Design, Integration and Testing Small Satellites

Muhammad Rizwan Mughal
Institute of Space Technology
Islamabad, Pakistan

Outline

- Small Satellite Classification
- AraMiS architecture:
- Concept of Tiles and Modules
- Smart Harness:
  - Module Life cycle
  - Spacecraft configurations
- Conclusion

Typical Classification of Small Satellites

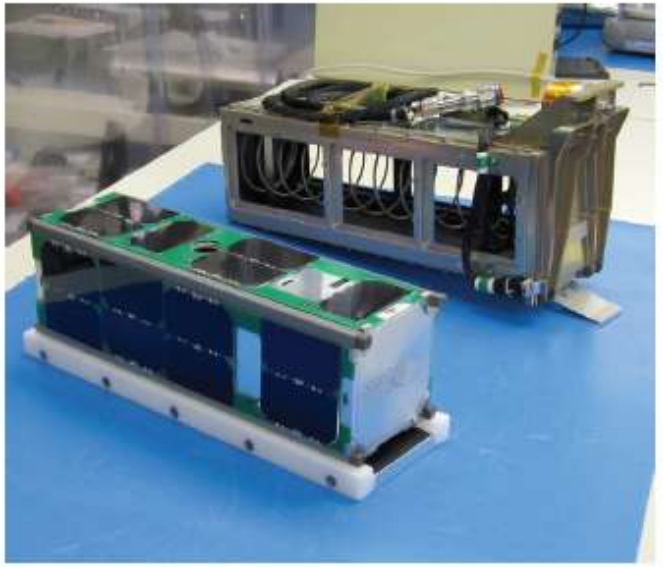
	Mass (kg)	Altitude (km) Orb period	Project lifetime	Total Cost (M$) [1]	Cost/Mass (k$/kg) [1]
Mini	100 - 500	1000 – 5000 (2 – 3 hrs)	4 - 7 yrs	10-150	200
Micro	10 – 100	500 – 2000 (1.6 - 2 hrs)	2 - 5 yrs	1-30	400
Nano	1 - 10	300 – 800 (1.4 – 1.7 hrs)	2 - 3 yrs	0.1-10	800
Pico	0.1 – 1	200 - 400 (1.4 – 1.5 hrs)	1 - 2 yrs	0.05-2	1600
Femto	< 100 g	200 – 400 (1.4 – 1.5 hrs)	1 yrs	< 0.05	3200

1 – Indicative values

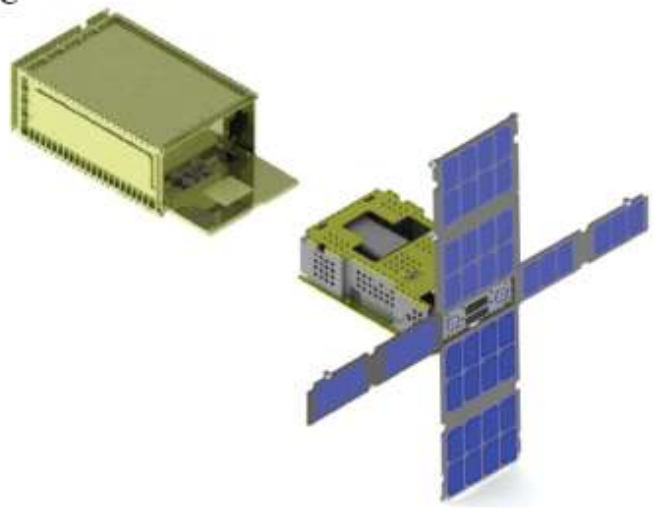
CubeSat Standard

A

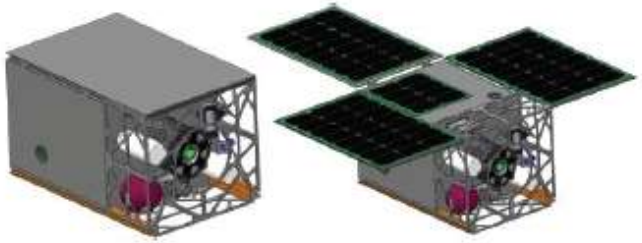
B



C



D

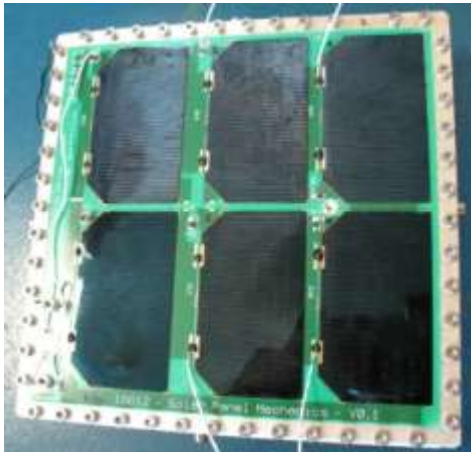


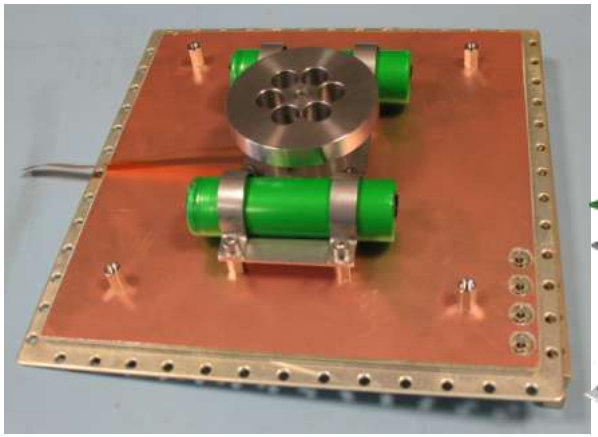
ARAMIS Approach

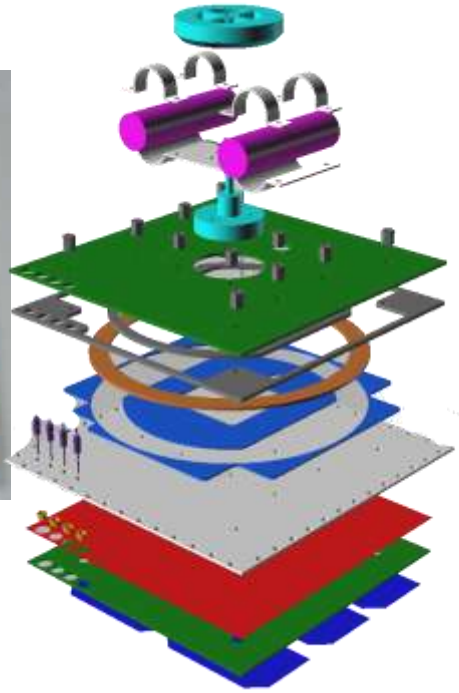
- ARAMIS (Modular Architecture for Satellites) is an innovative modular architecture for flexible and more demanding satellite configurations.
- Panel bodies or tiles
  - Different size and technology
  - Power and data standardized interfaces
- Modularity
  - Mechanical, electronic and testing level
- Low cost
  - Design, qualification and test cost shared among multiple modules
- The size of the satellite varies based on payload demands

