SpaceWire Backplanes for Assembly Integration and Test

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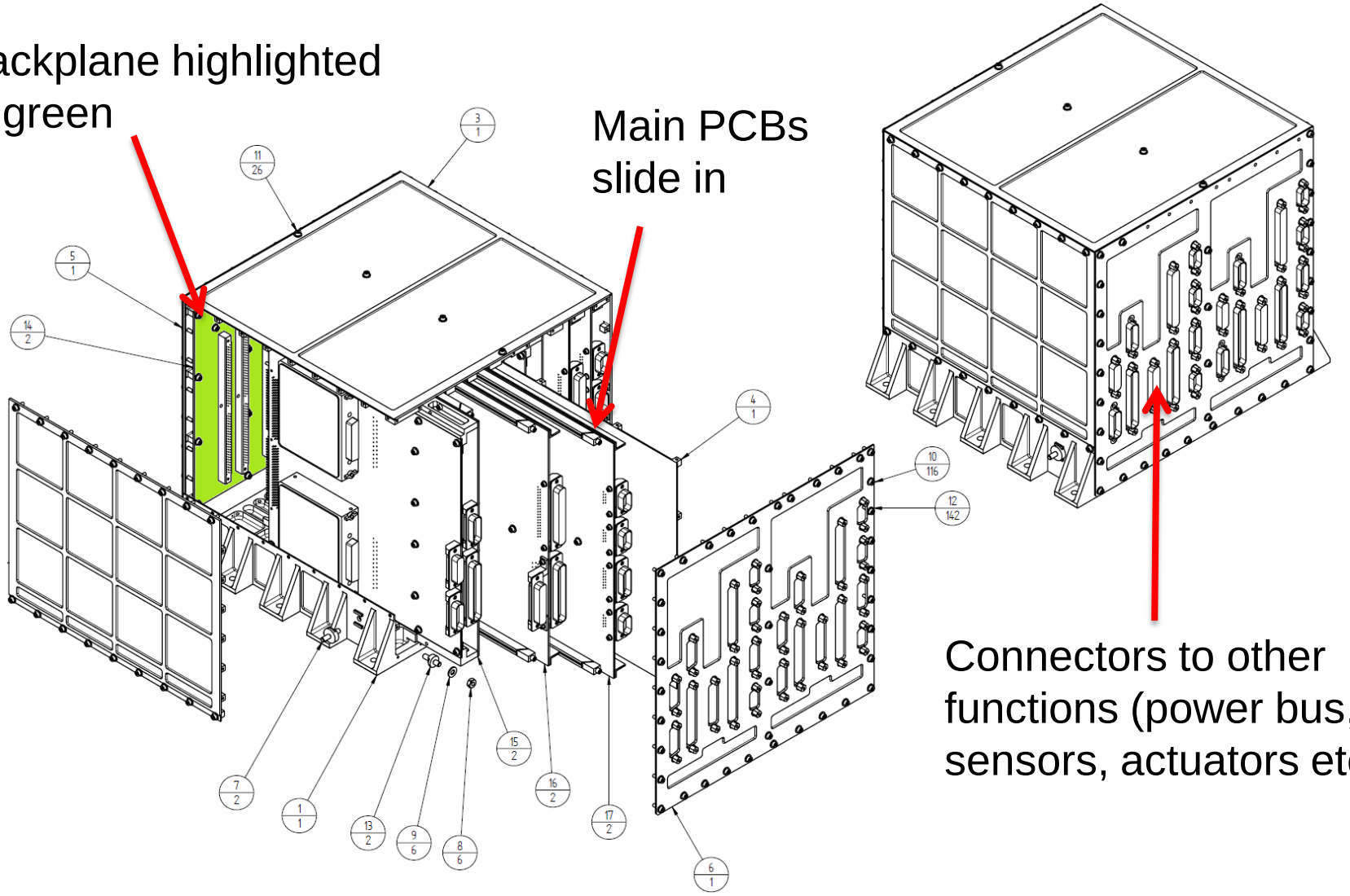
Spacecraft Unit Construction

- Spacecraft avionics systems are typically composed of a number of units connected together using harnesses
- The units themselves usually contain more than one printed circuit board (Module) for example:
  - Power conversion to produce unit internal voltage rails
  - Processing – usually a microprocessor running software
  - Mass memory
  - Interfaces to command/data busses, sensors and actuators
- The Modules need to be electrically linked to provide communication and power connections
- It is convenient for assembly, integration and test if the Modules are “plugged” into the unit

