Preparation for Interactive Human Tended Suborbital Flight Research

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Introduction

Human suborbital spaceflight began during the NASA X-15 hypersonic flight research program in 1959, where pilots conducted flight and scientific research above 50 miles altitude while limited to their seats. In 2021, we have seen the advent of passengers on commercial suborbital spacecraft that will eventually enable research projects beyond what an investigator can fit into their flight suit pockets. In anticipation of future flights where researchers will actively interact with experiments during the approximately 3-minute period of μ-g, we are conducting ground and parabolic flight-based evaluations of investigator performance and safety as an analog for suborbital research.

Methods

The trial experiment for this investigation is a surgical system under active development that addresses a particular need for advanced healthcare capabilities for exploration spaceflight. For an in-flight medical situation requiring surgical treatment, the crew medical officer will need to perform several surgical tasks. In our analog simulation, the investigator performs a scripted sequence of tasks on a bleeding wound model placed inside a glovebox providing secondary containment during reduced gravity created by parabolic flight. The glovebox is the equivalent size of two stacked ISS stowage lockers and was specifically designed for interactive experiments during suborbital flight, where the investigator accesses the experiment through one of three pairs of sleeved arm access ports in the sides and front of the glovebox. For an assessment mimicking flight in the Virgin Galactic SpaceShipTwo, the investigator is restrained by foots straps and inserts their arms through ports on the front of the glovebox, simulating a position in the aisle of the spacecraft. For an assessment mimicking flight on the Blue Origin New Shepard, the investigator will utilize the ports on the side of the glovebox, simulating positioning in the walkway of the spacecraft. It is assumed that the investigator will be working alone during the suborbital flight, attempting up to 25 surgical tasks while other project team members observed and provided prompts, minimizing involvement.

A second set of evaluations takes place in high-fidelity mock-ups of suborbital spacecraft cabins with the glovebox mounted inside. Investigator activity is assessed for how and when to leave their seat, position themselves by the glovebox, protocol task performance, glovebox preparation for re-entry, and return to seat. A human factors/safety engineer from the project team participates in the evaluation of this sequence of investigator activities along with the astronaut instructor from the suborbital flight provider. Evaluations considered room for and ease of movement to and from the glovebox, time available for productive work in microgravity, and potential for improvement of the research environment. Special attention was given to the physical hazards present, ergonomic efficacy and efficiency, environmental compatibility (e.g., noise, lighting, temperature, loads/vibration), mental stressors, and communication with flight and ground crews.

Results

Two pathfinding parabolic flights were conducted in May 2021 followed by four flights in May 2022; four surgeons performed scripted tasks for 15 parabolas using both configurations. Typically, 15 of the planned surgical tasks were successfully completed. Investigator foot restraint was sufficient. Ease of task performance varied with the location of surgical system components inside the glovebox. Suborbital spacecraft in-cabin evaluation sessions will be reported by March 2023.

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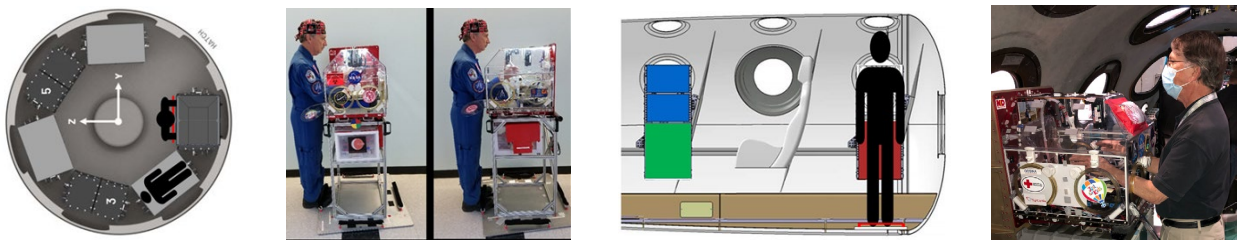

Figures: New Shepard cabin (left), SpaceShipTwo (SS2) cabin (center), In-cabin evaluation (right)