Hardware Architecture of Tile (1)

- Single-size Al: 16.5x16.5 cm^2 tile, a 1.6mm thick monolithic Aluminum structure, for cheaper and smaller configurations

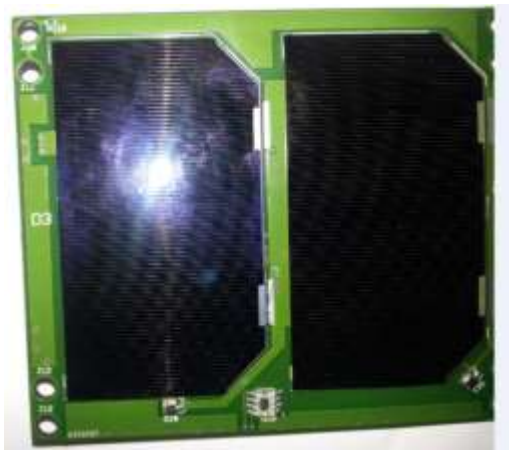




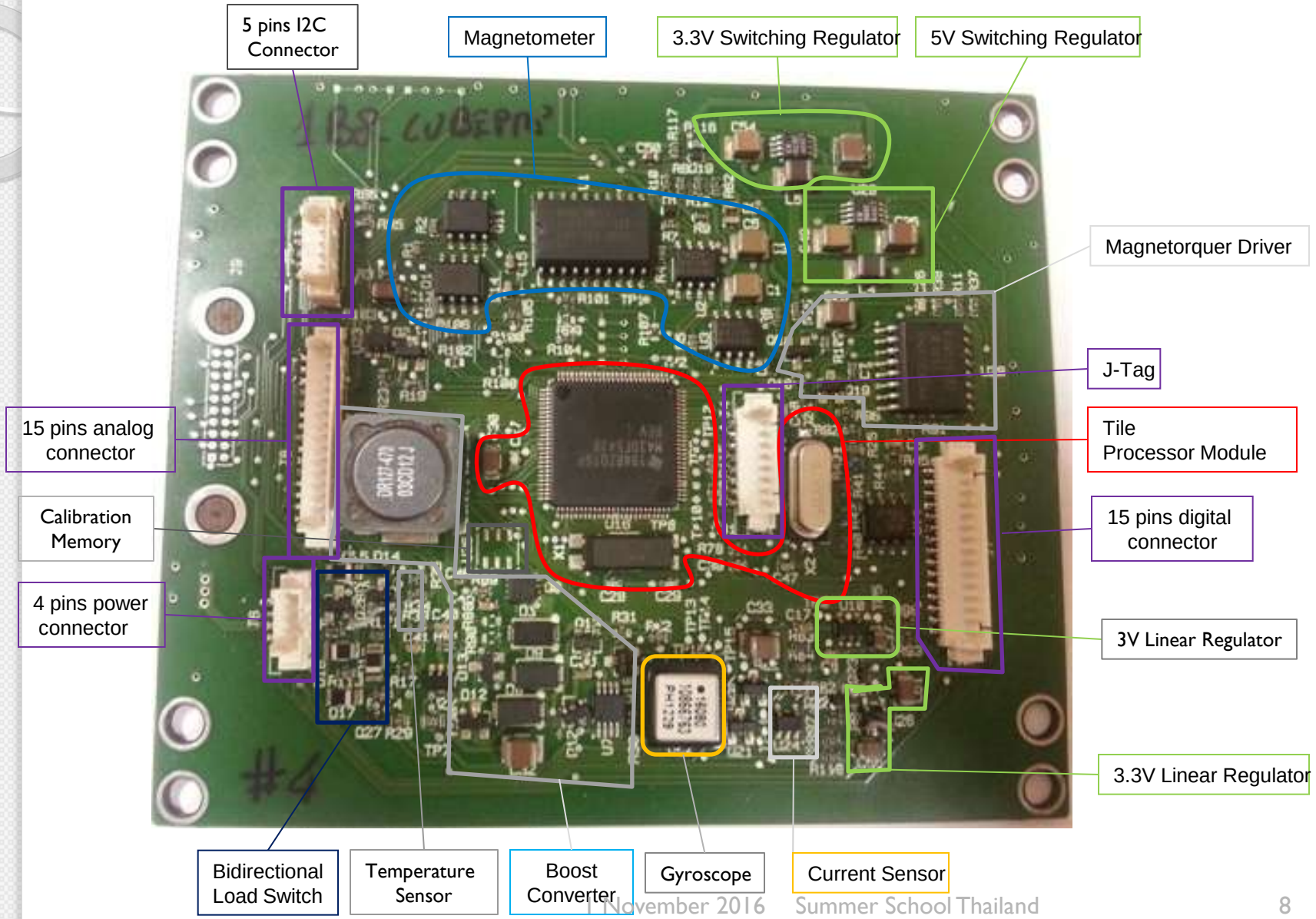


Hardware Architecture of Tile (2)

- CubeSat standard: (8.25 x 9.8cm^2) tile, with all electronic components integrated and compatible with CubeSat dimensions.
- All structure on PCB only
- All the subsystems integrated on each tile

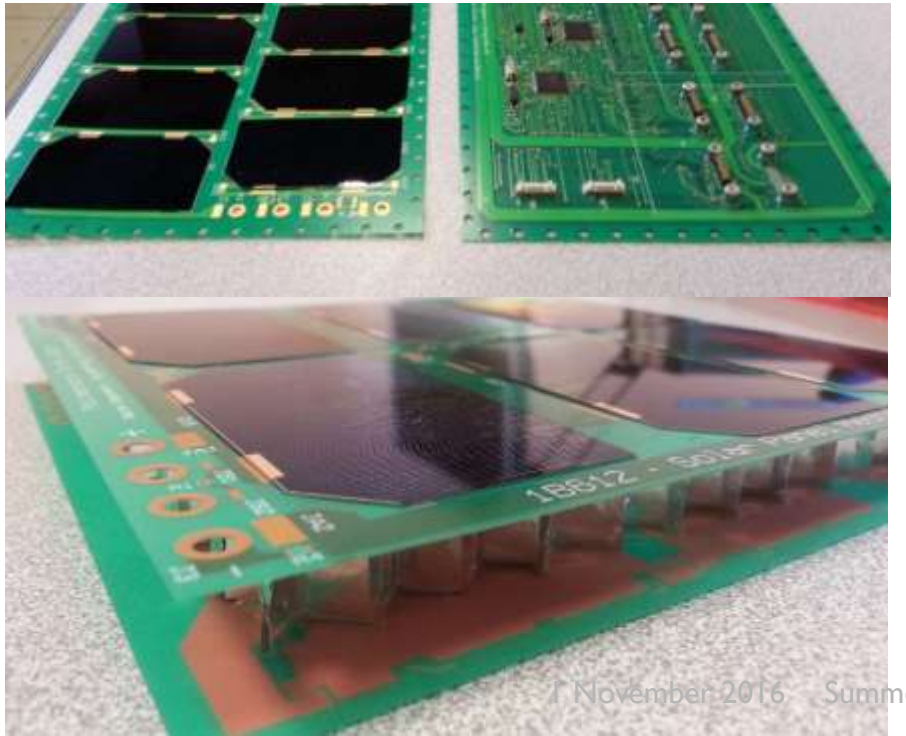


Hardware Architecture of Tile (2)



