

# NanoPower TSP 45W Tracking Solar Panel

## Manual

Tracking solar panels

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### 3 Changelog

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## 4 Introduction

This document gives a description on how to mount your GomSpace TSP 45W on your structure and prepare it for flight.

### 4.1 Unpacking and Handling Precautions

#### Handling

This product uses advanced solar cells that are fragile. Wear gloves when handling. Do not touch solar cell surface.



**Only handle solar panels with great care.**

**Never place anything on solar cells!**

For handling of the solar array it is recommended to avoid touching the cells, and instead touch the black nuts at the outer edge as shown in Figure 4-1.



*The TSP 45W requires anti-static handling precautions to be observed. Do not touch or handle the product without proper grounding. The solar cells and particular their interconnect tabs are fragile entities and should not be touched.*

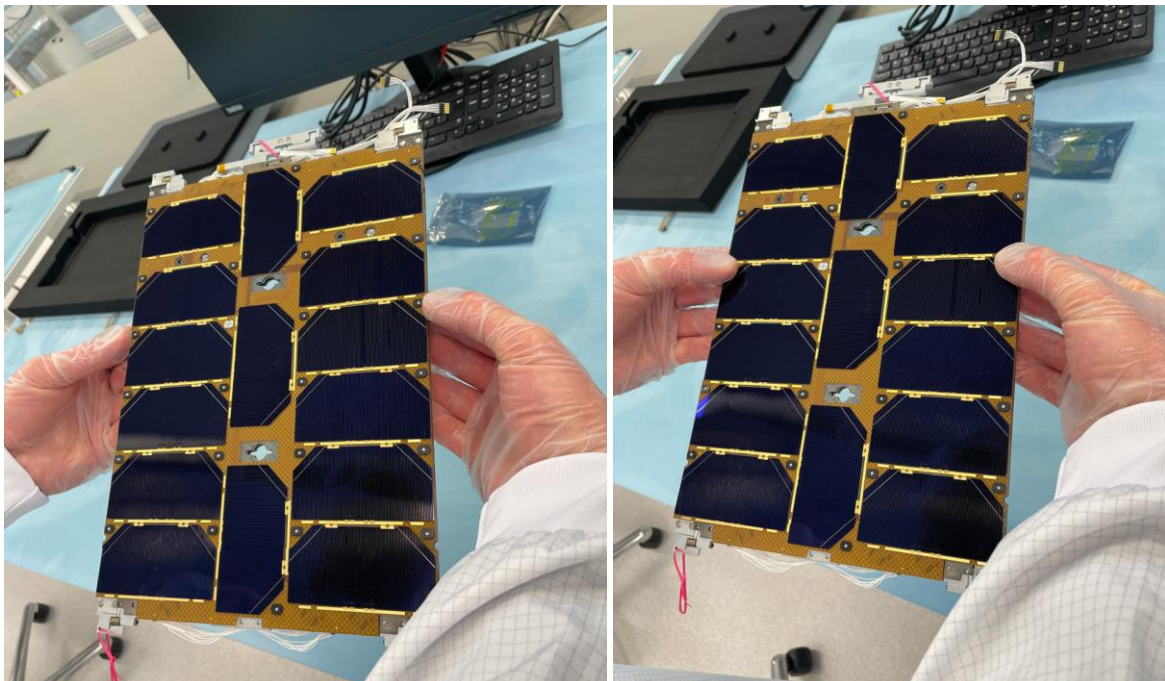


Figure 4-1: Safe handling of solar array.

## 5 Integration and verification overview

GomSpace recommends to following the integration and verification process depicted in Figure 5-1. This shall be regarded as sufficient verification of the TSP 45W. The product may be a part of a larger spacecraft verification campaign, however, be aware the product is qualified for a maximum of 8 on ground release and deploy events.

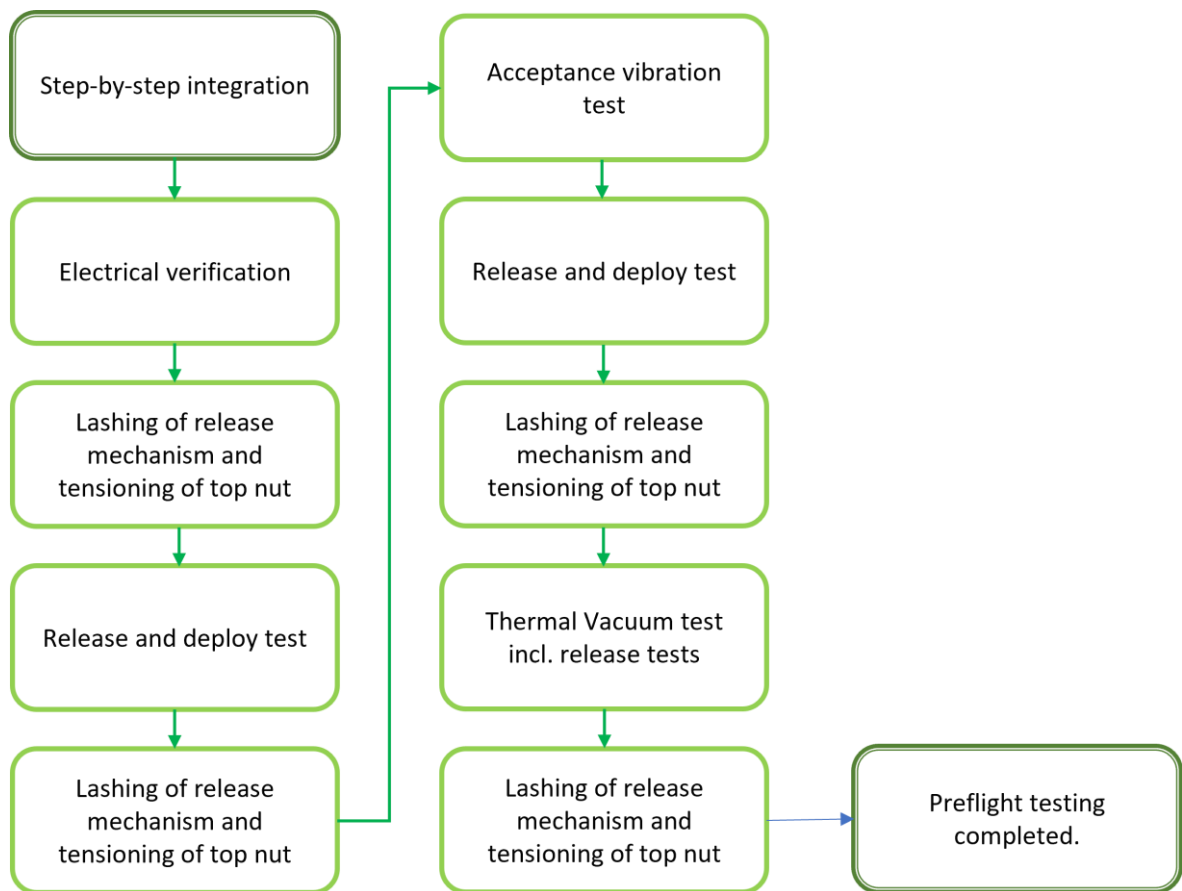


Figure 5-1 Recommended verification tests

The steps are described in more detail in the following chapters.

## 6 Supporting documentation

The following documentation is available to the support the integration and verification of the TSP 45W:

- NanoPower SADA-50 Datasheet (Document ID: 1027859)
- NanoPower SADA-50 Manual (Document ID:1028361)
- NanoPower TSP 45W Datasheet (Document ID: 1038993)
- NanoUtil AR6 SW Manual (Document ID:1013944)
- NanoSoft Product Interface Application (Document ID:1018560)

## 7 Unpacking

The TSP 45W is shipped in a pelicase 1560. In the first layer 2 cardboard boxes are found. Box 1 contains: the SADA-50, Mechanical release devices, and various mounting screws, Box 2 contains the Release controller PCBs, and the Z-close out assembly.



Figure 7-1: Unpacking.

The second layer contains the solar array stored in a cleanroom safe foam box, and the cover plate if this has been ordered. To remove take out the solar array from the foam box first remove it from the ESD bag and remove the tape which secures the lid of the foam box.



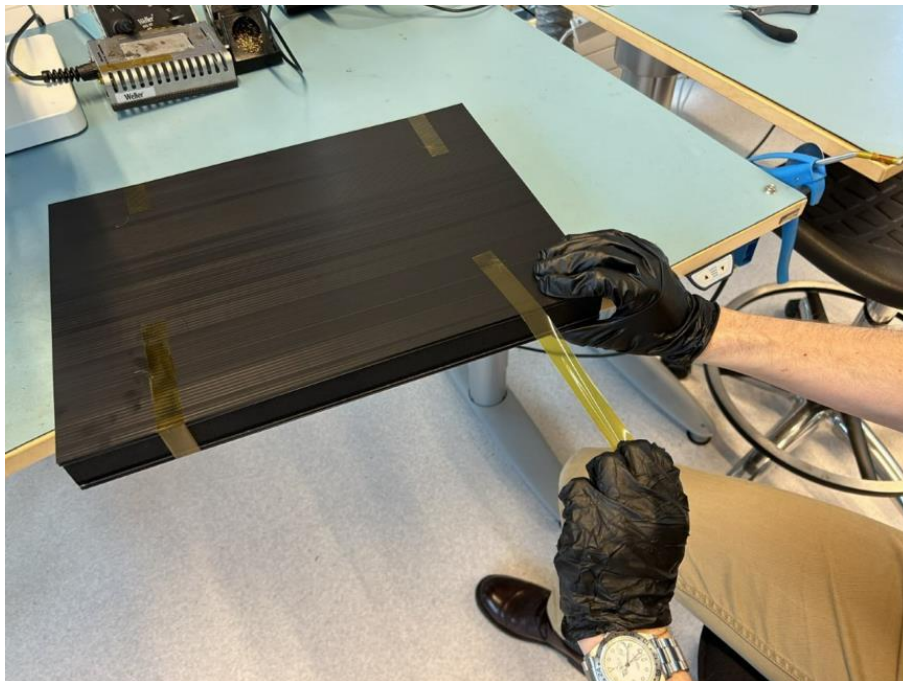


Figure 7-2: Opening of the solar array storage box.

