Flat Flexible Cables (FFC) in Picosatellites

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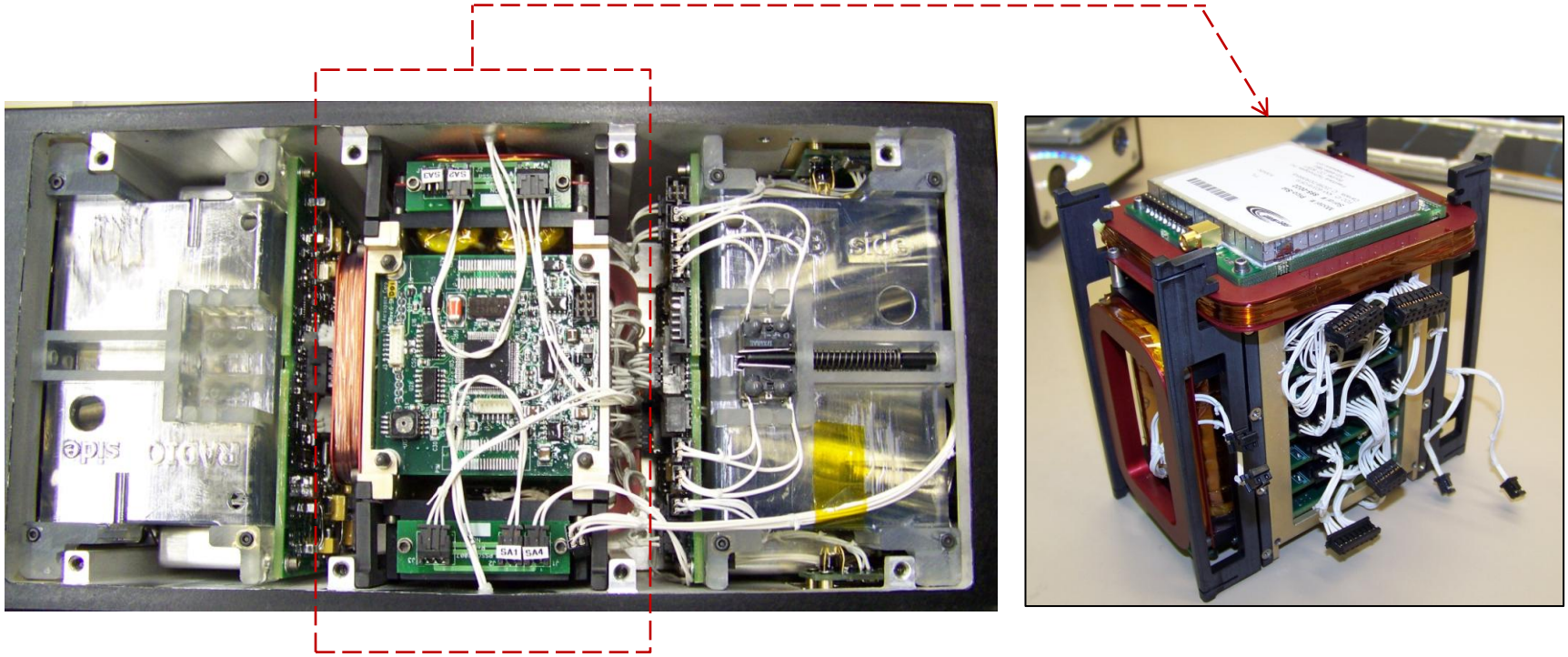
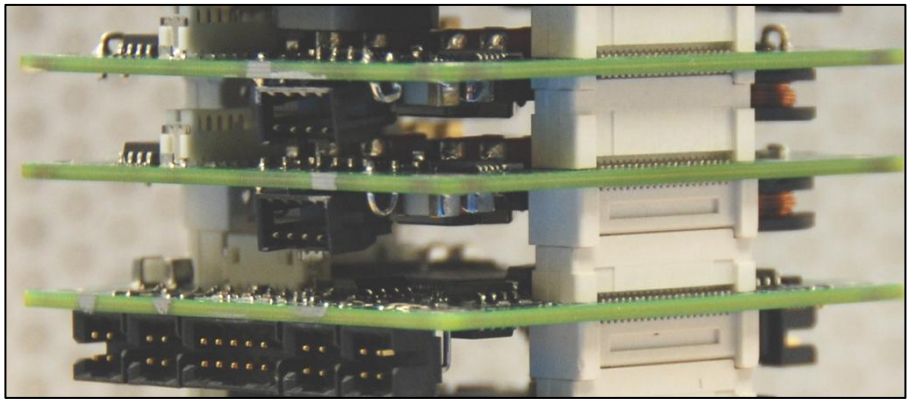
Motivation: PSSCT-1 Crimp-Harnesses



