International Academy of Astronautics – IAA
5th IAA Conference on University Satellite Missions and CubeSat Workshop

NANOSATC-BR3 CONCEPT DESIGN USING MODEL-BASED SYSTEMS ENGINEERING (MBSE)

Artur Gustavo Slongo*, Lorenzzo Quevedo Mantovani*, Nelson Jorge Schuch*, Otávio Santos Cupertino Durão, Fátima Mattiello-Francisco**, André Luís da Silva***, Andrei Piccinini Legg*** and Eduardo Escobar Bürger****

* Southern Regional Space Research Center – CRCRS/COCRE/INPE-MCTIC, in collaboration with the Santa Maria Space Science Laboratory - LACESM/CT-UFSM, Santa Maria, RS, Brazil, arturgustavoslongo@gmail.com, lorenzzo.mantovani@gmail.com, njschuch@gmail.com.
 ** National Institute for Space Research (INPE/MCTIC), São José dos Campos - SP, Brazil. otavio.durao@inpe.br,
fatima.mattiello@inpe.br.
 *** Federal University of Santa Maria - UFSM, Technology Center, Professors, Santa Maria - RS, Brazil.
n.br, andrei.legg@gmail.com, eduardoebrg@gmail.com

Rome - Italy, 28th - 31th January 2020

SUMMARY

1. NANOSATC-BR program;

2. NANOSATC-BR3;

3. OBJECTIVES;

4. MODEL-BASED SYSTEM ENGINEERING;

5. CAPELLA - ARCADIA;

6. NCBR3 CONCEPT DESIGN WITH MBSE;

7. NCBR3 MISSION CONCEPT;

8. DISCUSSION;

9. CONCLUSIONS.

NANOSATC-BR PROGRAM

NANOSATC-BR1

➢ 1U platform and GS purchased from ISL/ISIS, through international bid in 2010;

➢ Magnetometer (INPE/MCTIC), Fault Tolerant FPGA (UFRGS) and IC on/off driver (SMDH/UFSM);
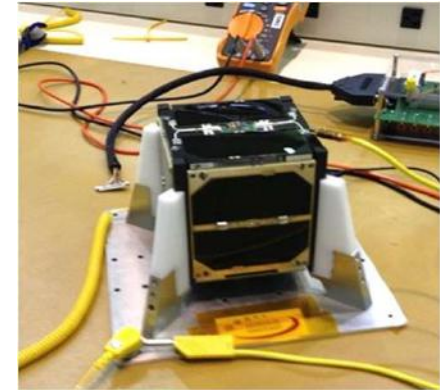
➢ Operational since 2014

Figure 1 - NANOSATC-BR1

http://www.inpe.br/crs/nanosat/galeria.php

NANOSATC-BR2

➢ Langmuir Probe (INPE/MCTIC), Attitude Determination System (Cooperation INPE/MCTIC with UFMG - UFABC), Other ICs (SMDH and UFRGS) and two magnetometers;

➢ Currently at Assembly, Integration & Tests process.

Figure 1 - NANOSATC-BR2 EM

NANOSATC-BR3

Figure 2 - NASA / SOHO

- ➤ Currently in its **Conceptual Phase of Development**;

- ➤ To study **Space Radiation** and develop **Capacity building**;

- ➤ Constraint: **Reuse** NANOSATC-BR1 EM;

- ➤ Stakeholders and their needs:

  - ➤ **INPE Scientists** need to validate a radiation protective material in space.

  - ➤ **UFRN/CRN** technologists need to validate their transceiver in space environment.

  - ➤ **UFSM and UFRGS** technicians and Professors need to validate their integrated circuits against space radiation.

