

Mechanical Engineering

Final Project

Sliding Table Cassette

PSDM6019



James Treviso

Declaration

I Mr. James Treviso declare that I am the sole author of this dissertation. Working with AIM Altitude for this project, the information contained must not be copied or disclosed in total or in part or used for tendering, manufacture or communication to others.

Signed: 

Date: 26-03-2020

Acknowledgements

I would like to thank AIM Altitude for providing useful advice allowing access to investigate further into previous programmes and showing interest in the study to standardise future assemblies.

I would also like to thank Coleg Sir Gar and John Williams for mentorship throughout this project.

1.1 Abstract

AIM Altitude specialises in aircraft cabin designs from engineering to manufacturing. Tasked with creating a standard sliding table assembly for AIM Altitude, a table that can be used on various programmes throughout the company. This table will be incorporated into the current programme Qatar Airways. It will satisfy customer requirements and the TC holder (aircraft manufacture), working accordingly to the technical milestone meetings throughout the entirety of the programme. Case studies looked at archive designs, such as Delta Air Lines, a previous programme where separate tables were created and unique to that specific programme.

Following an initial project timeline, working in conjunction with the milestone activities, ensured the project did not exceed its targets. Included in the timeline was a planned overlap which saw design hours being utilised. TC submittals were met along with advanced drawings supplied to the supplier to manufacture the prototype.

Designing of the table cassette saw many restrictions, whereby all materials were governed by a Boeing list of materials Appendix 10. Ensuring design is FDA (Food and Drug Administration) compliant limited the clearance around the table so once stowed, did not exceed 3/32" (6.35mm). Use of standard extrusions were utilised where necessary preventing third party manufacturing whereby parts are manufactured internally.

The unique design of the cassette required many attributes not yet seen previously. An assembly casing with a specific aperture that could be easily removable, a reversible countertop to provide a mirrored working surface and to be installed into various galleys throughout the aircraft.

Previous designs saw that manual deployment was used, this therefore was eliminated and a design was created whereby the table would sit flush along the decorative face once stowed. Investigation of previous designs and design hours were included in the timing plan. 11 weeks was allowed to design the assembly, which included various component assemblies. Previous designs saw that unnecessary material remained on the profile of the table, whereas the Qatar Airways design saw unused material removed and slots added to reduce weight and a symmetrical profile.

Throughout the design of the table, advanced drawings were sent to the supplier of the prototype to maintain an understanding of the design and to commence manufacturing. Designing the spring assembly, having calculated the estimated spring deployment of 13.49mm, we were restricted by the thickness of aperture by not exceeding 0.8" (20.32mm). This therefore saw a clash of the head of a countersunk screw with the table. I overcame this by countersinking the table along with the doubler to allow the head of the screw to sit flush with the surface shown in section (7.8).

Design of component parts and assemblies were on course and stress results saw the Delta Air Lines table tested to withstand a 680N downward force, being an unsymmetrical profile. The second moment of area is calculated by splitting the table in to two separate sections, the centroid is calculated for those specific areas. A yield stress of 190MPa was calculated shown in Appendix 22. The stress allowable for aluminium plate Al6082 T6 is 240MPa (Aalco, 2020). $SF = 240 / 190 = 1.26$ ∙ being below the yield point of the material, the table will not yield under this abuse load.

The Qatar Airways table has a symmetrical profile tested to withstand 44.0lbs (195.4N), this provided a more simple area to test than the Delta Air Lines profile. A yield stress of 28.9MPa stated in Appendix 23, is far below that of Delta Air Lines, based on material 2014-T651 plate per AMS 4029. A yield stress allowable of 414MPa (Specification, 2019). $RF = 414 / 28.9 = 14.3$ ∙ the applied force of 195.4N, makes it clear bending stress is not critical. Calculations of both tables proved that each table can withstand substantially more than 30lbs of force.

The initial allowance for manufacturing of the prototype was two weeks, yet this was postponed to four weeks until the prototype was delivered to the factory. This therefore had an impact on planned feedback and drawing submittals, along with production. Set back two weeks, it was imperative that inspection of the prototype would commence immediately therefore any defects that will affect production could be found prior to drawing submittals. Inspection of the prototype found that an angle used as the front facia of the assembly proved to be fragile and started to bow as a result of minimum material along the length of the part. As a result, referring to the list of materials Appendix 10- a channel section is used as an alternative, giving the material more stiffness and preventing deformation of the angle. Changing the design had an impact on the design and planned

feedback, setting the feedback back an additional week to week 25 of 28. The setback saw production being delayed to one week prior to inspection. Drawing submittals were met, by altering designs, and production were able to receive the table and fit ready for inspection.

The Delta Air Lines table, comprised of a sliding table and two runners, is at a combined weight of 6.280lbm. By contrast, the Qatar Airways table comprised of six additional component parts and assemblies weighing a total of 19.698lbm, a difference of 13.318lbm. The biggest weight difference was seen in the table runners. The Qatar Airways table runners are machined from aluminium bar whereas its predecessors were manufactured from a light polymer. Two runners are required at each side of the table, a runner used on Delta Air Lines weighed 0.820lbm (1.640lbm combined). Whereas the Qatar Airways table runner, an assembly with component parts, weighed 2.678lbm (5.356lbm combined).

Although not yet implemented, to reduce the weight of the table runners used for the Qatar Airways programme, slots can be added to the assembly where necessary to utilise free space that will be unused. By adding three slots as shown in Appendix 21, the weight of the assembly reduces from 2.678lbm to 2.267lbm, saving a combination 0.822, including both table runners, bringing the overall weight of the sliding table cassette to 18.876lbm.

The table cassette assembly is currently in production where it awaits inspection ahead of shipment in May 2020.

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2.1 Introduction

A lack of free surface area for cabin crew has been a constant issue within the aircraft as every space is substituted for extra seats, partitions, lavatories and galleys. To overcome this issue, one innovative design was to create a workspace that has a pull out a table from the galley on the aircraft when required. Then, when not in use, the table is simply stowed internally.

For this project, it is required to design a standard sliding table assembly that can be used on various programmes throughout the company. A table that is universal and both satisfies customer requirements and the aircraft manufacturer. Creating standard designs can eliminate unnecessary design hours and create a standard table that can be used throughout the company therefore reducing cost.

Previous designs show no standardisation, a bespoke table is designed for each programme. The aim is to create a sliding table that can be used on various galleys and airliners saving engineering hours and cost creating new assemblies per programme. The sliding table is to provide extra surface area for the cabin crew, additional area that can be used when required. Previous contracts had many variants of sliding tables with no consistency, the current programme Qatar Airways will be implementing a new innovative standard design that can be used on various galleys and airliners, creating a design that contains a mechanism to release the sliding table without the need to manually pull to use in service. The table must withstand 30lb load when used and be universal throughout each monument that requires a sliding table stowed.

Analysing the data gathered and by attending meetings with the customer, we will be able to interoperate the outcome of the design. By maintaining constant communication, less errors are made therefore less hours are spent designing a concept. In this case, communication is essential, liaising with the customer ensuring they are satisfied with the end result.

3.1 Milestones

Throughout the entirety of the programme there are drawing and model submittals in conjunction with critical milestones that must be contained with the Design Plan/Activity Schedule.

- Initial Technical Coordination Meeting (ITCM)
- Preliminary Design Review (PDR)
- Critical Design Review (CDR)
- Final Product Design Review (FPDR)
- First Article Inspection (FAI)

3.2 Initial Technical Coordination Meeting (ITCM)

The first of the milestones is the Initial Technical Coordination Meeting. Its main objective is to ensure technical specification requirements have been identified with the original equipment manufacturer and airworthiness of the proposed programme.

3.3 Preliminary Design Review (PDR)

The second meeting of the milestones is PDR, where technical specification requirements have been validated whereby G.A. drawings of the proposed units are thoroughly checked by the interface specifications of the airline manufacturer and design layout of the customer.

3.4 Critical Design Review (CDR)

The main objective of CDR is to check the definition of the first equipment standard, ensuring that the hardware is compliant. This is the last stage that design changes can be implemented outside specification before additional costs are applied.

3.5 Final Product Design Review (FPDR)

The purpose of the Final Product Design Review is for the TC holder (Airbus/ Boeing). The design organisation evaluates AIM equipment certification maturity ahead of FAI. FPDR will validate CDR results and evaluate if the final product or equipment is in accordance with definition documents.

Referring to Appendix 1- CDR minutes state that AIM Altitude is to provide a presentation that demonstrates the differences between the standard table and the cassette table options. AIM Altitude will need to have approval from the customer to proceed with design. A requirement from the customer is for the cassette table design to be flush with the face of the benchtop once the table is stowed.

3.6 First Article Inspection (FAI)

Attended by the TC holder and the airliner, the purpose of this review is to assess the final product to aircraft specification ensuring interfaces are accurate. This is the final phase where the product can be inspected prior to delivery, a chance for the TC holder and airliner to snag imperfections on both interfaces and decorative aspects of the product.

4.1 Project Timeline

Illustrating a project schedule is essential to track progress of a specific programme. By using such a method we are able to initially plan tasks by managing projects ensuring programmes finish by hitting their deadlines. This project management technique is used for the sliding table cassette, over an eight-month period, and hours are assigned to specific milestone tasks ensuring targets are achieved.

Over the lifecycle of the programme, various critical milestone meetings are attended feeding back to the customer and TC holder. Throughout the entirety of the programme,

specification requirements must be adhered to. Hours are designated for customer and TC specification ensuring requirements are met as shown in Appendix 2. Feedback is provided once the minutes of the meetings are completed. Boeing submittals are required throughout the programme for certain stowages and galleys within the aircraft, also configurations and presentations of catering equipment which is included in the timeline.

Starting at week six, 11 weeks have been assigned to designing the sliding table cassette as well as other tasks, this should allow enough time for design of the table to be completed. Two additional weeks have been planned for any further design work. Commencing week 21, two weeks prior to the end of designing the assembly, advanced drawings will be drawn of each component and assembly. Once complete, these are passed to the supplier to manufacture the sliding table. This gives the supplier two weeks to manufacture the prototype, six weeks prior to demand from production where the table cassette assembly will be installed to the galleys for inspection.

5.1 Factory Design

Working alongside Qatar Airways, an industrial design company Factory Design proposed several design concepts of the products shown to the airline. Various configurations are presented of each galley and its catering equipment as shown below.

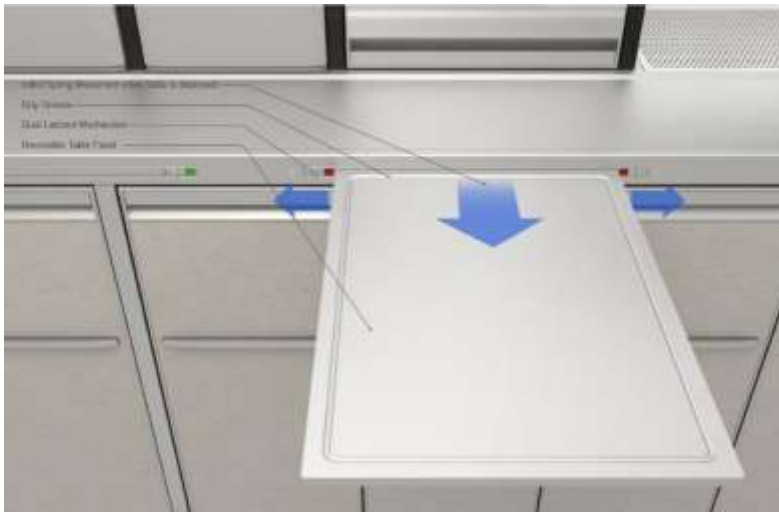
5.2 Galley Concept



Door four houses the largest of galleys, located at the rear of the aircraft where the insert equipment stored is the most complex. The galley stows trolleys, ovens, coffee makers, trash compactors and electrical modules along with standard containers.

(FactoryDesign2019)

5.3 Sliding Table Proposal



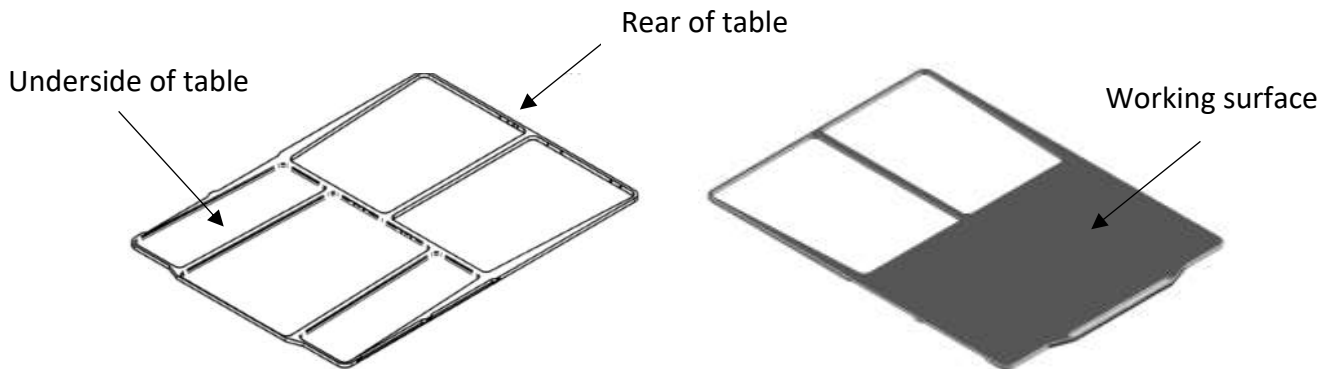
(FactoryDesign2019)

Factory Design, with the agreement of Qatar Airways, proposed a design of the sliding table with requirements that it will be spring deployed, with a dual latched mechanism and reversible table panel.

6.1 Sliding Table Investigation

The table design must accommodate a spring assembly, investigation looks to add cut-outs to the rear of the table where they can be placed. The table design itself must be universal, whereby during installation of the table into the cassette, the spring assembly must be able to be inserted either side of the table. In this case the table surface will be mirrored along the 'X' axis of the table. Previous designs show a workable surface on top, on the underside a ribbed cut layout to reduce component weight as shown on overleaf.

6.2 Delta Air Lines Sliding Table

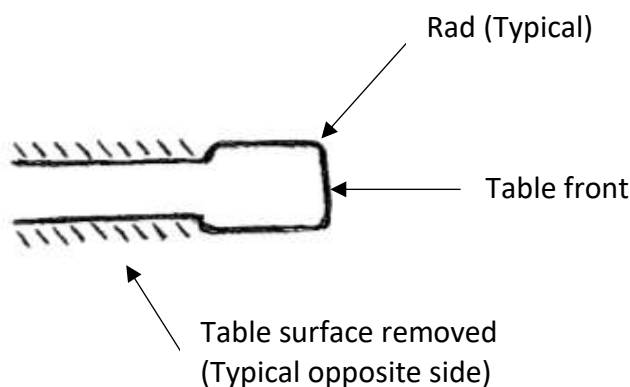


(AIMAltitude 2018)

By adding these cut- outs the component weight can drop dramatically. A combination of parts that have these cut- outs to reduce weight have a sufficient amount of weight reduction on an aircraft, especially when thousands of parts, different yet similar can reduce weight removing any unnecessary material. Weight is a major factor in aircraft construction and operation explained by Literacy, 2017. To assure that the lift generated is sufficient to counteract weight, loading an aircraft beyond the maufacturer's recommended weight must be avoided.

A proposed design is somewhat similar that each side of the working surface will be stepped, therefore providing a working surface on both faces of the table as shown below.

6.3 Proposed Sliding Table Profile



By removing a small proportion of the table surfaces, the weight of the table will reduce, yet ensuring the table could withstand an average of 30lbs abuse load. By doing so, the table will be lighter and easier to work with for the cabin crew when deploying and stowing the component.

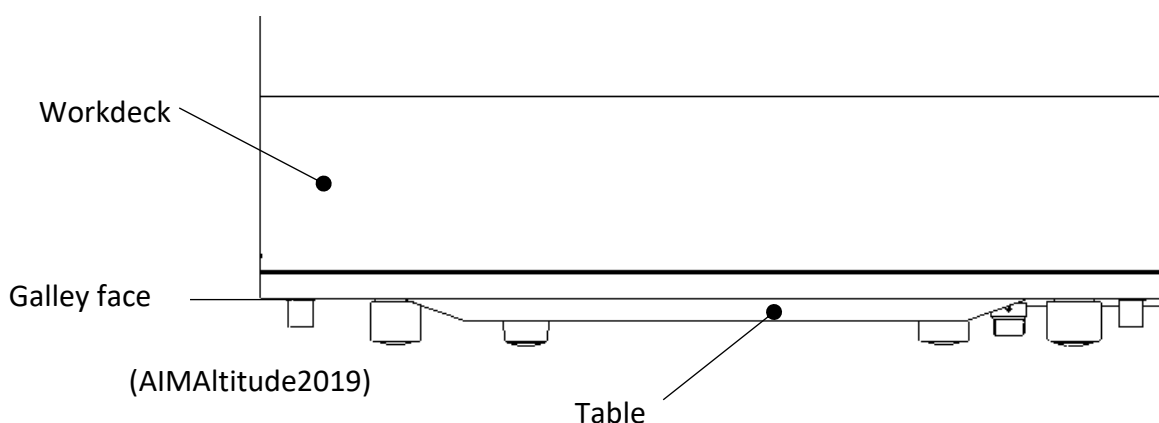
The design of the table is based on previous table designs, but it can be improved to be adapted on various contracts not only on the Qatar Airways programme but going forward on all future programmes. The design intent for this table is to fit inside a cassette, this table cassette can then be taken out by removing fasteners on the underside of the work deck, and if necessary placed in to another unit on the aircraft that is designed to stow that table.

6.4 Deployment of Sliding Table

Previous designs of sliding tables require cabin crew to deploy them manually when in flight. A new design looks to replace what would be a manual action with the sliding table to be released by a push of a button.

Currently the sliding tables protrude outside of the galley as shown below.

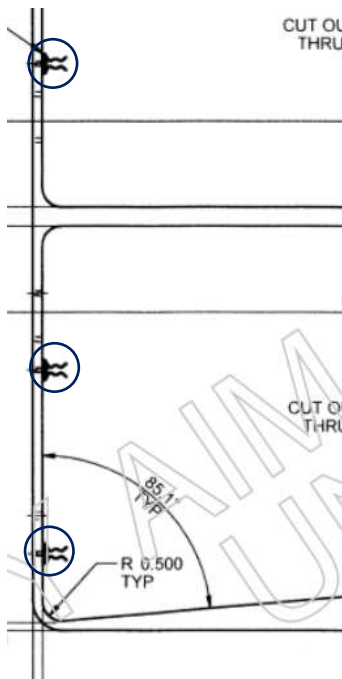
6.4.1 Table Deployment



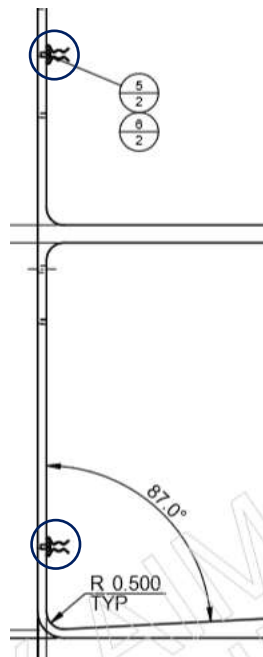
6.4.2 Alternative Deployment

An alternative for manual deployment would be a spring-loaded table, where the cabin crew push a button which allows the table to deploy. A table stop will have to be put into place to prevent the removal of the sliding table when in use.

6.4.3 Sliding Table Stops



Saudi Airlines A330
(AIMAltitude2018)



Delta Air Lines A330
(AIMAltitude2019)

 Terry Clip

To eliminate manual deployment of the tables and use of terry clips, a new innovative design was required. A way for the table to sit flush with the galley face, for those only to know there was additional working surface area otherwise to go unnoticed. Using a spring assembly at the rear of the table to hold the table in place, a spring-loaded button is positioned either side of the table.

7.1 Spring Assembly

A shaft will be located at the rear of the table where a spring is attached, once positioned the spring assembly will be embedded within the table. Once stowed the table will sit flush with the front of the unit without the need for crew members to manually handle the table to release.

The shaft must be manufactured using Boeing approved material shown in Appendix 10, ensuring the material is safe for aircraft use. The screw must have a sufficient amount of spring deflection for the table to be deployed by a substantial amount.

7.2 Spring Shaft



(AIMAltitude2020)

5251 H22 aluminium alloy is a Boeing approved material, medium strength with high corrosion resistance and a tensile strength of 190- 230MPa (Aalco, 2020).

Based on previous designs of the table, the average weight is estimated at 11lb (5kg). For an even weight distribution of the table, the shafts will be positioned at equal distances from the side of the table ensuring a fluid motion of deployment.

A 22.231N load is applied whilst the screw is in compression, a spring rate of 1.45N/mm (LeeSpring, 2020), the required deployment of 0.5" (12.7mm).

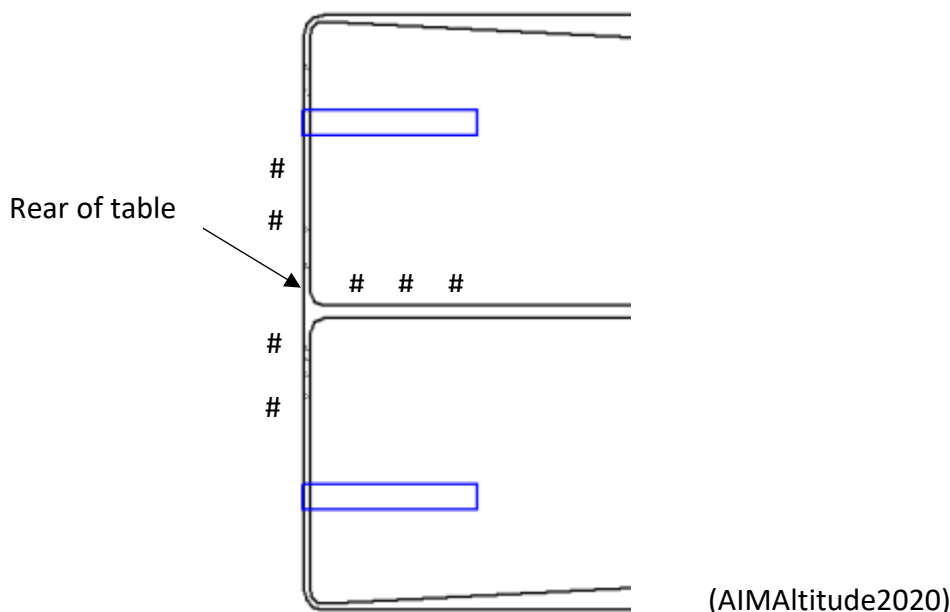
$$\text{Where spring deflection } \delta = \frac{\omega}{\text{Spring Rate}}, \quad \frac{22.231}{1.45} = 15.33$$

∴ spring deflection = 15.33mm.

The shaft diameter for the location of the spring is 5.00mm, based on these parameters, spring *LC030D07 S* is suitable (LC030D07S, 2020), an outside diameter of 7.619mm, a wire diameter 0.761mm therefore a rotational clearance of 0.93mm. The spring provides a length difference from compressed to free length of 14.4mm within the 12.7mm requirement.

By calculating the spring deflection and the shaft that will house the assembly, work started on where to position the screw and other component parts. Referring back to previous designs, we looked at placing the spring in locations shown below in blue.

