Development of Adaptable Payload Interface Solutions

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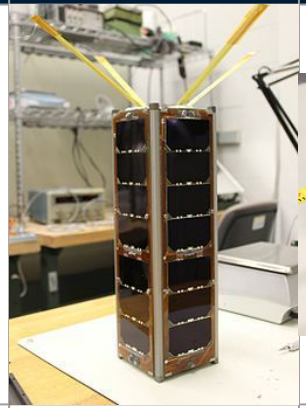
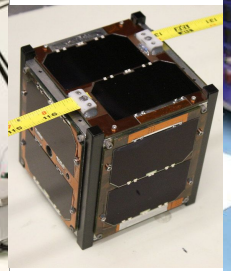
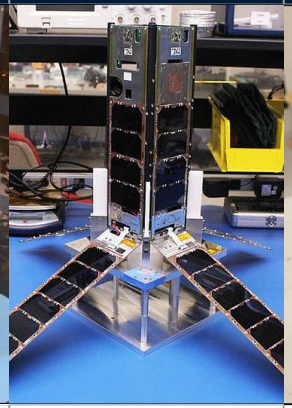
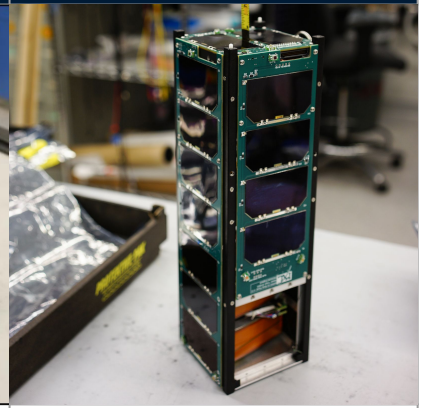
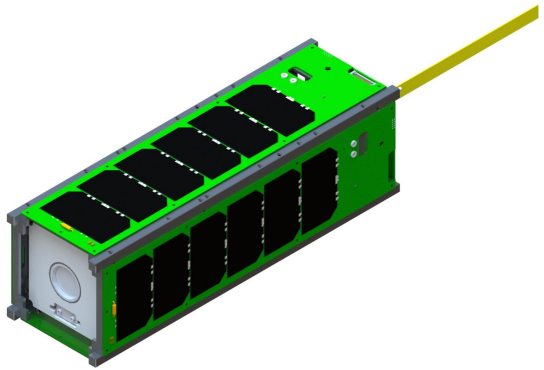
MXL: Low-Cost, Novel, University-Based

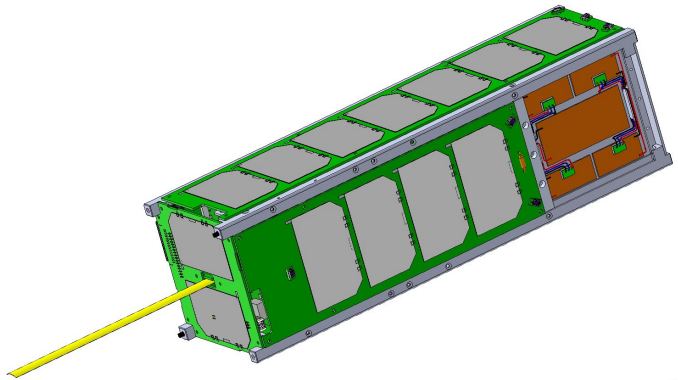
Mission	RAX 1 & 2	MCubed 1 & 2, GRIFEX	CADRE	TBEx	MARIO
		 			
Timeline	2008-2012	2007-2015	2012-2016	2013-pres.	2016-pres.
Cost	$900K (NSF)	$300K, $300K (NASA ESTO, CSLI)	$1.0M (NSF, CSLI, UNP)	$1.4M (NASA, STP)	$375K (NASA SBIR, CSLI)
Partners	SRI International, NASA	UM-S3FL, JPL, NASA	NRL, UM-S3FL, NASA GSFC	SRI Int'l, USAF, NASA	NASA LRC, UM-AIMS, JPL, Extreme Diagnostics

Common Mission Elements

1. Unique payloads from different partners.
2. Heritage bus capabilities.

- How does one accommodate novel payload requirements?
- How do we simplify and improve our payload interfaces?





