Human Life Sciences Studies in Sub-Orbital Flight: Insights from Parabolic Flight

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Summary
Although cheaper than spaceflight, sub-orbital flight will be costly. For human life sciences studies in which subject performance is critical, parabolic flight in aircraft presents an ideal and relatively inexpensive test bed that permits hardware, and procedure testing in microgravity and hypergravity, both of which will be present in sub-orbital flight. Parabolic flights also crucially provide subjects with important experience of microgravity and the g-transitions in preparation for suborbital studies.

Introduction
Sub-orbital flight presents a range of opportunities and challenges for studies involving humans. Compared to spaceflight, the rapid access to sustained (albeit short) periods of microgravity, coupled with the potential for repeat studies either in the same subject or in different subjects has the potential to greatly expand or enable certain studies that require longer periods of microgravity than the ~25 seconds available in aircraft parabolic flight. However the constraints of sub-orbital flight will impose a level of experimental rigor and preparation more akin to spaceflight then to parabolic flight. In order to meet these constraints in a robust manner, parabolic flight provides a potentially useful test bed environment for experiment development and testing. Between us we have a collective experience of more than 5000 parabolas, and within that experience, a fair number of failures either of equipment, procedures, or at times, subjects. In contemplating sub-orbital flight we find it hard to imagine embarking on a flight campaign without first flying as much of the experiment as possible in aircraft parabolic flight.

Microgravity
The obvious advantage of parabolic flight is that one can test the experiment in microgravity, something that is simply not possible on the ground. Hardware testing in microgravity helps drive the “gotchas” out of the system. In the context of human life sciences studies this is even more important. With the occasional exception of studies of initial adaptation to microgravity in which truly naïve subjects are required, it is undoubtedly true that prior experience of microgravity greatly raises the likelihood of success. If the proposed studies involve humans, then experience goes a long way towards having procedures that work, and having subjects with a clear head, not fuddled with the combined effects of motion sickness and anxiety.

Hypergravity
The often-overlooked aspect of both parabolic flight and sub-orbital flight are the periods of hypergravity that sandwich the microgravity phase. Although able to be simulated in terrestrial facilities, the transitions between gravity levels are challenging for subjects, and sometimes equipment. Further, the need for experiment operations during the hypergravity phase can present real risks to human studies if care is not taken to minimize the development of motion sickness.

Other environmental changes
It seems likely that sub-orbital flight may provide a more stable environment than parabolic flight in terms of other environmental changes such as cabin pressure and temperature. But it may well be the case that these will not necessarily match those on the ground. Many of these changes require testing.

Conclusions
The secret to success is testing, testing, testing, and the higher the fidelity of those tests, the higher the likelihood of success. Given the unique aspects of sub-orbital flight, the best high-fidelity test may be parabolic flight in aircraft, which allows testing of hardware, procedures and perhaps most importantly, subjects before undertaking more expensive sub-orbital flight.

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