ADCSS 2022

16th ESA Workshop on Avionics, Data, Control and Software Systems

Power Reference Architecture, interface with Avionics and relevant MBSE model

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Acronyms and definitions

Acronyms

- **ADHA** Advanced Data Handling Architecture parallel studies (RUAG/ADS, TAS-I)
- **APA** Advanced Power Architecture (still in ITT phase)
- **APS** Auxiliary Power Supply
- **EPS** Electrical Power Sub-system
- **ITT** Invitation To Tender
- **LCL** Latching Current Limiter
- **MBSE** Model Based System Engineering
- **MPPT** Maximum Power Point Tracker
- **OBDH** On-board Data Handling (sub- system)
- **PCDU** Power Conditioning and Distribution Unit
- **RTU** Remote Terminal Unit
- **S3R** Sequential Shunt Switching Regulator
- **SA** Solar Array
- **SADE** Solar Array Drive Electronics
- **SAR** Solar Array Regulator
- **TMTC** Telemetry and Telecommand module

Definitions (NB – only key ones)

- **Observability of a system**
  A system is said to be observable if its current state can be estimated using only the information from its outputs.
  In other words, one can determine the behaviour of the entire system from the system's outputs.
- **Functional/logical view**
  The perspective of a system that identifies its functionality *without* specifying the physical allocation of the relevant functions
- **Physical view**
  The perspective of a system that identifies its functionality *including* the physical allocation of the relevant functions

Outline

- Introduction
- Motivation
- Subject and Methods
- Work performed
- Achievements
- EPS reference architecture ≠ MBSE “model”
- Focus of the reference EPS architecture
- Exploitation of the work done so far

- Acronyms and definitions

Introduction

- SAVOIR Sub-Working group appointed and ToR established mid March 2020

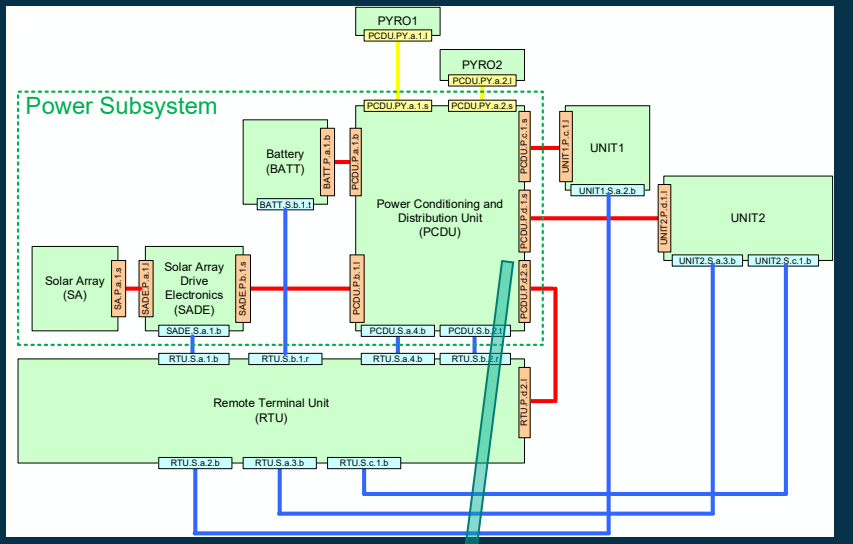
- Participants (only original composition, others joined later for specific discussions or as MBSE experts):
  - ADS, N. Neugnot, J. Seronie-Vivien
  - CNES, C. Elisabelar
  - DLR, N. Aksteiner
  - ESA, S. Landstroem, O. Mourra, F. Tonicello
  - OHB, J. Caudepon
  - RUAG (now Beyond Gravity), H. Myllymaki (then P. Koivisto)
  - SENER, C. Tato
  - TAS, G. Bouhours, J.L. Bolsee

