Books & Reports

Methodology for Designing Fault-Protection Software

A document describes a methodology for designing fault-protection (FP) software for autonomous spacecraft. The methodology embodies and extends established engineering practices in the technical discipline of Fault Detection, Diagnosis, Mitigation, and Recovery; and has been successfully implemented in the Deep Impact Spacecraft, a NASA Discovery mission. Based on established concepts of Fault Monitors and Responses, this FP methodology extends the notion of Opinion, Symptom, Alarm (aka Fault), and Response with numerous new notions, sub-notions, software constructs, and logic and timing gates. For example, Monitor generates a RawOpinion, which graduates into Opinion, categorized into no-opinion, acceptable, or unacceptable opinion. RaiseSymptom, ForceSymptom, and ClearSymptom govern the establishment and then mapping to an Alarm (aka Fault). Local Response is distinguished from FP System Response. A 1-to-n and n-to-1 mapping is established among Monitors, Symptoms, and Responses. Responses are categorized by device versus by function. Responses operate in tiers, where the early tiers attempt to resolve the Fault in a localized step-by-step fashion, relegating more system-level response to later tier(s). Recovery actions are gated by epoch recovery timing, enabling strategy, urgency, MaxRetry gate, hardware availability, hazardous versus ordinary fault, and many other priority gates. This methodology is systematic, logical, and uses multiple linked tables, parameter files, and recovery command sequences. The credibility of the FP design is proven via a fault-tree analysis "top-down" approach, and a functional fault-mode-effects-and-analysis via "bottoms-up" approach. Via this process, the mitigation and recovery strategy(s) per Fault Containment Region scope (width versus depth) the FP architecture.

This work was done by Kevin Barltrop, Jeffrey Levison, and Edwin Kan of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (818) 393-2827. Refer to NPO-41344.

Ground-Based Localization of Mars Rovers

The document discusses a procedure for localizing the Mars rovers in site frame, a locally defined reference frame on the Martian surface. MER onboard position within a site frame is estimated onboard and is based on wheel odometry. Odometry estimation of rover position is only reliable over relatively short distances assuming no wheel slip, sinkage, etc. As the rover traverses, its onboard estimate of position in the current site frame accumulates errors and will need to be corrected on occasions via relocalization on the ground (mission operations). The procedure provides a systematic process for ground operators to localize the rover. The method focuses on analysis of acquired images used to declare a site frame and images acquired post-drive. Target selection is performed using two main steps. In the first step, the user identifies features of interest from the images used to declare the current site. Each of the selected target's position in site frame is recorded. In the second step, post-traverse measurements of the selected features' positions are recorded again, this time in rover frame, using images acquired post-traverse. In the third step, we transform the post-traverse target's positions to local level frame. In the fourth step, we compute the delta differences in the pre- and post-traverse target's position. In the fifth step, we analyze the delta differences with techniques that compute their statistics to determine the rover's position in the site frame.

This work was done by Ashitey Trebi-Ollennu of Caltech for **NASA's Jet Propulsion Laboratory**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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