



## Integrated Truss Structure 3-4-5-6 from ISS

BY  
**MUSTARD** (meshes)  
**BRIANJ** (coding)  
**RUSSH** (coding)

## Summary

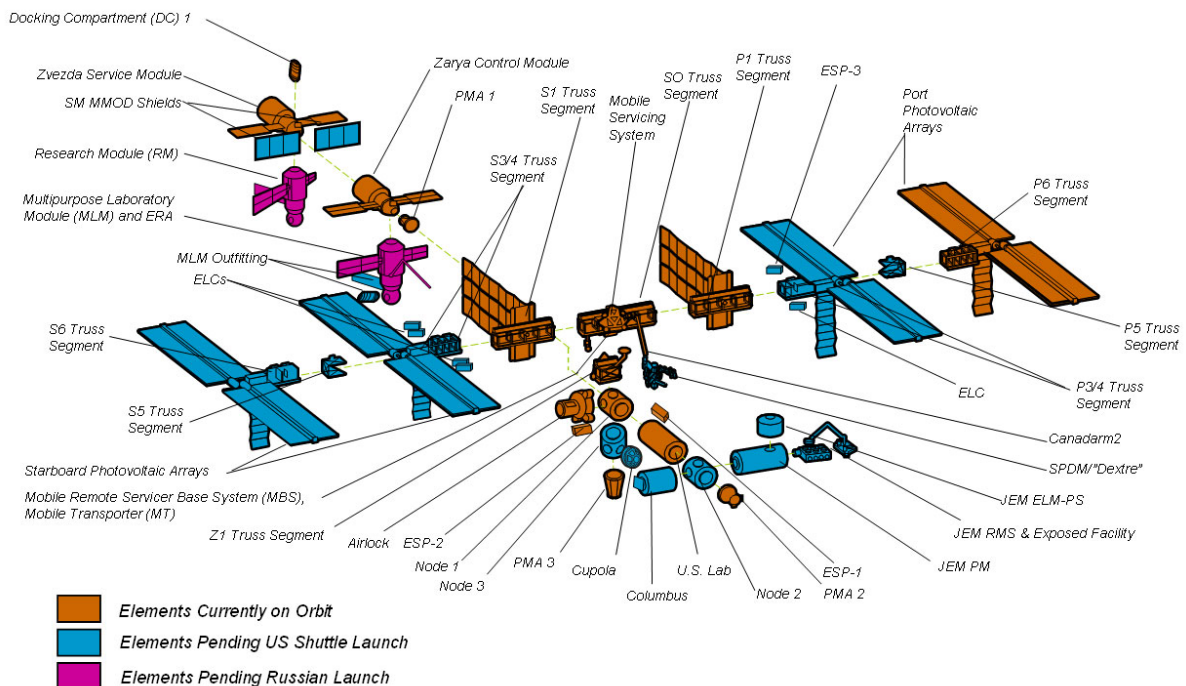
- 1) What are ITS 3-4-5-6 from ISS ?
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### 1) What are ITS from ISS ?

The space station needs energy to power all the systems. For this, it uses solar array mounted on a large Truss over the module Destiny. This truss is composed of modules named S0 (central), S1, S3, S4, S5, S6, and P1 to P6. P# or S# designates Port or Starboard modules. P6 is almost identical to S6, etc. The modules in this add-on can be used for either the port or Starboard modules, so we will use the generic name from Nasa for each module in this Truss: **ITS**, for Integrated Truss Structure ([http://en.wikipedia.org/wiki/Integrated\\_Truss\\_Structure](http://en.wikipedia.org/wiki/Integrated_Truss_Structure)). So we won't speak about P6 or S6 but ITS6. This will simplify the designation.