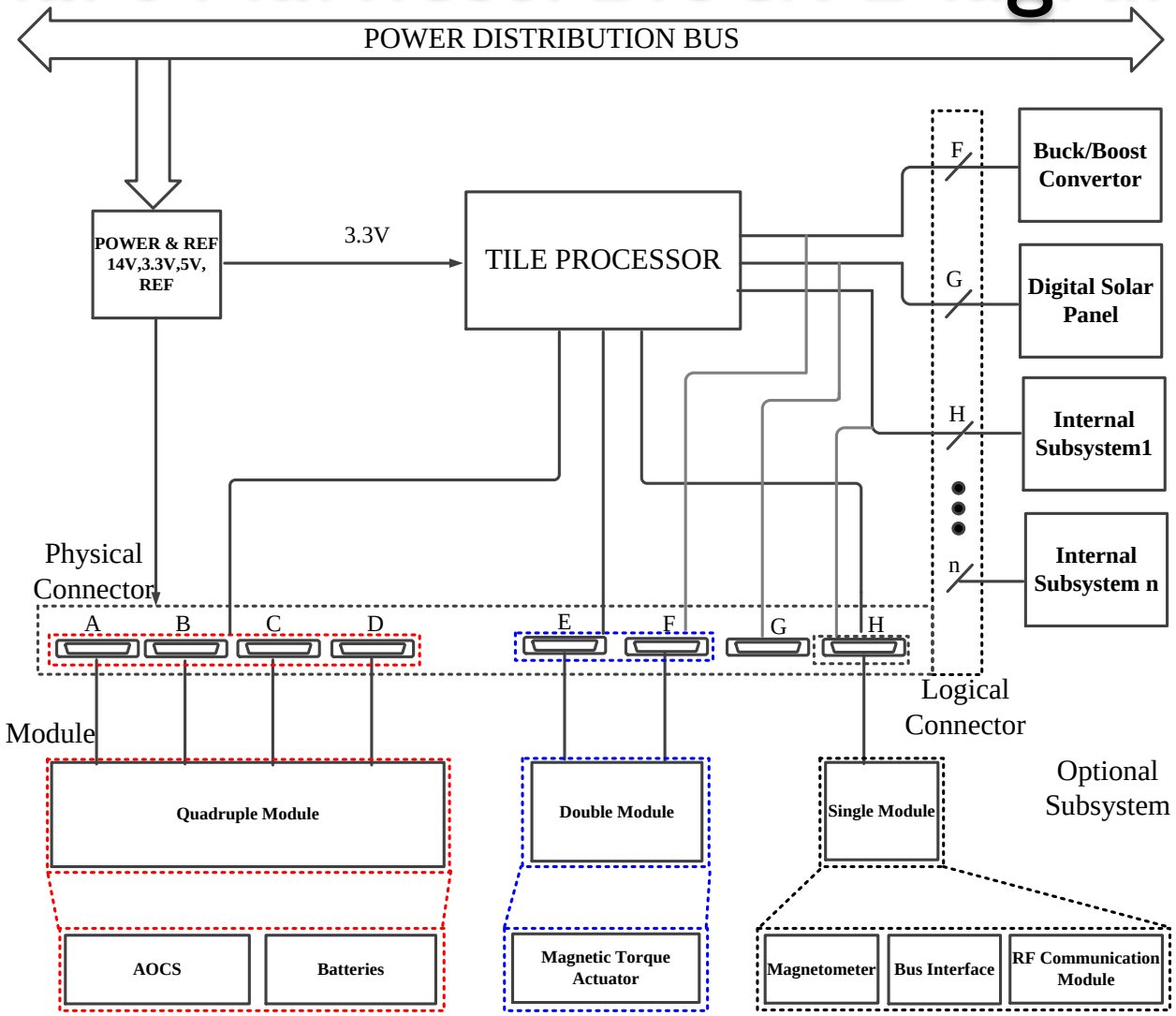
Hardware Architecture of Tile (3)

- Honeycomb Structure: 16.5x33 cm^2 tile, with 10mm thick honeycomb structure for more rigid and larger structures



