Flight Operations Quality Assurance Analysis for SpaceShipTwo Contingency Scenarios

Student Researcher: Christopher Hays  
Faculty Principal Investigator: Pedro Llanos, Ph.D.

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:

- 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.

Results

![SpaceShipTwo Flight Profiles](image1)

![Block Divided Altitude Flight Profiles](image2)

![Block Divided Altitude Flight Profiles](image3)

![Average effects of MECO altitude on Boost Time and NAS Ascent Time](image4)

![Block 5 Flight Trajectories](image5)

![Apogee Height Effect on Glide Parameters](image6)

Methodology

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. 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>
<thead>
<tr>
<th>Block Number</th>
<th>Thrust Termination Altitude</th>
<th>Flight Designation Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 1</td>
<td>No failure</td>
<td>CFP-12K</td>
</tr>
<tr>
<td>Block 2</td>
<td>14,000 ft (4,200 m)</td>
<td>CFP-12KK</td>
</tr>
<tr>
<td>Block 3</td>
<td>25,000 ft (7,600 m)</td>
<td>CFP-12KK</td>
</tr>
<tr>
<td>Block 4</td>
<td>35,000 ft (10,668 m)</td>
<td>CFP-12KK</td>
</tr>
<tr>
<td>Block 5</td>
<td>30,000 ft (9,144 m)</td>
<td>CFP-12X</td>
</tr>
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<td>Block 6</td>
<td>45,000 ft (13,716 m)</td>
<td>CFP-12X</td>
</tr>
<tr>
<td>Block 7</td>
<td>62,500 ft (19,049 m)</td>
<td>CFP-12X</td>
</tr>
<tr>
<td>Block 8</td>
<td>60,000 ft (18,288 m)</td>
<td>CFP-12X</td>
</tr>
</tbody>
</table>

* Blocks 4 flights exhibit no or low characteristics as usual flight and therefore those flights were not included in this study.

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References