Backplane within a unit

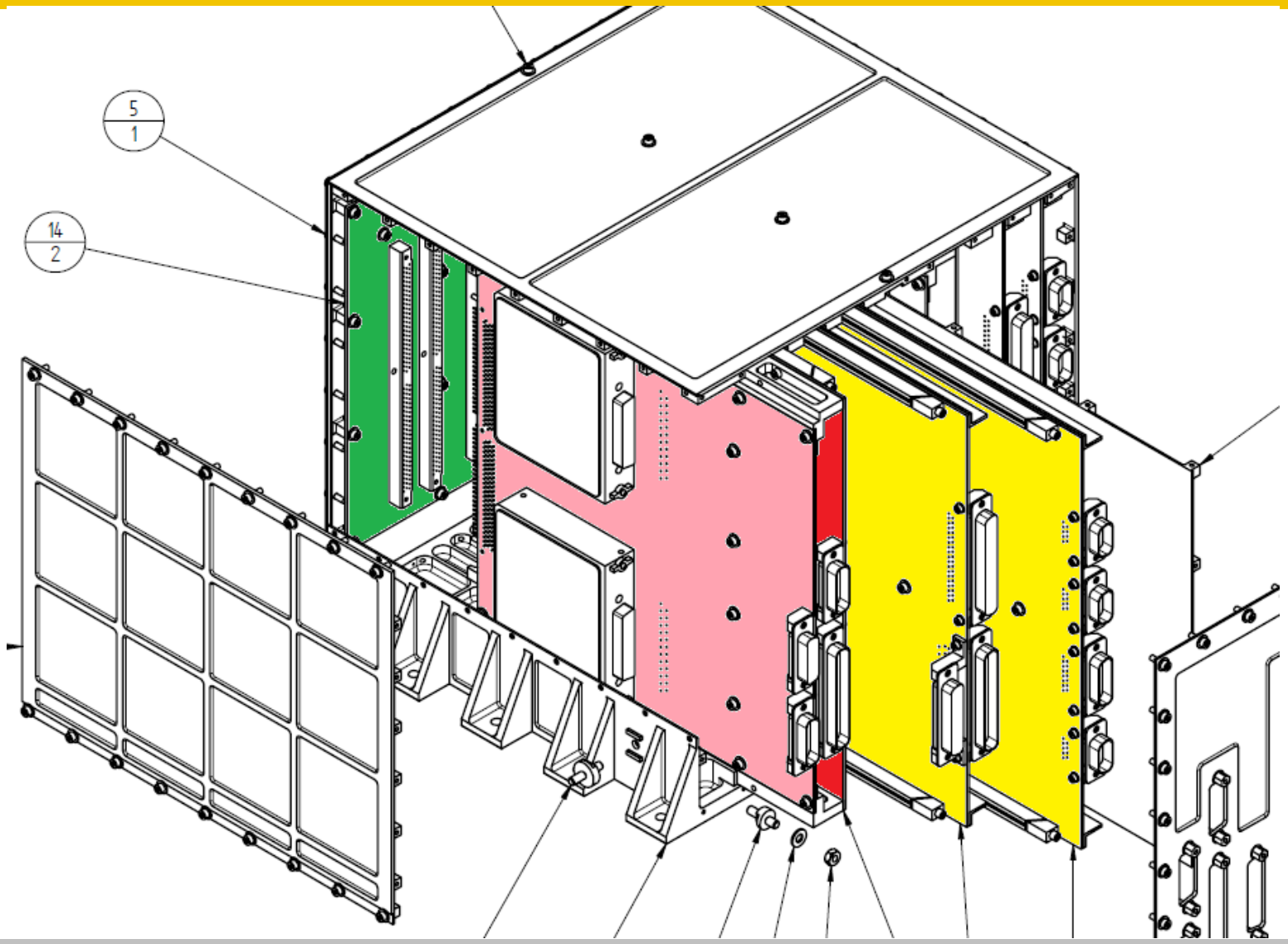
Backplane highlighted in green

Main PCBs slide in



Connectors to other functions (power bus, sensors, actuators etc)