7.3 Proposed Spring Locations



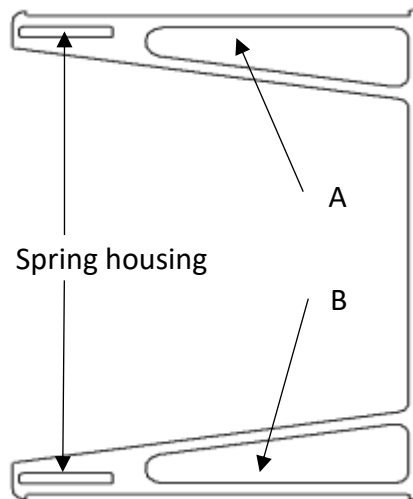
Placing the spring assembly in this location meant that the edges of the table would have to be tapered to accommodate for the position and leave unnecessary material at the rear that wasn't being used.

A proposed design is to utilise the space at the rear of the table, removing the legs of the table where indicated '#'. This will reduce the weight of the table further making it more lightweight and easier to work with once in use.

The rear of the table had changed to suit the springs using far less material than those of previous designs. By incorporating this change more material was removed, the lighter the table therefore the further the deployment.

7.4 Spring Assembly Layout

Further slots are added ensuring a nestled fit of the shaft and spring as shown.



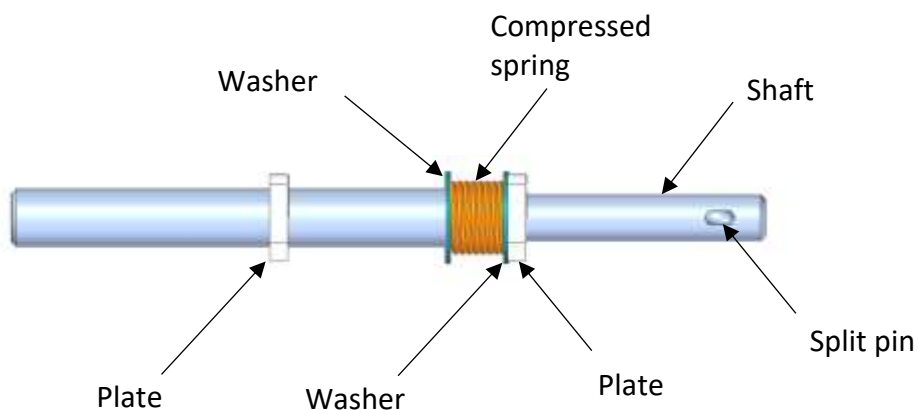
For the spring to work, a through hole is needed so the shaft can extend the rear of the table. When in compression the shaft will be pushed inwards, then when released the shaft will extend pushing the table outwards. Slots A & B are added to reduce weight.

(AIMAltitude2020)

To keep the spring in place, two separate square metal plates were designed with an arc for the shaft to move through holding the assembly in place.

The assembly shown below included washers and a split pin preventing the shaft from fully releasing.

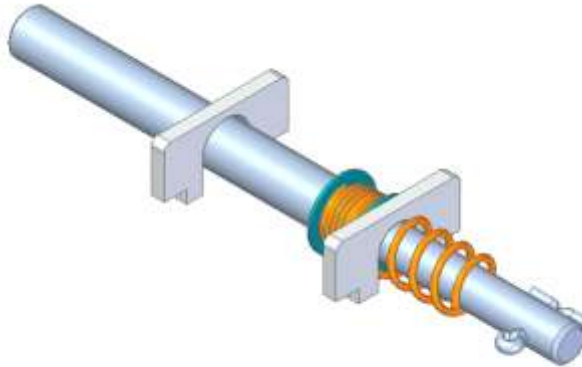
7.5 Spring Assembly Components



(AIMAltitude2020)

7.6 Spring Assembly Isometric View

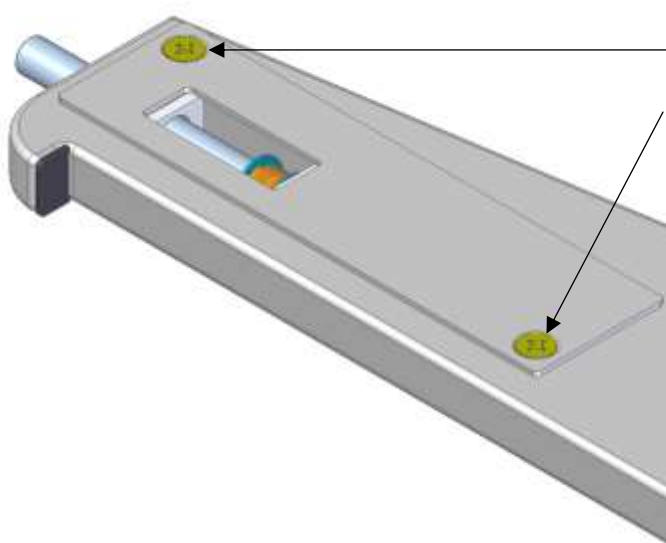
For further clarity an isometric view is shown below.



(AIMAltitude2020)

To keep the spring assembly in place, two packers are needed either side of the table. The table and its components are restricted to thickness no greater than 0.8" (20.32mm) as there will be a certain amount of thickness aperture set that is typical of all the galleys, therefore the packers thickness must be at a minimum of 1.0mm. When designing the doublers, it was discovered that the washer overall height exceeds that of the sliding table thickness. To overcome this, slots were added to the packers ensuring the spring and washer can run freely along the shaft when in use as shown below.

7.7 Spring Assembly Installation



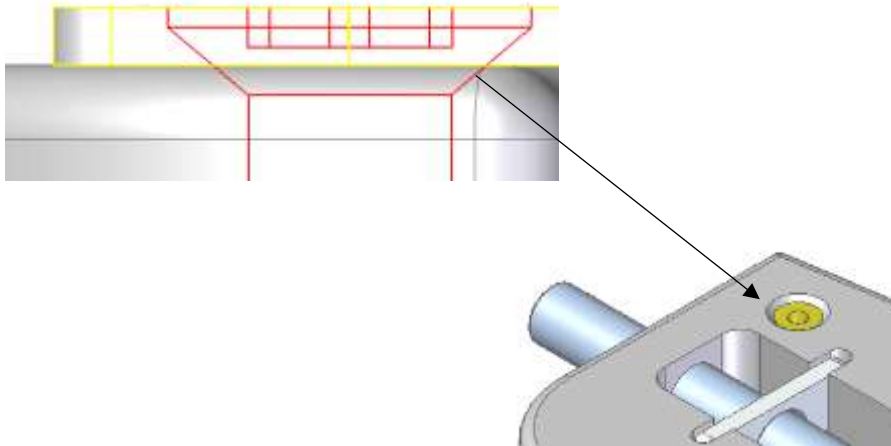
2 off 6-32 UNC P/N
NAS514P632-4P CSK Screws

(AIMAltitude2020)

Two off countersunk screws were added to keep the doubler in place, typical opposite side of table. Once in place a clash was found, this was in fact that the countersunk depth

required for the screw was more than the thickness of the packer. Referring to Appendix 3, 0.057" (1.44mm) head thickness of the screw exceeds that of the 1.0mm packer as shown.

7.8 Screw Attachments



(AIMAltitude2020)

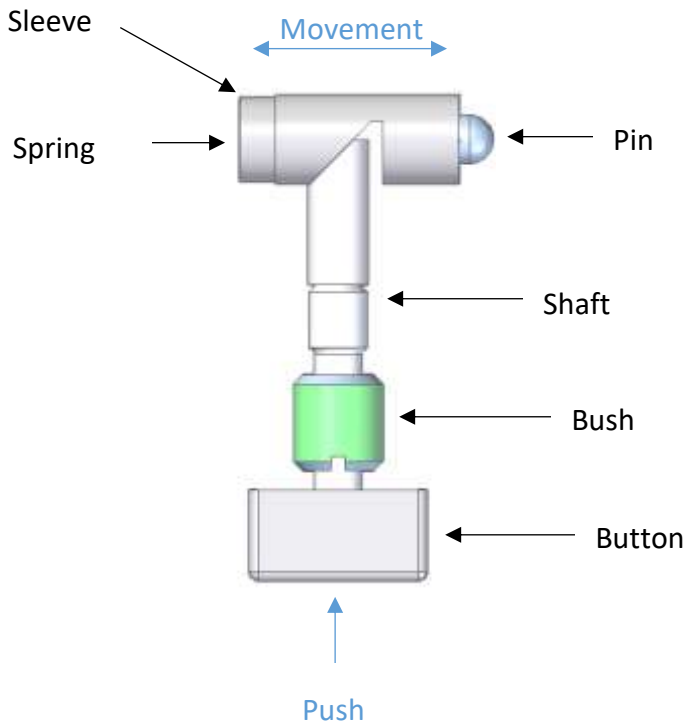
The screws initially were to be fixed using 06-32 helicoils embedded in the table. To overcome this, prior to inserting the helicoils, the table will continue the countersink to compensate for the necessary depth required.

The customer required the table to be deployed without the need of cabin crew manually pulling the table from the galley when in use, and for the table to be deployed to 7.0" of workspace area to an intermediate stop, then a further 7.0", a full deployment of 14.0". For this to be designed, the table will have to stop in two 7.0" intervals. The design firstly looked back at previous tables, at what was used to stop the table when deployed. Investigation showed that terry clips were used as mentioned in (6.4.3), fixed to the rear of the table, a bolt would come through the work deck of the galley, when the table is deployed to the maximum distance, the terry clip would lock the bolt in place thus preventing the table from exceeding the distance.

8.1 Qatar Airways Table Deployment

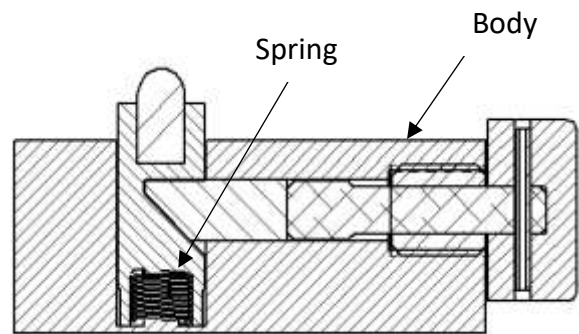
The button will be located within table runners, the pin currently in the locked position.

8.2 Push Button Assembly



(AIMAltitude2020)

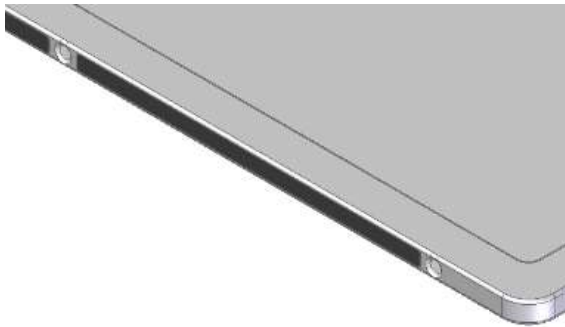
Once the button is pushed, moving the shaft upwards will slide the sleeve to the left. By doing this theoretically the pin should then remove itself from a groove within the table so it can be deployed for service in flight. The parts will be enclosed within an aluminium body keeping all parts in their place and protecting from compression.



Section through showing the button assembly once the button has been pressed, spring *LCM060C08M* (Spring, 2020) is compressed, using both buttons either side the table should then deploy, once pulled an extension of 7.0" the spring will extend and the pin will slot back into a groove of the table until released to a total of 14.0".

Holes were added to the table assembly for the pin to slot into once deployed to the set distances, grooves are added in between the 7.0" increments and filled by nylatron GSM – a nylon material. The material will be used as a packer therefore requires no structural testing, the material is lightweight, corrosion resistant with a tensile strength of 80MPa as shown Appendix 4.

8.3 Intermediate Stops



(AIMAltitude2020)

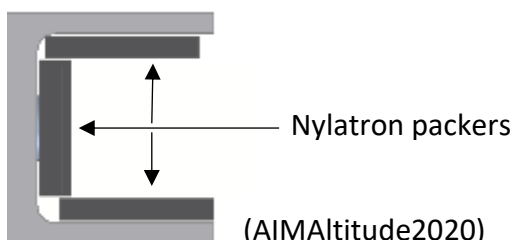
Once the button has been deployed, the pin will be brought back towards the table runner, when released the button will run along the nylatron embedded within the side of the table as shown. As the table will be manufactured from aluminium and the pin stainless steel this will prevent friction and wear.

9.1 Qatar Airways Table Runners

For the table to be deployed smoothly, the table sits within runners, positioned either side of the table. On previous contracts, Delta Air Lines used multiple sliding tables and runners where the table would slide along when in use. Table runners are commonly machined from nylacast, a polymer with a yield strength of '75- 80Mpa' (Nylacast, 2019), although this part is seen as a non- structural part, the polymer provides light, excellent mechanical, thermal and chemical resistance properties with guarantee of no corrosion enhancing its shelf-life.

Nylacast is a preferred option as a lighter, less expensive material. As the design of the table assembly progresses, inserts are required on the surface of the table runners. This therefore meant that nylacast could not be used as insert or helicoil could only be installed on a metallic or honeycomb material. As the runners will be machined from aluminium bar, to ensure the tables run smoothly along the surface nylatron packers are added as shown below.

9.2 Aluminium Runners

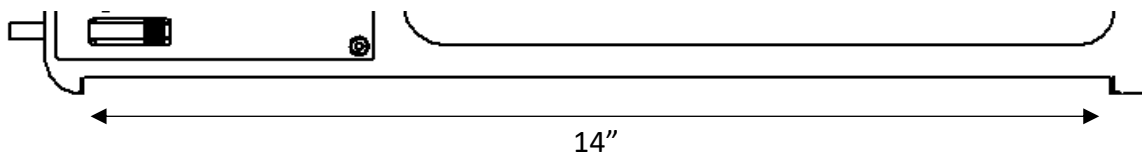


(AIMAltitude2020)

The table runner must house the button assembly where it will sit flush with the front face of the galley, parts within the assembly will not be visible as they will be stowed internally of the unit. As the pin of the button assembly will stop the table at its required distances, it will not prevent the table from being fully removed when a tensile force is applied. Similar to the terry clip, a stop is needed to avoid the table from being removed. Terry clips could not be used as where previously placed as the Qatar Airways table is machined to remove any unnecessary material. After discussions the decision is to have the stops protruding through the runners into the table. For this to be accomplished, the table must have a cut- out the length of 14.0" for the part to run across, when the part reaches the maximum distance the table will come to a stop.

A machined cap head NAS1351-5-24P 5/16" (7.9375mm) bolt Appendix 5, will be machined down with an end of 6.5mm where it will run along a 0.25" deep groove on each side of the table as shown below.

9.3 14" Table Deployment Clearance

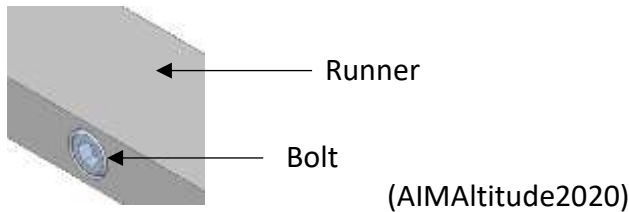


(AIMAltitude2020)

The thread of the bolt will be CNC machined from the end 'X' distance, whilst keeping the remaining thread. To secure the bolt in position, the runners will be machined to cater for a cap head bolt and therefore require a counter bore hole, at the end of the bore will be a 5/16" thread where the bolt will be locked securely, over 1.5D of engagement. The exposed end will then run along the table groove where it will be stopped by padded foam ends as shown above. This prevents any corrosion and friction between two materials and softer deployment. By proceeding with this concept, the stop can be easily removed for maintenance and spares.

The bolt will sit comfortably within the side of the runner, flush with the outer edge as shown below.

9.4 Sliding Table Stop



To understand the concept, Appendix 6 shows the relationship of the button pin and the stop whilst the table is being deployed.

To make the table and components easily installed and removed, all parts are to be within one cassette assembly. Thus, when the table cassette is removed, all component parts will accompany. The idea is for the cassette entirety to be easily removable, robust yet light and flexible enough to be moved to another unit in the aircraft or to be removed entirely. The design will have components where the table is fixed top and bottom and either ends of the table.

Due to stock levels and cost of machining parts externally, components are designed with the mind-set of using standard, internal materials and machining without the need of involving a third party therefore reducing costs.

Standardisation is the baseline for continuous improvement, Japanese philosophy of Kaizen states 'A change for the better'. A method to improve the system of a company, quality and productivity, therefore reducing cost. Japanese firms explain that, 'cost management is proactive in planning, managing and reducing costs' (Modarress, Ansari, & Lockwood, 2016). Firms consider cost reduction to be one of the main priorities of the company. 'It is estimated that 80% of product costs are sealed during the design stage' (Bakerjian, 1992), this limits the design changes and restricts as cost reduction therefore any purchasing changes need to be captured in the R&D (Research and Development) stage to prevent changes post design. (Treviso, 2019).

Standardisation improves the quality of the product, increasing efficiency and becoming more profitable. The focus is directed on reducing waste in manufacturing.

At the front and rear of the table cassette, standard angles can be used. These are stocked within the facility, for a 'X' length of the angle without any modifications, these can be demanded on the drawing without the need of a separate drawing. If modifications are required, a drawing will be needed, and the part will be machined internally without the requirement of a third party.

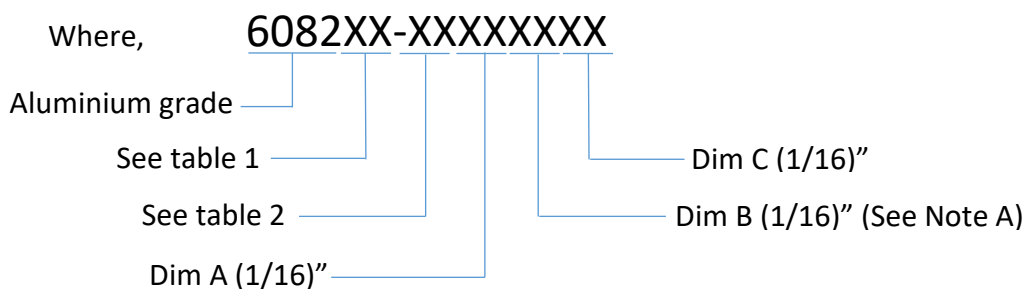
10.1 Table Facia

The table facia is manufactured in conjunction with internal extrusions used at AIM Altitude, shown in Appendix 7, an 'L' angle is required where referring to the datasheet.

10.2 Standard Extrusions



(AIMAltitude2020)

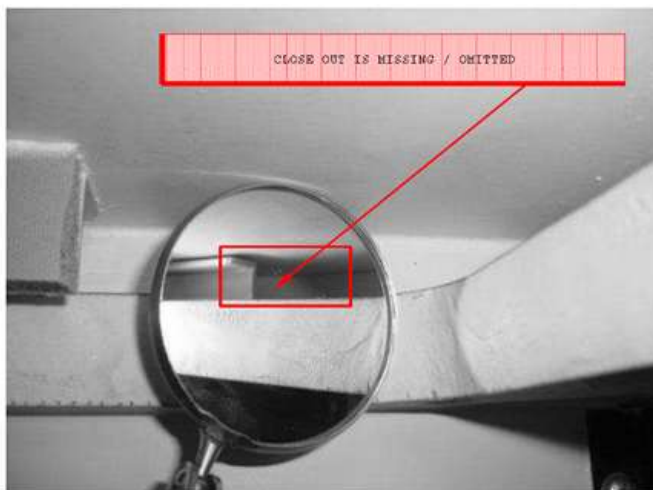


6082T6-Al161601 is required, this demands an 'L' angle, 1.0" x 1.0" x 0.625". Initially the angle only required a slot for the table and button. As the design progressed more holes were required to attach a plate at the top and bottom of the table to fully enclose the assembly as a cassette therefore a drawing is required to add the features to the standard angle.

11.1 FDA Conformance

There are limitations designing a sliding table, according to the FDA (Food and Drug Administration), 'Fitted together snugly to have surface-to-surface contact leaving no opening greater than 3/32 inch.' (FDA, 2014). Therefore once the table is stowed, the front of the table should be flush with the decorative capping with minimum clearance around the perimeter of the table to prevent any dust and dirt forming.

11.2 FDA Compliant



An example of a table that is not FDA compliant where there are visible non-cleaning gaps. Pull out table compartments: must have access to all areas for cleaning, otherwise completely closed out. (Tables within trays are a good design resolution).

(Boeing, 2014)

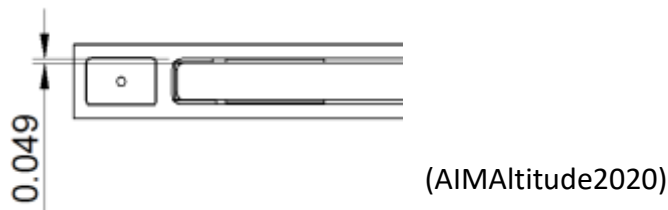
There are many legislations to follow in the aircraft industry, the FAA (Federal Aviation Authority) is the governmental body which regulates all aspects of civil aviation in America and internationally.

The angle is designed in an assembly mode including the button and table to ensure it complies with FDA regulations.

The FAA certifies the designs of aircraft and its components (FAA, 2019), ensuring all design aspects are certified for aircraft use. Aircraft certification enables suppliers to work in conjunction with aircraft manufacturers ensuring they comply with the FAA certification. The supplier must retain design approval certifications, an airworthiness certification. Once obtained, a supplier is part of a group of companies allowed to work with the major airline

manufacturers. Every design needs to be approved internally. Drawings are approved by engineering ensuring each part is fit for purpose, aircraft approved material and able to withstand the necessary stress load. These signatories would have needed to obtain approval by the FAA to sign engineering drawings. (Treviso, 2019).

11.3 Table Facia Clearance

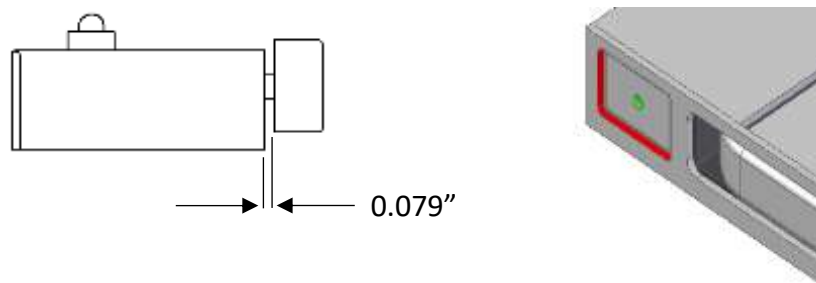


A gap of 0.049" (1.24mm), being within the requirement of the FDA 0.93" (2.4mm). Any greater, the gaps will have to be filled with a sealant preventing any dirt from penetrating internally.

12.1 Push Button Indication

Currently there is no indication to show when the table is stowed safely or if the table is loose and not locked into the intermediate stops. Along the shaft of the push button assembly there is 0.079" (2.0mm) gap between the rear of the button and the front of the body.

12.2 Table Engagement Warning

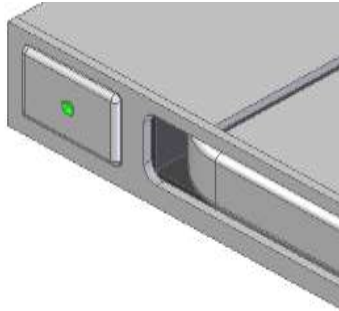


(AIMAltitude2020)

The table front facia thickness is 1/16" (1.6mm) therefore once the button is pressed to release the table, the button will sit inside the facia. To show that the table isn't fully engaged, red paint is added to the perimeter of the cut-out. This alerts the cabin crew that

the table is yet to be safely secured. Once the table is locked In an intermediate stop or fully stowed, the red paint will not be visible as shown below.