Now take off the lid of the foam box and notice that the solar array is stored inside a pocket with a tight fit, and is prepared with lifting strings, to safely remove it from the pocket.

**IMPORTANT:** The solar panels are not mutually locked to prevent deployment. So, when removed from the packaging material be sure to not accidentally open/deploy the solar array.

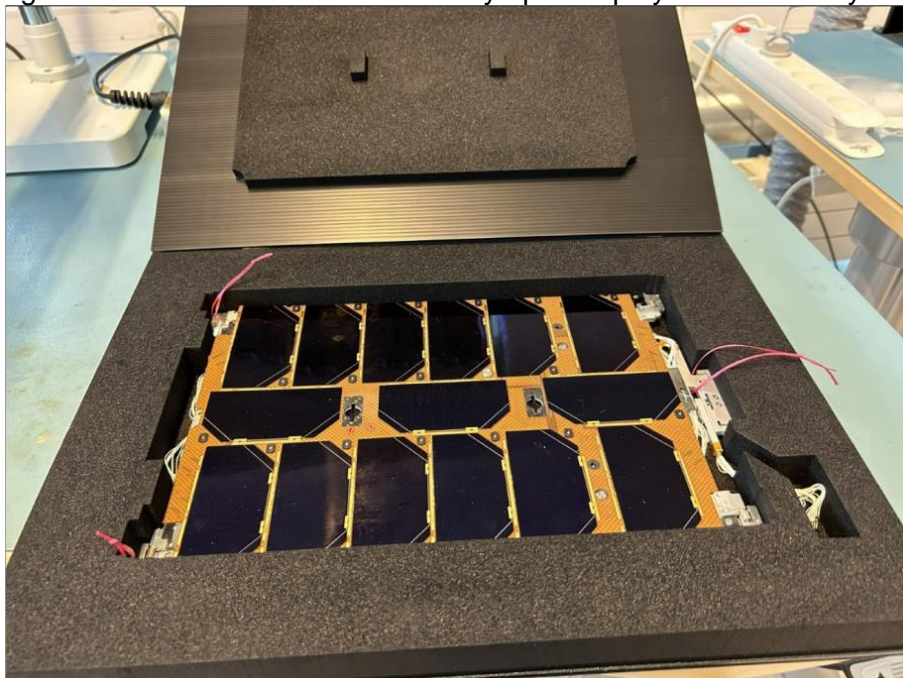


Figure 7-3: Opened solar array storage box. Lifting strings shown.

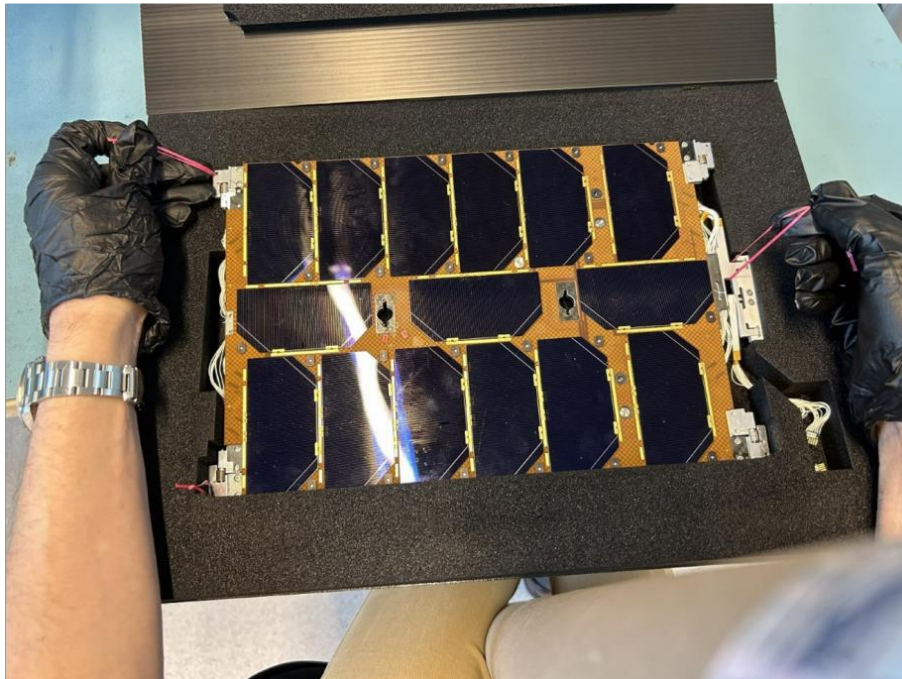


Figure 7-4: Usage of lifting strings to remove solar array from storage foam box.

The solar array can safely be stored laying on flat surface, but GomSpace recommends keeping it in the storage box for as long as possible.

The lifting strings shall be cut off when the solar array is removed from the storage box.

## 8 Pre-integration activities

GomSpace recommends that the SADA-50 and release controller PCBs are configured before integrated for easier access to the PCB connectors. This is done by modifying the parameter system of the unit.

### 8.1 Addressing, routing and configuration of NanoPower SADA-50

The NanoPower SADA-50 supports two physical communication interfaces: CAN and I2C. The details to configure the unit are contained in the NanoPower SADA-50 manual, including a list of the mission-specific parameters to configure.

GomSpace recommend setting the CAN and I2C addresses of the NanoPower SADA-50 before integrating into a spacecraft. This is the simplest approach to avoid the risk of conflicting addresses in the spacecraft internal network, which would require further troubleshooting once the spacecraft is assembled and integrated.

### 8.2 Addressing and configuration of release controller PCBs.

The release controller PCB is a GomSpace Sensor Bus device (GSSB), which is based on I2C as physical communication interface. The details to configure the unit is contained in the NanoSoft Product Interface Application manual (see `libgssb_client`).

The units are usually configured with a separate subsystem supporting the GSSB library, which acts as a proxy server for the GSSB devices connected to the I2C lines. GomSpace GSSB library provide both drivers for all its GSSB devices and a CSP service handler.

If a separate device supporting the GSSB library is not available, the NanoUtil AR6 manual contains a description of the AR6 Client API.



To configure the units using the GSSB library, these are connected to the addressing device one at a time and the address is set through the *gssb addr* and *gssb setaddr* commands.

The *gssb scanbus* command can be handy to identify the original address of the board before the configuration and to validate the result of the configuration afterwards.

### 8.3 Release controller boards harnessing

The release controller PCBs are interfaced to the rest of the system through a GomSpace Release Bus (GSRB), which is a typically daisy-chained bus connected directly to the device controlling the release. The bus lines include the I2C clock and data, the logic Vcc and return lines (3.3V) and the release power and return lines (5V or 32V).

If several NanoPower TSP-45 release controller boards are daisy-chained together or with other GSRB devices, the voltage drop along the bus needs to be considered to ensure the release can occur without risks. If necessary, the release voltage can be brought directly to each unit instead of daisy chained. In this case, extra precaution is necessary for units that are cross-strapped together to avoid the risk of shorting lines at different voltage levels (e.g. if the release voltage coming from different regulators is short together during the burn).

### 8.4 Control of release PCBs

The user is encouraged to study the options for using the release controller PCBs described in the AR6 software manual. It is generally recommended to use the option for manual deploying the solar arrays, to simultaneous deployment with eg. TMTC antennas, which could lead to collisions during the deployment motion. It is furthermore advised to always burn on both release controller boards at the same time, since both need to release for the solar array to deploy.

Under nominal conditions (supply voltage and temperature) a burn time of 5 seconds is typically sufficient. In a few cases it is necessary to send a second burn command in case the first did not result in a successful release. If the deployment is done under more extreme conditions (i.e. low temperatures and low supply voltages) a burn time of up to 20s may be necessary.

## 9 Integration step-by-step

This section demonstrates how the TSP 45W product is integrated. The procedure assumes integrated on a 6U/12U GomSpace structure.

Before the user gets started with the step-by-step procedure for integrating the product it is recommended to read section 8.

### 9.1 Use of thread locker

GomSpace recommends that all threads are secured using a suited thread locker, such as Loctite 262, when these are installed without screw lock helicoils.

### 9.2 Tightening torques

For bolt assemblies with screw lock helicoils GomSpace recommends tightening torques according to table Table 9-1, unless otherwise stated throughout the step-by-step integration procedure.

Table 9-1: Tightening torques for assemblies with screw lock helicoils.

Standard Bolt Assembly <u>with</u> Screw lock Helicoils			
Thread	First-time on nom. (min/max) [Nm]	First-time off nom. (min/max) [Nm]	Fifth-time off nom. (min/max) [Nm]
<b>M2</b>	0.51 (0.44/0.57)	0.38 (0.31/0.44)	0.37 (0.30/0.43)
<b>M2.5</b>	0.97 (0.83/1.11)	0.75 (0.61/0.89)	0.72 (0.58/0.86)
<b>M3</b>	1.69 (1.41/1.90)	1.34 (1.10/1.59)	1.30 (1.06/1.55)
<b>M4</b>	3.68 (3.12/4.24)	2.96 (2.40/3.52)	2.90 (2.34/3.46)
<b>M5</b>	7.19 (6.07/8.31)	5.88 (4.76/7.00)	5.79 (4.67/6.91)
<b>M6</b>	12.42 (10.53/14.3)	9.87 (7.98/11.75)	9.72 (7.83/11.60)

### 9.3 Installation of the HDRM

The release mechanism is made of 2 subassemblies:

- A burn PCB which contains a hold down bar, two burn resistors, and a spring for release detection.
- A mechanical release device consisting of a hold down, a sleigh, top nut, and to actuating springs.

It is recommended that the various parts are installed as in the order presented below.

#### 9.3.1 Installation of Release controller PCBs

The *Release controller PCB* is mounted on the inside of the structure wall as shown in the Figure 9-1.