  - ➤ **Galileo Mission Scientists** need to analyze the dynamics of trapped particles in radiation belts and their influence on embedded electronics.
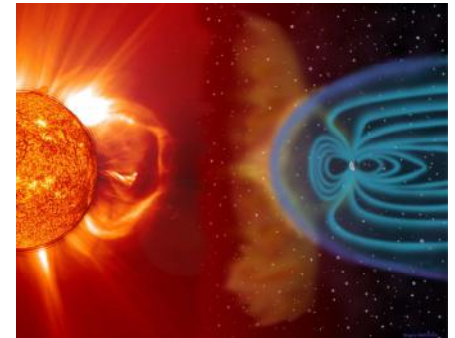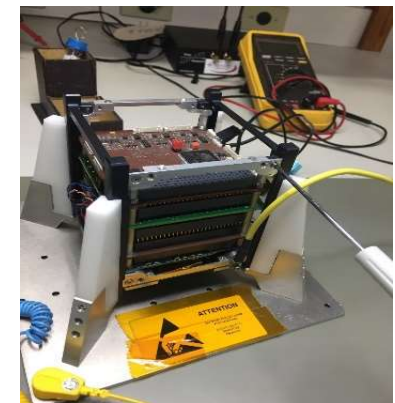

Figure 3 – NCBR3 EM

OBJECTIVE

- Use an MBSE software with an embedded Systems Engineering method to:

  - Identify Mission needs and their interrelation;

  - Identify high level system functions;

  - Develop a mission concept;

  - Capture requirements;

  - Build the first NCBR3 Model;

  - Introduce the use of MBSE in the Program.

Operational Capabilities

Operational Activities

System Functions
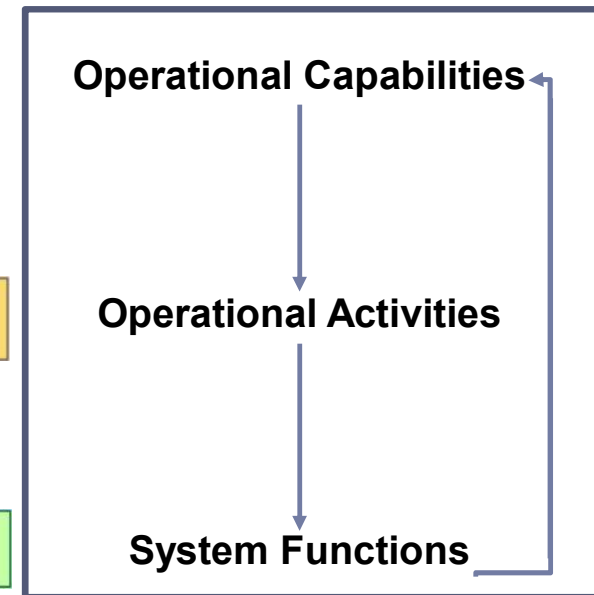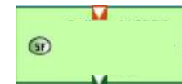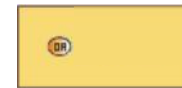
MODEL-BASED SYSTEM ENGINEERING

"*Formalized application of modeling to support requirements definition, design, analysis, verification and validation activities*"

➢One of the main Goals:
    ➢**Integrate** information, communication and the analysis of systems engineering products.

➢Modeling is based on three pillars:
    ➢**Tool**: Concerns to the instrument (usually software) that will be used to develop the work;
    ➢**Language**: Method of communication between the user and the tool (similar to a programming language);
    ➢**Method**: process that sometimes is conveniently embedded in the tool.

CAPELLA - ARCADIA

- Integration of all model views;

- Open source;

- Largely used by space industry;

- Meets all three pillars;