## ISS Configuration

As of April 2006

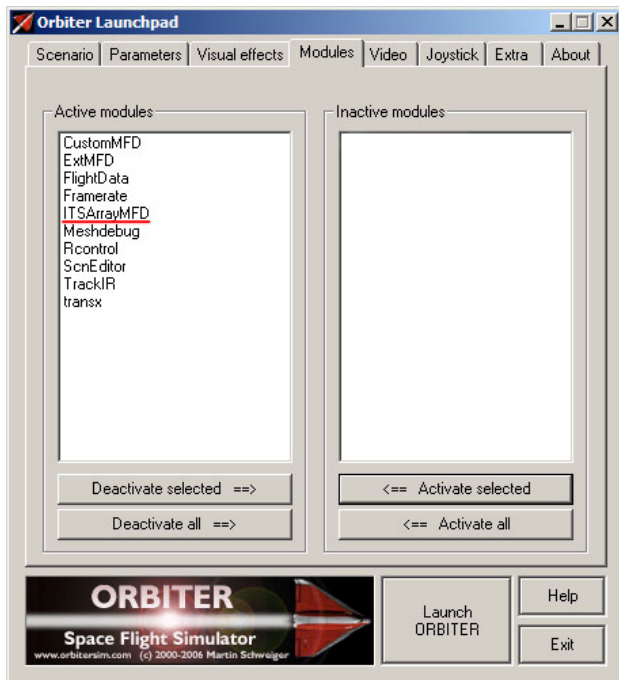


The solar panels are mounted on the modules ITS-3/4 and ITS-6 (remember S3/4, S6, P3/4, P6). The whole is rotated by the Solar Alpha Rotary Joint (SARJ) on module ITS-3 which has given NASA some problems. Each solar module has solar panels and radiators to remove the heat from the station equipment, etc. To allow the assembly of several solar modules end to end, it's necessary to insert an intermediate module named ITS-5.

## 2) Installation

Just Unzip archive in your Orbiter directory.

Next, you must activate the Power management MFD. In the launchpad of Orbiter, go to Modules and select « ITSArrayMFD » in the Inactive module window, and click on the *Activate Selected* button.

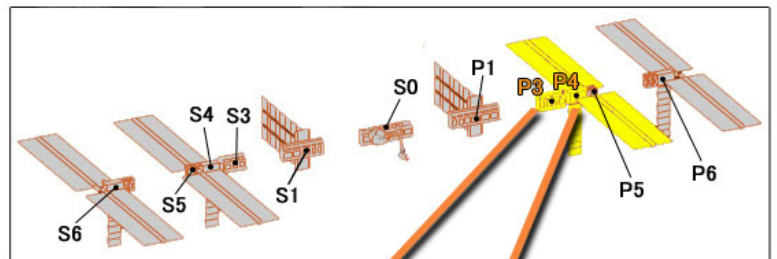


Several example scenarios are available in the scenario directory MBR\_ITS (note : MBR for Mustard.Brian.Russ)

## 3) ITS-3/4

ITS 3/4 is 2 modules in one, one section with the solar panels and radiators (ITS4) and one section (ITS3) for rotation by the SARJ.

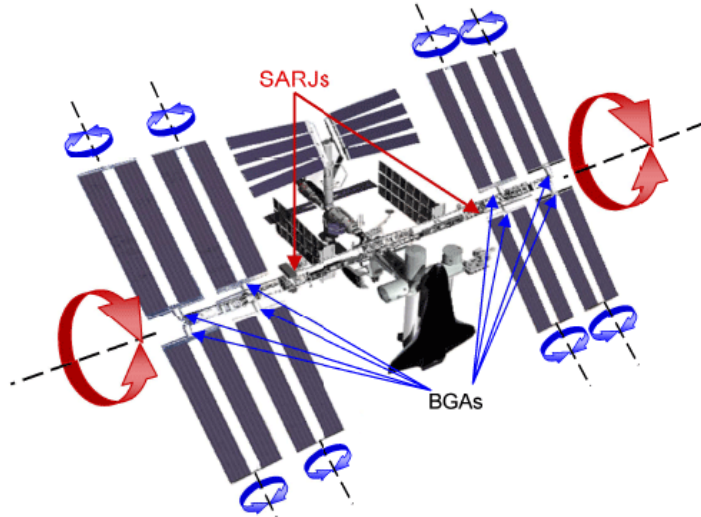
The function of this last part (SARJ) is to rotate the other modules attached to ITS4. So it's not necessary to install a SARJ in ITS-6 (S6 or P6). ITS3 must be the first module installed in a serie of several solar modules end to end.



In the real ISS, the both pairs of solar panels are deployed in the same time, but the complexity of the animation cause a low FPS, so we prefer to choose an alternative deployment. After deployment the FPS becomes normal.