Mounting hardware:

- 8 pcs M2x4 Hexagon socket head screws (part number: 102199)
- 8 pcs M2x0.1 washer (part number: 108103)
- Torque: 0.3Nm

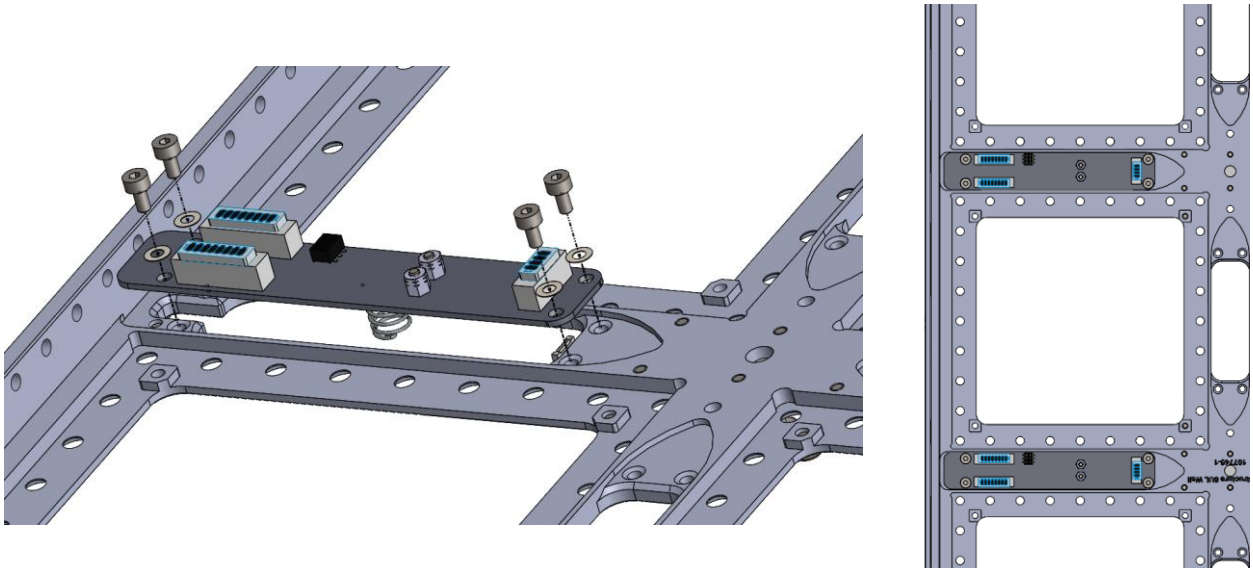


Figure 9-1: Mounting of a Release controller PCB on a GomSpace 6U structure.

Remark, that the release boards shall be electrically connected before internal integration is completed. To make use of the optional cross burn functionality J103 on one Release Control board must be connected with J103 on the other Release Control board on the same face.

### 9.3.2 Installation of mechanical release device

The *mechanical release device* is installed as shown in Figure 9-2.

Mounting hardware and torque:

- 6 pcs M2x4 CSK screws (part number 102401).
- Torque: See Table 9-1

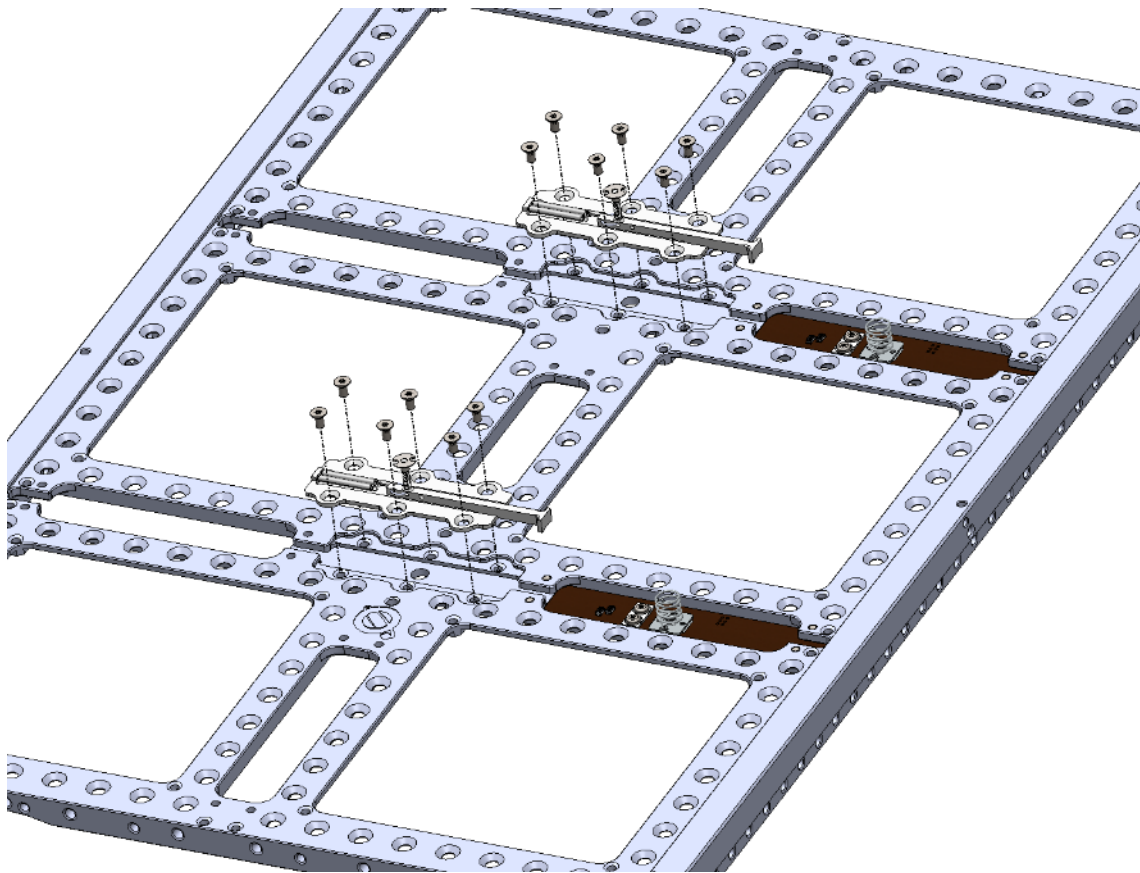


Figure 9-2: Mounting of mechanical release device.

## 9.4 Installation of cover plate

When the structure is closed, and the external integration is started, the cover plate may now be mounted as shown in Figure 9-3. Mounting hardware and torque:

pcs of

- 14 pcs M2x3 Ultra Low Head screws (part number: 101710)
- Torque: 0.18Nm

For alignment of the cover plate it is expedient to use the Ø1.5mm found at each corner of the cover plate. These should align to the Ø1.5mm holes in the 6U GOMSpace structure – see Figure 9-4. Typically, visual inspection suffices, but it is also possible to align the holes using guide pins. If guide pins are used it is recommended to remove them after the alignment, to avoid the risk of loose debris.



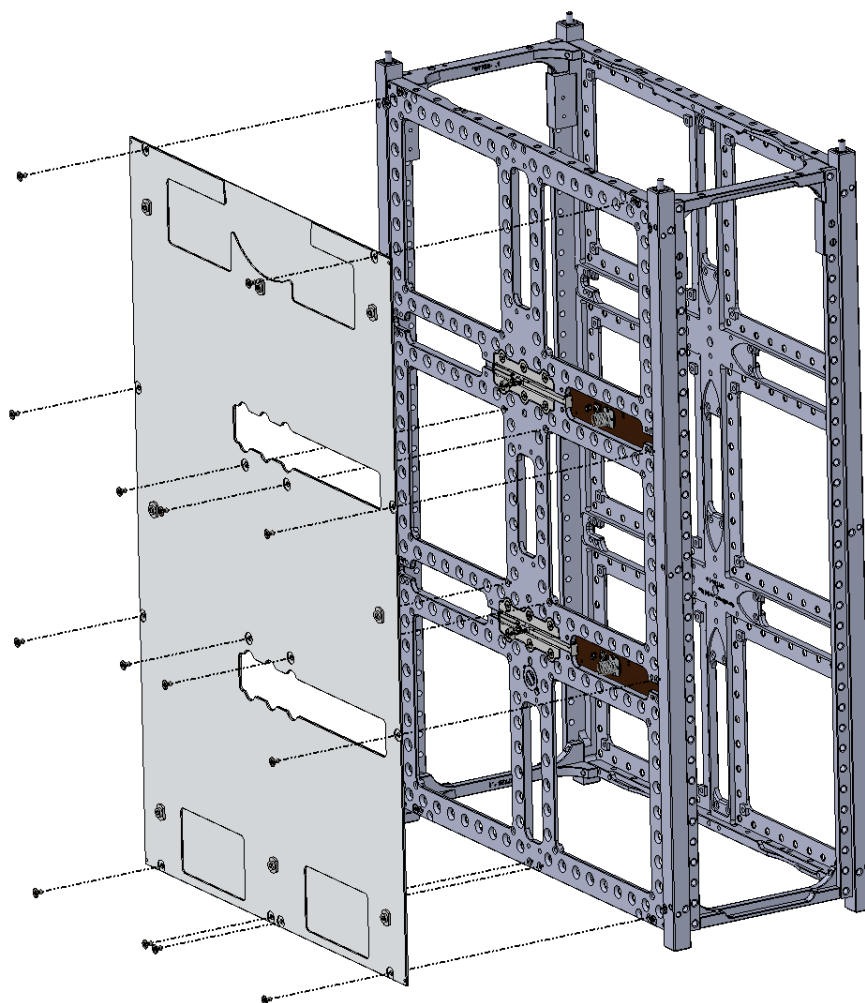


Figure 9-3: Mounting of cover plate

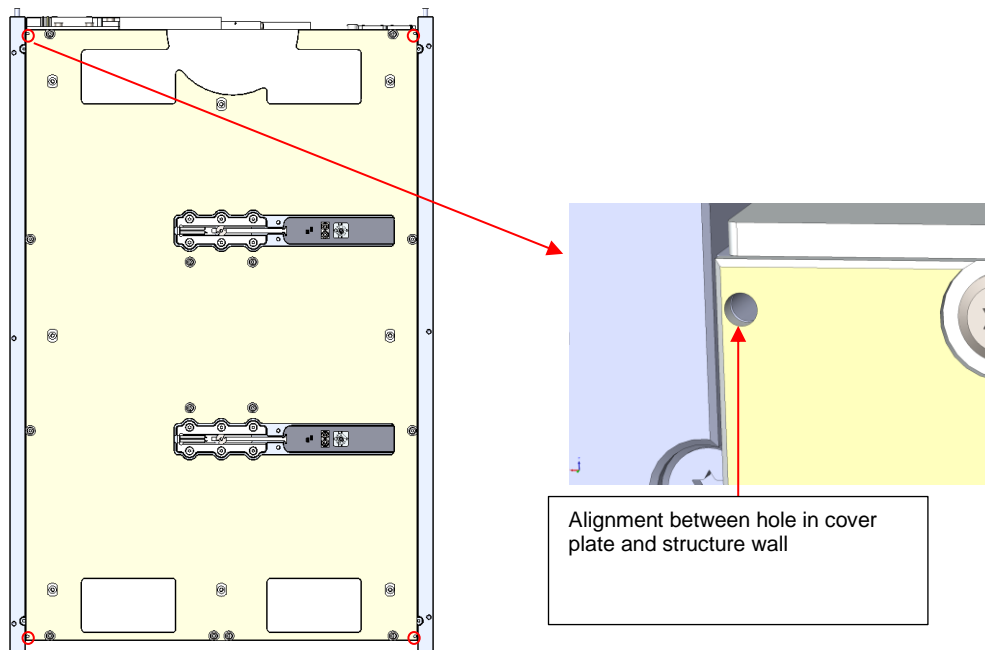


Figure 9-4: Alignment of cover plate.

