Networking
for
Nanosats

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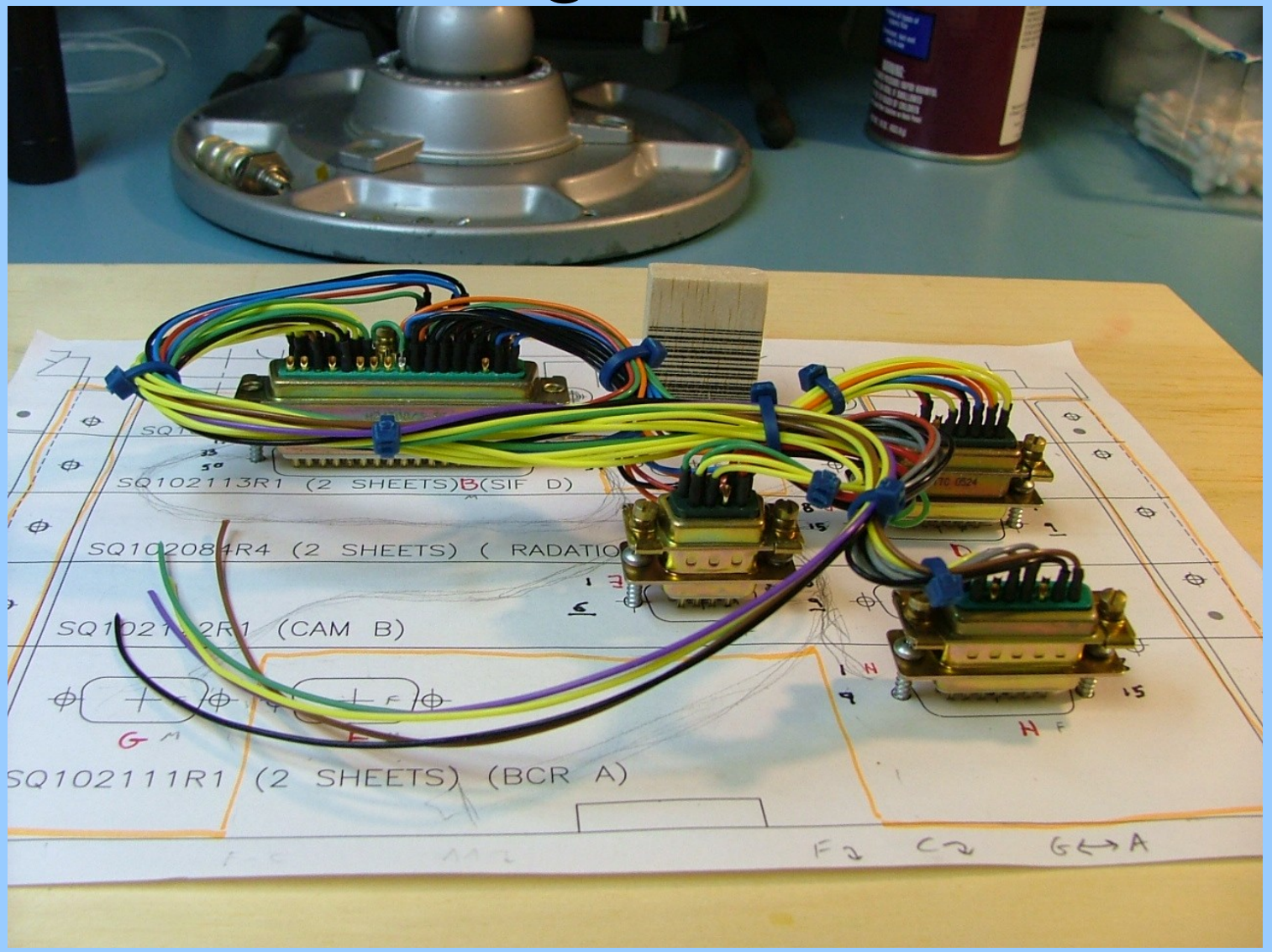
A Step Back

