Flight Operations Quality Assurance Analysis for SpaceShipTwo Contingency Scenarios

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Abstract

This research addresses critical flight contingencies for Virgin Galactic's SpaceShipTwo (SS2) suborbital vehicle to analyze and evaluate the feasibility of its flight operations. The research suborbital data was obtained using the Embry-Riddle Aeronautical University Suborbital Space Flight Simulator. These suborbital flight profiles were simulated after drop from WhiteKnightTwo for several contingency scenarios, such as on-trajectory failures (thrust termination), fuel dumping, loss of vector control, and tumbling turn failures. The simulated data obtained from these flights will be used as a preliminary step for future developments of flight planning to better estimate the space flight corridors during descent and ascent trajectories, which will provide flight and ground safety operators with key information to better understand hazard and safety risks and establish pertinent procedures and preventive measures when the vehicle goes through the National Air Space (NAS).

Introduction

Problems of interest as outlined by the Federal Aviation Administration[1]:

- Altering the launch or reentry trajectory, to the extent possible, to avoid placing airspace restrictions in congested airspace.
- Inserting corridors in an aircraft hazard area that allow aircraft to traverse the area in a controlled manner that does not exceed acceptable safety limits.
- Implementing a responsive approach to airspace management in which the FAA monitors a launch or reentry operation in real-time and relies on a capability to compute and distribute a real-time aircraft hazard area to tactically respond to a contingency scenario rather than preemptively closing the airspace. This also includes using hotlines with the vehicle operator, air traffic control (ATC) facilities, and other parties to expedite the direct communication of cancellations, delays, and contingencies.

Figure 1: Suborbital Space Flight Simulator and Mission Control Center[2]

Acknowledgements

The authors would like to thank the Applied Aviation Sciences department and the IGNITE office for sponsoring the Summer Undergraduate Research Fellowship (SURF) program in 2017.