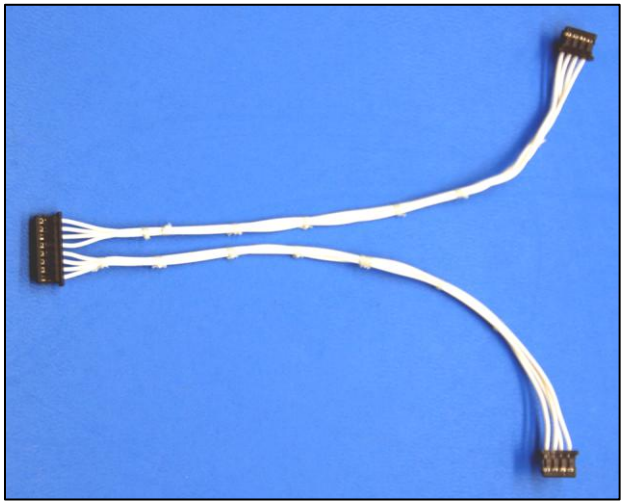
- **Get rid of the mess!**
- Make better use of our internal volume.
- Make assembly and disassembly of the satellite quicker and easier.

Common Harnessing Methods

1. Board-to-Board
   - *Avoids harnessing*
   - *Convenient*
   - *Reliable*
   - *Requires planning*
   - *Restrictive*
   - *Long lead time*

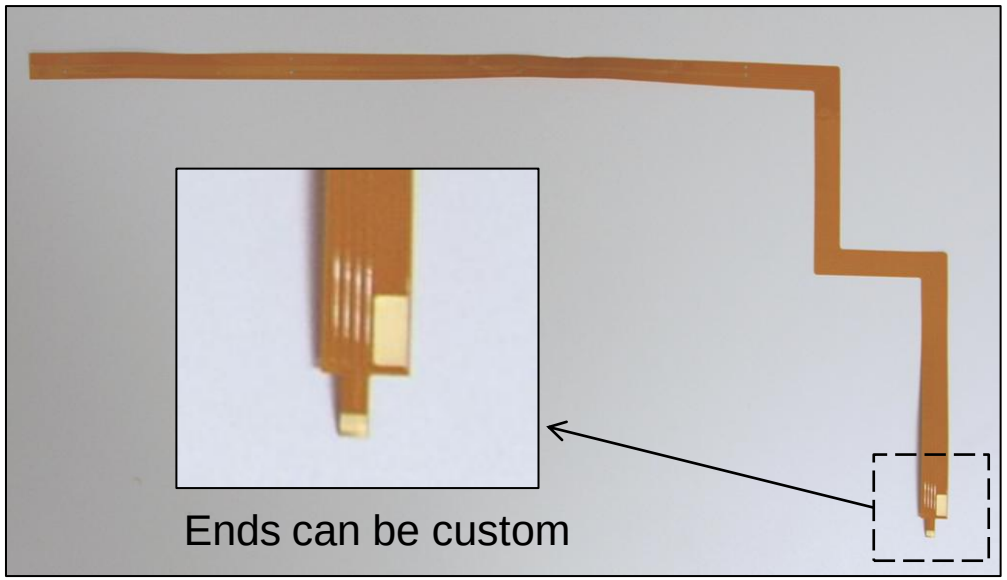


2. Board-to-Wire
   - *Reconfigurable on the fly*
   - *Place components where they need to go*
   - *Constructed after mechanical assembly*
   - *Can be unreliable*
   - *Cable management required*
   - *Prone to mis-wiring (need test harnesses)*



