Iris: SmallSat Transponder for Exploration Mission One (And Beyond)

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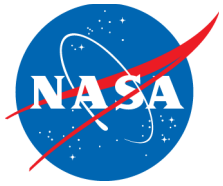
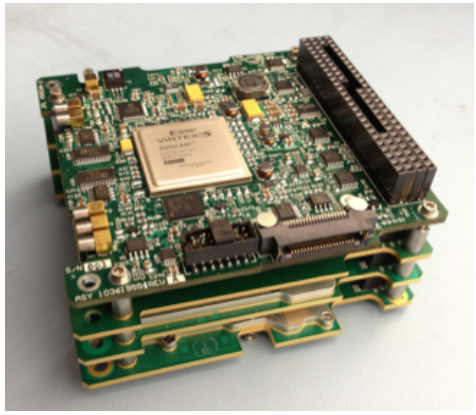
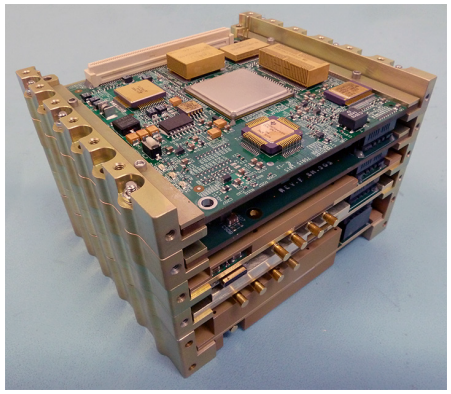


Iris Deep Space Network Compatible SmallSat Compatible Transponder

- Transponder: Communications, Science *and* Navigation support
- Deep Space Network Protocols, Standards, and Techniques supported
- Iris Development Progress
  - V1 – for INSPIRE mission, 2013-2014
  - V2 – for MarCO mission, 2014-2015
  - V2.1 – for EM-1 CubeSats, 2016-2017

