Design Approaches for Maintaining Autonomous Determinism within a Small Sat System-of-Systems

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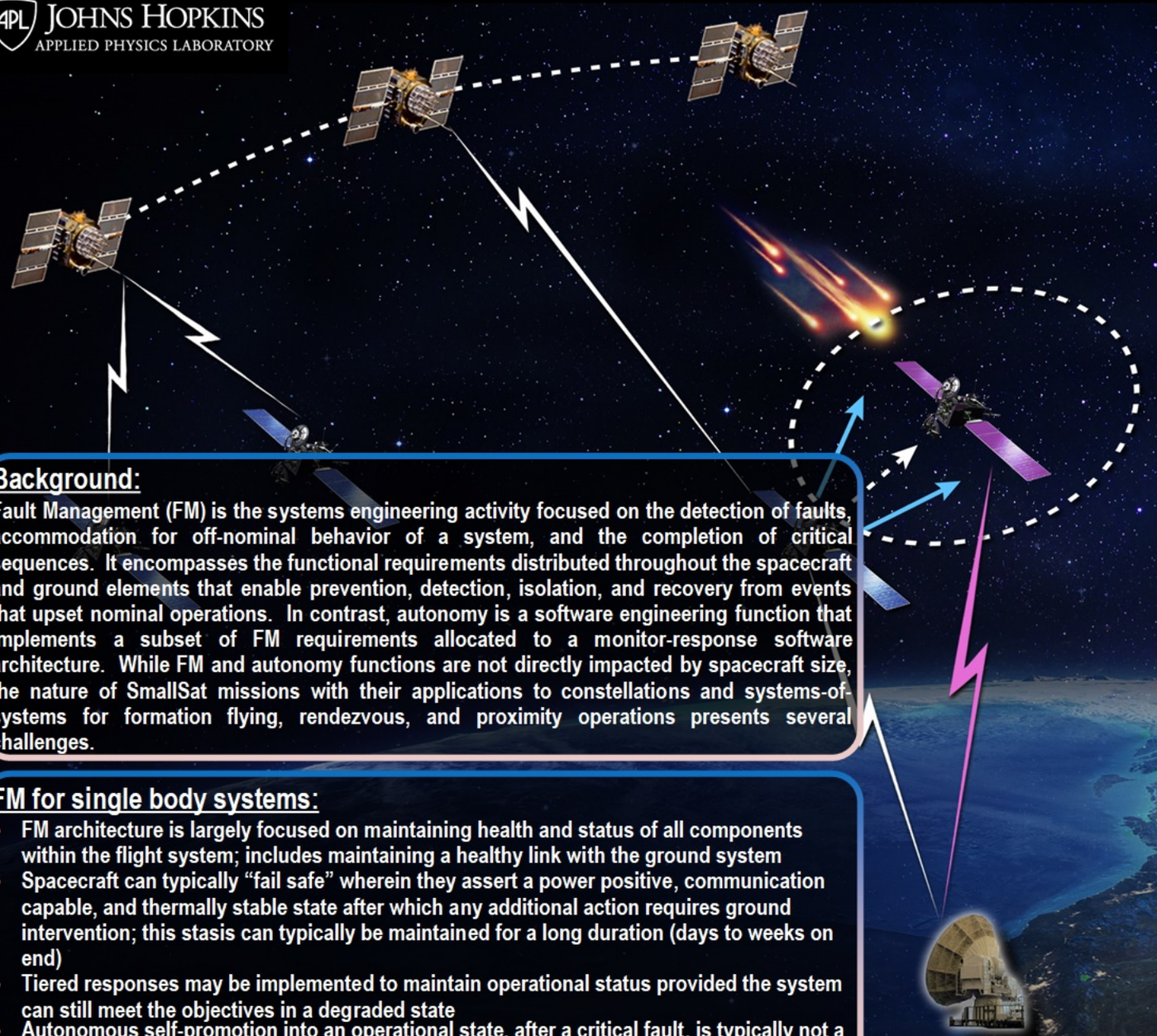
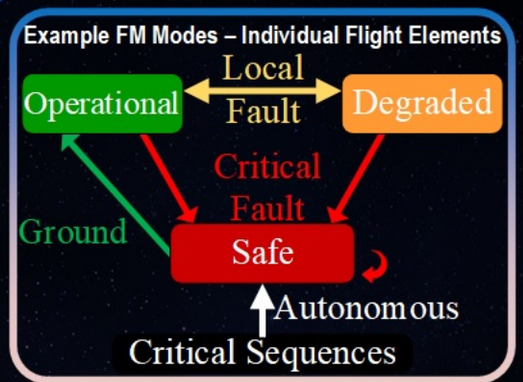


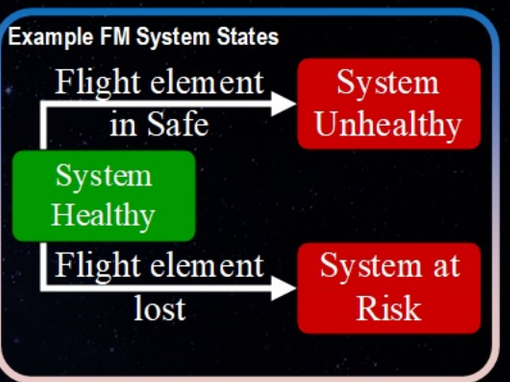
Background:

Fault Management (FM) is the systems engineering activity focused on the detection of faults, accommodation for off-nominal behavior of a system, and the completion of critical sequences. It encompasses the functional requirements distributed throughout the spacecraft and ground elements that enable prevention, detection, isolation, and recovery from events that upset nominal operations. In contrast, autonomy is a software engineering function that implements a subset of FM requirements allocated to a monitor-response software architecture. While FM and autonomy functions are not directly impacted by spacecraft size, the nature of SmallSat missions with their applications to constellations and systems-of-systems for formation flying, rendezvous, and proximity operations presents several challenges.

FM for single body systems:

- FM architecture is largely focused on maintaining health and status of all components within the flight system; includes maintaining a healthy link with the ground system
- Spacecraft can typically "fail safe" wherein they assert a power positive, communication capable, and thermally stable state after which any additional action requires ground intervention; this stasis can typically be maintained for a long duration (days to weeks on end)
- Tiered responses may be implemented to maintain operational status provided the system can still meet the objectives in a degraded state
- Autonomous self-promotion into an operational state, after a critical fault, is typically not a necessary function at this level of FM





FM for multibody systems (i.e., formation flying, rendezvous, proximity ops):

Considerations

- Determinism applies to both element-to-element and flight system-to-ground links
- Balance self-sufficiency and independence for the individual flight elements with the safety of the entire fleet
- The collision probability for the individual flight elements must be assessed
- Each element needs awareness of the position and trajectory for all other elements in the system and must also determine if any distance thresholds are at risk of being violated

Challenges

- Responding to a situation where one element falls silent
- Designating which element takes action in response to a collision threat
- Adapting the system level navigation plan when one element becomes degraded
- Frequency and duration of the ground contact periods as and/or communications across flight elements
- Maintaining a high level of systems operational availability, potentially with a faulted flight element
- Developing fault responses that do not increase risk to other flight elements

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