The solar panels have an active side with black cells, and an inactive side in orange. The motors for the solar panels rotation, big cylinders, are named BGA (Beta Gimbal Assembly) by NASA.



#### 4) ITS-5

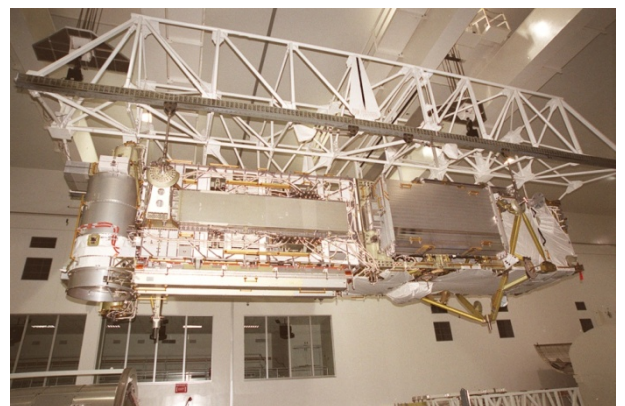
It's not possible to connect a solar Module (ITS6) directly to another Solar module due to the position of the BGA's. You must use an intermediate module named ITS5. Whole function is to provide the necessary clearance of the BGA's.



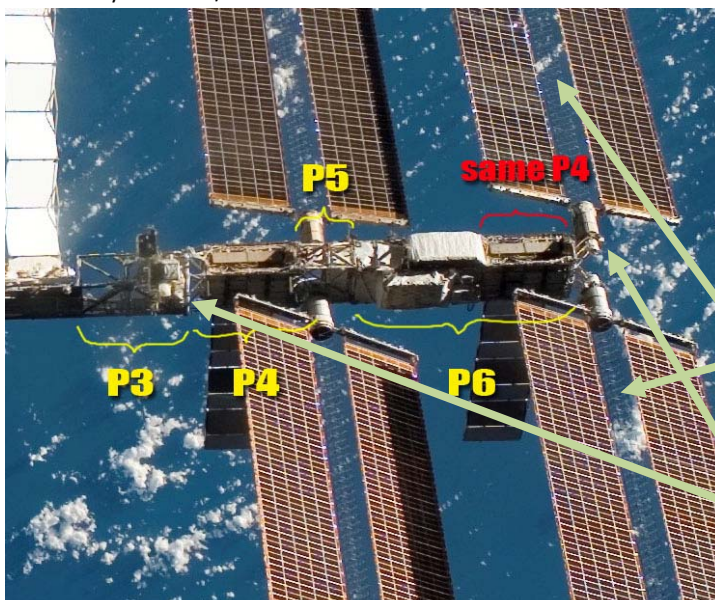
#### 5) ITS-6

ITS-6 is very similar to ITS 3/4. In fact, only the ITS3 part (with the SARJ) is replaced by a truss with radiators, which was used temporarily (not active in this add-on).

ISS has only ITS3/4-5-6, but if you want, you can add others ITS5 and ITS6 to mount 4 or 6 or more solar modules. You must just increment the name of this others modules (ITS7-8-9-10, etc)



ISS assembly with ITS3/4-5-6 :



Note :each solar modules have 2 pairs of solar array. We named it like this :

Panel AB

Panel CD

Motor BGA

Motor SARJ

## 6) Assembling of the ITS modules

Normally we would use a *Docking port* for attaching modules to each other. However, this presents a problem when attaching anything to ITS3\4 since docking ports cannot be rotated. Thus, anything docked to ITS3\4 will not be rotated when the SARJ rotates.

Fortunately, there is a solution - we can use an *Attachment point*, just like the Shuttle RMS arm.

The procedure for attaching ITS5 module to ITS3\4 module is similar to docking the ITS3\4 module to an ISS/station module, except that capture must be performed manually.

Use the Shuttle RMS (or ISS RMS) to place the ITS5 in position at the end of ITS3\4, enclosing the BGA's. Next you must release the ITS5 module from the RMS. Switch focus to ITS3\4 and press key **N** to capture ITS5.

The procedure for attaching ITS6 to ITS5 is similar, capture is performed by switching focus to ITS5 and pressing key **N**.

You can release a module by pressing key **M**.