Alternative to Wire-to-Board Crimp Type Harnessing

- Flat Flexible Cable (FFC) are single copper layer between two layers of insulation
- FFC are available as off-the-shelf straight sizes of fixed lengths
- Make your own custom shape, with higher current capability
  - *For reference: a single layer design, 5 pcs delivered, is ~$1500*
  - *Advice: have the custom vendor send you a sample first*



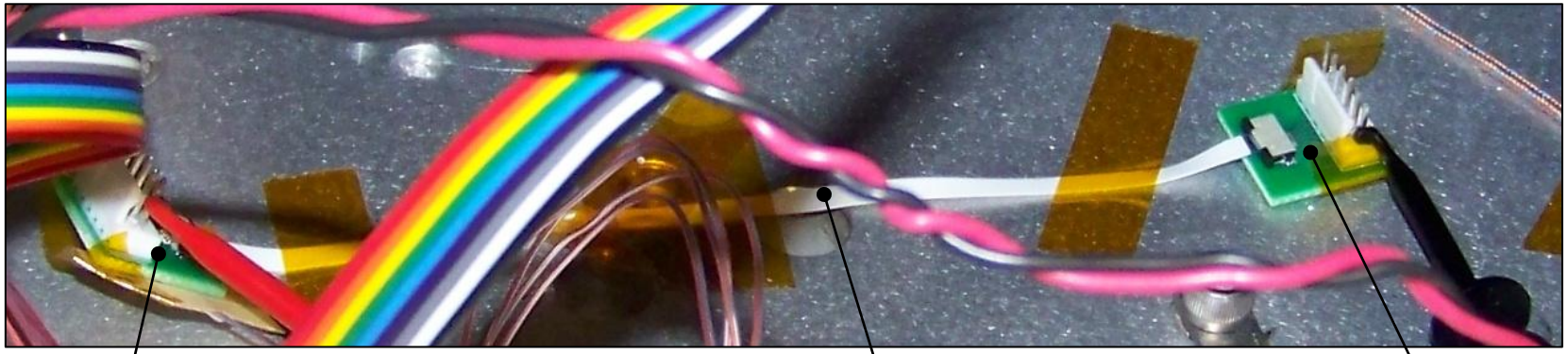
Benefits of using FFC

- Cables can run through narrow clearances or adhered to the body of the spacecraft
  - *Particularly useful when running cables with many contacts*
- Cables can be routed such that there is no confusion as to what connector they route to
  - *Difficult to shift a FFC sideways along its plane to connect it to an identical connector. Chances are that you will damage it.*
- FFC cables efficiently stack on top of one another to route to different PCB's on an electronics stack (which are also stacked on each other…)
- Cabling mistakes are a thing of the past in mass production
  - *Cables can be mass produced which results in less time spent worrying if a cable is wired correctly*
  - *Each CubeSat that is produced will take less time to build which results in cost savings*

Drawbacks of using FFC

- Due diligence is needed in the initial design stage to accommodate for harness routes
  - *Result: Design phase may take longer*
  - *Orientation of harness needs to be considered with every board made*
- Must remake an incorrect FFC (cannot rewire..)
  - *$1500 typical for a custom cable (5 piece lot)*
  - *2-3 week turnaround or longer for “reasonably priced” custom cables*
- Contacts wear out faster than typical “crimp” contacts
  - *Advice 1: use one of your 5-piece lot as the workhorse and keep the others pristine for flight*
  - *Advice 2: use standard FFC off-the-shelf (if not a high current special application) for engineering and development to not waste polyimide high price custom cables*

Verifying FFC Connector 0.5 A Max Limit in Vaccuum



End #1
Thermistor under connector daughterboard

6 inch FFC off-the-shelf thermally bonded at 3 points (similar to application)

End #2
connector daughterboard

Current (A)	Presssure (mTorr)	Duration (hours)	Final Temperature (deg C)
1.0	35	1.5	27.3
1.5	10	10	33.5
2.0	10	10	41.2
2.5	10	16	50.6

Please repeat this test for your cables and application (i.e. current requirement)

