

# Benefits of Human-tended Sub-orbital Research

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## Summary

The start of human-tended sub-orbital spaceflight research is one persistent pursuit of the Sub-orbital Applications Researchers Group (SARG) of the Commercial Spaceflight Federation. The researchers and educators serving on SARG have explored the promise of this pending research format of the purpose of their advocacy efforts, and this paper reports on their determinations.

## The Study

The pursuit of human-tended sub-orbital research has been on the agenda of SARG (the Sub-orbital Applications Researchers Group) since its founding in 2009. The era of automated experiments in commercial re-usable sub-orbital rockets was initiated by Blue Origin in 2015. In addition, Masten Space Systems flies many low-altitude flights now for planetary landing research, and Virgin Galactic has started to fly automated payloads to space. To date Blue Origin and the NASA Flight Opportunities Program are the major participants in this new space research format. With frequent and dependable flights of un-tended sub-orbital payloads, enabling human-tended sub-orbital research has increased in priority to SARG.

Describing and documenting the need for, or analogously, the benefits to be had from, human-tended sub-orbital research in commercial re-usable rockets became the focus of an *ad hoc* working group within SARG. This Human-Tended Working Group is led by Dr. Marsh Cuttino and served by SARG members Dr. Todd Smith, Prof. Mark Shelhamer, Prof. Anna-Lisa Paul, and Prof. Michael Banish. Other SARG members contribute to this cause as they are able.

## Determinations

Historically most scientific investigations have been conducted directly by people. This is true even in unusual environments, such as the ocean floor, Antarctica, the SOFIA observatory, and volcanoes. In contrast, to date, the orbital laboratory has been generally devoid of principal investigators. Commercial sub-orbital rocket flight delivers the opportunity to return the investigator to the spaceflight laboratory, when the laboratory is a

weightless one. That researchers can function well in weightlessness has been shown for decades in parabolic aircraft flights.

Benefits expected from flying the researcher with the experiment differ depending on the type of experiment. In many cases, an automated experiment will still suffice for advancing science, but such automated payloads, or remote control of payloads via telemetry, can not deliver for all science needs. Thus, the need for human-tended sub-orbital experiments.

Researchers flying with their experiments extend the laboratory to sub-orbital altitudes. This extension delivers, for example:

- Expert operation and observation of the experiment. This will produce superior data and results.
- Reduced cost by avoiding expensive automation and the lengthy development and critical testing of robotic hardware and software,
- Opening new fields of research for which re-flight of evolved experiments can be rapid,
- Researcher observations in spaceflight may develop the necessary knowledge and experience with an experiment to define a path to automation for future flights of the experiment,
- Access the infrequent but immensely valuable act of serendipitous discovery by researchers.

Funding for research is always necessary. Published sub-orbital tourist and payload costs provides an estimate for total cost. This cost estimate shows that sub-orbital researchers will fly with their experiments orders of magnitude cheaper than in any current or near-future orbital laboratory.

It is found in this on-going study that commercial, re-usable, sub-orbital spaceflight is an ideal laboratory in which humans will conduct their experiments. SARG is actively advocating for and educating about the benefits to be had in diverse fields of science. This advocacy and educating is conducted with policy makers, funding agencies, and science communities. Conversations with flight providers support the effort. Commercial Spaceflight Federation guidance and advice are critical to progress in this advocacy effort. .