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Aerobatic parabolic flights in Barcelona. Review of research and educational activities.

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Introduction

We present an innovative method of performing parabolic ights with aerobatic single-engine planes. A parabolic platform has been stablished in Sabadell Airport (Barcelona, Spain) to provide an infraestructure ready to allow Life Sciences and Physical hypogravity experiments to be conducted in parabolic flights. We report on diverse research and educational experiments that have been conducted throughout the last decade.

1. Parabolic Flight Operations

Test flights have demonstrated that up to 8 seconds of reduced gravity can be achieved by using a two-seat CAP10B aircraft, with a gravity range between 0.1 and 0.01g in the three axis. A parabolic flight campaign may be implemented with a reduced budget, and with a very short time-to-access to the platform. Operational skills and proficiency of the pilot controling the aircraft during the maneuvre, sensitivity to wind gusts, and aircraft balance are the key issues that make a parabola successful. Efforts have focused on improving the total zero-g time and the quality of reduced gravity achieved, as well as providing more space for experiments. We report results of test flights that have been conducted in order to optimize the quality and total microgravity time. A computer sofware has been developed and implemented to help the pilot optimize her or his performance (Brigos et al., 2014).

Figure 1: CAP10B aircraft.

2. - Objectives

The objectives of these unique parabolic flights with an aerobatic single-engine aircraft are:

2.1.- Scientific:

- To study different processes in which abrupt changes of gravity workload are applied. In particular: hyper (3 – 3.5g) to hypogravity (0.01g) , and hypo to hypergravity periods.
- To analyse transient phenomena that may occur after short periods of hyper and hypogravity.
- To allow experiments for testing the equipment in a real parabolic flight, with the opportunity to manually interact with the equipment and provide a proof-of-concept before accessing other microgravity research platforms.
- If the experiment can be run in less than 8 seconds of exposure to hypogravity, and the residual acceleration of 0.05 g is acceptable, then quantitative and qualitative measurements can be made, thus providing meaningful data. The parabolic flight can provide 10-15 parabolas in a single flight, and weather permitting the procedure can be repeated in a single day. The facility enables different subjects to test the scientific hypotheses, one by one on board.

2.2. Technological:

- Assessment of technological equipment behaviour in a hyper and hypogravity environment with abrupt changes in a tiny environment.
- Safety assessment of experiments and technological demonstrations within a parabolic flight aircraft 127 cockpit.
- Training of wannabe or future astronauts for foreseen private or public space missions.

2.3. Educational and outreach

- Allowing students to conduct hands-on experiments in a real weightlessness experience.
- Increasing their interest for studying Science, Technology, Engineering and Mathematics (STEM) studies, in particular in the aerospace field.
- Providing students from different backgrounds and nationalities with the opportunity of working as a team with a common goal, while interacting with space professionals.
- Raising public interest in space research.
- Creating the opportunity for students to write and present their space research in relevant journals and congresses, and also to further apply to the space agencies educational programs.

3. Review of Life Sciences experiments.

A number of mainly Life Sciences experiments have been conducted throught the last decade (Perez-Poch et al., 2016). These experiments include some of them which have been conducted by students, who have later presented their results in relevant scientific meetings and journals. Human physiology experiments include validation of numerical models of microgravity effects, effect of gravity loads on brain signals, and more recently, a pioneering study on the effect of microgravity on human sperm samples (Boada et al, 2019).

Student projects include some Bachelor and Master Thesis with technological studies, and three editions of the Barcelona Zero Challenge, which resulted in journal papers and scientific meeting presentations. The topics of these student-led experiments were: reversible images in space, altered perceptions in microgravity, and the effect of mental calculations on the cardiovascular system.

Details of all these research projects will be given in the final presentation, with emphasis in the data outcome of these experiments.

Conclusions

We conclude that aerobatic parabolic flights have proven to be a safe and reliable way to conduct life sciences and physical hypogravity experiments, both for research and educational purposes. This unique platform, a result of a cooperation between a leading Tech University (UPC) and an aerobatic team at the Barcelona Flight School provides a unique testbed for experimentation prior to access to other microgravity platforms. International and multidisciplinar cooperation has been very important to make this platform successful. The platform is permanently open to scientific cooperation.

References

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