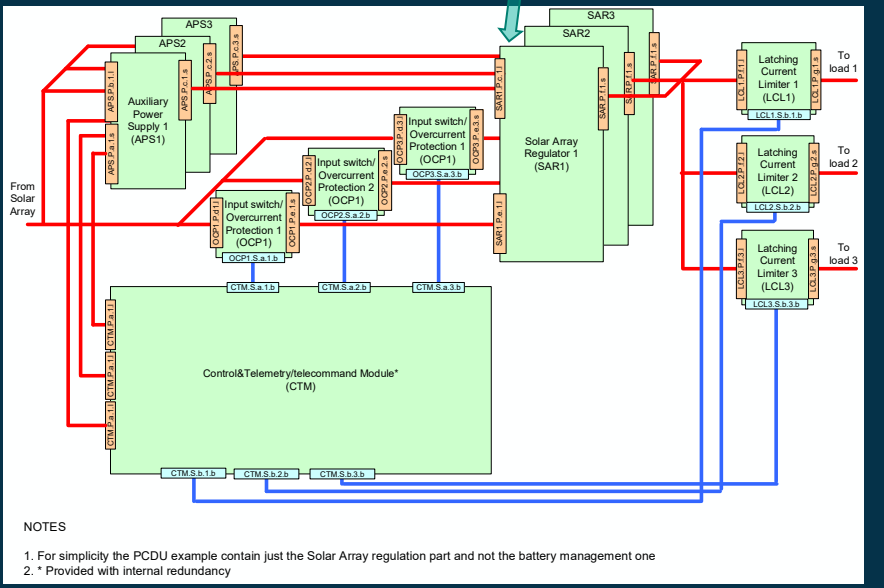
- 35 web meetings organised so far

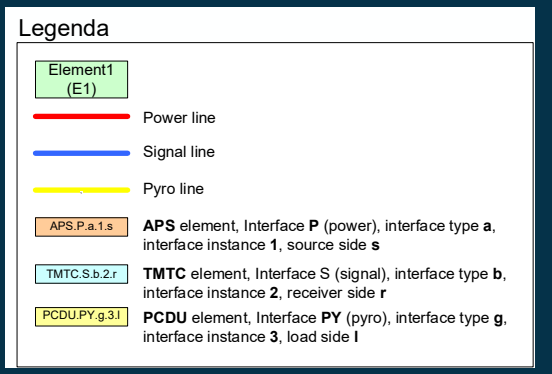
Avionics-Power interfaces / MOTIVATION

=> *Standardisation* effort for Power Sub-system

- At interface level
- As a first step towards more recurrent products
- With a realistic attitude based on consensus
- Making treasure of previous successful experiences
- With the aim to be MBSE ready!



