Phase C

Fabrication Plan (mechanical parts)

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12/03/2008
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RECORD OF REVISIONS

ISS/REV	Date	Modifications	Created/modified by
1/0	09/07/07	Initial Issue	Guillaume Roethlisberger
1/1	09/08/07	M.N. and R.K. comments	Guillaume Roethlisberger
1/2	10/01/08	Phase C update	Guillaume Roethlisberger
1/3	17/01/08	Assembly procedure	Guillaume Roethlisberger
1/4	13/01/08	Appendices updates	Guillaume Roethlisberger
1/5	12/03/08	Surface treatments info Appendices updates Manufacturing status	Guillaume Roethlisberger

1 REFERENCES

1.1 Normative references

2 TERMS, DEFINITIONS AND ABBREVIATED TERMS

2.1 Abbreviated terms

ADCS	Attitude Determination and Control System
ADS	Antenna Deployment System
CDMS	Command and Data Monitoring System
CDS	CubeSat Design Specifications document
C.o.M.	Center of Mass
COTS	Commercial off The Shelf
CSDS	CubeSat Design Specification Document
EPS	Electrical Power System
EQM	Engineering Qualification Model
FEA	Finite Element Analysis
FM	Flight Model
ICD	Interface Control Document
NA	Not applicable
P-POD	Poly Picosatellite Orbital Deployer
PCB	Printed Circuit Board
RBFP	Remove Before Flight Pin
RF	Radio Frequency
STM	Structural and Thermal Model
TBC	To be confirmed
TBD	To be defined

2.2 Definitions

3 INTRODUCTION

This document describes the fabrication process for the mechanical parts of the SwissCube satellite. It includes information about the material, machining, surface treatment, planning, cost and list of contact.

Figure 1 shows the configuration of the different subsystems and parts composing the SwissCube satellite.

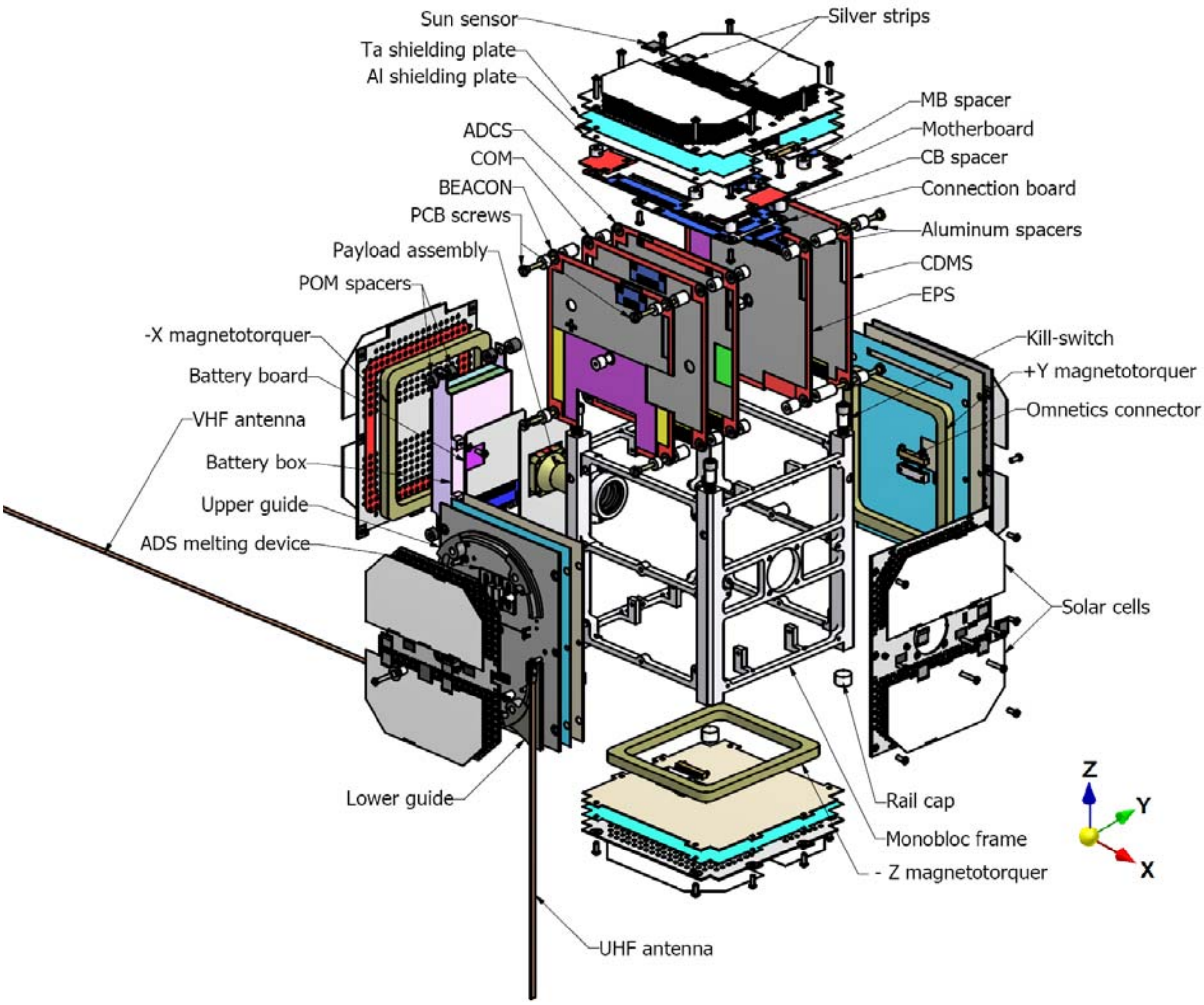

Figure 1 : Exploded view of the SwissCube satellite.

4 MONOBLOC FRAME

The monobloc frame is the primary structure of the SwissCube. This part is made from a block of aluminum.

4.1 Material

The used material for this part is an aluminum alloy called Certal© (see Appendix L). The supplier of the aluminum is Metallica SA. They are a partner of the project and provide all necessary aluminum.

4.2 Machining

The machining of the monobloc frame can be separated in two steps, the milling machining and the electro-erosion machining (wire electrical discharge machining). The engineering drawing is provided in Appendix A.

4.2.1 Traditional machining

The First step in producing the monobloc frame structure consists in milling the six side faces into a cube thanks to the use of a CNC milling machine. This work is done in the machine shop of mechanical engineering at the EPFL.

4.2.2 Electro-erosion machining

The second step is the cutting of the internal volume by electro-erosion machining. This process cuts metal by producing a rapid series of repetitive electrical discharges. These electrical discharges are passed between a very thin wire serves as the electrode and the piece of metal being machined. The path of the wire is controlled by computer.

The part that has to be removed with this process is in red in the Figure 2. The electro-erosion task is carried out by the atelier of the material science institute (EPFL - ATMX).

After this task, the frame will be finished by traditional machining which means drilling thread, filing of the edges, etc.

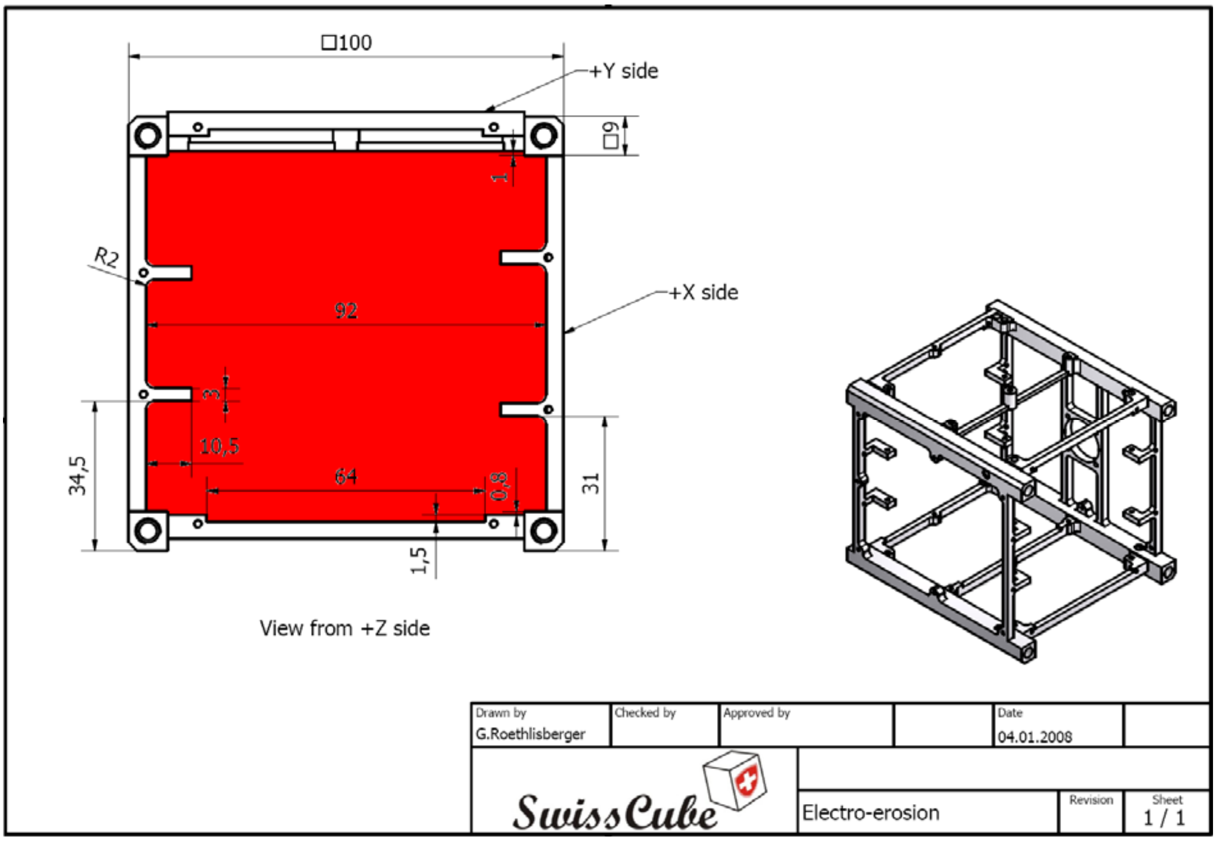

Figure 2 : Electro-erosion of the monobloc frame.

4.3 Surface treatment

After machining, the monobloc frame undergoes three kinds of treatment. First a sanding of the whole part, and then a hard anodizing.

4.3.1 Sanding

The goal of this treatment is to prepare the surface for the anodizing as well as to have homogeneous surfaces. The sanding machine is in EPFL mechanical building (ME G0 566).

4.3.1 Alodine 1200 S

The first chemical surface treatment consists of a chromating of the aluminum named Alodine 1200 S. This treatment is very thin (2-3 µm) and its goal is to increase the electrical and thermal conductivity of the aluminum surface. The whole frame except rails, holes and threaded hole undergoes this treatment.

This task will be done by an external enterprise, P. Niklaus SA, close to Geneva. They are a partner of the project and will perform this treatment for EQM as well as FM.

4.3.2 Titanox

In order to have a low friction between the satellite and the P-POD the rails have to be hard anodized (requirement 4_SC_41_04). This process allows also to electrically isolating the structure (4_SC_43_02).

Our partner suggests another surface treatment to us. Its name is Titanox (Ematal 78) and has already a huge space heritage. Its advantages in comparison with traditional hard anodizing are an extremely high wear and abrasion resistance and also excellent anti-friction properties.

The surface of aluminum and its alloys is converted into a hard, very compact and isolating aluminum oxide coating, with intercalated titanium dioxide. The thickness is increased by 10 µm. The hardness of this layer is 500 Vickers and its breakdown voltage is between 35 and 50 V/m.

This task will be done by an external enterprise, P. Niklaus SA, close to Geneva. They are a partner of the project and will perform this treatment for EQM as well as FM.

4.4 Schedule and fabrication time

The delay to obtain the material is practically non-existent. We have already received enough material for the EQM and FM.

The CNC milling will last around 3 to 4 working days.

The electro-erosion machining will last 1 to 2 working days.

The sanding requires only some minutes and the machine is always available.

The hard anodizing treatment lasts 4 to 5 working days.

4.5 Costs

The aluminium is free. Metallica is one of our sponsors.

The CNC and electro-erosion machining are also free.

The sanding is free.

Finally, the Alodine and Titanox treatments are free as well. P. Niklaus SA is one of our sponsors.

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5 PCB AND MB SPACERS

The role of these parts is to mechanically and thermally connect the various electronic boards and battery box with the primary structure.

5.1 Material

Two various materials are used, aluminium for the spacers between PCBs and structure, and POM for spacers between battery box and structure.

The aluminum alloy is called Certal© (see Appendix L). The supplier of the aluminum is Metallica SA. They are a partner of the project and give us all necessary aluminum.

The characteristics of the POM are provided in Appendix N. The supplier of the POM is Dynatec SA. They are a partner of the project and give us all necessary material.

5.2 Machining

The machining of these parts requires only a basic turning machine. This work is done in the machine shop of mechanical engineering at the EPFL. The engineering drawings are shown in Appendix B.

5.3 Surface treatment

The spacers undergo a sanding. The goals of this treatment are to have homogeneous surfaces and to clean them. The sanding machine is in mechanical building (ME G0 566).

Then the spacers undergo a chromating treatment named Alodine 1200 S. The goal is to increase the electrical and thermal properties of the aluminum surfaces. This task will be done by Niklaus SA.

5.4 Schedule and fabrication time

The delay to obtain the material is practically non-existent. We have already received enough material for the EQM and FM.

The turning will last around 1 to 2 working days.

The sanding requires only some minutes and the machine is always available.

The Alodine treatment lasts 4 to 5 working days.

5.5 Costs

The aluminium is free. Metallica is one of our sponsors.

The POM is free. Dynatec is one of our sponsors.

The CNC machining is also free.

The sanding is free.

Finally, the Alodine treatment is free as well. P. Niklaus SA is one of our sponsors.

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6 SCREWS FOR PCB

The PCB stacks and the battery box are fixed on the monobloc frame with custom-made M2 screws.

6.1 Material

The screws for PCB are made of Titanium Grade 5. The supplier of the titanium is Bibus Metals AG. The characteristics of this Titanium are stated in Appendix M.

6.2 Machining

The four screws are machined on a traditional turning machine. This work is done in the machine shop of mechanical engineering at the EPFL.

The engineering drawings of these parts are stated in Appendix C.

6.3 Surface treatment

The only surface treatment that the stress reliefs will undergo is a sanding. The goals of this treatment are to have homogeneous surfaces and to clean them. The sanding machine is in mechanical building (ME G0 566).

6.4 Schedule and fabrication time

The delay to obtain the Titanium is practically non-existent. We have already received enough material for the EQM and FM.

The traditional turning requires 1 to 2 working days.

The sanding requires only some minutes and the machine is always available.

6.5 Costs

The Titanium is free. Bibus Metal AG is one of our sponsors.

The machining is also free.

The sanding is free.

6.6 Contacts

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7 Stress reliefs

The role of these parts is to mechanically protect the welding of the cables against vibration.

7.1 Material

The used material for these parts is an aluminum alloy called Certal© (see Appendix L). The supplier of the aluminum is Metallica SA. They are a partner of the project and give us all necessary aluminum.

7.2 Machining

The machining of these parts requires electro-erosion technology. An Aluminum plate of 4mm of thickness is used, all stress reliefs are cuted by electro-erosion in one time. The electro-erosion task is carried out by the atelier of the material science institute (EPFL - ATMX).

After this task, these parts will be finished by traditional machining which means drilling thread, filing of the edges, etc.

The engineering drawings are shown in Appendix D.

7.3 Surface treatment

The stress reliefs undergo a sanding. The goals of this treatment are to have homogeneous surfaces and to clean them. The sanding machine is in mechanical building (ME G0 566).

Then the stress reliefs undergo a chromating treatment named Alodine 1200 S. The goal is to increase the electrical and thermal properties of the aluminum surfaces. This task will be done by Niklaus SA.

7.4 Schedule and fabrication time

The delay to obtain the material is practically non-existent. We have already received enough material for the EQM and FM.

The machining will last around 2 working days.

The sanding requires only some minutes and the machine is always available.

The Alodine treatment lasts 4 to 5 working days.

7.5 Costs

The aluminium is free. Metallica is one of our sponsors.

The machining is also free.

The sanding is free.

Finally, the Alodine treatment is free as well. P. Niklaus SA is one of our sponsors.

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8 BATTERY BOX

Under high vacuum, the battery block can undergo a physical expansion. To counteract this effect on SwissCube, it is enclosed in a milled aluminum box.

An active thermal control of the battery subassembly will avoid extremely cold temperature for the both batteries. A dissipation system will be located onto a copper plate, itself between the both batteries.

8.1 Material

The used material for this part is an aluminum alloy called Certal© (see Appendix L) for the box itself. The supplier of the aluminum is Metallica SA. They are a partner of the project and give us all necessary aluminum.

Copper will be used for the active thermal control of the batteries. The supplier of the copper is Metallica SA. They are a partner of the project and give us all necessary copper.

8.2 Machining

The machining of the battery box frame can be separated in two steps, the milling machining and the electro-erosion machining. The engineering drawing is provided in Appendix E.

The machining of the copper plate is done by laser cutting. The engineering drawing is provided in Appendix E.

8.2.1 Traditional machining

The First step in producing the battery box consists in milling the exterior of the part thanks to the use of a CNC milling machine. This work is done in the machine shop of mechanical engineering at the EPFL.

8.2.2 Electro-erosion machining

The second step is the cutting of the internal volume by electro-erosion machining. The electro-erosion task is carried out by the atelier of the material science institute (ATMX).

8.2.3 Laser cutting

The copper plate is machined from a copper foil, using laser technology. This work is done in the machine shop of microengineering at the EPFL.

8.3 Surface treatment

The battery box and copper plate undergo a sanding. The goals of this treatment are to have homogeneous surfaces and to clean them. The sanding machine is in mechanical building (ME G0 566).

Then the battery box undergoes a chromating treatment named Alodine 1200 S. The goal is to increase the electrical and thermal properties of the aluminum surfaces. This task will be done by Niklaus SA.

8.4 Schedule and fabrication time

The delay to obtain the material is practically non-existent. We have already received enough material for the EQM and FM.

The CNC milling will last around 1-2 working days.

The electro-erosion machining will last no more than 1 working day.

The laser cutting will last around 1 to 2 hours.

The sanding requires only some minutes and the machine is always available.

The Alodine treatment lasts 4 to 5 working days.

8.5 Costs

The aluminium and copper are free. Metallica is one of our sponsors.

The CNC, electro-erosion machining and laser cutting are also free.

The sanding is free.

Finally, the Alodine treatment is free as well. P. Niklaus SA is one of our sponsors.

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9 PAYLOAD MECHANICAL PARTS

9.1 Material

The Payload frame, Spacer Filter-Lens1, Spacer Lens1-2, Spacer Lens2-3 and Spacer Lens3-End (see drawing of the assembly in Appendix F) are made of Titanium Grade 5. The supplier of the titanium is Bibus Metals AG.

The five vanes are made of stainless steel 1.4310. This material is provided by the machine shop of microengineering at the EPFL.

The closing cap and the four spacers between the vanes are made of aluminum Certal©. The supplier of the aluminum is Metallica SA.

9.2 Machining

The machining of the Payload assembly requires many kinds of techniques. The engineering drawings of these parts are stated in Appendix F.

9.2.1 CNC turning

The Payload frame the four spacers that hold the lens and the closing cap are machined thanks to the use of a CNC turning machine. This work is done in the machine shop of mechanical engineering at the EPFL.

9.2.2 Traditional turning

The four spacers between the vanes are machined on a traditional turning machine. This work is done in the machine shop of mechanical engineering at the EPFL.

9.2.3 Laser cutting

The five vanes are machined from a thin plate of stainless steel. Laser technology is used to cut these rings. This work is done in the machine shop of microengineering at the EPFL.

9.3 Surface treatment

The inner parts of the payload assembly (vanes, spacers between vanes and spacers between lenses) should undergo a treatment in order to reduce the reflecting factor. This treatment will consist of a sanding and blackening of these parts.

9.3.1 Sanding

The goal of this treatment is to prepare the surface for the blackening. The more the parts are dull, the smaller will be the reflecting factor. The sanding machine is in mechanical building (ME G0 566).

For the parts in stainless steel, the sanding machine from microengineering machine shop is used.

9.3.2 Blackening

Three kinds of material should undergo a blackening. For this reason, three types of treatments are employed by two various suppliers.

For the parts in aluminium and stainless steel, the enterprise in charge of the blackening is Niklaus SA.

For the parts in titanium, the enterprise is Steiger Galvanotechnique SA.

9.4 Schedule and fabrication time

The delay to obtain the aluminium as well as Titanium is practically non-existent. We have already received enough material for the EQM and FM. The stainless steel is provided by the machine shop of microengineering.

The CNC turning will last around 2 to 3 working days.

The traditional turning requires 1 to 2 working days.

The laser cutting of the vanes lasts only 1 to 2 hours.

The sanding requires only some minutes and the machine is always available.

The blackening treatment lasts 4-5 working days. It should be noted that the shipping can consume up to 1 week for the parts in Titanium.

9.5 Costs

The aluminium is free. Metallica is one of our sponsors. For the titanium, we have also a partnership with Bibus Metals.

The turning and laser machining are also free.

The sanding is free.

Finally, the blackening at P. Niklaus SA is free as well. This enterprise is one of our sponsors. For the blackening at Steiger Galvanotechnique SA, the price is 400 CHF by batch.

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10 ANTENNA DEPLOYMENT SYSTEM

There are two antennas on the satellite, one of 180 mm long, the other of 610 mm. The other components of the antenna deployment system (ADS) are two melting devices and two guides. Figure 3 shows the various parts of the ADS.

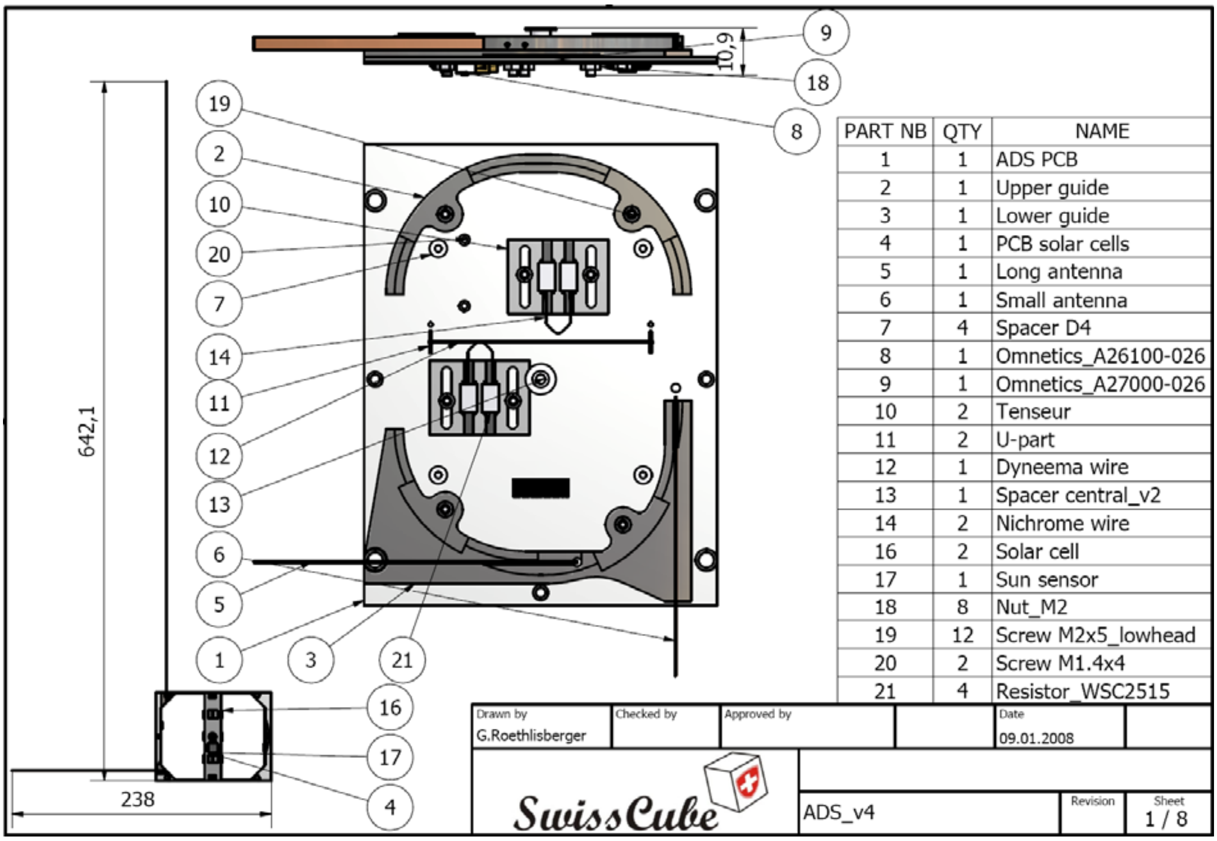

Figure 3 : ADS assembly.

10.1 Material

The following Table summarizes the various materials used for the ADS. For the denomination of the parts, see Figure 3.

Table 1 : Components of the ADS and their material.