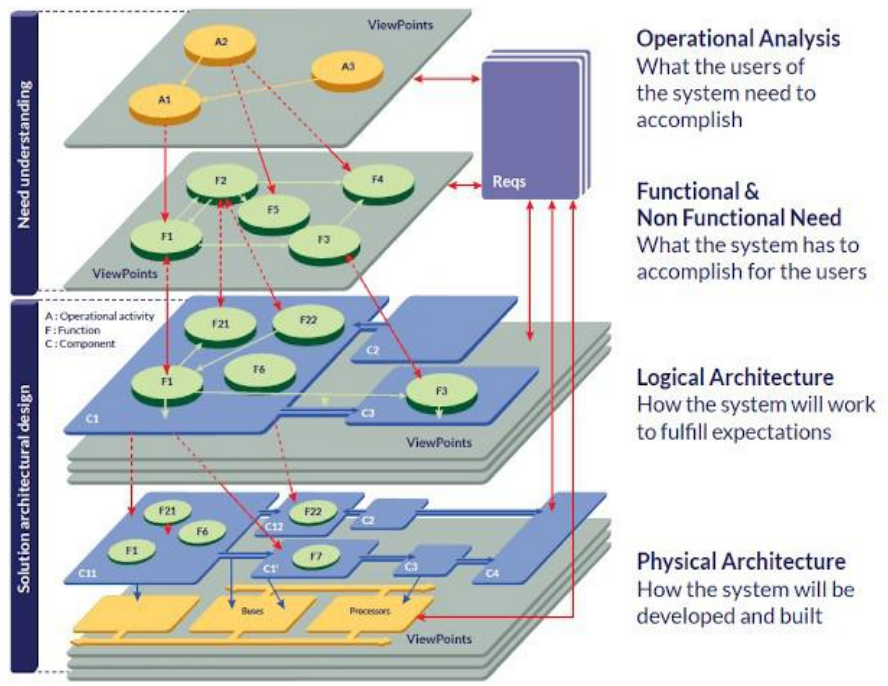- Four steps of development;

- Interactive and recursive method.