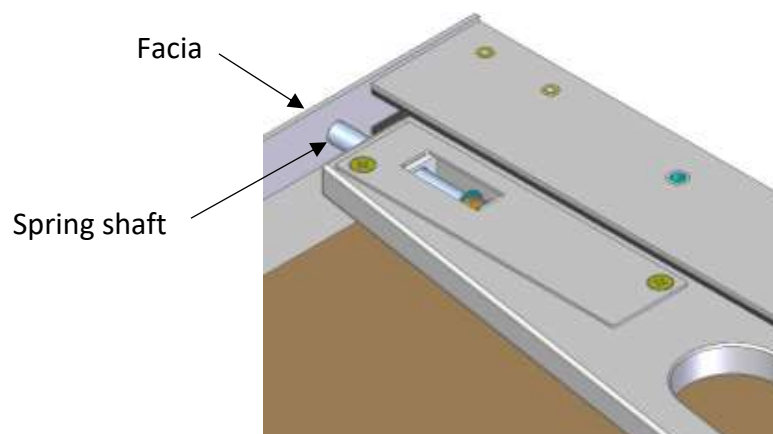
12.3 Sliding Table Secured



(AIMAltitude2020)

A fascia added to the rear of the table does not require any slots, only through holes to connect the runners via helicoil to secure its position. Once the table is stowed, to keep the spring in compression the rear of the shaft is pressed against the inside of the fascia, once the button is pressed, the table will deploy.

12.4 Cassette Rear Facia Component



(AIMAltitude2020)

13.1 Panel Assembly

Honeycomb panels are flexible, light and can withstand considerable high stresses; these sheets are manufactured by AIM Composites. Structural panels for galleys and stowages are manufactured using a honeycomb material.

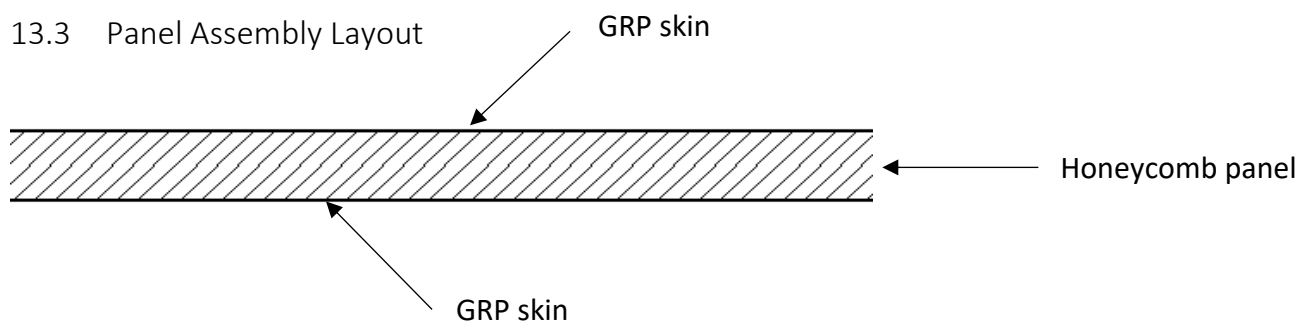
13.2 Composite Panel



(AIMAltitude2020)

Either side of the honeycomb is a standard GRP (Glass Reinforced Plastic) doubler, a composite construction material obtained as a result of 'combining the unsaturated polyester based resin' (Polser, 2019), the material is flexible yet strong with high heat resistance.

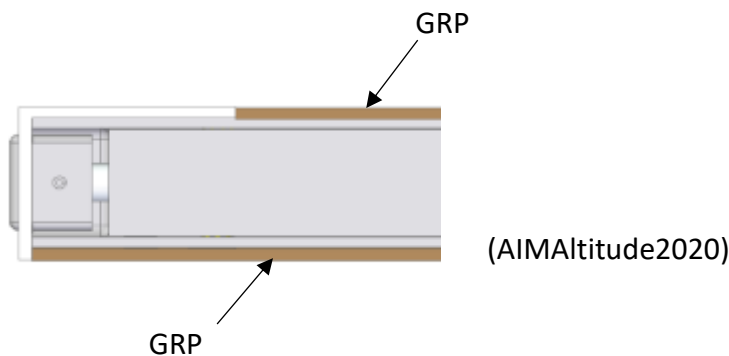
13.3 Panel Assembly Layout



The strength is held with the skin either side. Keeping the skin intact is essential to the panels strength properties. If required to make a 90° bend, the inner doubler must be split and therefore blocks may be required to compensate for loss of stiffness.

These GRP skins are demanded on the cassette table, with these extra components the cassette table will be fully secure. These are standard parts within AIM Altitude therefore and per the 'L' angles, a large amount of stock is stored in the facility and does not need to be machined through a third party. Used from standard material *SD70*, 0.06" (1.5mm), a density of 0.028lbm/inch³. Currently a volume of 42.417inch³ ∴ a mass of 1.187lbm (0.54kg). Initially it was thought to use alternative material *6061-T6*, 0.063" (1.6mm), a density of 0.101lbm/inch³ based on the same volume, a mass of 4.284lbm (1.94kg) ∴ over 3.5 x heavier than that of the GRP skin. As the cassette that contains the components of the sliding table design, the covers are not structural nor will it have an impact on the deployment of the sliding table therefore GRP doublers can be utilised to reduce cost of weight over the assembly.

13.4 Table Cassette GRP Layout



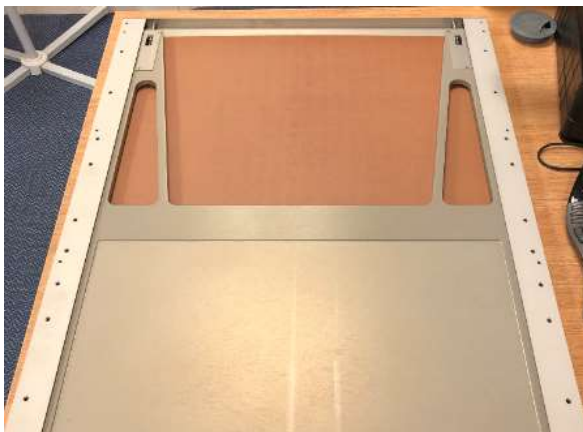
The GRP doublers sandwich the table and the runners together thus making it easier for when the table cassette is removed once fixed into the galley.

14.1 Prototype

Once drawings have been checked, approved, and added to the system, purchasing investigate where to source manufacturing of the assembly.

Two galleys in door one were due to be on the assembly line by the second week of March, the table due to be delivered to AIM Altitude by the second week of February allowing the supplier three weeks to manufacture the assembly. The supplier had been sent advanced drawings towards the end of the design stage, with minor changes towards completion therefore the prototype could be manufactured in advance. Internal tests will be carried out prior to installation.

14.2 Sliding Table Cassette Prototype

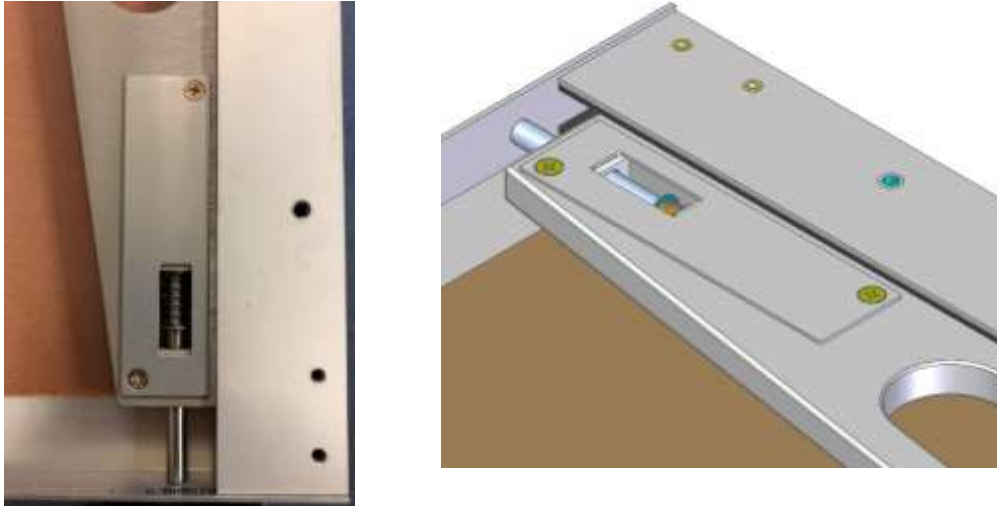


(AIMAltitude2020)

Prior to installation of the galleys, the sliding table is tested within the inspection bay. It is critical that any flaws are detected at this stage before mass production of the product. Each component assembly is tested, the table is surface inspected and dimensions checked to technical drawings. The GRP skin is removed to make the moving parts of the spring assembly visible.

The prototype duplicated that of the CAD model where the arrangement and dimensions were to drawing.

14.3 Spring Assembly Prototype



(AIMAltitude2020)

Although this table cassette is not for aircraft use, each part is tested rigorously to ensure deployment of the table is smooth along the nylatron packers. Once the table is stowed, it must be flush with the front facia of the assembly. When the release buttons are pressed, the table should deploy to a minimum of 12.7mm requirement. Tests were carried out and showed an average deployment of 15mm as shown below.

14.4 Sliding Table Deployment



This proved to be acceptable for the customer. All components were tested to check if any wear and damage were noticeable over a period of time. At the front of the table, an 'L' angle facia runs the length of the table (24.0"), the angle is machined centrally for deployment of the table and either side for the push button assemblies. A result of this left 0.143"

(AIMAltitude2020)

(3.63mm) either side of the slots running the mass majority of the fascia. Because of this the fascia started to bow once the GRP doubler is removed. This showed that the angle design was not sufficient and needed to be of a stronger material, or more material surrounding the most vulnerable areas was needed.

The area most effected is at the centre of the fascia as shown below.

14.5 Cassette Front Facia

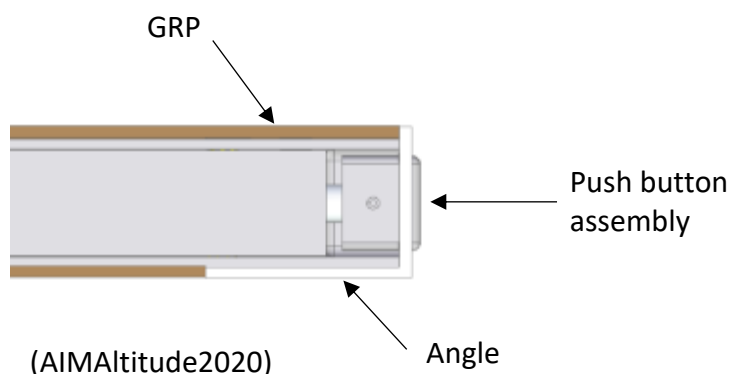


(AIMAltitude2020)

15.1 Modifications

To overcome the deformation of angle, a channel section is available which can be utilised to replace that of the 'L' angle fascia shown in Appendix 7- Commercial Extrusion Standard, various extrusion profiles such as square, circular and T sections are available. To prove this can work, the channel section must be designed around the same parameters of the original fascia, ensuring the slots are identical. Where previously the GRP skin came to the front of the table, now the channel extrusion will run along the top surface, similar to the underside of the table where the GRP is cut short.

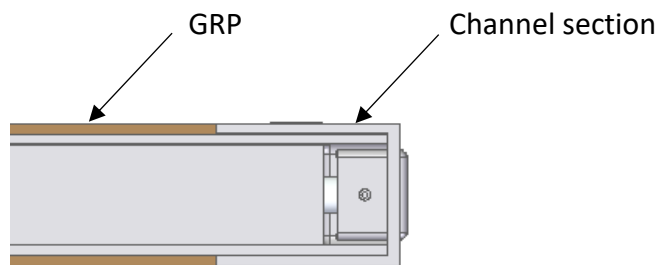
15.2 Current Front Facia Design



(AIMAltitude2020)

The channel extrusion is also a standard part therefore stocked internally with no need for third party manufacture. A drawing will be required adding the features of the sliding table and button assembly that can be machined internally. The added leg of the channel provides a much stiffer material preventing deformation of the angle. The layout can be seen below.

15.3 Modified Front Facia Design



(AIMAltitude2020)

16.1 Weight Comparison

Delta Air Lines table *G33DLADMD045* dimensions 32.251" x 23.000" x 0.365" weighing 6.28lbm. Qatar Airways table *G77TRAZMD003* dimensions 30.934" x 21.750" x 0.394" weighing 10.872lbm (weight of table excluding assembly).

Although using the same material aluminium plate Al6082 T6, Delta Air Lines table is 4.6lbm (2.08kg) lighter than the newly Qatar Airways tables. Properties show that a recorded volume of the Delta Air Lines table is 61.535inch³ compared to that of Qatar Airways table 109.129inch³ proving that more material is required on the Qatar Airways table to compensate the weight difference.

Areas where the Qatar Airways table is heavier than those of its predecessors are the front and rear of the table. Compared to other designs, the Qatar Airways table has a working surface on either side of the table and therefore can be turned 180° and continued to be used as a working table. Other tables have machined ribs on the underside to give a lighter table as there was no requirement for two working surfaces. At the rear of the table, to stow the Delta Air Lines table securely, terry clips were used as mentioned in section (6.4.2),

where it was not necessary for the use of spring deployment. Due to requirements of the customer it was essential that the table was spring loaded rather than using traditional methods of deployment. Therefore although the rear of the Qatar Airways table is machined to remove any unnecessary material, either end of the table still had to house a spring assembly that required substantial material around its perimeter to ensure the assembly is safely positioned.

Previous table designs were not removable and universal throughout the aircraft. Qatar Airways offers the option to remove the assembly design and relocate to other units within the aircraft that have the additional option of stowing sliding tables. The Delta Air Lines sliding table had separate component parts rather than an assembly design. Demanded on a higher stage of the galley assembly, table parts such as table, runners and stops were individual parts. Thus when ordering a new part if damaged, three parts will have to be ordered rather than one assembly that contained various parts.

Delta Air Lines runners were manufactured using nylacast, compared to those used on Qatar Airways which are aluminium. Nylacast was used as no potted inserts were required which proved to be a far lighter material. Delta Air Lines Table *G33DLADMD045*, including two off table runners *G33DLAAMD141* at 0.820lbm each.

As the Delta Air Lines table is manually deployed therefore there was no need of a spring assembly. A combined weight of table *G33DLADMD045* 6.280lbm + table runners *G33DLAAMD141* at $(0.820\text{lbm} \times 2) = 7.920\text{lbm}$ (3.6kg).

16.2 Qatar Airways Component Weight List

Description	QTY	Part Number	Weight (lbm)
Table Assembly Including Spring Assembly	1	G77TRAZMD003-01	11.084
Table Facia	1	G77TRAZGD012	0.192
Facia Angle	1	G77TRAZGD013	0.265
Table Guide Including Push Button	1	G77TRAZMD032-03	2.678
Table Guide Including Push Button	1	G77TRAZMD032-01	2.678
Table Stop	2	G77TRAZSA026-15	0.035
GRP Skin	1	G77TRAZGD017-03	1.306
GRP Skin	1	G77TRAZGD017-01	1.381
Screw CSK 6-32 UNC	22	NAS514P632-5P	0.002
Total			19.698

Total assembly weight of 19.698bm (8.95kg) 2.5 x heavier than Delta Air Lines and runners.

17.1 Cost Evaluation

Delta Air Lines design offers a light, low cost-effective sliding table. The table is manufactured from aluminium plate, yet other parts including table runners are manufactured using a polymer with excellent mechanical properties with guarantee of no corrosion enhancing its shelf-life. Due to this, basic nylacast is a preferred option as it is lighter.

As a result of this, the costs are far lower than that of the Qatar Airways cassette. Shown in Appendix 9, Delta Air Lines table *G33DLADM045* manufactured cost £545.90, table runners *G33DLAAMD141* cost $(£47.35 \times 2) = £94.7$ ∴ a sum of £640.6.

Qatar Airways cassette design, a much more complex design than of its predecessor, included much more detailed parts and assemblies. Table *G77TRAZMD003* cost £468.9, cassette assembly *G77TRAZSA026* (including sub components parts and table) cost £1,185.1.

A cost difference of £544.5. Per average programme, 40 hours are set aside to design a unique sliding table. According to (GlassDoor, 2020), the average mechanical design engineers' salary £32,730 therefore £17ph based on a 37.5 working week. A new programme- an additional £680.0 predicting that the hours do not exceed 40 hours will cost AIM per programme, per table therefore when table cassette is used on the next programme, a saving of £135.5 will be made.

18.1 Evaluation

A project to create a standard sliding table assembly that can be used on various programmes throughout the company. A table that is universal and both satisfies customer requirements and the aircraft manufacturer. An assembly that comprises of various component parts to produce a table cassette that is uniquely presented, seen only when deployed and in use, a surface that provides an additional working space. The project ran from August 2019 – March 2020 with numerous milestone activities between. The cassette sliding table design was put forward by the airline Qatar Airways, to create a standard table used for all locations throughout the aircraft, a cassette design table which sits flush with the face of the benchtop once stowed, as stated in Appendix 1.

Following an initial project timeline, working in conjunction with the milestone activities to ensure the project does not exceed its targets. Hours were assigned to specific tasks such as reviewing customer requirements and TC holder specifications ensuring the design of the sliding table cassette is to specification. Allowing 11 weeks of designing the cassette, with an additional two weeks of planned overlap.

Working accordingly to the technical milestone meetings throughout the entirety of the programme, and working in conjunction with Factory Design, proposals were brought forward graphically to have an initial start of the design. The sliding table design is incorporated into many galleys throughout the aircraft, no more so than door four galleys positioned at the rear of the aircraft. Thorough investigation of previous sliding table designs showed Delta Air Lines designs included separate parts as an alternative to an assembly, whilst table runners were machined out of a nylacast polymer and table stops were used by adding terry clips to the rear of the table. These sliding tables were ribbed on one side of the working surface, the other, machined to reduce the weight of the table. Yet the Qatar Airways design will include various parts, demanded in one assembly. This cassette- like design will enclose these parts where if needed to be removed, the entirety of the cassette can be removed with ease, carrying all components at once rather than dismantling numerous parts separately.

The sliding table is to have a working surface on either side of the table therefore if damaged, both surfaces can be used while ensuring the table can still withstand 30lbs of abuse load. Previous designs showed deployment of the tables once on aircraft required manual use. As per CDR minutes- Appendix 1, there is a requirement to have the front surface of the table flush with the face of benchtop capping when stowed. This eliminated manual deployment, thus design looked in to spring deployment using a push button assembly that would go unnoticed once installed with each component running flush along the decorative edge.

All material on a Boeing programme must adhere to specific metallic materials shown on Appendix 10, depending on the requirement of the component, whether structural or decorative. Spring design initially started with a shaft component which will be used to push the table out from the rear. The assembly includes various parts such as washes, split pin and spring. A minimum of 0.5" (12.7mm) deployment is required, based on a 22.231N load whilst the screw is in compression, an initial spring rate of 1.45N/mm (LeeSpring, 2020), where a spring deflection of an estimated 13.49mm spread over two springs. By positioning the spring assembly equally distanced from the central axis of the table at the rear, unnecessary material is removed and slots added to the table to keep the weight of the table low.

Restricted with the aperture of the galley design, thickness of the table must not exceed 0.8" (20.32mm). This therefore saw a clash of the head of a countersunk screw with the table. To overcome this, being within the design stage, the table is countersunk along with the doubler to allow the head of the screw to sit flush with the surface.

To overcome manual deployment, a push button assembly is used whereby pushing the button positioned at the front of the cassette design will deploy the table. To prevent the table from uncontrollably deploying, intermediate stops are added to the side of the table offset 7.0" with a total deployment of 14.0" as per customer specification. Intermediate stops are deployed using a 5/16" bolt through the table runners. By machining table runners from aluminium bar 2014-T651 per AMS 4029, which is used for structural applications, i.e. blocks and machined parts, this had an impact on weight compared to those of its predecessors that used a polymer rather than metallic.

Standard extrusions are utilised preventing third party manufacturing, rather having the material stocked internally where grooves can be manufactured without the need of sourcing a supplier externally. These fascia angles are added at the front and the rear of the table as 'L' angles as per 6082 standard extrusions shown on Appendix 7.

Being FDA compliant limited the clearance around the table once deployed, already restricted with the galley aperture of 0.8". The front fascia cut- out around the table could not exceed 3/32" (2.4mm), saw the gap of 0.049" (12.5mm), being FDA compliant preventing any dust and dirt forming internally. As shown on Figure (12.1), initially there was no indication to show if the table was not fully engaged. To prevent this, a table engagement warning was added around the perimeter of the angle cut- out which housed the push button assembly that saw once the button was pressed and table was not in a locked position, a red indication will be shown until the table is locked securely and the button pushes back out.

The cassette table design saw the two week planned overlap used, ensuring the last of advanced drawings were submitted by the end of week 18. After initially allowing manufacturing of the prototype two weeks, this became four weeks until the prototype was delivered to factory. This therefore had an impact on planned feedback and drawing submittals, along with production.

Set back two weeks, it was imperative that inspection of the prototype would commence immediately therefore any defects could be found prior to drawing submittals that would affect production. Investigation showed deployment of the table reached 15mm, above the minimum requirement of 12.7mm. Standard 'L' extrusion 8082 used as the front and rear fascia angle of the cassette table proved to be too fragile at the front. Removing material from the fascia for the push button and table resulted in having 3.63mm either side of the slots running the length of the fascia. This meant the fascia started to bow and the design was not sufficient.

To overcome this, various extrusions are available in the standard extrusions. Investigation looked at multiple options and concluded on a channel section, this was to be designed around the same perimeters of the original fascia ensuring slots are identical. The channel will provide a 'U' channel therefore giving more material stiffness preventing deformation of

the angle. Changing the design had an impact on the design and planned feedback setting back an additional week to week 25 of 28. The setback saw production being delayed one week prior to inspection. Drawing submittals were met, by altering designs, production were able to receive the table and fit ready for inspection.

The Delta Air Lines table initially tested to withstand a 680N downward force, being an unsymmetrical profile the second moment of area $\frac{bd^3}{12}$ is calculated splitting in to two separate sections, the centroid is calculated for those specific areas. To stipulate the figures accordingly, they were added to a table as shown in Appendix 22, from which we are able to calculate $\bar{Y}$, by calculated h^1 and h^2 , this taken from the second moment of area of both sections giving Ah^2 which is added to the second moment of area of both sections to give the total I_{xx} 8876.79mm⁴. Where $\sigma = MY/I$, $M = 680 \times 350 = 238,000N/mm$.

$\Sigma = 238,000 \times 7.07 / 8877 = 190MPa$. Yield stress allowable for aluminium plate Al6082 T6 – 240MPa (Aalco, 2020). $SF = 240 / 190 = 1.26 \therefore$ being well below the yield point of the material, the table will not yield under this abuse load.

Qatar Airways material 2014-T651 plate per AMS 4029 tested to withstand 44.0lbs (195.3N), the table provided a more simple area to test where the second moment of area $\frac{bd^3}{12}$ is calculated by addition of the profile perimeters and length of table x 2 as the profile is on either sides of the table to give I_{xx} 11600.8mm⁴ calculated in Appendix 23, From $\sigma = MY/I$
 $M^B = 195.4 \times 342.9 \therefore M_B = 67,002 N/mm$

$$\bar{Y} = 10.0 / 2 = 5.0$$

$$67,002 \times 5.0 / 11600.8 = \sigma \therefore \sigma = 28.9MPa$$

Based on material 2014-T651 plate per AMS 4029. A yield stress allowable of 414MPa (Specification, 2019). $RF = 414 / 28.9 = 14.3 \therefore$ the applied force of 195.4N, it is clear bending stress is not critical. Calculations of both tables proved that each table can withstand a total of substantially more than 30lbs of force upon the table.