## 9.5 Installation of SADA-50

The SADA-50 may now be installed – see Figure 9-5.

Mounting hardware:

- 3pcs M2x10 csk screws (part number 102405).
- Torque: See Table 9-1

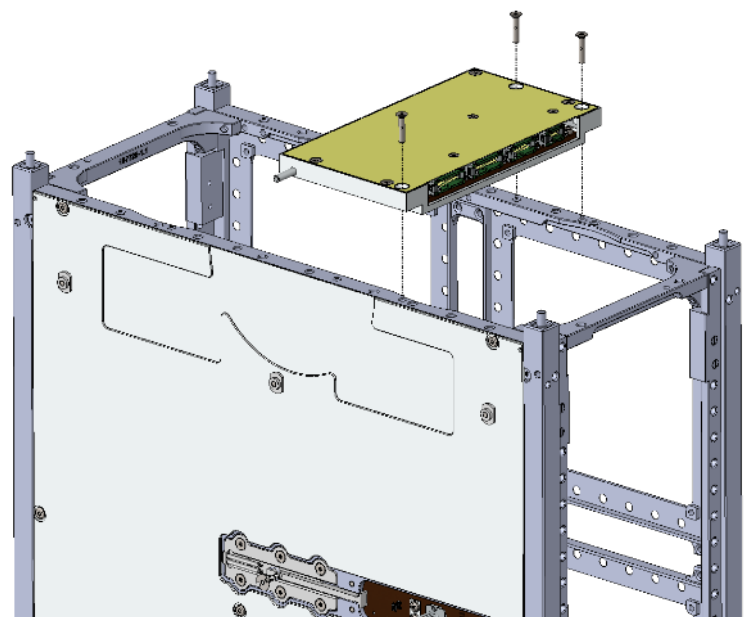


Figure 9-5: Mounting of SADA-50.

It is expedient to insert the harness to the SADA-50 before advancing to next step. The harness from the SADA includes 4 separate harnesses for each connector. J1 and J2 are identical and J2 can be

used as backup. J3 is a power connector for 5V and 3.3V, J6 is for the connection of 3.3V power and GomSpace protocol. For details on the SADA-50 connector pin out, please the SADA-50 manual.

## 9.6 Installation of Z cover close out

The Z cover shall now be installed. Before this is mounted, the harness from the EPS shall be connected to the 26pin connector (J110) on the bottom of the *TSP connect PCB* (the PCB built into the Z cover close out). Likewise, shall the I<sup>2</sup>C harness between the SADA-50 and the *TSP connect PCB*. For detailed connector pin out please see the TSP-45W datasheet.

The Z cover close out is mounted as shown in Figure 9-6.

Mounting hardware:

- 6pcs M2.5x6 Socket head screws (part number 102301)
- Torque: See Table 9-1

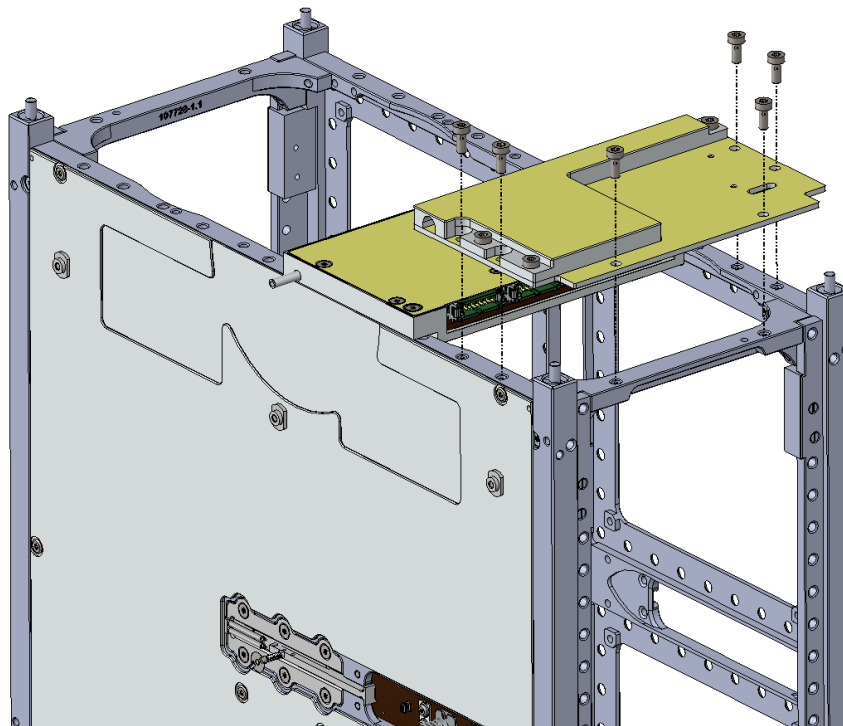


Figure 9-6: Mounting of Z cover close out.

This concludes the installation of the TSP 45W product with exception of the solar array itself and the harness.

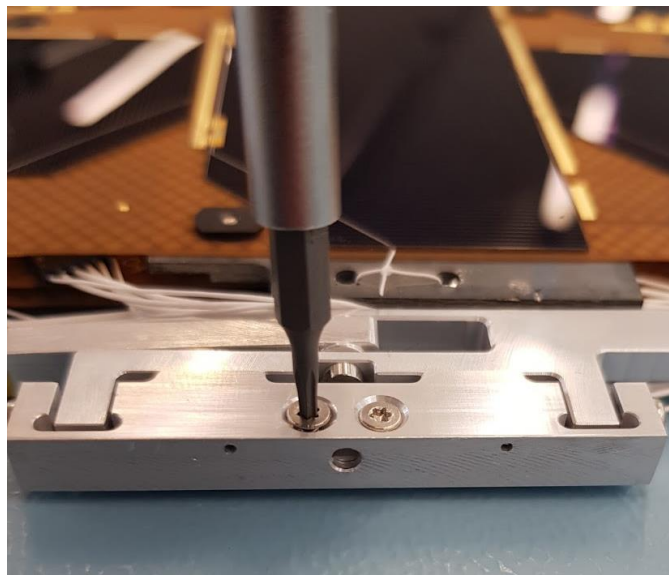
## 9.7 Installation of the solar array

This section describes how to correctly mount and secure the solar array. Before the solar array is mounted it is recommended to lash the release devices, see section 9.9.1, so the solar array can be secured after the installation.

- Place the space craft laying down with the output shaft of the SADA-50 pointing upwards.

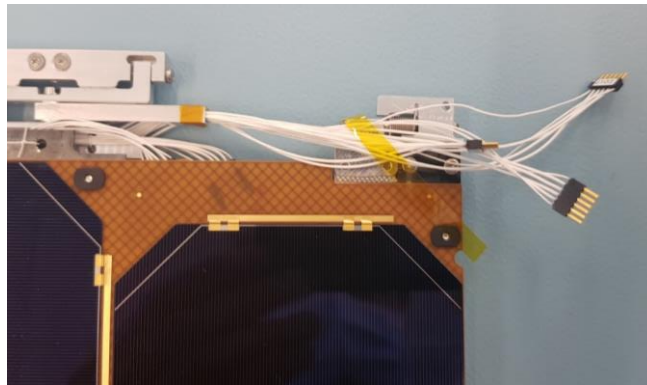


- The two screws in the primary hinge shall be loosened to ensure that the output shaft of the SADA-50 can slide into the hole in the primary hinge.

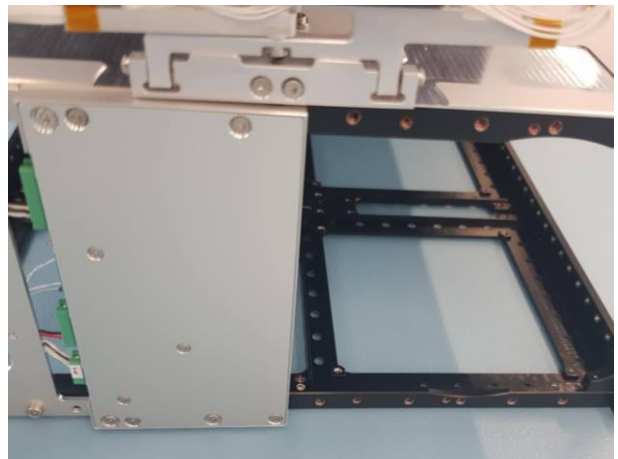
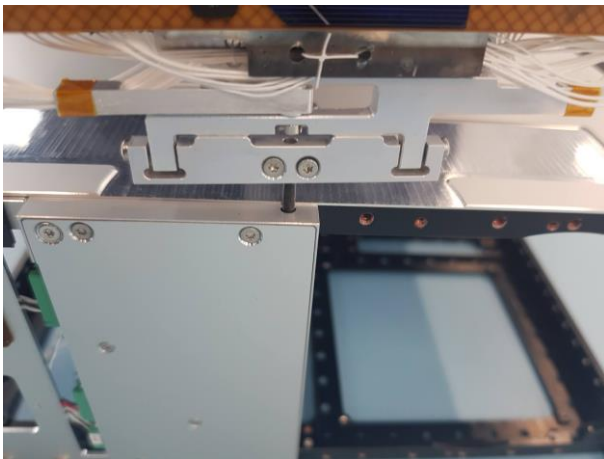


- Temporarily tape the Primary harness to the hinge to ensure it does not get in the way when mounting the solar array.