Figure 5: The Arcadia Method
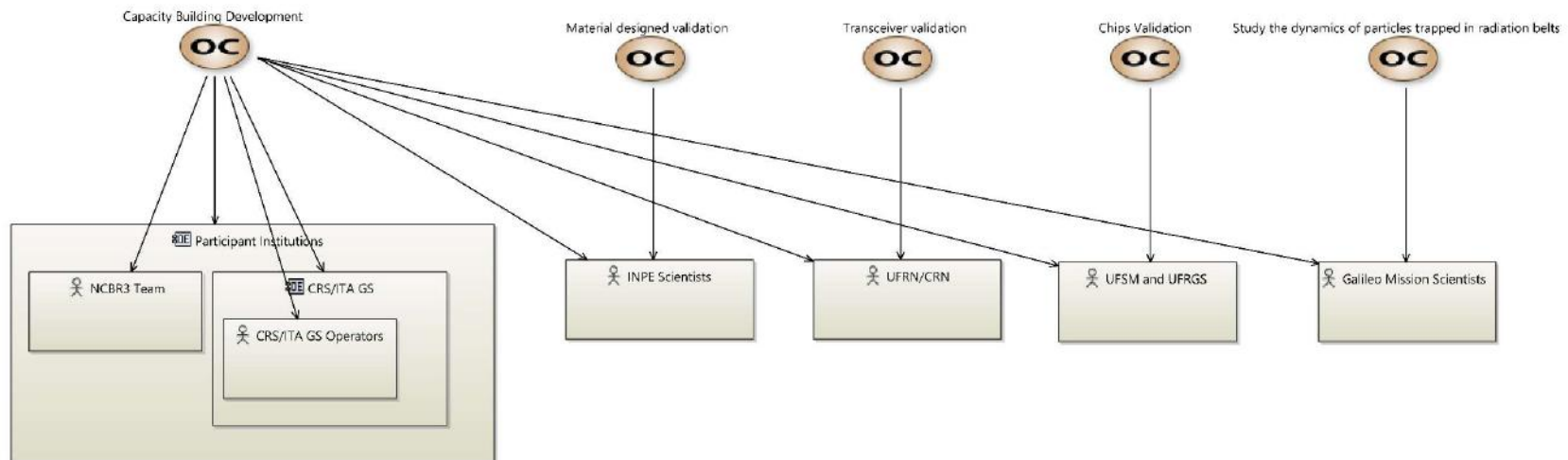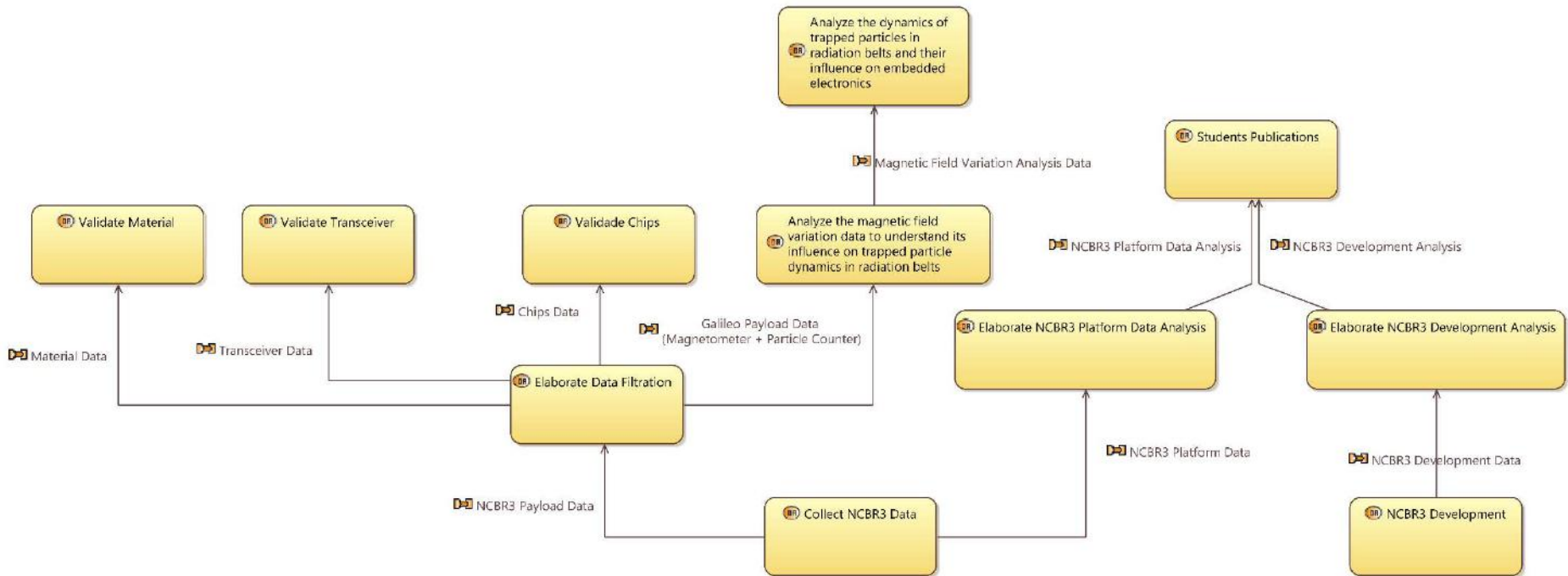**Source:** https://www.eclipse.org/capella/arcadia.html

Operational Capabilities:

Figure 4: Operational Capabilities

- Operational Capabilities (Needs);
- Actors (Stakeholders).

Operational Activities Interaction:

Figure 6: Operational Activities Interaction

➢ Operational Activities;