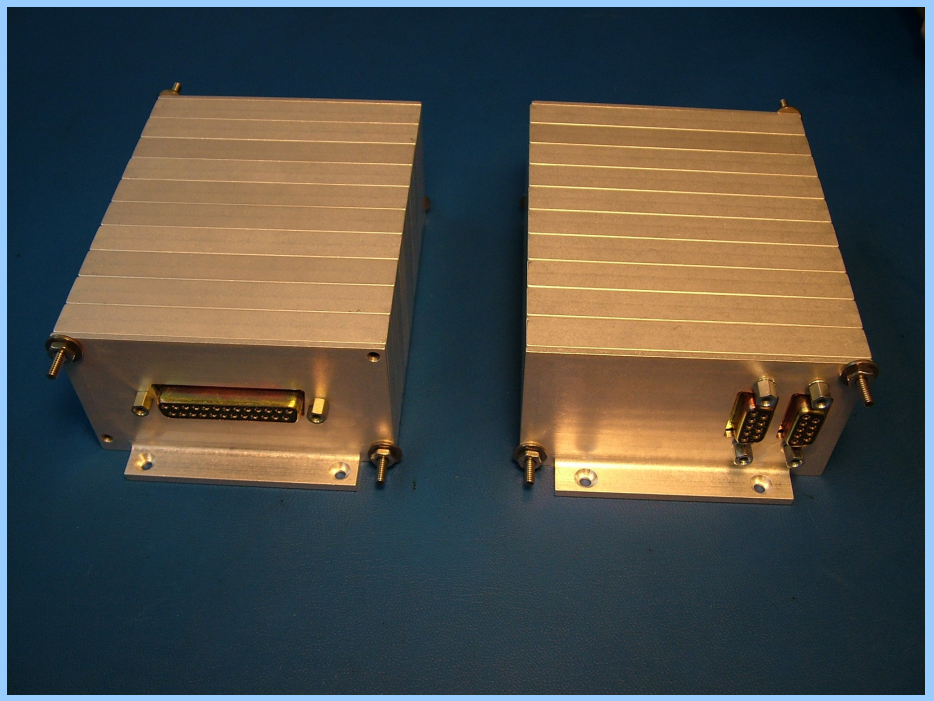
- old-school design – centralized CPU
- works great, but...
  - massive wire harnesses
    - complex, heavy, inflexible
  - harder to do interactive integration
  - centralized point of failure
  - people step on each other's toes
    - and everyone wants hardware to play with

Building a Harness



So, Distribute

- put CPUs and I/O where they're needed
- hardly revolutionary
  - MIL-STD 1553, 1773
  - Hubble, SMEX, MIDEX, SAMPEX, ISS
    - 1980s-vintage Battlestars
- but Moore's Law helps
  - MOST
    - late 1990s 50 kg microsat
  - SNAP-1
    - 2000 6.5 kg nanosat
  - SpaceQuest Distiller
    - 2006 0.5 kg



Why?

- smaller wiring harness
  - just power + data
    - though still need “last-inch” I/O
  - smaller connectors
- improved robustness
  - node crash won't cascade
  - quasi-redundant (with careful partitioning)
  - decrease MTTF, but increase availability

Still Why?

- easy to partition work
  - each sub-system gets their own S/W and H/W
  - easier to distribute geographically
- easier integration
  - plug-and-play
  - pull bad nodes
  - use surrogate nodes for unfinished hardware
  - piecewise integration

How To Do It

I. pick a technology

II.implement it

III.done!

Standards Are Great

- ... because there's so many to choose from
- look at some factors
  - speed
  - power consumption
  - physical layer
  - link layer
  - network layer
- but don't make your own
  - unless that's your mission

Physical Stuff

- speed: 100 kbps to 400 Mbps
- power consumption
  - speed is power
  - consider steady-state power vs. E/bit
- topology
  - hubs need space, power, reliability
  - buses are slower, have funny connectors
- physical medium
  - pickier for faster networks

Software and Protocols

- often coupled to physical network
  - TCP over Ethernet, CANOpen over CAN
  - but IP over ATM, too
- standards are great
  - often have subtle design features
- simple terminal software is good
  - leverage existing technology
- think this through!
- good toolkits are worth their weight in bits

Some Practical Standards

Std	Speed	Topo *	Pwr [mW]	E/bit [µJ/bit]	Proto? **	Complex
RS-232	100k	PtP peer	45	0.45	No	Low
RS-485	100k	bus peer	45	0.45	No	Low
I2C/SPI	100k	bus M/S	13	0.13	Some	Low
CAN	125k	bus peer	100	0.86	Yes	Med
Ethernet	100M	PtP peer	260	0.0026	Yes	Med/Hi
Ethernet	10M	PtP peer	125	0.013	Yes	Med/Hi
USB	12M	PtP M/S	6	0.0005	Yes	Hi
FireWire	400M	PtP peer	930	0.002	Yes	Hi