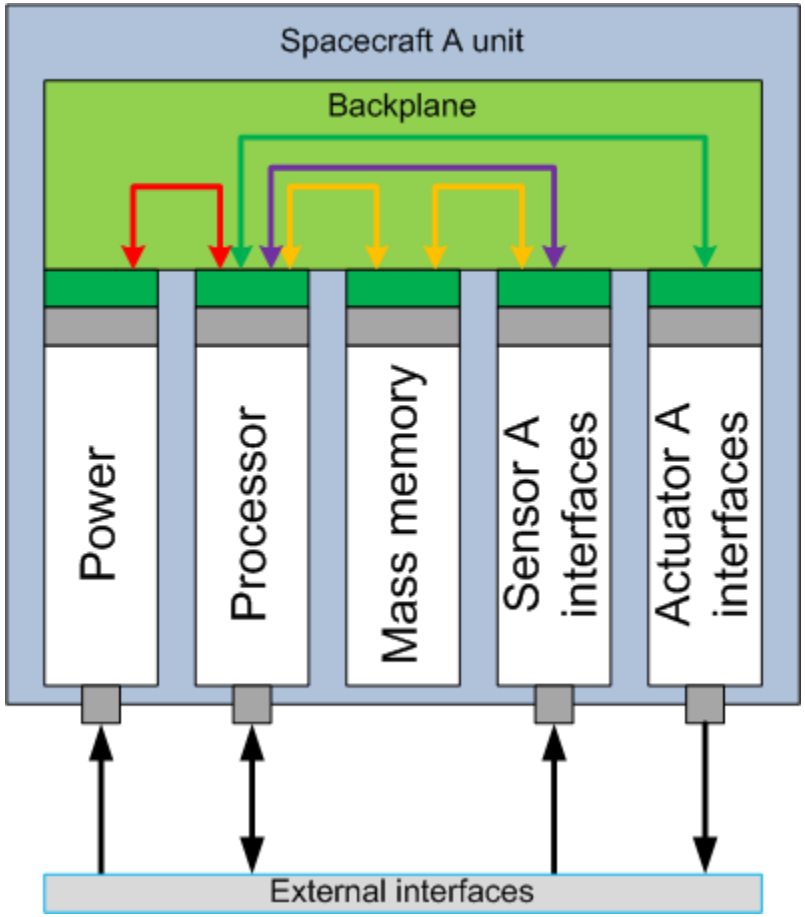
Module interface to backplane



Historical use of the backplane

- 1980's : 8 bit and 16 bit processor busses at 4 to 8MHz
- 1990's : Processor speeds increase to >20MHz so routing processor bus signals becomes impractical. SpaceWire looks attractive but it is in its infancy, so bespoke serial or parallel busses used
- 2000 – 2010 : FPGA technology permits more sophisticated backplane bus signals with autonymous collection of fresh data, hardware based digital filtering and processing
- 2011 and the future : SpaceWire technology now mature, ground support equipment and tools available, should we employ a SpaceWire backplane?

Bespoke backplane bus



- Assume modules are designed specifically for the “Spacecraft A” mission
- The backplane connects different modules via different bespoke electrical interfaces (to simplify the design and minimise part costs)
- The processor usually supports all backplane interfaces