NAME	QUANTITY	MATERIAL	WEIGHT (GRAMS) PER PIECE	TOTAL WEIGHT
ADS PCB	1	FR4	24	24

Lower guide	1	POM	4.58	4.60
Upper guide	1	POM	2.607	2.60
Tensor	2	FR4	0.82	1.65
Resistor	2	-	0.2 (not confirmed)	0.4
Nichrome wire	2	Nichrome	--------	--------
Dyneema wire	1	Dyneema	--------	--------
Electrical cable	(for heater)	-	--------	0.10
Long antenna (with Kapton)	1	Copper-Brryllium	4.83	4.85
Small antenna (with Kapton)	1	Copper-Brryllium	1.426	1.45
Lock pin	4	Steel	0.05	0.2
Solar cells PCB	1	FR4	20.5	20.5
Solar cell	2	GaAs	2.45	4.90
Sun sensor	1	Si	1 (not confirmed)	1
Coax. Cable with RF connector	2	-	0.462	0.90
Spacer	4	Aluminum	0.1643	0.65
Omnetics connector	1	-	5	5
Screw M2x10 low head	4	Stainless Steel	0.23	0.90
Screw M2x5 low head	8	Stainless Steel	0.15	1.2
Nut M2	8	Stainless Steel	0.114	0.90
TOTAL				75.8

The aluminum is provided by Metallica SA. The POM is provided by Dynatec. For the antennas, the Berylco is provided by Glucymet GmbH. The nichrome is provided by Machine-Tech Engineering. We have already enough materials for three models (one EQM and two FM).

10.2 Machining

The machining of these parts requires a CNC milling machine. This work is done at Dynatec SA, Préverenges (Switzerland). The engineering drawings are stated in Appendix G.

10.3 Surface treatment

The ADS parts undergo a sanding. The goals of this treatment are to have homogeneous surfaces and to clean them. The sanding machine is in mechanical building (ME G0 566).

The five spacers undergoe a chromating treatment named Alodine 1200 S. The goal is to increase the electrical and thermal properties of the aluminum surfaces. This task will be done by Niklaus SA.

Antennas are electrically isolated from each other. It is done by taping Kapton (50 µm thickness) on the external face of both antennas. The datasheet of this Kapton tape is provided in Appendix P.

10.4 Schedule and fabrication time

The delay to obtain the materials is practically non-existent. We have already received enough material for the EQM and FM.

The milling machining will last around 3 to 4 working days.

The sanding requires only some minutes and the machine is always available.

The Alodine treatment lasts 4 to 5 working days.

10.5 Costs

The aluminium is free. Metallica is one of our sponsors.

The Berylco is free. The enterprise provides us sample.

The POM is free. Dynatec is one of our sponsors..

The Nichrome is free. The enterprise provides us sample

The CNC machining is free. Dynatec SA is one of our sponsors.

The sanding is also free.

Finally, the Alodine treatment is free as well. P. Niklaus SA is one of our sponsors.

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11 KILL SWITCH

These four kill-switches are used to turn off all power of the SwissCube when compressed, so when stacked in the P-POD. The kill switches act also as separation springs which allow giving a relative velocity after deployment from P-POD to separate from the other CubeSats.

11.1 Material

The main used material for the kill-switch is a plastic called POM (see Appendix N). The supplier of the POM is Dynatec SA. They are a partner of the project and give us all necessary material.

The parts that act as electrical contact are made of Beryllium-Copper alloy. This material is provided by the machine shop of microengineering at the EPFL.

The part that close and lock the kill-switch inside the SwissCube frame is made of aluminum alloy called Certal© (see Appendix L). The supplier of the aluminum is Metallica SA. They are a partner of the project and give us all necessary aluminum.

The spring is made of music wire and provided by Vanel. Its characteristics are in Appendix O.

11.2 Machining

The machining of the kill-switch parts uses two various technologies, the CNC turning machining and the laser cutting. The engineering drawing is provided in Appendix H.

11.2.1 Traditional machining

The POM and Aluminum parts are machined using CNC turning. This work is done in the machine shop of mechanical engineering at the EPFL for the Aluminum part, and in the machine shop of microengineering at the EPFL for the parts in POM.

11.2.2 Laser cutting

The contact parts are machined from a beryllium-copper foil, using laser technology. This work is done in the machine shop of microengineering at the EPFL.

11.3 Thermal treatment

In order to fold the beryllium-copper parts, thermal treatment is needed. The fist treatment consists of a quenching, i.e. heat the material up to its alpha phase (780°C), then rapidly cooling in water. The quenching gives more flexibility and permits to fold the beryllium-copper to the right shape.

For this process two mechanical parts are used to fold the beryllium-copper, see drawings named “fold Assembly” in Appendix H.

Afterwards, a second thermal treatment is needed to rigidify again the beryllium-copper. This treatment is a hardening which consists of heating the parts at 330°C during at least 3 hours. After this treatment, the beryllium-copper is again rigid and has again good electrical properties.

These both thermal treatments are realized in the lab of metallurgy of the EFFL (contact : Vincent Laporte).

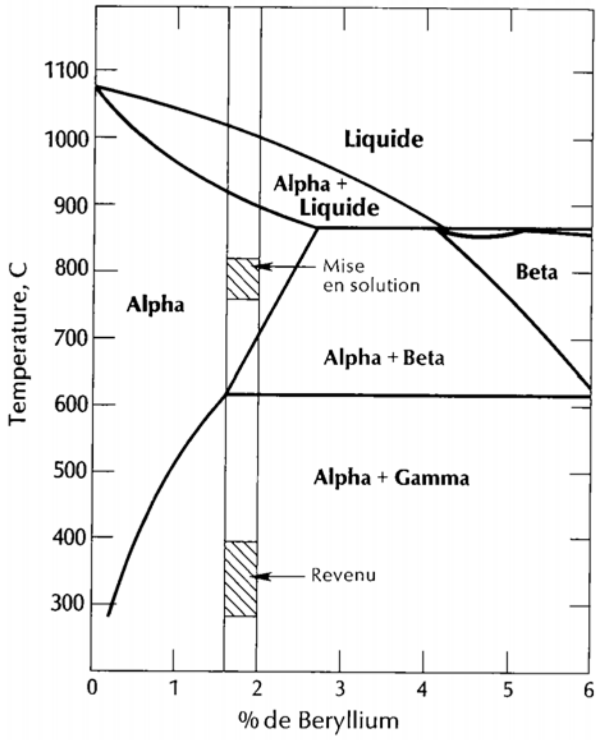

Figure 4 : Beryllium-copper phase diagram.

11.4 Surface treatment

The kill-switch parts undergo a sanding. The goals of this treatment are to have homogeneous surfaces and to clean them. For the beryllium-copper parts, the goal is to remove the oxide layer, in order to be able to weld electrical cable on it. The sanding machine is in mechanical building (ME G0 566).

In order to decrease the electrical contact resistance of the beryllium-copper parts, a gold plated treatment is done on these parts. This treatment consists of a sulphuric acid attack in order to remove the oxide layer, then a nickel plating of 3-5 μm and finally a gold plating of 0.5-0.75μm. This task will be done by LEMO.

The cap, the only aluminum part of the kill-switch, undergoes a hard-anodizing treatment named Titanox (Ematal 78). The goals are to have a low friction between the satellite and the P-POD (requirement 4_SC_41_04) and also to electrically isolating the structure (4_SC_43_02) from the P-POD. This task will be done by Niklaus SA.

11.5 Schedule and fabrication time

The delay to obtain the material is practically non-existent. We have already received enough material for the EQM and FM.

The delay to obtain the spring can be up to 10 days.

The CNC machining will last around 2 to 3 working days.

The laser cutting will last around 1 to 2 hours.

The thermal treatment will last around 1 to 2 working days.

The sanding requires only some minutes and the machine is always available.

The Titanox treatment lasts 4 to 5 working days.

The gold plating treatment requires only 3 to 4 working days.

11.6 Costs

The aluminium is free. Metallica is one of our sponsors.

The POM is free. Dynatec is one of our sponsors..

The beryllium-copper is free. This material is provided by the machine shop of microengineering at the EPFL.

The machining is free.

The thermal treatments are free of charge.

The sanding is also free.

Finally, the Titanox and gold plating treatments are free as well. Niklaus SA and LEMO are one of our sponsors.

11.1 Contacts

Metallica SA
Jacques-Alain Diacon
Route de marcolet 37
CH-1023 Crissier
+41(0)79 413 55 24
j.a.diacon@metallica.ch

Dynatec SA
Jean-Claude Borloz
Chemin du Vuasset 4
CH - 1028 Préverenges
Tel: +41 21 804 56 26
Fax: +41 21 804 56 29
jc.borloz@dynatec.ch

Marc Jeanneret (marc.jeanneret@epfl.ch)
ME C0 401
phone 33 881 or 33 887

Claude Amendola (claude.amendola@epfl.ch)
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phone 33818

Vincent Laporte (vincent.laporte@epfl.ch)
MXE 130
phone 32992

P. Niklaus S.A.
Jack Niklaus
Rue de l'Epinglier 3
1217 MEYRIN
Phone 022 780 15 70
p.niklaus.sa@bluewin.ch

LEMO
Hervé Menzel
Chemin de Champs-Courbes 28
CH-1024 Ecublens
Phone +41 21 695 16 00

12 RAIL CAP

The passing holes of the four rails shall be closed by a cap to give a support to the springs of the other CubeSats.

12.1 Material

The caps of the rails shall be made of aluminum Certal©. Its datasheet is in Appendix L. The supplier of the aluminum is Metallica SA. They are a partner of the project and give us all necessary aluminum.

12.2 Machining

These parts are machined using traditional turning machine. This work is done in the machine shop of mechanical engineering at the EPFL. The engineering drawings are provided in Appendix I.

12.3 Surface treatment

The first treatment that the caps parts undergo is a sanding. The goals of this treatment are to have homogeneous surfaces and to clean them. The sanding machine is in mechanical building (ME G0 566).

Secondly, these parts undergo a hard-anodizing treatment named Titanox (Ematal 78). The goals are to have a low friction between the satellite and the P-POD (requirement 4_SC_41_04) and also to electrically isolating the structure (4_SC_43_02) from the P-POD. This task will be done by Niklaus SA.

12.4 Schedule and fabrication time

The delay to obtain the material is practically non-existent. We have already received enough material for the EQM and FM.

The turning will last around 1 working day.

The sanding requires only some minutes and the machine is always available.

The Titanox treatment lasts 4 to 5 working days.

12.5 Costs

The aluminium is free. Metallica is one of our sponsors.

The machining is free.

The sanding is also free.

Finally, the Titanox treatment is free as well. P. Niklaus SA is one of our sponsors.

12.6 Contacts

Metallica SA
Jacques-Alain Diacon
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+41(0)79 413 55 24
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phone 33 881 or 33 887

P. Niklaus S.A.
Jack Niklaus
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13 SHIELDING PLATES

In order to protect the internal PCBs from space radiation, shielding plates will be located just behind external panels, more precisely + Z, -Z, +Y and –Y panels.

According to a publication[1], an optimal shield consists of multiple layers of different shield materials, a high-Z layer sandwiched between the two low-Z layers.

13.1 Material

Two various materials are used; Tantalum for high-Z layer material and Aluminum for low-Z layer material. The datasheet of these materials are provided in Appendix Q and Appendix L respectively.

The 0.1 mm thickness Tantalum foil is provided by Carbone Lorraine. They are a partner of the project and give us all necessary material.

The aluminum alloy is called Certal©. The supplier of the 0.5 mm thickness aluminum foil is Metallica SA. They are a partner of the project and give us all necessary aluminum.

13.2 Machining

The various plates are machined from foils of Tantalum or Aluminum. Laser technology is used to cut these parts. This work is done in the machine shop of microengineering at the EPFL. The engineering drawings are shown in Appendix J.

13.3 Surface treatment

These plates undergo a sanding. The goals of this treatment are to have homogeneous surfaces and to clean them. The sanding machine is in mechanical building (ME G0 566).

Then the aluminum shielding plates undergo a chromating treatment named Alodine 1200 S. The goal is to increase the electrical and thermal properties of the aluminum surfaces. This task will be done by Niklaus SA.

---

[1] Wesley C. Fan, Clifton R. Drumm, Stanley B. Roeske and Gary J. Scrivner, *Shielding Considerations for Satellite Microelectronics*, IEEE Transactions on nuclear science, vol 43, n°6, December 1996.

13.4 Schedule and fabrication time

The delay to obtain the material is practically non-existent. We have already received enough material for the EQM and FM.

The laser machining will last 1 working day.

The sanding requires only some minutes and the machine is always available.

The Alodine treatment lasts 4 to 5 working days.

13.5 Costs

The aluminium is free. Metallica is one of our sponsors.

The Tantalum is also free, Carbon Lorraine is one of our sponsors.

The Laser cutting is free.

The sanding is free.

Finally, the Alodine treatment is free as well. Niklaus SA is one of our sponsors.

13.6 Contacts

Metallica SA
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CH-1023 Crissier
+41(0)79 413 55 24
j.a.diacon@metallica.ch

Carbone Lorraine
Holger Flemig (holger.flemig@carbonelorraine.com)

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phone 33818

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14 GYRO BRACKET

As the gyro electronic chip can measure only on axis, three chips are used by the ADCS. The first one is directly mounted on the ADCS PCB. The two remaining are mounted on a bracket that is screwed on the ADCS PCB.

14.1 Material

The gyro bracket shall be made of aluminum Certal©. Its datasheet is in Appendix L. The supplier of the aluminum is Metallica SA. They are a partner of the project and give us all necessary aluminum.

14.2 Machining

This part is machined using traditional turning machine. This work is done in the machine shop of micro-engineering at the EPFL. The engineering drawings are provided in Appendix K.

14.3 Surface treatment

The bracket undergoes a sanding. The goals of this treatment are to have homogeneous surfaces and to clean them. The sanding machine is in mechanical building (ME G0 566).

Then the part undergoes a chromating treatment named Alodine 1200 S. The goal is to increase the electrical and thermal properties of the aluminum surfaces. This task will be done by Niklaus SA.

14.4 Schedule and fabrication time

The delay to obtain the material is practically non-existent. We have already received enough material for the EQM and FM.

The machining will last 1 to 2 working days.

The sanding requires only some minutes and the machine is always available.

The Alodine treatment lasts 4 to 5 working days.

14.5 Costs

The aluminium is free. Metallica is one of our sponsors.

The machining is free.

The sanding is free.

Finally, the Alodine treatment is free as well. Niklaus SA is one of our sponsors.

14.6 Contacts

Metallica SA
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15 ADCS MAGNETOTORQUERS

There are three identical magnetotorquers (MT) on the satellite, one per axis. The MT are quite complex to build. First, the wire is winded to form a coil. Then this coil is molded with epoxy, in order to protect the wire and to have precise external dimensions.

15.1 Material

The wire used is a CAB-200 non space-qualified copper wire with a diameter of 150µm, provided by EPFL electromechanical machine shop.

The epoxy used is EPO-TEK 920, provided by Polyscience AG.

15.2 Machining step

15.2.1 Winding

The winding is done using a specific winding stand with the coil dimensions (see Figure 5 and Figure 6). Then, the coil is heated in an oven to bond the wires together.

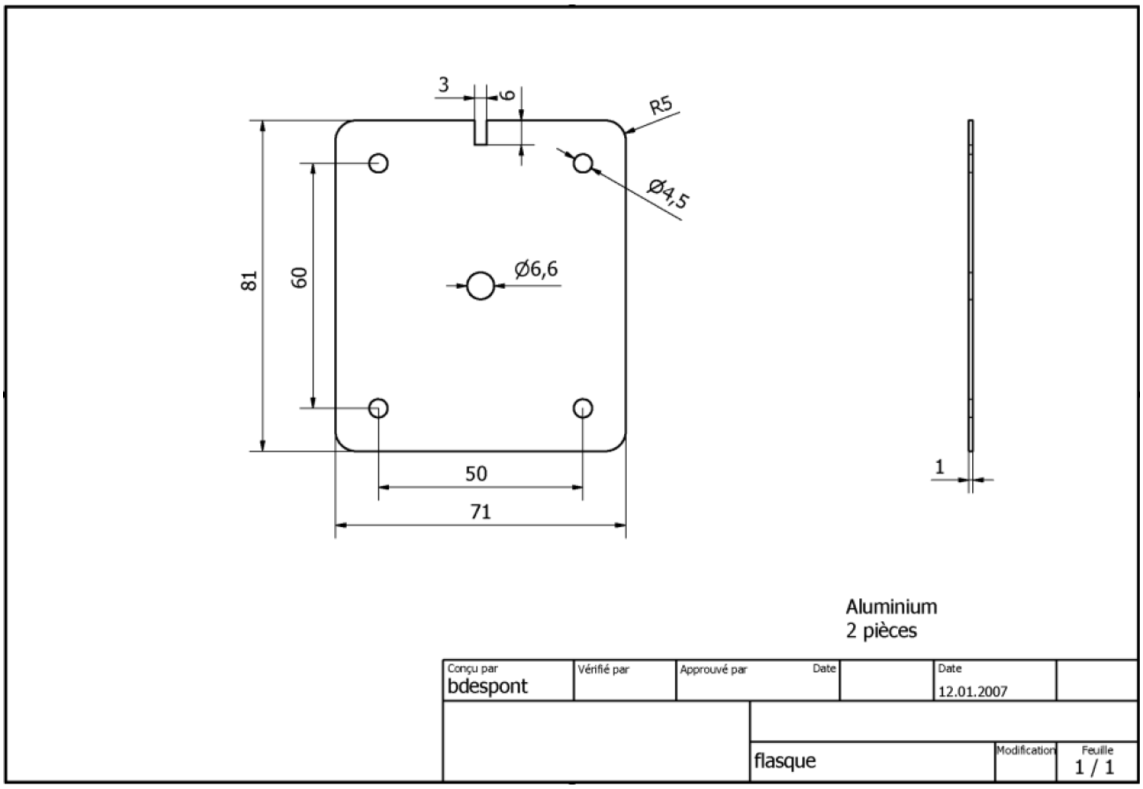

Figure 5 : Coil winding flange.

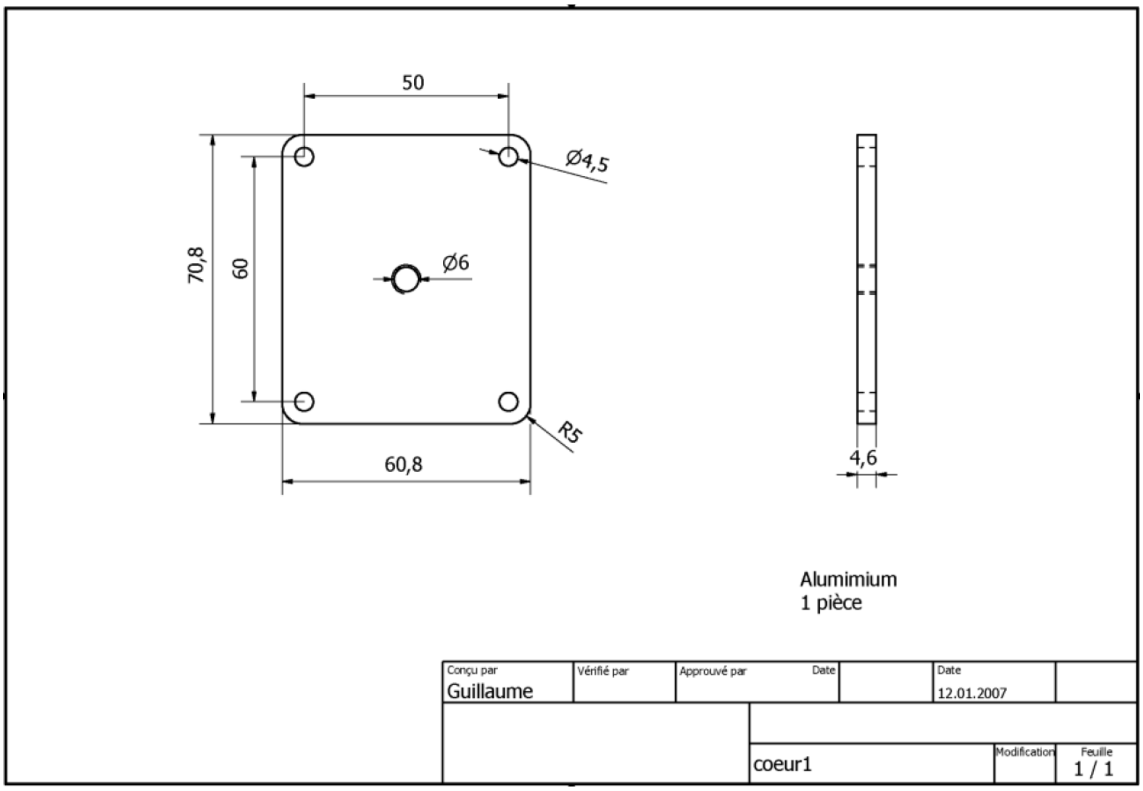

Figure 6 : Coil winding heart.

15.2.2 Moulding

The magnetotorquer are molded with the EPO-TEK 920 epoxy provided by Polyscience AG. After the resin have mixed and dropped, the mould must be put into vacuum (for about 1h) to decrease the number and size of bubbles. Then the epoxy is cured in an oven (about 80°C during 5-6h; the lower the temperature, the smaller the remaining constrains).

15.3 Surface treatment

NA

15.4 Schedule and fabrication time

The delay to obtain the cable is practically non-existent. The electromechanical machine shop has already enough material for the EQM and FM. For the epoxy, the delay is 5 working days.

The winding process will last around 1 to 2 working days.

The molding will last 1 to 2 working days.

15.5 Costs

The winding process is free.

The wire is free.

The cost of the epoxy is around 100 CHF/100 grams.

15.6 Contacts

POLYSCIENCE AG
Beatrice Iten
Riedstrasse 13
CH-6330 Cham
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Roland Dupuis (roland.dupuis@epfl.ch)
AEM - Electromechanical workshop, MT
phone 32 618

16 ASSEMBLY PROCEDURE

It is assumed that major assemblies of the panels are done in advance, meaning that solar cells, sun sensors, connectors, magnetotorquers and the corresponding electronics are mounted on the panels. The both PCBs stacks are also assembled together before the integration into the satellite. The assembly procedure is based on the allowed design space of each PCB, which gives a relatively complicated assembly procedure, since the design space only allows small clearance during assembly. Figure 7 gives an overview of the assembly procedure.

The assembly procedure starts with the monobloc frame. The four kill-switches are integrated, and screwed in the four +Z end faces of the feet, their cables are routed along crossbars in direction of the +Y panel. Then the +Y panel and Antennas deployment system (ADS) are attached to the satellite structure (see Figure 7 step I). The electrical connections between the four kill-switches and the +Y panel are done.

The internal PCBs shall be prepared outside the satellite (see Figure 7 step II). The stacks assembly consists in:

- integrate CDMS and EPS board on one part. To mechanically attach these two boards, spacers at the center of the PCB are used.
- integrate ADCS, Beacon and COM on the other part. To mechanically attach these three boards, spacers at the center of the PCB are used. The RF connection between the COM and Beacon is done at this moment.

All the wires which have to go from these PCBs to other place of the satellite shall be prepared (cut at the right length, stripped at the both extremities and welded). Then the both stacks of PCBs are fixed inside the satellite frame on the Y+ and Y- sides with the remaining spacers and customized M2 screws (see Figure 7 step III).