Approaching Payload Interfaces

Payload Interface - points where the payload connects and interacts with spacecraft bus systems, encompassing multiple aspects.

Payload interfaces are often as varied as the payloads themselves due to **mission goals**, **mission conops**, and **payload requirements**.

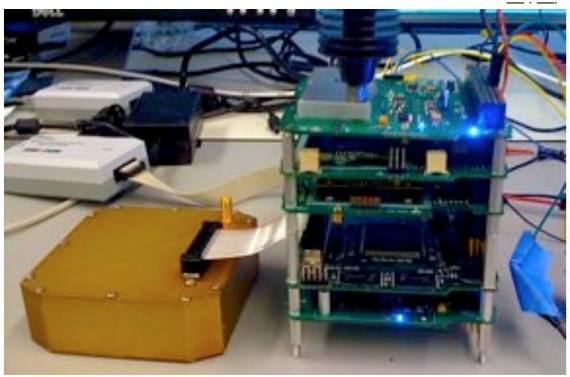
Managed through ***Interface Control Documents*** (ICDs) - “document agreements at every level of design” for “integrating and maintaining relationships between [the payload and bus] segments.” (*SMAD III*).

Interface Regimes

1. ***Structural*** Payload space claim, fasteners, mates, harnesses
2. ***Electrical*** Load on bus EPS, required voltages
3. ***Thermal*** Payload temperature regulation, waste heat generation
4. ***EMI*** Payload-bus hardware interactions, magnetic noise
5. ***RF*** Payload-comms interactions
6. ***Software*** Conops/control scheme, serial protocol usage

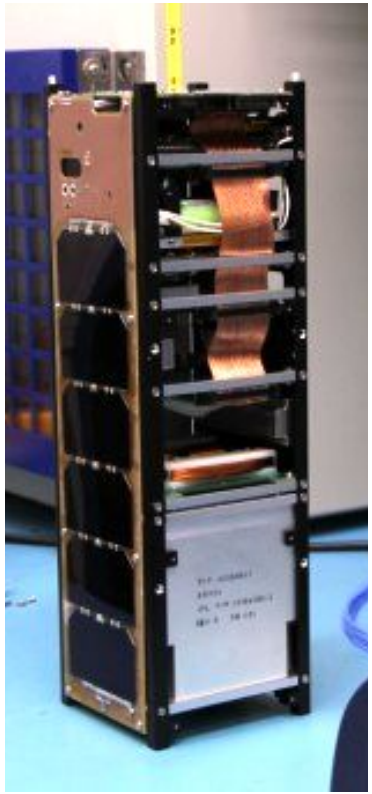
MXL Approach: narrowest interface possible