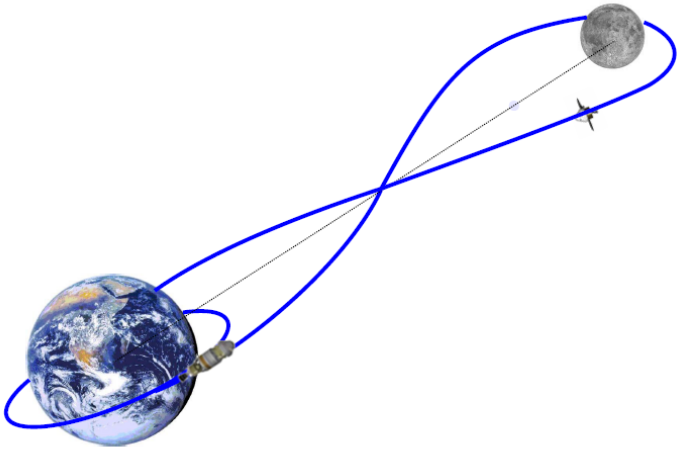


V1



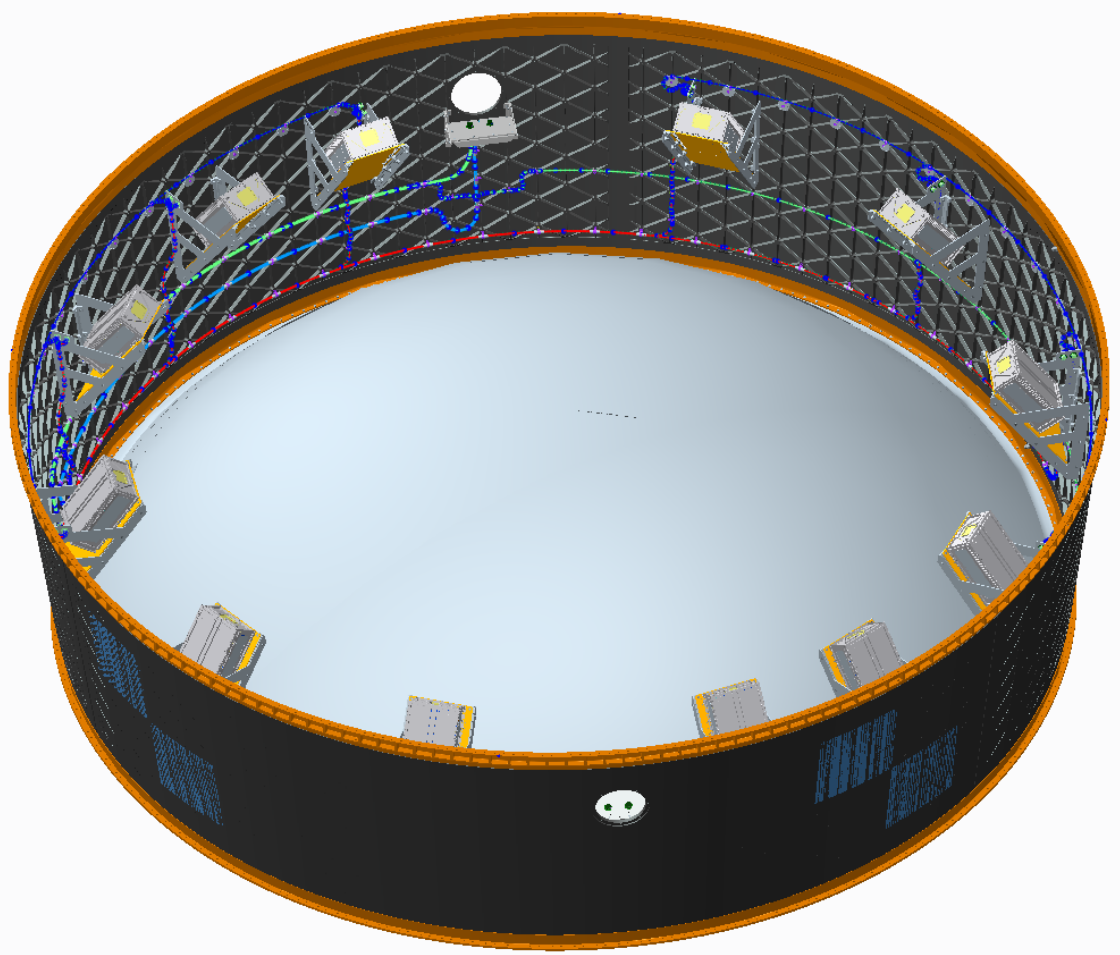
V2

EM-1 – Exploration Mission One



First test flight of
SLS – Space Launch System
The deep space carrier for
Orion crew vehicle.
Launch ~2018

EM-1 Secondary Ring



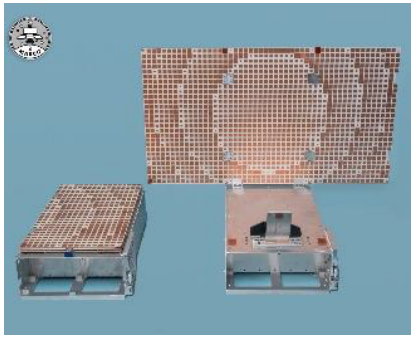
About half going to Cis-Lunar or lunar orbit
The other half to deep space – trailing/leading drift, L1, etc.
Plus “Centennial Challenge” and others

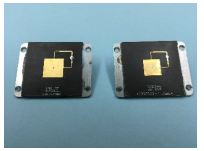
EM-1 6U CubeSats Using Iris V2.1

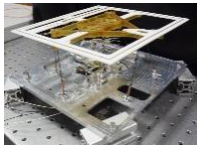
Name	Institution	Mission
BioSentinel	Ames Research Center	Study the impact of interplanetary space radiation on yeast
Lunar Flashlight	Jet Propulsion Laboratory	Estimate the size and composition of water ice deposits on the moon
Near Earth Asteroid Scout	Marshall Spaceflight Center	Fly by and return data from a near earth asteroid
Lunar Ice Cube	Morehead State University	Search for water ice and other resources from above the moon
Lunar H-Map	Arizona State University	Determine the abundance of lunar hydrogen in permanently shadowed craters at the poles
CubeSat for Solar Particles	SouthWest Research Institute	From solar orbit, study the dynamic particles and magnetic fields that stream from the Sun