Typical bespoke interfaces

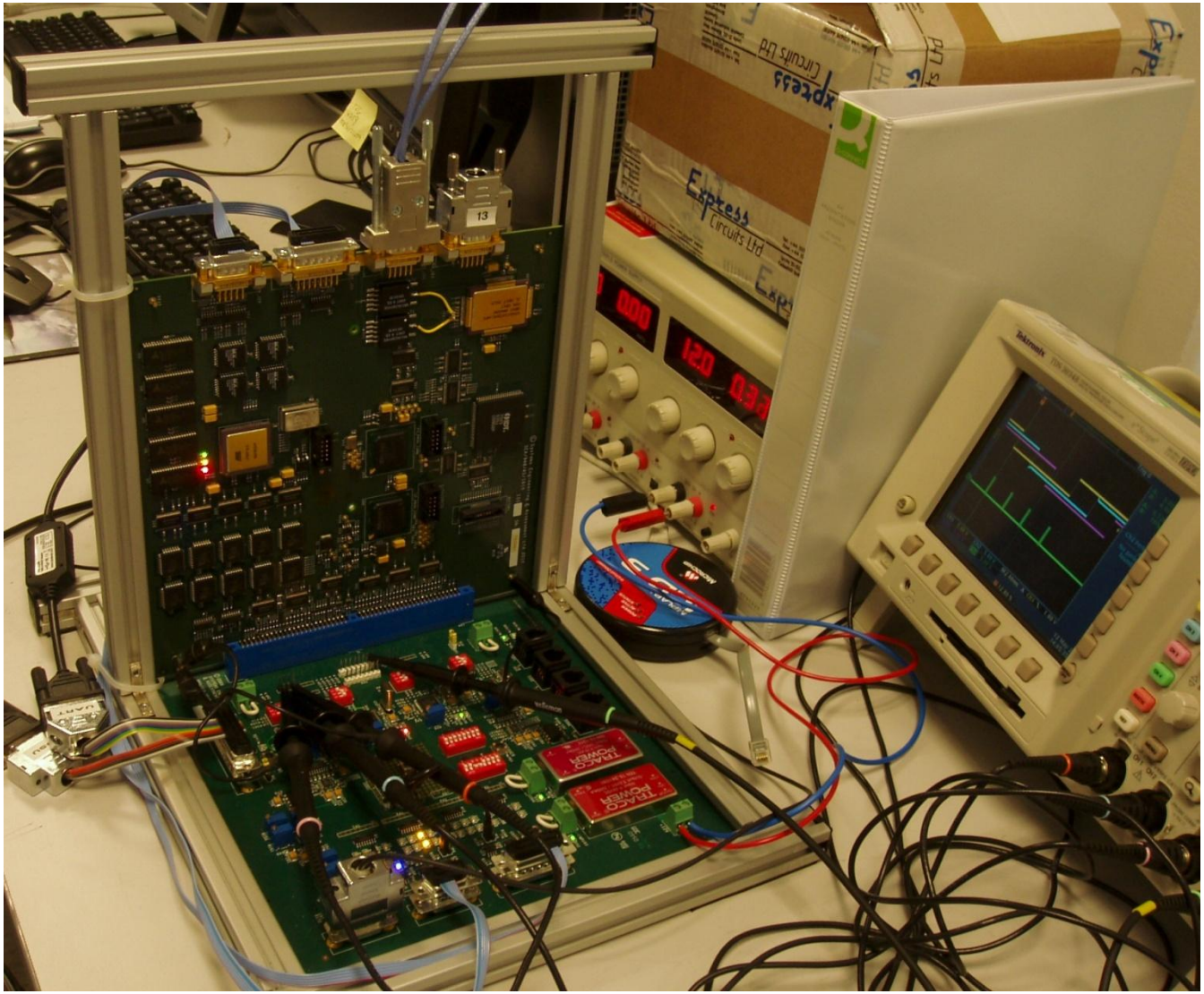
- Power
- Discrete on/off lines
- Address lines to control multiplexers
- Periodic, pulse or PWM signals
- Parallel busses to ADCs and DACs
- Serial busses to ADCs and DACs
- Miscellaneous control and status monitoring signals
- Etc
- Etc

How do we test all these interfaces on the modules?

Module testing

- Typically the first module to be built and tested as a standalone item is the processor module
- The hardware interfaces must be proven before running the mission software to minimise the number of “unkown” issues during software debug activities
- Spacecraft interface EGSE can be used for the unit external interfaces but stimulating all the different backplane interfaces is non-trivial
- So we now need to design, develop and test board a board to stimulate and verify the bespoke interfaces... so there is a significant amount of additional work to do!