FFC connector far exceeds 0.5A maximum specification

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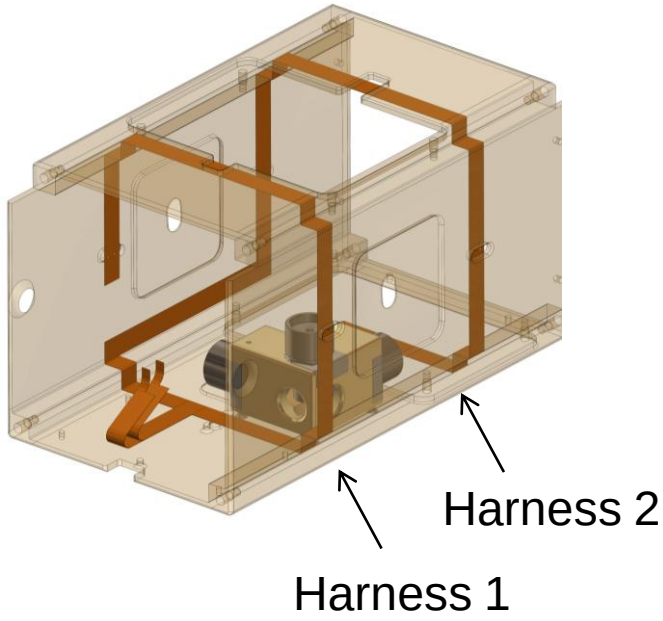
FFC Example: PSSCT-2 Solar Cell Harness

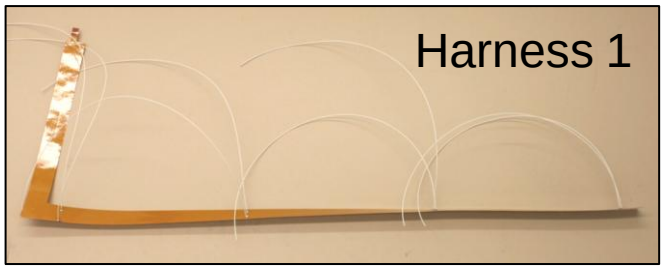
- Problem: PSSCT-2 had 14 solar cells adhered to an aluminum body which required harnessing to the Solar/Battery PCB
- Usual solution: crimp style harnesses BUT clearances are tight so running wires around the SC body was not an elegant solution
- FFC solution: Adhere an FFC to the inside of the satellite body and have PCB thru-holes present on the harness protrude exactly at drilled hole areas on the body where wires could be soldered