9

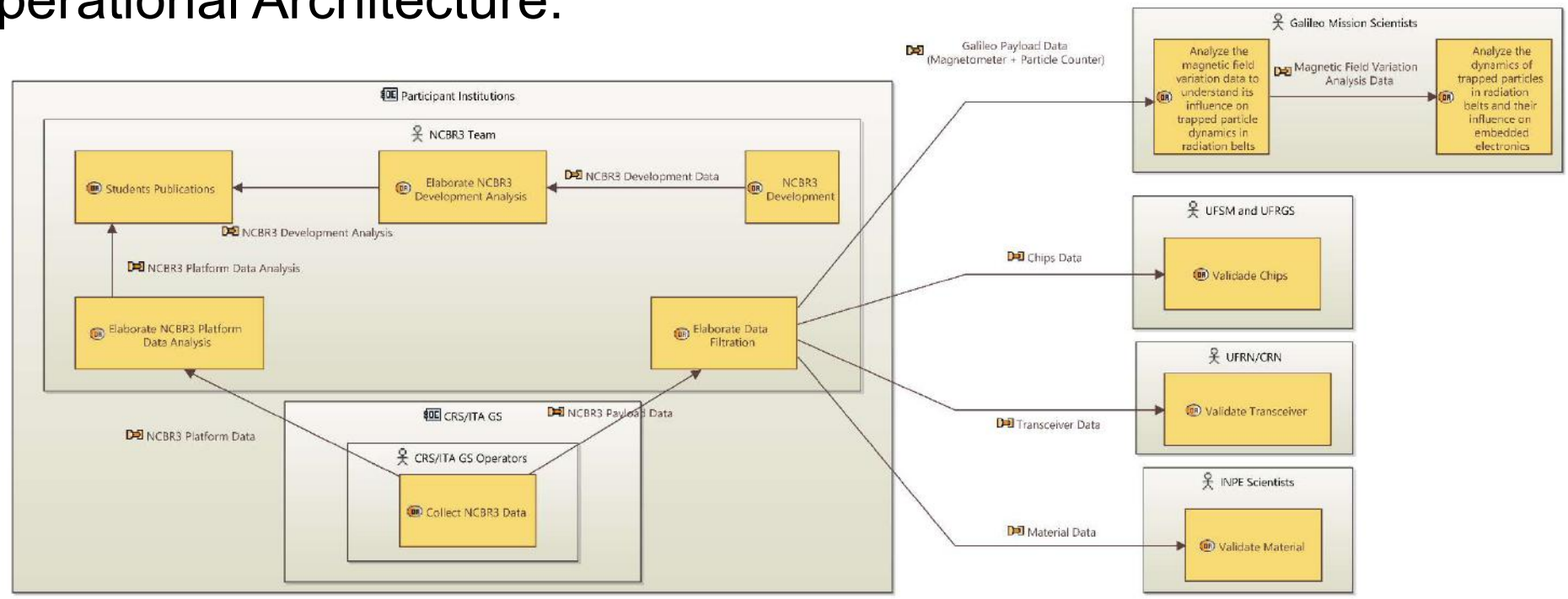