Results

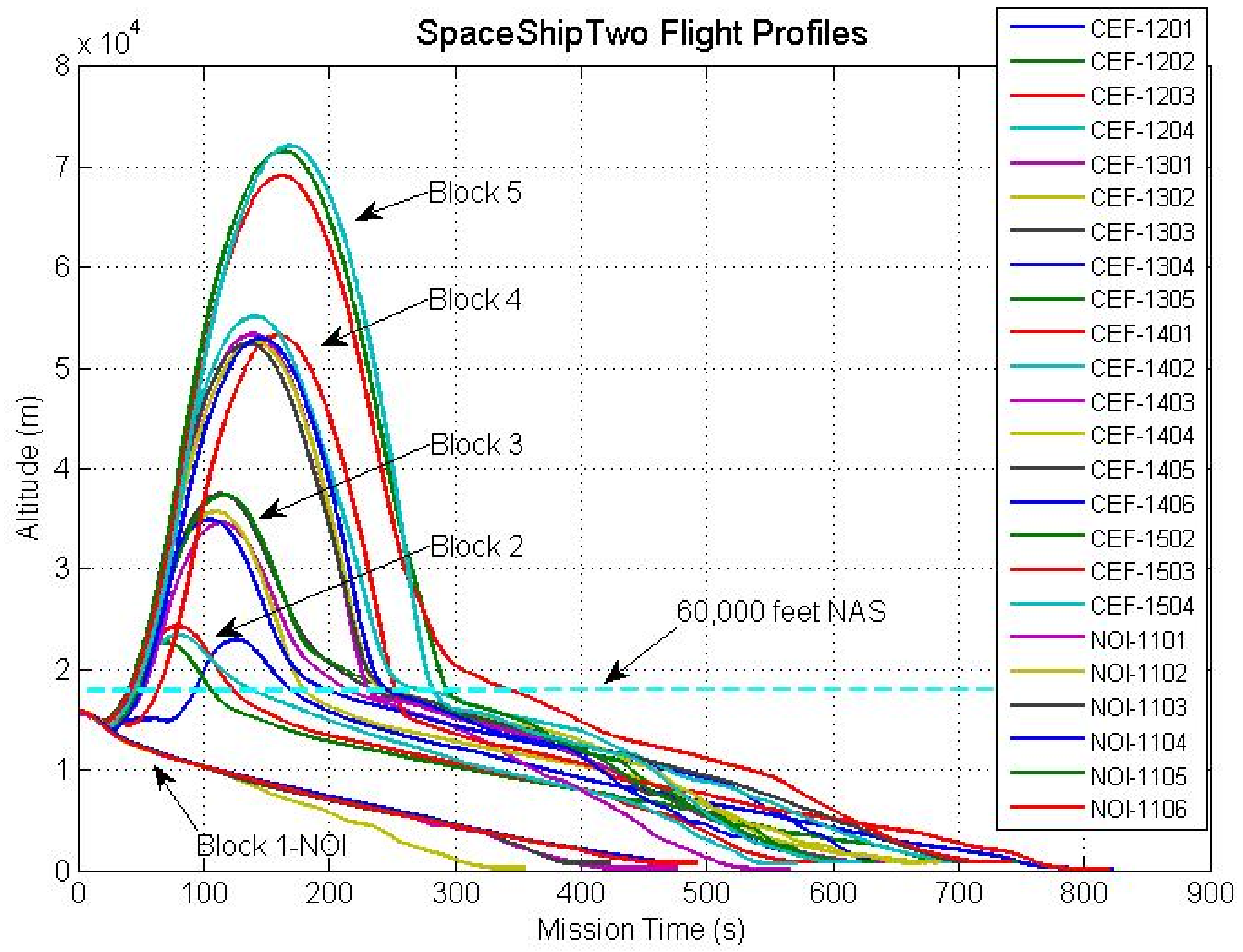

Figure 2: Block Divided Altitude Flight Profiles

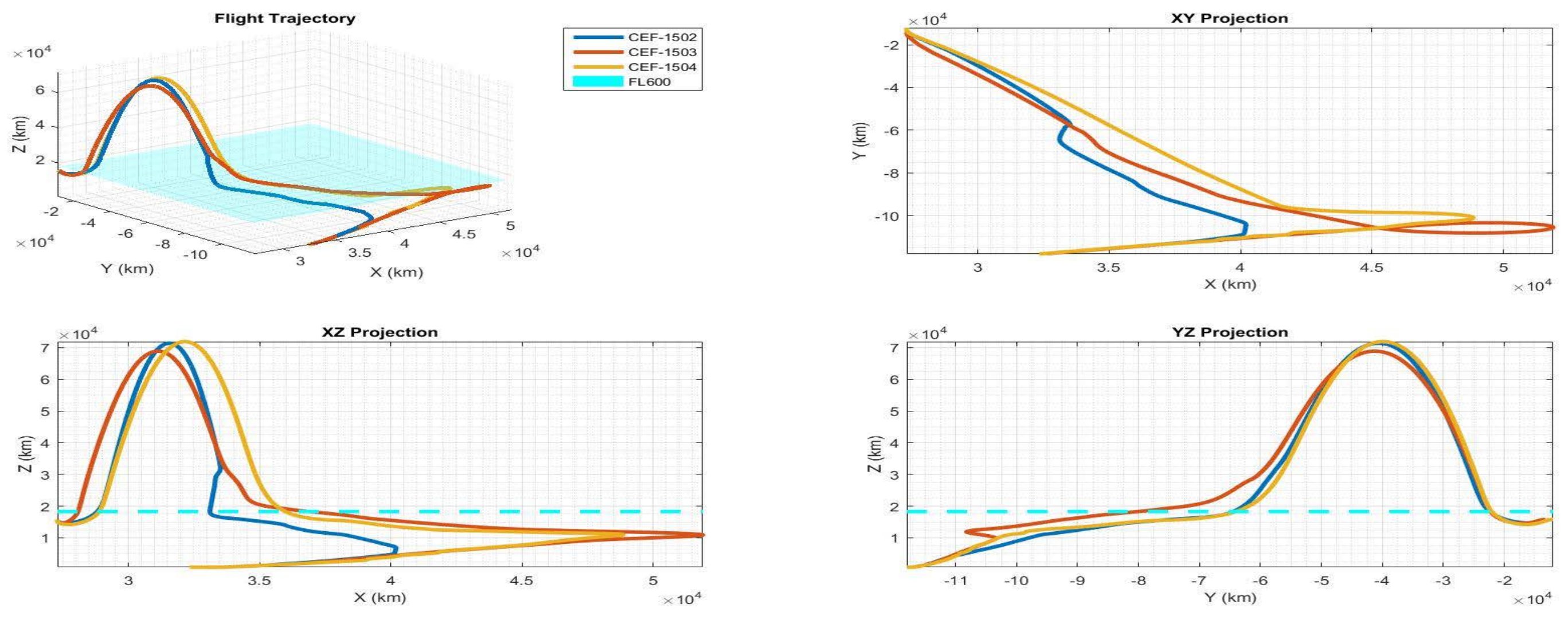

Figure 3: Block Divided Altitude Flight Profiles

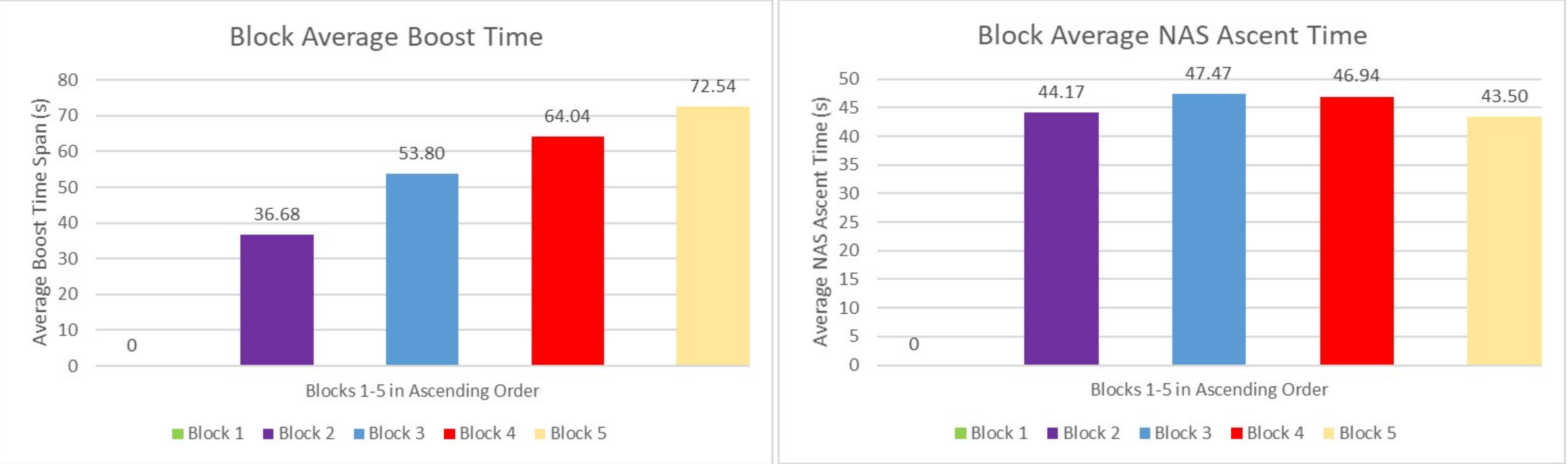

Figure 4: Average effects of MECO altitude on Boost Time and NAS Ascent Time

Figure 5: Block 5 Flight Trajectories

Figure 6: Apogee Height Effect on Glide Parameters

Methodology

1. Air Launch Takeoff
2. Boost Phase
3. Coast Phase
4. Deceleration/Reentry Phase
5. Glide Phase

Flight blocks were divided into sections based on MECO altitude, shown in Table 1. Data was collected through simulated flights, and parsed through a MATLAB Data Analytics Tool.