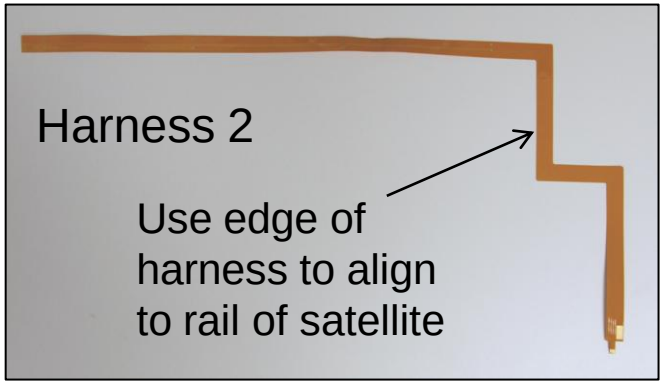
PSSCT-2 Solar Cell Harness

Step 1: Draw harness in Solid Works



Step 2: Use “sheet metal layout tool” to unfold it





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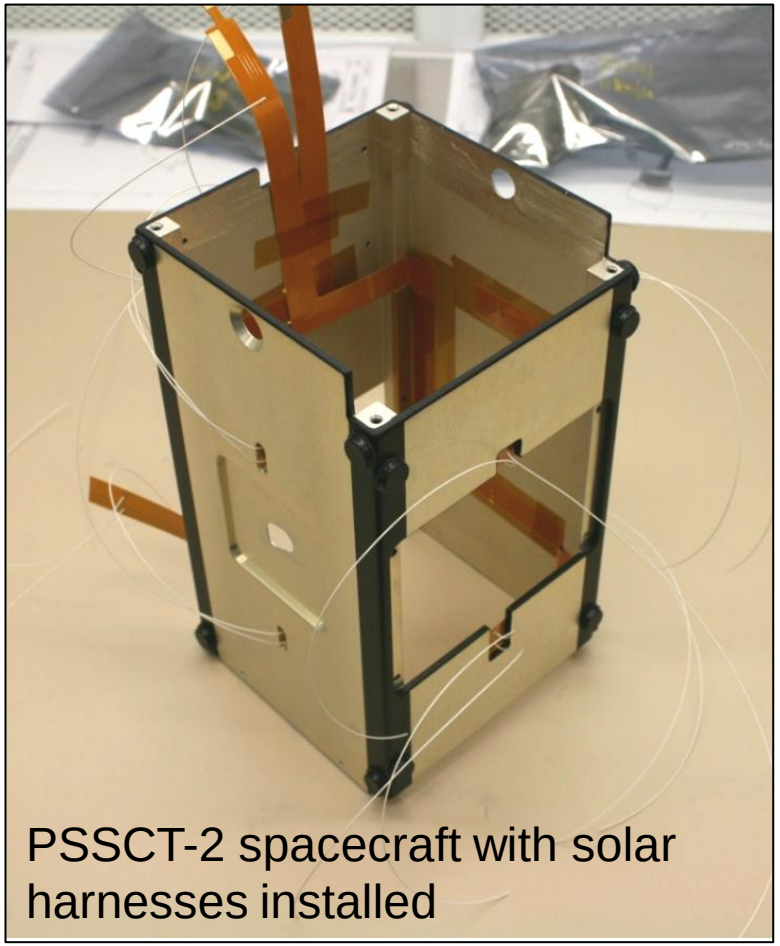
FFC Solar Harness installed into PSSCT-2

Step 3: Fabrication

- *get sample from vendor*
- *look for clean cut ends where they enter FFC connector*
- *look for doubler being well bonded*

Step 4: Use Kapton tape to bond harness to spacecraft wall.

Tape is easily removed so this is good bonding method.



PSSCT-2 spacecraft with solar harnesses installed

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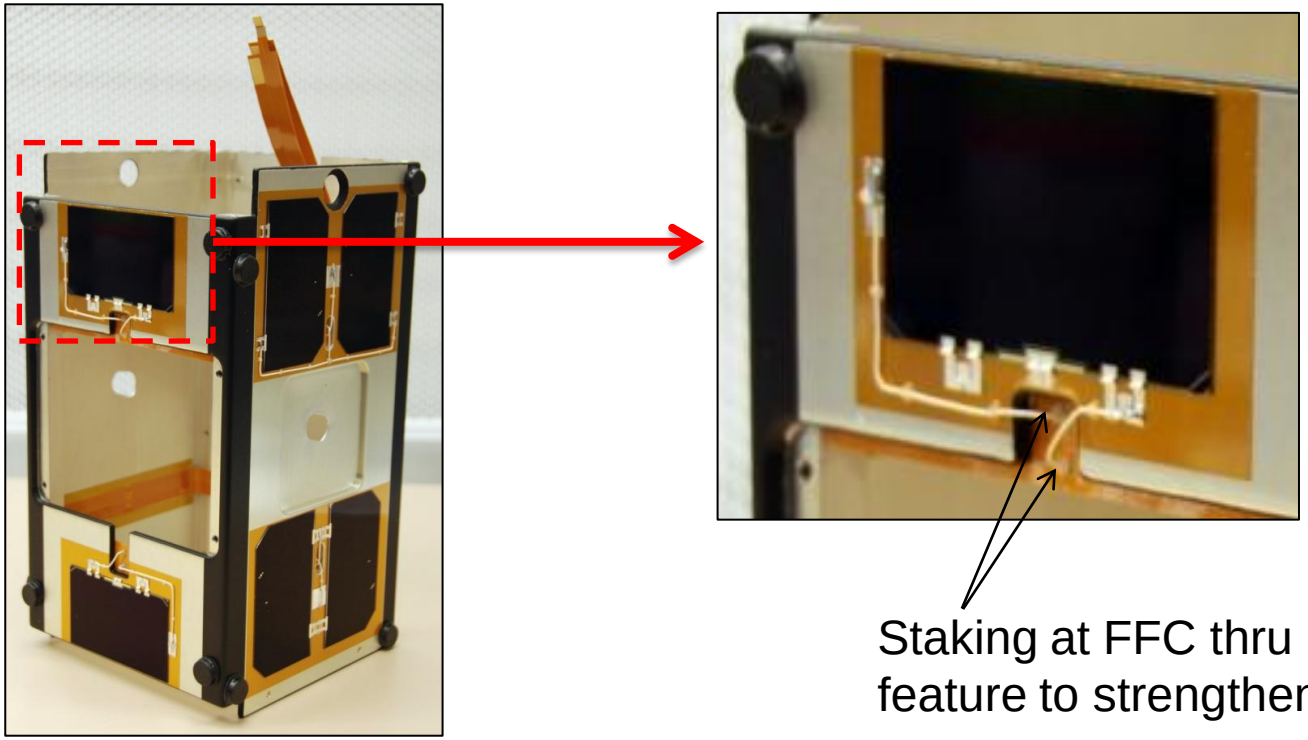
FFC Solar Harness installed into PSSCT-2