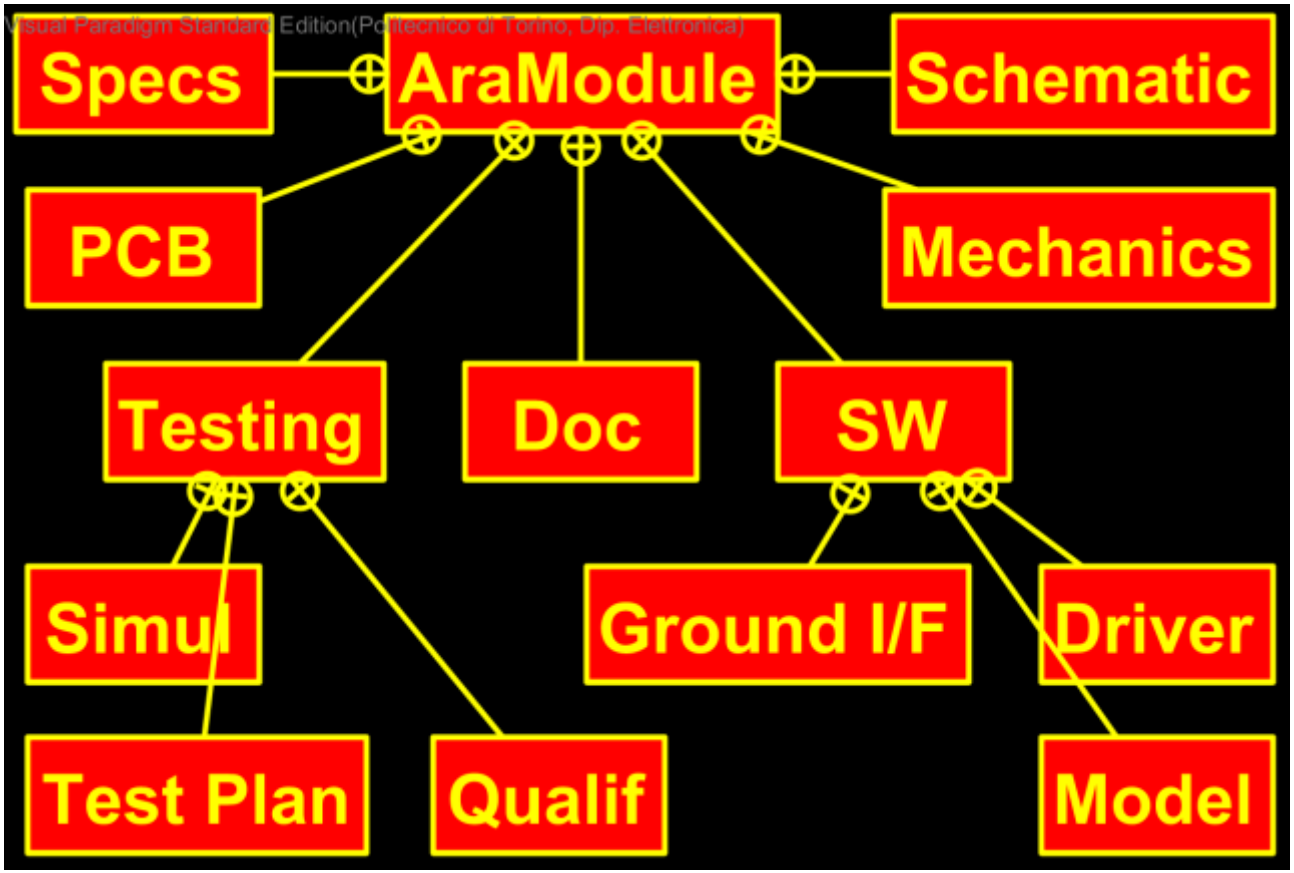
MOCKUP

Smart Harness: Block Diagram



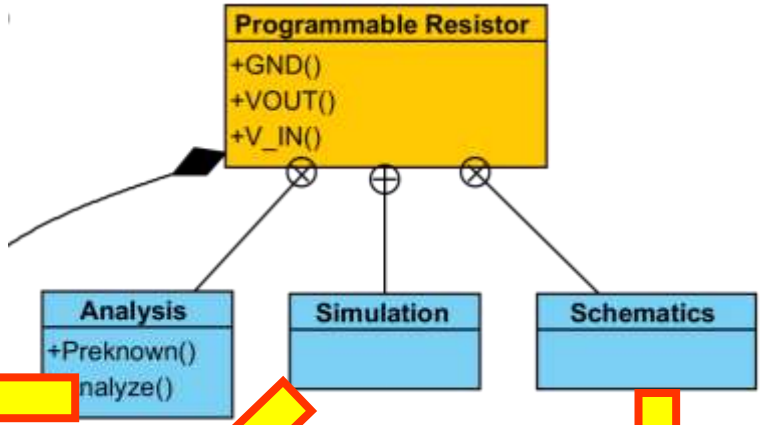
AraMiS → "AraModules" and "Tiles"

An AraModule is a small P&P subsystem

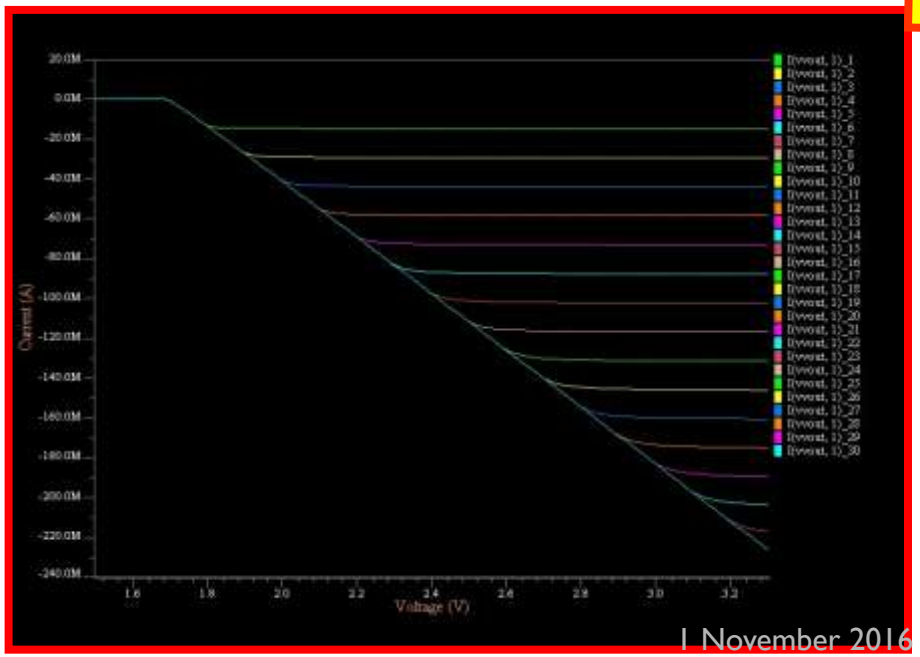


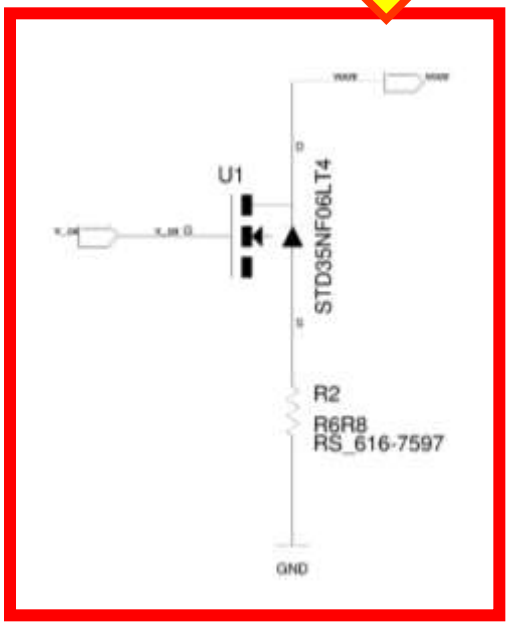
AraMiS → "AraModules" and "Tiles"

Inside an AraModule.