Lessons: RAX 1 & 2



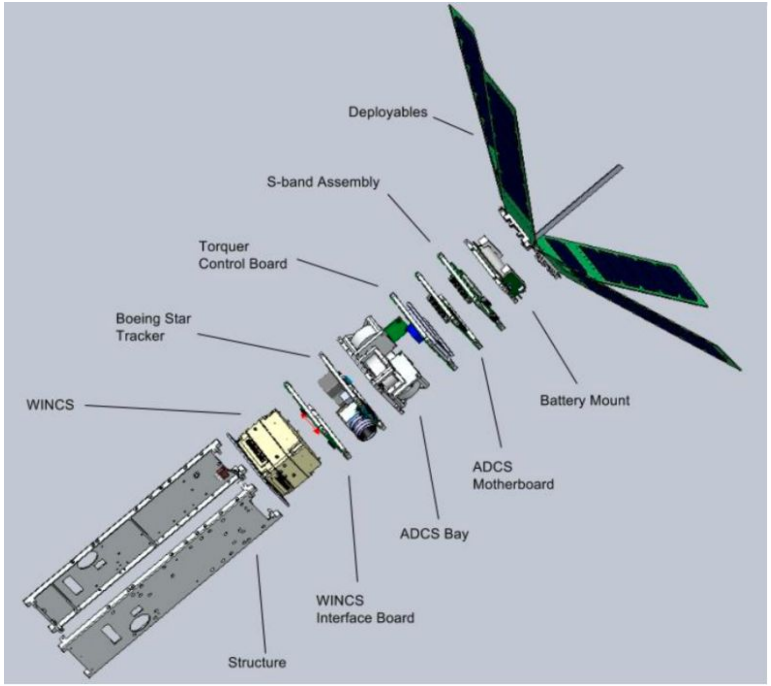
- Formal ICD between MXL and SRI teams
- FPGA provided fast, custom interface
- Electromagnetic Interference issue:
  - FPGA clock showing up in payload data
  - GPS locking challenges
  - Harnessing - affected other wires' signals
- Mechanical issue: harnessing turn radius

Lessons: MCubed 1 & 2, GRIFEX



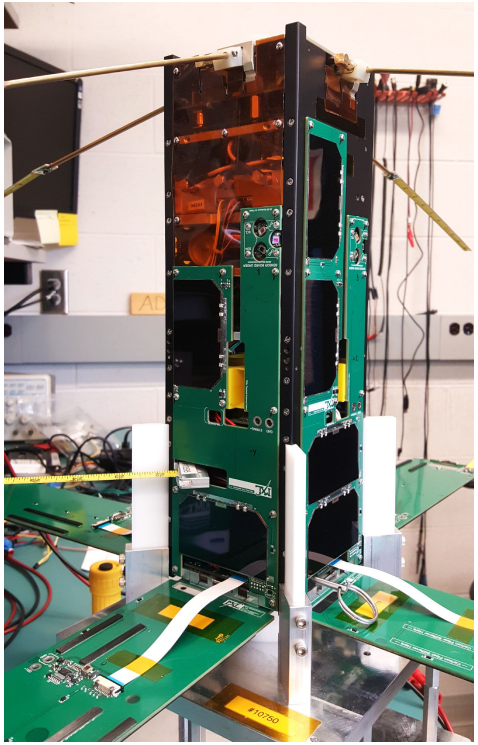
- New payload (COVE) required new processor
- Bus harnessing: changed from PC104 to ribbon cable for data
- Shared ICD among the three missions eased design
  - GRIFEX could rapidly follow-on: MCubed-like mission using CADRE-like hardware

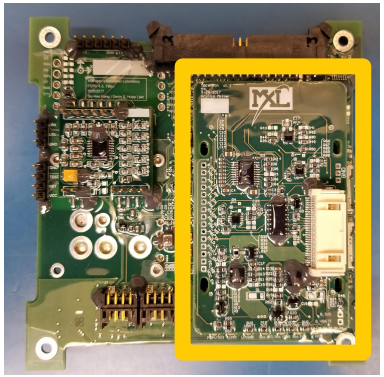
Lessons: CADRE



- Lab's first "***drop in structure***" payload module with WINCS
  - Removable when bus fully integrated
- First ***Payload Interface Module*** (PIM) - peripheral board mounted to the flight computer (FCPU), provides payload electrical interface
- Developments enabled by MXL converging on more modular 3U bus

Lessons: TBEx





FCPU-mounted PIM

- Repeated drop-in payload module with FCPU-mounted PIM
- Payload, volume violation shortened body panels
- Special placement, deployment mechanism for UHF antenna to avoid payload antenna array

Lessons: MARIO

- Again repeated drop-in payload module with FCPU-mounted PIM, UM-developed payload
- Body panel shortening to open “window”, improve payload temperature cycling
- Challenging ICD due to UM internal requirements creep - too *much* flexibility