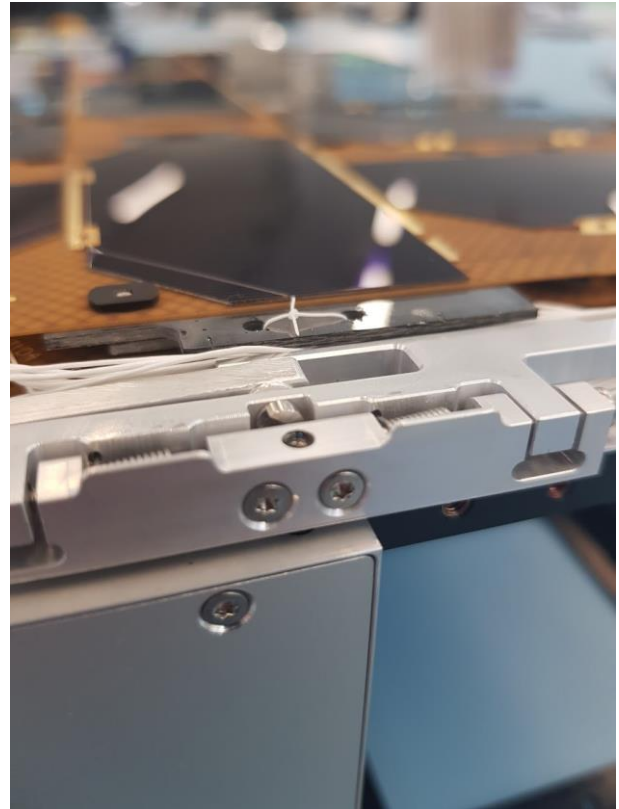
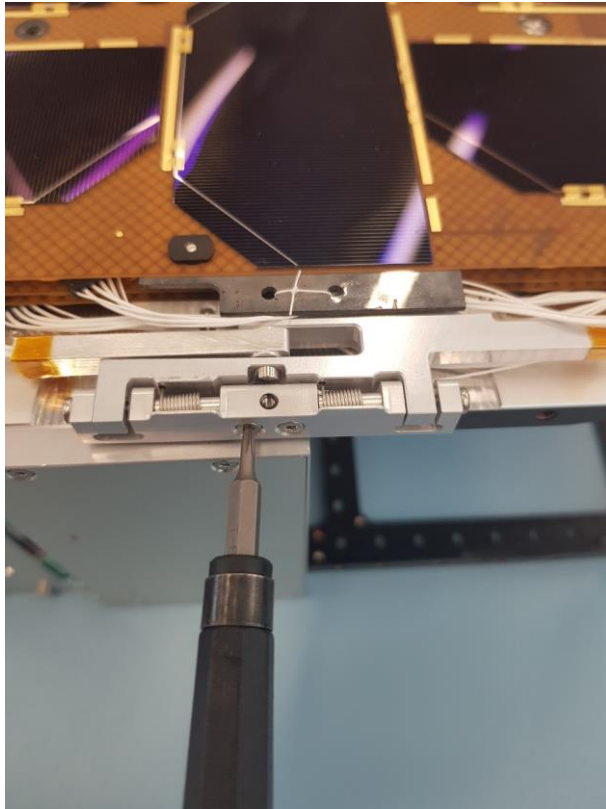




- Carefully slide the stowed solar array onto the output shaft and fold it down on the cover plate so the fixation pins on the cover plate engage with the holes in the backplate of the first panel (see section 9.9.3 for more details).



- Ensure that the tip of the output shaft is flush to the top face of the primary hinge and clamp the primary hinge to the output shaft using the 2 screws in the hinge.
  - Remember thread locker
  - Torque: 0.09Nm



- Fasten the two top nuts to the release device according to section 9.9.2.

**WARNING:** At this stage the solar array is not secured and therefore the space craft may not be lifted or rotated. See section 9.9 for information on how to correctly arm the HDRMs, solar array stowage and pretension of top nut.

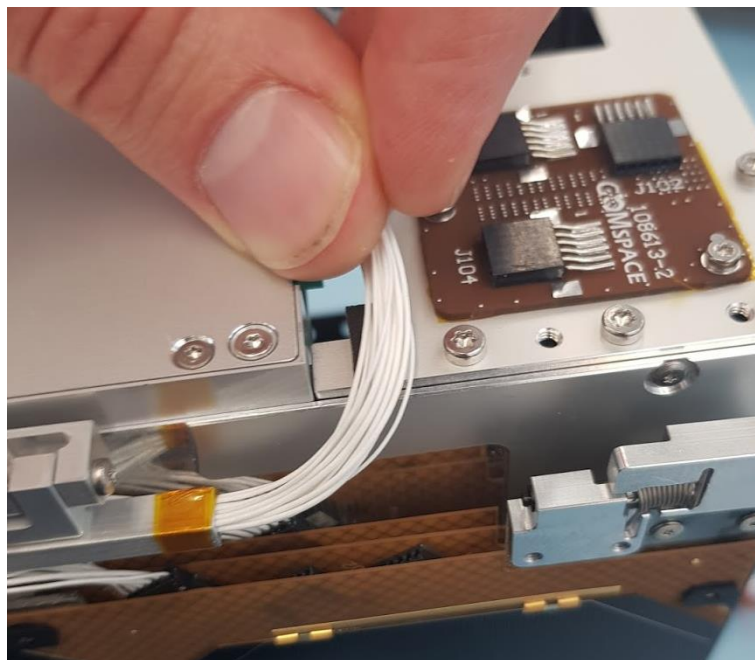
## 9.8 Mounting of solar array harness

This section describes how to integrate the solar array harness correctly.

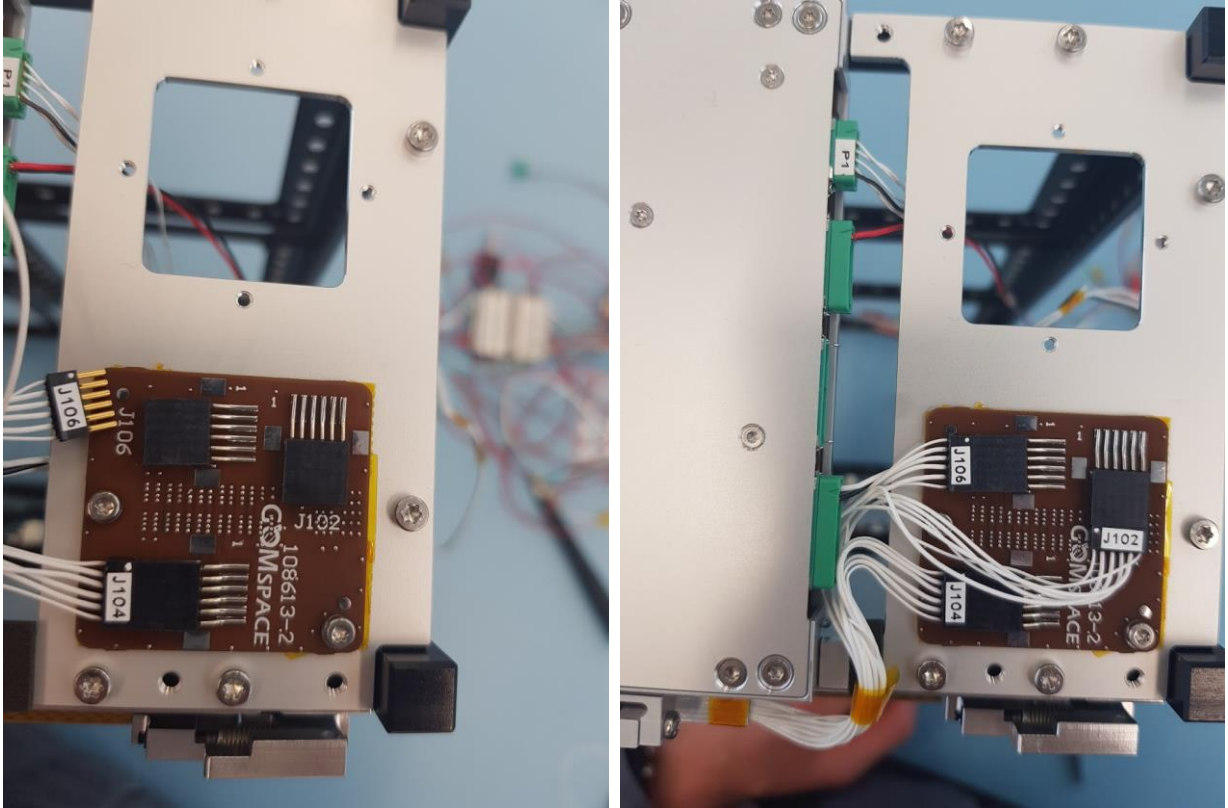
- Unmount the cover part of the Z bracket to access the *TSP connect PCB*.