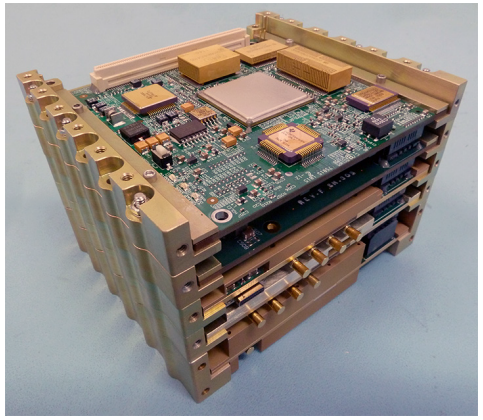
Iris Slice Architecture

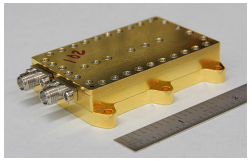
Iris V2 for Mars CubeSat One (MarCo)

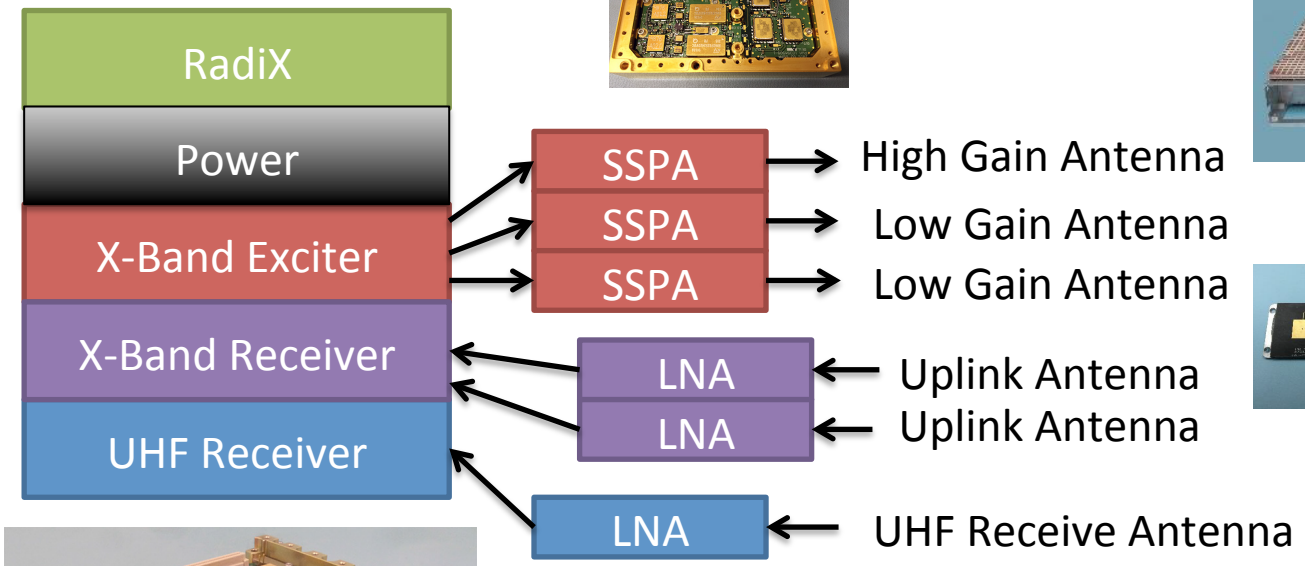










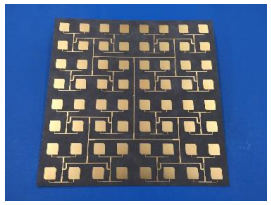


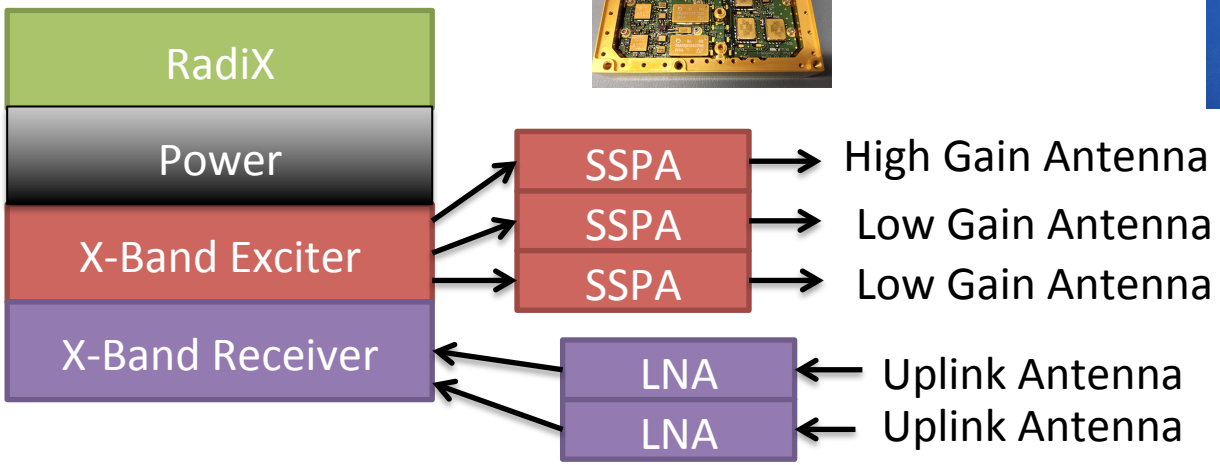
SSPA: Solid State Power Amplifier
LNA: Low Noise Amplifier

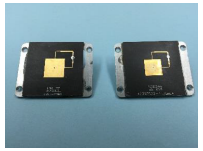
RadiX: Virtex 6 with
- Modems
- LEON3 core
- SPI C&DH I/F