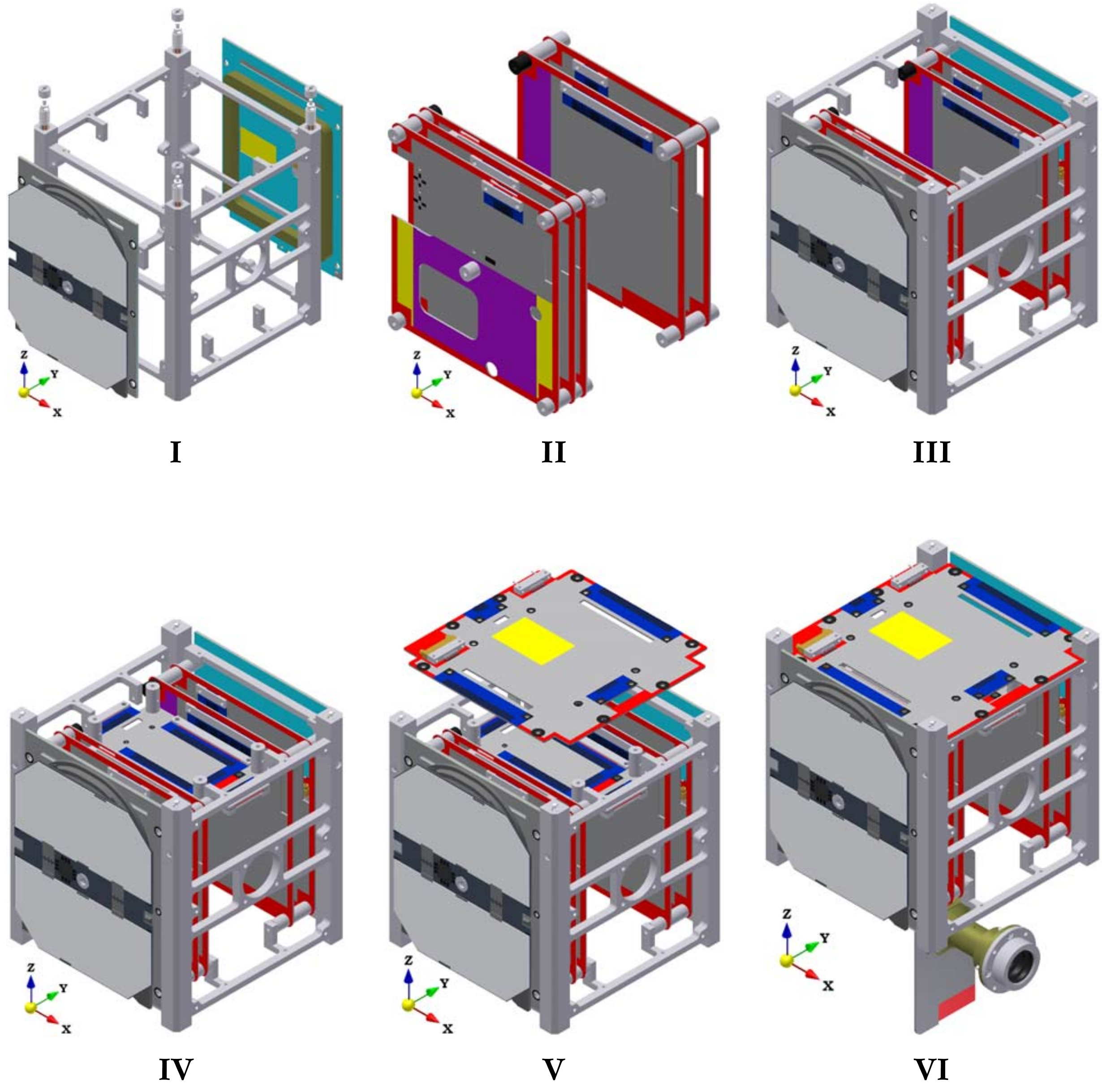
The connection board (CB) shall be prepared in advance. All electrical connection to the side panels of the satellite is realized via Ometics connectors. For this reason all cables that come from these connectors shall be prepared (cut at the right length, stripped at the both extremities) and welded on the connection board. The cables going from the connection board to the motherboard shall be also prepared and welded. Then the connection board shall be inserted between the both PCBs stacks (see Figure 7 step IV). The electrical connection between these PCBs and the CB shall be done (welding).

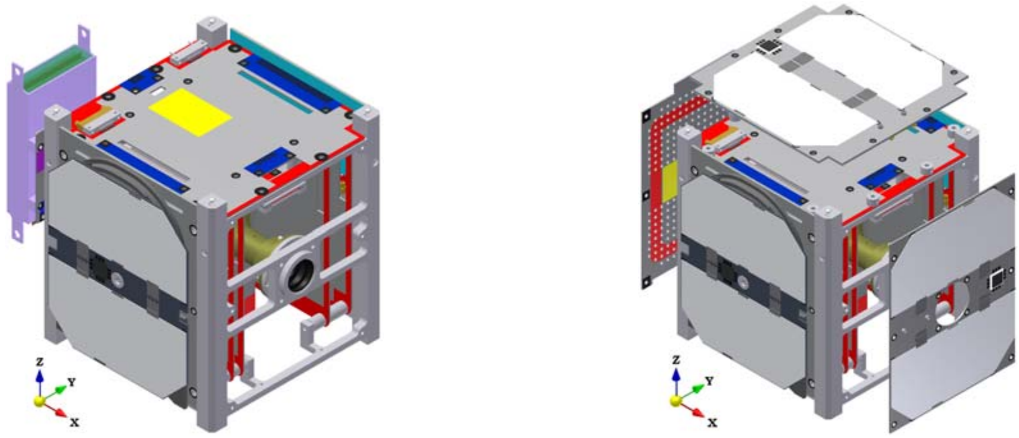
Then the motherboard (MB) shall be inserted onto the Z+ side of the satellite frame (see Figure 7 step V). The mechanical connection of the CB at the bottom face of the MB shall be done using spacers and screws. The wires coming from the CB shall be welded on the MB. Afterwards the connections between the PCBs stacks and motherboard are done.

The next task consists of the Payload (PL) subassembly integration (see Figure 7 step VI). The PL is introduced between the PCB's stacks and fixed on the X+ side of the frame by M2 screws. The electrical connection between this subsystem and the MB is done by welding the cables coming from the Pl onto the MB.

After that the battery subsystem is inserted between the both PCBs stacks at the –X side of the satellite (see Figure 7 step VII). POM spacers and the customized M2 screws that already hold in place the PCBs stacks are used to mechanically attach the battery subsystem. The electrical connection between this subassembly and the CB is done thanks to an Omnetics connector.

The last task consists in integration of the four last panels +X, -X, +Z and –Z (see Figure 7 step VIII). The electrical connections to the internal PCBs are done with Omnetics connectors, just before screwing the panels onto the satellite structure.





VII VIII

Figure 7 : SwissCube assembly procedure.

17 GANTT CHART

According to the delay cited previously, Figure 8 shows the schedule to manufacture the mechanical parts of the SwissCube. Due to complex surface treatments, the longest processes concern the fabrication of the monobloc frame and payload assembly.

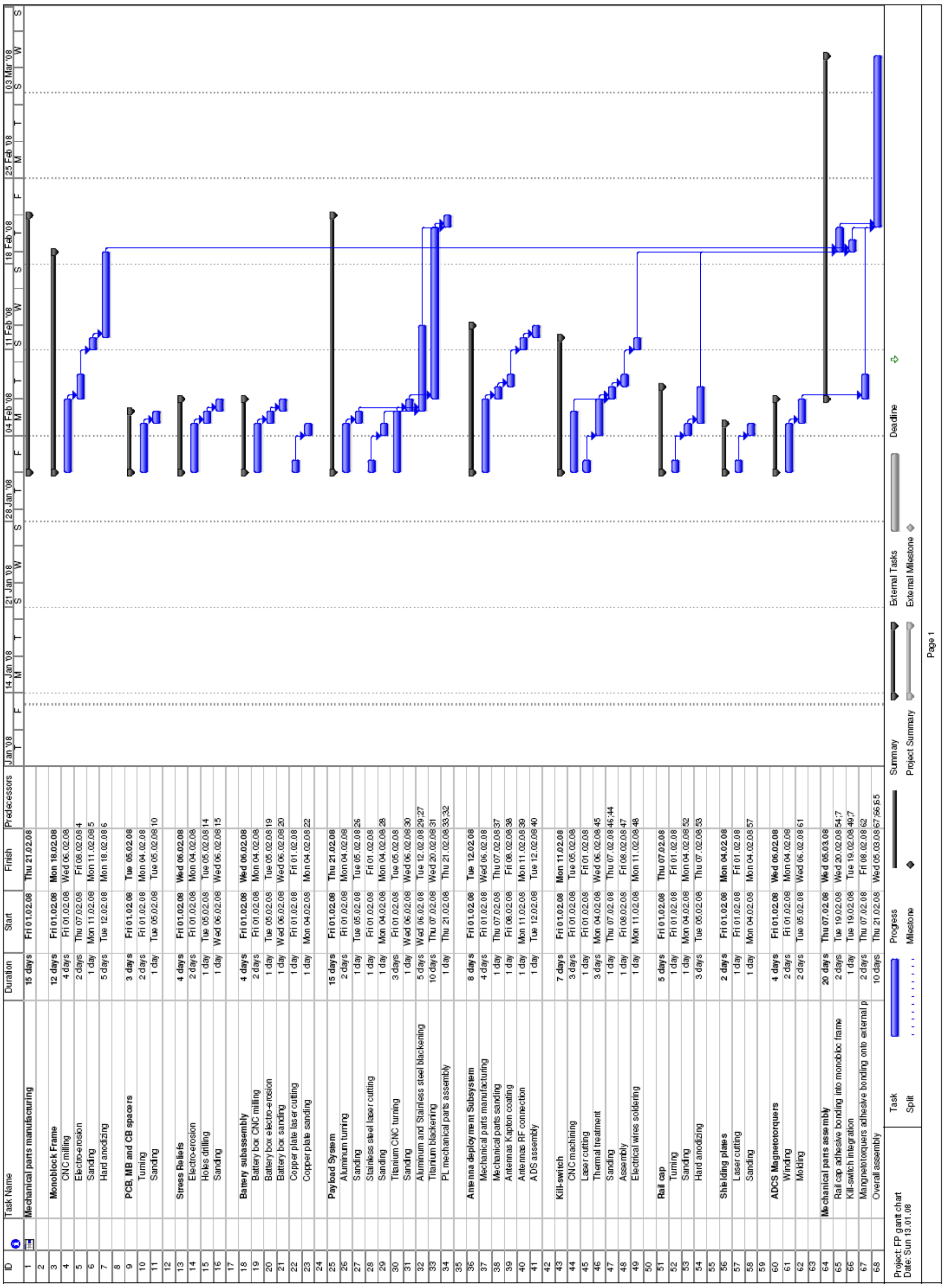


Figure 8 : Gantt chart for the mechanical parts.

18 MANUFACTURING STATUS

The following tables give the manufacturing status of the various mechanical parts of the SwissCube. The EQM and FM parts will be manufactured in various EPFL machine shops.

TBC : to be checked

TBD : to be done

AMB – Marc Jeanneret (33 881 / 33 887)

Part Name	Material	Machining step	Complexity	Drawing status	Manufacturing status
Monobloc Frame	Alu Certal	External CNC milling	5	TBC	TBD
Stress reliefs	Alu Certal	Leveling & hole drilling	2	TBC	TBD
PCB & MB spacers	Alu Fortal & POM-H	All (turning & drilling)	1	checked	ongoing
PL frame	Titanium	All (CNC turning & milling)	4	TBC	TBD
PL lens spacers	Titanium	All (CNC turning)	4	TBC	TBD
PL vane spacers	Titanium	All (turning)	1	TBC	TBD
PCB screw	Titanium	All (turning)	2	checked	ongoing
M2x14	Stainless Steel or Titanium	All (turning)	2	TBC	TBD
ADS spacers	Alu Fortal	All (turning)	2	checked	ongoing
Rail cap	Alu Certal	All (turning)	1	checked	ongoing
Carry box	Alu Fortal	All (CNC turning)	3	checked	done

ATMX – Pierre-André Despont (32 965)

Part Name	Material	Machining step	Complexity	Drawing status	Manufacturing status
Monobloc Frame	Alu Certal	Internal wire EDM	5	TBC	TBD
Stress reliefs	Alu Certal	Wire EDM cutting	1	TBC	TBD

Battery Box	Alu Certal	Internal wire EDM	3	TBC	TBD

ATPR – Claude Amendola (33 818 / 33 819)

Part Name	Material	Machining step	Complexity	Drawing status	Manufacturing status
Shielding plates	Ta and Alu	All (laser cutting)	1	TBC	TBD
BB copper plate	Copper	All (laser cutting)	1	TBC	TBD
PL vanes	Stainless Steel	All (laser cutting)	1	TBC	TBD
Kill-switch plastic parts	POM-H	All (turning)	4	TBC	TBD
Kill-switch contact parts	Beryllium-Copper	All (Laser cutting)	1	TBC	TBD
ADS antennas	Beryllium-Copper	All (Laser cutting or clipping)	1	TBC	TBD
Gyro bracket	Alu Certal	All (CNC milling & drilling)	3	checked	ongoing

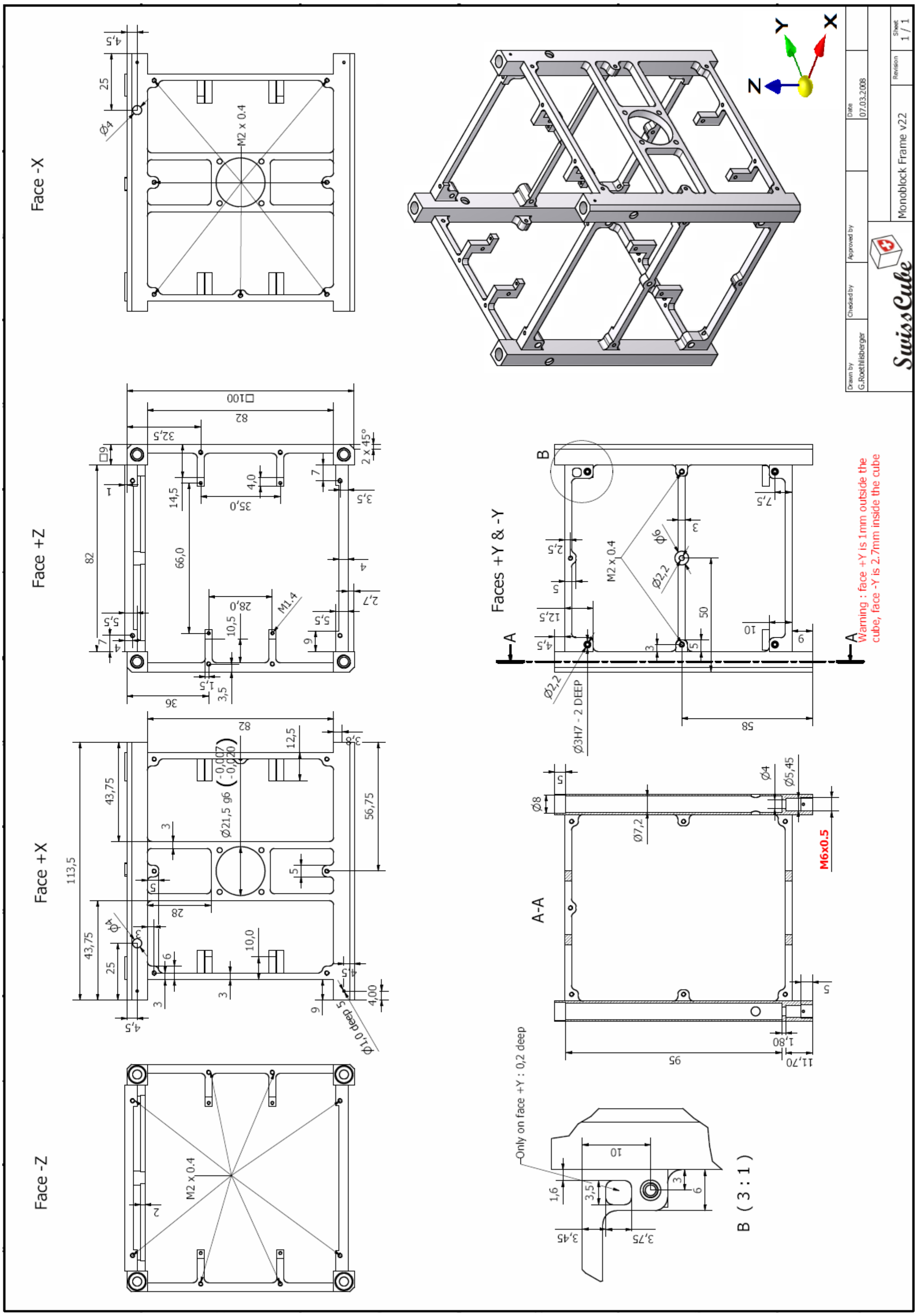
AEM – Jean-Paul Brugger (33 933)

Part Name	Material	Machining step	Complexity	Drawing status	Manufacturing status
Battery Box	Alu Certal	External CNC milling	3	checked	ongoing
PL cap	Alu Fortal	All (turning)	2	TBC	TBD
Magnetotorquer	Copper wire	All (Winding and molding)	2	TBC	TBD

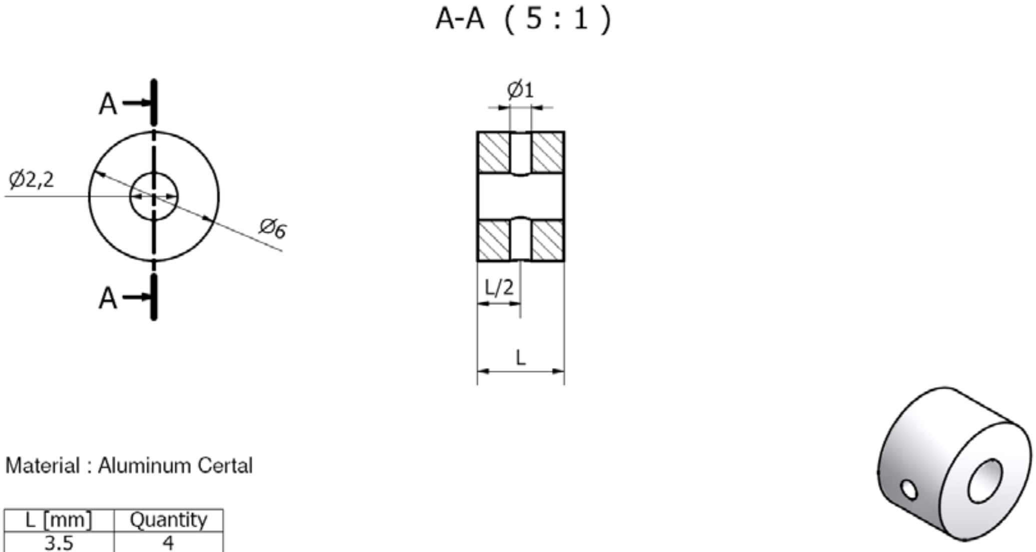
Dynatec – Jean Claude Borloz (021 804 56 26)

Part Name	Material	Machining step	Complexity	Drawing status	Manufacturing status
ADS guides (by pair)	POM-H black	All (CNC machining)	4	checked	ongoing

Appendix A Monobloc frame drawings



Appendix B PCB and MB spacers drawings

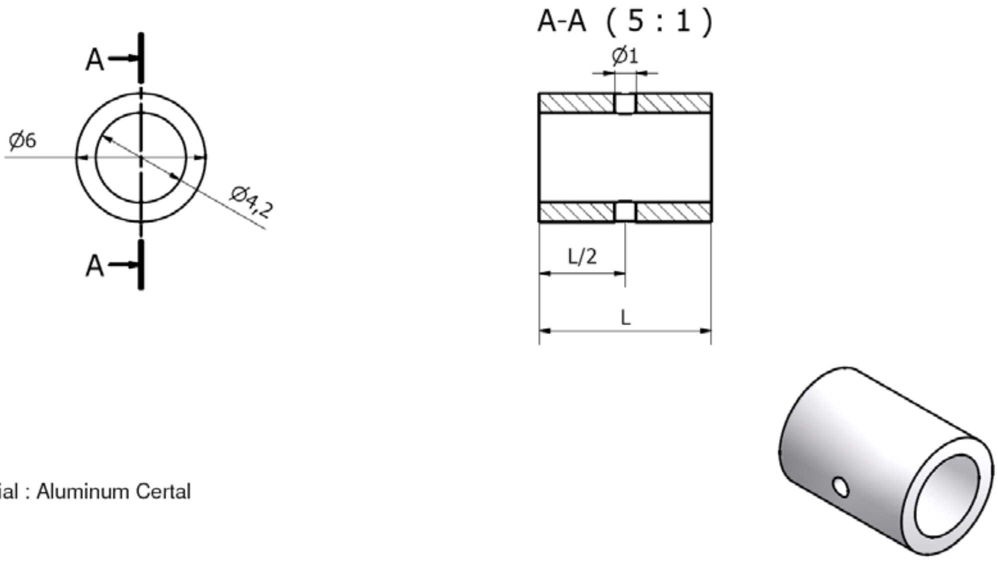


Material : Aluminum Certal

L [mm]	Quantity
3.5	4
4.0	8
4.4	2
4.5	4
6.0	4
6.9	2
8.0	4
12	4

Conçu par	Vérifié par	Approuvé par	Date	Date	
G. Roethlisberger				05.01.2008	

SwissCube — Spacers D6/D2.2 — Modification — Feuille 1 / 1

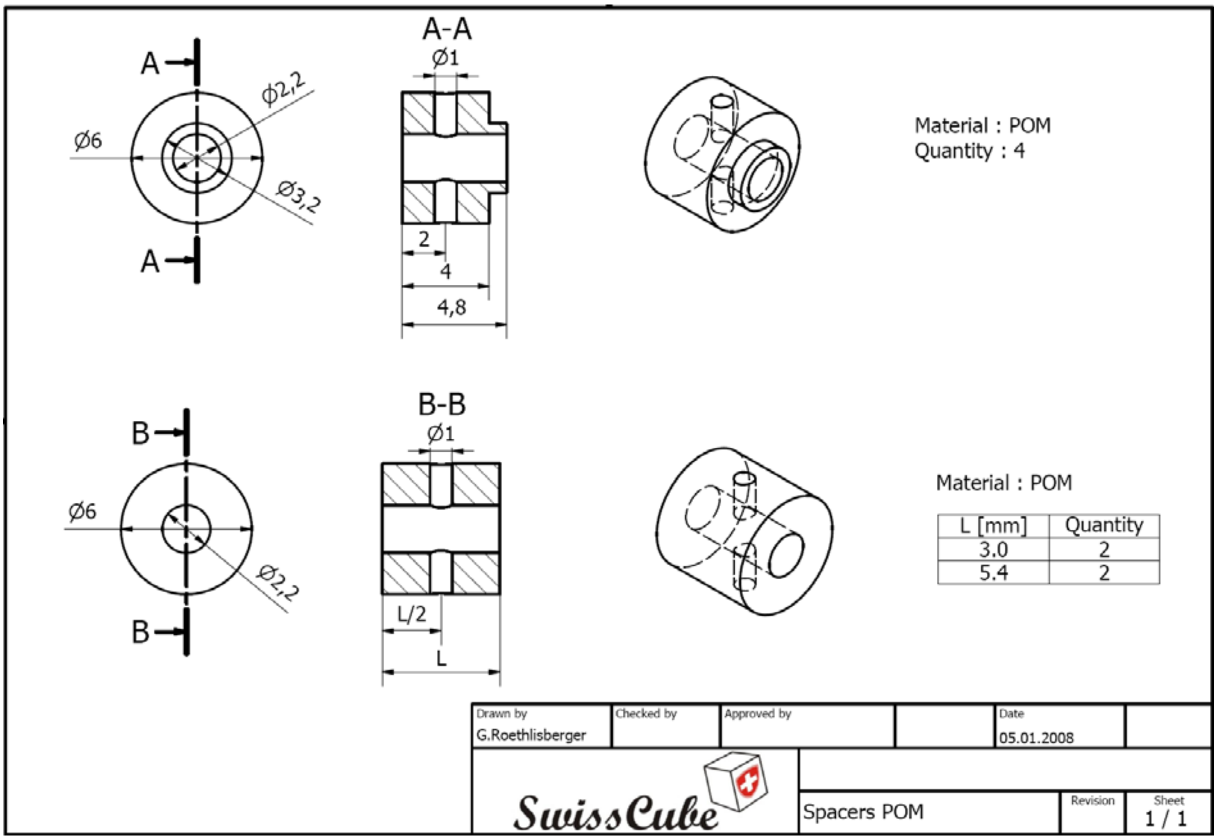


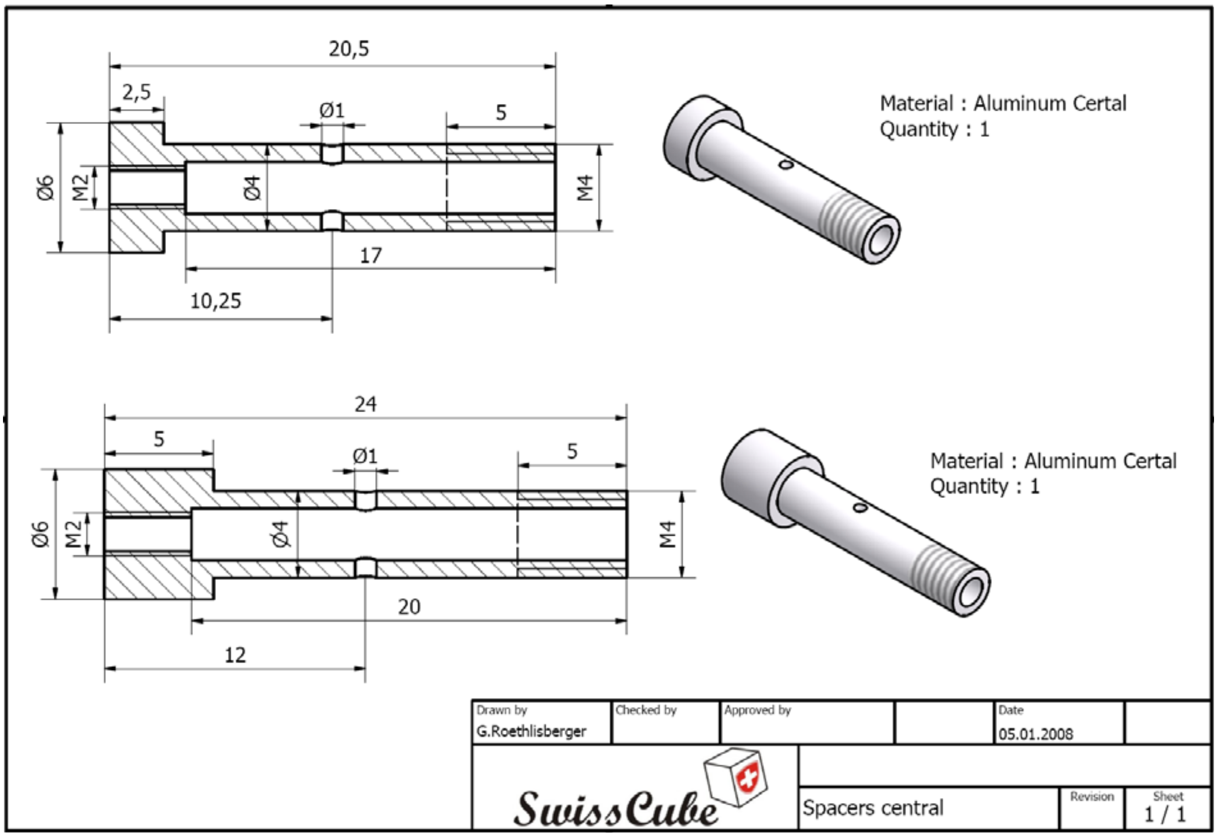
Material : Aluminum Certal

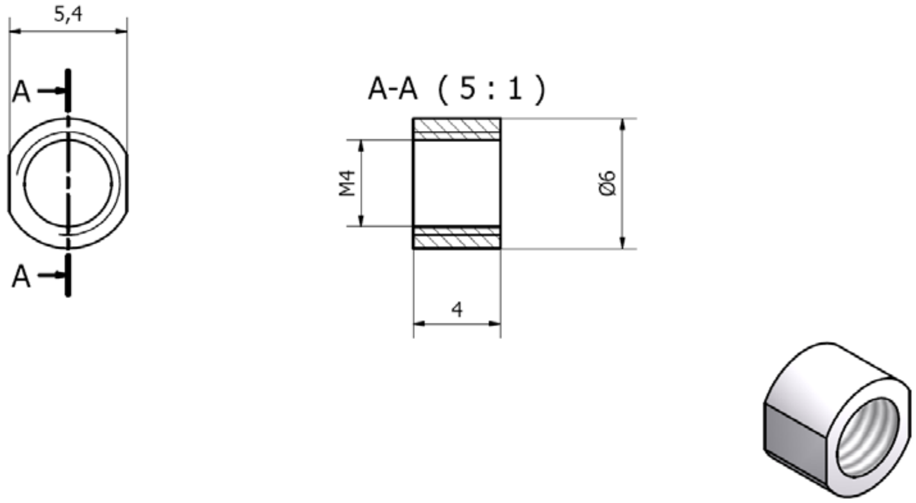
L [mm]	Quantity
4.5	1
8.0	1
12.0	1

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				05.01.2008	

SwissCube — Spacers D6/D4.2 — Revision — Sheet 1 / 1


A-A
Ø1
A
A
Ø6
ϕ2,2
Ø3,2
2
4
4,8
Material : POM
Quantity : 4
B-B
Ø1
B
B
Ø6
Ø2,2
L/2
L
Material : POM
L [mm] Quantity
3.0 2
5.4 2
Drawn by
G.Roethlisberger
Checked by
Approved by
Date
05.01.2008
SwissCube
Spacers POM
Revision
Sheet
1 / 1