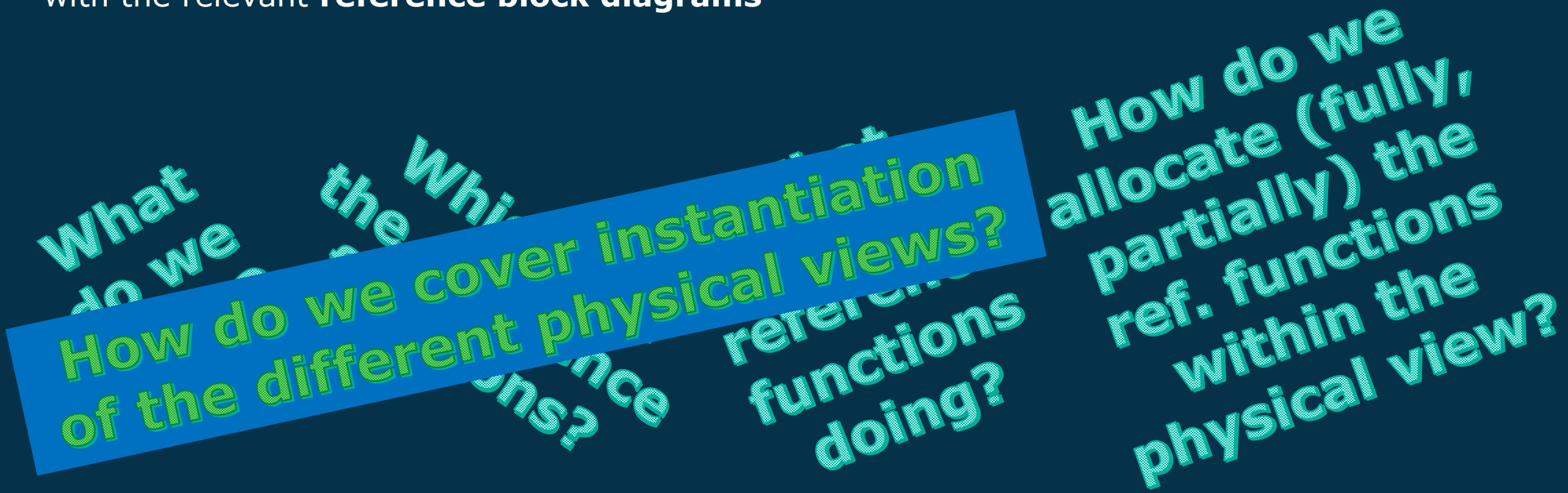




Avionics-Power interface / SUBJECT and METHODS

Reference architecture definition!

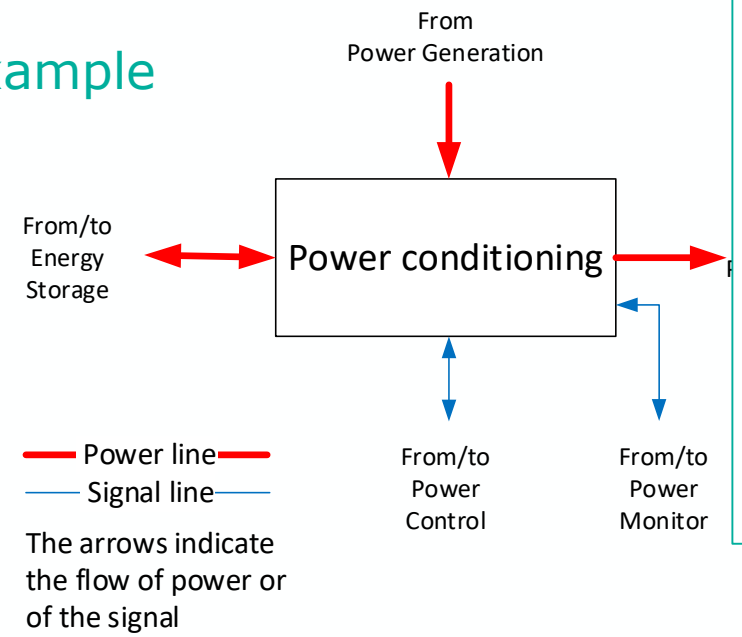
- Two step approach, **functional/logical** layer first, **physical** layer after that
- Most importance given to the precise correspondence of **verbal** definitions and assumptions with the relevant **reference block diagrams**