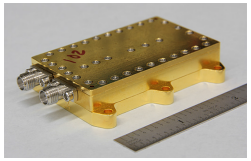
Iris Slice Architecture

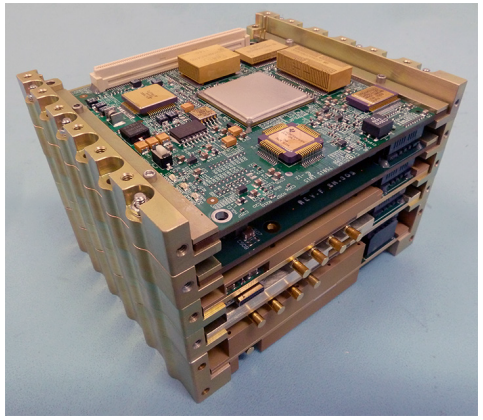
Iris V2.1 for EM-1 CubeSats











RadiX: Virtex 6 with
- Modems
- LEON3 core
- SPI C&DH I/F

SSPA: Solid State Power Amplifier
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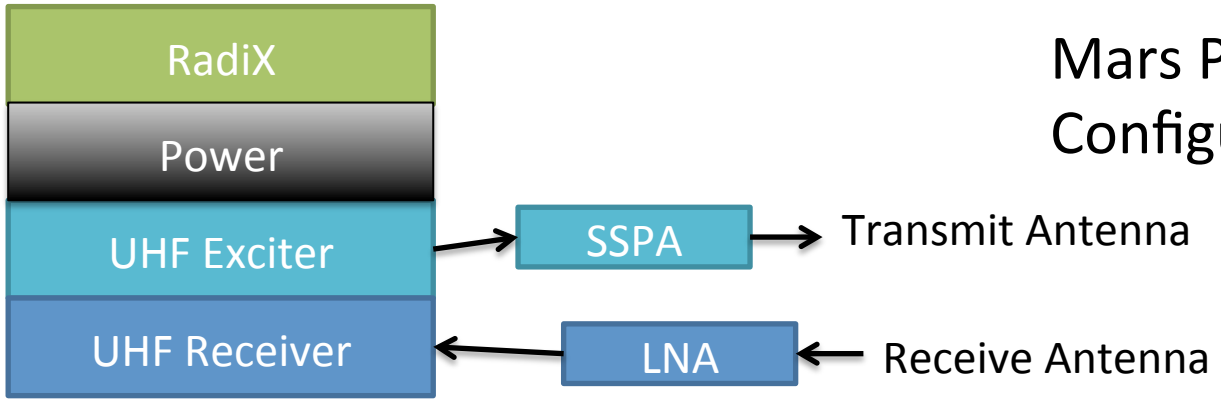
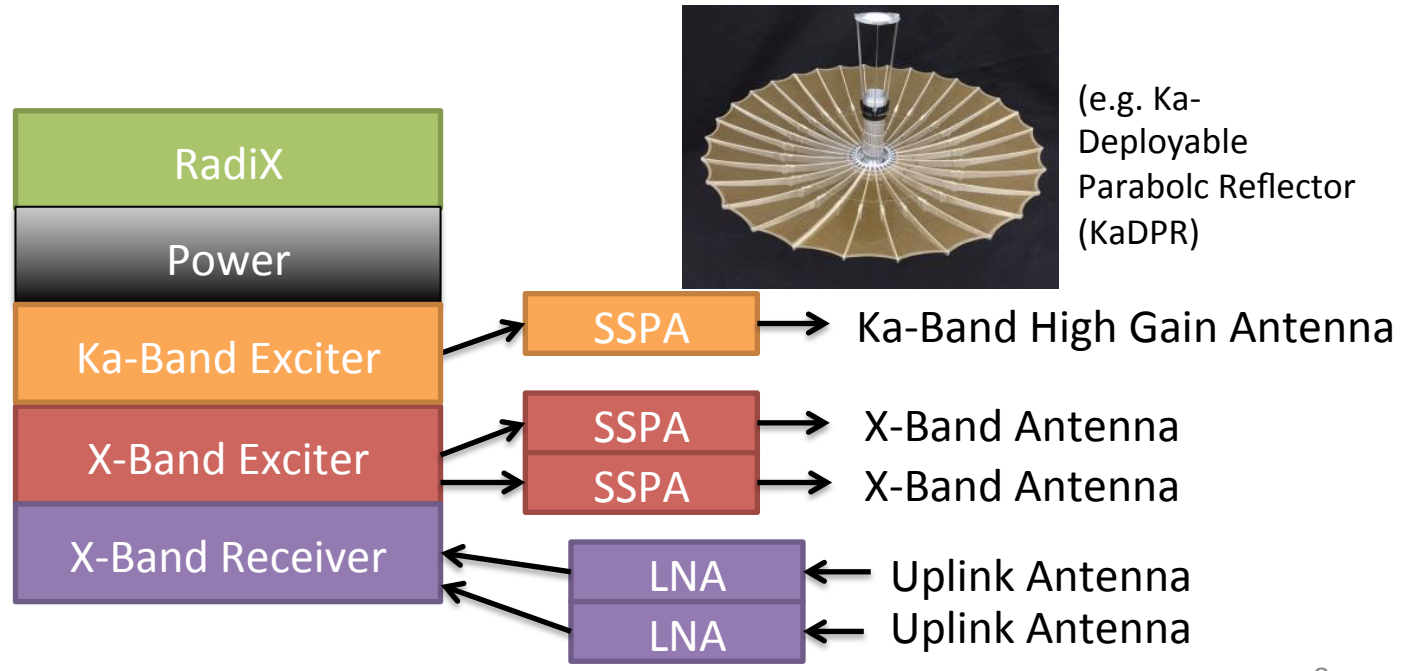
Slice Architecture Examples

Mars Proximity Ops Configuration



Deep Space Ka-Band Configuration



(e.g. Ka-Deployable Parabolc Reflector (KaDPR)

Iris Hardware Slices FY16

Slice	TRL-	Iris Version
RadiX	6	2.0
Power Supply Board	4	2.1 (radiation tolerance updates)
X-Band Exciter	6	2.0
X-Band SSPA	6	2.0
X-Band Receiver	6	2.0
X-Band LNA	6	2.0
UHF Receiver / LNA	6	2.0
UHF Exciter	4	3 (R&D)
UHF SSPA	3*	3 (Proposed)
Ka-Band Exciter	4	3 (R&D)
Ka-Band SSPA	3**	3+ (To be Proposed)

TRL: Technology Readiness Level
*UHF SSPA not difficult, need Iris form factor implementation
**KaDPA Compatible

Iris Navigation / Science FY16

Slice	TRL-	Note
2-Way Doppler	6	DSN certified
2-Way Ranging	6	DSN certified
Delta DOR*	4	DSN certified
1-Way Range	3	R&D
Opportunity Radar	2	R&D (i.e., using reflected telecom signals)
Plasma / Occultation Science	3	Proposed
Gravity Science	3	To be proposed
Proximity Navigation	3	To be proposed