20,5
2,5
Ø1
5
Ø6
M2
Ø4
M4
17
10,25
Material : Aluminum Certal
Quantity : 1
24
5
Ø1
5
Ø6
M2
Ø4
M4
20
12
Material : Aluminum Certal
Quantity : 1
Drawn by
G.Roethlisberger
Checked by
Approved by
Date
05.01.2008
SwissCube
Spacers central
Revision
Sheet
1 / 1



Material : Aluminum Certal

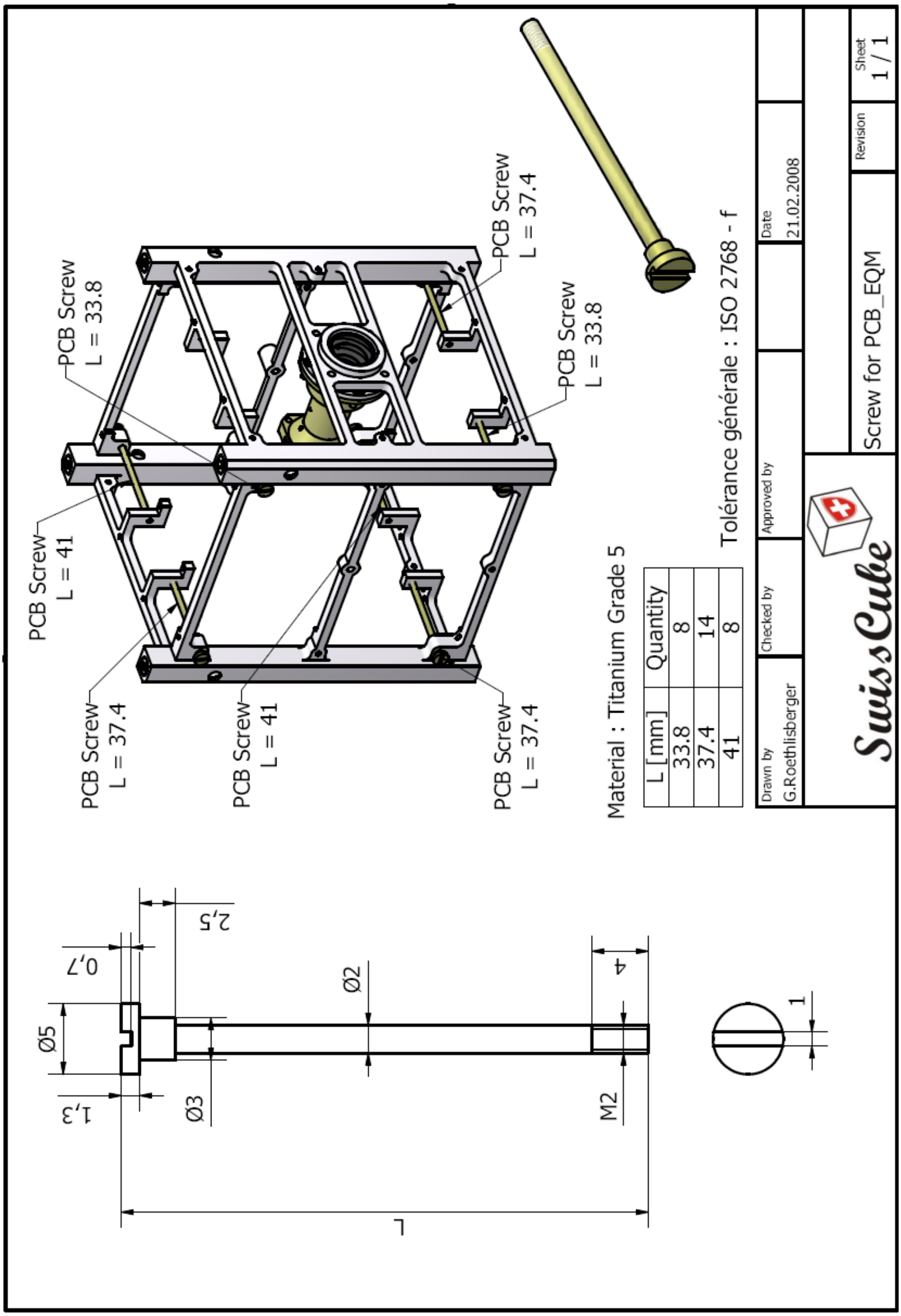
Quantity : 2

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				05.01.2008	

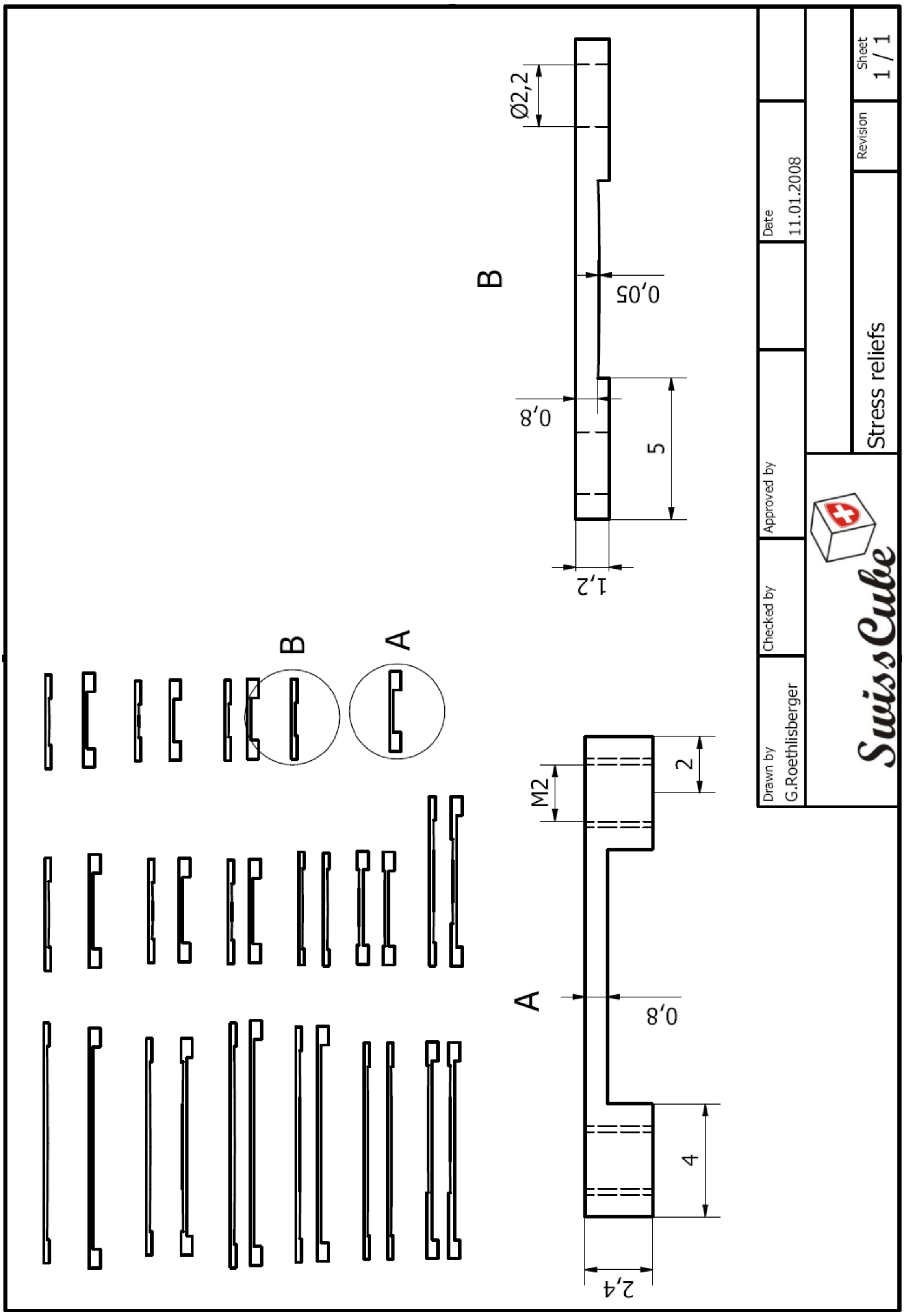
SwissCube

	Revision	Sheet
Spacer central nut		1 / 1

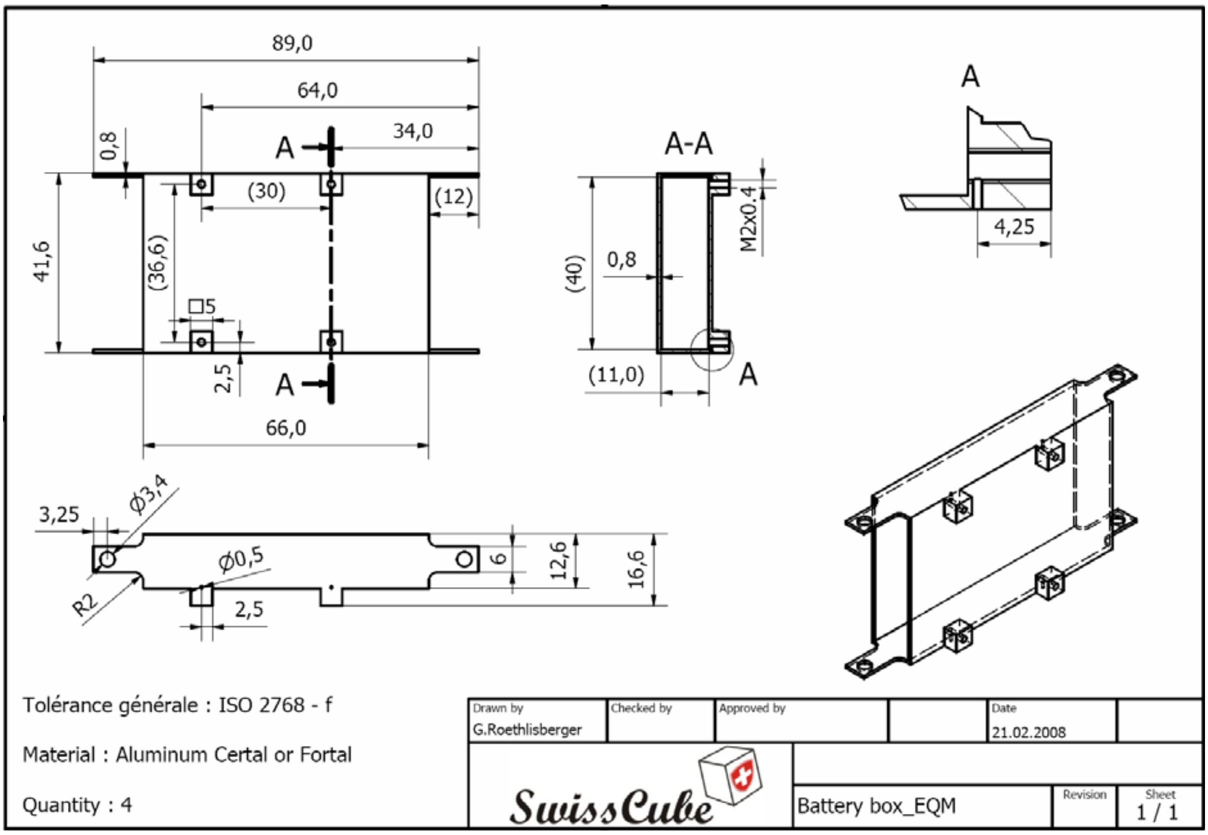
Appendix C Screws for PCB

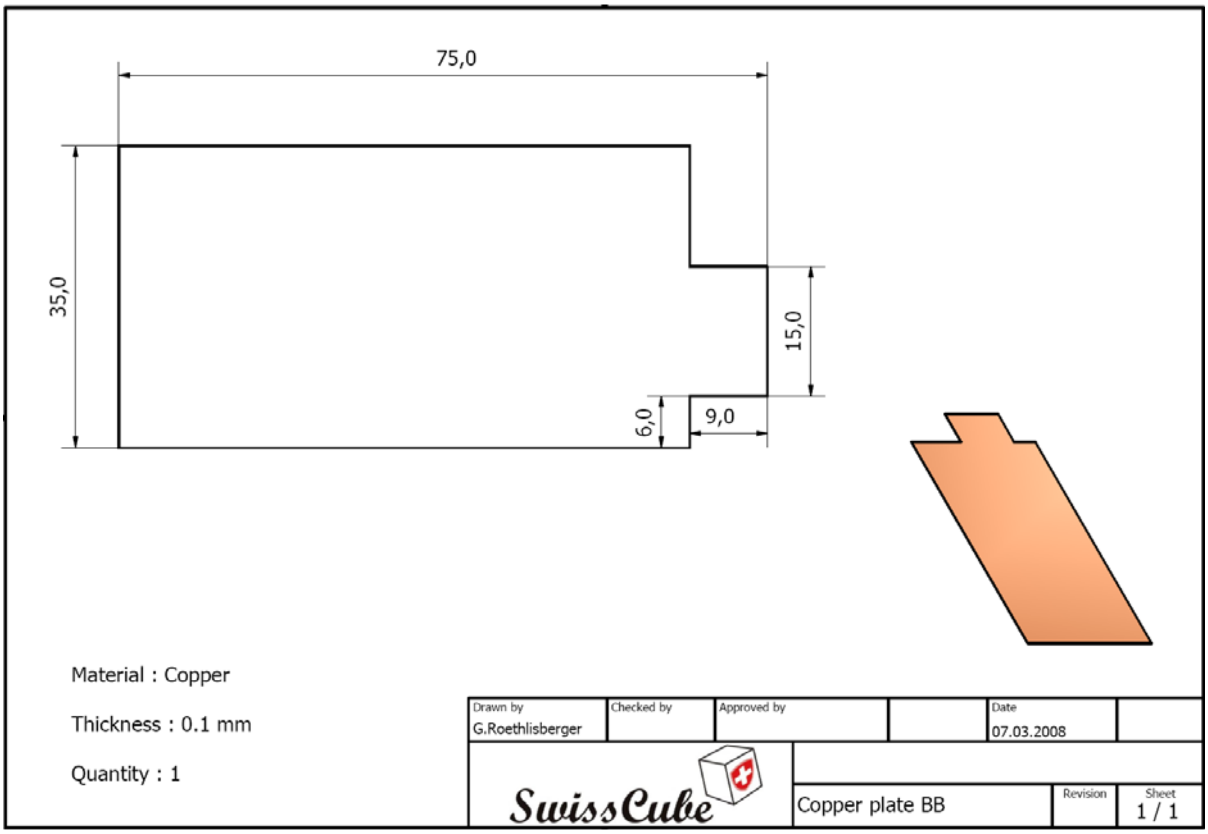


Appendix D Stress reliefs

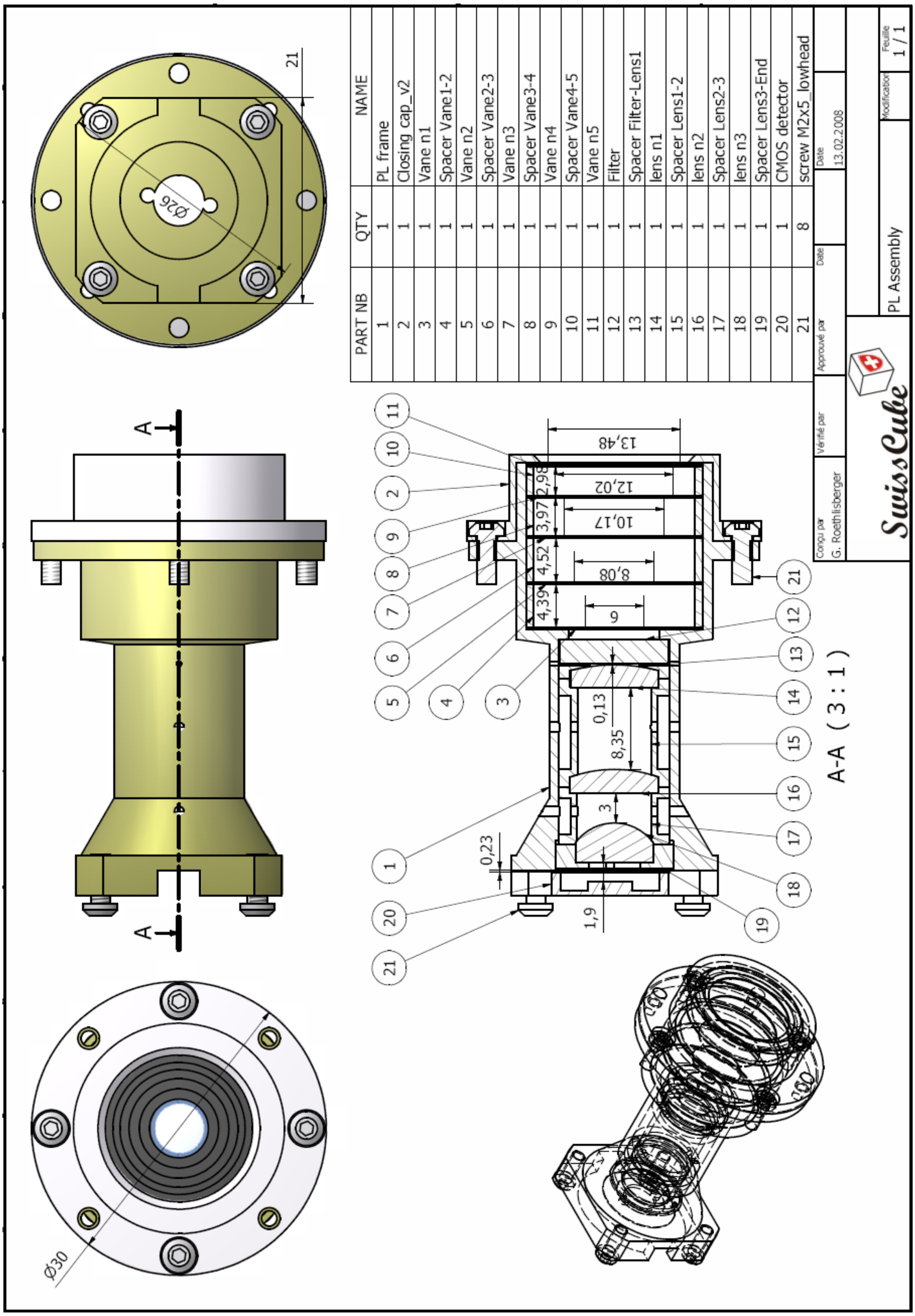


Appendix E Battery box drawings

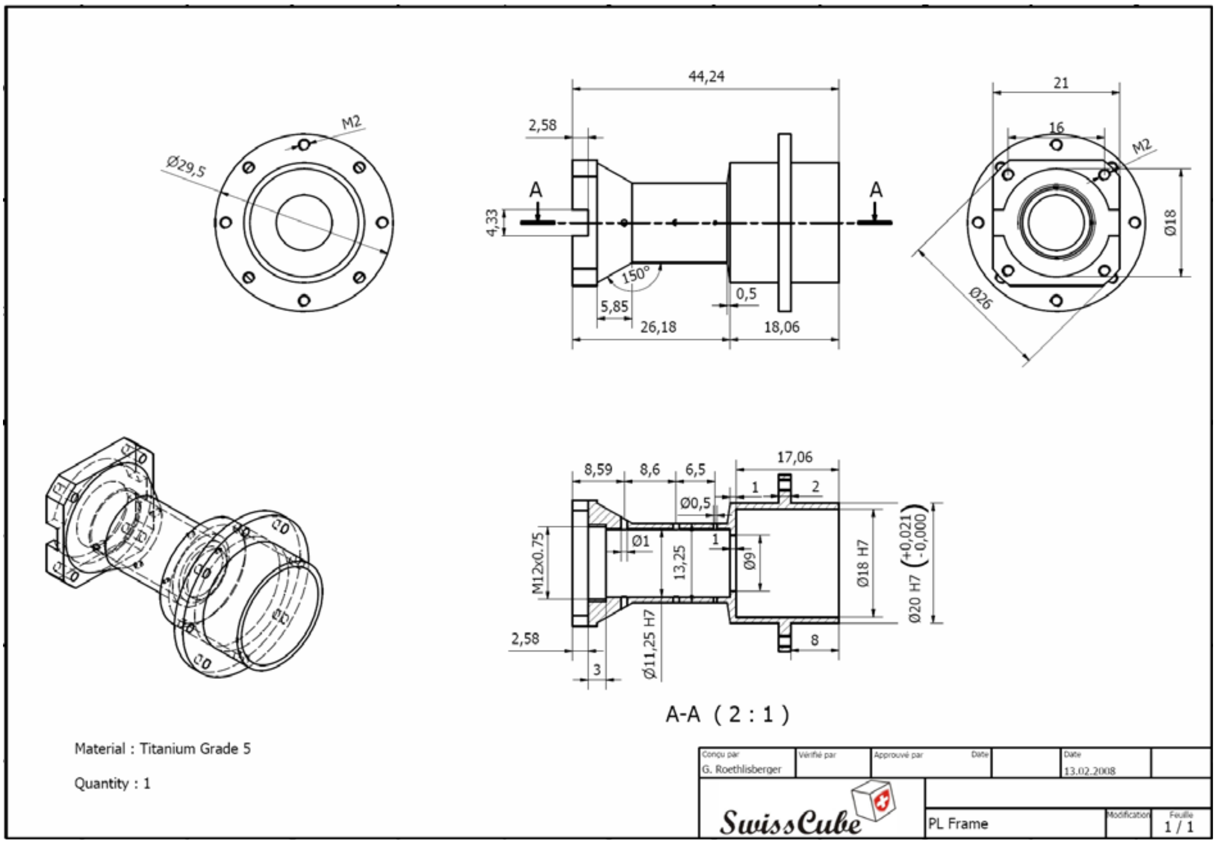


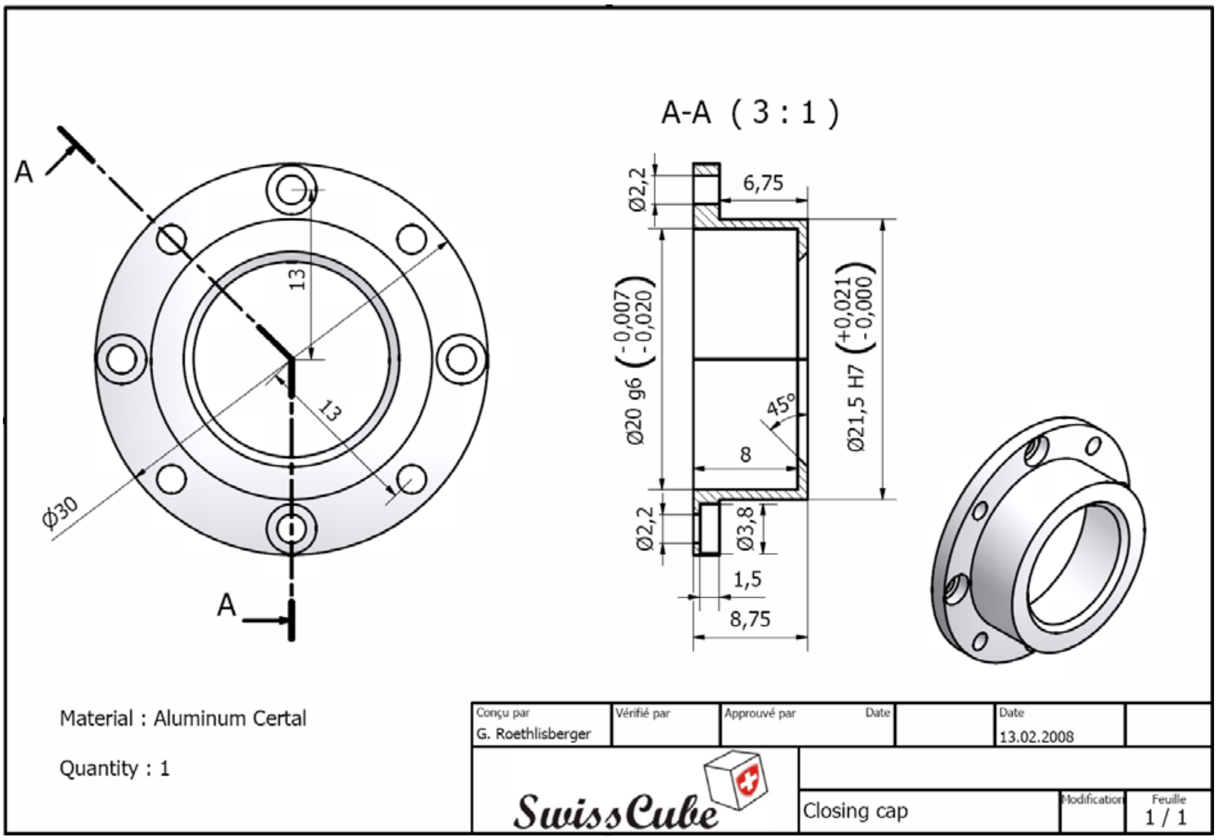


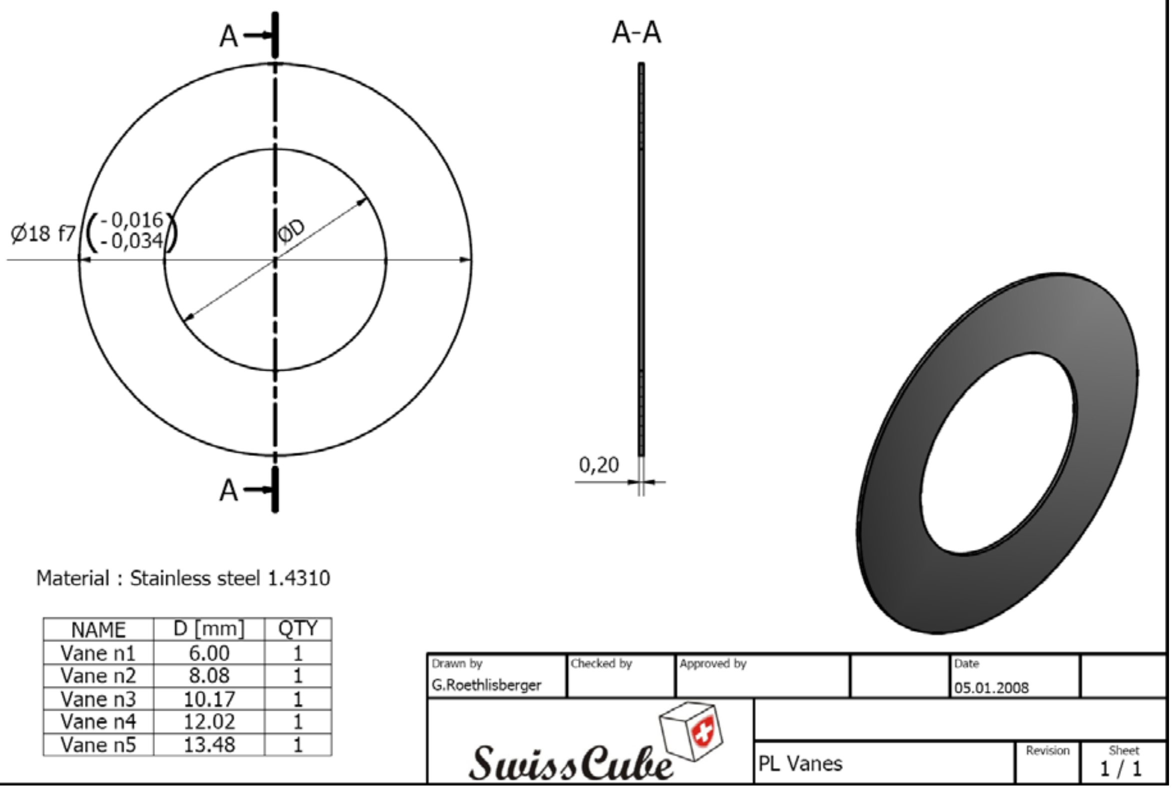
Appendix F Payload mechanical parts



PART NB	QTY	NAME
1	1	PL frame
2	1	Closing cap_v2
3	1	Vane n1
4	1	Spacer Vane1-2
5	1	Vane n2
6	1	Spacer Vane2-3
7	1	Vane n3
8	1	Spacer Vane3-4
9	1	Vane n4
10	1	Spacer Vane4-5
11	1	Vane n5
12	1	Filter
13	1	Spacer Filter-Lens1
14	1	lens n1
15	1	Spacer Lens1-2
16	1	lens n2
17	1	Spacer Lens2-3
18	1	lens n3
19	1	Spacer Lens3-End
20	1	CMOS detector
21	8	screw M2x5_lowhead

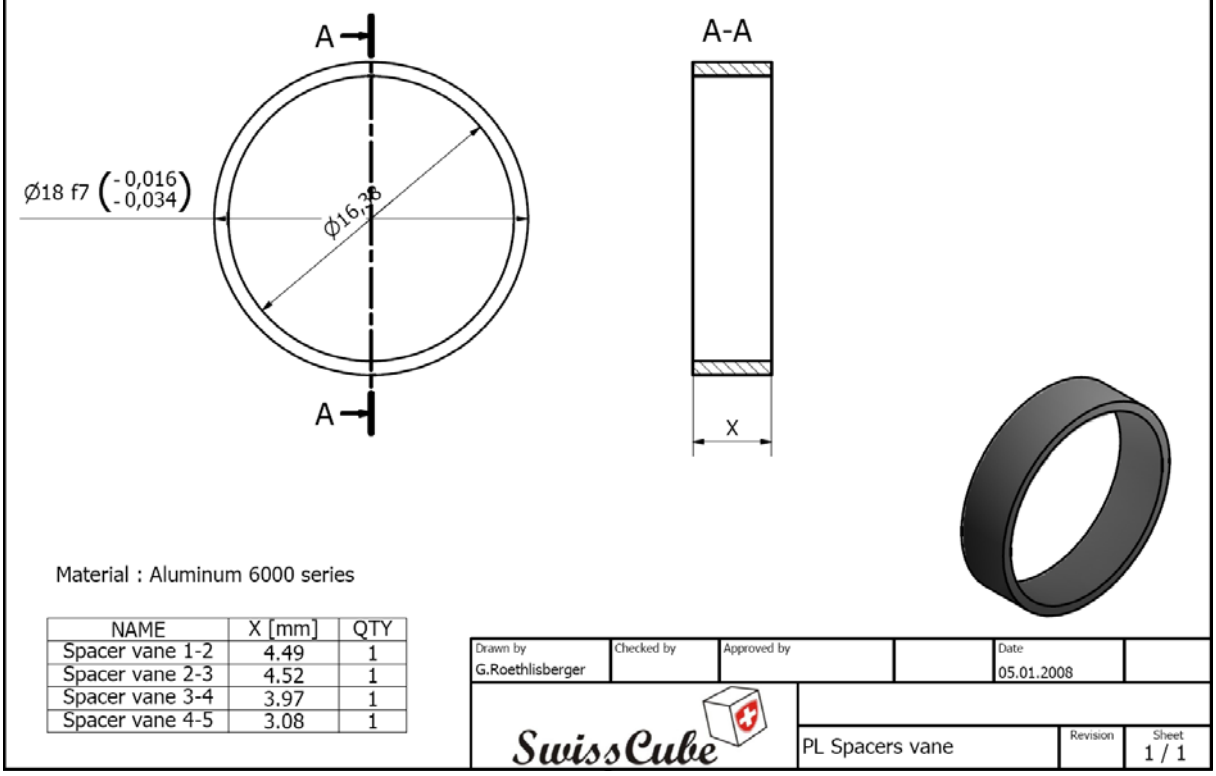

Ø29,5
M2
44,24
2,58
A
A
4,33
150°
5,85
26,18
0,5
18,06
21
16
M2
Ø18
Ø26
8,59
8,6
6,5
17,06
1
2
Ø0,5
Ø1
1
M12x0.75
13,25
Ø9
Ø18 H7
Ø20 H7 (+0,021 / -0,000)
2,58
3
Ø11,25 H7
8
A-A (2 : 1)
Material : Titanium Grade 5
Quantity : 1
Conçu par
G. Roethlisberger
Vérifié par
Approuvé par
Date
Date