* Network topology
  - PtP = point-to-point
  - bus = common bus
  - peer = nodes are equivalent peers
  - M/S = nodes are in master/slave relationship

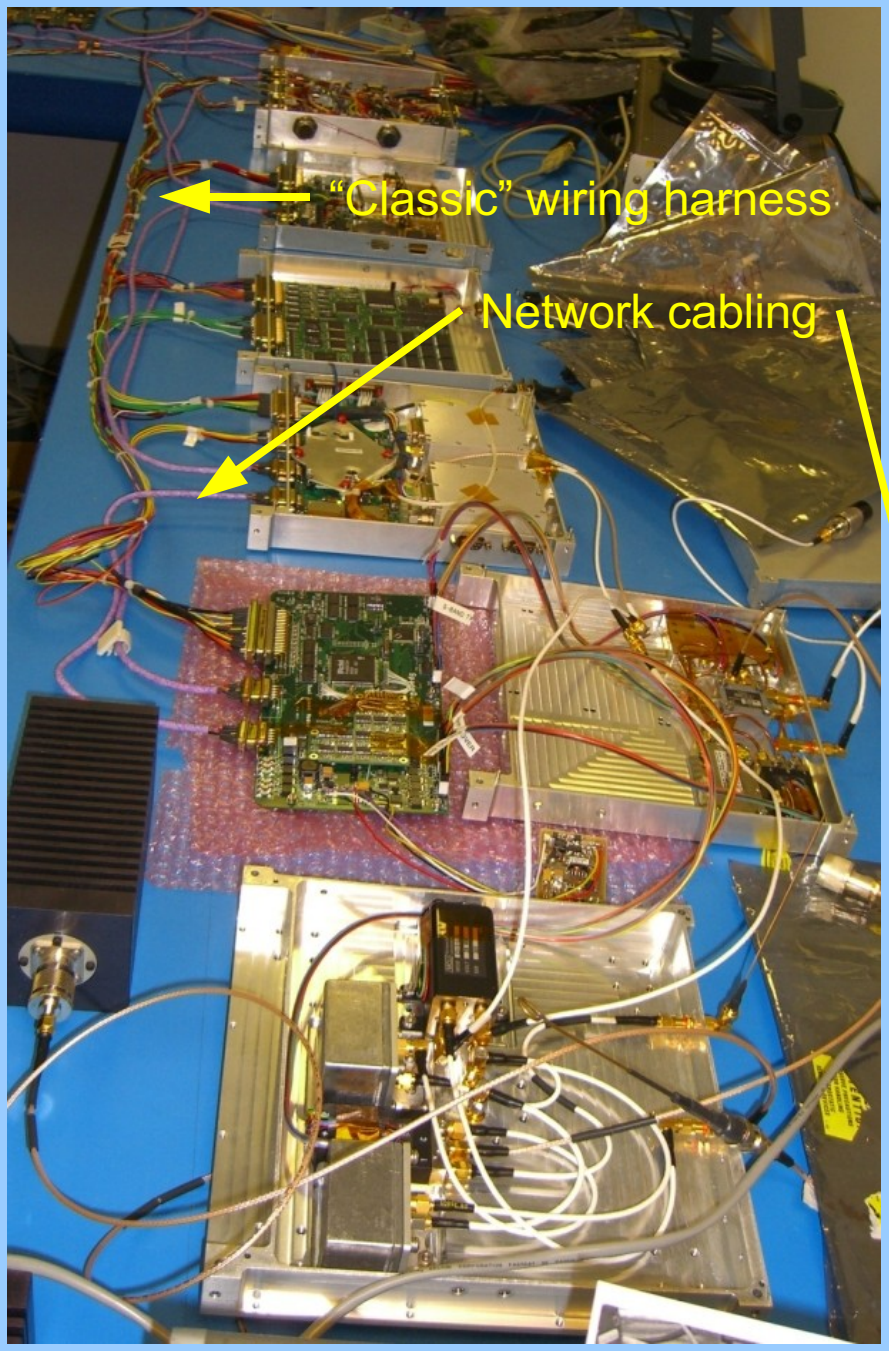
** Higher-level protocols defined?

