Integrated information architectures for space missions

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***Abstract*—Current information management solutions for space missions are heavily based on manual operations. An integrated information architecture that addresses challenges of mission development and operations can reduce this burden and allow people to maximize their contribution to the mission.**

***Index Terms*—Information architecture, mission data life cycle, system engineering.**

I. Introduction

Space missions are of great complexity and necessarily use, generate and maintain an immense amount of information throughout the mission life cycle. The primary function of a mission is to transfer information in the case of satellite communications or to generate it through measurements in the case of science missions. Traditionally the data life cycle and the information architecture supporting it have been overshadowed by the sheer physical challenges associated with spacecraft. We have come, however, to the point where all aspects of the mission, except for fabrication of the physical spacecraft and its delivery into space, are mediated by computers and are therefore information based. The majority of the expenditures during mission development (whose objective is to deliver the physical spacecraft) involves only information and does not involve any physical realization of the spacecraft. Under such circumstances it is certain that issues relating to the mission data life cycle, information management and the information architecture that underlies them has a great effect on cost, schedule and risk.

II. An integrated information architecture approach

The approach is based on the recognition that primary function of the mission is transfer or generation of information and that by bringing modern information tools, techniques and processes to bear we can obtain improvements in risk, reliability, cost, schedule, performance and above all exploitation of the data.

In general terms the mission life cycle consists of three parts: (1) preliminary concept development work leading to approval of funding for the mission, (2) mission development and (3) operations and mission data exploitation. We can focus on (2) and (3) since concept development is a microcosm of the other two. With the complexity of modern mission development, the primary challenges are visibility, i.e., "what has been accomplished", and synchronization, i.e., "do we agree?" We address these challenges with UML/SysML modeling tools, executable models, simulation, test driven development and automated regression testing from agile software development methodology and automated workflow tools. The challenges in operations and data exploitation currently revolve around the lack of a strategic focus on the data and its integration into terrestrial applications and around processes that are based on a lot of manual effort. Use of modeling tools in mission development will help to establish strategic focus. In addition deployment of the space internet and tighter integration between space assets and terrestrial networks (e.g., virtual observatories for astronomy, sensor networks for earth observation, grid or cloud computing for data processing and the terrestrial internet for communications) will simplify operations and improve data access and exploitation.

III. Results

We have begun exploring the use of these tools in an integrated fashion in small internal projects at the Canadian Space Agency in order to establish a base of experience and demonstrations to show how these techniques work together. Space standards development work has begun [1],[3] to address information architecture issues in order to serve applications such as sharing of planetary data [2].

IV. Benefits for Space Systems

Sophisticated information architecture will allow people to maximize their contribution to mission development or data applications by reducing the manual steps in the management of mission related information.

References

[1] D. J. Crichton, J. S. Hughes, and S. Kelly. “A Science Data System Architecture for Information Retrieval.” In Clustering and Information Retrieval, edited by W. Wu, H. Xiong, and S. Shekhar, 261-298. Network Theory and Applications. Norwell, Massachusetts, USA, and Dordrecht, The Netherlands: Kluwer, 2003.

[2] NASA-PDS/ESA-PSA Planetary Data Interoperability, Pedro Osuna, Steve Hughes, Joe Zender, http://planetarydata.org/documents/white-paper-wp/IPDA-STC-WP-001_1_0-2005JUL01-NASA%20ESA%20Interoperability.pdf

[3] CCSDS Information Architecture Working Group Charter, http://cwe.ccsds.org/fm/Lists/Charters/PrintView.aspx?ID=21, November, 2008.

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