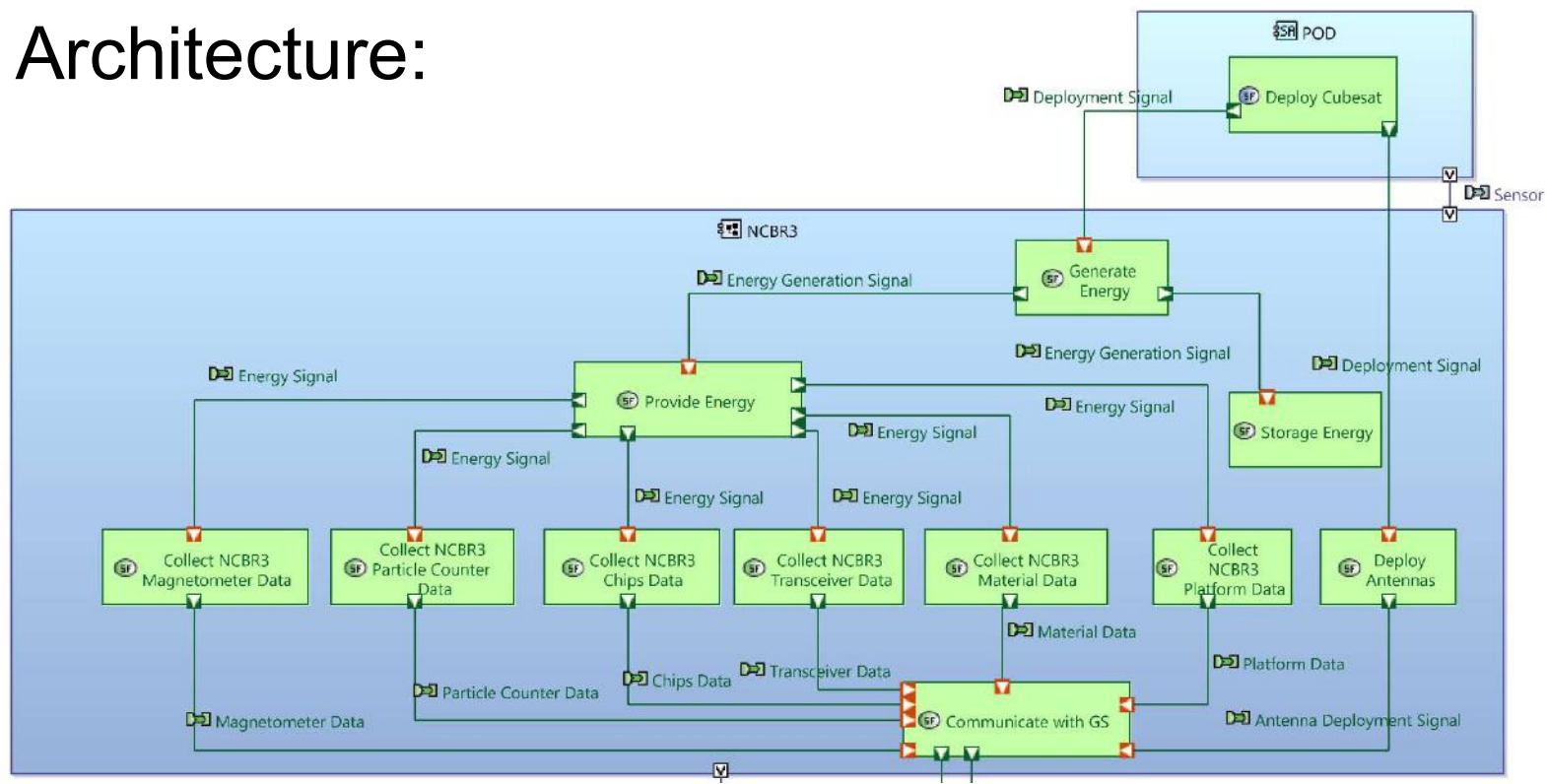# NCBR3 CONCEPT DESIGN WITH MBSE