*Delta Differential One-Way Range

Firmware FY16

Slice	TRL-	Note
Downlink Signals, MarCO	6	62.5*, 1000*, 8000 bps, Turbo 1/6
Downlink Signals, general	4	Other 2^N rates, codes, to 256K
Uplink Signals, MarCO	6	62.5**, 1000** bps, BCH
Uplink Signals, general	4	Other 2^N rates, codes
FireCode	6	Spacecraft reset only
FireCode, Iris control	3	proposed
In-Flight Reconfiguration	4	configurations determined pre-launch
Code Division Multiple Access	3	R&D
Safe / Beacon Modes	2	To be proposed
Significant power reductions	2	R&D, and later Iris versions to be proposed

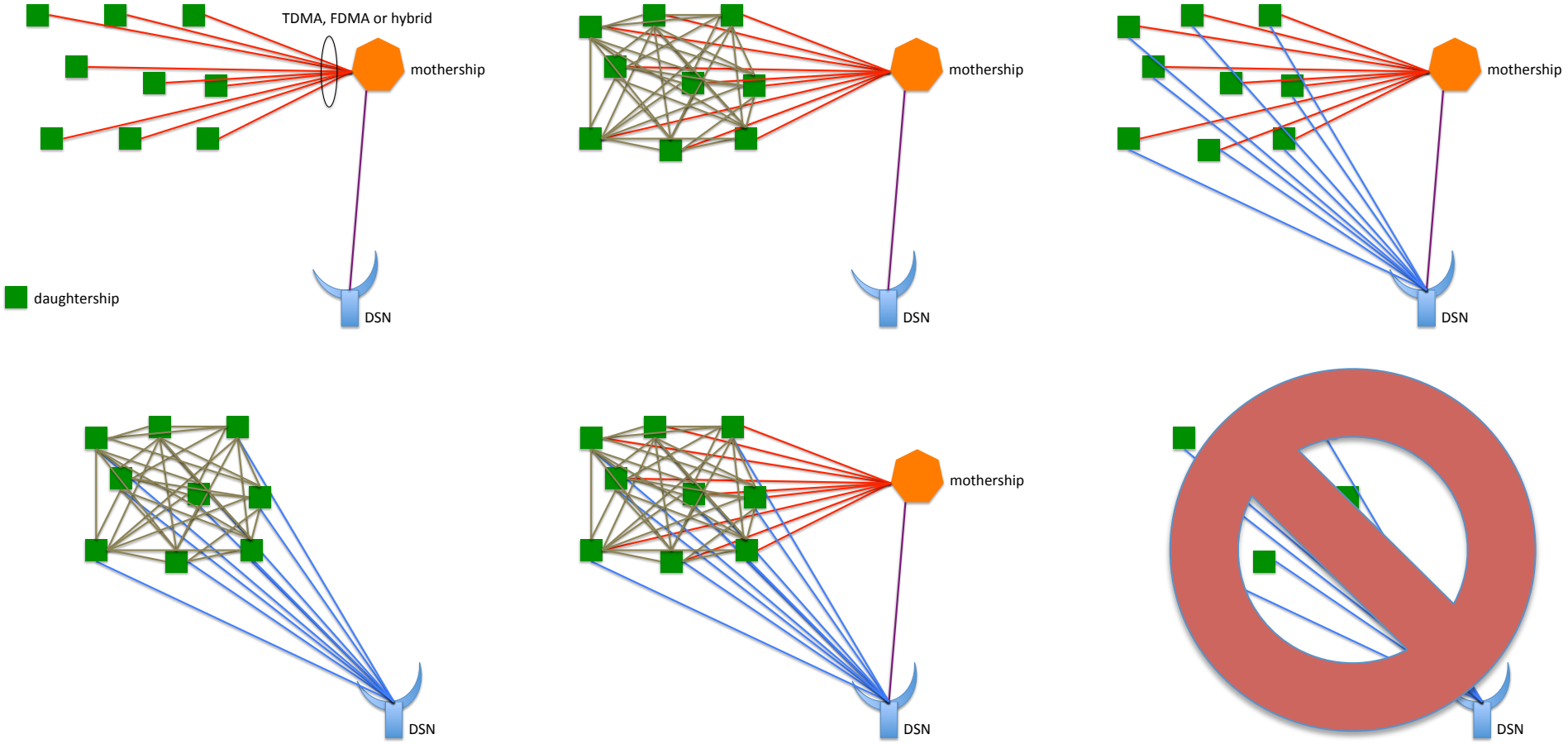
* On 25 KHz subcarrier
** On 16 KHz subcarrier