Avionics-Power interface / METHODS / in practice…

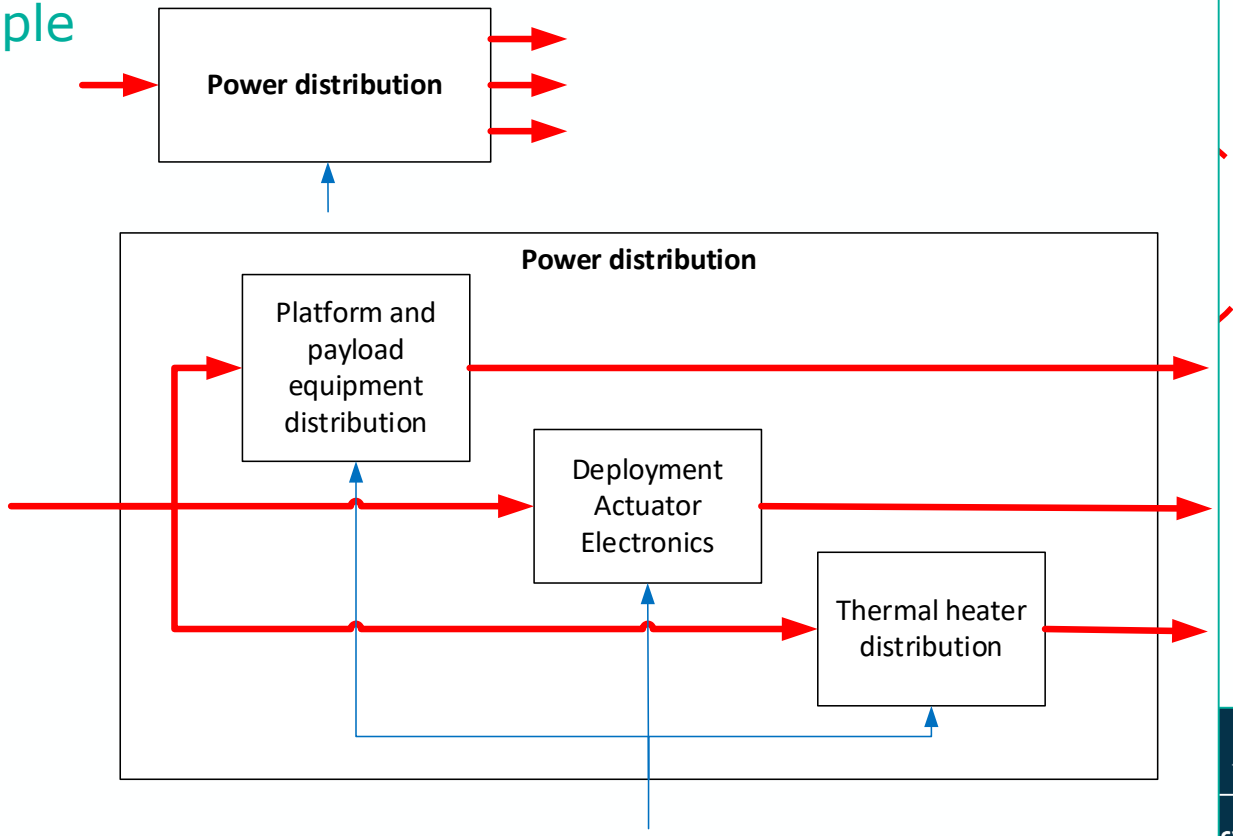
1. Broad system/subsystem functional/logical definition
2. Relevant (verbal) functions functional/logical description (as exhaustive as possible)
3. Block diagram ("twin") func function description