Operational Architecture:

Figure 7: Operational Architecture

➢ Operational Activities;

➢ Actors.

NCBR3 CONCEPT DESIGN WITH MBSE

System Architecture:

Figure 8: System Architecture

- Actors;
- System;
- System High-Level Functions.

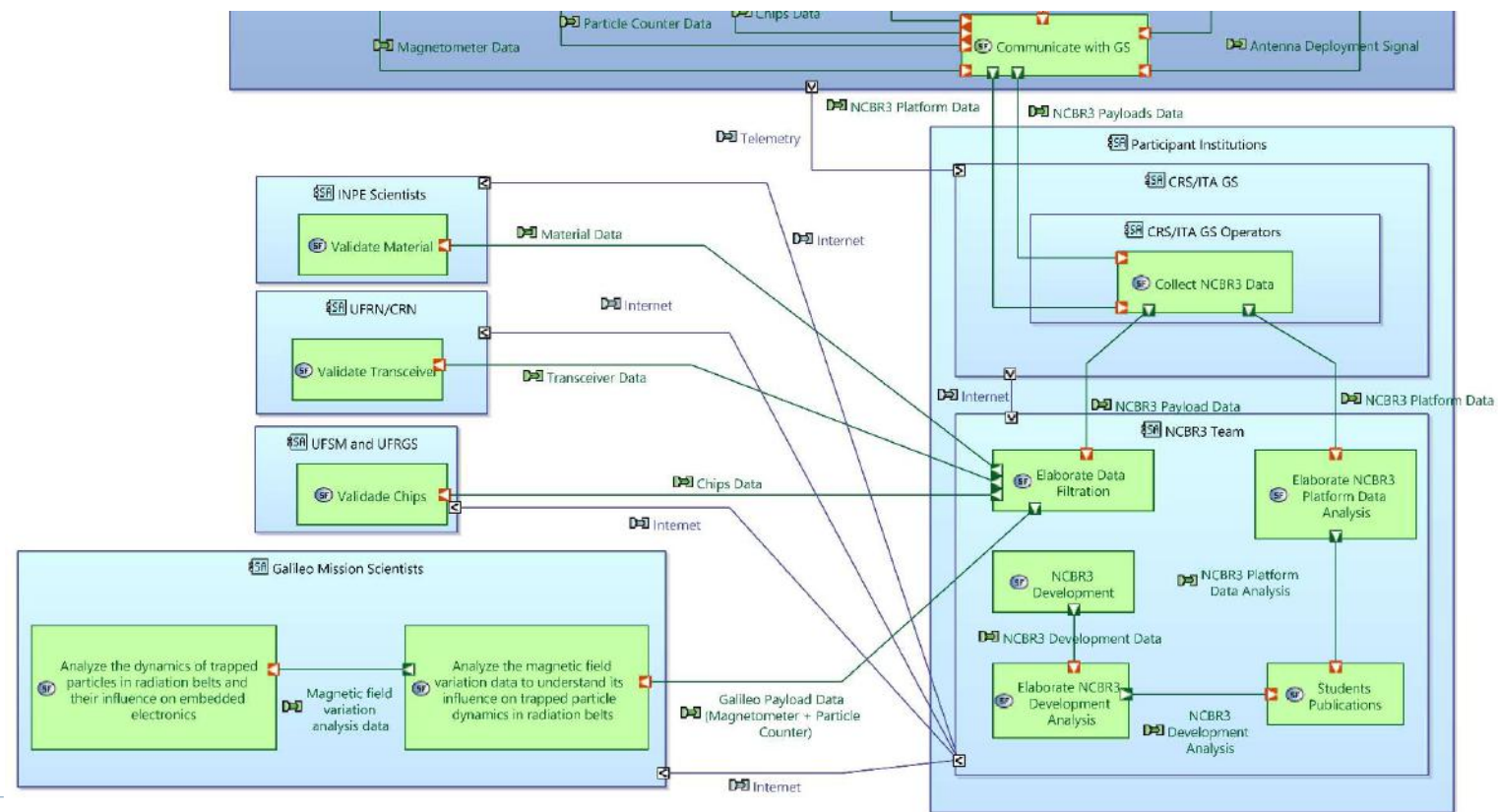# NCBR3 CONCEPT DESIGN WITH MBSE

System Architecture:

