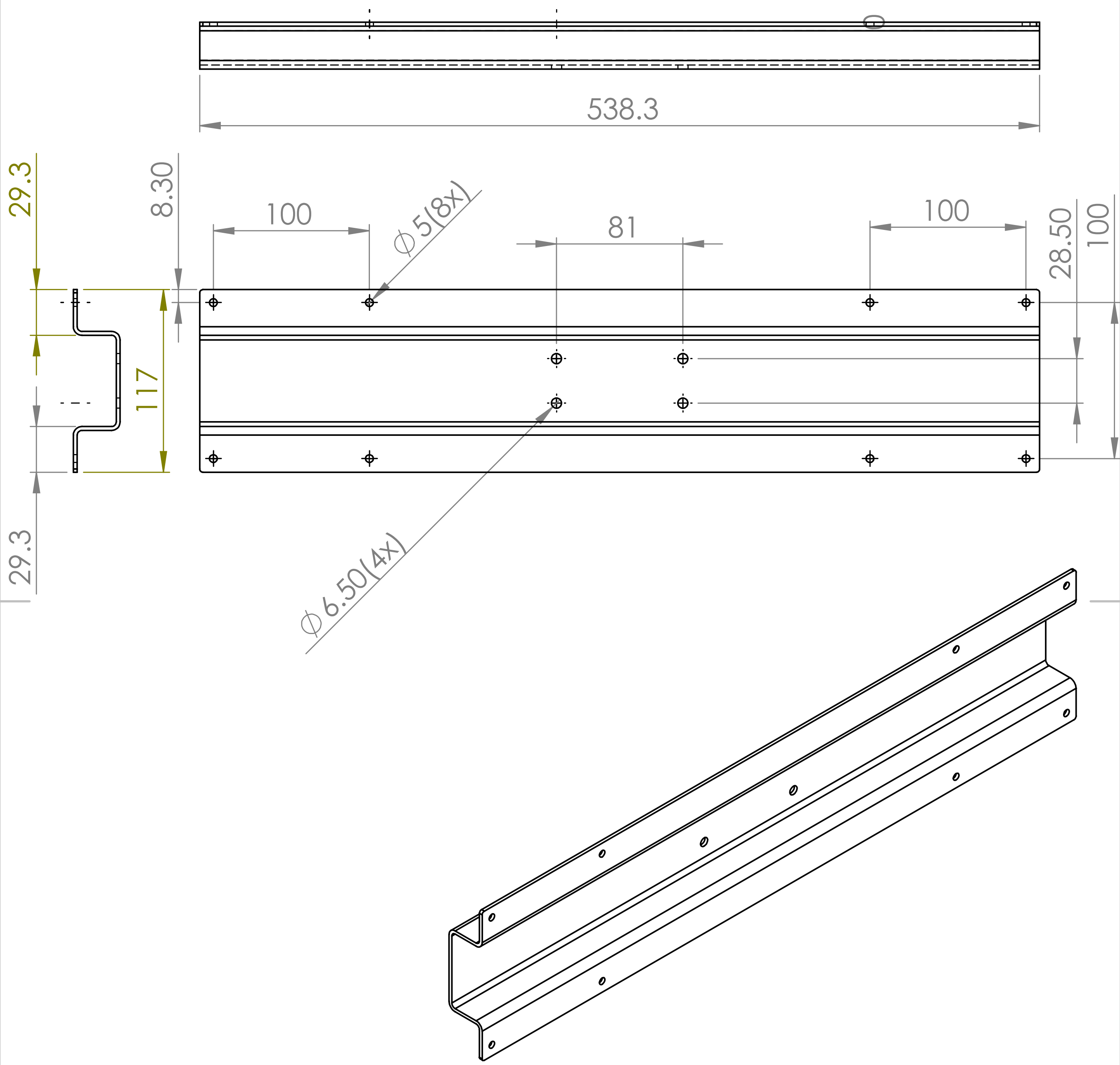
DWG NO.

A4

WEIGHT:

SCALE:1:10

SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	Aniruddh L.		
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:

Monitor mounting bracket

MATERIAL:

S215G DIN1623 2.5 mm thick

DWG NO.

A4

WEIGHT:

SCALE:1:5

SHEET 1 OF 1