Fault Management at JPL: Past, Present, and Future

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The remote destinations and ambitious science objectives of the space missions flown by JPL has led to the development of robust autonomous capabilities, particularly in the field of Fault Management (FM), which encompasses fault detection, isolation and recovery (FDIR) functions. This presentation will discuss the fundamentals considered in development and deployment of these systems, our past experiences and lessons we have derived from them, the current state of our fault management practice, and paths we are exploring to advance the state of the art. In considering fundamentals, we will discuss key terminology, principles upon which our FM practices are founded, and the basic challenges of managing complex system behaviour in off-nominal situations. Discussion of past experiences will include typical constraints associated with JPL missions, in-flight experience with FM, operational lessons learned, and a comparison of past architectures. Our discussion of the current state of the practice will provide a high-level description of FM design and implementation at JPL - touching on processes and design considerations - and the set of limitations associated with these current practices. Finally, we will present a path to address these limitations and a set of associated R&D efforts to improve current theory and develop new FM architectures, techniques, processes and tools. This topic will consider the benefits from: (i) system/software architecture specification languages and analysis technology (e.g., AADL, ACME), (ii) Model-Based Systems Engineering approaches and their potential to help us capture patterns for upfront nominal/off-nominal design, (iii) state-of-the-art autonomy technology to enable additional automation of FM functions (e.g., diagnosis, prognosis, recovery) and transfer of control cognizance to the onboard execution system, and (iv) incorporation of top-down design approaches into the systems engineering process.

Position Statement: At JPL and across the spacecraft engineering community, the development of robust FDIR capabilities has been more of an “art” than a “science”. We posit that there is significant benefit to be gleaned from applying greater rigor and a more systematic approach to FDIR system development, and that the burgeoning field of Model-Based Systems Engineering can provide useful techniques and tools to help us in this endeavour.

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