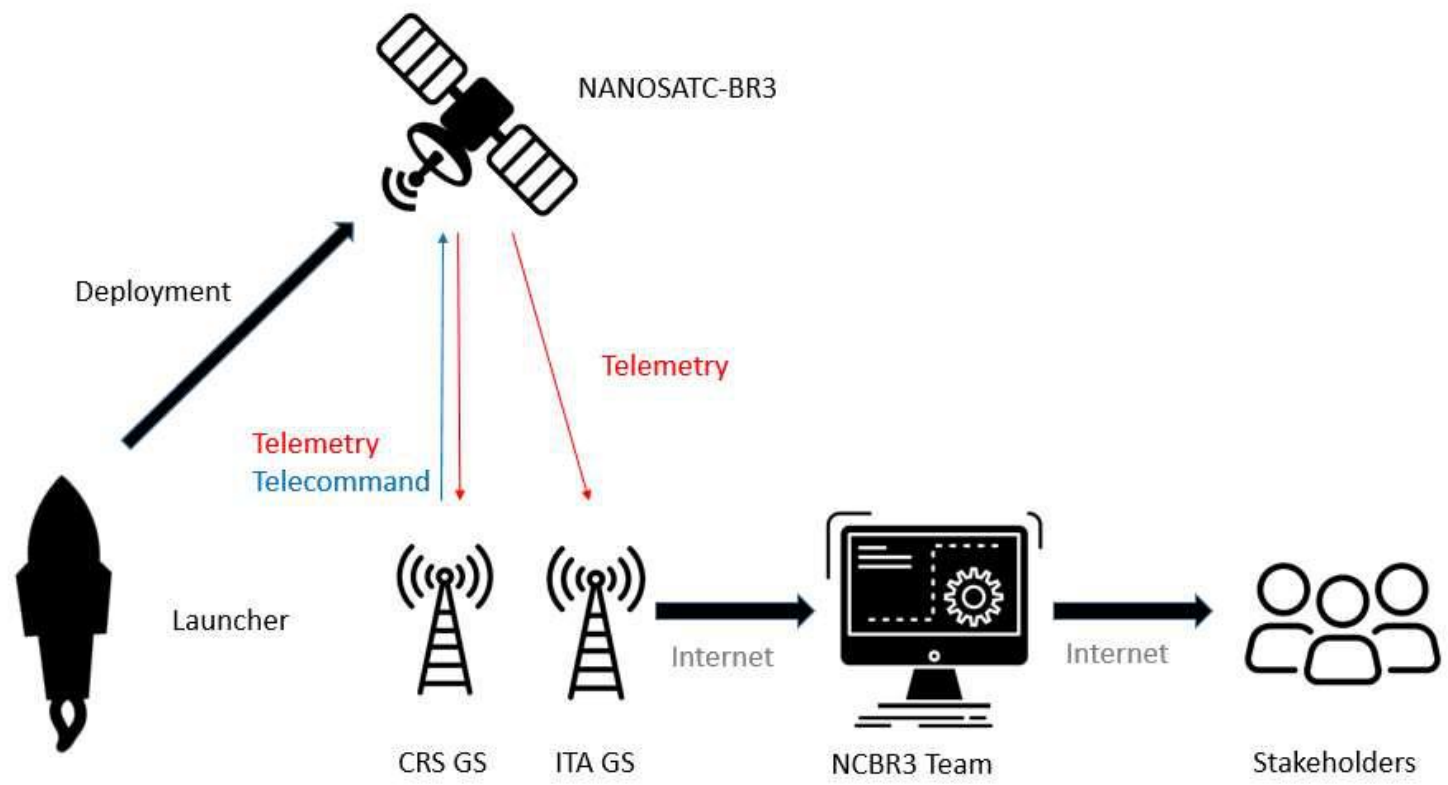**Figure 9: System Architecture**

Figure 10: NCBR3 Mission Concept

DISCUSSION

> **MBSE** main contributions:

> Hidden requirements;

> Improve communication;

> Visual tool – unify system understanding;

> System boundaries and basic functions;

> Viable system concept;

> Reduced project paper work;

> Traceability raises reliability.

CONCLUSIONS

- MBSE:
  - Made possible a much more structured mission **Phase 0**;
  - Has educational purposes competence;
  - **Consolidates** and **unifies** understanding;
  - Very useful to Project Reviews.

- Future Works:
  - Further modeling through next steps;
  - Encourage MBSE culture within NANOSATC-BR Program.

ACKNOWLEDGMENTS

The NANOSATC-BR Program site is: www.inpe.br/crs/nanosat/

Muito Obrigado

Thanks

Grazie

ARTUR GUSTAVO SLONGO
arturgustavoslongo@gmail.com

International Academy of Astronautics - IAA
5th IAA Conference on University Satellite Missions and CubeSat Workshop
Rome - Italy , 28th - 31th January 2020