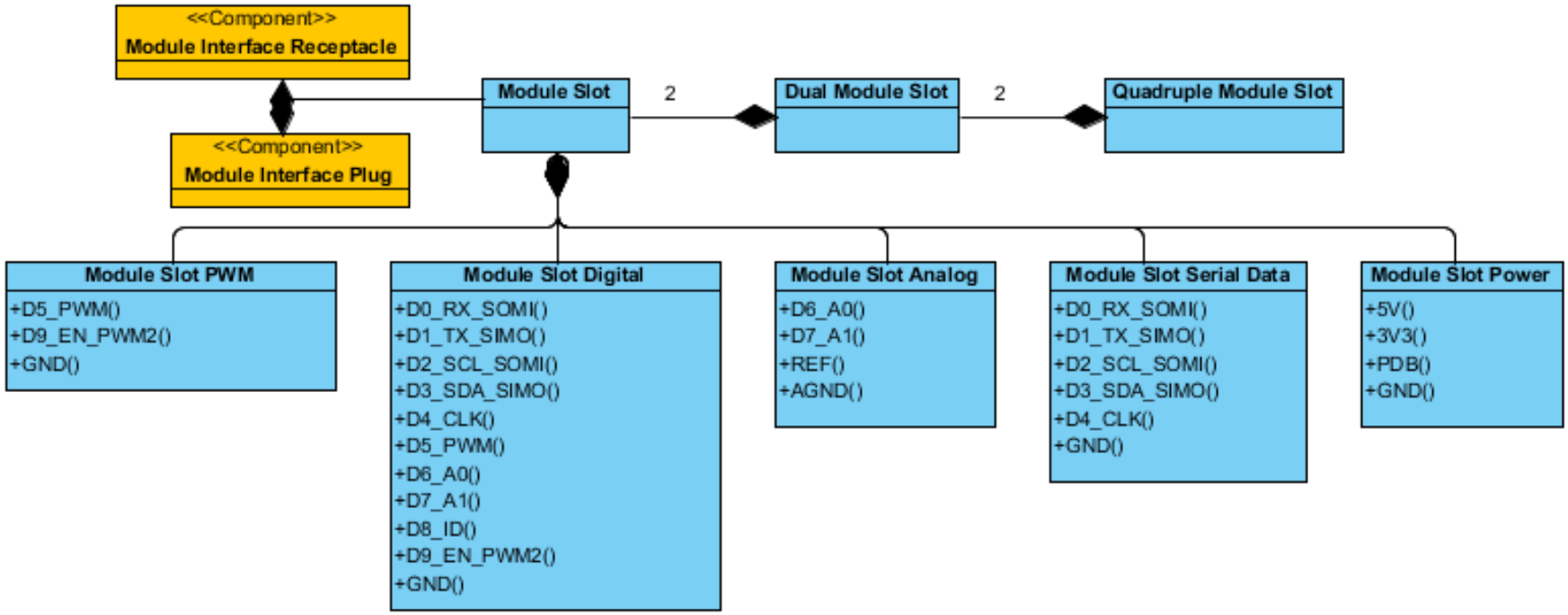


$$I = \frac{(1 - 2.k.R_s.V_T) + 2.k.R_s.V_{in} - \sqrt{4.k.R_s.(V_{in} - V_T) +}}{2.k.R_s^2}$$