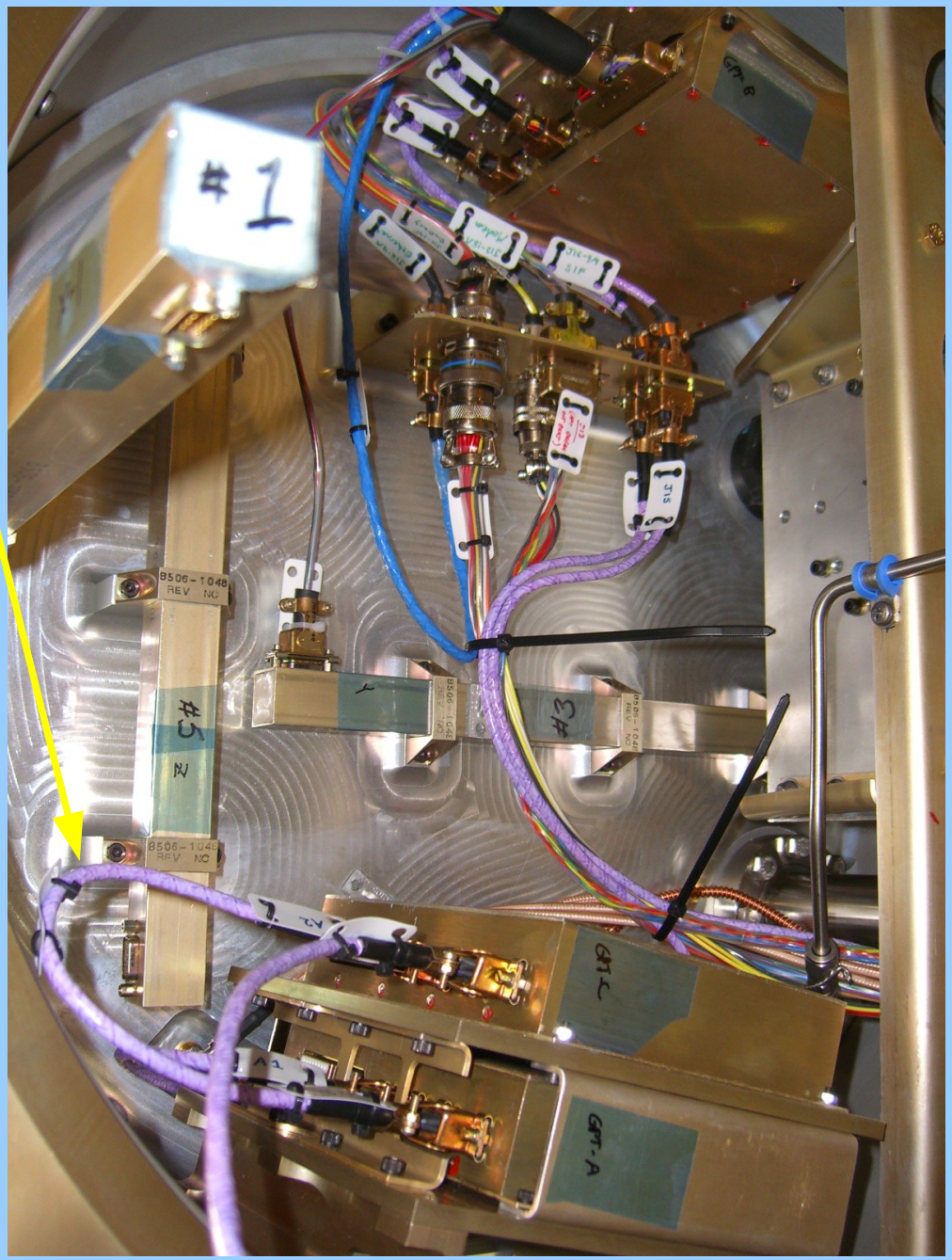
No Silver Bullets

- more power
- more area
- funny connections (maybe)
- more pieces to test
- more software to write
  - remember Brooks' Law

Conclusions

- small satellites don't have to be bespoke
  - getting less so every year
- easy to partition work
  - especially for multi-year projects with high staff turnover
- sometimes, you plug it all in, and it just works
  - but when it doesn't, you can isolate broken bits


"Classic" wiring harness
Network cabling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