Example



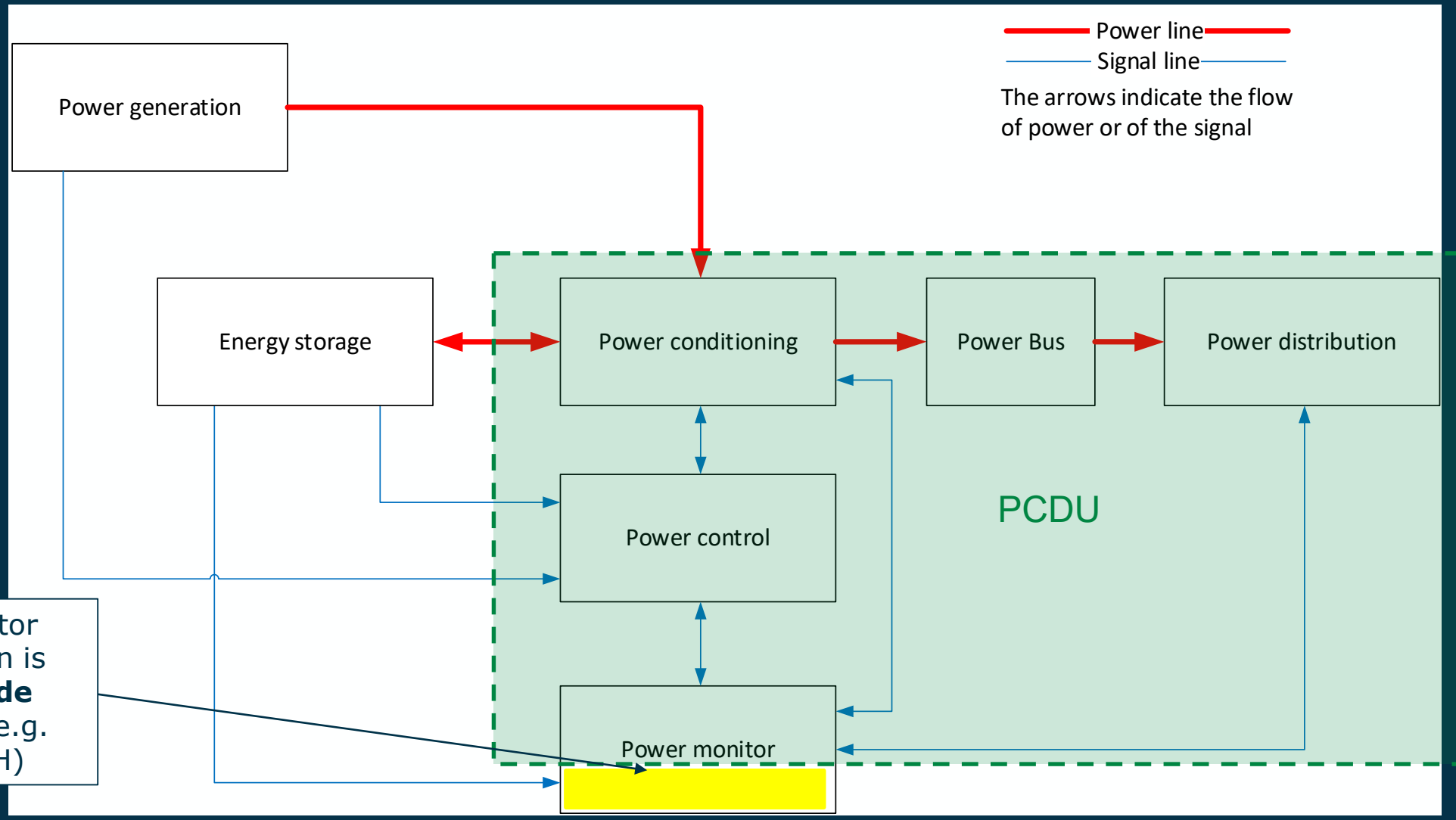
4. **Overall** Block diagram ("twin") functional/logical function description
5. "**Get inside the box**", functional/logical function description

Example



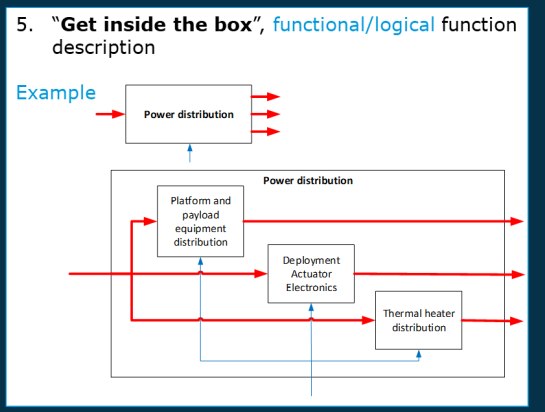
Avionics-Power interface / METHODS / in practice…

From functional/logical to physical block diagram (Validation)



Avionics-Power interface / WORK PERFORMED SO FAR

- Consolidating agreements on
  - Functional/logical EPS description, including both nominal and contingency aspects
  - The level of depth to go to
  - Possible instantiation options on EPS physical view



- Observability and commandability needs of all Primes/LSI discussed and generally agreed
  - Work in progress: translate this need into recommended standard interfaces where possible and convenient
    - E.g. from observability to telemetry needs, from commandability to command needs

