Analysis of the Quality of Parabolic Flight

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Abstract

Parabolic flight allows researchers to conduct several micro-gravity experiments, each with up to 20 seconds of micro-gravity, in the course of a single day. However, the quality of the flight environment can vary greatly over the course of a single parabola, thus affecting the experimental results. Researchers therefore require knowledge of the actual flight environment as a function of time. The NASA Flight Opportunities program (FO) has reviewed the acceleration data for over 400 parabolas and investigated the level of micro-gravity quality. It was discovered that a typical parabola can be segmented into multiple phases with different qualities and durations. The knowledge of the microgravity characteristics within the parabola will prove useful when planning an experiment.

Hardware and Data Analysis

The Suborbital Flight Environment Monitor (SFEM,) is a compact, low power, self-contained, user-programmable, Commercial Off The Shelf (COTS) environmental sensor package used to measure values of acceleration, temperature and humidity level in reduced gravity flights. The data from the 3-axis accelerometer was filtered, integrated and analyzed using an algorithm specially conceived in Matlab for this purpose. Over 400 parabolas from two different aircraft were post-processed to identify trends and define factors for determining quality to be used for scientific and engineering purposes.

Anatomy of a Parabola

A typical acceleration profile during a parabola is depicted in Figure 1 for the aircraft Z-axis. This process can be divided into 5 zones:

1) *Parabola Entrance*: The aircraft transitions from high-g to the desired g level.
2) *Sweet Zone Entrance*: This zone defines the beginning of the micro-gravity flight. The acceleration signal oscillates slightly-around the desired g level.
3) *Sweet Zone (SZ)*: Lasting usually between 4 and 10 seconds, this zone offers the highest quality micro-gravity and is propitious for experiments requiring a very stable environment.
4) *Sweet Zone Exit*: This is characterized by a few oscillations at a slightly increased gravity level compared to the SZ.
5) *Parabola Exit*: The exit is defined by a sudden increase in positive acceleration. The beginning of this phase marks the end of the zero-g phases and completes the parabola.

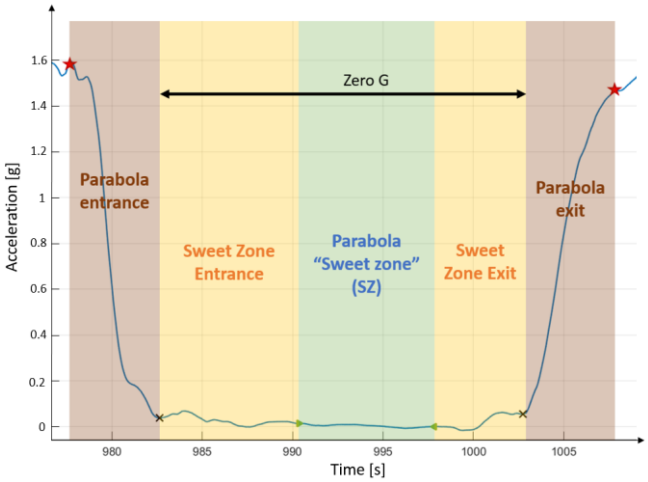

Figure 1: *Typical acceleration profile versus time along the aircraft Z-axis as measured during a typical parabola. The zones have been automatically detected by a custom developed algorithm.*

Conclusions

The data acquired from over 400 parabolas shows that within a typical parabola, multiple zones with various qualities and durations are present and can be defined. Therefore, researchers may consider these factors while designing micro-gravity experiments in order to obtain the best possible results.