The weight of the Delta Air Lines table, comprised of a sliding table and two table runners, is at a combined weight of 6.28lbm. Qatar Airways comprised of six additional component parts and assemblies weighing a total of 19.698lbm, a difference of 13.318lbm. The biggest weight difference was seen in the table runners, Qatar Airways table runners were

machined from aluminium bar whereas its predecessors manufactured from a light polymer.

Two runners are required at each side of the table. A runner used on Delta Air Lines weighed 0.820lbm (1.640lbm combined), whereas the Qatar Airways table runner, although an assembly with component parts, weighed 2.678lbm (5.356lbm combined), over three times the weight of Delta Air Lines. This therefore had an impact on the overall weight of the assembly. Containing many component parts and assemblies saw the weight surpass the Delta Air Lines weight.

Although not yet implemented, to reduce the weight of the table runners used for the Qatar Airways programme, slots can be added to the assembly where necessary to utilise free space that will be unused. By adding three slots as shown in Appendix 21, the weight of the assembly reduces from 2.678lbm to 2.267lbm, saving a combination 0.822 including both table runners bringing the overall weight of the sliding table cassette to 18.876lbm.

19.1 References

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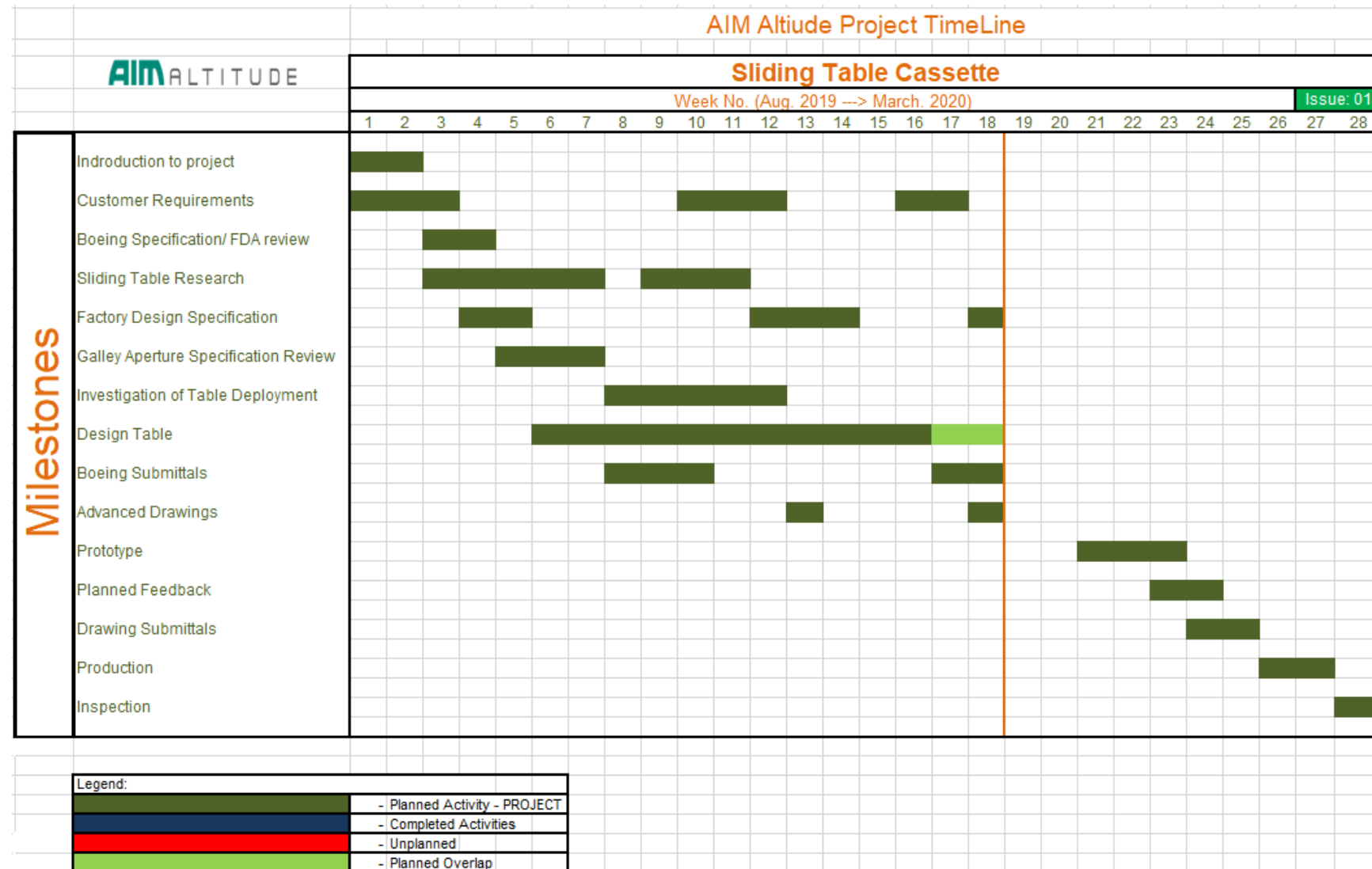
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Appendix 1- CDR Minutes



Item	Unit	Description	Action Owner	Status	Date Required
	Galleys	locations - paint only the first 5 inches and paint back of the doors			
CDR - 6	All Monuments & Galleys	Cart Bays - Door 3 and Door 4 - All backs of doors painted, and cart bays not painted. Except for Air through -- first 5 inches of the cart bay painted.	AIM Altitude	Note	
CDR - 7	Door 2 Galleys (All)	Cart Bays - Paint the first 3-5 inches. Cart Bay Doors - back side to be painted. Pantry to be fully painted.	AIM Altitude	Note	
CDR - 8	All Monuments & Galleys	Foot Step - Preference is for the AIM Altitude Flush mounted Footstep. Red Indication to be incorporated to show when the foot step is not locked in the stowed position.	AIM Altitude (Andrew)	Note	
CDR - 9	All Monuments & Galleys	Foot Step - AIM Altitude Footstep - review torsion springs and also is it possible to lock without going through a complete cycle	AIM Altitude (Andrew)	Open	19-Apr-19
CDR - 10	All Monuments & Galleys	Standard tables to be used in all locations except for Door 2. Door 2 to remain with cassette design table which is flush with face of benchtop capping when stowed.	AIM Altitude (Phil)	Note	
CDR - 11	All Monuments & Galleys	Standard Table - which has two 1/4 turns. Need to review lock when it is fully out, so that it doesn't retract if the table is leaned on. This is to be reviewed by AIM Altitude	AIM Altitude (Phil)	Open	19-Apr-19
CDR - 12	All Monuments & Galleys	AIM Altitude to provide a presentation that demonstrates the differences between the Std Table and the Cassette table options.	AIM Altitude (Phil)	Open	20-Mar-19

Appendix 2- Timing Plan Issue 01



Appendix 3- NAS514 Datasheet

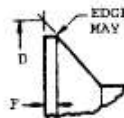


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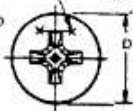
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WASHINGTON, D.C. 20005

MARK STEEL SCREWS WITH TWO "X" CONNECTED WITH A BAR. ONLY ONE "X" NEED BE VISIBLE AFTER SLOTTING. POSITION OPTIONAL



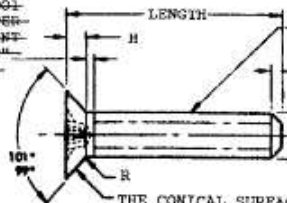
EDGE OF HEAD MAY BE ROUNDED



RECESSED HEAD SCREW

THIS TYPE OF RECESS HAS A LARGE CENTER OPENING, TAPERED WINGS, AND BLUNT BOTTOM, WITH ALL EDGES RELIEVED OR ROUNDED. RECESS SHALL BE IN ACCORDANCE WITH MS9006

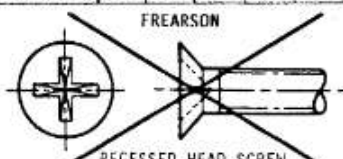
⑧ SEE NOTE 6
AN INCREASE OF .001 OVER .14 DIA IS PERMISSIBLE FROM POINT OF TANGENCY OF .R4 AND CHAMFER TO 1/32



THREAD T SPEC
MIL-S-8879
SEE NOTE 4
M X 45°
APPROX (OPTIONAL)

THE CONICAL SURFACE OF THE HEAD SHALL BE CONCENTRIC WITH THE BODY WITHIN .003 TIR

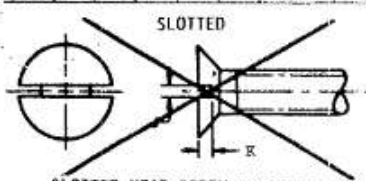
THREAD T	A DIA		D DIA				F MAX	H REF	J				K		M MAX	R RADIUS		MIN ULT TENSILE STRENGTH	MINIMUM SHEAR STRENGTH
			MAX	MIN	ABS MIN	W/TH MAX F			MAX	MIN	MAX	MIN	MAX	MIN					
	MAX	MIN	SHARP	SHARP	MAX											MIN	MAX		
SEE NOTE 4	MAX	MIN	SHARP	SHARP	W/TH MAX F	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	LBS REF	LBS REF	NOTE 8	
.1120-40UNC-3A	.1110	.1080	.225	.213	.183	.012	.045	.039	.031	.024	.017	.031	.012	.002		750		450	
.1380-32UNC-3A	.1372	.1340	.279	.267	.233	.014	.057	.048	.039	.030	.022	.031	.012	.002		1,120		670	
.1640-32UNC-3A	.1631	.1600	.332	.319	.282	.015	.068	.059	.045	.036	.027	.031	.015	.005	1,740		1,040		
.1900-32UNC-3A	.1890	.1860	.385	.371	.332	.016	.080	.060	.050	.042	.031	.031	.015	.005	2,490		1,490		
.2500-28UNC-3A	.2490	.2460	.507	.491	.447	.018	.106	.075	.064	.055	.042	.031	.015	.005	4,520		2,710		
.3125-24UNC-3A	.3115	.3085	.635	.617	.568	.020	.133	.094	.073	.069	.053	.047	.020	.010	7,240		4,340		
.3750-24UNC-3A	.3740	.3710	.762	.742	.686	.023	.159	.094	.081	.083	.064	.047	.020	.010	10,950		6,570		



RECESSED HEAD SCREW

THIS TYPE OF RECESS CONSISTS OF TWO INTERSECTING SLOTS WITH PARALLEL SIDES CONVERGING TO A SHARP APEN AT BOTTOM OF RECESS. RECESS SHALL BE IN ACCORDANCE WITH THE 1955 SUPPLEMENT TO HANDBOOK, H-20 SCREW THREADS FOR FEDERAL SERVICES 1944 (RECESS TYPE-11)

FREARSON RECESSED HEAD SCREW INACTIVE FOR DESIGN AFTER 15 OCT. 1958.



SLOTTED

SLOTTED HEAD SCREW INACTIVE FOR DESIGN AFTER 1 SEPT. 1963.

FOR DEFINITION OF DRAWING STATUS NOTES, SEE NAS380.

MATERIAL: ALLOY STEEL, 4037 (UNS G40370) PER AMS6300 (RESTRICTED TO 612K5 THROUGH .3750 DIAMETER), 4130 (UNS G41300) PER MIL-S-6758, 4340 (UNS G434000) PER MIL-S-5000, 8630 (UNS G86300) PER MIL-S-6050, 8735 (UNS G87350) PER MIL-S-6094 OR 8740 (UNS G87400) PER MIL-S-6049. SEE NOTE 7.

HEAT TREAT: 125,000 TO 145,000 PSI TENSILE STRENGTH SPEC MIL-H-6875

FINISH: CADMIUM PLATE, SPEC QQ-P-416 TYPE I, CLASS 2. CADMIUM PLATE, SPEC QQ-P-416 TYPE II, CLASS 2. FOR PARTS CARRYING "B" OR "P" AFTER LAST DASH NO. (SEE CODE)

PARTS WITH CLASS 3 PLATING MAY BE FURNISHED FROM SUPPLIER'S STOCK UNTIL 30 NOVEMBER 1975.

- NOTES:
1. REFERENCE DIMENSIONS ARE FOR DESIGN PURPOSES ONLY AND ARE NOT AN INSPECTION REQUIREMENT
 2. DIMENSIONS IN INCHES
 3. SCREWS SHALL BE FREE OF ALL BURRS AND SHARP EDGES
 4. SCREW MANUFACTURERS MAY SUPPLY SCREWS WITH MIL-S-7742 THREADS UNTIL 31 DEC. 1970. SCREWS WITH MIL-S-7742 THREADS MAY BE USED UNTIL STOCK IS DEPLETED.



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1	H	2	H

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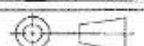
PROCUREMENT SPECIFICATION

MIL-S-7839

TITLE

SCREW, MACHINE, 100°, FLAT HEAD FULL THREADED, ALLOY STEEL

THIRD ANGLE PROJECTION



CLASSIFICATION STANDARD PART

NAS 514

SHEET 1 OF 2

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APPROVAL DATE 25 April 1991

Appendix 4- Nylatron Data Sheet

PRODUCT DATA SHEET

Technical Data Sheet for Nylatron GSM Rod, Sheet & Tube

NYLATRON[®] GSM



Nylatron GSM contains finely divided particles of molybdenum disulphide to enhance its bearing and wear behaviour without impairing the impact and fatigue resistance inherent to unmodified cast nylon grades. It is a very commonly used grade for gears, bearings, sprockets and sheaves.

Physical properties (indicative values *)

PROPERTIES	Test methods	Units	VALUES
Colour	-	-	grey-Black
Density	ISO 1183-1	g/cm ³	1.16
Water absorption:			
- after 24/96 h immersion in water at 23 °C (1)	ISO 62	mg	52 / 98
- at saturation in air at 23 °C / 50 % RH	ISO 62	%	0.76 / 1.43
- at saturation in water at 23 °C	-	%	2.4
- at saturation in water at 23 °C	-	%	6.7
Thermal Properties (2)			
Melting temperature (DSC, 10 °C/min)	ISO 11357-1/3	°C	215
Glass transition temperature (DSC, 20 °C/min) - (3)	ISO 11357-1/2	°C	-
Thermal conductivity at 23 °C	-	W/(K.m)	0.30
Coefficient of linear thermal expansion:			
- average value between 23 and 90 °C	-	m/(m.K)	80 x 10 ⁻⁶
- average value between 23 and 100 °C	-	m/(m.K)	90 x 10 ⁻⁶
Temperature of deflection under load:			
- method A: 1.8 MPa	* ISO 75-1/2	°C	80
Max. allowable service temperature in air:			
- for short periods (4)	-	°C	170
- continuously: for 5,000 / 20,000 h (5)	-	°C	105 / 90
Min. service temperature (6)	-	°C	-30
Flammability (7):			
- "Oxygen Index"	ISO 4589-1/2	%	25
- according to UL 94 (3) (5 mm thickness)	-	-	HB / HB
Mechanical Properties at 23 °C (8)			
Tension test (9):			
- tensile stress at yield / tensile stress at break (10)	* ISO 527-1/2	MPa	80 / -
- tensile strength (10)	** ISO 527-1/2	MPa	50 / -
- tensile strength at break (10)	** ISO 527-1/2	MPa	82
- tensile strain at yield (10)	* ISO 527-1/2	%	5
- tensile strain at break (10)	** ISO 527-1/2	%	25
- tensile modulus of elasticity (11)	** ISO 527-1/2	MPa	3400
- tensile modulus of elasticity (11)	** ISO 527-1/2	MPa	1650
Compression test (12):			
- compressive stress at 1 / 2 / 5 % nominal strain (11)	* ISO 694	MPa	33 / 62 / 91
Charpy impact strength - Unnotched (13)	* ISO 179-1/1eJ	kJ/m ²	no break
Charpy impact strength - Notched	* ISO 179-1/1eJ	kJ/m ²	3
Ball indentation hardness (14)	* ISO 2039-1	N/mm ²	180
Rockwell hardness (14)	* ISO 2039-2	-	M 84
Electrical Properties at 23 °C			
Electric strength (15)	* IEC 60243-1	kV/mm	24
Volume resistivity	** IEC 60243-1	ΩV/mm	16
Surface resistivity	* IEC 60093	Ωcm	> 10 ¹¹
Surface resistivity	** IEC 60093	Ωcm	> 10 ¹¹
Relative permittivity ε _r - at 100 Hz	* IEC 60250	-	3.8
- at 1 MHz	** IEC 60250	-	6.6
- at 1 MHz	* IEC 60250	-	3.2
- at 1 MHz	** IEC 60250	-	3.7
Dielectric dissipation factor tan δ - at 100 Hz	* IEC 60250	-	0.013
- at 1 MHz	** IEC 60250	-	0.14
- at 1 MHz	* IEC 60250	-	0.016
- at 1 MHz	** IEC 60250	-	0.05
Comparative tracking index (CTI)	* IEC 60112	-	600
Comparative tracking index (CTI)	** IEC 60112	-	600

Note: 1 g/cm³ = 1,000 kg/m³; 1 MPa = 1 N/mm²; 1 kV/mm = 1 MV/m.

Availability: see "Guide to Diameter/Sheet Tolerances and Weights" or contact us

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Appendix 5- NAS1351 Data Sheet



Aerospace
Industries
Association

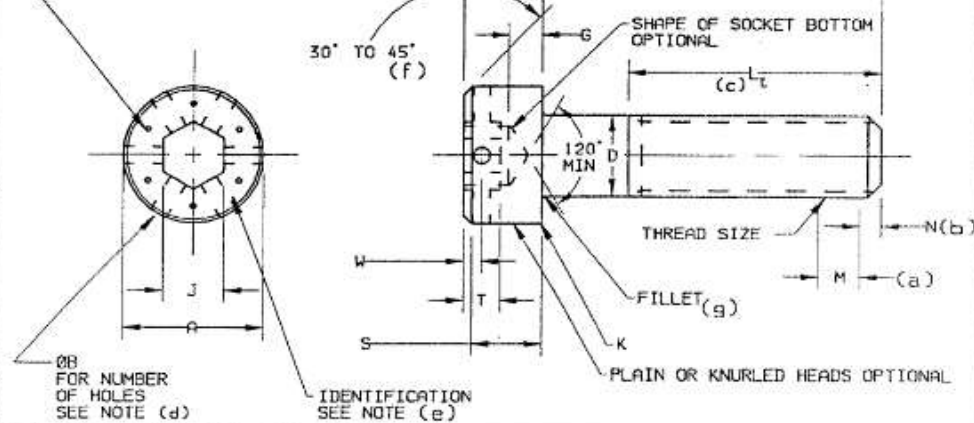
NATIONAL AEROSPACE STANDARD

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FED. SUP. CLASS
5305

WHEN SELF-LOCKING ELEMENT IS SPECIFIED
HEAD MARKING OF A MINIMUM OF SIX (6)
DOTS RAISED OR DEPRESSED IS REQUIRED.
TOP OF SIDE LOCATION OPTIONAL.
(SCREW SIZES 64 AND LARGER).



NOMINAL SIZE DASH NO.	THREAD SIZE	D BODY DIAMETER		A HEAD DIAMETER		H HEAD HEIGHT		S HEAD SIDE HEIGHT MIN.	J SOCKET SIZE	T KEY ENGAGEMENT MIN.	G WALL THICKNESS MIN.	K CHAMFER OR RADIUS MAX.
		MAX.	MIN.	MAX.	MIN.	MAX.	MIN.					
00	.0600-80	.060	.0568	.096	.091	.060	.057	.054	.050	.025	.020	.003
01	.0730-72	.073	.0695	.118	.112	.073	.070	.066	.062	.031	.025	.003
02	.0860-64	.086	.0822	.140	.134	.086	.083	.077	.078	.038	.029	.003
03	.0990-56	.099	.0949	.161	.154	.099	.095	.089	.078	.044	.034	.003
04	.1120-48	.112	.1075	.183	.176	.112	.108	.101	.094	.051	.038	.005
06	.1380-40	.138	.1329	.226	.218	.138	.134	.124	.109	.064	.047	.005
08	.1640-36	.164	.1585	.270	.262	.164	.159	.148	.141	.077	.056	.005
3	.1900-32	.190	.1840	.312	.303	.190	.185	.171	.156	.090	.065	.005
4	.2500-28	.250	.2435	.375	.365	.250	.244	.225	.188	.120	.095	.008
5	.3125-24	.3125	.3053	.469	.457	.312	.306	.281	.250	.151	.119	.008
6	.3750-24	.375	.3678	.562	.550	.375	.368	.337	.312	.182	.143	.008
7	.4375-20	.4375	.4294	.656	.642	.437	.430	.394	.375	.213	.166	.010
8	.5000-20	.500	.4919	.750	.735	.500	.492	.450	.375	.245	.190	.010
10	.6250-18	.625	.6163	.937	.921	.625	.616	.562	.500	.307	.238	.010
12	.7500-16	.750	.7406	1.125	1.107	.750	.740	.675	.625	.370	.285	.010
14	.8750-14	.875	.8647	1.312	1.293	.875	.864	.787	.750	.432	.333	.015
16	1.0000-12	1.000	.9886	1.500	1.479	1.000	.988	.900	.750	.495	.380	.015

LIST OF CURRENT SHEETS

NO.	REV.
1	9
2	4
3	9
4	1

Ⓢ COMPLETELY REVISED

CUSTODIAN NATIONAL AEROSPACE STANDARDS COMMITTEE

THIRD
ANGLE
PROJECTION

PROCUREMENT
SPECIFICATION
NOTED

TITLE
SCREW, CAP, SOCKET HEAD
UNDRILLED AND DRILLED, PLAIN AND SELF-LOCKING
ALLOY STEEL, CORROSION-RESISTANT STEEL
AND HEAT-RESISTANT STEEL, UNF-3A

CLASSIFICATION
PART STANDARD

NAS 1351
SHEET 1 OF 4

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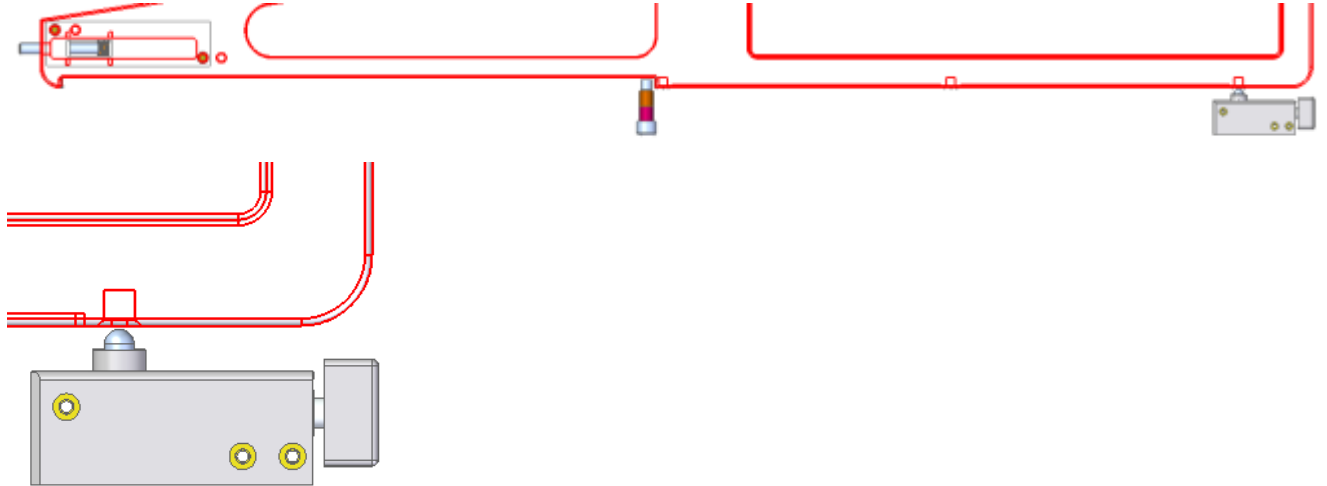
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Appendix 6- Table Deployment