Hint: by ticking the «Show Grapple Points» box on the Shuttle RMS Control window, you can see the red and blue arrows indicating the attachment points. The tips of the arrows must be within 0.3m of each other to achieve capture.

Note: Attachment points use a Parent/Child hierarchy. The receiver module is the Parent, and the new module mounted is the Child. Note that a Child module can become Parent for the next module.

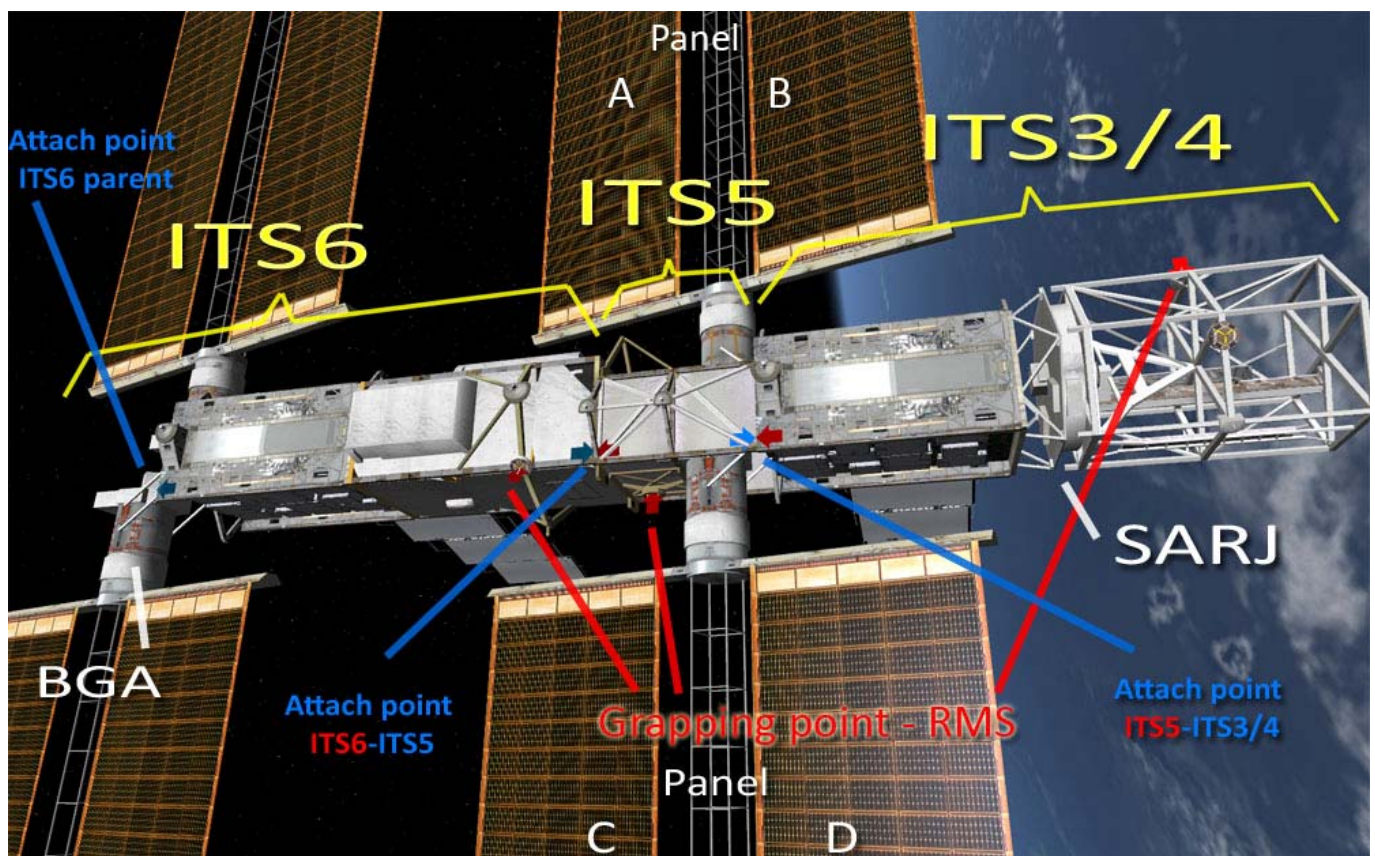
In short, ITS3/4 must be dock on your station by a classical docking port.