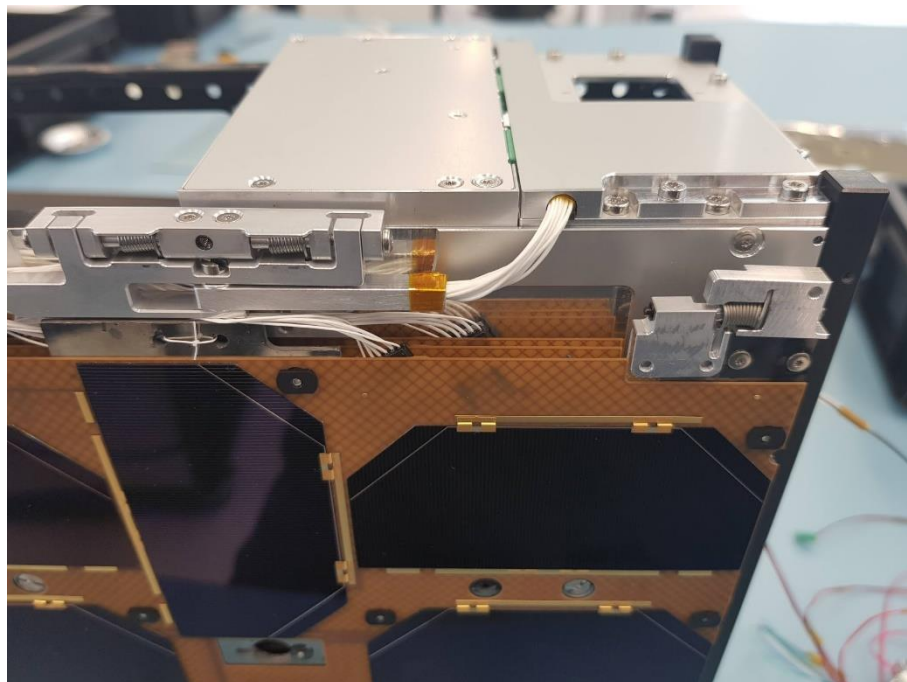
- Insert add a piece of Kapton tape (or similar) to the harness where it will enter through the hole in the Z bracket cover part:



- Insert the connectors so the tags (J102, J104, and J106) matches the designations on the connect PCB.



- Re-mount the cover part of the Z- bracket. The segment of the harness with Kapton shall lay in the channel in the cover part.
  - Remember threadlocker
  - Torque: 0.3Nm





**CHECK:** The harness shall be well stuck in the channel below the Z-bracket. If the harness bundle can easily be pulled in and out it may be necessary to add more Kapton.

This completes the mounting of the main harness.

## 9.9 Prepare release device for testing and launch.

### 9.9.1 Lashing of the Release device

This section describes how to prepare the release device for launch.

Hardware needed:

- Burn wire (about 25 cm) (Part number: 106262)
- Thread locker
- 8mm flat drill bit or similar
- Tweezer with ESD safe tips
- T5 bit

The lashing procedure is explained in the steps below, but beforehand it is expedient to repeat the part annotations also mentioned in the datasheet – see Figure 9-7.

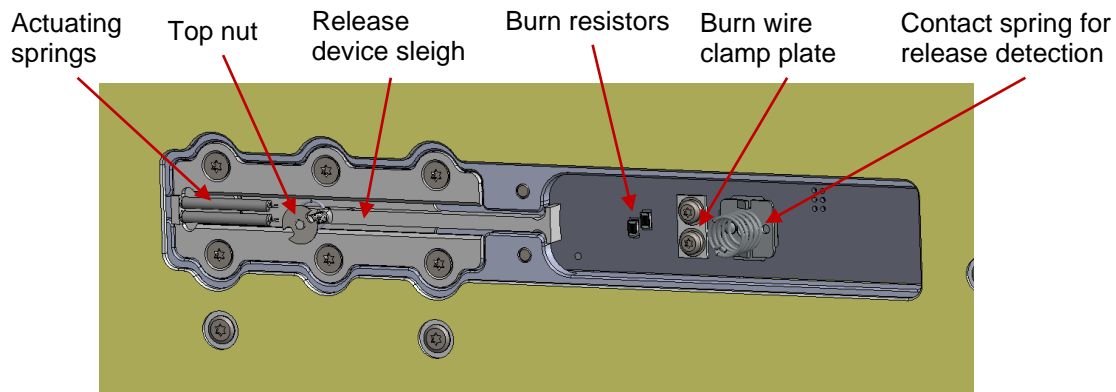
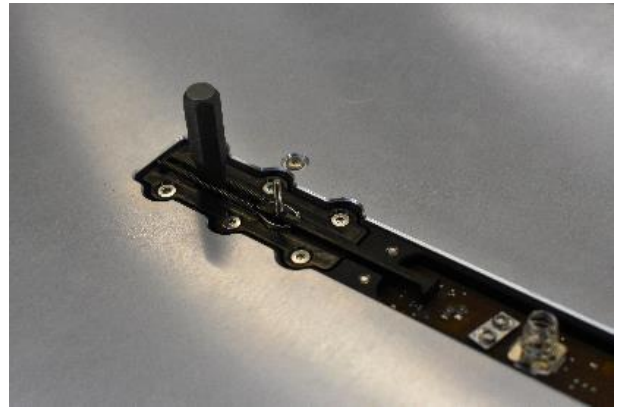
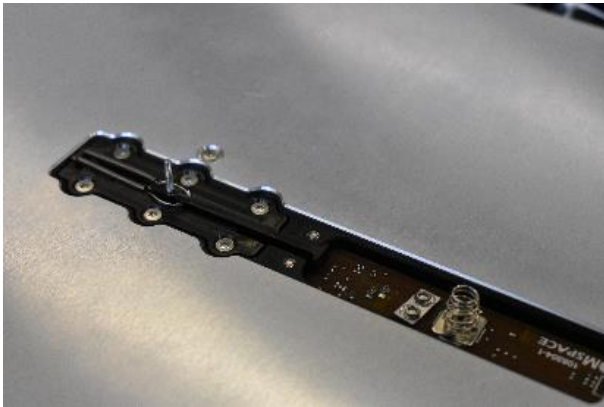


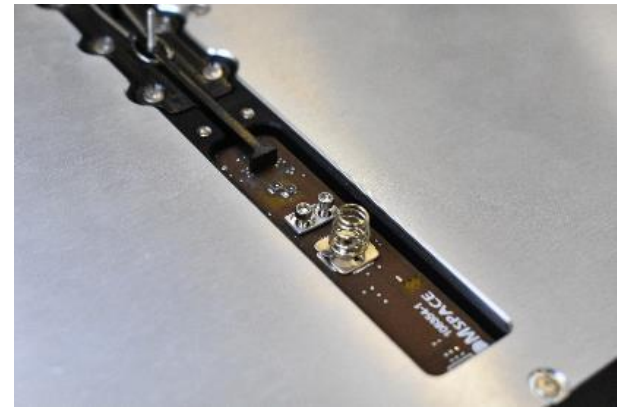
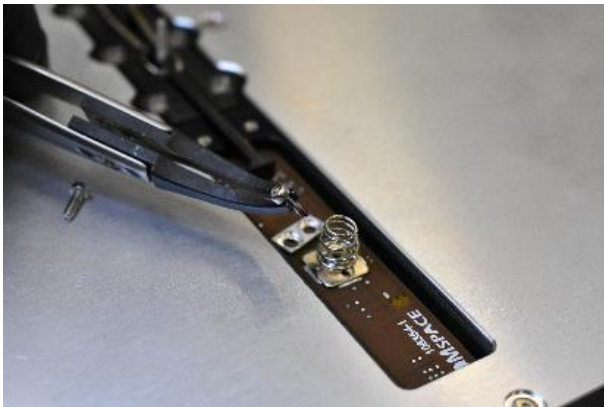
Figure 9-7: HDRM part annotations.

The HDRM are lashed correctly by the following steps:

- Start out by removing the *Top Nut* from the release sleigh.
- Slide the release device sideways to its locked position and insert the 8mm flat drill bit in the slit of the hold down behind the sleigh.



- Prepare each of the screws at the clamp plate with an appropriate thread locker. Insert the screws using the T5 bit a few revolutions into the threads in the PCB.



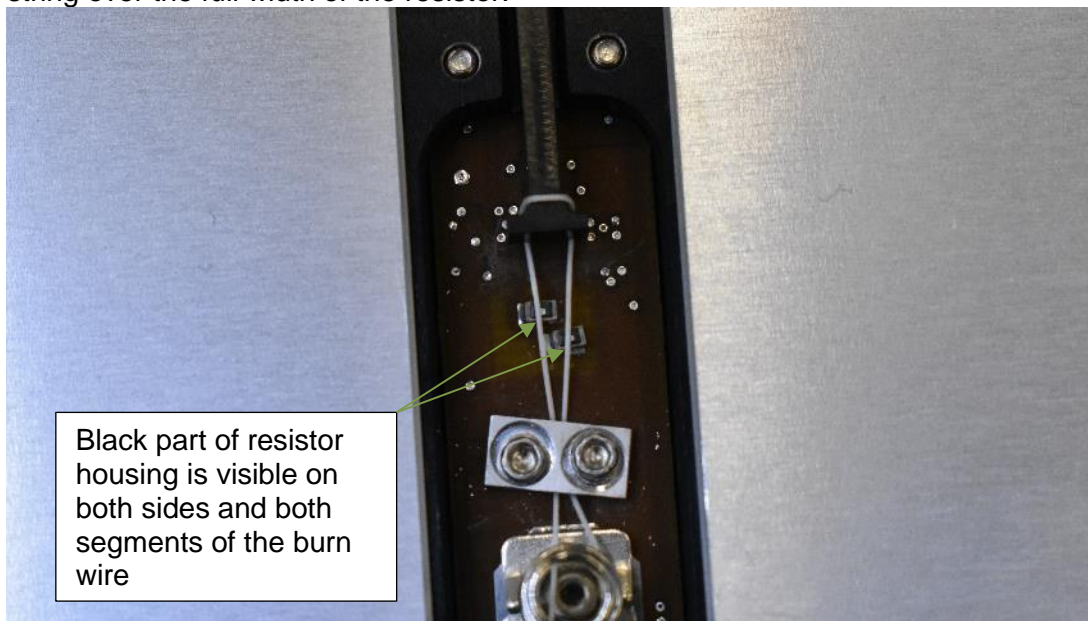
- Slide the two ends of the burn wire underneath the clamp plate on the burn PCB and wound the burn wire around the finger part of the sleigh as shown in the photo below. A tweezer with ESD safe polymer tips is practical here.