Step 5: Run short wires from the FFC to interconnects on the solar cell. Goal is to keep resistance down.

Step 6: Stake the FFC thru hole solder points to protect from debris and for rigidity because FFC thru hole features are weak (tear out). Never put a bend next to a solder joint on a FFC because the FFC will break.



FFC Solar Harness installed into PSSCT-2

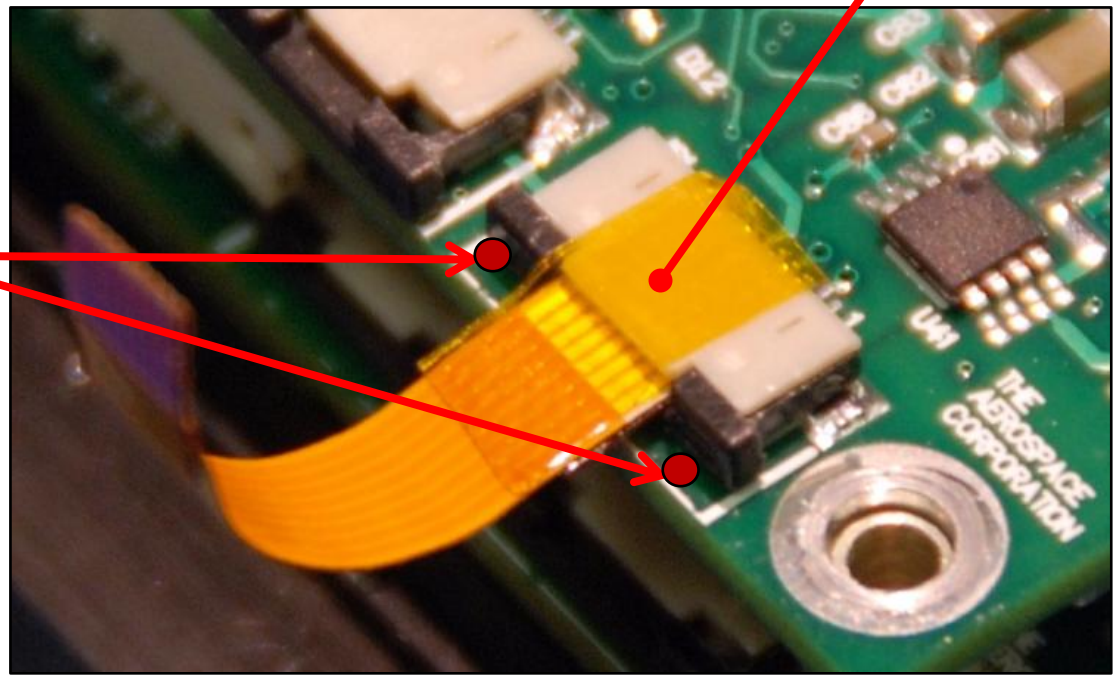
Step 7: Stake the FFC connector to the connector in two ways

a) use a small piece of Kapton tape to prevent FFC pull-out

b) use staking so FFC connector lock stays locked

Kapton tape

Staking points (Recommended: Arathane 5753 A/B with thickener)