ITS5 uses an *Attachment point* to ITS3/4 (parent)

ITS6 uses an *Attachment point* to ITS5 (parent)

You can attach a new ITS5 on ITS6 by a *attach point*, etc (don't forget to rename it to avoid a conflict name).

So all objects which must rotate with the SARJ of ITS3\4 must use an *Attachment point*. Of course, a different add-on to ITS5 or ITS6 can be adapted to have an *Attachment point* and mounted on these modules. An add-on with a *docking port* can't be assembled on them.



On this pic, the Attachments are possible when the red and blue arrows are close, and capture active (N key). The grapple point for the Shuttle RMS capture are in red.

These modules use DLLs, so you can use multiple instances of them in the same scenario. You can have P3P4, P5, P6, and S3S4, S5, S6 simply by renaming them in the scenario file (see chapter 8).



## 7) Keys used and HUD options

All the possible actions are in the HUD interface, in cockpit view. We have:

- G** : Deployment of the solar panels and radiators
- K** : Auto Sun tracking on/off
- N** : Capture of the child module (if attachment point within 0.3m)
- M** : Release of the child module attached

If the Sun Tracking is inactive you can move manually the position of SARJ and BGA :

- Numpad 1,2,3** : SARJ's Rotation, CW, Stop, CCW. Only available with ITS3/4
- Numpad 4,5,6** : BGA's Rotation (solar panels AB), CW, Stop, CCW
- Numpad 7,8,9** : BGA's Rotation (solar panels CD), CW, Stop, CCW

On the HUD you can read the electric power output provides by each solar panels of the module, dependant of the orientation. Of course, in the shadow of the earth the energy is none.

*Note : The BGA can't move and no power is generated during deployment.*



## 8) Create a scenario

You can use the example scenarios included in this pack to create your own.

Modules ITS use DLL, so you can use one type of module several times. You must just use a different name (in red) in the scenario lines.

For example :

```
P5:MBR_ITS/mbr_its5
STATUS Orbiting Earth
RPOS 3746536.17 5110311.36 -2256355.44
RVEL 6207.906 -4554.265 -19.285
AROT 9.02 -6.90 179.12
ATTACHED 2:0,P3P4
NAVFREQ 0 0
END
```

```
S5:MBR_ITS/mbr_its5
STATUS Orbiting Earth
RPOS 3746526.41 5110297.10 -2256429.51
RVEL 6207.906 -4554.265 -19.285
AROT -170.98 6.90 -179.12
ATTACHED 2:0,S3S4
NAVFREQ 0 0
END
```

If you want use several modules ITS-5 after a P6 et S6 you can add it in the scenario and name it P7 and S7 etc ...

## 9) Power output

Power output for each SolarArrayWing(SAW) is displayed on the HUD and the ITSArrayMFD.

Power is generated only if SAW is completely open.

Auto Sun-Tracking Pointing Error = 0~3 deg (random variable changes slowly over time).

### Power Output calculation:

-32.8kW per SAW , 2 SAW's per module.

- Output from rear-facing side of SAW (in direct illumination) assumed to be 30% of front-facing side (in direct illumination).

Earth Albedo assumed to be 0.35 .

### Earth Albedo flux approximated by:

Direct Solar flux \* Earth Albedo \* cos(Sun-Earth-Array angle)

### Direct Solar Illumination:

Output = 29.6832 kW \* cos(Sun-ArrayNormal angle)

If Sun-ArrayNormal angle > 90deg, rear-facing side is illuminated, so:

Output = 29.6832 kW \* -cos(Sun-ArrayNormal angle) \* 0.3

### Earth Albedo Illumination:

Output = 29.6832 kW \* cos(Earth-ArrayNormal angle) \* cos(Sun-Earth-Array angle) \* (EarthAlbedo)

If Earth-ArrayNormal angle > 90, rear-facing side is illuminated, so:

Output = 29.6832 kW \* -cos(Earth-ArrayNormal angle) \* cos(Sun-Earth-Array angle) \* (EarthAlbedo) \* 0.3

SAW Total Output = (Direct Solar Illumination + Earth Albedo Illumination) \* (% Sun disc visible)Power Output and Remote

Control data exchanged between ITS .dll's and ITSArrayMFD .dll via

### KEY COMM method described here:

<http://www.orbiterwiki.org/wiki/KeyComm>

See enclosed .cpp's for keystroke "channels".