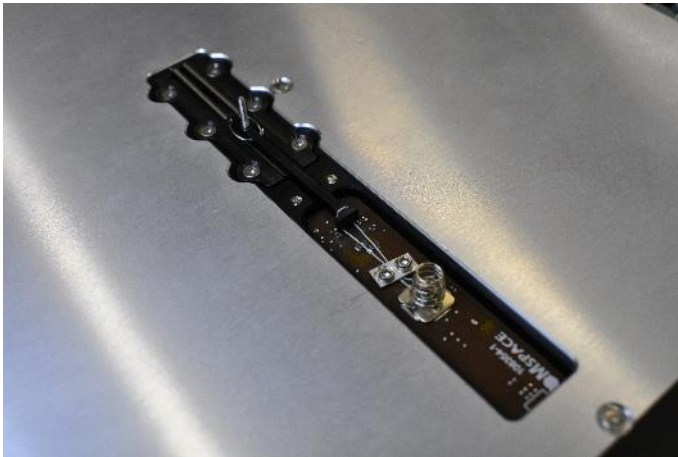
- Tighten up the burn wire while sliding it sideways to ensure that it is positioned correctly on the burn resistors. This means that the black part of the burn resistor shall be visible on each side of the burn wire. Tighten the two screws in clamp plate.
  - Torque: 0.16Nm



- Make a final check to ensure that both segments of the burn wire lie over the corresponding burn resistor. Again, the black part of the resistor housing shall be seen on both sides of the string over the full width of the resistor.



- Remove the flat drill bit and cut off the excess burn wire between the clamp plate and the contact spring for release detection.



This completes lashing of release device.

### 9.9.2 Pretension of top nut

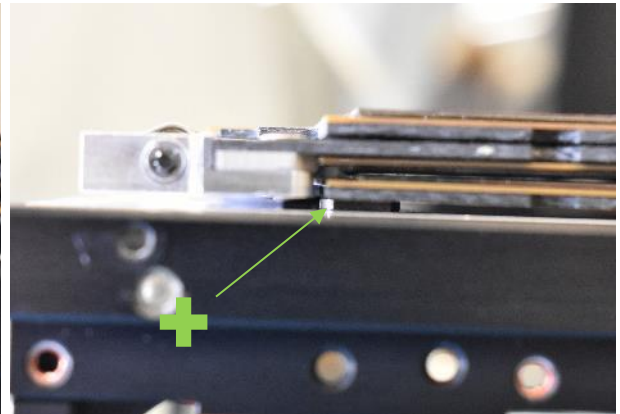
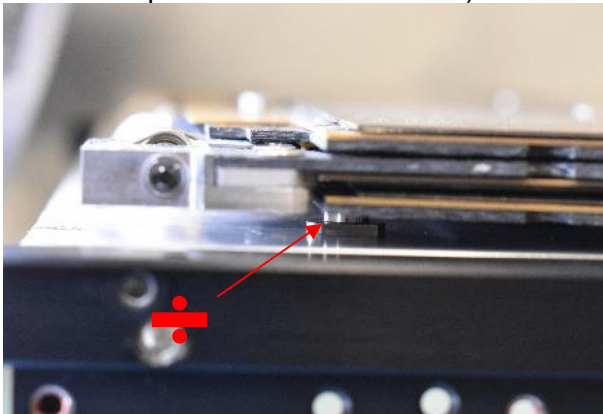
In this section it is demonstrated how the top nut shall be mounted.

Hardware needed:

- Threadlocker
- SP10 bit
- 2 x Top Nuts (removed during lashing of the HDRM)

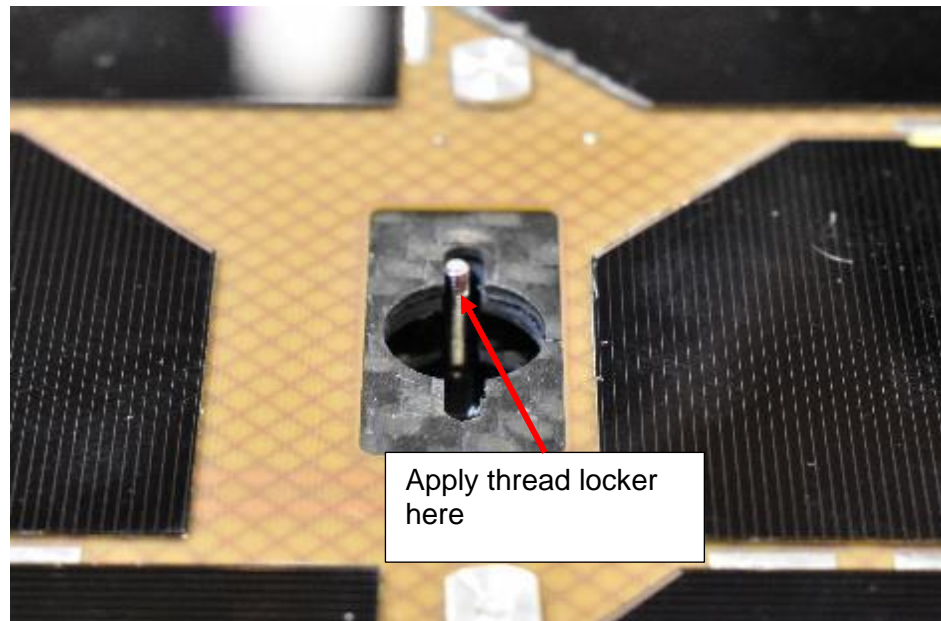
Tightening of the top nut is done by the following steps:

- First ensure visually that the panels engage correctly to the fixation pins in the cover plate (More details are provided in section 9.9.3).

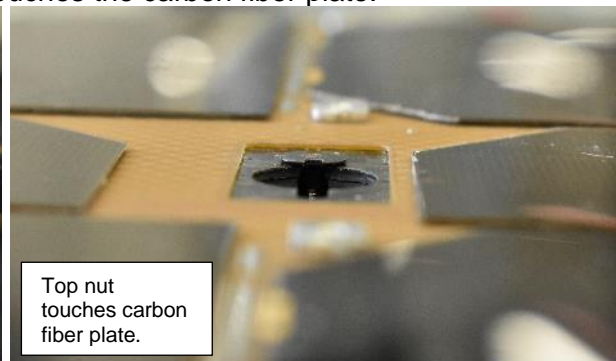
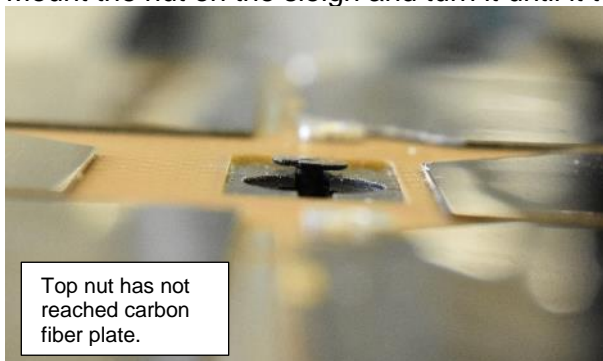




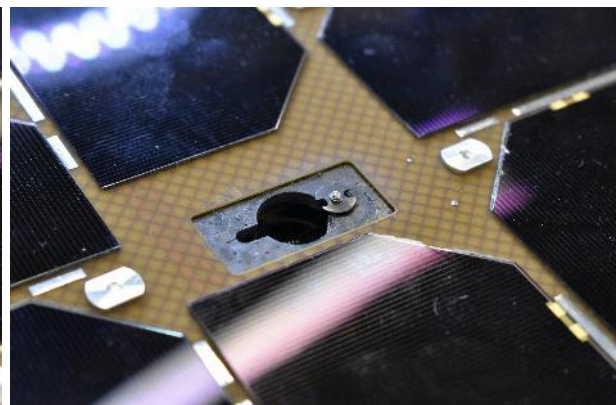
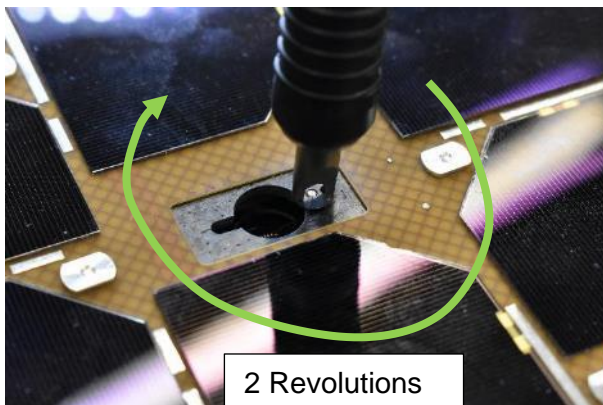
- Apply thread locker on the external thread of the sleigh of the release device.



- Mount the nut on the sleigh and turn it until it touches the carbon fiber plate.



- Turn the top nut 2 full revolution clockwise, using the SP10 bit. Leave it to allow the thread locker to cure according to its specification.



This completes the tightening procedure of the top nut.



GomSpace recommends to always check that the thread locker has cured before eg. vibration tests or launch. This may be done using a handheld SP10 bit and testing that the top nut cannot be turned with minimal resistance.

### 9.9.3 How to ensure correct solar array stowage

While the HDRM devices fixes the solar array in terms of out-of-plane motion, the TSP-45W build in features to prevent the in-plane motion between the solar array and the spacecraft. This feature is achieved by the support pins found on the cover plate and a hole pattern on the back side of the backplate of the first panel. This is illustrated in Figure 9-8, in which the engagement between support pins and the panel backplate is encircled. At the green encirclements a gap of 0.15mm is present, and at the red encirclements have larger clearances. Thus, the support pins at the two green encirclements are the primary in plane support, and the rest are effectively only out-of-plane supports locally around the hole. Nevertheless, the engagement/disengagement at all supports shall be with no or minimal resistance. It is recommended to test the engagement in the following way: Gently push out (eg. with a tweezer or similar) the panel locally at each support and observe that the panel bends back and engages with the support pin when the panel is no longer pushed out. This is illustrated in Figure 9-9. If this pin-to-hole interface does not engage/disengage freely this way, the panel or cover plate is not aligned properly.