AraModule: Electrical Interface

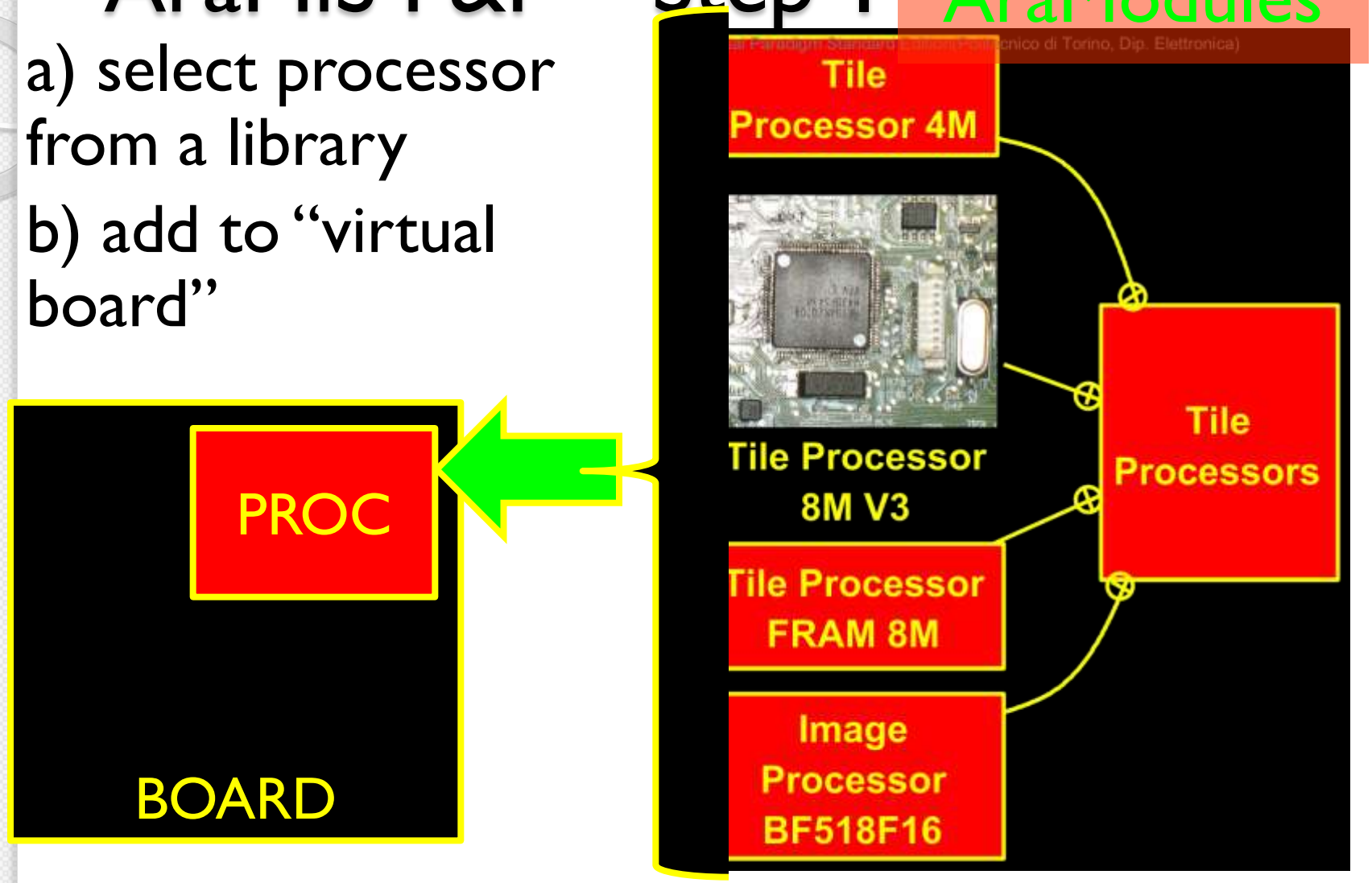


AraMiS P&P – Step 1

AraModules

a) select processor from a library

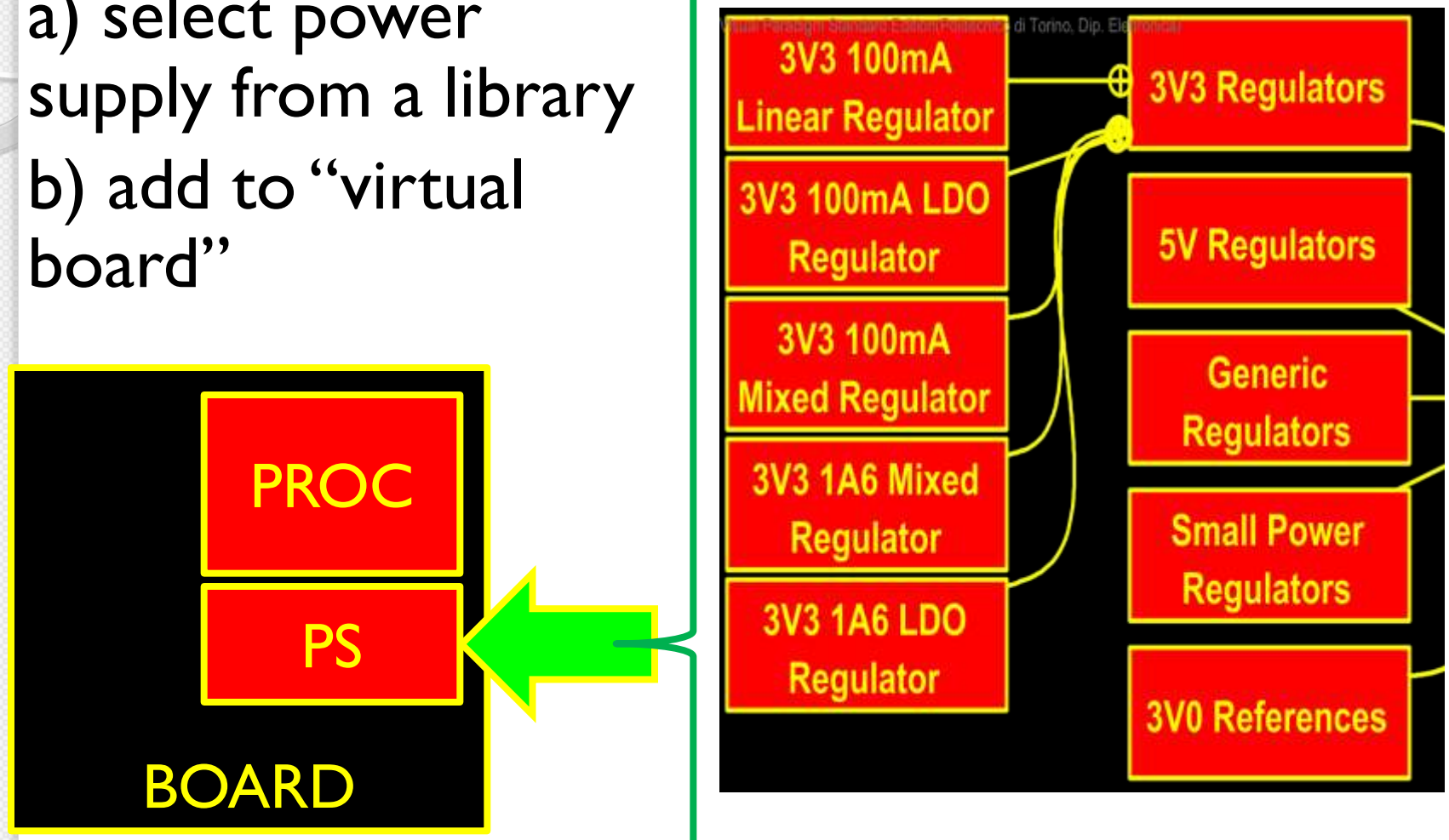
b) add to "virtual board"



AraMiS P&P – Step 2

a) select power supply from a library

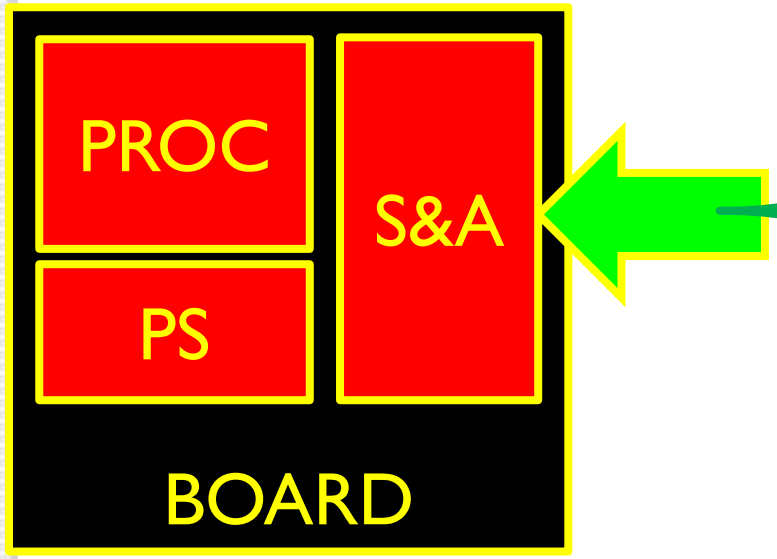
b) add to "virtual board"

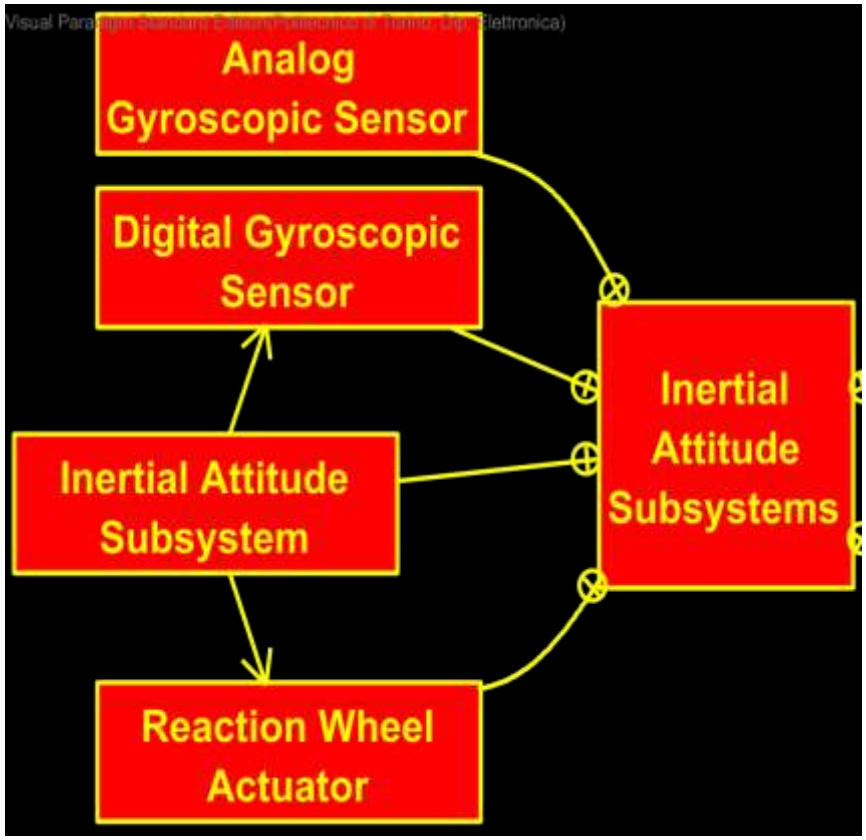


AraMiS P&P – Step 3

a) select AOCS sensors and actuators…

b) add to "virtual board"