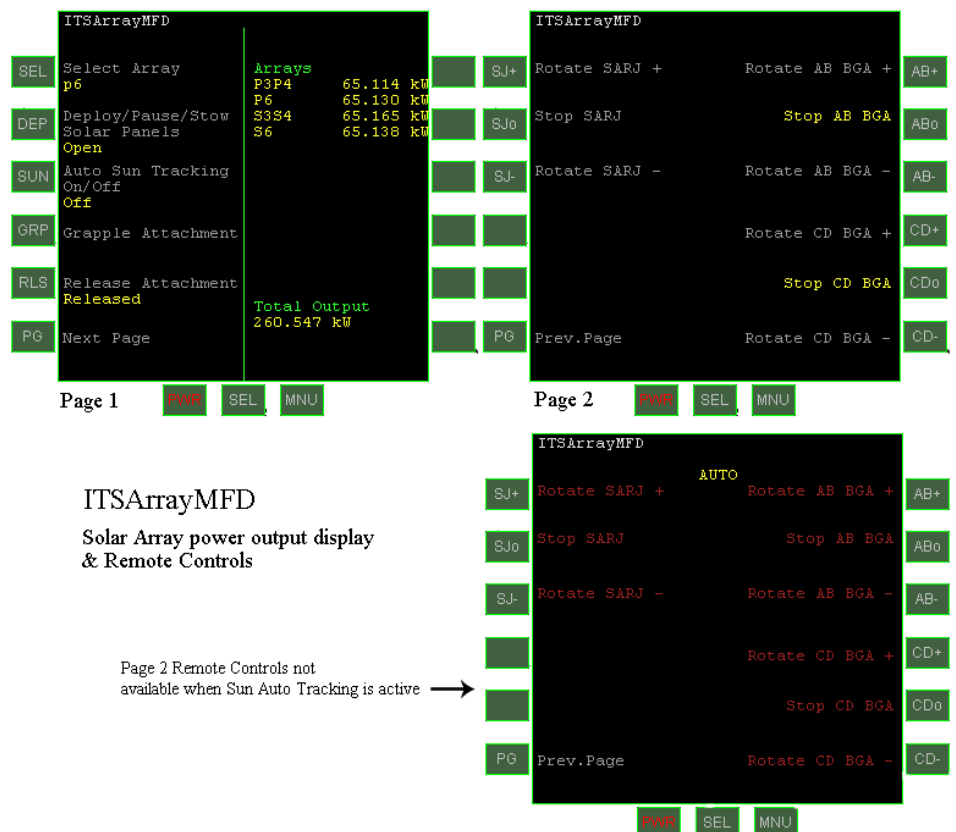
More info:

[gltrs.grc.nasa.gov/reports/2002/TM-2002-211724.pdf](http://gltrs.grc.nasa.gov/reports/2002/TM-2002-211724.pdf)

<http://www.grc.nasa.gov/WWW/RT/2003/6000/6920gustafson.html>

<http://www.grc.nasa.gov/WWW/RT/2003/6000/6920delleur.html>

You can also activate the functions of the solar arrays by the MFD "ITSArrayMFD". Don't forget to activate this module in Orbiter (read chapter 2)



## 10) Thanks

3D realised by Mustard with Anim8or, manager of the project.

Coding by BrianJ & RussH, which realised an awesome work long and hard. Thanks to them for their essential and wonderful work.

Thanks to the members of the francophone and anglophone's forums, for their passion, their patience and their support in this long project.

And finally thanks to Dansteph for the hosting of the francophone's addons website.

Website francophone of Orbiter : <http://orbiter.dansteph.com/forum/index.php>

Official website of Orbiter : <http://www.orbitersim.com>

Official Forum of Orbiter : <http://orbiter-forum.com/index.php>

Mustard's website with the francophone's addons : <http://orbiter.mustard-fr.com/>

To contact me : [mustard27@orange.fr](mailto:mustard27@orange.fr) or on the Orbiter forum Fr or english.