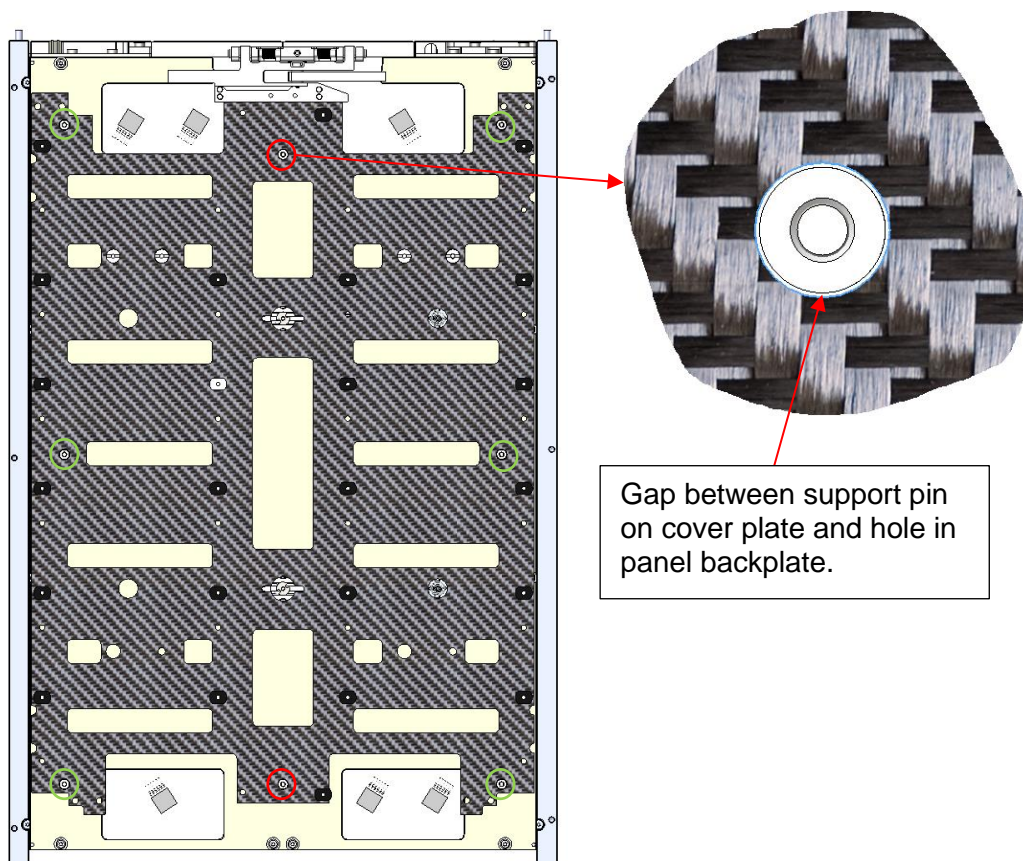


Figure 9-8: Engagement between support pin on cover plate and hole in panel backplate.

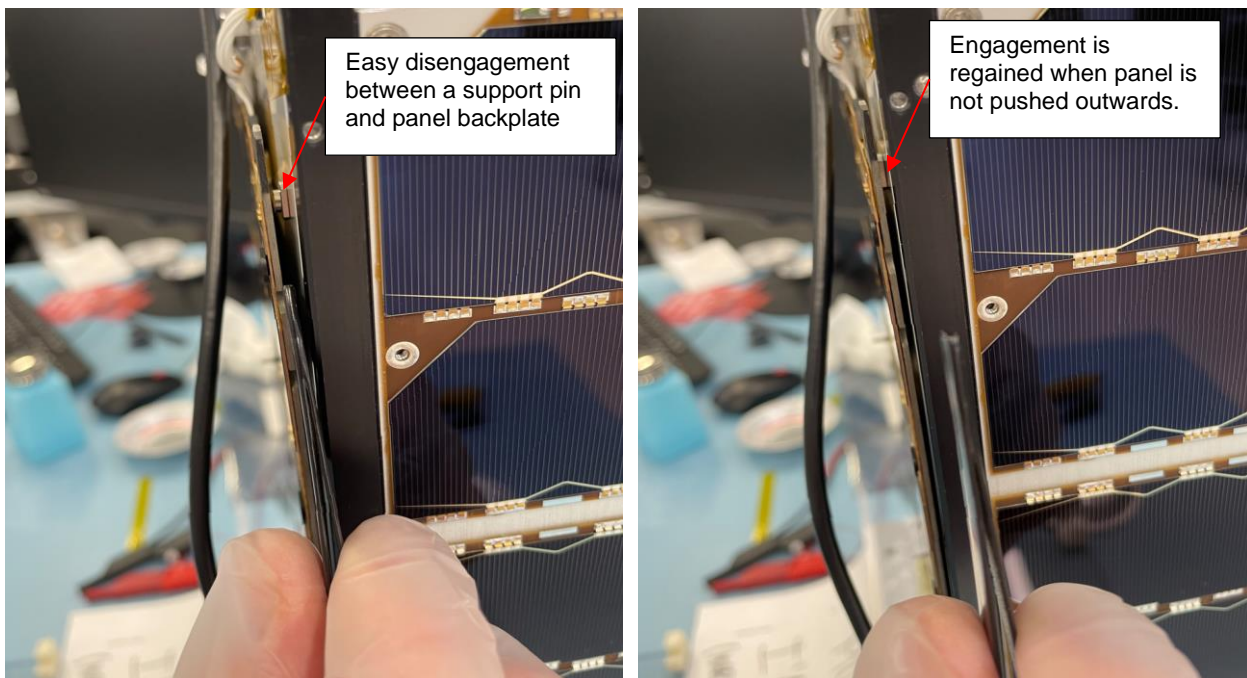


Figure 9-9: Test of correct stowage of solar array.

## 10 Verification tests

This section presents a short description of the GomSpace recommended test sequence for the TSP-45W when integrating them on a spacecraft. The sequence is intended to be used as a starting template to plan the overall spacecraft AIV/AIT phase and should be tailored to the specific needs of the project.

### 10.1 Electrical Tests

The main purpose of the electrical tests is to verify that all the panel electrical connections of the TSP-45W are connected as intended. The test should be designed to be as simple and quick as possible, in order to be repeatable throughout the satellite AIV phase. In particular, the tests should be designed as much as possible to be carried out with a fully integrated spacecraft in flight ready configuration (stowed and/or deployed).

It is recommended to include the Electrical Tests as part of the spacecraft FFT (Full Functional Tests) and RFT (Reduced Functional Tests) procedures. For the RFT, it is recommended to avoid Electrical Tests that require a fully deployed TSP-45W to simplify the RFT procedure.

As part of either the FFT or RFT, it is recommended to carry out the Electrical Tests after each major milestone of the AIV process including, as a minimum, Vibration Test, TVAC Test and LEOP rehearsal, as well as after any spacecraft rework(s) that requires the temporary removal or electrical disassembly of the TSP-45W.

As part of the Electrical Tests, the following connections should be verified:

- Power generation and delivery from each of the three panels of the TSP-45W
- Power delivery to the SADA sub-assembly
- TT&C to and from the SADA sub-assembly
- Power delivery to the release devices
- TT&C to and from the release devices
- TT&C to and from the temperature sensor on the solar array (if connected)

## 10.2 Release and Deploy Tests

The main purpose of the Release and Deploy Tests is to confirm that the TSP-45W is capable of transitioning from the stowed to deployed configuration once in orbit. If possible, it is recommended to use the same procedure that will be used in orbit for the Release and Deploy Tests performed on ground, including commanding routine, deploy sequence, timers and burn time.

**WARNING:** To perform a deployment test involving the full range of motion, an appropriate offloading device, which fully compensates for gravity, is required. **Do not** attempt to release and deploy the solar array without an off-loading device.

It is recommended to include the Electrical Tests as part of the spacecraft FFT and to repeat the test after each major milestone of the AIV process. However, the TSP-45W are qualified for a maximum of 8 on ground release and deploy events. This limitation should be considered when planning the number of Release and Deploy Tests, taking into account the possibility of repeating the test.

As part of the Release and Deploy Test, the following is validated:

- Mechanical integrity and functionality of the deploy hinge.
- Mechanical integrity and functionality of the release devices.
- Software interface between the unit commanding the deployment and the release devices.
- Deploy timers and burn times.

## 10.3 Sun tracking test

The main purpose of a sun tracking test is to verify the functionality of the SADA-50 and, if possible, to ensure that the main harness of the wing does not entangle with other components of the integrated space craft. A sun tracking test may be performed either before the solar array is integrated, or after the solar array is integrated. In the latter case the solar array must be deployed and supported by an appropriate off-loading device.

**WARNING:** Do not perform a sun tracking test while the solar array is stowed.

## 10.4 Acceptance Level System Vibration Test

The main purpose of the Acceptance Level System Vibration Test is to validate the mechanical integration, the structural coupling, and the mechanical simulations of the TSP-45W with the hosting spacecraft.

As part of the preparation for the Vibration Test, it is important to ensure that the TSP-45W is properly stowed according to this manual, all cables are properly connected, and all RBFs are removed. It is also recommended to verify the clearance between the stowed solar panels and the vibration test equipment during the test. If possible, the clearance should match the clearance of the Launch Deployer selected for the mission, or in any case exceed this value.

## 10.5 Acceptance Level System Thermal Vacuum Test

The main purpose of the TVAC Test is to validate the thermal integration and the thermal simulations of the TSP-45W with the hosting spacecraft.

As part of the TVAC test, it is moreover recommended to validate the release timers and burn time of the system in the most extreme thermal condition (worst hot and cold cases). The system shall be able to deploy the TSP-45W in the worst cold case conditions and lowest allowed battery voltage, as well as in the worst hot case conditions and highest allowed battery voltage. The test shall be performed using the same configuration for timers and burn times. The release devices shall be carefully inspected and photographed before and after the test to ensure they were not affected during the test.

## 10.6 LEOP Rehearsal

The main purpose of the LEOP Rehearsal is to perform a dry-run of the Launch and Early Operation phase of the mission. The test is aimed at validating the expected sequence of events (automatically or manually triggered) after the release of the spacecraft in orbit.

## 10.7 Antenna radiation test

In case the space craft verification campaign involves antenna radiation tests, it shall be considered if the solar arrays shall be deployed or stowed during such a test, as this may affect the radiation pattern. In case the solar arrays must be deployed for such a test, an appropriate fixture shall be prepared to off-load the solar arrays.