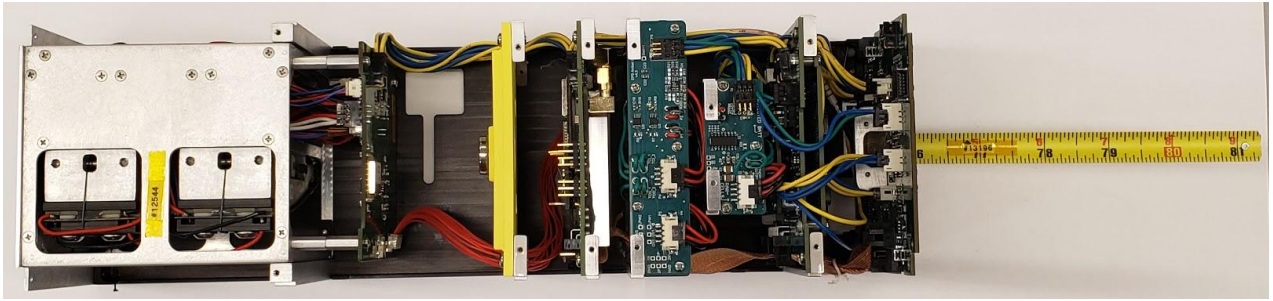
Maturing the Payload Interface

Ideally, **drop-in payloads** with a flexible **PIM** maximizes decoupling between payload and bus designs.

In practice, CubeSat payloads force coupling.

- May force unwanted bus changes (TBEx).
- May offer the chance to upgrade (MCubed-1).

When coupling is forced, important to define who pays for and who performs the work to guarantee the interface.

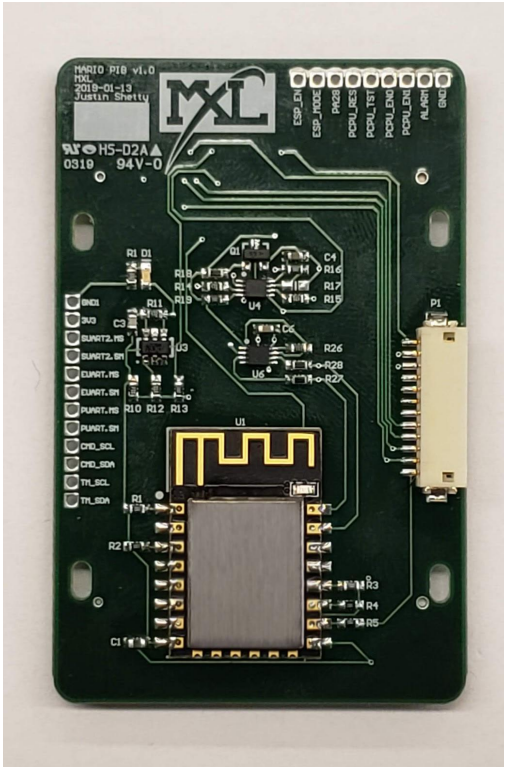


Advantages of the PIM

The PIM *narrows* and *matures* the bus interface.

- Absorbs electrical interface changes
- Clear definition of "where the bus ends"
- Aids payload-bus decoupling
- Helps scope ICD - what is the bus flexibly capable of?
- Remains a standard modular bus part

Result: simpler ICDs, easier interfaces.



Standardizing Provides Agility

Mature interfaces may preempt bus changes, saving time and resources, and enabling modular buses.

Common ICDs among missions eases development and quickens mission turnaround.

Defines expectations: payload interfacing is also about team interfacing and management.

Conclusion

MXL uses its PIM and drop-in payloads to narrow and mature its electrical and mechanical interfaces.

This improves lab agility, simplifies design, smooths management, reduces mission turnaround time.

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Please follow up with any questions or collaboration interests!

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