13.02.2008
SwissCube
PL Frame
Modification
Feuille
1 / 1


A-A (3 : 1)
A
13
13
Ø30
A
Ø2,2
6,75
Ø20 g6 (-0,007 / -0,020)
Ø21,5 H7 (+0,021 / -0,000)
45°
8
Ø2,2
Ø3,8
1,5
8,75
Material : Aluminum Certal
Quantity : 1
Conçu par
G. Roethlisberger
Vérifié par
Approuvé par
Date
Date
13.02.2008
SwissCube
Closing cap
Modification
Feuille
1 / 1



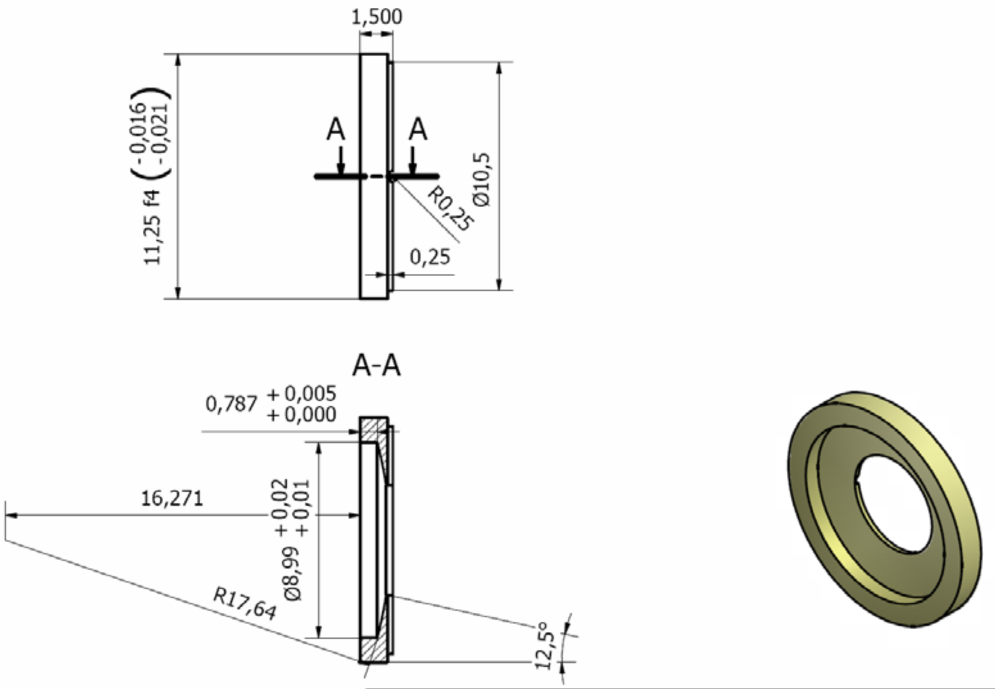
Material : Stainless steel 1.4310

NAME	D [mm]	QTY
Vane n1	6.00	1
Vane n2	8.08	1
Vane n3	10.17	1
Vane n4	12.02	1
Vane n5	13.48	1



Material : Aluminum 6000 series

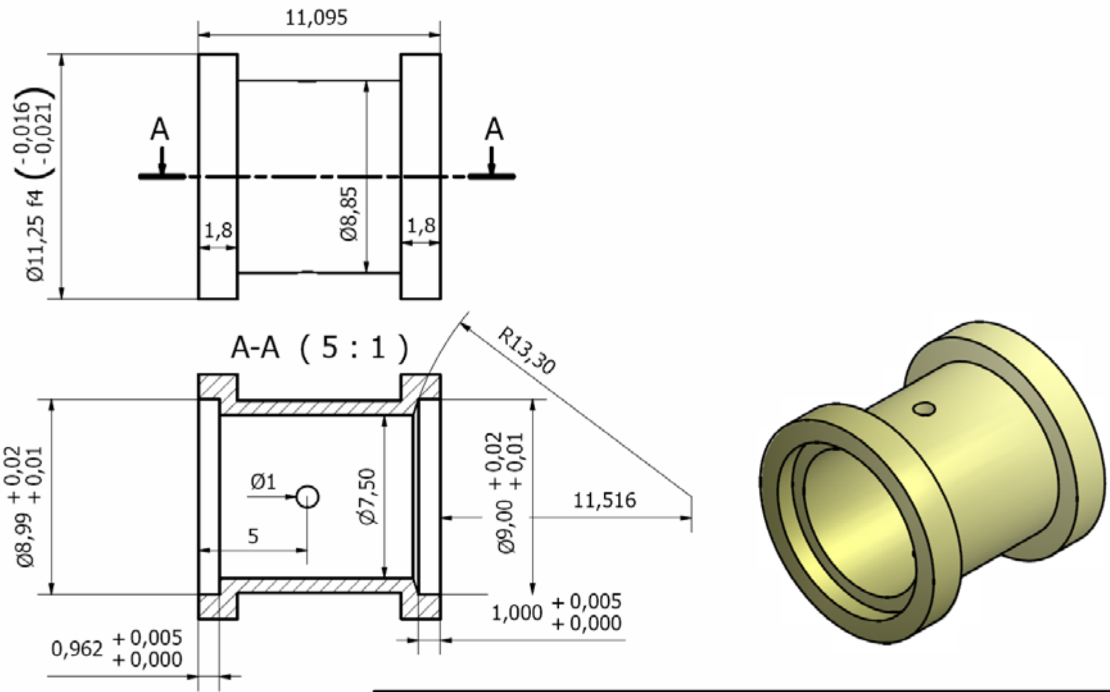
NAME	X [mm]	QTY
Spacer vane 1-2	4.49	1
Spacer vane 2-3	4.52	1
Spacer vane 3-4	3.97	1
Spacer vane 4-5	3.08	1



Material : Titanium Grade 5

Quantity : 1

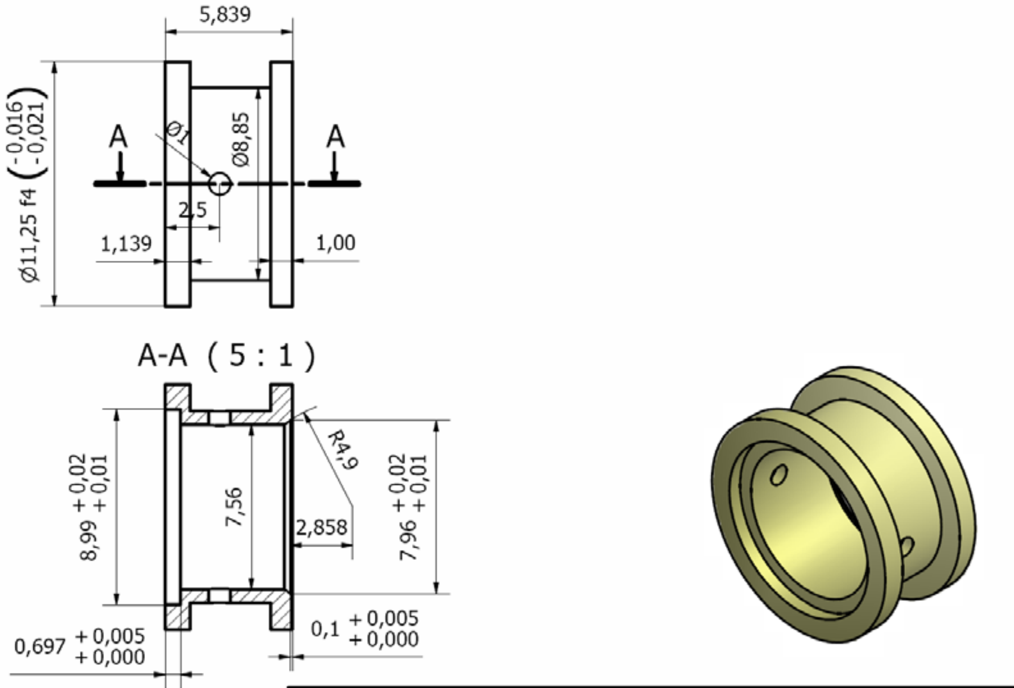
Conçu par	Vérifié par	Approuvé par	Date		Date	
G. Roethlisberger					13.02.2008	
SwissCube		Spacer Filter-Lens1			Modification	Feuille 1 / 1



Material : Titanium Grade 5

Quantity : 1

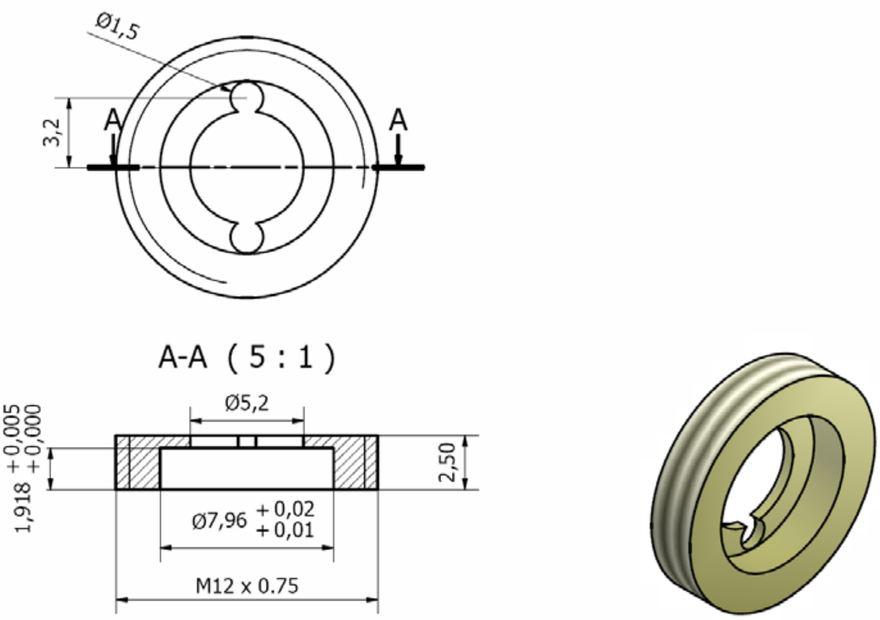
Conçu par	Vérifié par	Approuvé par	Date		Date	
G. Roethlisberger					13.02.2008	
SwissCube		Spacer Lens1-2			Modification	Feuille 1 / 1



Material : Titanium Grade 5

Quantity : 1

Conçu par	Vérifié par	Approuvé par	Date	Date	
G. Roethlisberger				13.02.2008	
SwissCube	Spacer Lens2-3			Modification	Feuille 1 / 1

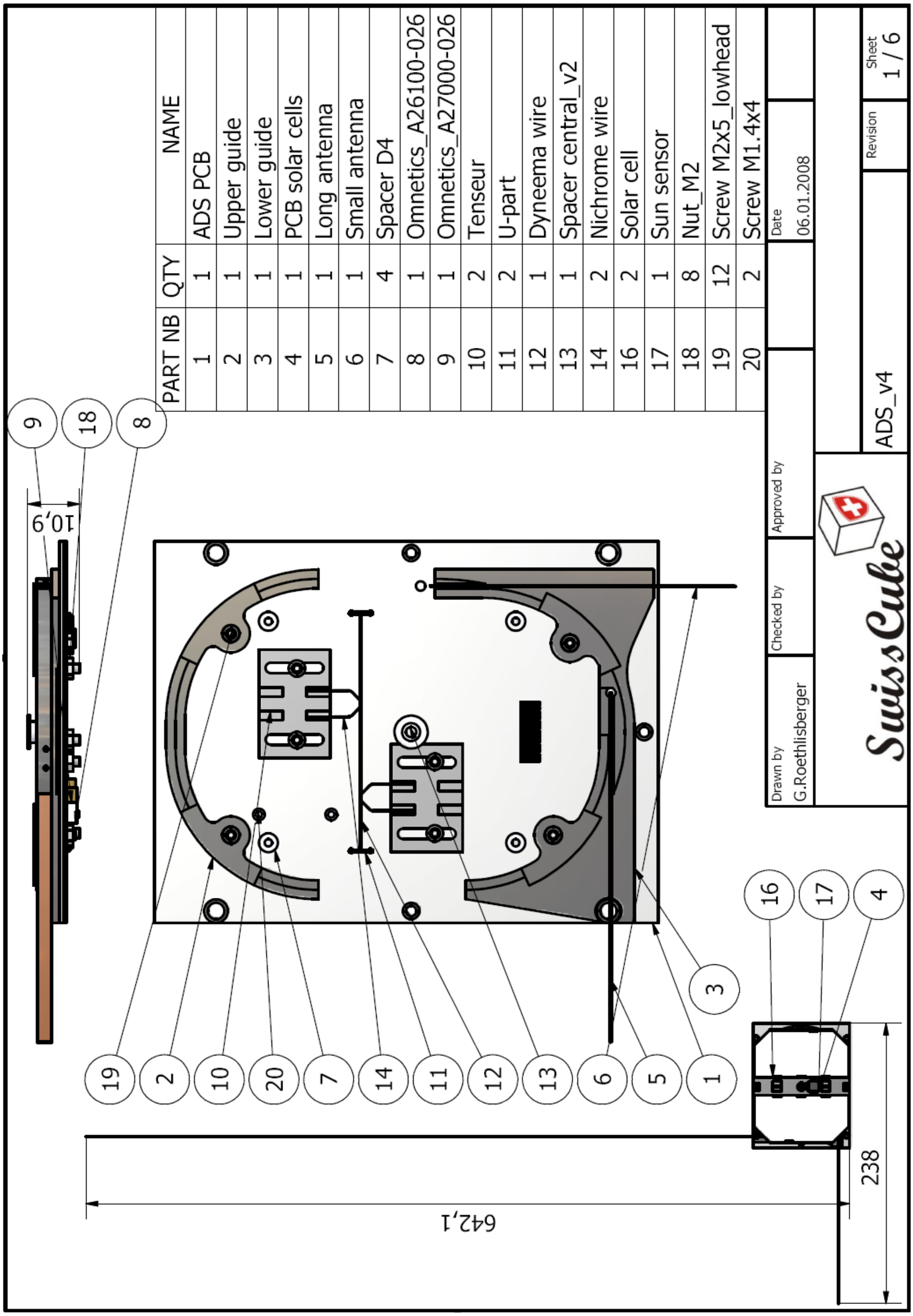


Material : Titanium Grade 5

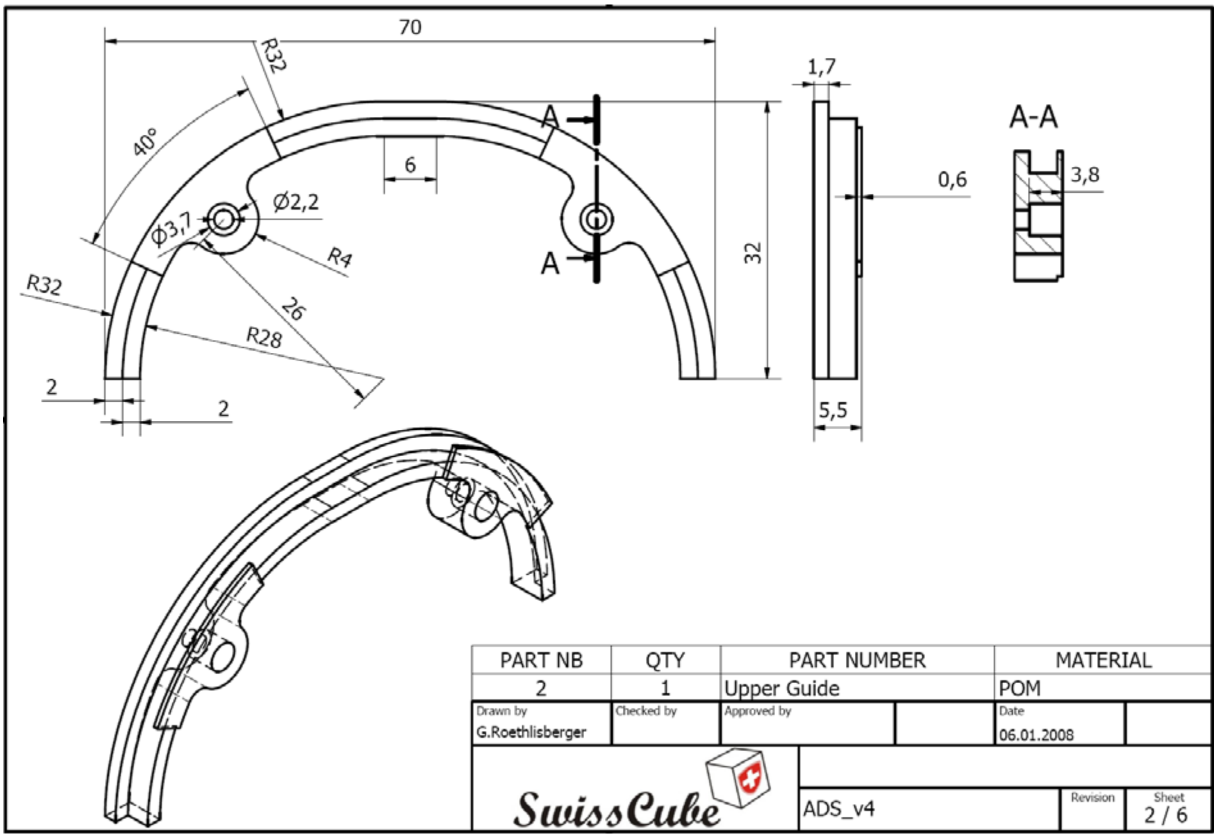
Quantity : 1

Conçu par	Vérifié par	Approuvé par	Date	Date	
G. Roethlisberger				13.02.2008	
SwissCube	Spacer Lens3-End			Modification	Feuille 1 / 1