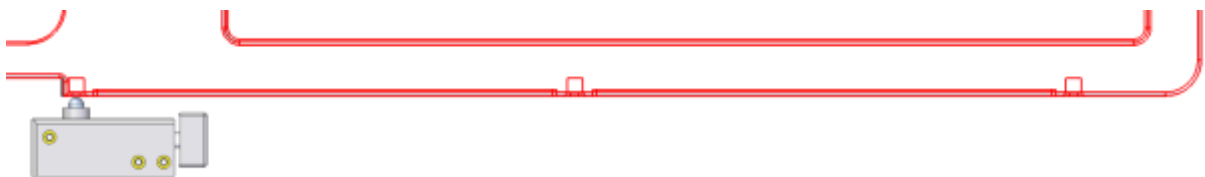
6:1 Table Stowed



6:2 7.0" Table Deployment



6:3 14.0" Table Deployment



6:4 14.0" Table Deployment with Table Stop

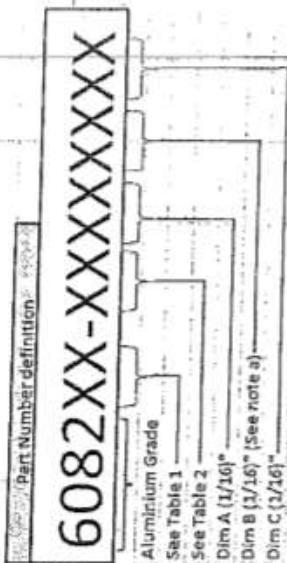
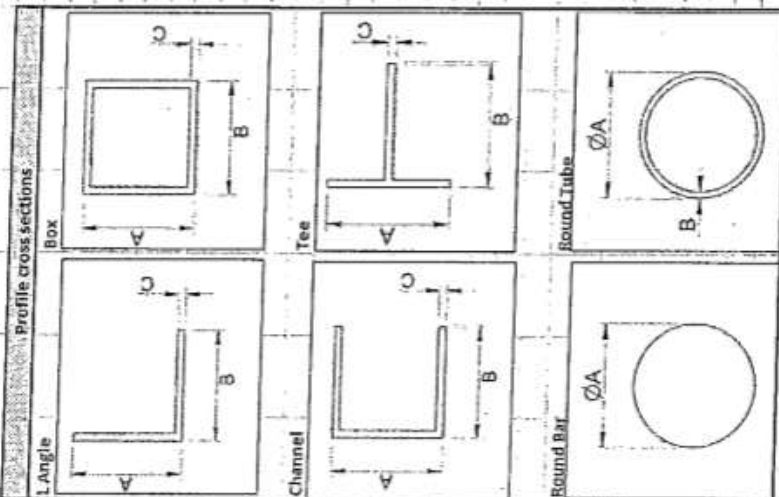


Appendix 7- Commercial Extrusion Standard

AIM ALTITUDE

3.2.1.3. Commercial

Extrusion held in stock - preferred				Part Number	
Profile	Dim A	Dim B	Dim C		
L Angle	0.625	0.625	0.0625	6082TF-A101001	
L Angle	0.75	0.75	0.0625	6082TF-A1121201	
L Angle	1	0.75	0.125	6082TF-A1161202	
L Angle	1	1	0.0625	6082TF-A1161601	
L Angle	1	1	0.125	6082TF-A1161602	
L Angle	1	1	0.1875	6082TF-A1161603	
L Angle	1.25	1	0.25	6082TF-A1161604	
L Angle	1.25	1.25	0.125	6082TF-A1201602	
L Angle	1.5	1	0.125	6082TF-A1202002	
L Angle	1.5	1.5	0.125	6082TF-A1241602	
L Angle	1.5	1.5	0.0625	6082TF-A1242401	
L Angle	1.5	1.5	0.125	6082TF-A1242402	
L Angle	2	2	0.125	6082TF-A1321202	
L Angle	2.5	1.5	0.125	6082TF-AW02402	
L Angle	3	1	0.125	6082TF-A1481602	
L Angle	3	1.5	0.125	6082TF-A1482402	
L Angle	3	3	0.125	6082TF-A1484802	
L Angle	4	2	0.125	6082TF-A1643202	
L Angle	4	4	0.25	6082TF-A1646404	
Box	0.75	0.75	0.0625	6082TF-B1121216	
Box	1	1	0.0625	6082TF-B1161616	
Channel	3	1	0.25	6082TF-C1481602	
Tee	1.5	1.5	0.125	6082TF-M1242402	
Tee	2	2	0.125	6082TF-M1323202	
Tee	2	2	0.1875	6082TF-M1323203	
Round Bar	0.1875	n/a	n/a	6082TF-R103	
Round Bar	0.75	n/a	n/a	6082TF-R128	
Round Tube	2.5	0.064	n/a	6082TS-T14016	



Note at:
Dim B for Round Tube profile is noted in SWG (eg 16 = 16SWG)

Table 1 - Aluminium Temper	
Code	Treatment
TF	Heat treated & artificially aged
T6	Heat treated & artificially aged

Table 2 - Profile	
Code	Profile Description
AI	L Angle
BI	Box
CI	Channel
MI	Tee
RI	Round Bar
TI	Round Tube

Appendix 8- Standard Doublers and Packers

Rev	Rev	Rev	Rev	Rev	Rev
1	2	3	4	5	6
1	2	3	4	5	6

SDXX-XXX-XXX Standard Doublers/Packers

Where the first four digits will refer to standard doubler type of material, gauge of material & treatment. The following six digits will refer to size in Tenths of inches. Eg SD61-090-090 = Aluminium 16swg, Alclonox doubler 9 inches by 9 inches. See list below for details: -
 Standard doublers to have Ø2.45mm rivet holes in 2 opposite corners 0.50 inches from the edges. Holes Not required if either size is less than 0.70 inches.
 Standard Nylacast and Macrolon Packers do not require rivet holes.

SD01-XXX-XXX	STD DOUBLER/PACKER 16SWG	SD21 H22 16SWG, OP37 ALOCROM FINISH, WH556 BONDING PRIMER
SD01-XXX-XXX	STD DOUBLER/PACKER 16SWG	SD21 H22 16SWG, OP37 ALOCROM FINISH, WH556 BONDING PRIMER
SD21-XXX-XXX	STD DOUBLER/PACKER 20SWG	SD21 H22 20SWG, OP37 ALOCROM FINISH, WH556 BONDING PRIMER
SD42-XXX-XXX	STD DOUBLER/PACKER 14SWG	SD21 H22 14SWG, 2-02 ANODIZE FINISH, WH556 BONDING PRIMER
SD62-XXX-XXX	STD DOUBLER/PACKER 16SWG	SD21 H22 16SWG, 2-02 ANODIZE FINISH, WH556 BONDING PRIMER
SD62-XXX-XXX	STD DOUBLER/PACKER 16SWG	SD21 H22 16SWG, 2-02 ANODIZE FINISH, WH556 BONDING PRIMER
SD22-XXX-XXX	STD DOUBLER/PACKER 20SWG	SD21 H22 20SWG, 2-02 ANODIZE FINISH, WH556 BONDING PRIMER
SD63-XXX-XXX	STD DOUBLER/PACKER 16SWG	L163 16SWG, OP37 ALOCROM FINISH, WH556 BONDING PRIMER
SD63-XXX-XXX	STD DOUBLER/PACKER 16SWG	L163 16SWG, OP37 ALOCROM FINISH, WH556 BONDING PRIMER
SD23-XXX-XXX	STD DOUBLER/PACKER 20SWG	L163 20SWG, OP37 ALOCROM FINISH, WH556 BONDING PRIMER
SD64-XXX-XXX	STD DOUBLER/PACKER 16SWG	L163 16SWG, 2-02 ANODIZE FINISH, WH556 BONDING PRIMER
SD64-XXX-XXX	STD DOUBLER/PACKER 16SWG	L163 16SWG, 2-02 ANODIZE FINISH, WH556 BONDING PRIMER
SD24-XXX-XXX	STD DOUBLER/PACKER 20SWG	L163 20SWG, 2-02 ANODIZE FINISH, WH556 BONDING PRIMER
SD65-XXX-XXX	STD DOUBLER/PACKER 16SWG	304 D51 16SWG
SD65-XXX-XXX	STD DOUBLER/PACKER 16SWG	304 D51 16SWG
SD25-XXX-XXX	STD DOUBLER/PACKER 20SWG	304 D51 20SWG
SD66-XXX-XXX	STD DOUBLER/PACKER 16SWG	DM381 2-02-24K GRP
SD26-XXX-XXX	STD DOUBLER/PACKER 22SWG	DS22H2 2-02-24K GRP
SD01-XXX-XXX	STD NYLACAST PACKER 1/32 THK	NYL00401 (0.004mm THK)
SD02-XXX-XXX	STD NYLACAST PACKER 1/16 THK	NYL00402 (0.008mm THK)
SD03-XXX-XXX	STD NYLACAST PACKER 1/8 THK	NYL00403 (0.016mm THK)
SD04-XXX-XXX	STD NYLACAST PACKER 1/4 THK	NYL00404 (0.032mm THK)
SD05-XXX-XXX	STD NYLACAST PACKER 3/8 THK	NYL00405 (0.048mm THK)
SD06-XXX-XXX	STD NYLACAST PACKER 1/2 THK	NYL00406 (0.064mm THK)
SD07-XXX-XXX	STD NYLACAST PACKER 5/8 THK	NYL00407 (0.080mm THK)
SD08-XXX-XXX	STD NYLACAST PACKER 3/4 THK	NYL00408 (0.096mm THK)
SD09-XXX-XXX	STD NYLACAST PACKER 7/8 THK	NYL00409 (0.112mm THK)
SD10-XXX-XXX	STD NYLACAST PACKER 1 THK	NYL00410 (0.128mm THK)
SD11-XXX-XXX	STD NYLACAST PACKER 1 1/8 THK	NYL00411 (0.144mm THK)
SD12-XXX-XXX	STD NYLACAST PACKER 1 1/4 THK	NYL00412 (0.160mm THK)
SD13-XXX-XXX	STD NYLACAST PACKER 1 3/8 THK	NYL00413 (0.176mm THK)
SD14-XXX-XXX	STD NYLACAST PACKER 1 1/2 THK	NYL00414 (0.192mm THK)
SD15-XXX-XXX	MACROLON PACKER	F3-2134H (1.2mm THK) CREAM
SD16-XXX-XXX	MACROLON PACKER	F3-2134H (1.5mm THK) GREY
SD17-XXX-XXX	GRP DOUBLER, .03" THK	PER AAMS005-060
SD17-XXX-XXX	GRP DOUBLER, .03" THK	PER AAMS005-060
SD17-XXX-XXX	GRP DOUBLER, .03" THK	PER AAMS005-060
SD17-XXX-XXX	GRP DOUBLER, .03" THK	PER AAMS005-060

NOTES:
 SEE SHEET 27 FOR PREVIOUS REVISIONS PRIOR TO THIS RELEASE

MACHINED COMPONENTS NOTES:
 1. PART MARK IN ACCORDANCE WITH JP4H.
 2. COMPONENT WEIGHT IN ACCORDANCE WITH JP33.
 3. FOR MANUFACTURING PURPOSES THE CAD MODEL IS THE MASTER.
 4. REMOVE SHARP EDGES IN ACCORDANCE WITH JP34.
 5. DRILL HOLES IN ACCORDANCE WITH JP12.

Rev	Rev	Rev	Rev	Rev	Rev
1	2	3	4	5	6
1	2	3	4	5	6

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STANDARD DOUBLERS

SDXX-XXX-XXX

Page: A

Appendix 9- Table Costs

9:1 Delta Air Lines Runners *G33DLAAMD141*

Cost Values By Part					
Part Number	G33DLAAMD141-11	TABLE RUNNER	PURCHASED	U.O.M.	EACH
Path No	1	PRODUCTION	PURCHASED		
Lot Reference	Line Costed Date	Cost	How Costed	Details?	
GR180249	1	47.35	LOT ACTUAL	☐	

9:2 Delta Air Lines Table *G33DLADMD045*

Part Number	G33DLADMD045-01	TABLE ASSY SLIDING	MANUFACTURED	U.O.M.	EACH
Path No	1	PRODUCTION	MANUFACTURED		
Cost Set	1 STANDARD COST	Cost on File	545.90	Incomplete Cost?	
CALCULATED COSTS ONLY					
Cost Head	Additional	This-Level	Rolled-Up	Total	
10 MATERIALS			499.9000	499.9000	
20 LABOUR		29.2500		29.2500	
50 OVERHEADS		16.7500		16.7500	
Totals		46.0000	499.9000	545.9000	

9:3 Qatar Airways Table *G77TRAZMD003*

Part Number	G77TRAZMD003-01	SLIDING TABLE ASSY	MANUFACTURED	U.O.M.	EACH
Path No	1	PRODUCTION	MANUFACTURED		
Cost Set	1 STANDARD COST	Cost on File	468.90	Incomplete Cost?	Y
CALCULATED COSTS ONLY					
Cost Head	Additional	This-Level	Rolled-Up	Total	
10 MATERIALS			422.8548	422.8548	
20 LABOUR		19.5098	9.7696	29.2794	
50 OVERHEADS		11.1723	5.5946	16.7669	
Totals		30.6821	438.2190	468.9011	

9:4 Qatar Airways Assembly G77TRAZSA026

Part Number	G77TRAZSA026-01			TABLE CASSETTE ASSY	U.O.M.	EACH
Def Supplier	A411				Buyer	BOUR
Qty Stock	0	On Order	15	Firm Orders	0	
PURCHASE HISTORY DETAILS						
Date	Order No	Line	Supplier	Quantity	Unit Price	Cur Req Date Status
300919	PD43671	1	A411	2	1185.11	STL 30/10/19 RELEASED
300919	PD43671	2	A411	4	1185.11	STL 03/02/20 RELEASED
300919	PD43671	3	A411	2	1185.11	STL 06/04/20 RELEASED
300919	PD43672	1	A411	3	1185.11	STL 06/07/20 RELEASED
300919	PD43672	2	A411	3	1185.11	STL 07/09/20 RELEASED
300919	PD43676	1	A411	1	1185.11	STL 06/04/20 RELEASED

Appendix 10- Qatar Airways List of Materials

AIM ALTITUDE

AADG001
Issue C
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5. STANDARD METALLIC MATERIALS:

5.1. Aluminium Alloys

Refer to Table 1 for aluminium alloy materials to be used on all programs other than Boeing Line Fit 787 programs, for Boeing Line Fit 787 programs refer Table 2.

Form	Cat.	Material Designation	Thickness	Tensile Strength ¹	Use For	Allowables
Sheet & strip	NS	5251 H22 Sheet per EN 485	0.5, 1, 1.5, 2, 2.5 and 3 mm	210-250 MPa 30-36 ksi	Low strength, non-structural applications, i.e. cover plates, mounting brackets, etc.	No
	S ₁	2024-T3 (Bare) Sheet per AMS 4037 or AMS-QQ-A-250/4	0.032, 0.050 and 0.080 in ^a	435-455 MPa 63-66 ksi	Structural applications, i.e. doublers, brackets, etc.	Yes
		6061-T6 Sheet per AMS 4027	0.032, 0.050 and 0.080 in ^a	290-300 MPa 42-43 ksi	Structural applications, i.e. doublers, brackets, etc. where a decorative anodised finish is required.	Yes
	S ₂	7075-T6 (Bare) Sheet per AMS 4045 or AMS-QQ-A-250/12	0.032, 0.050 and 0.080 in ^a	525-550 MPa 76-79 ksi	High strength applications	Yes ^c
Plate	NS	6082-T651 Plate per EN 573-3	6.35 - 254 mm	300 MPa 43 ksi	Low strength, non-structural applications, i.e. cover plates, blocks, decorative parts, etc.	No
	S ₁	2014-T651 Plate per AMS 4029	0.250 - 2.5 in	405-475 MPa 59-69 ksi	Structural applications, i.e. blocks, machined parts, etc.	Yes ^d
		2024-T351 (Bare) Plate per AMS 4037 or AMS-QQ-A-250/4	2.50 - 4.0 in	405-455 MPa 59-66 ksi	Structural applications, i.e. doublers, blocks, machined parts, brackets, etc.	Yes
		6061-T651 Plate per AMS 4027	0.250 - 2.0 in	290-300 MPa 42-43 ksi	Structural applications, i.e. doublers, blocks, machined parts, brackets, etc. where a decorative anodised finish is required.	Yes ^e
	S ₂	7075-T651 (Bare) Plate per AMS 4045 or AMS-QQ-A-250/12	0.250 - 4.0 in	455-545 MPa 66-79 ksi	High strength applications. Note 7075-T6 is not recommended for use in a corrosion environment.	Yes

Table 1: Standard Aluminium Alloys

¹ Tensile strength is indicative only and should not be used for analysis/substantiation.

^a 0.032, 0.050 and 0.080 in constitute the preferred thicknesses. Other thicknesses are available (0.020, 0.040, 0.063, 0.100 and 0.125 in), but should be discussed per Section 2 prior to application.

^c MMPDS-09 contains a set of allowables for 0.040-0.125" thick sheet only. Allowables for other thicknesses are only available in MMPDS-04 and earlier revisions.

^d MMPDS-09 contains a set of allowables for plate thinner than 2.5in only.

^e MMPDS-09 contains a set of allowables for plate thinner than 2.0in only.

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Form: AADP005 Issue A

Form	Cat.	Material Designation	Thickness	Tensile Strength ¹	Use For	Allowables
Bar & Extrusions	All	6061-T6/T6510/T6511 Extrusion per AMS 4150, AMS 4173 or AMS-QQ-A-200/9	Area < 32 sq. in Thickness < 6.5in	260-280 MPa 37-40 ksi	Standard, custom decorative and structural extrusions	Yes
Tube	NS	6082-T4 Tube per EN AW-6082		205 MPa 29 ksi	Non-structural applications, i.e. conduit	No

Table 1 (continued): Standard Aluminium Alloys

Boeing 787 Line Fit

The following materials and thickness ranges meet the requirements of D6132000-01 and D6202414-01 for use on Boeing Line Fit programs for the 787. Deviation approval from Boeing is required for materials outside of those approved in D6202414-01 Section 4.

Form	Cat.	Material Designation	Thickness	Tensile Strength ¹	Use For	Allowables
Sheet & strip	NS ^a	5251 H22 Sheet per EN 485	0.5, 1, 1.5, 2, 2.5 & 3mm	210-250 MPa 30-36 ksi	Low strength, non-structural applications, i.e. cover plates, etc.	No
	S ₁	2024-T3 (Bare) Sheet per AMS-QQ-A-250/4	0.032, 0.050 and 0.080in ^a	435-455 MPa 63-66 ksi	Structural applications, i.e. doublers, brackets, etc.	Yes
		6061-T6 Sheet per AMS 4027	0.032, 0.050 and 0.080in ^a	290-300 MPa 42-43 ksi	Structural applications, i.e. doublers, brackets, etc. where a decorative anodised finish is required.	Yes
	S ₂	7075-T6 (Bare) Sheet per AMS-QQ-A-250/12	0.032, 0.050 and 0.080in ^a	525-550 MPa 76-79 ksi	High strength applications	Yes ^c

Table 2: Aluminium Alloys for Boeing Line Fit 787 Programs

¹ Tensile strength is indicative only and should not be used for analysis/substantiation.

^a Materials used for non-structural applications should be identified as such in the Parts Material's Process List (PMPL).

^a 0.032, 0.050 and 0.080 in constitute the preferred thicknesses. Other thicknesses are available (0.020, 0.040, 0.063, 0.100 and 0.125 in), but should be discussed per Section 2 prior to application.

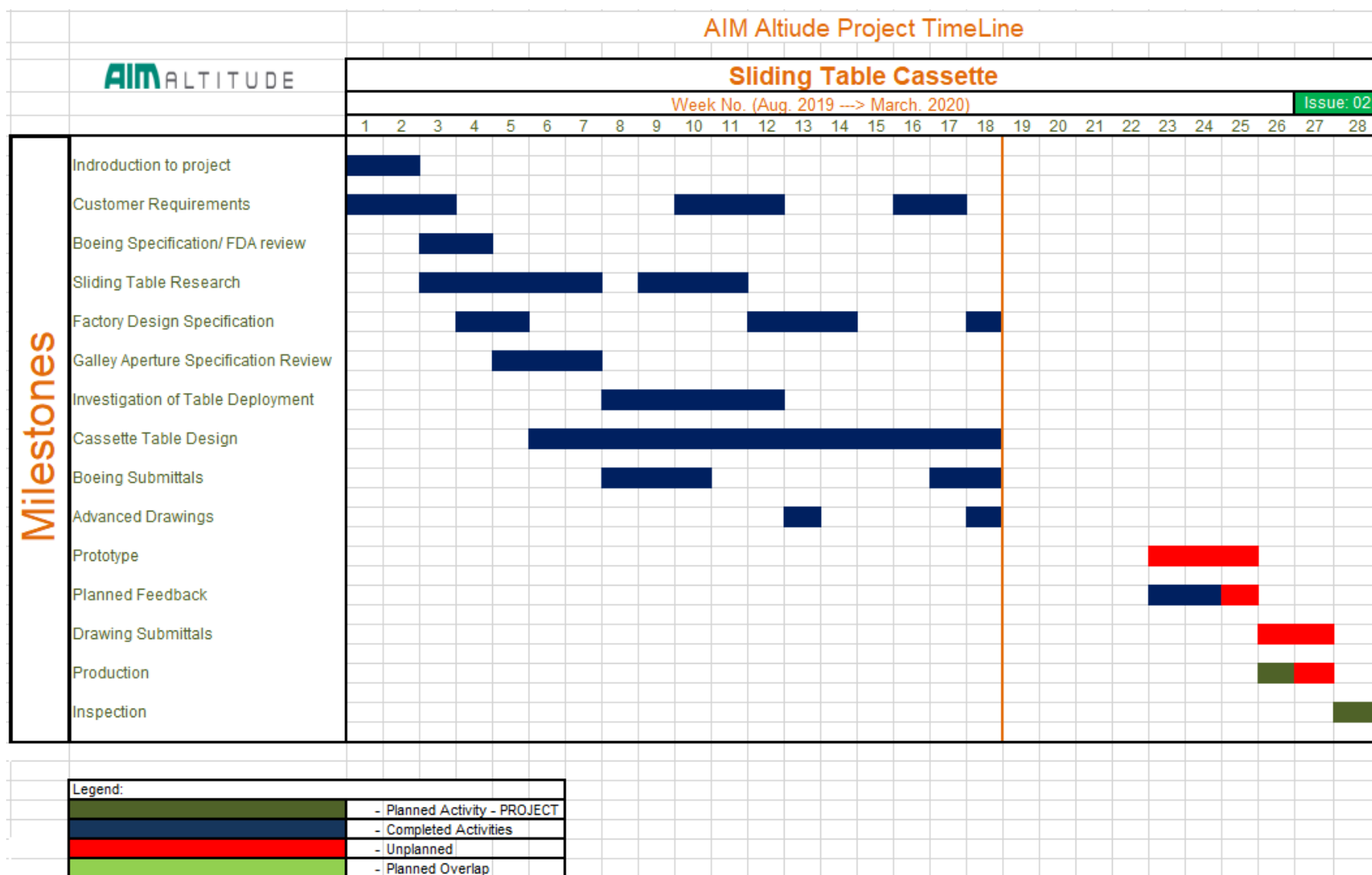
^c MMPDS-09 contains a set of allowables for 0.040-0.125" thick sheet only. Allowables for other thicknesses are only available in MMPDS-04 and earlier revisions.

