

Commentary on the paper “MEXAR2 – An Operational Tool for Continuous Support to Mission Planning” by Amedeo Cesta et. al.

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Abstract

This paper is a very interesting example of the application of A.I. technologies applied to a European space mission ground system. It is well thought-out and well-presented from an A.I. technology perspective, however there is some information on the impact of MEXAR2, both from a the SW architecture and operations point of view which are missing from the paper. Knowing the ESA operations environment, this is a particularly interesting paper with many interesting points, and some very interesting potential applications both in the commercial and institutional worlds.

Introduction

The paper discusses a very interesting application of A.I. technologies to a fairly new terrain of application, particularly in Europe. Given that spacecraft operations environments are typically very conservative and change their operations approaches only with reluctance, it is very interesting to see that MEXAR2 has been adopted and incorporated into the operations concept for Mars Express by ESOC. It appears to provide a very innovative solution to a difficult problem, and have a significant impact on the Mars Express operations team.

Commentary

Coming from an operations and SW environment perspective, there are several comments and questions which immediately come to mind:

- Knowing how conservative operations environments are traditionally, the manual work involved in the Spacecraft Memory Dumping Problem must have been very considerable for an alternative approach to be even considered. Was there any attempt to quantify this effort?
- The paper mentions briefly the initial skepticism of the ESA personnel with respect to the new technology. The human factor in finally getting

MEXAR2 accepted into the routine operations of the mission must have been a source of a considerable amount of work. With a proven solution which worked, even if it did generate a lot of work, the operations team would normally be reluctant to change operations concepts for a new technology, SW and operations concept, even if the new technology significantly reduced the work load and improved the results. There was also probably a significant barrier created by the fact that MEXAR2 uses technology which was probably not well understood initially by the operations team, given the little application of A.I. technologies to the spacecraft mission domain.

- The amount of work needed to integrate MEXAR2 into the routine operations of Mars Express must have been considerable. Would it be possible to comment more on this?
- Presumably Mars Express had a fairly typical ESA ground system architecture whose SW components were based around a SCOS-2000 Monitoring and Control system which served MEXAR2 its packet telemetry via the MPS. Was the MPS incorporated into the SCOS-2000 M&C, and did it do any additional processing of the CCSDS packets from the spacecraft beyond what SCOS-2000 did? In what format did MEXAR2 receive the packets?
- Interfaces between different components of a ground systems are typically a source of problems. How was MEXAR2 incorporated into the operations of the Mars Express Mission Planning and how was this done without disturbing the on-going operations?
- There has been a great deal of discussion over the last few years of standardization in the area of satellite ground systems. In particular, CCSDS packet standards have been promoted, particularly in institutional missions. Were these standards useful or helpful in defining the problem in the A.I. technology domain? For the satellite monitoring and command systems,

CCSDS standards have provided significant benefits from a ground systems SW perspective.

- The paper mentions that MEXAR2 provides multiple solutions to the problem, whereas before MEXAR2, the operations personnel were content with only one solution. Under what circumstances are the additional solutions provided by MEXAR2 of particular interest? These additional solutions may be particularly interesting in cases of possible data loss.
- We've seen a number of areas in the last 2-3 years in which A.I. technologies have been applied to space missions. There are really some very interesting areas within space missions (in addition to mission planning, payload reconfiguration and redundancy planning) in which A.I. technologies have provided significant improvements to the way in which spacecraft operations are carried out. These improvements ultimately benefit space missions in many ways, not only by providing more possible solutions, but also by reducing human error, and having human operators concentrate on determining the best possible solutions for a problem without getting bogged down in the minutia of solving every step of every problem. The potential applications of A.I. technologies to the spacecraft operations domain is only beginning to be explored, and that is being done mostly at an institutional level. The commercial potential of these technologies remains mostly unexplored.

Conclusions

This paper provides a very interesting look into a different application of A.I. technology (a technology which is widely used in other fields) and which is slowly gaining a foothold in spacecraft operations – traditionally a very conservative environment. This technology has a great deal of potential to improve spacecraft operations. It is probably underutilized currently, but has some significant commercial appeal, as well as institutional appeal, because of how it improves spacecraft operations and reduces errors. The human factor in getting acceptance of this type of SW in a spacecraft operations environment is probably not insignificant.