Appendix G Antenna deployment system drawings



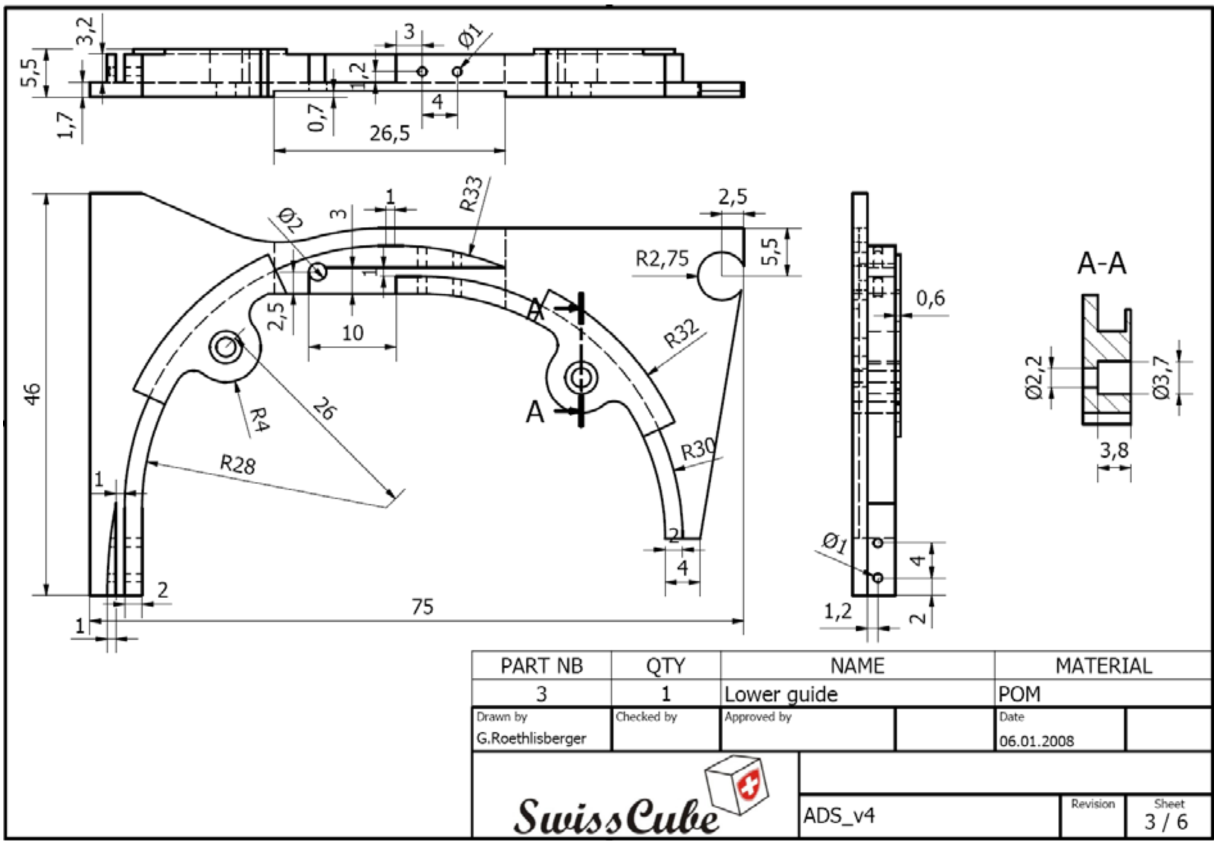
PART NB	QTY	NAME
1	1	ADS PCB
2	1	Upper guide
3	1	Lower guide
4	1	PCB solar cells
5	1	Long antenna
6	1	Small antenna
7	4	Spacer D4
8	1	Omnetics_A26100-026
9	1	Omnetics_A27000-026
10	2	Tenseur
11	2	U-part
12	1	Dyneema wire
13	1	Spacer central_v2
14	2	Nichrome wire
16	2	Solar cell
17	1	Sun sensor
18	8	Nut_M2
19	12	Screw M2x5_lowhead
20	2	Screw M1.4x4



PART NB	QTY	PART NUMBER	MATERIAL
2	1	Upper Guide	POM

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				06.01.2008	

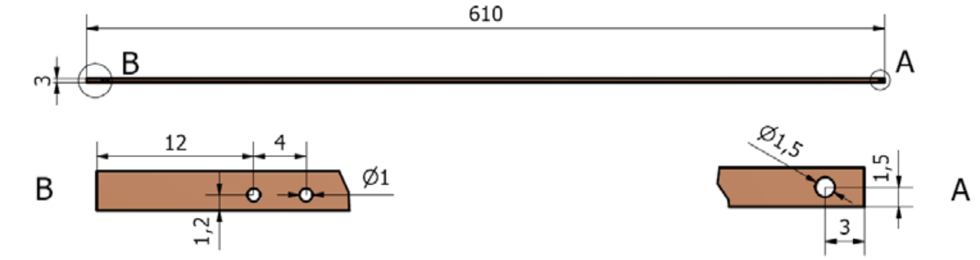
		Revision	Sheet
SwissCube	ADS_v4		2 / 6

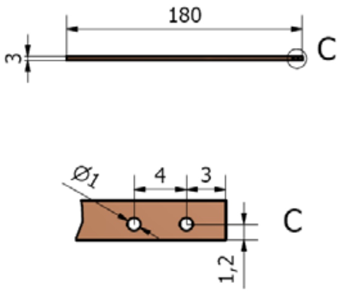


PART NB	QTY	NAME	MATERIAL
3	1	Lower guide	POM

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				06.01.2008	

		Revision	Sheet
SwissCube	ADS_v4		3 / 6



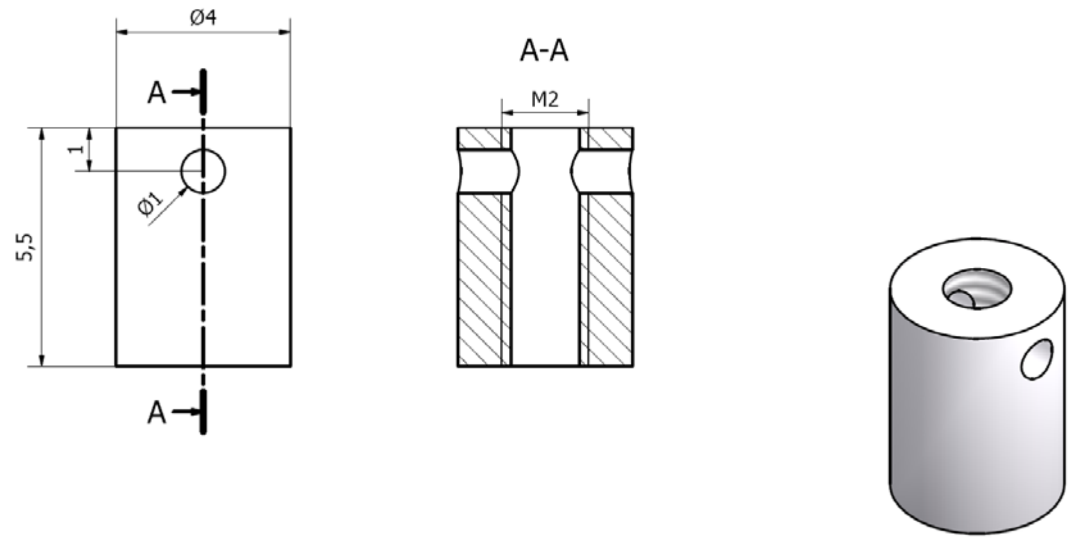


Thickness of the antennas : 0.3 mm

PART NB	QTY	NAME	MATERIAL
5	1	Long antenna	Copper-Beryllium
6	1	Small antenna	Copper-Beryllium

Drawn by	Checked by	Approved by	Date
G.Roethlisberger			06.01.2008

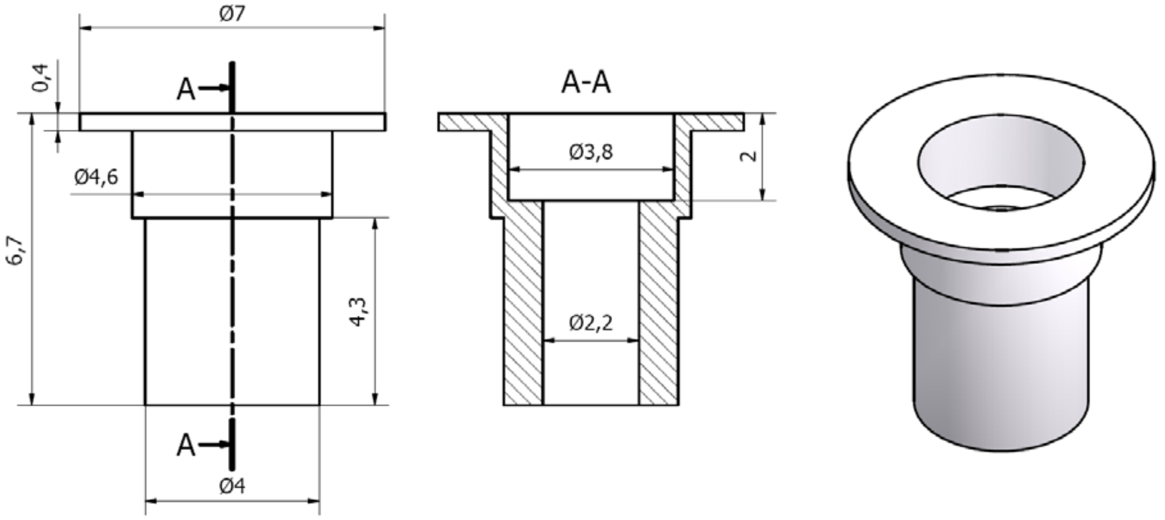
		Revision	Sheet
SwissCube	ADS_v4		4 / 6



PART NB	QTY	NAME	MATERIAL
7	4	Spacer D4	Aluminum Certal

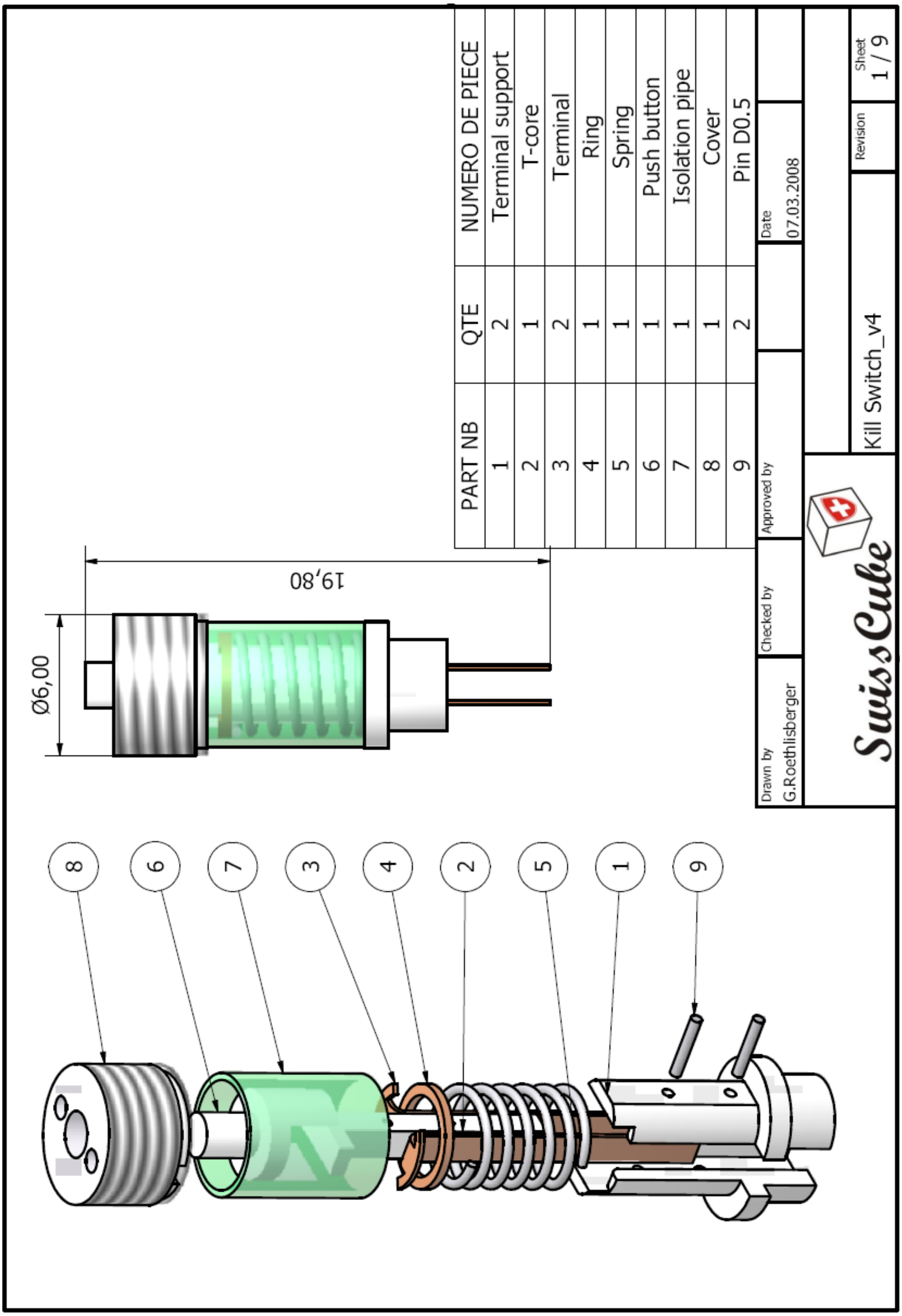
Drawn by	Checked by	Approved by	Date
G.Roethlisberger			06.01.2008

		Revision	Sheet
SwissCube	ADS_v4		5 / 6

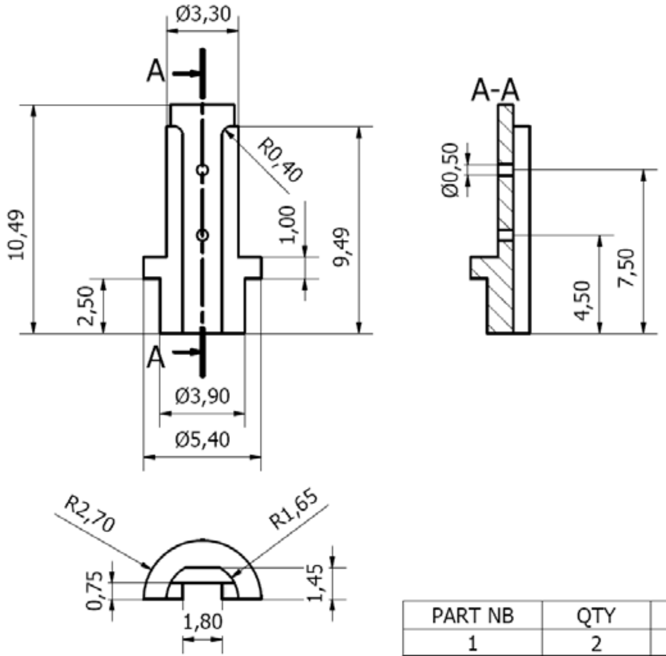


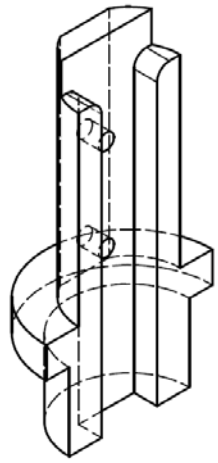
PART NB	QTY	NAME	MATERIAL
13	1	Spacer central_v2	Aluminum Certal
Drawn by G.Roethlisberger	Checked by	Approved by	Date 06.01.2008
SwissCube	ADS_v4	Revision	Sheet 6 / 6

Appendix H Kill-switch drawings

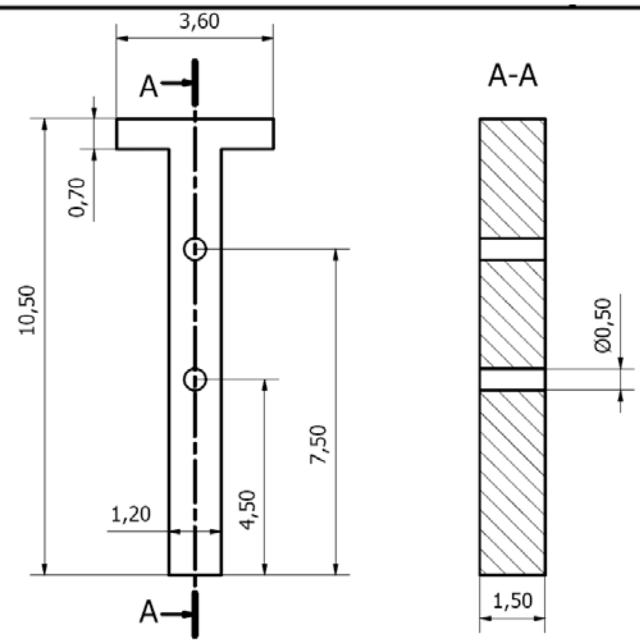


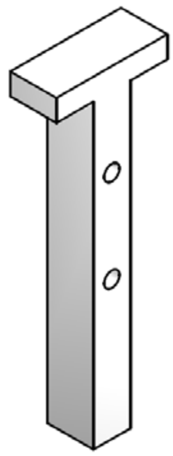
PART NB	QTE	NUMERO DE PIECE
1	2	Terminal support
2	1	T-core
3	2	Terminal
4	1	Ring
5	1	Spring
6	1	Push button
7	1	Isolation pipe
8	1	Cover
9	2	Pin D0.5



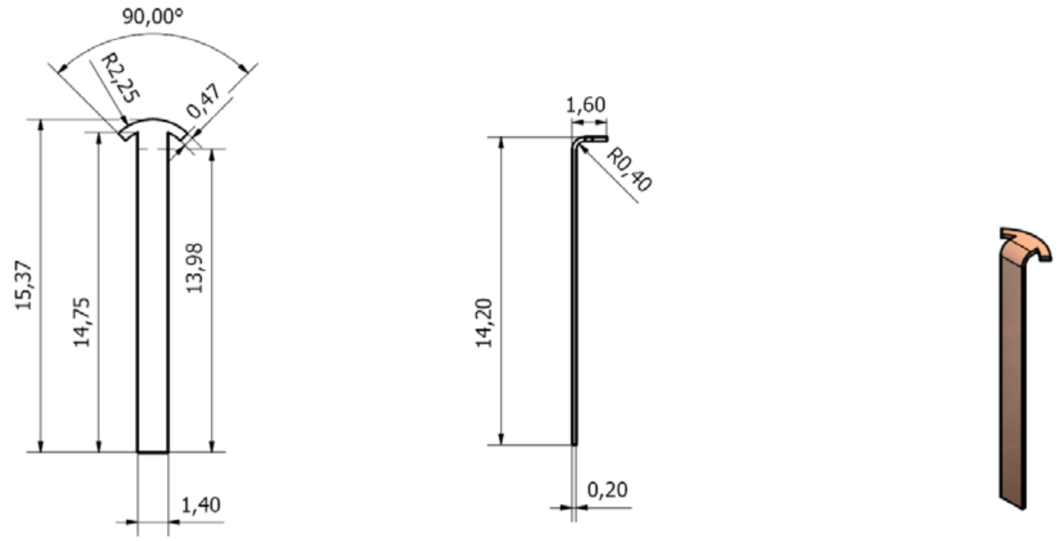


PART NB	QTY	NAME			MATERIAL
1	2	Terminal support			POM
Drawn by G.Roethlisberger	Checked by	Approved by		Date 07.03.2008	
SwissCube		Kill Switch_v4		Revision	Sheet 2 / 9

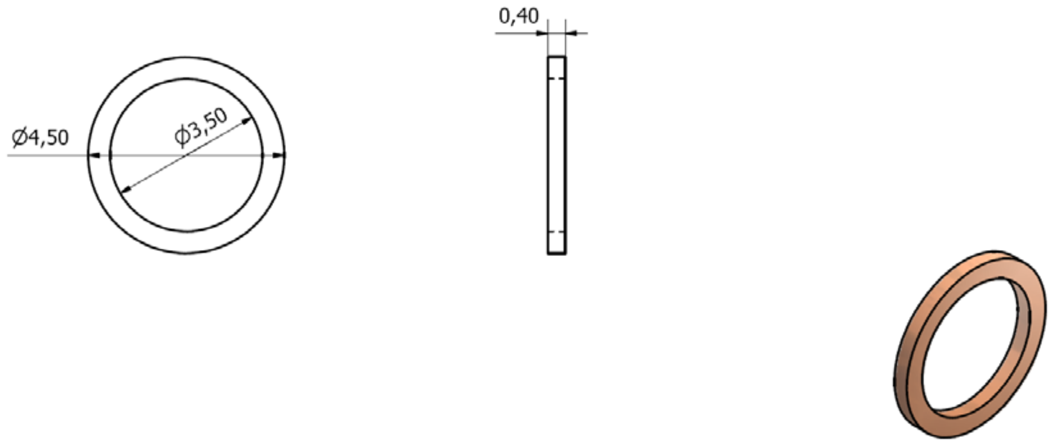




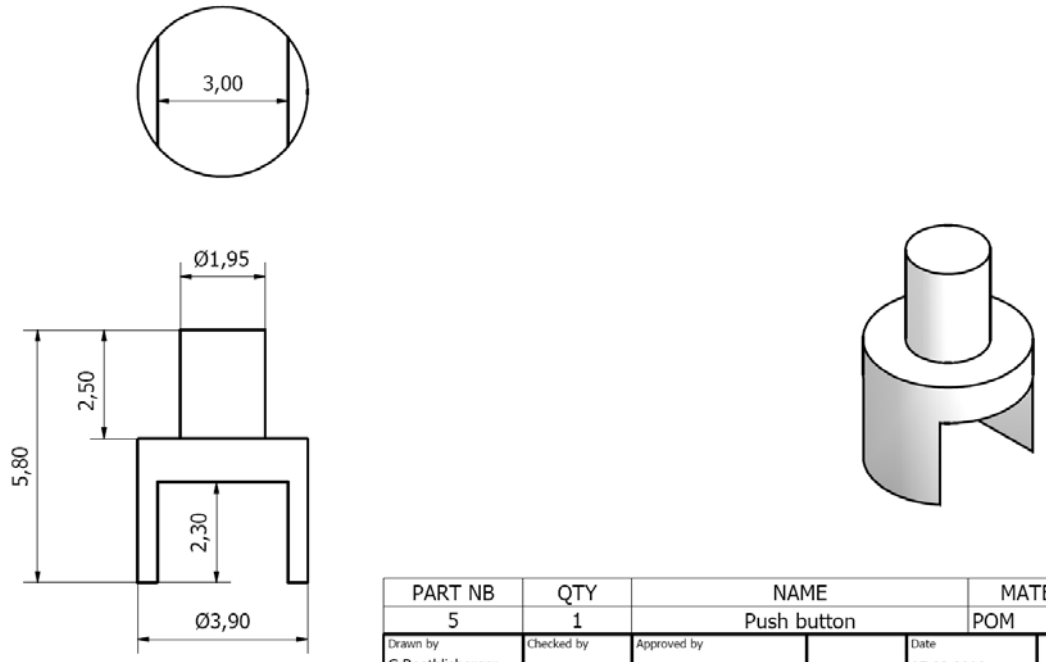
PART NB	QTY	NAME			MATERIAL
2	1	T-core			POM
Drawn by G.Roethlisberger	Checked by	Approved by		Date 07.03.2008	
SwissCube		Kill Switch_v4		Revision	Sheet 3 / 9