Table 1. Flight designation code descriptions and block categorization system

Block Number	Thrust Termination Altitude	Flight Designation Code
Block 1	No Ignition	NOI-11XX
Block 2	18,300 m [60,000 ft]	CEF-12XX
Block 3	24,400 m [80,000 ft]	CEF-13XX
Block 4	30,500 m [100,000 ft]	CEF-14XX
Block 5	36,600 m [120,000 ft]	CEF-15XX
*Block 6	42,700 m [140,000 ft]	*CEF-16XX

* Block 6 flights exhibited many of the same characteristics as nominal flights and therefore those flights were not included in this study.

Flight Corridors in NAS

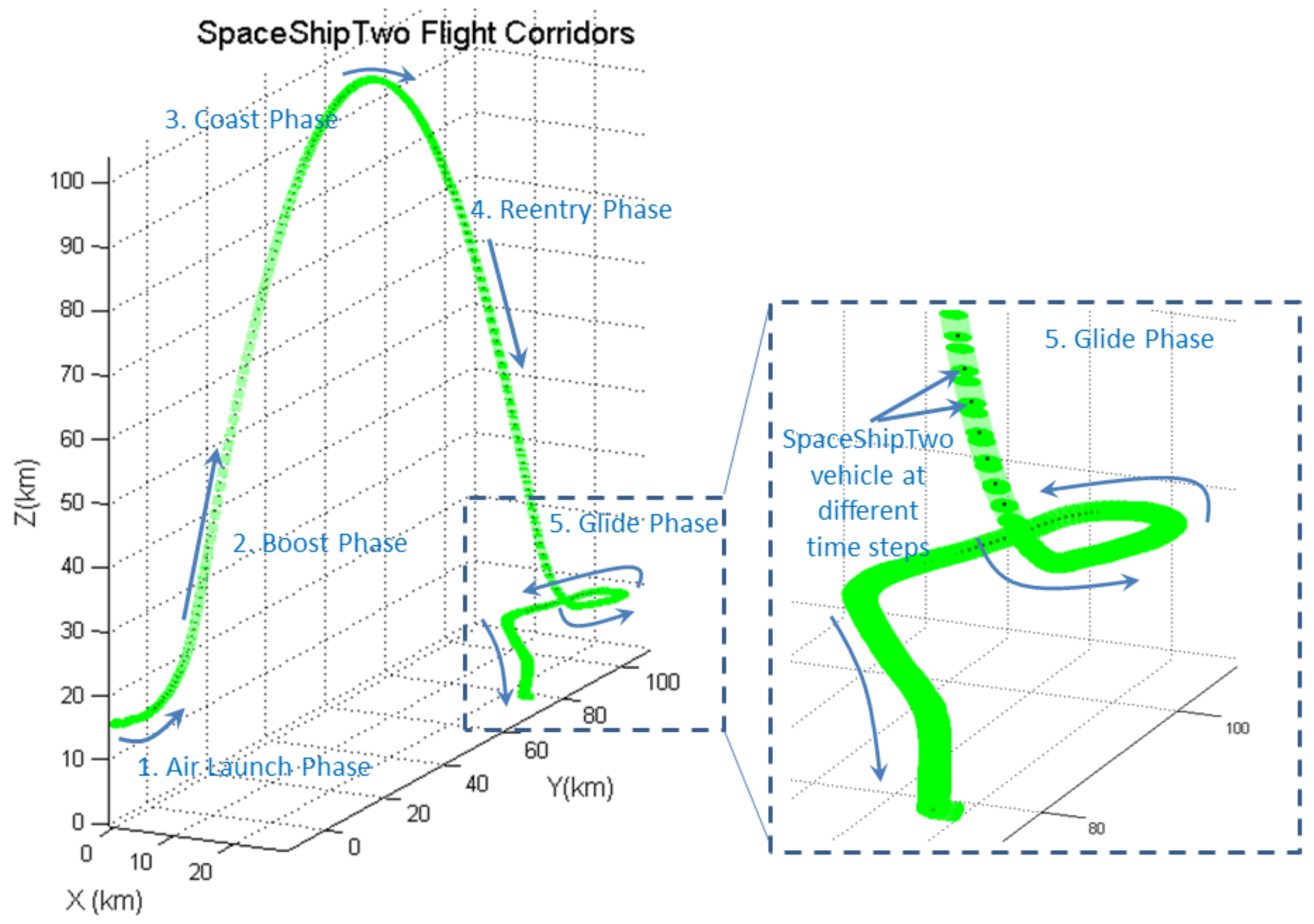

Figure 7: Flight Corridors during different phases of suborbital path.