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Form: AADP005 Issue A

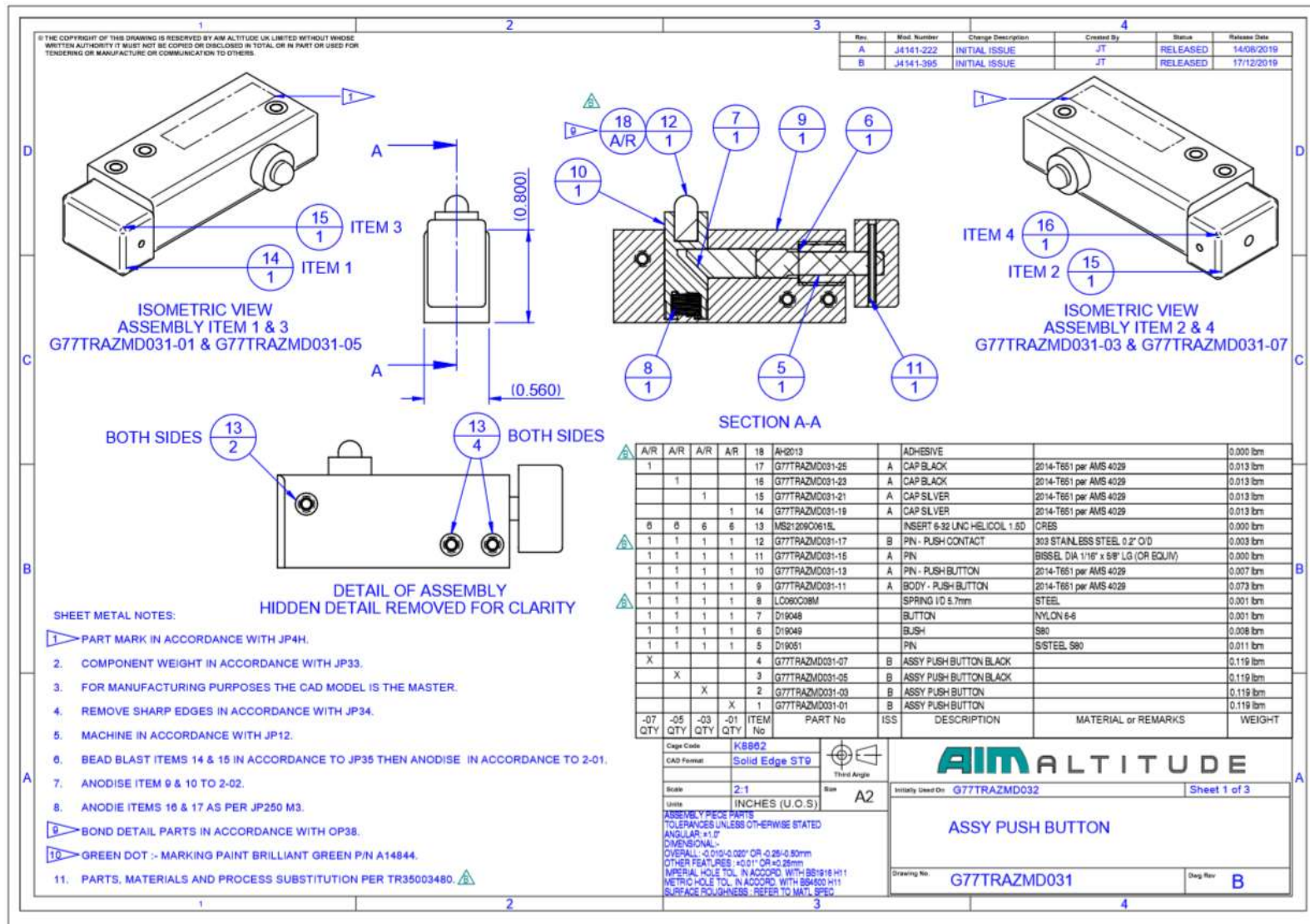
Form	Cat.	Material Designation	Thickness	Tensile Strength	Use for	Allowables
Plate	NS ¹⁰	6082-T651 Plate per EN 573-3	6.35 - 254mm	300 MPa 43 ksi	Low strength, non-structural applications, i.e. cover plates, blocks, decorative parts, etc.	No
	S ₁	6061-T651 Plate per AMS 4027	0.250 - 2.0in	290-300 MPa 42-43 ksi	Structural applications, i.e. doublers, blocks, machined parts, brackets, etc, where a decorative anodized finish is required.	Yes ^b
	S ₂	7075-T651 (Bare) Plate per AMS-QQ-A-250/12	0.250 - 0.375in	455-545 MPa 66-79 ksi	High strength applications. Note thickness limitation for 7075-T6 on 787 aircraft.	Yes
Bar & Extrusions	All	6061-T6/T6510/T6511 Extrusion per AMS-QQ-A-200/8	Area < 32 sq. in Thickness < 6.5in	260-280 MPa 37-40 ksi	Standard, custom decorative and structural extrusions	Yes
Tube	NS ¹	6082-T4 Tube per EN AW 6082		205 MPa 29 ksi	Non-structural applications, i.e. conduit	No

Table 2 (continued): Aluminium Alloys for Boeing Line Fit 787 Programs

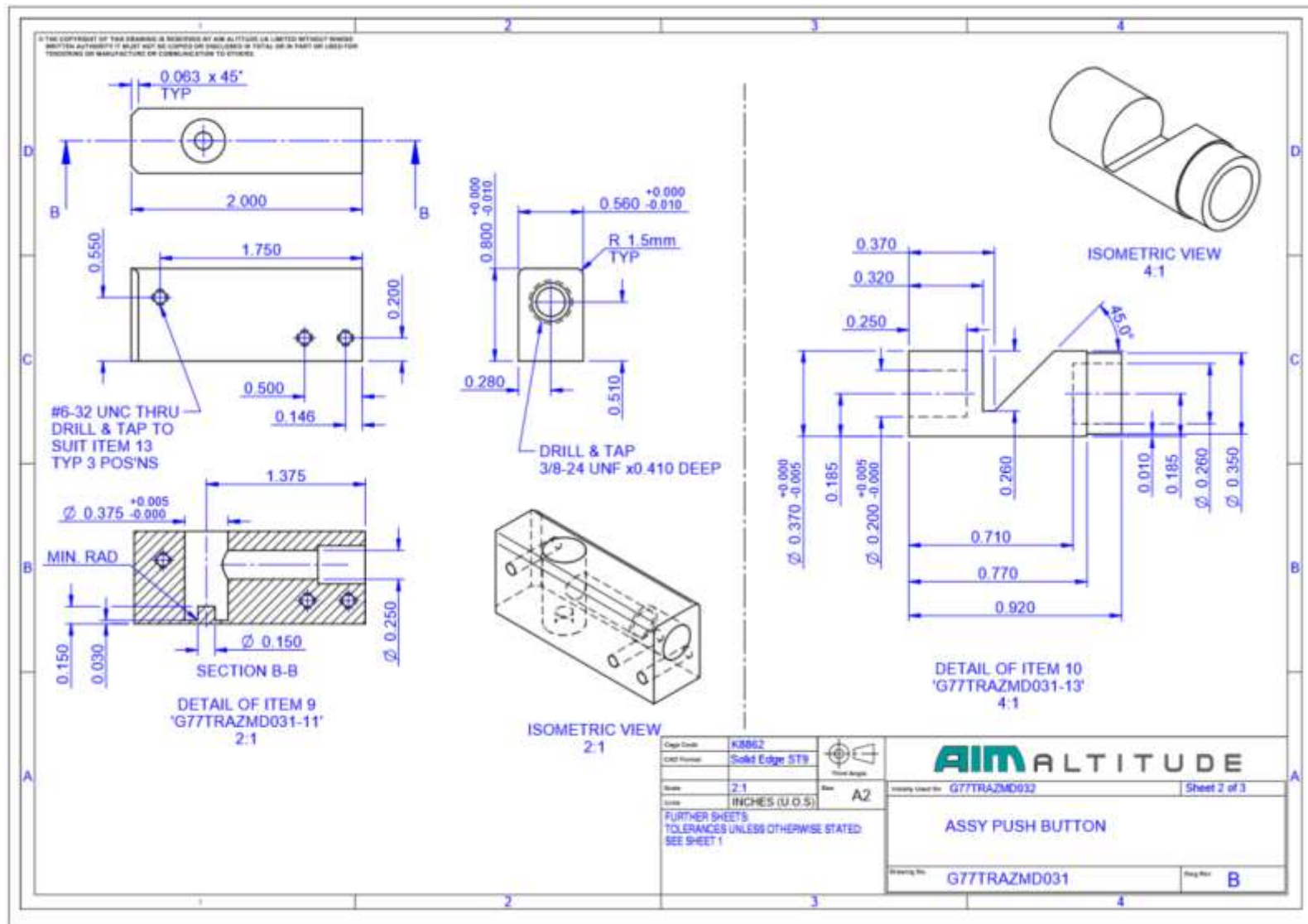
Appendix 11- Timing Plan Issue 02



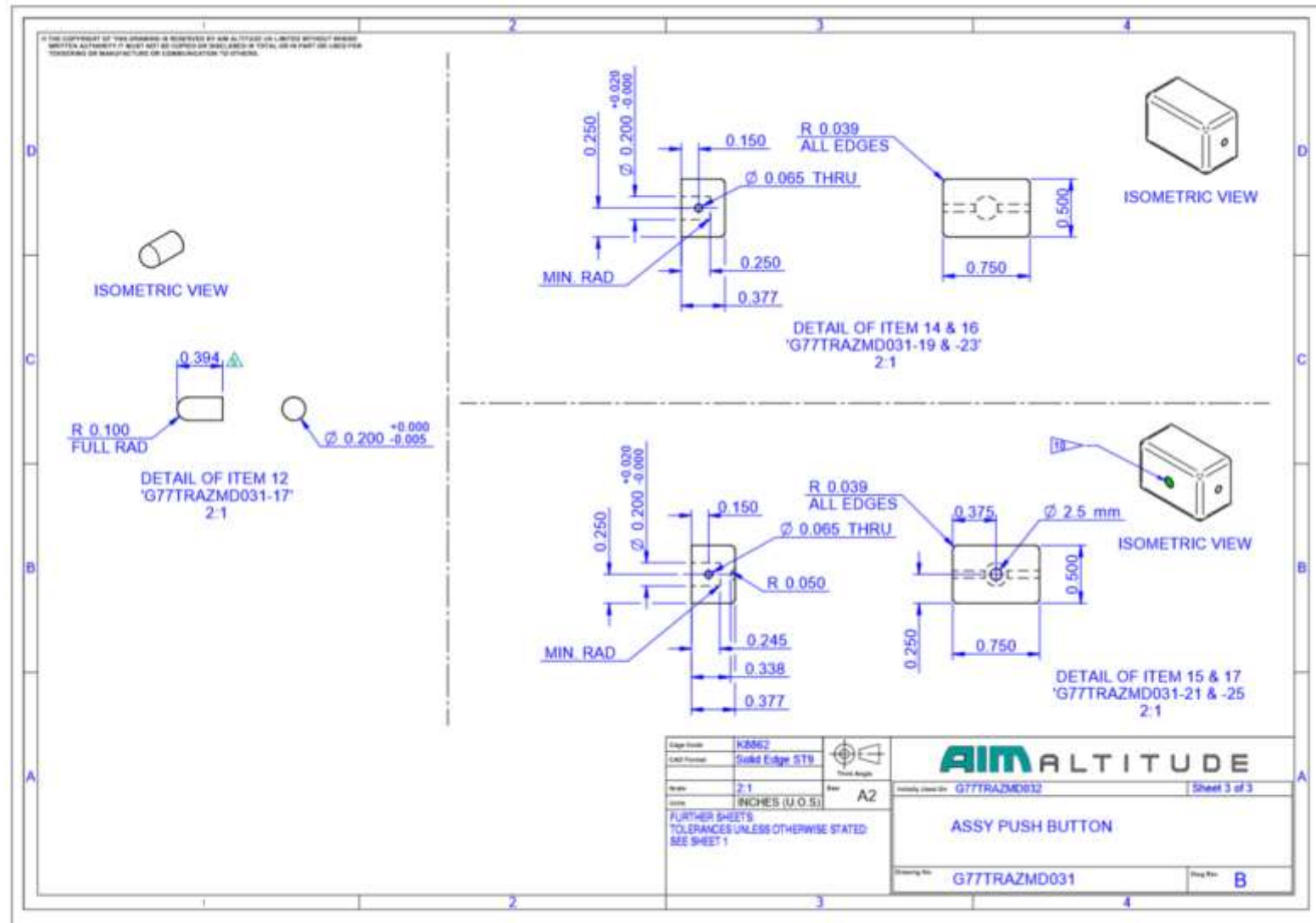
Appendix 12.1- Assembly Push Button 'G77TRAZMD031'



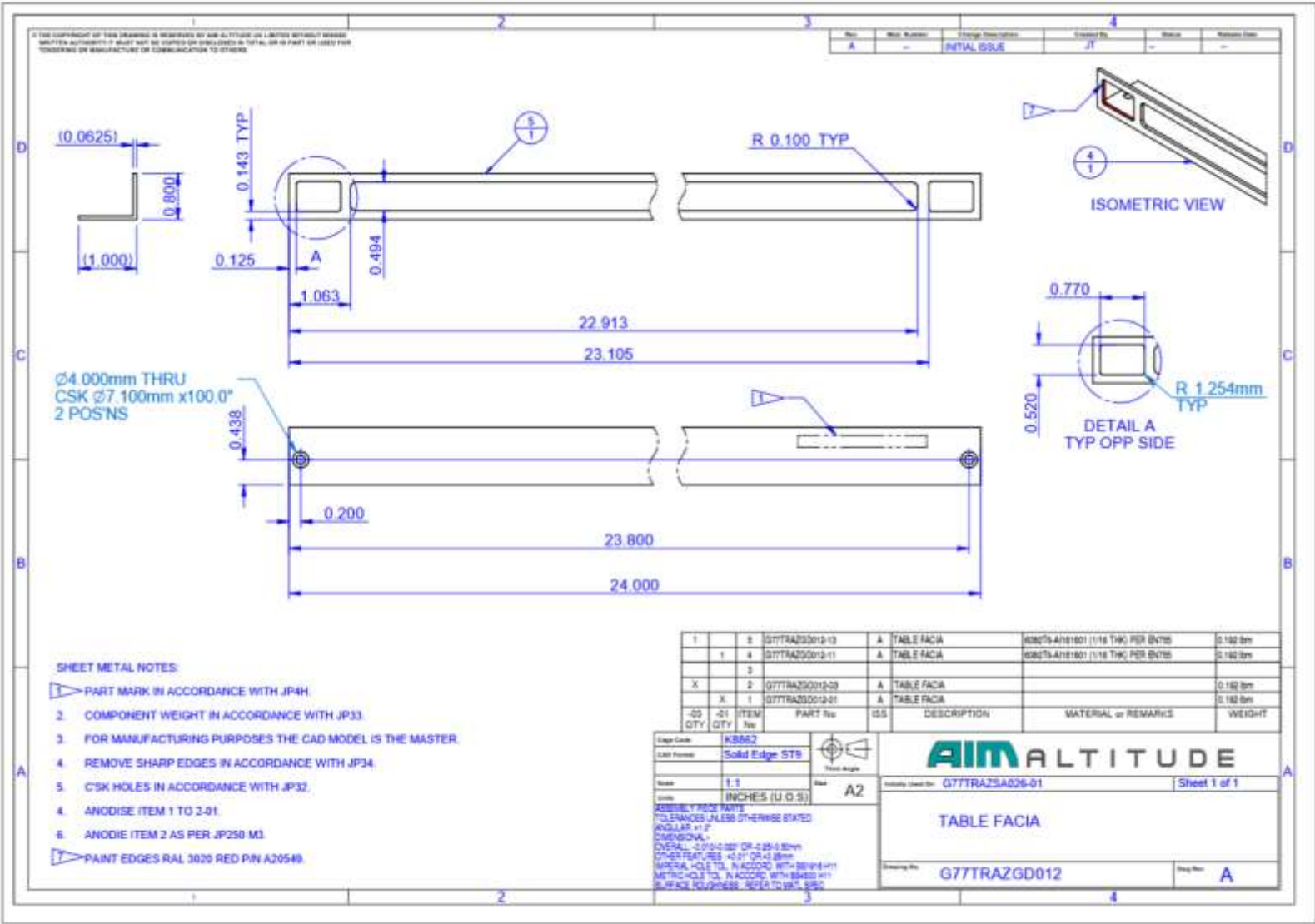
Appendix 12.2- Assembly Push Button 'G77TRAZMD031'



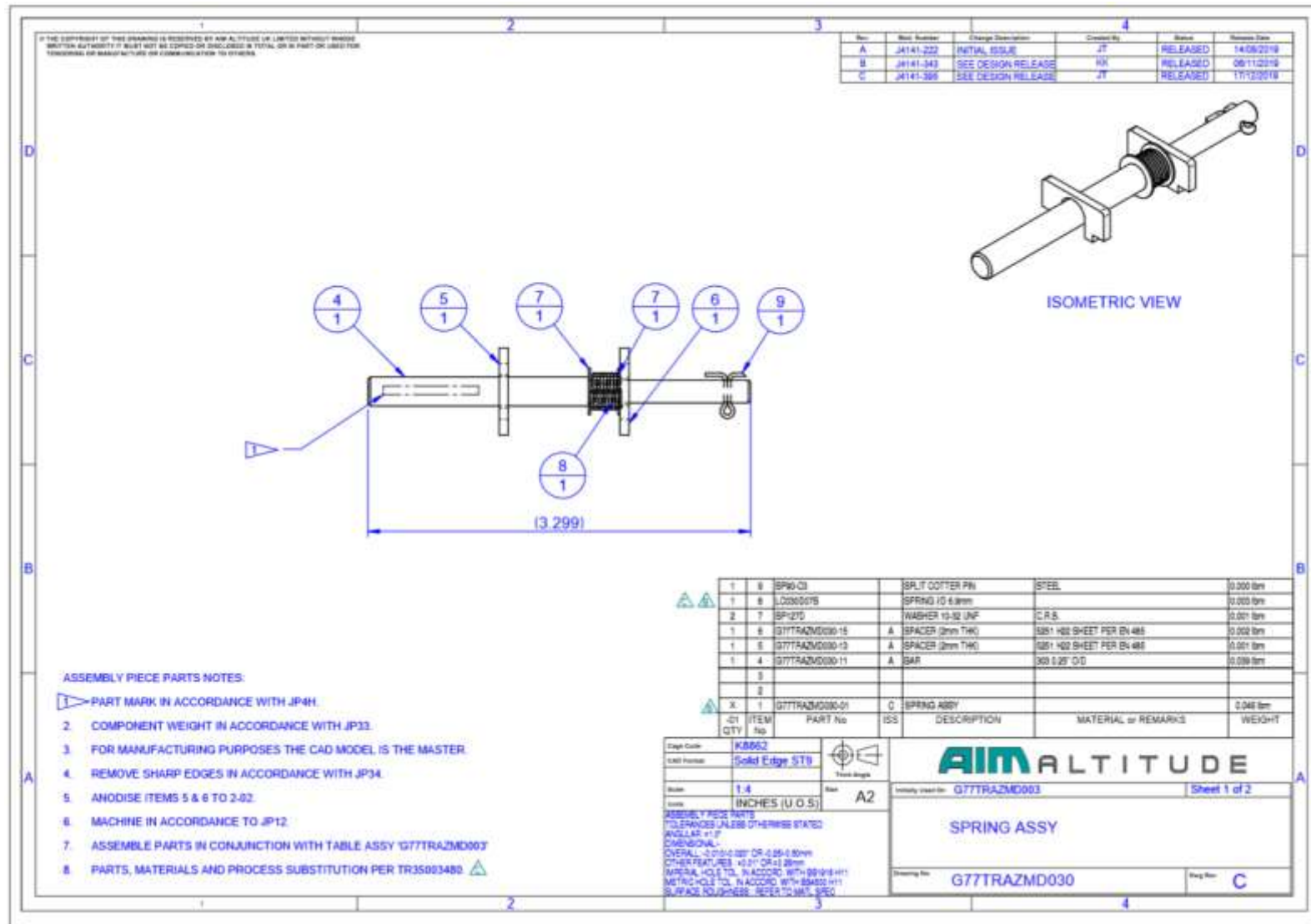
Appendix 12.3 Assembly Push Button 'G77TRAZMD031'



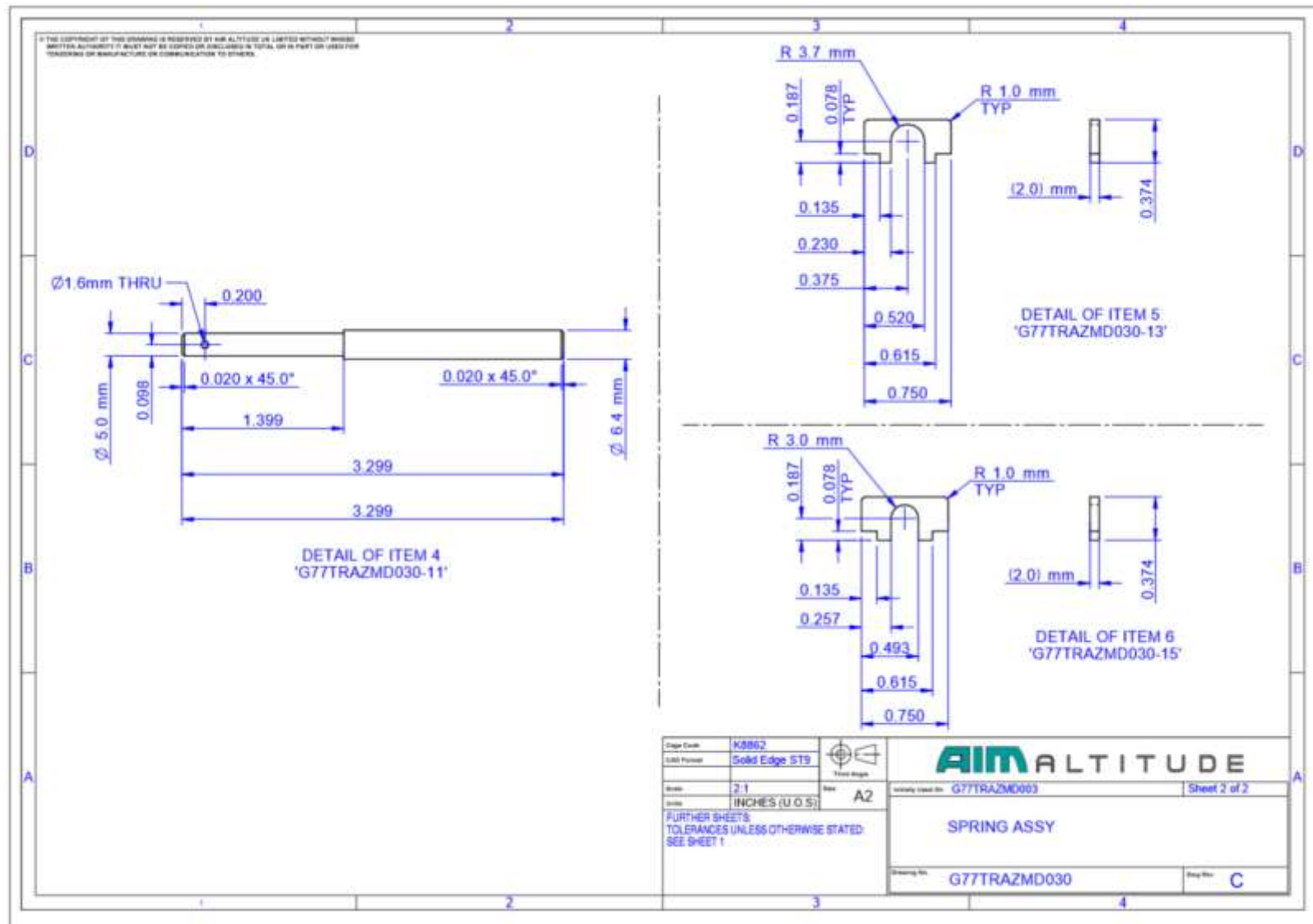
Appendix 13- Table Facia 'G77TRAZGD012'