PART NB	QTY	NAME	MATERIAL
3	2	Terminal	COPPER-BERYLLIUM
Drawn by G.Roethlisberger	Checked by	Approved by	Date 07.03.2008
SwissCube	Kill Switch_v4	Revision	Sheet 4 / 9



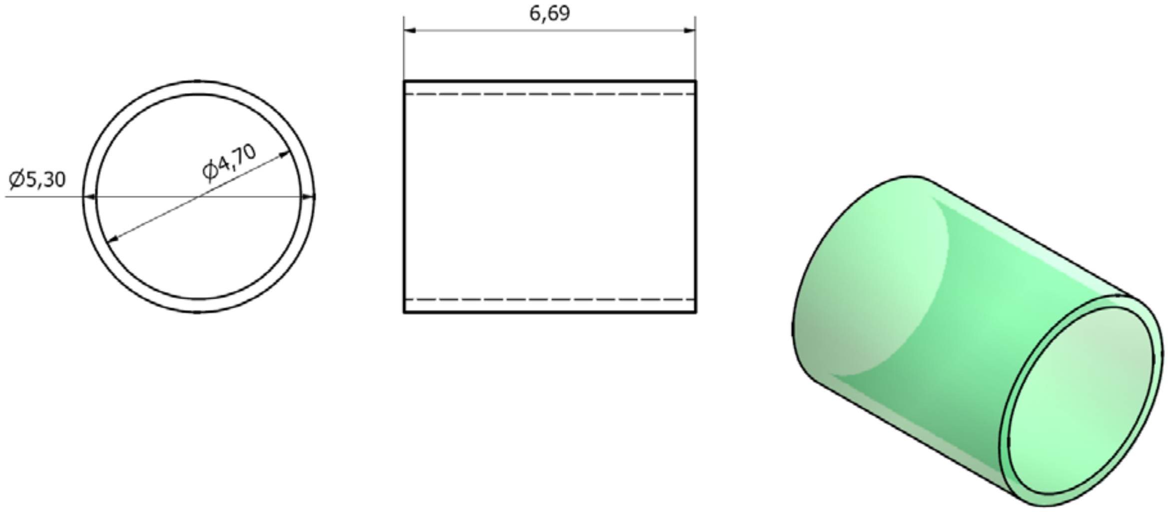
PART NB	QTY	NAME	MATERIAL
4	1	Ring	COPPER-BERYLLIUM
Drawn by G.Roethlisberger	Checked by	Approved by	Date 07.03.2008
SwissCube	Kill Switch_v4	Revision	Sheet 5 / 9



PART NB	QTY	NAME	MATERIAL
5	1	Push button	POM

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				07.03.2008	

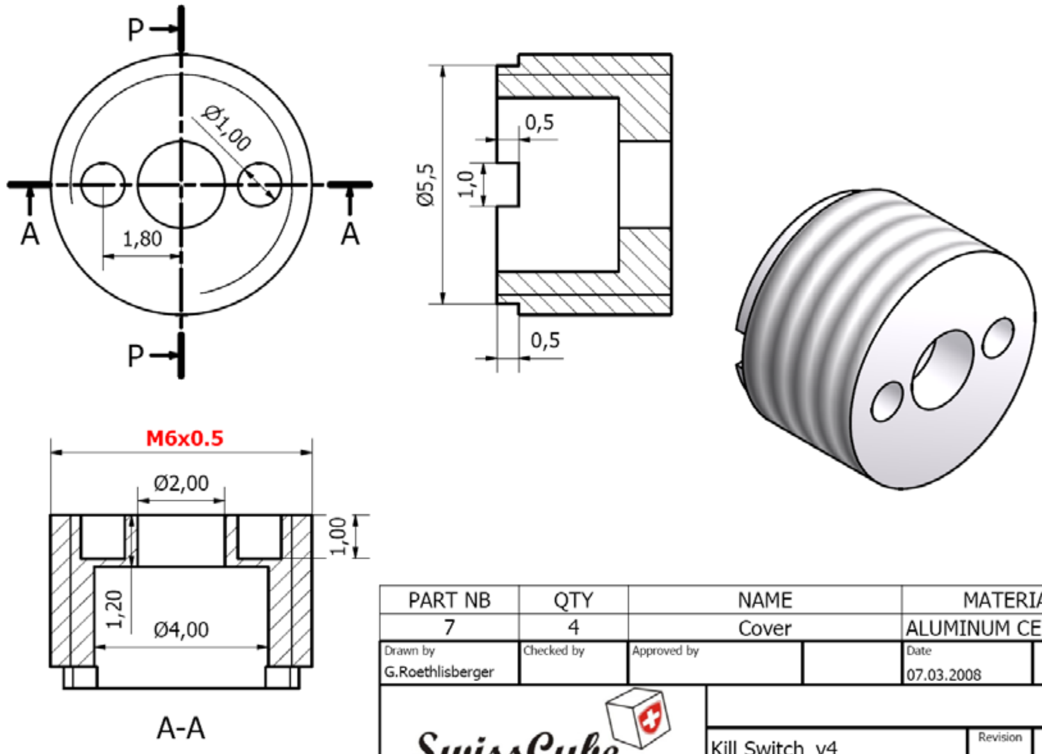
		Revision	Sheet
SwissCube	Kill Switch_v4		6 / 9



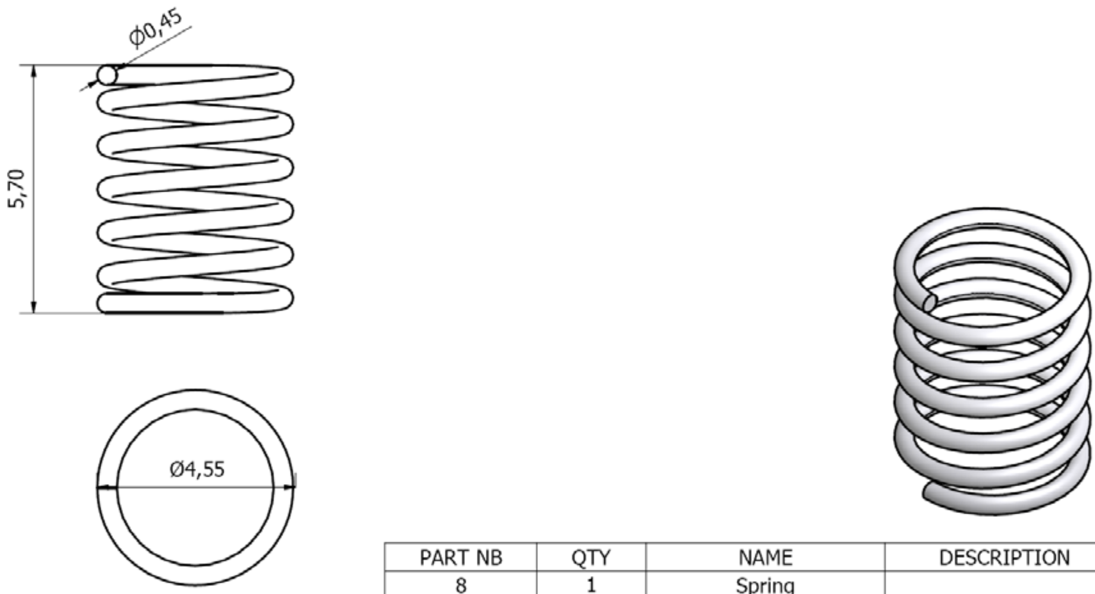
PART NB	QTY	NAME	MATERIAL
6	1	Isolation pipe	POM

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				07.03.2008	

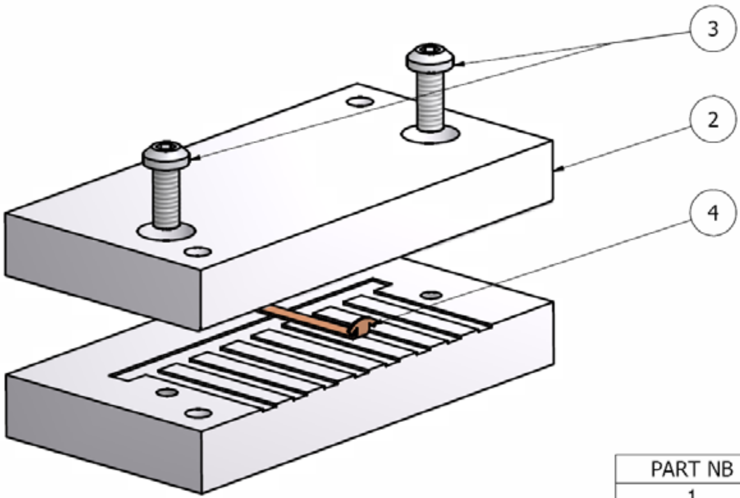
		Revision	Sheet
SwissCube	Kill Switch_v4		7 / 9



PART NB	QTY	NAME	MATERIAL
7	4	Cover	ALUMINUM CERTAL
Drawn by G.Roethlisberger	Checked by	Approved by	Date 07.03.2008
SwissCube	Kill Switch_v4	Revision	Sheet 8 / 9



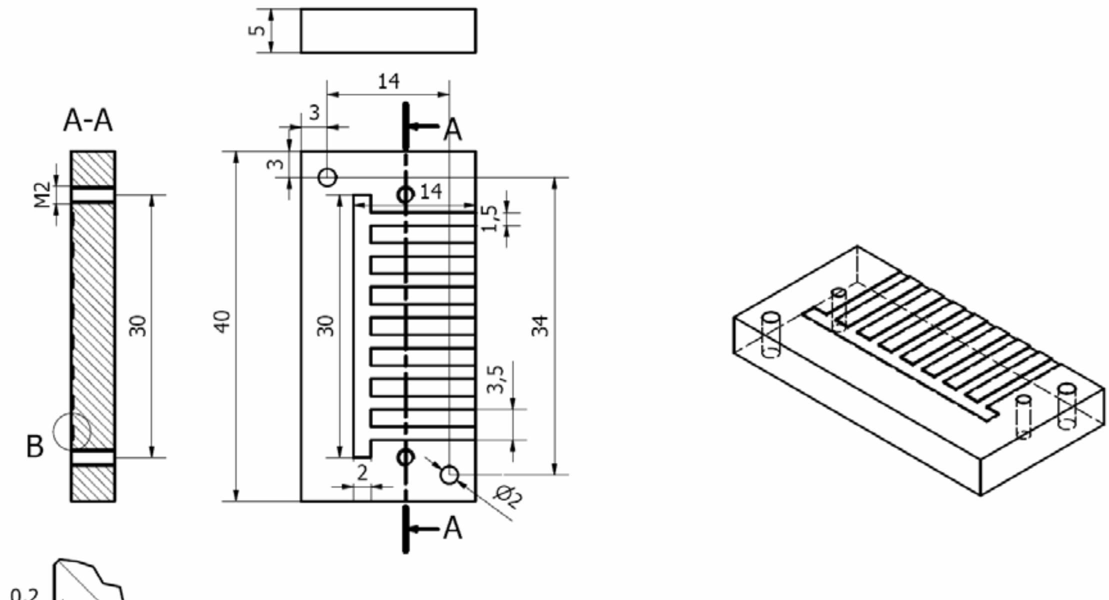
PART NB	QTY	NAME	DESCRIPTION
8	1	Spring	
Drawn by G.Roethlisberger	Checked by	Approved by	Date 07.03.2008
SwissCube	Kill Switch_v4	Revision	Sheet 9 / 9

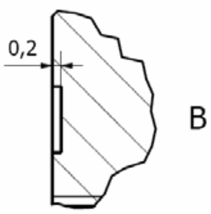


PART NB	QTY	NAME
1	1	fold part_1
2	1	fold part_2
3	2	screw M2x5_lowhead
4	1	Terminal

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				12.02.2008	

SwissCube — Fold assembly — Revision — Sheet 1 / 3

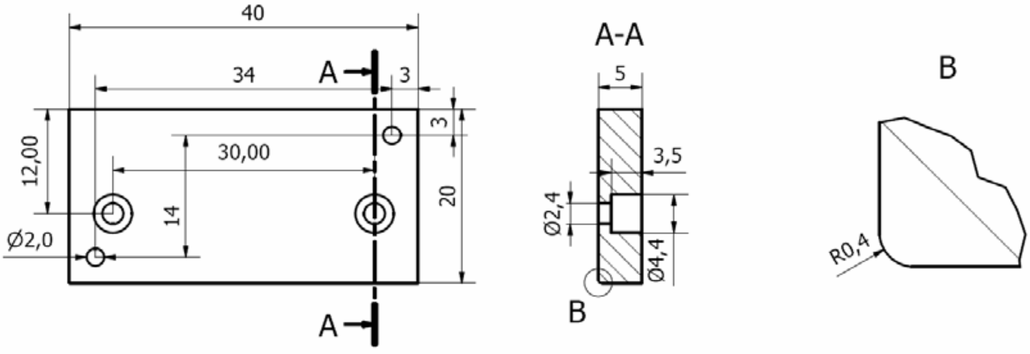




PART NB	QTY	NAME	DESCRIPTION
1	1	fold part_1	Aluminum

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				12.02.2008	

SwissCube — Fold assembly — Revision — Sheet 2 / 3

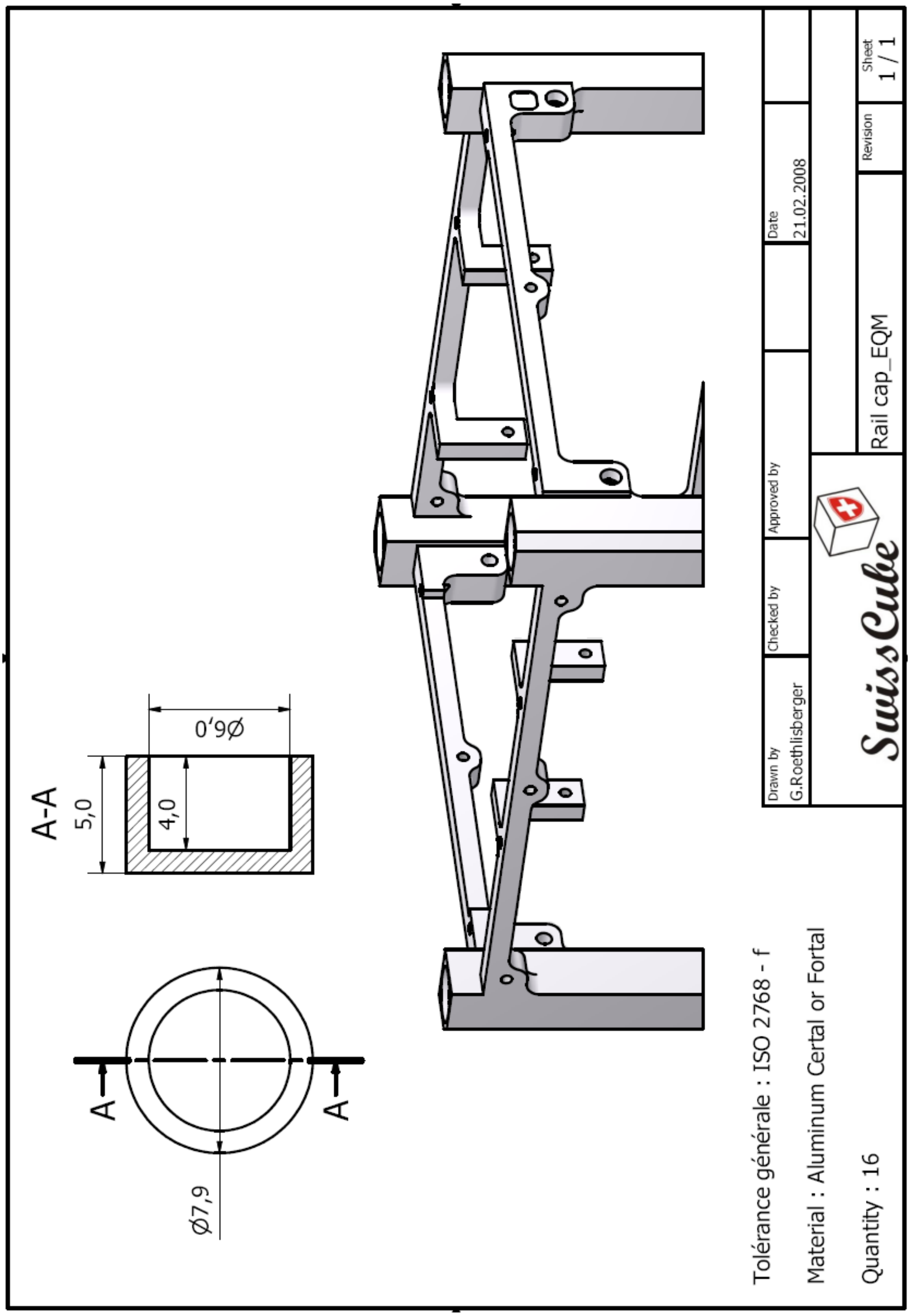


PART NB	QTY	NAME	MATERIAL
2	1	fold part_2	Aluminum

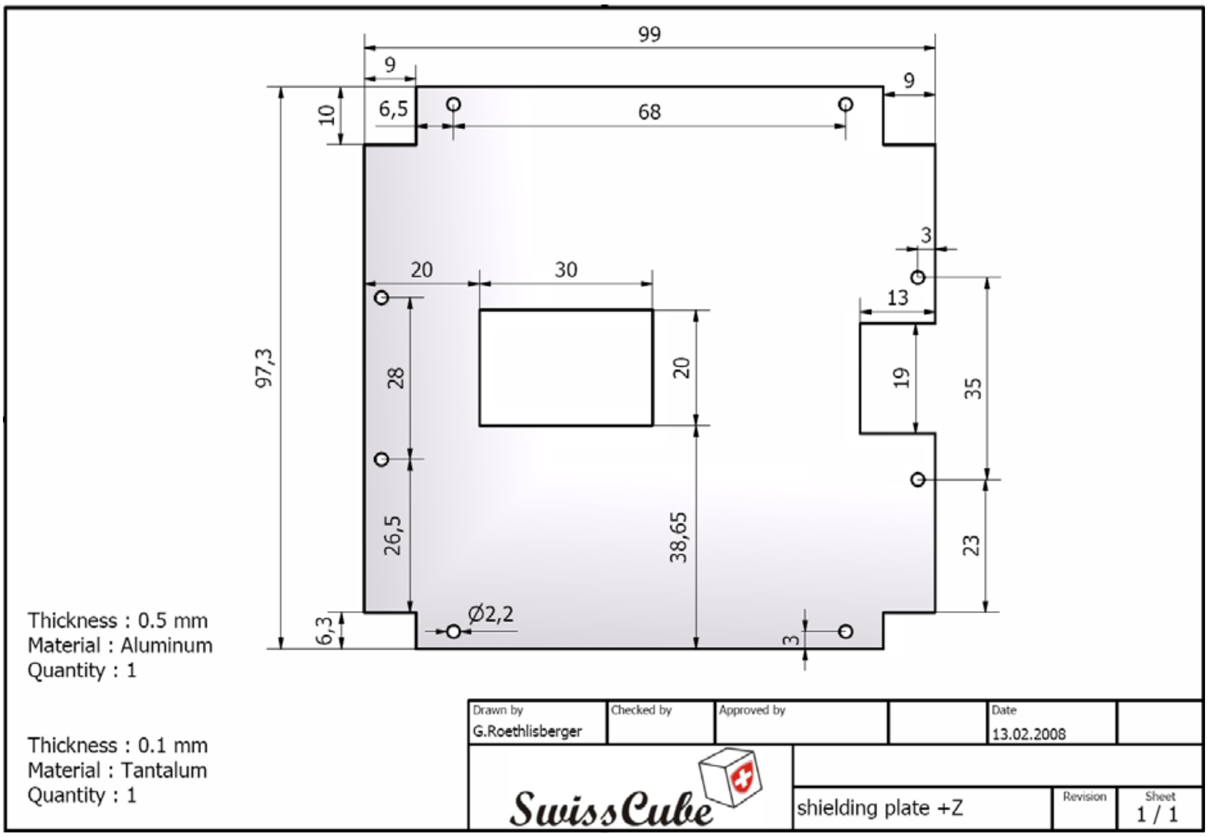
Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				12.02.2008	

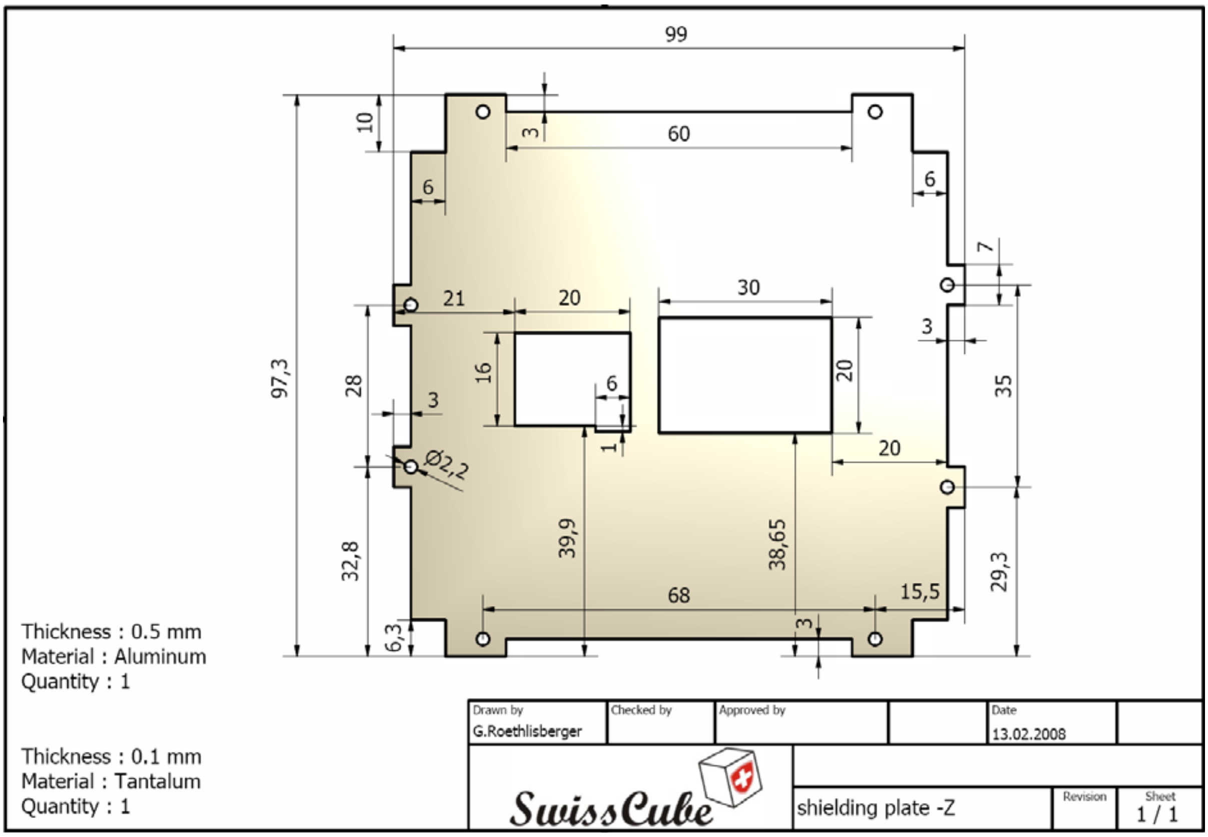
		Revision	Sheet
SwissCube	Fold assembly		3 / 3