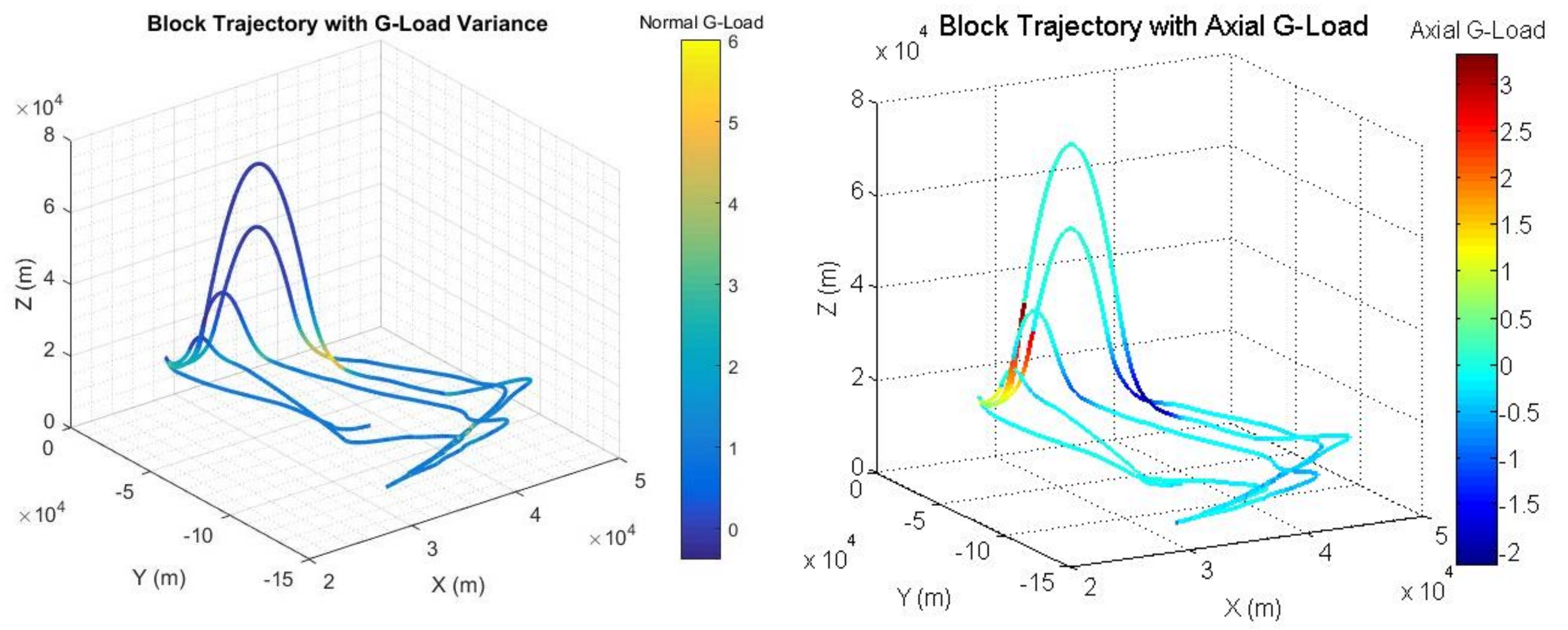

Figure 8: G-load maps for normal and axial forces of suborbital path.

References

[1] Murray, D., "The FAA's Current Approach to Integrating Commercial Space Operations into the National Airspace," 2013.
[2] Llanos, P., Kitmanyen, V., Seedhouse, E., and Kobrick, R., "Suitability Testing for PoSSUM Scientist-Astronaut Candidates using the Suborbital Space Flight Simulator with an IVA Spacesuit," International Conference on Environmental Systems, ICES-2017-100, July 20, 2017.