Processor Module testing



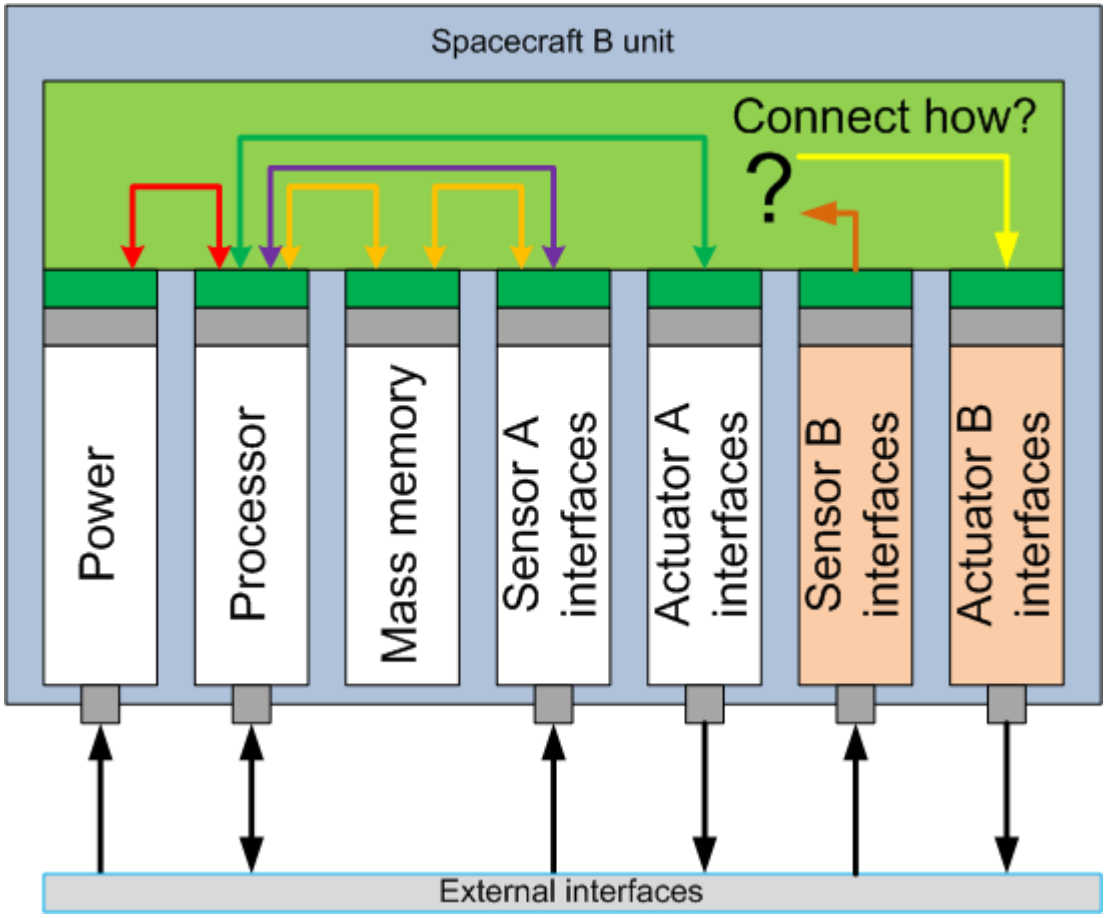
Adaption for Spacecraft B

- So we now have a working unit for “Spacecraft A”
- For the next mission we need a new unit for “Spacecraft B” that is similar to “Spacecraft A”, but the unit needs additional interfaces (or mass memory etc)?

This raises some new questions:

- Can we re-use existing Spacecraft A hardware and test equipment?
- What do we need to re-design?
- Can we interface with modules from another supplier who has already developed tested designs for the additional interfaces?

