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# Toward Enabling Safe Earth-Independent Mission Operations

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**Abstract**

Although it often comes as a surprise to the general public, most of space safety actually happens on Earth. In NASA's case, while processes and technologies for mission operations have evolved steadily throughout the years, from Apollo, Shuttle, to ISS, astronauts have always relied on flight controllers and mission engineers on the ground for real-time problem solving.

For missions near Low Earth Orbit, such as the International Space Station (ISS), the availability of near real-time communication affords the flight crew a safety net that is as wide as 150+ experts with a combined 600+ years of system-specific experience across 22 unique console disciplines.

For exploration beyond Low Earth Orbit, however, intermittent and delayed communication with ground will require a small crew of roughly four astronauts to, on their own, address urgent, unanticipated anomalies that have historically been handled by a team 20 times their size.

The fundamental challenge for long-duration exploration missions (LDEMs) is how to enable Earth-independent, on-board anomaly response. Our research is focused on identifying and prioritizing the on-board capabilities needed to do so. To do that, we investigated real ISS anomalies and leveraged Mission Evaluation Room (MER) data and artifacts to create comprehensive event timelines that outline which data were utilized at specific decision points. We then extrapolated how events may unfold in a similar anomaly scenario in deep space, where crew would take the lead in the initial response, and any advice from ground would always lag ~1 hour behind current events.