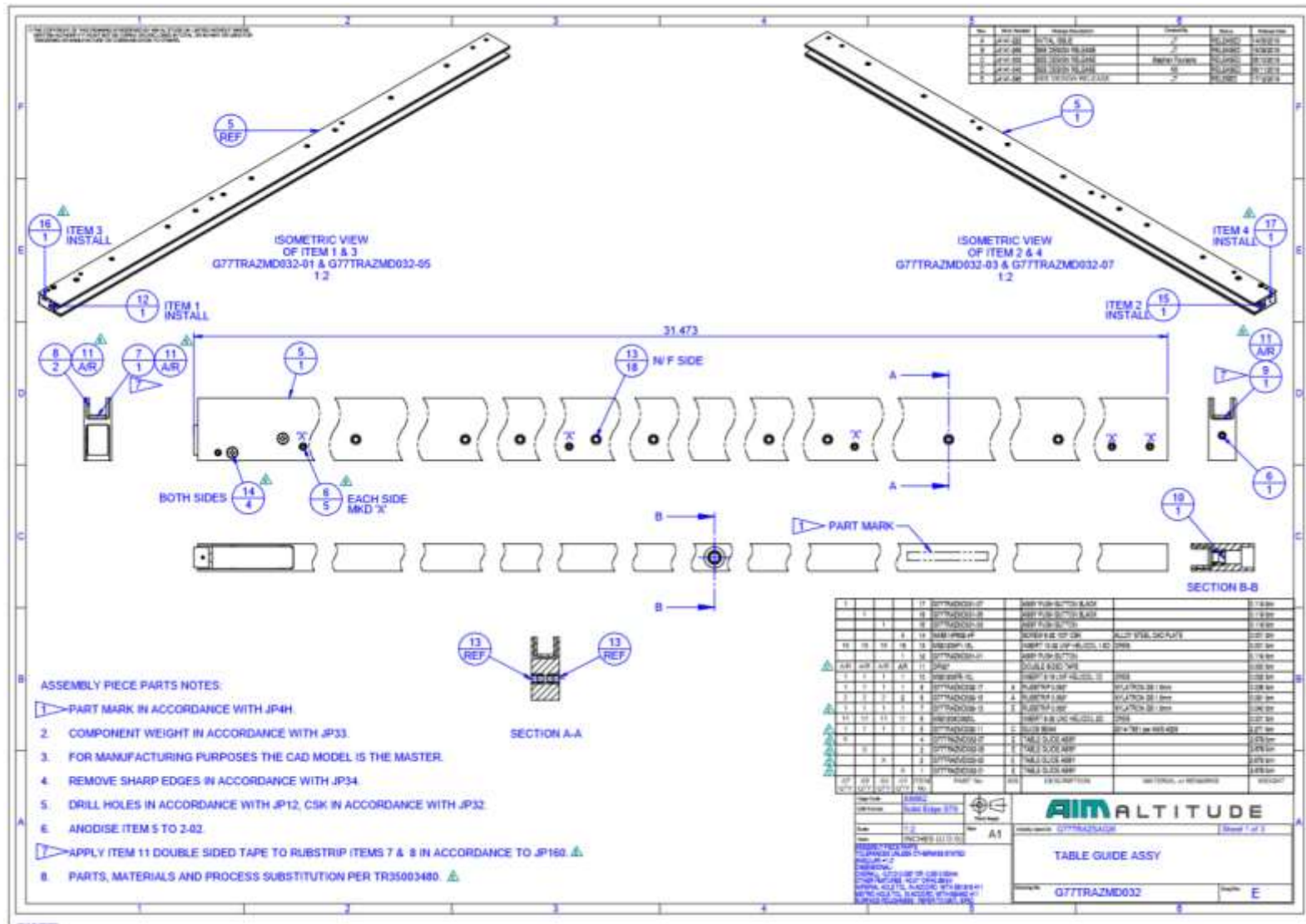
Appendix 15.1- Spring Assembly 'G77TRAZMD030'



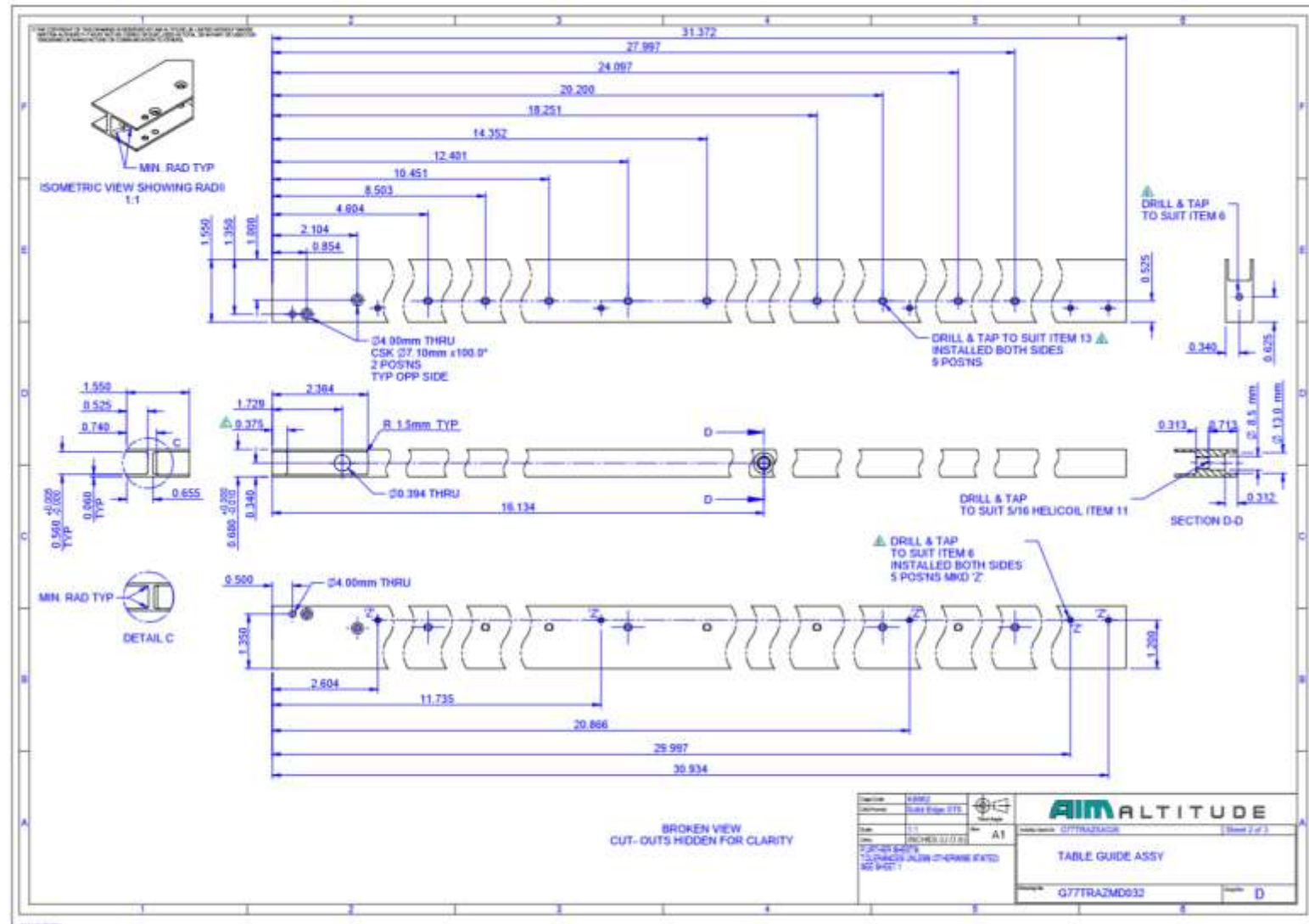
Appendix 15.2- Spring Assembly 'G77TRAZMD030'



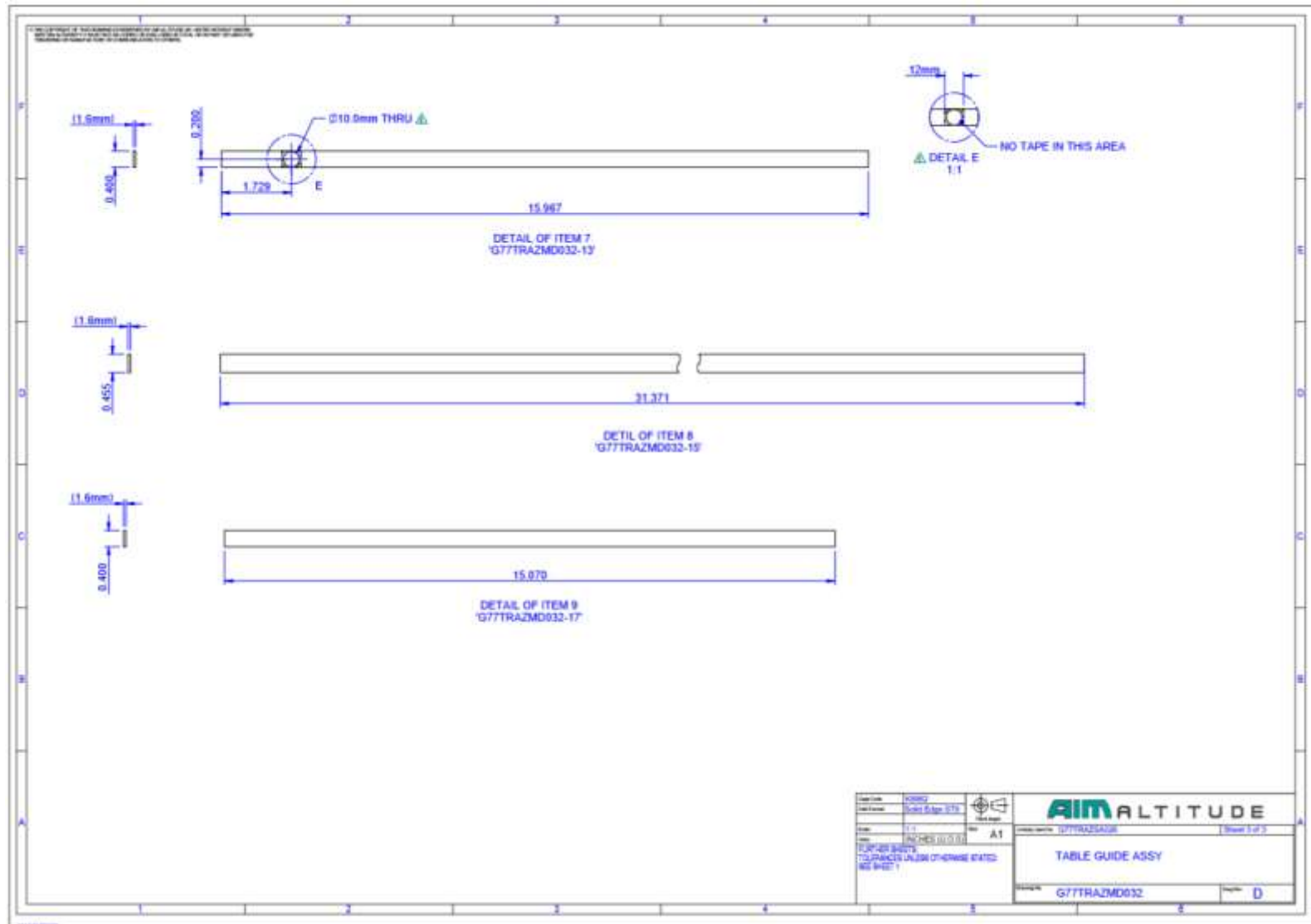
Appendix 16.1- Table Guide Assembly 'G77TRAZMD032'



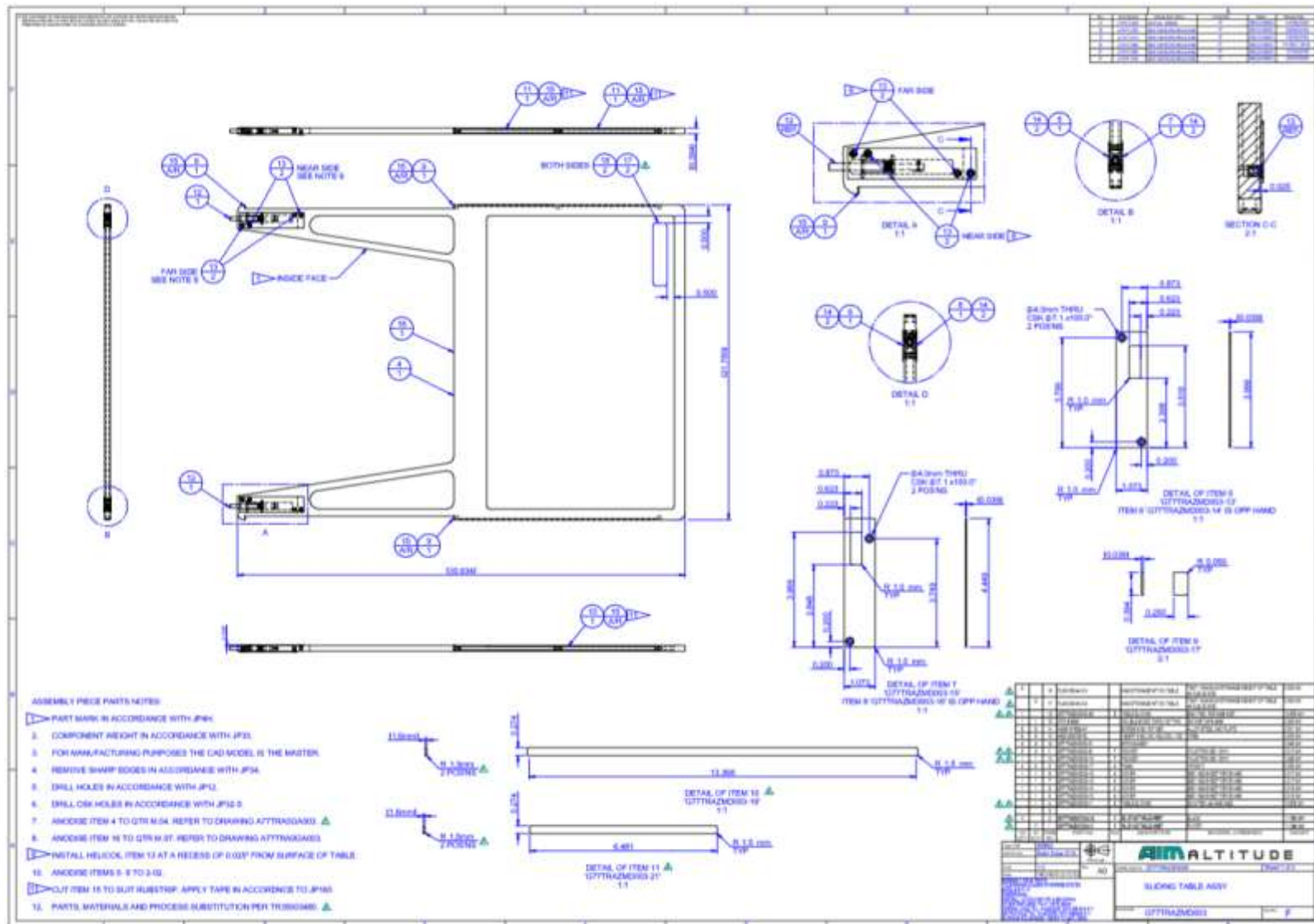
Appendix 16.2- Table Guide Assembly 'G77TRAZMD032'

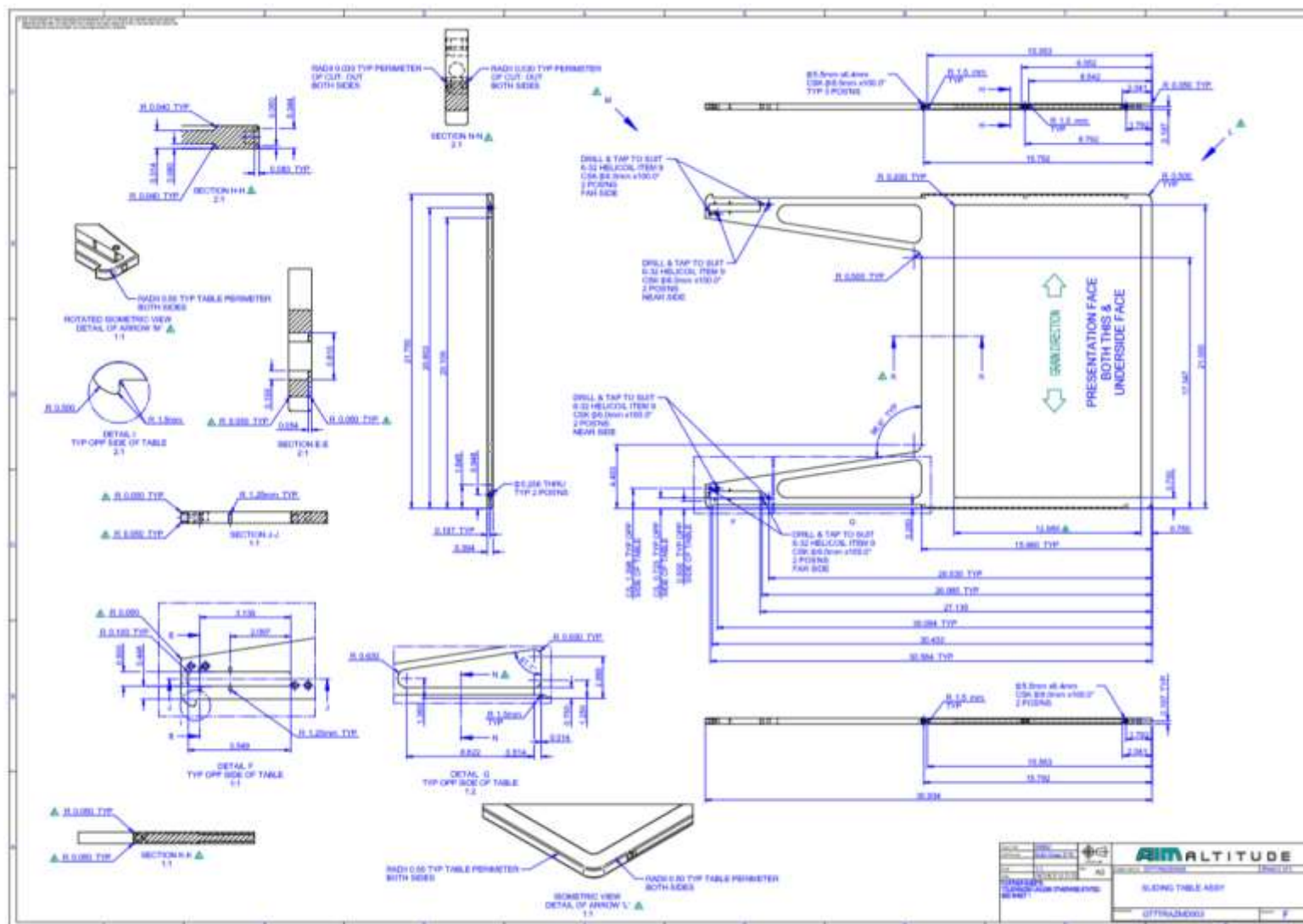


Appendix 16.3- Table Guide Assembly 'G77TRAZMD032'

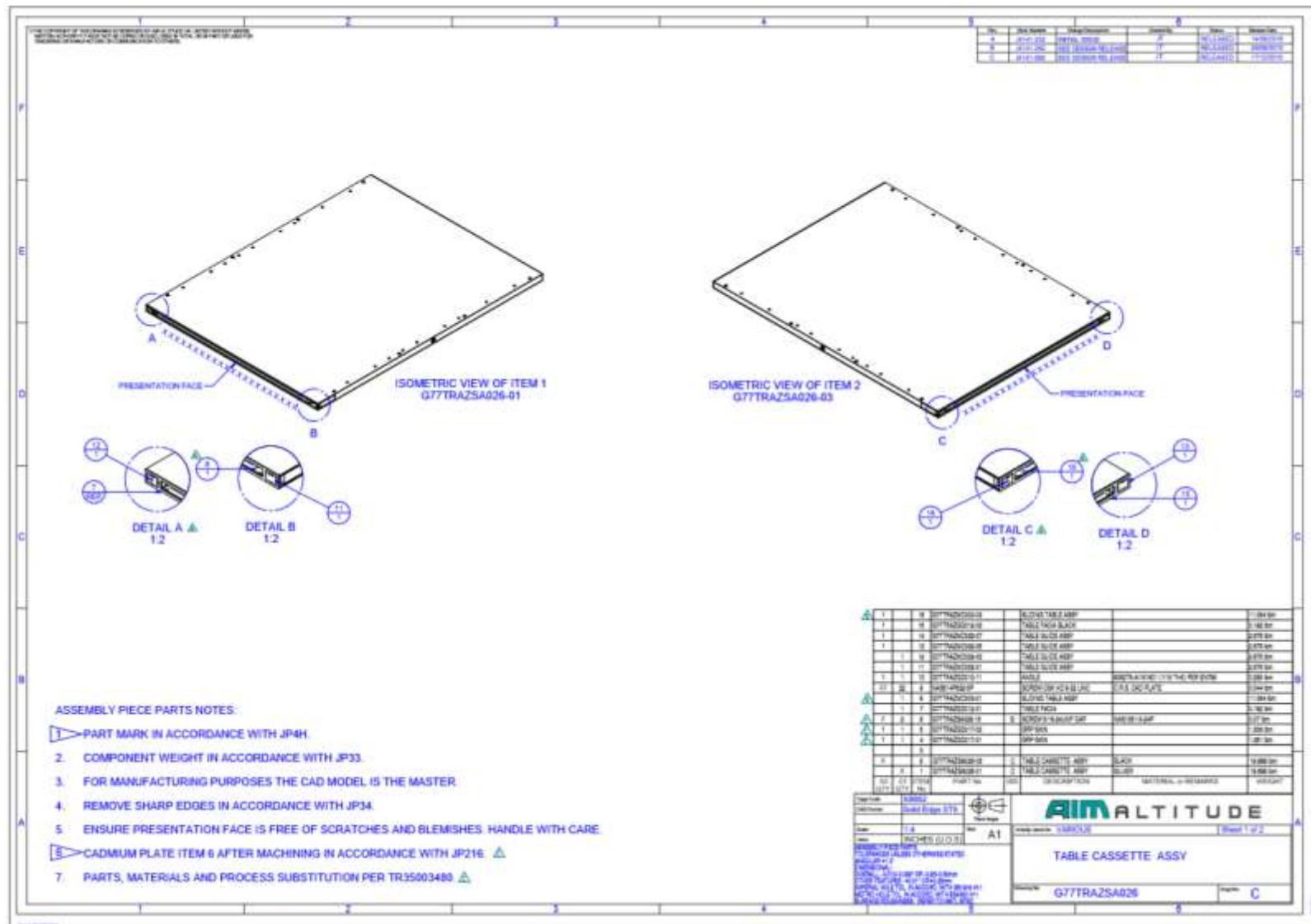


Appendix 17.1- Sliding Table Assembly 'G77TRAZMD003'