Avionics-Power interface / MBSE “challenge” : selected path

•Use **formal MBSE tools**…

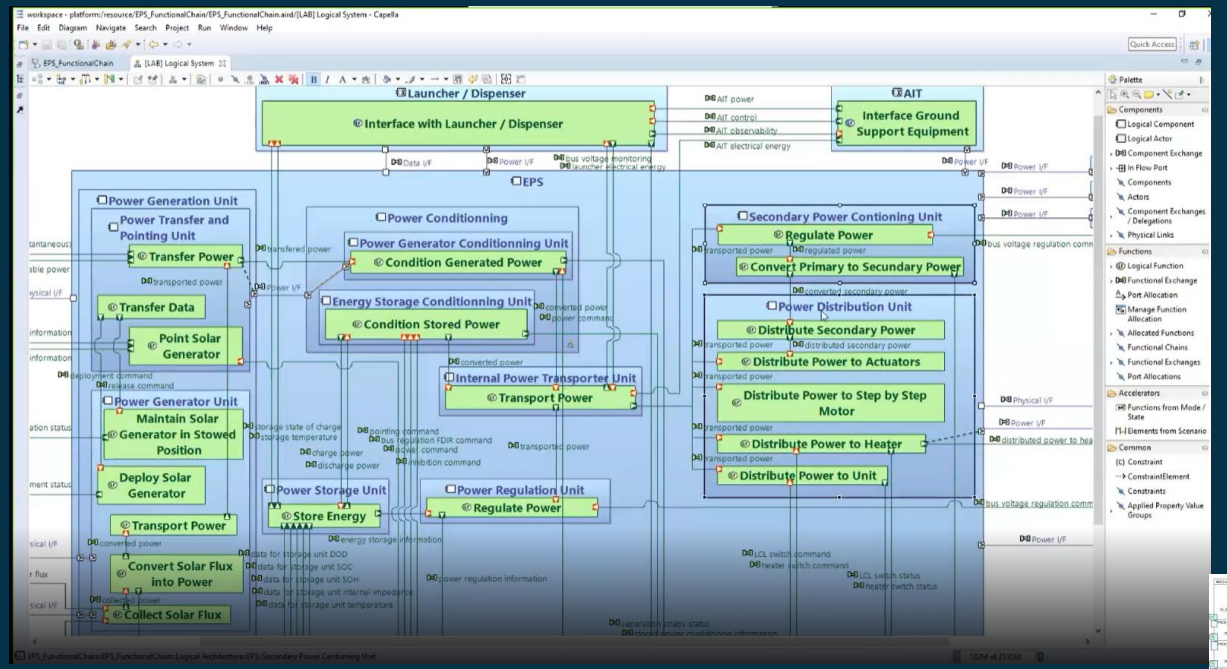
MBSE experts joined and contributed to the WG