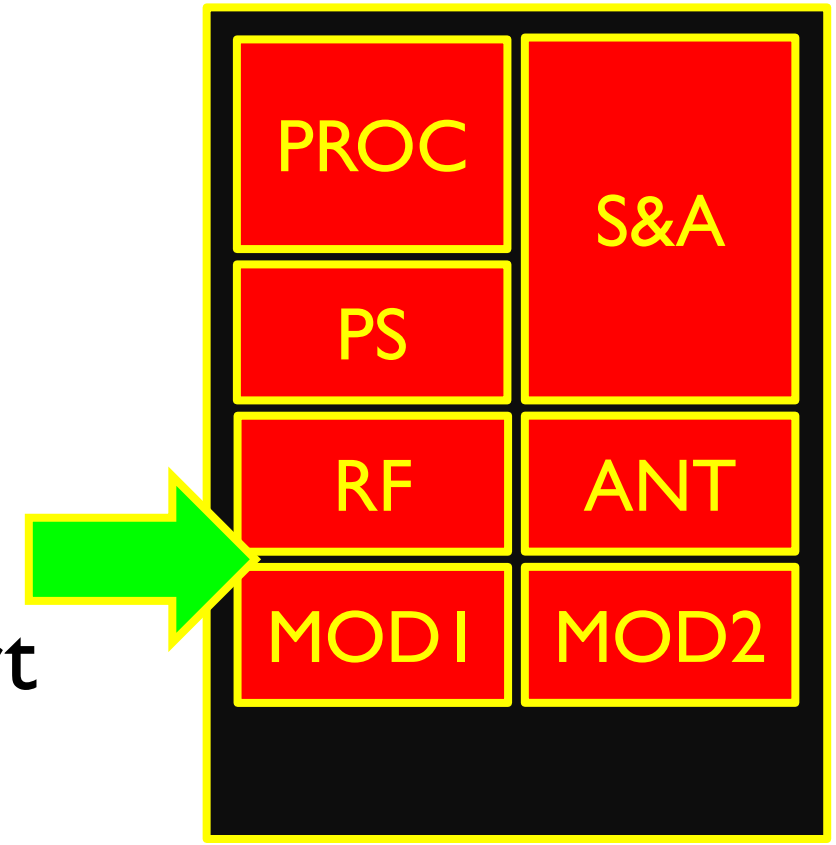




AraMiS P&P – Step 4

select and add:

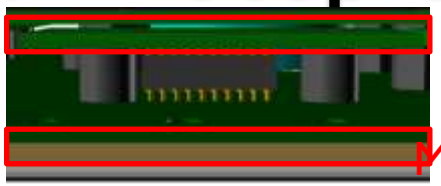
a) RF module(s)
b) antenna(s)
c) Other sensors
d) On-board modules
e) Payload support
f) Any other…

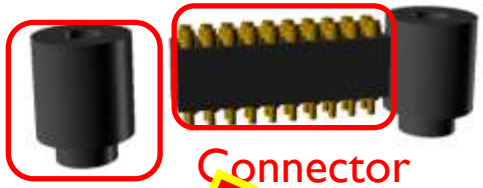


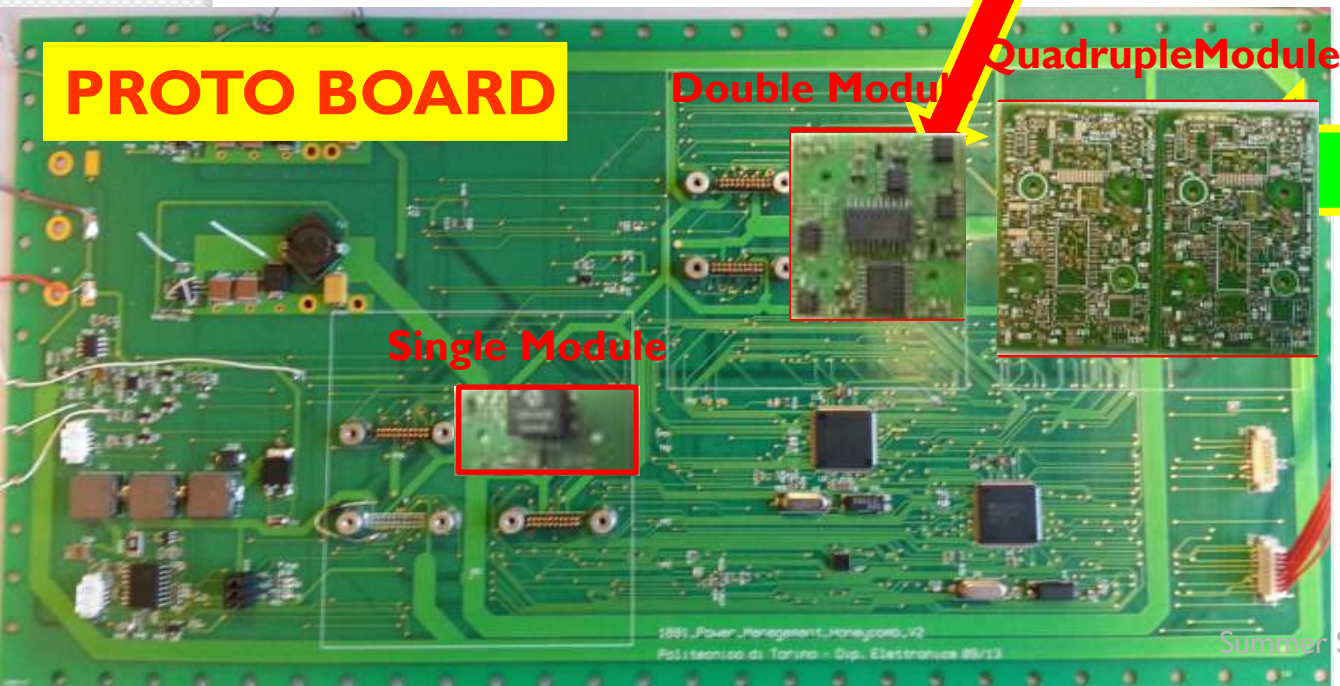
AraMiS P&P – Step 5 (proto)

