AUTONOMOUS MEDICAL OFFICER SUPPORT (AMOS) ISS TECHNOLOGY DEMONSTRATION: ENABLING EARTH-INDEPENDNT PROCEDURE GUIDANCE

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INTRODUCTION

Successful performance of medical procedures during missions beyond low Earth orbit requires novel solutions to replace real-time support from the ground since the communication delay will be longer as the crew travels farther from Earth. The Autonomous Medical Officer Support software Technology Demonstration project (AMOS Tech Demo) on the International Space Station (ISS) evaluates a novel software tool that shifts the emphasis from preflight training and real-time guidance (current ISS paradigm) to in-flight just-in-time (JIT) instruction (a new paradigm for crew medical autonomy). The AMOS platform introduces a novel, streamlined, skill-management archetype for exploration missions; the current AMOS version features comprehensive training and guidance modules for urinary bladder and kidney ultrasound examinations.

The primary goal of the AMOS Tech Demo was to confirm telemedical proof-of-concept through initial use of the platform for autonomous imaging activities in an operational setting. Success metrics encompassed 1) successful software deployment, 2) collection of click tracking data, and 3) recording of ultrasound images. Additional aims included collecting crew feedback on a) AMOS implementation, and b) integrated training and procedure support concepts, as well as c) evaluation of AMOS use in an operational setting.

METHODS

Two ISS crewmembers participate in each in-flight Tech Demo; the Operator uses AMOS to perform ultrasound under software guidance, and the Subject serves as the "patient" for the ultrasound scans. The recommended scan order is: full bladder, empty bladder, right kidney, and left kidney. Ultrasound images are collected using the ISS Ultrasound II with a 4C-RS broadband curved array transducer. Imaging instances (cine-loops and still frames) are rated with a custom analytical framework consisting of nine elements; eight are rated 0 (poor) - 3 (excellent) with one overall success rating (yes or no). Crewmembers receive no preflight AMOS training and have no prior exposure to the AMOS software. AMOS tracks Operator use and incorporates a user experience survey within each module. Both crewmembers participate in a postflight debrief.

RESULTS

As of September 2022, two instances of the tech demo have been performed on the ISS: April 2020 and June 2022. First use of the AMOS software in 2020 demonstrated successful installation and deployment of the platform in the ISS server environment, and both demos have resulted in positive user experience and successful image collection for kidney and urinary bladder. Both demonstrations were conducted in full autonomy with no assistance or interference from the ground. For demo #1, Seventeen bladder imaging instances were acquired; all instances were rated '3' in all image quality elements and were deemed successful, and twenty-five kidney imaging instances were acquired; image quality averaged 2.6 over both kidneys and all eight rating elements, and all but three were deemed successful. Kidney instances collected later in the procedure were rated '3' across all elements (i.e., successful) indicating the desired learning effect. Demo #2 appeared similarly successful, and formal image analysis is ongoing.

DISCUSSION

Success of these Tech Demos signify the beginning of a shift from the existing model of preflight training with modest retention of conceptual and procedural knowledge (non-permanent skills), to a new paradigm of preflight familiarization with an in-flight JIT platform, which would be used as necessary to bolster effective skills for in-flight medical needs. The AMOS platform provides training and in-mission support using a single training and procedure instrument for all phases of skill management including acquisition, retention, and application, which reinforces the "train as you fly, fly as you train" mentality. This approach also streamlines the training process, provides a more consistent experience for the user, and allows flexibility for JIT training of tasks with no prior instruction.

The AMOS Tech Demo has successfully demonstrated autonomous imaging activities in an operational setting in two instances, fulfilling the telemedicine proof-of-concept objective. Imaging quality scores were excellent for demo #1, however represent a single operator/subject team so should be interpreted with caution. Repeated instances are planned, which should include Operator/Subject teams of varied backgrounds to fully validate the platform. Future work should also include development of additional modules (medical and other), gradual incorporation into operational procedures, and integration with other components that will be critical to exploration medical support systems such as clinical decision support, data storage and transmission, and specific hardware interfaces.

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