Software FY16

Slice	TRL-	Note
SPI C&DH interface	6	1 Mbps intra-spacecraft interface
C&DH Command Processing	6	V 2.0
In-Flight Reprogramming	3	proposed
Delay Tolerant Networking	3	R&D
RTEMS operating system	3	R&D
Proximity One protocol	3	R&D

Support for: Networked Constellation Communications Technologies

High-level alternative physical communications architectures



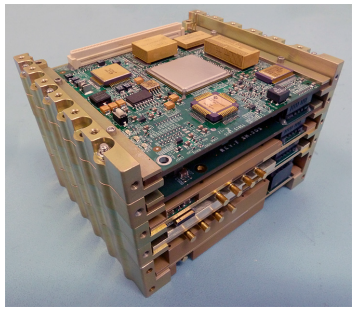
From Joe Lazio and Loren Clare

Constellation Support

- Constellation support enabled by slice architecture and programmability
  - Iris is a Software Defined Transponder (SDT)
- Note: Iris does *one* simultaneous receive and transmit per RadiX board
  - And only *one* antenna each at a time
  - More *simultaneous* signals means more RadiX boards (i.e. Irises)
  - Or operate sequentially, not simultaneously
  - Multiple slices can make multiple bands *available*
- All currently TRL-2-4
  - R&D, proposed, or to be proposed
  - No identified missions today

Summary

- Iris now at V2.1, TRL-6 based on mission needs to date
- Additional slices, programmed features in R&D or proposed
- Constellation and other advance studies supportable



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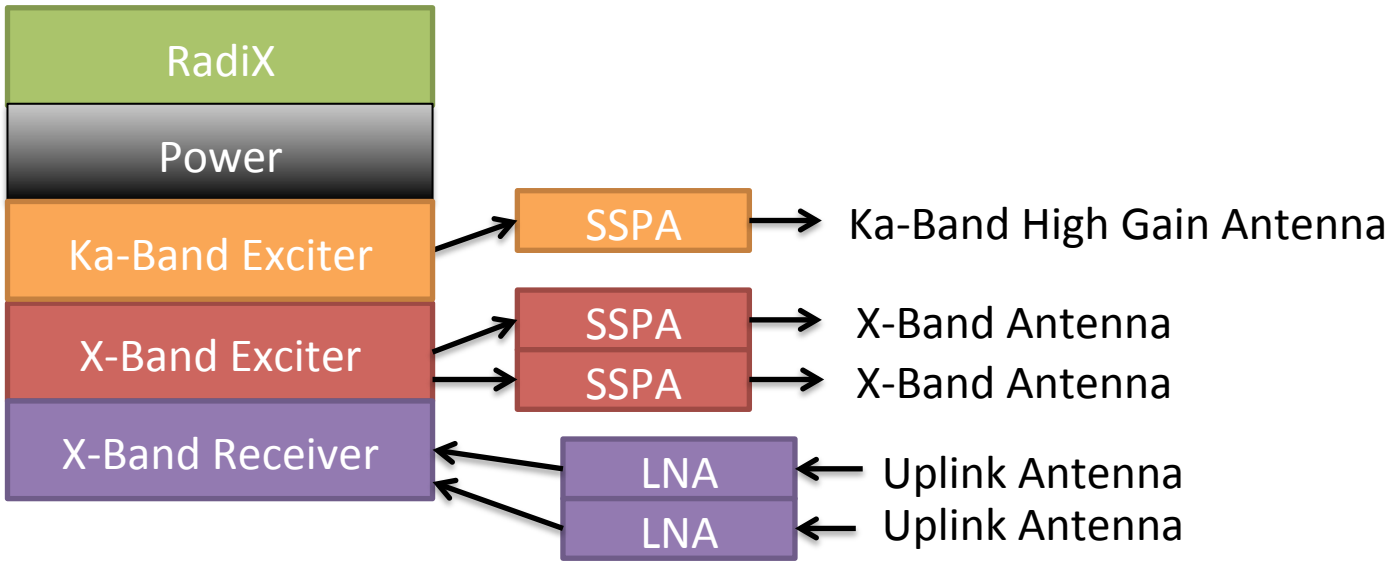

Backup