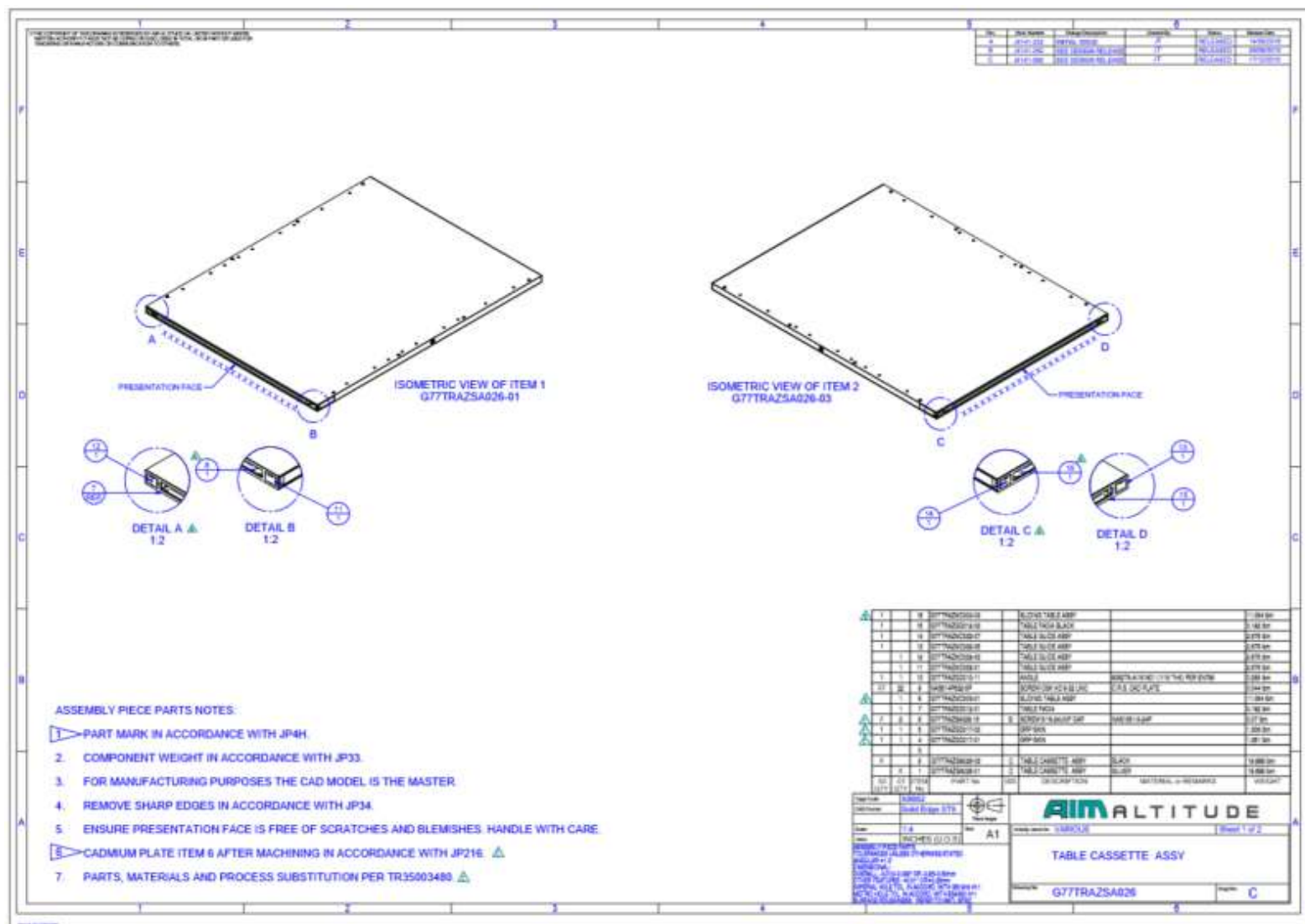


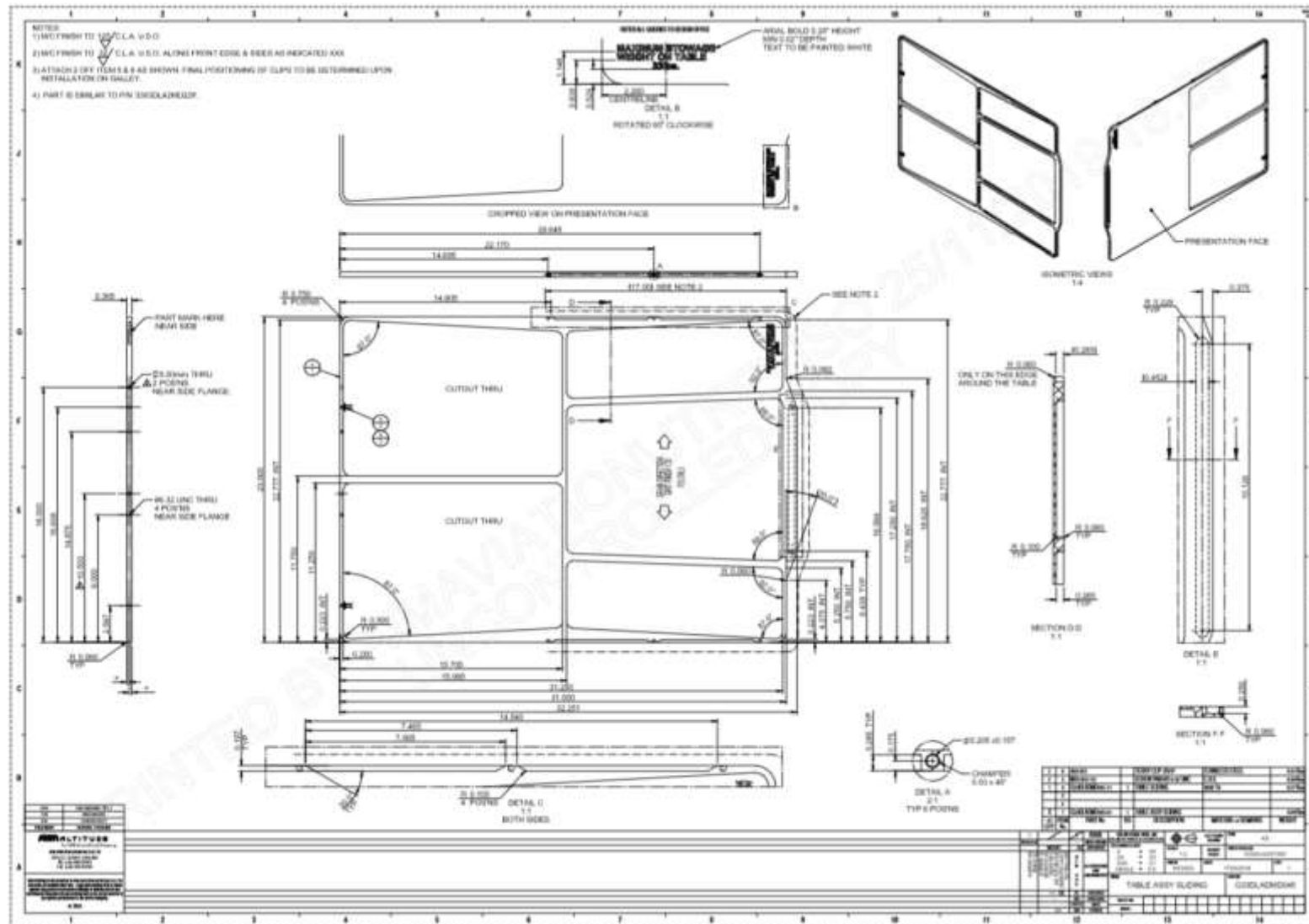


Appendix 18.1- Table Cassette Assembly 'G77TRAZMD026'

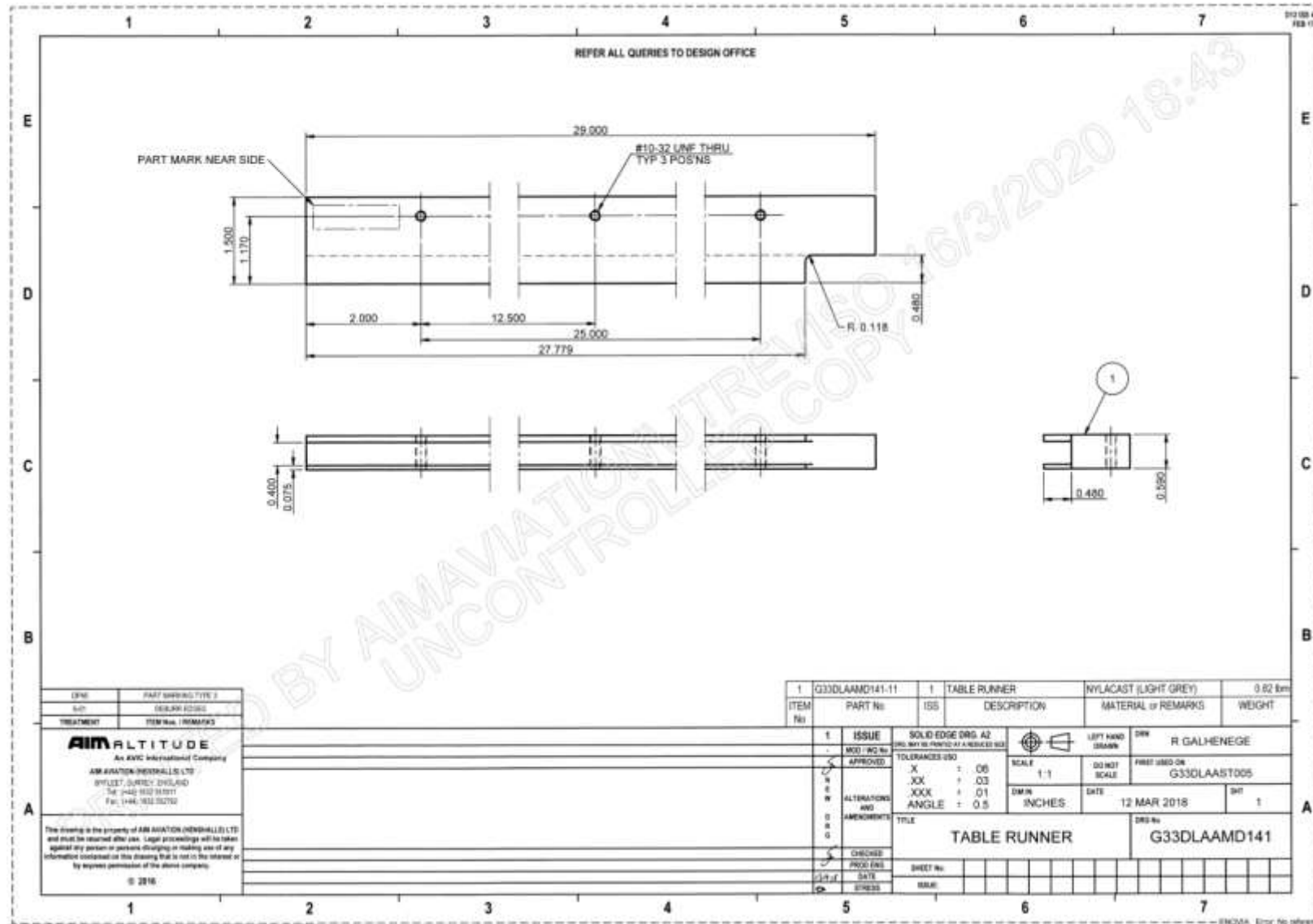


Appendix 18.2- Table Cassette Assembly 'G77TRAZMD026'

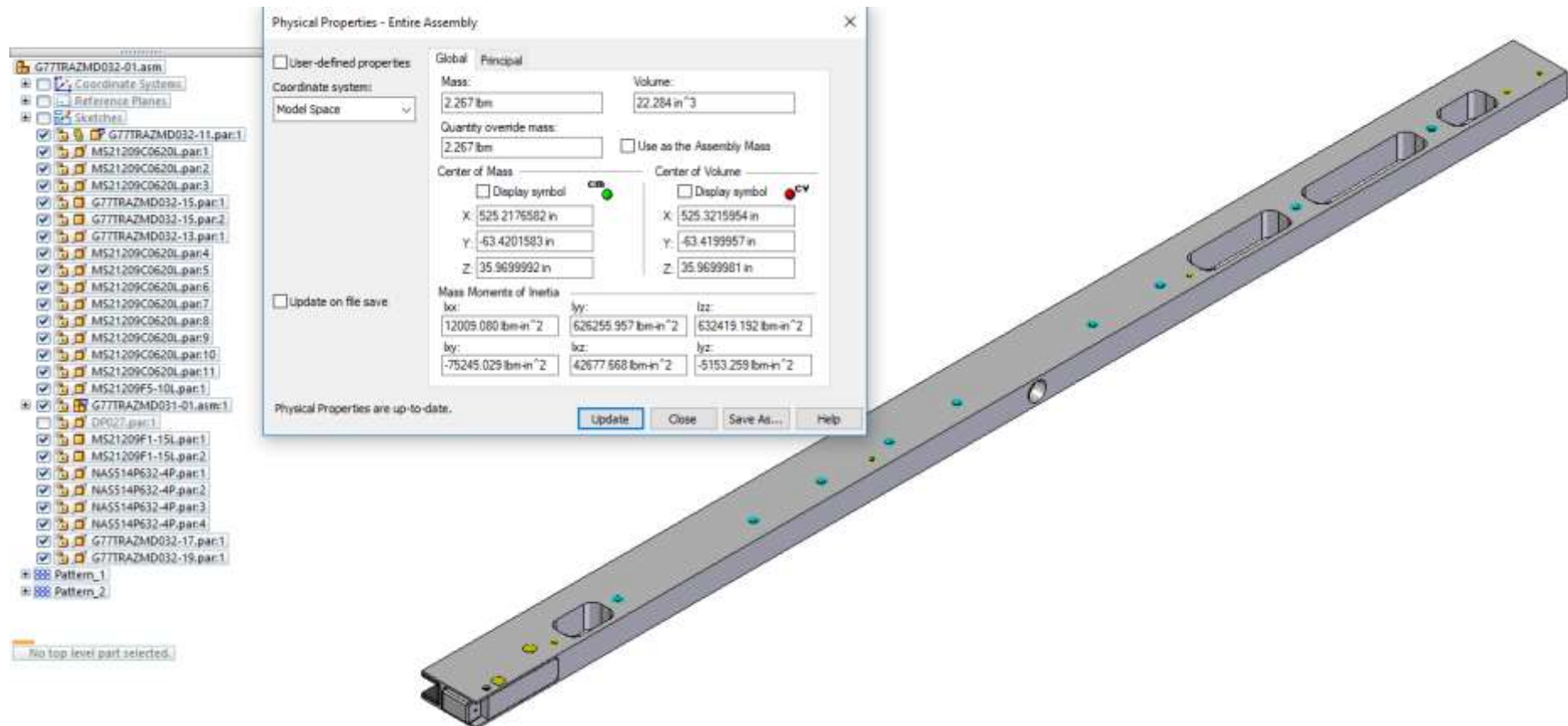




Appendix 20- Table Runner 'G33DLAAMD141'



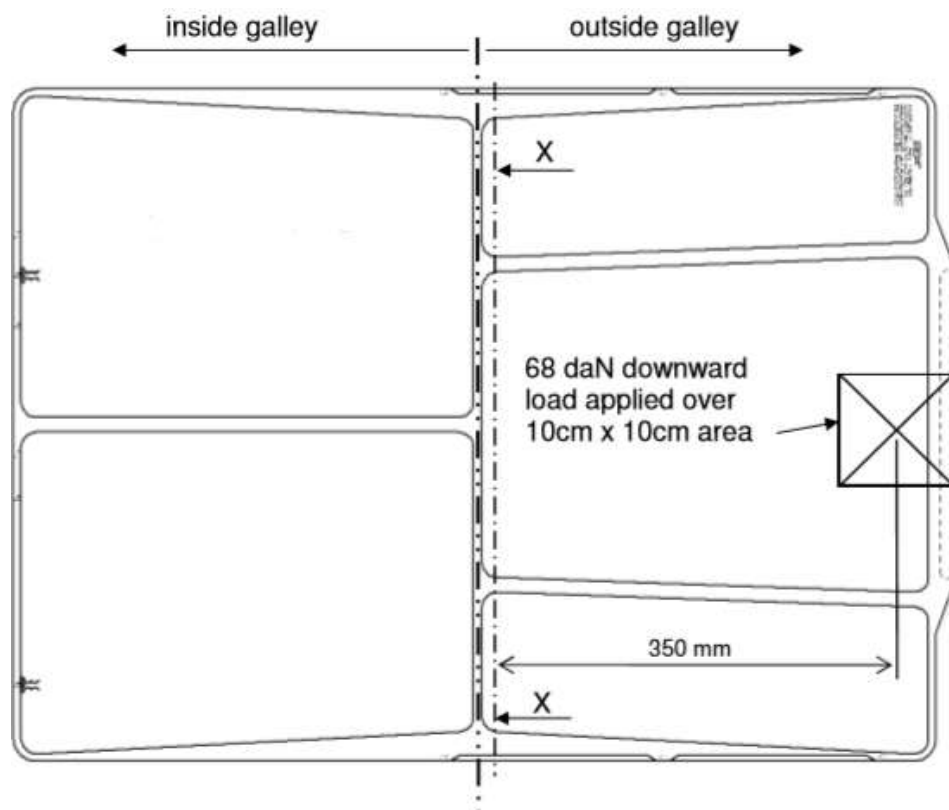
Appendix 21- Table Guide Proposed Weight Reduction



Appendix 22.1 Stress of Delta Air Lines Sliding Table

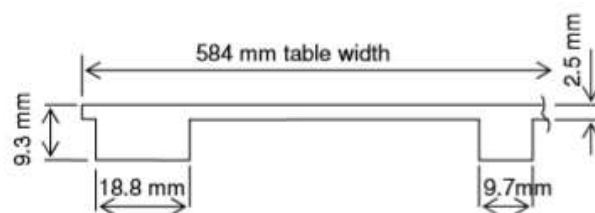
Based on Delta Air Lines table *G33DLADM045* shown below, calculations are carried out to ensure the table does not exceed the yield stress 240MPa of aluminium material Al 6082 T6 (Aalco, 2020).

22.2 Delta Air Lines Sliding Table



Consider a 68daN (680N) down load force applied over 10cm x 10cm area when table is fully extended. Section X – X is the critical section reacting the moment of this force.

22.3 Section X-X

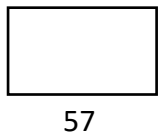


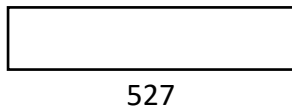
There are two ribs of 18.8mm and two ribs of 9.7mm over the width of the table. A total width of 9.3mm deep section, $2 \times (18.8 + 9.7) = 57\text{mm}$.

Total width of 2.5mm deep section, $584 - 27 = 527\text{mm}$

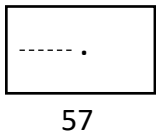
Second moment of area $I = \frac{bd^3}{12}$, Finding total I_{xx} , $I_{xx} = \frac{bd^3}{12} + Ah^2$

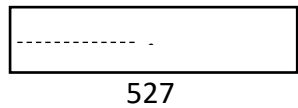
Finding second moment of area,

 9.3 Where $\frac{bd^3}{12}$, $\frac{57 \times 9.3^3}{12} = 3820.7\text{mm}^4$

 2.50 $\frac{527 \times 2.5^3}{12} = 686.20\text{mm}^4$

To find centroid 'Y',

Y^1  9.3 $Y^1 = 9.3 / 2 \therefore Y^1 = 4.65$

Y^2  2.50 $Y^2 = 9.3 - 1.5 \therefore Y^2 = 8.05$

22.4 Calculated Figures

b	d	A	Y	AY	I_{na}	h	Ah^2
57	x 9.3	= 530.1	4.65	2464.97	3820.7	-2.42	3104.5
527	x 2.50	= 1317.5	8.05	10605.88	686.20	-0.98	1265.4
		Σ 1847.6		Σ 13070.84	Σ 4506.89		Σ 4369.9

$$\frac{\Sigma AY}{\Sigma A} = \bar{Y} \therefore \bar{Y} = \frac{13070.84}{1847.60} = 7.07$$

$$h^1 = Y - \bar{Y}, 4.65 - 7.07 \therefore h^1 = -2.42$$

$$h^2 = 7.07 - 8.05 \therefore h^2 = -0.98$$

$$I_{xx} = \frac{bd^3}{12} \cdot Ah^2 \longrightarrow 4506.89 + 4369.9 \therefore I_{xx} = 8876.79 \text{mm}^4$$

Max bending stress in section X-X $\sigma = MY/I$

$$M = 680 \times 350 = 238,000 \text{N/mm}$$

$$\Sigma = 238,000 \times 7.07 / 8877 = 190 \text{MPa}$$

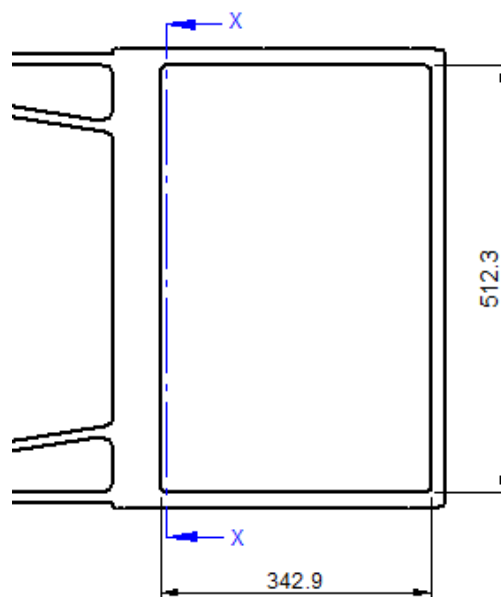
Yield stress allowable for aluminium plate Al6082 T6 – 240MPa (Aalco, 2020).

SF = 240 / 190 = 1.26 $\therefore$ being well below the yield point of the material, the table will not yield under this abuse load.

23.1 Stress of Qatar Airways Sliding Table

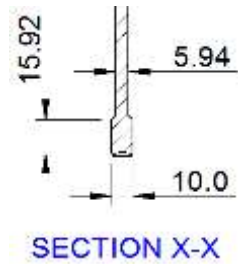
Based on Delta Air Lines table *G77TRAZMD003* shown below, calculations are carried out to ensure the table does not exceed the yield stress 414MPa of aluminium material 2014-T651 plate per AMS 4029 (Specification, 2019).

23.2 Qatar Airways Sliding Table



P_z 44.0 lbs (195.4N)

23.3 Section X-X



Second moment of area = $\frac{bd^3}{12}$

$$I_{xx} = 2 \left[\frac{(15.92 \times 10.0^3)}{12} \right] + \left[\frac{(512.3 \times 5.94^3)}{12} \right] = 11600.8 \text{ mm}^4$$

$$\sigma = MY / I$$

$$M^B = 195.4 \times 342.9 \therefore M_B = 67,002 \text{ N/mm}$$

$$\bar{Y} = 10.0 / 2 = 5.0$$

$$67,002 \times 5.0 / 11600.8 = \sigma$$

$$\therefore \sigma = 28.9 \text{ MPa}$$

Based on material 2014-T651 plate per AMS 4029. A yield stress allowable of 414MPa (Specification, 2019).

RF = 414 / 28.9 = 14.3 $\therefore$ the applied force of 195.4N, it is clear bending stress is not critical.