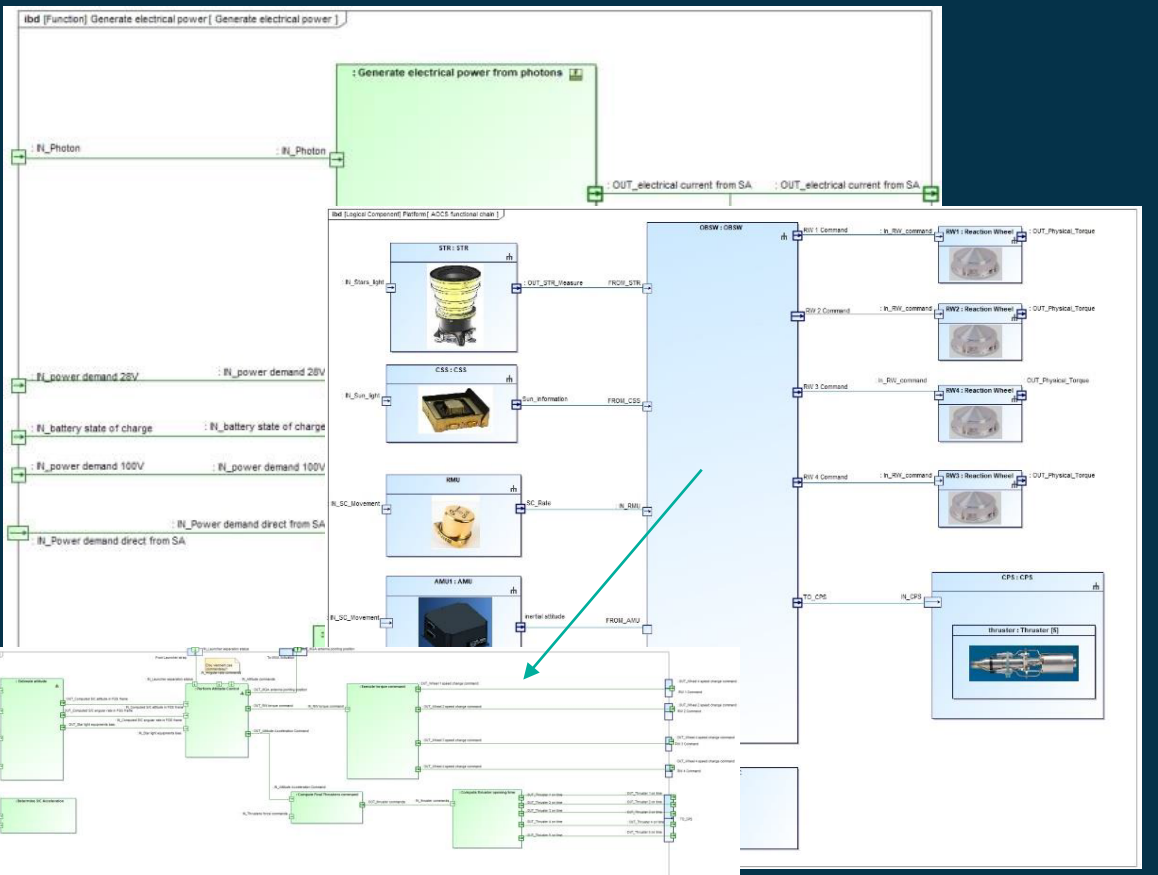
- Advantage: EPS model is immediately exploitable and connectable to the “system” models
- Disadvantage: may shift the WG effort to MBSE learning and formal compliance aspects and less to the identification of effective and unique (or minimum number of) reference architecture(s)

- … or we keep **“natural”description approach** **reference architecture**( ) to trans MBSE experts in a second time
  - Adv ori
  - Dis ge: second round of formalization ssary

Achievements

1. **Capella** Model (Functional/logical level) – TAS
2. **Cameo/SYSML** Model (Functional/logical and “Technical” level) – ADS
3. **Cameo/SYSML** Model (Functional/logical level) – OHB





Achievements

The developed MBSE models are similar at least on the logical/functional level but not equal

The problem remains to identify a **common**, **shared** reference architecture for the EPS

The original idea for the WG is to identify such reference architecture for the EPS at interface level such to promote the development of recurrent elements (at equipment but also at module level) that might be used for a set of different applications and missions.

Power reference architecture ≠ MBSE “model”

In fact… there is a difference between a certain subsystem (or system) definition and its model

The EPS reference architecture should respond to the original objective, e.g. be rather specific for the intended scope, while the MBSE model can indeed be of generic nature (for example, being provided with an extensive library of functions at logical or technical block level)

The focus of the WG is now directed into the identification of those EPS *properties* that on the basis of a commonly shared approach should be the basic ones for the “reference” architecture

NB

Properties and not *requirements* in the strict sense… their adoption is based on a mutual agreement based on the convenience to have a common approach

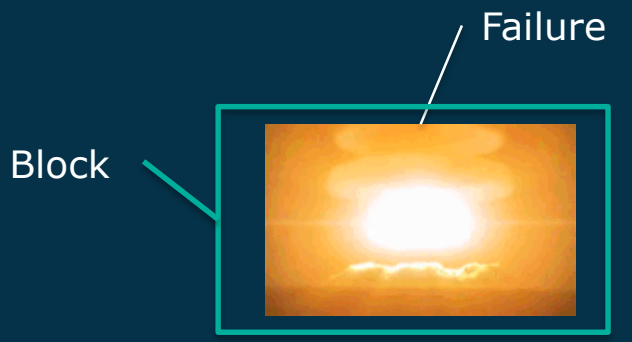
Focus on the reference EPS architecture

So the focus of the WG is now on

- Consolidation of observability and definition of (alternative) telemetry sets
- Consolidation of commandability and definition of (alternative) command sets
- Identification of recurrent issues on EPS development and definition of common, shared resolution strategies and approaches:

