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Use of SysML and Model-Based System Engineering in the development of the Brazilian Satellite VCUB1

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This work presents an integrated system modeling approach for VCUB1, the first nanosatellite 100% developed by the Brazilian private sector. The Brazilian company Visiona needs to master some key technologies to better play its role as a national integrator of satellite systems and the 6U nanosatellite VCUB1 represents a low cost alternative to reach higher levels of maturity of these technologies. The satellite development is under a partnership between Visiona and the Brazilian applied research institute named “Senai Innovation Institute for Embedded Systems.” The main objectives of the VCUB1 mission is to validate the software of both the Attitude and Orbit Control System (AOCS) and On-Board Data Handling (OBDH), the development of a ground station (Ground Station, GS), an integration bench for the OBDH (intended to assist the integration tests of the Embedded Computer with the other subsystems, sensors and actuators of the VCUB1 nanosatellite), and test future space missions for both communications relay (IoT connectivity and earth imaging). The reliability requirements of space systems entail their validation in the space environment and can only be achieved by an orbiting / flight test campaign. The VCUB1 satellite represents a low cost alternative to reach higher levels of maturity of these technologies.

The tests in operation aims at providing solutions for the retransmission of data collected on land and generation of information through imaging. Brazil is a country of continental dimensions and requires low cost connectivity solutions for various sectors of the economy, such as water reserves management, agriculture, cattle raising, and truck fleets. A network of Data Collection Platforms shall be used for validation of the communication protocols during the operations phase. The generated imagery data will be transmitted to both control centers and transportable ground stations to generate diverse information on plantations, forest deforestation, and populated areas (applications in smart cities). The information generated by the imagery should benefit not only the large rural producers, but also the family agriculture. At the Brazilian State of Santa Catarina, 90% of the producers are family farmers, accounting for about 70% of the state's agricultural and livestock production. In Brazil, 84.4% of the rural establishments are family-based and occupy 74.4% of the labor force in the countryside. Thereby, the experiments with communication relay for connectivity and local information generation using imagery shall improve many different sectors of Brazilian economy and represents an important result for VCUB1.

The development approach is top-down (system to the implementation level) and uses the Model Based Systems Engineering (MBSE) [1] [2] and Systems Modeling Language (SysML) [3] [4] concepts and tools to stablish the Concept of Operations (CONOPS) [5], requirements

analysis, use cases, functional analysis, system architecture, and interfaces and tasks associated with a given system. MBSE is used to produce model repository for analysis, verification, and validation since initial design phases through a coherent system design. The SysML modeling language is used to better define, trace, validate requirements, and establish relationships among various design elements. The software Innoslate and TTool are used in the system design. Innoslate is a modern web-based MBSE tool that supports the full lifecycle from Requirements Definition and Management to Operations. The free software TTool is adapted to modeling the control part of real-time systems and to analyze their models in terms of temporal ordering of events.

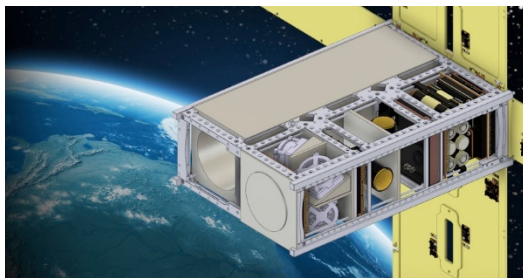


Figure 1: VCUB1 general design.

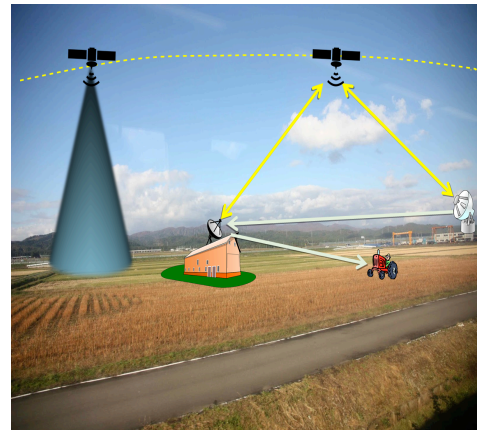


Figure 2: VCUB1 will execute missions for data relay and remote sensing.

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