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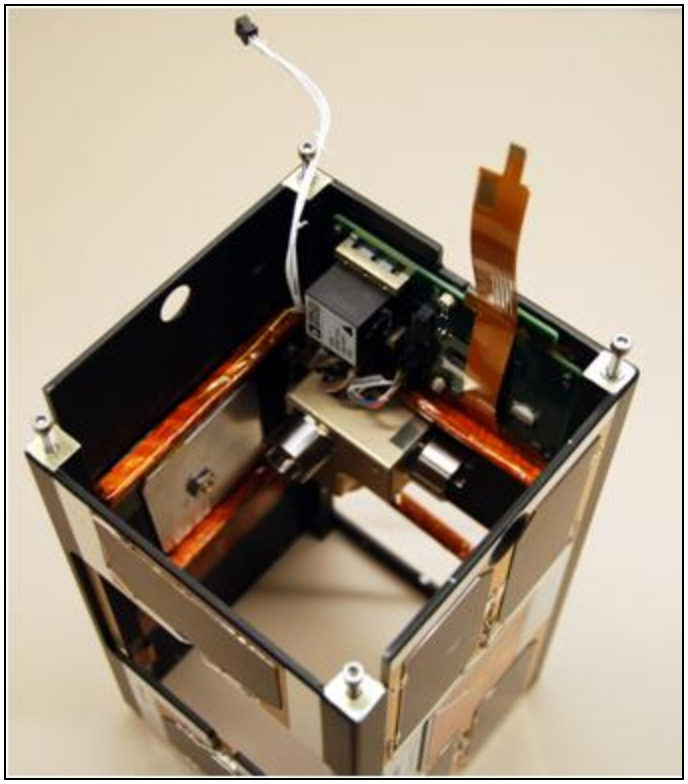
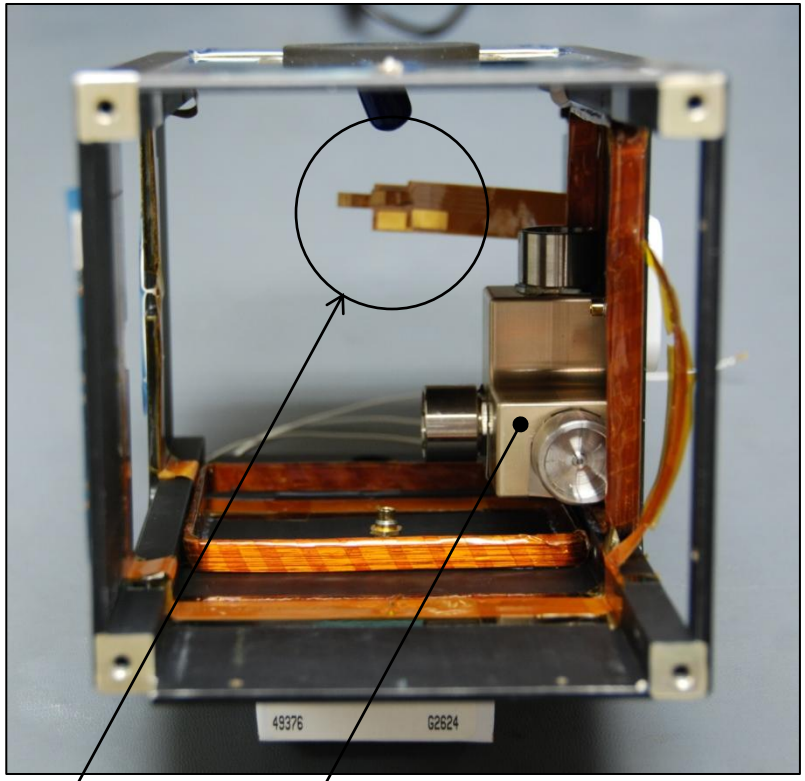
PSSCT-2 with Solar Harnesses Installed