  - Internal interfaces (examples)
    - Resolution of possible spurious switch OFF events for essential modules (TMTC, SARs, BCDRs, other)
    - General protection of low level electronics from failure to or from power lines (failure confinement approach)

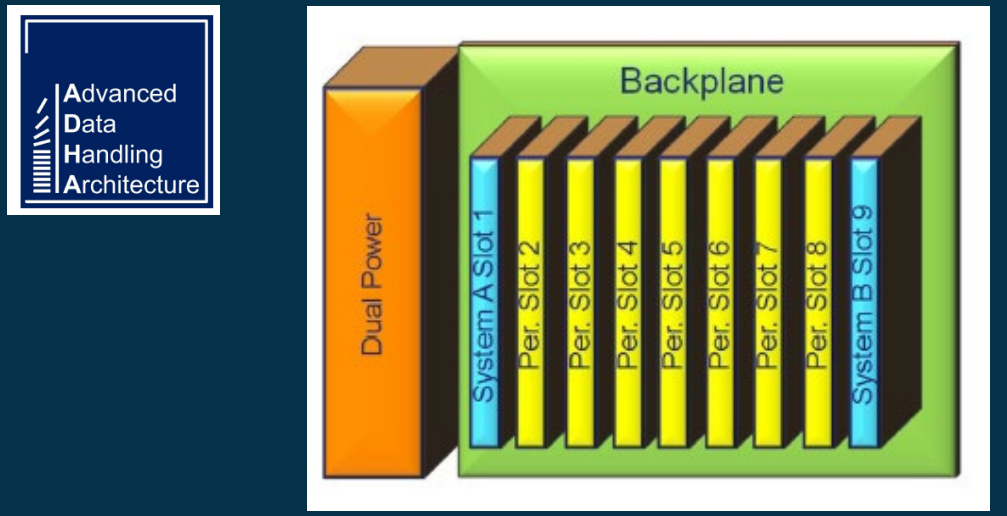
  - External interfaces (examples)
    - Battery Low Alarm, satellite reconfiguration (rely on dedicated lines)
    - Failure propagation to and from external power and signal interfaces (verification of fault emission and fault tolerance concepts)
    - Battery Passivation for debris mitigation purposes

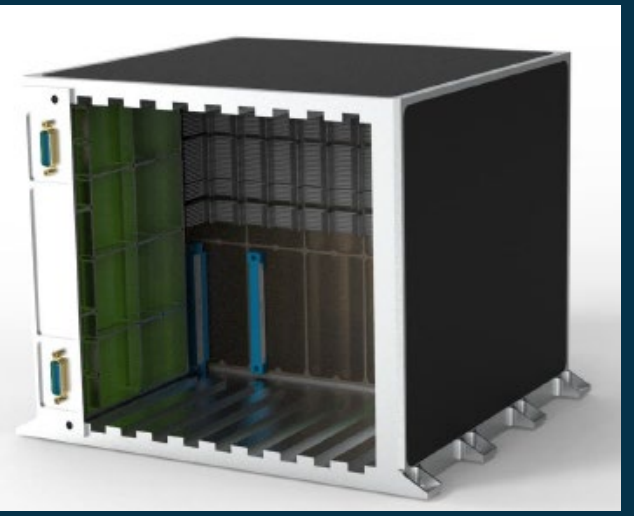


Exploitation of the work done so far

The outcome of the work performed by the group for the definition of the EPS reference architecture can be immediately and beneficially exploited in the following current standardisation initiatives:

- APA (Advanced Power Architecture) - *globally*
- ADHA (Advanced Data handling Architecture) – *at interface level*





Thanks for your attention!

Are there any questions?

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