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AUTONOMOUS OPERATIONS FOR SPACEFLIGHT MISSION CONTROL: CHALLENGES AND BENEFITS

Abstract

This paper studies available technologies within various levels of autonomy, circumstances of their usage, and benefits and challenges to their implementation in spaceflight mission control.

Spaceflight missions are currently highly dependent on ground control centers to make decisions and carry out standard operations. Nearly real-time continuous communication coverage is maintained in Low Earth Orbit (LEO) via various control centers. However, for spaceflight beyond LEO, the critical challenge is time-delay in communications. This can be mitigated to an extent via a robust space-based communication network, but some latency between a mission and its Mission Control Center (MCC) is unavoidable. Thus, there is the desire for an autonomous system to support overall mission operations and address these challenges to communications, similar to CIMON (Crew Interactive MObile CompanioN). Implementation of such systems presents several challenges ranging from security to human factors.

In addition to mitigating the issue of communication latency, autonomous systems can help with knowledge transfer and status updates during the mission life cycle. Aside from latency, other environmental factors such as solar storms and systems failure during the mission will add more communication challenges. Isolation for a longer duration can have psychological repercussions and consequently impact the mission performance. In addition, future missions to the Moon or Mars will require autonomous ambulatory care, autonomous advanced life support, autonomous surgical care, and integrating levels of autonomous advanced care in the form of medications, equipment, and training. This would account for monitoring the changes of the human body, and advanced life support autonomously, in contrast to the current terrestrial telemedicine.

On-board assistants like CIMON represent an increasing interest to utilize autonomous applications for spaceflight operations. In order to maximize the development of such applications, machine learning processes and scenarios are best addressed in analog missions. This allows for a controlled environment to train system inputs and adaptive behavior to human interactions. Therefore, this serves as a practical

model in terms of preparatory activities for future missions to the moon and Mars. Additionally, it is also important to have a methodology developed for efficient and secure coordination between the MCC and the crew members. This is done through a trade study of various systems and operations methodologies from chatbots to spaceflight analogues on Earth.