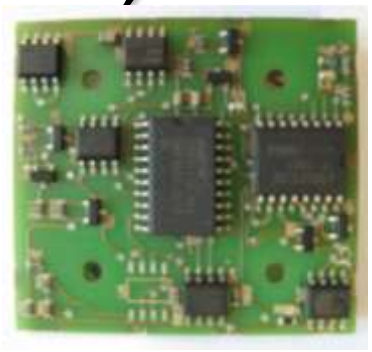
a) take corresponding proto modules

b) assemble to proto system







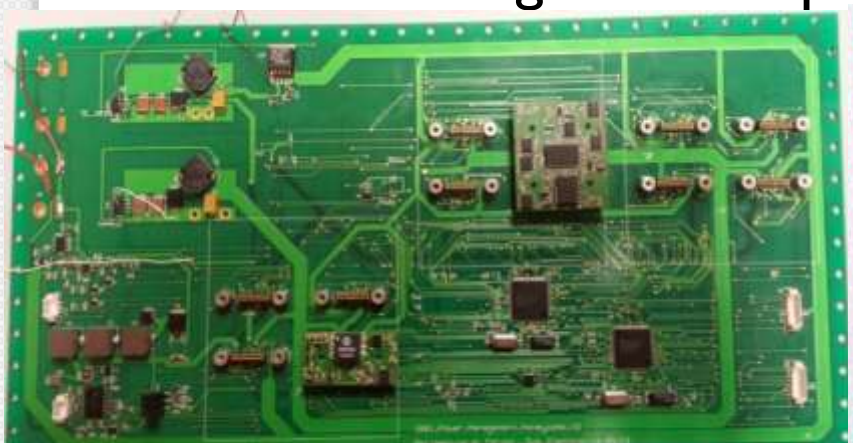


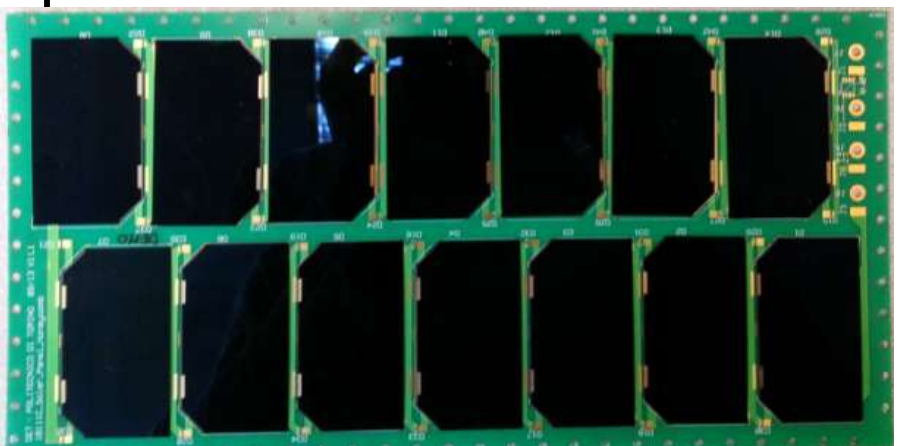
Smart Harness: Spacecraft Configurations

- Design the new subsystems either on single, double or quadruple module configuration.
- Test the subsystems on ground using development board.
- Integrate each physical module in a physical module based satellite configuration.
- Embed the logical modules in the main tile for a Satellite on demand configuration.
- The Satellite on demand configuration can be altered very easily for Reusable design configuration

Physical Module Based Configuration

- Develop standard tiles hosting multiple connectors
- Physical daughter boards connected to the tile via pluggable connectors
- The subsystem module only plugged if mission needs it.
- High level of design flexibility, testability and upgradability
- Testing of modules, tiles and whole satellite is needed
- For teaching/research purposes

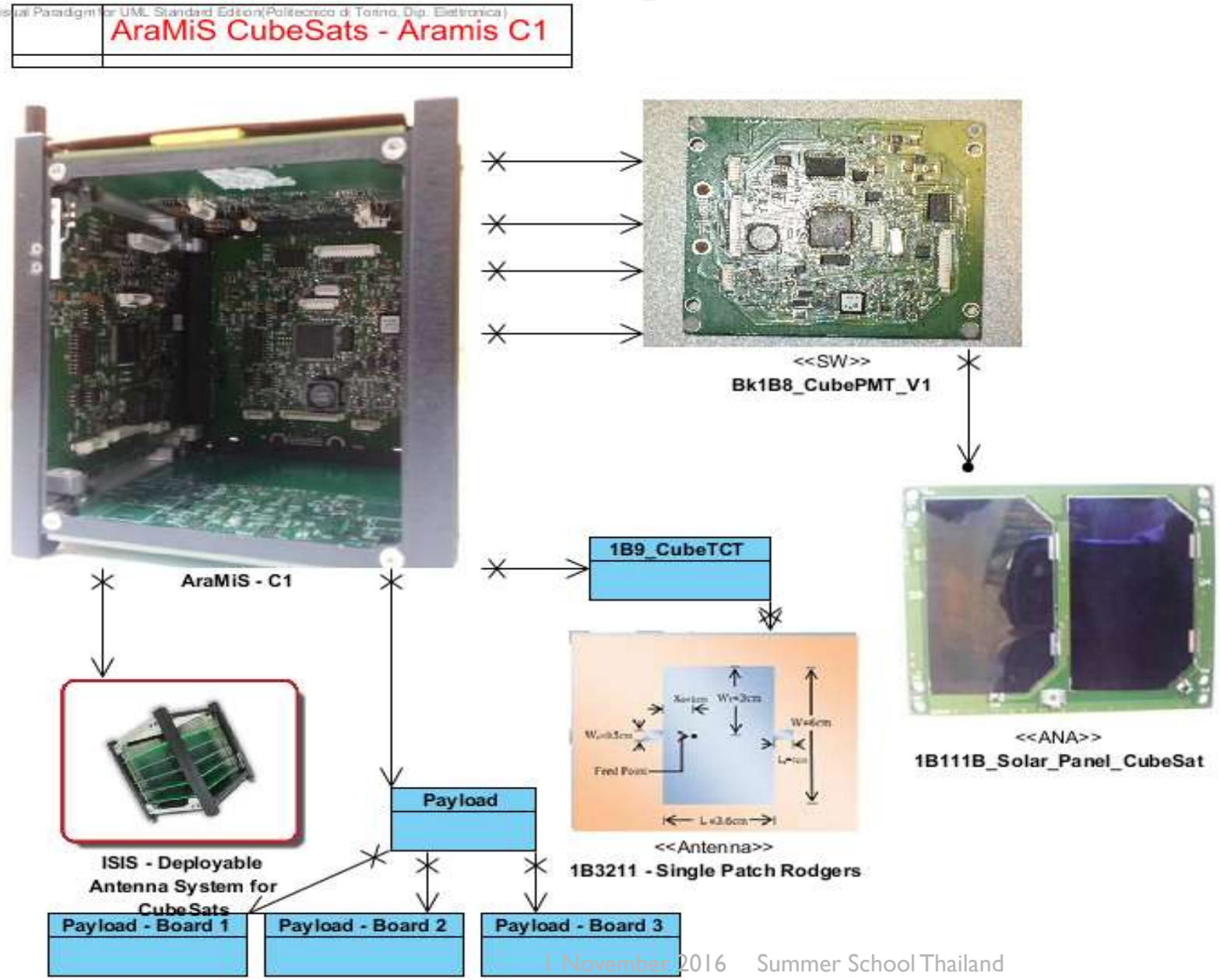




Satellite on demand Configuration

- Already tested modules integrated inside the PCB.
- Reusability of physical subsystem modules
- Permanent configuration
- Testing of modules: not required
- Testing of tiles and mission is required only
- CubeSat standard tile built using this approach

Satellite on demand Configuration - Aramis C1



Reusable design configuration

- Optimised spacecraft configuration based on mission requirements
- Reuse of the satellite on demand configuration
- Minor addition or removal of subsystems on customer demands
- Follows the Cheaper-Faster-Better philosophy
- Module and tile testing: not required
- Only mission testing is needed for this configuration

Conclusion

- The design technique achieves simple-faster-better design philosophy
- The modularity, flexibility and testability has been achieved at mechanical, electrical, protocol and testing level.
- Multiple spacecraft configurations possible with very short development times.

Thank You !!!