Spacecraft B unit

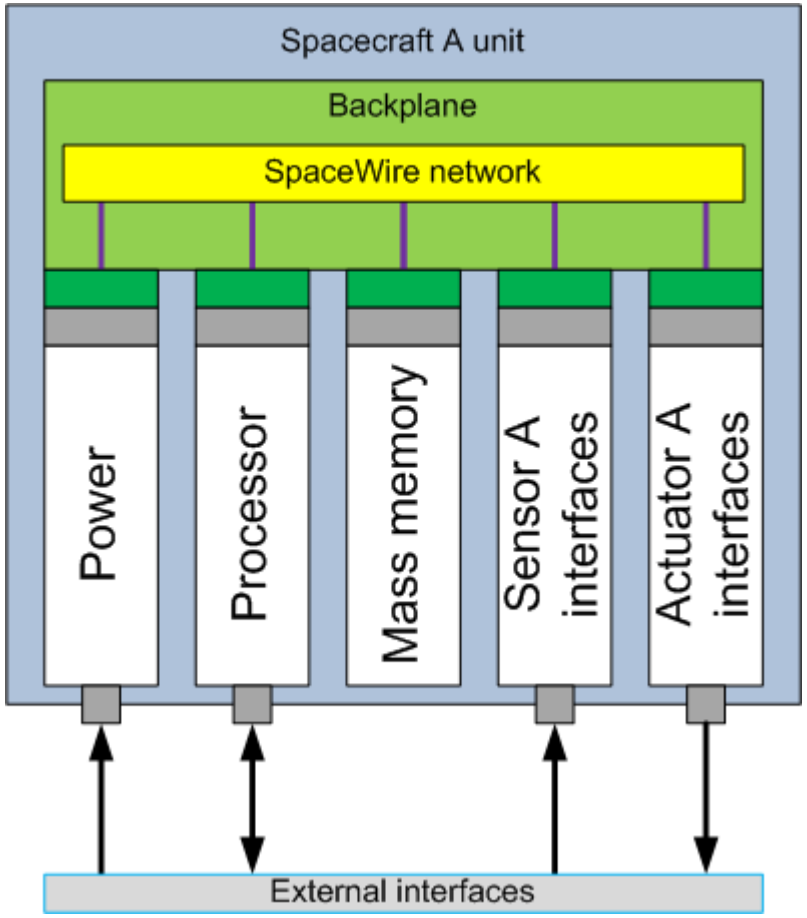


We must re-design:

- Backplane
- Processor backplane interfaces
- Mass memory backplane interfaces

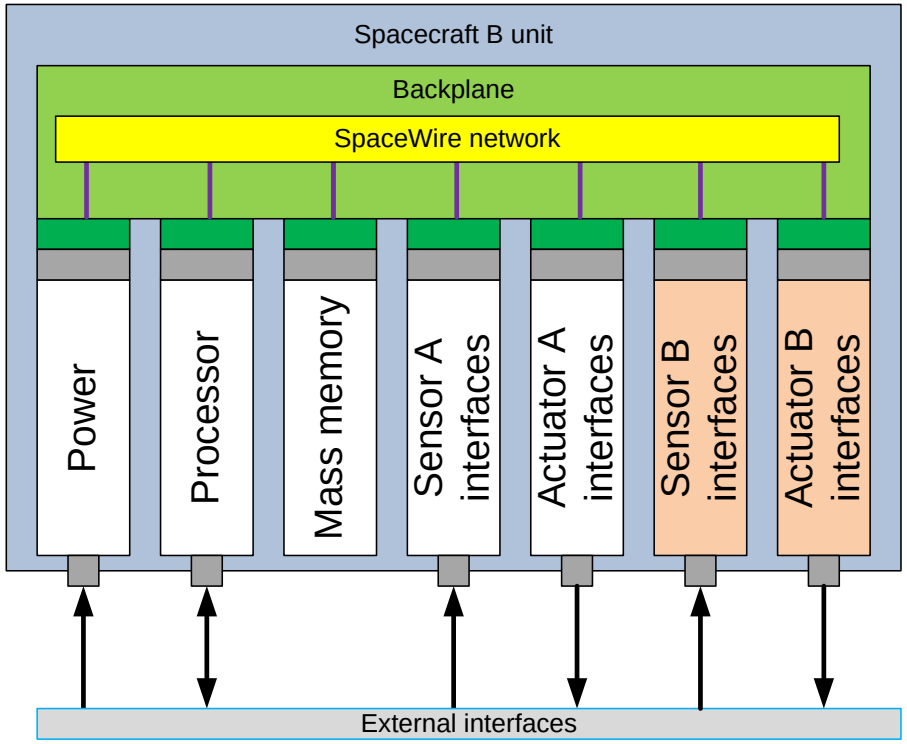
If modules are available from another vendor, it is likely the new interfaces will be incompatible!

SpW Backplane



- What if we use a SpaceWire backplane?
- Modules may be designed specifically for the mission but have the capability for re-use
- All modules connected via a SpW network (this can be an active or a passive SpW backplane)

Migration Spacecraft B is easier!