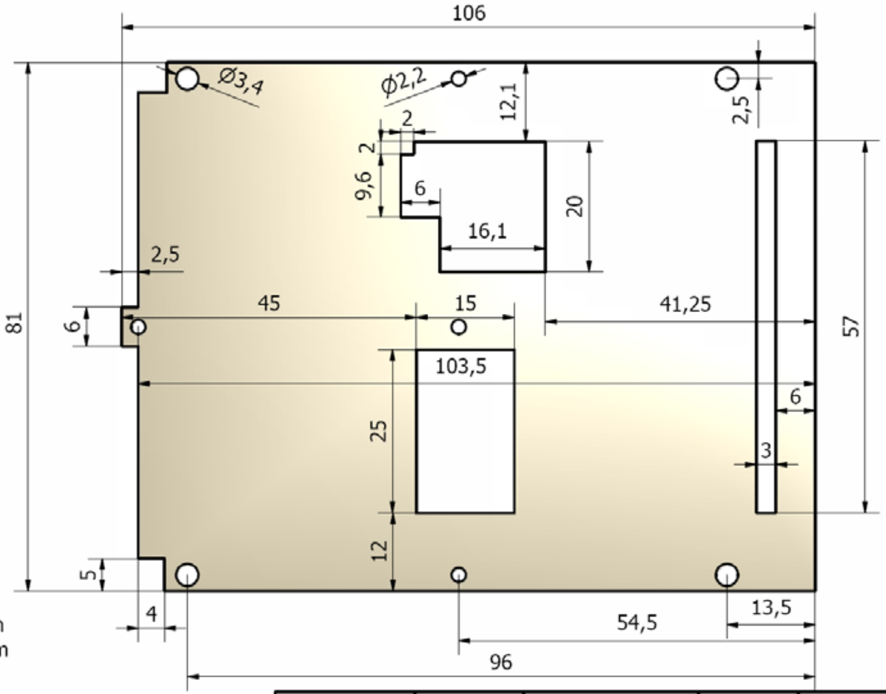
Appendix I Rail cap drawings



Appendix J Shielding plates drawings



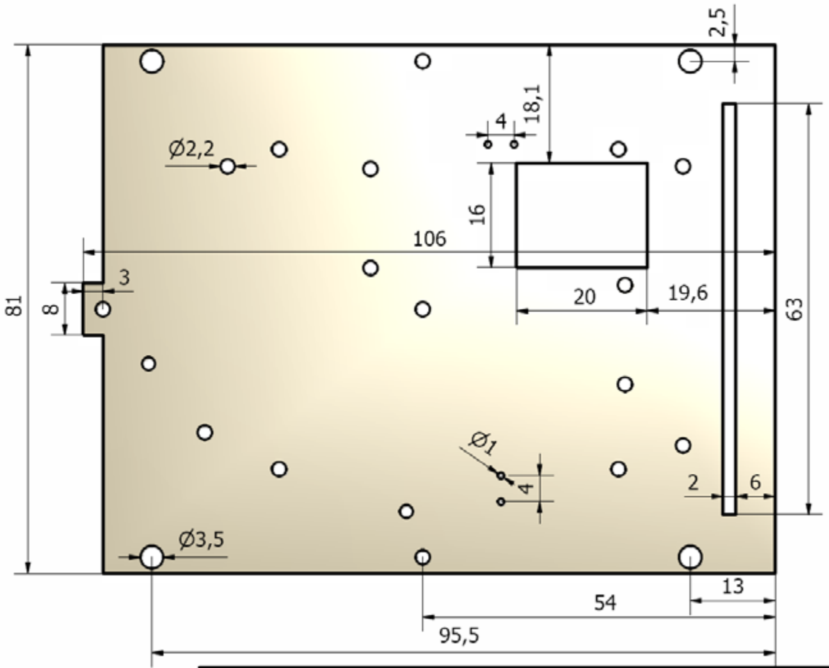




Thickness : 0.5 mm
Material : Aluminum
Quantity : 1

Thickness : 0.1 mm
Material : Tantalum
Quantity : 1

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				13.02.2008	
SwissCube	shielding plate +Y			Revision	Sheet 1 / 1

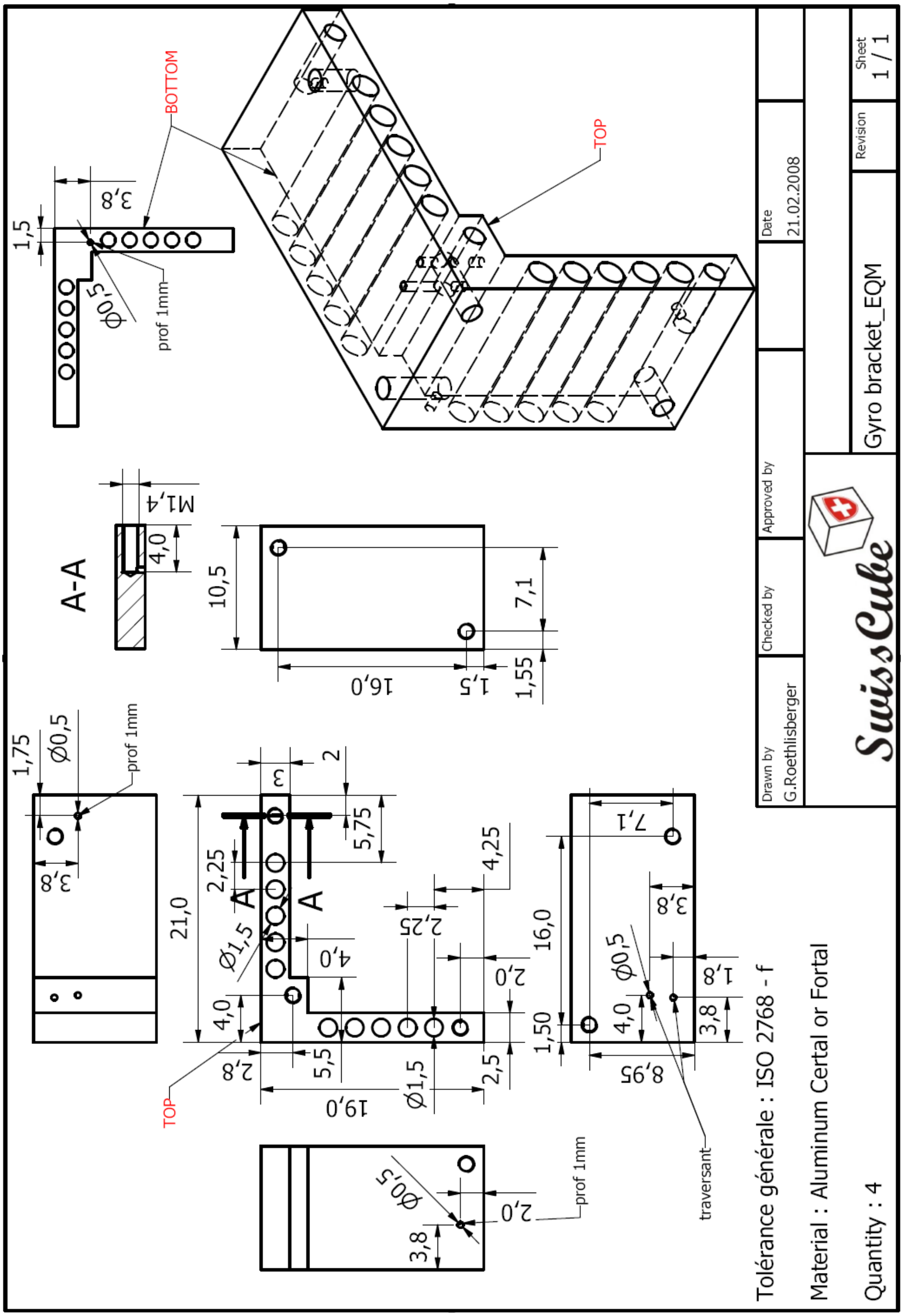


Thickness : 0.5 mm
Material : Aluminum
Quantity : 1

Thickness : 0.1 mm
Material : Tantalum
Quantity : 1

Drawn by	Checked by	Approved by		Date	
G.Roethlisberger				13.02.2008	
SwissCube	shielding plate -Y			Revision	Sheet 1 / 1

Appendix K Gyro bracket



Appendix L Certal

Technical Datasheet

CERTAL®

EN AW-7022 / AlZn5Mg3Cu

Edition September 2001

ALCAN ROLLED PRODUCTS

Alcan Aluminium Valais Ltd t +41 27 457 51 11
CH-3960 Sierre, Switzerland f +41 27 457 65 15

BRIEF DESCRIPTION

Certal® thick plates have been optimised to provide excellent **machinability, shape stability** and **high strength.** Certal® is therefore ideal for industrial tools. Applications include injection and blow-moulds for plastic bottles, plastic containers and shoes as well as heating plates, mechanical guides, tooling supports, jigs and fixtures.

PROCESSING METHODS

Weldability

• TIG/MIG	possible
filler alloy	AA 5183
	AA 5356
• by resistance	good

Surface Treatments

Anodizing

• technical	good
• decorative	not adequate
Polishing	excellent
Hard Chroming	good
Chemical Nickel-Plating	good
Chemical texturing	well adapted
Machinability	excellent

AVAILABILITY

Certal® plates are delivered in temper T651 (quenched – stretched – artificially aged) in the following dimensions :

Thickness	Max. width
8.0 - 70 mm	2020 mm
71 - 90 mm	1820 mm
91- 120 mm	1520 mm
121- 140 mm	1020 mm

For thicknesses above 140 mm, the alloy Certal® SPC is recommended.

CHEMICAL COMPOSITION (weight %)

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti +Zr
max. 0.5	max. 0.5	0.5 1.0	0.1 0.40	2.6 3.7	0.1 0.3	4.3 5.2	max. 0.2

PHYSICAL PROPERTIES (nominal values)

Density	2.76 g/cm^3
Elastic Modulus	72000 MPa
Lin. thermal expansion coefficient (20°-100°C)	23.6 10^{-6} K^{-1}
Thermal conductivity (Temper T651)	120 - 150 W/mK
Electrical conductivity (Temper T651, 20°C)	18 - 22 MS/m

MECHANICAL STRENGTH

Min. tensile properties (Temper T651)1)

Thickness (over ... to)	Rm [MPa]	Rp0.2 [MPa]	A50 [%]
12.5 - 25 mm	540	460	8
25 - 50 mm	530	460	7
50 - 100 mm	500	420	6
100 - 140 mm	490	400	6

1) These guaranteed values are much higher than EN AW-7022 T651 values

Typical strength for various thicknesses

Thickness (over ... to)	Rm [MPa]	Rp0.2 [MPa]	A50 [%]	HB
8.0 - 25 mm	555	495	9	170
25 - 100 mm	550	495	8	165
100 - 140 mm	545	490	7	165

Appendix M Titanium Grade 5

TITAN Grade 5 (6Al-4V) W-Nr. 3.7165

Die Legierung Ti-6Al-4V ist die am meisten verwendete der Alpha-Beta Gruppe und ist die bekannteste aller Titanlegierungen. Bearbeitetes Material wird in der Luftfahrtindustrie, Medizin und anderen Anwendungen eingesetzt, bei denen eine gute Festigkeit im Verhältnis zum Gewicht, sowie gute korrosionsbeständige Eigenschaften gefordert werden. Weiter ist sie giesbar und findet vermehrt Anwendungen auch bei Sportgeräten.

Ti-6Al-4V alloy is the most widely used titanium alloy of the alpha-plus-beta class, and is also the most common of all titanium alloys. The alloy is castable and is utilized "as cast" in sporting goods. The wrought material is used in aerospace, medical, and other applications where moderate strength, good strength to weight, and favorable corrosion properties are required.

Produktformen Product Forms	Blech, Band, Stab, Draht, Gussteile, Schmiedestücke, Ringe und Knüppel	Sheet, Plate, Strip, Bar, Rod, Wire, Castings, Forgings, Rings and Billet
Normen und Bezeichnungen Major Specifications	UNS R56400 W-Nr.: 3.7165 ASTM B 265 / AMS 4911 (Blech, Band), ASTM B 348 / AMS 4928 (Stab) MIL-T-9046	UNS R56400 W-Nr.: 3.7165 ASTM B 265 / AMS 4911 (plate, sheet, strip), ASTM B 348 / AMS 4928 (bar) MIL-T-9046
Chem. Zusammensetzung Chemical Composition, %	**Grenzwerte** Ti .... Rest; O .... 0.20; V .... 3.5/4.5 Fe .... 0.40; AL ... 5.50 - 6.75; H ... max. 0.015 N .... 0.05; C 0.08	**Limiting** Ti .... Remainder; O .... 0.20; V .... 3.5/4.5 Fe .... 0.40; AL ... 5.50 - 6.75; H ... max. 0.015 N .... 0.05; C 0.08
Physikalische und thermische Eigenschaften Physical Constants and Thermal Properties	Dichte, lb/in³ .... 0.160 g/cm³ .... 4.43 Schmelzbereich, etwa. °F .... 3000 °C .... 1648 Beta Transus °F +/- 25 .... 1784 °C +/- 4 .... 980 Ausdehnungsbeiwert, 10^{-6} in/in • F: 32 - 212°F .... 5.0; 32 - 1200°F .... 5.9 32 - 600°F .... 5.3; 32 - 1500°F .... 6.1 32 - 1000°F ..... 5.6 um/m • °C: 0 - 100°C .... 9.1; 0 - 649°C .... 10.7 0 - 316°C .... 9.6; 0 - 816°C .... 11.0 0 - 538°C ...... 10.1 Wärmeleitfähigkeit, Btu • in/ft²•h•°F .... 3.9 W/m•°C .... 0.56 Elastizitätsmodul, 10^6 psi .... 16.5 Torsionsmodul, 10^6 psi .... 6.1 Spezifische Wärme, Btu/lb•°F .... 0.135 J/kg•°C .... 565.2 Glühtemperatur ganz °F .. 1300-1525°/15 min., -2 Std., AC °C ...... 704-838°/15 min., -2 Std., AC spannungsarm °F .... 900-1200°/1-4 Std., AC °C .... 495-659°/1-4 Std., AC Schmiedetemperatur Vorschmieden °F .... 1750 - 1800° °C .... 962 - 989° Fertigschmieden °F .... 1650 - 1750° °C .... 812 - 962°	Density, lb/in³ .... 0.160 g/cm³ .... 4.43 Melting Range, approx. °F .... 3000 °C .... 1648 Beta Transus °F +/- 25 .... 1784 °C +/- 4 .... 980 Coefficient of Expansion 10^{-6} in/in • F: 32 - 212°F .... 5.0; 32 - 1200°F ...... 5.9 32 - 600°F .... 5.3; 32 - 1500°F ...... 6.1 32 - 1000°F .... 5.6 um/m • °C: 0 - 100°C .... 9.1; 0 - 649°C .... 10.7 0 - 316°C .... 9.6; 0 - 816°C .... 11.0 0 - 538°C .... 10.1 Thermal Conductivity, Btu • in/ft²•h•°F .... 3.9 W/m•°C .... 0.56 Elasticity-Tension Modulus, 10^6 psi .... 16.5 Elasticity-Torsion Modulus, 10^6 psi .... 6.1 Specific Heat, Btu/lb •°F .... 0.135 J/kg • °C .... (565.2) Annealing Temp full °F ...... 1300-1525°/15 min., -2 hrrs, AC °C .... 704-838°/15 min., -2 hrs, AC stress relief °F .... 900-1200°/1-4 hrs, AC °C .... 495-659°/1-4 hrs, AC Forging Temp Blocking °F .... 1750 - 1800° °C .... 962 - 989° Finishing °F .... 1650- 1750° °C .... 812 - 962°
Typische mechanische Eigenschaften Typical Mechanical Properties	**(Geglüht)** — ksi / MPA Zugfestigkeit, RT .... min. 130 / min. 895 Streckgrenze, RT .... min. 120 / min. 826 Dehnung, % RT .... min. 10 (Bruch) Einschnürung, % Bar 25	**(Annealed)** — ksi / MPA Tensile Strength, RT .... min. 130 / min. 895 Yield Strength, RT .... min. 120 / min. 826 Elongation, % RT .... min. 10 Reduction of Area, % Bar 25

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SUPPORTING YOUR SUCCESS

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E-Mail info@bibusmetals.ch
www.bibusmetals.ch

Appendix N Polyoxyméthylènes (POM)

dynatec et son équipe sont à même de vous trouver des solutions parfaitement adaptées à vos besoins.

	Désignation selon DIN	Méthode ISO (IEC)	UNITÉ	POM H
	Couleurs			blanc / noir
	Poids moléculaire (selon Margolies)		10^6g*mol^{-1}	-
	Densité	1183	g*cm^{-3}	1,43
ABSORPTION	Conditionné dans l'eau à 23° C pendant 24/96 heures (1)	62	mg	18/36
ABSORPTION		62	%	0,21/0,43
ABSORPTION	Climat normal 23° C, 50% d'humidité relative		%	0,20
ABSORPTION	Conditionné dans l'eau à 23°C	-	%	0,85
PROPRIETES THERMIQUES	Température de fusion	-	°C	175
PROPRIETES THERMIQUES	Température de transition vitreuse	-	°C	-
PROPRIETES THERMIQUES	Conductibilité thermique à +23°C	-	W/(m*K)	0,31
PROPRIETES THERMIQUES	**COEFFICIENT DE DILATATION THERMIQUE**			
PROPRIETES THERMIQUES	Valeur moyenne entre +23°C et + 60°C	-	k^{-1}	95*10^{-6}
PROPRIETES THERMIQUES	Valeur moyenne entre +23°C et 100°C	-	k^{-1}	110*10^{-6}
PROPRIETES THERMIQUES	Valeur moyenne entre +23°C et 150°C	-	k^{-1}	-
PROPRIETES THERMIQUES	Valeur moyenne au-delà +150°C	-	k^{-1}	-
PROPRIETES THERMIQUES	Tenue à la déformation thermique (A=1,8N/mm^2)	75	°C	115
PROPRIETES THERMIQUES	Température Vicat (VST/B50)	306	°C	-
PROPRIETES THERMIQUES	**TEMPÉRATURE MAXIMALE D'UTILISATION EN CONTINU**			
PROPRIETES THERMIQUES	de courte durée (2)	-	°C	150
PROPRIETES THERMIQUES	Pendant 5000/20000 heures (3)	-	°C	105/90
PROPRIETES THERMIQUES	Température minimale d'utilisation en continu (4)	-	°C	-50
PROPRIETES THERMIQUES	**COMPORTEMENT AU FEU (5)**			
PROPRIETES THERMIQUES	«Index d'oxygène»	4589	%	15
PROPRIETES THERMIQUES	Selon UL 94 (à 1,5/3/6 mm)	-	-	-/HB/HB
PROPRIETES MÉCANIQUES à +23°C (*)	Essai de traction (éprouvette de type 1-B)			20 mm/min.
PROPRIETES MÉCANIQUES à +23°C (*)	Contrainte de traction	527	N*mm^{-2}	78
PROPRIETES MÉCANIQUES à +23°C (*)	Contrainte de rupture	527	N*mm^{-2}	-
PROPRIETES MÉCANIQUES à +23°C (*)	Allongement spécifique	527	%	-
PROPRIETES MÉCANIQUES à +23°C (*)	Allongement de rupture	527	%	35
PROPRIETES MÉCANIQUES à +23°C (*)	Module d'élasticité (vitesse: 1mm/min.)	527	N*mm^{-2}	3600
PROPRIETES MÉCANIQUES à +23°C (*)	Essai de traction en continu (6)	899	N*mm^{-2}	15
PROPRIETES MÉCANIQUES à +23°C (*)	**ESSAI DE COMPRESSION (VITESSE: 1 MM/ MIN.) (7)**			
PROPRIETES MÉCANIQUES à +23°C (*)	à 1% de déformation	604	N*mm^{-2}	22
PROPRIETES MÉCANIQUES à +23°C (*)	à 2% de déformation	604	N*mm^{-2}	40
PROPRIETES MÉCANIQUES à +23°C (*)	à 5% de déformation	604	N*mm^{-2}	75
PROPRIETES MÉCANIQUES à +23°C (*)	**RÉSILIENCE (8)**			
PROPRIETES MÉCANIQUES à +23°C (*)	Résilience entaille Izod	180	kJ*m^{-2}	10
PROPRIETES MÉCANIQUES à +23°C (*)	Résilience Charpy	179	kJ*m^{-2}	>200
PROPRIETES MÉCANIQUES à +23°C (*)	Résilience entaille Charpy	179	kJ*m^{-2}	10
PROPRIETES MÉCANIQUES à +23°C (*)	**DURETÉ**			
PROPRIETES MÉCANIQUES à +23°C (*)	Dureté à la bille	2039-1	N*mm^{-2}	160
PROPRIETES MÉCANIQUES à +23°C (*)	Dureté Rockwell	2039-2	-	M88
PROPRIETES MÉCANIQUES à +23°C (*)	Dureté Shore	868	-	-
PROPRIETES MÉCANIQUES à +23°C (*)	Coefficien de frottement cinématique (10)	-	-	0,15-0,35
PROPRIETES ELECTRIQUES à +23°C (*)	Tension de claquage (11)	(243)	KV*mm^{-1}	20
PROPRIETES ELECTRIQUES à +23°C (*)	Résistivité	(93)	Ohm*cm	>10^{14}
PROPRIETES ELECTRIQUES à +23°C (*)	Résistance de surface	(93)	Ohm	>10^{13}
PROPRIETES ELECTRIQUES à +23°C (*)	Coefficient diélectrique à 100 Hz	(250)	-	3,8
PROPRIETES ELECTRIQUES à +23°C (*)	Coefficient diélectrique à 1 MHz	(250)	-	3,8
PROPRIETES ELECTRIQUES à +23°C (*)	Coefficient de perte (tan) à 100 Hz	(250)	-	0,003
PROPRIETES ELECTRIQUES à +23°C (*)	Coefficient de perte (tan) à 1 MHz	(250)	-	0,008
PROPRIETES ELECTRIQUES à +23°C (*)	Comparaison au fluage	(112)	CTI	600

Appendix O Spring C.056.090.0100.AP

Details of spring 'C.056.090.0100.AP'

Nr of Coils	6
Reference	C.056.090.0100.AP
Wire Diam. [mm]	0.9
Ext. Diam. [mm]	5.6
Free Len. [mm]	10
Spring Rate [daN/mm]	1.607993
Material	Music Wire
Grinding	Yes
Int. Diam. [mm]	3.8
Block [mm]	5.85
Weight [g]	0.445
Hole [mm]	5.712
Shaft [mm]	3.724
Pitch [mm]	2.04
Tariff code	4E
Buckling at length [mm]	no risk
Allowable Length	6.64

Appendix P 3M Kapton Tape

3M

Low Static Polyimide Film Tape

5419

Technical Data

Product Description

3M™ Low Static Polyimide Film Tape 5419 is a translucent, polyimide film-backed silicone adhesive tape with unique and extremely low electrostatic discharge properties.

Product Construction

Backing	Adhesive	Color	Standard Roll Length
Polyimide	Silicone	Gold	36 yds. (33 m)

Typical Physical Properties

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

		ASTM Test Method
Adhesion to Steel:	20 oz./in. width (22 N/100 mm)	D-3330
Tensile Strength at Break:	33 lbs./in. width (578 N/100 mm)	D-3759
Elongation at Break:	60%	D-3759
Backing Thickness:	1.0 mil (0.03 mm)	D-3652
Total Tape Thickness:	2.7 mils (0.07 mm)	D-3652
Temperature Use Range:	-100° to 500°F (-73° to 260°C)	
Dielectric Strength:	7000 volts	
Insulation Resistance:	$>1*10^6$ ohms	
Static Charge: (measured at 50% RH, 70°F (21°C) in an ESD controlled environment)	Removal from roll: <150 volts Removal from PWB: <50 volts	

Features

- Employs a proprietary technology that results in extremely low electrostatic discharge at unwind and removal from the PWB. Conventional polyimide tapes can typically generate over 10,000 volts during use which can damage board mounted electronic components. 3M tape 5419 overcomes this problem without any of the typical drawbacks of conventional "anti-static" or "static-free" tapes (e.g., variable adhesion and opaqueness).
- At room temperature the properties of polyimide and polyester film are similar. However, as the temperature increases or decreases, the properties of the polyimide film are less affected than polyester.
- Polyimide film does not soften at elevated temperatures, thus, the film provides an excellent release surface at elevated temperatures.
- Gold tab protection during wave solder of printed circuit boards.

Appendix Q Tantalum foil

Material Test Report

Manufacturer:NINGXIA NON-FERROUS METALS SMELTERY
ADD: P.O.BOX105, SHIZUISHAN CITY, NINGXIA 753000.P.R.CHINA
TEL:86-952-2019416 FAX:86-952-2012018 E-mail:nniec@public.yc.nx.cn

Manufacturer's job no.: INSPECTOR 1 Date: Dec.13,2007
Customer: COMETEC P.O.: 911 158
Specification : ASTM B 708-98 Type:RO5200
Name of material: Ta Foil Method of manufacturer: Electro-beam melted
Condition :Annealed Surface: Up to grade
Size:0.1×170×Coil (mm) Quantity: 1 Coil Net Weight:8.0kg
Lot No.: W2007-11-19-071213 Material No.:TD7008
Material Certificates EN 102043.1B

1.Chemical Requirements and Analysis(PPM) Max, weight

Element	Requirements	Analysis Ingot
C	100	16
O	150	36
N	100	20
H	15	5
Nb	1000	<30
Fe	100	<5
Ti	100	<1
W	500	10
Mo	200	<10
Si	50	<10
Ni	100	<5
Ta	Remainder	Remainder

2. Chemical Requirements and Analysis of Finish Product (PPM) max, weight

Element	Requirements	Analysis Finish Product
O	250	36
N	100	20
H	15	5
C	200	16

3.Mechanical Properties

	Requirement	Results
Ultimate Tensile Strength min,psi(Mpa)	30000(207)	30668(211.5)
Yield strength min,psi (Mpa)(0.2% offset)	20000(138)	21750(150.0)
Elongation min,% (1 inch GL)	20	38.0

4. Dimension ,Flatness and Surface

The product is up to standard.

Quality Control Representative
Signature: Li Feng

质量检验章