FFC cables are conveniently stacked

Triax Reaction Wheel Assembly

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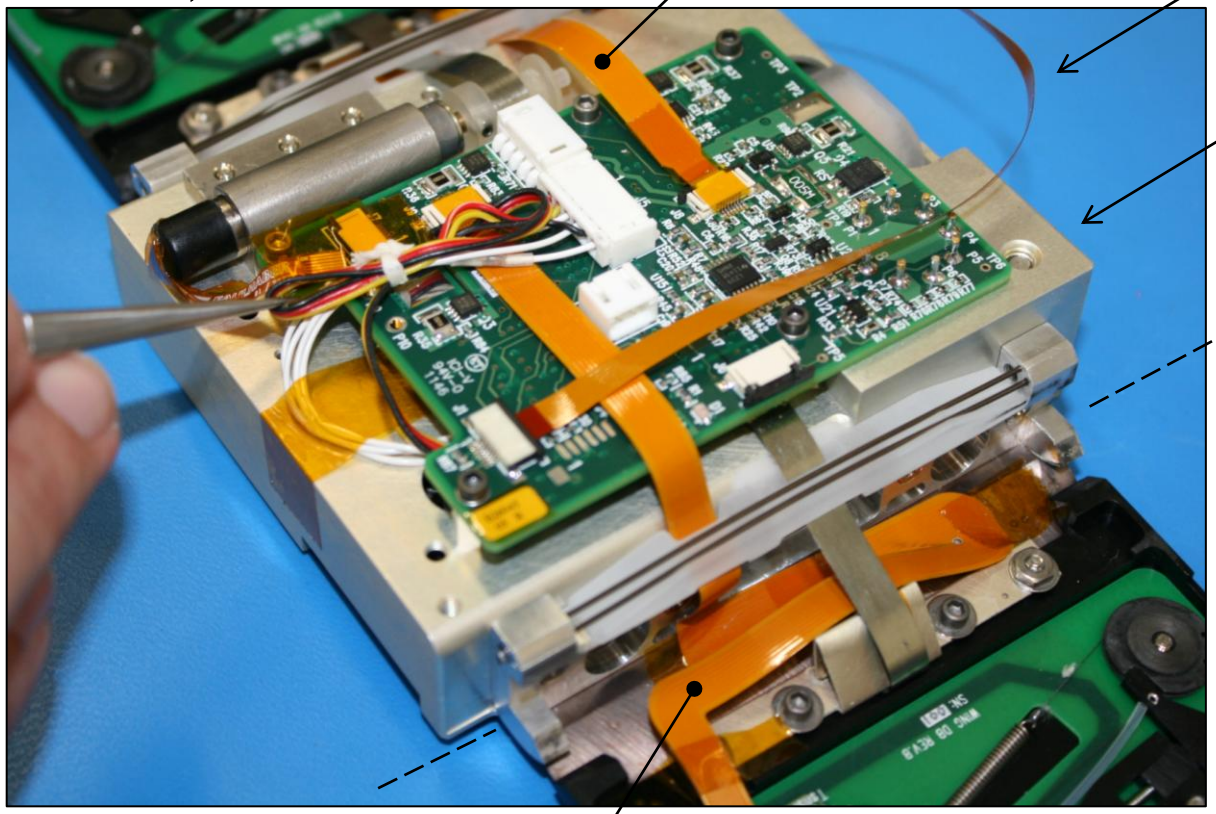
FFC for AeroCube-4 Moveable



Summary

- Flat Flexible Cables (FFC) improve packaging and ease of assembly
- The FFC connectors are rated for 0.5A but can handle more
  - *You can also double up on channels for high current needs*
- Custom FFC are designed with CAD sheet metal tool
- Custom FFC take about 2-3 weeks to fabricate (1 week with rush)
- Custom FFC yield 1 panel for approximately $1500
- Custom FFC can have 1 oz or 2 oz copper just like printed circuit boards
- Custom FFC can have unique features like thru holes or open copper
- Watch out for shoddy work
  - *Get a sample from your vendor*
  - *Look for well cut ends that interface with connector*
  - *Look for well bonded doubler*

Acknowledgements

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(image courtesy NASA and the USAF Space Test Program)