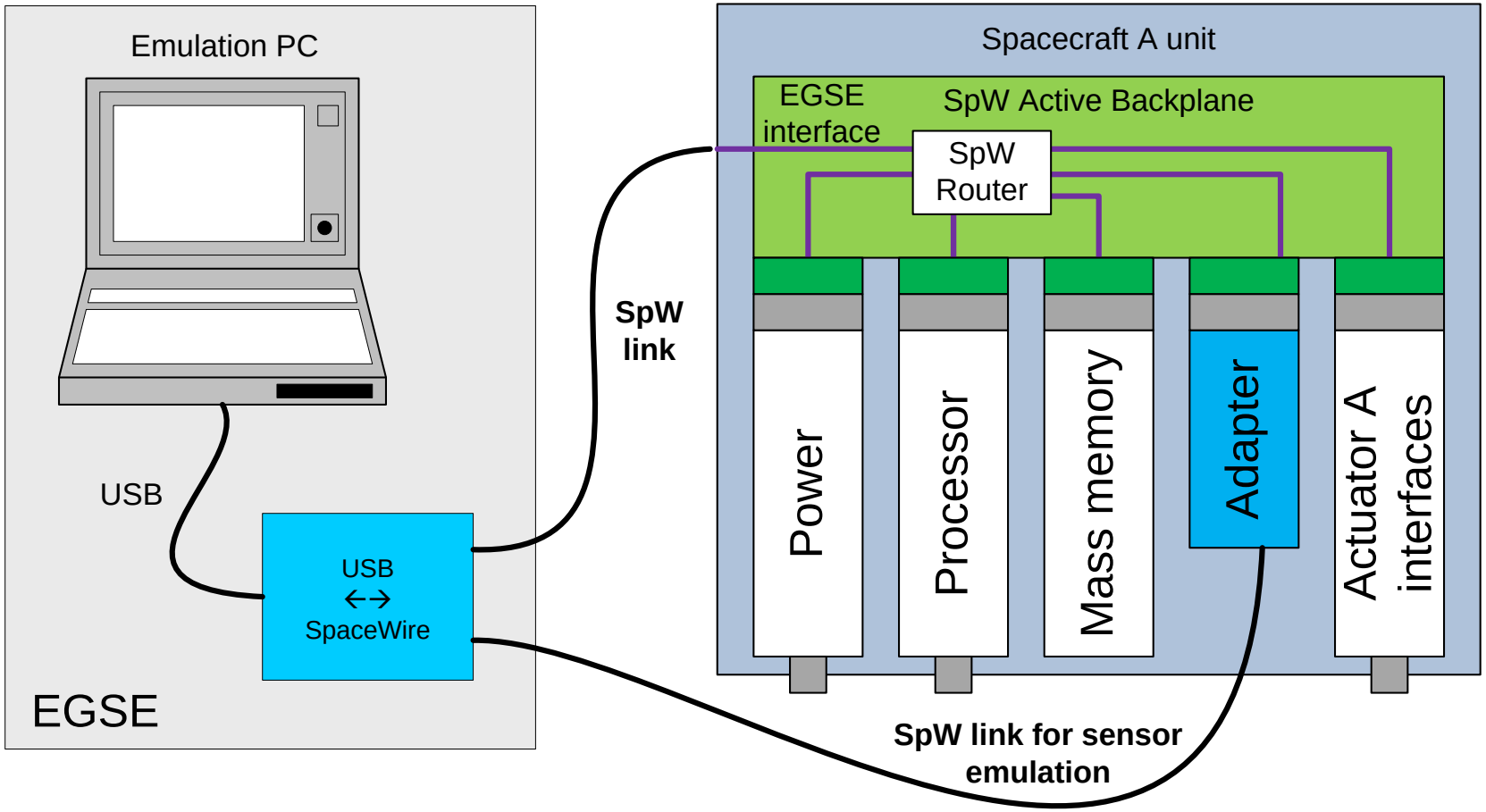
- Backplane extended to add more SpW interfaces
- If modules are available from another vendor, the interfaces will be at least electrically compatible!
- Software extended to support new modules.

If unit gets “too big” it can now be split

Testing the SpW modules

- All modules now have a common electrical interface standard – SpaceWire
- Proven and tested modules can be procured from other suppliers, reducing the number of repeated developments and reducing subsequent mission costs
- Particularly important point is that sophisticated test equipment and interconnect cables are now available from a number of suppliers

Unit test and module emulation



Conclusion

- Module performances and higher functionality means that bespoke backplanes are now far less attractive due to the complexity of the test environment
- SpaceWire has natured and components and test equipment are available to simplify the design and subsequent test
- The perceived cost savings of designing a bespoke bus that reduces component level costs are easily lost during integration and test
- The time is right to employ SpaceWire backplanes within future spacecraft units!