Synopsis:
The Heliophysics Low Cost Access to Space (H-LCAS) and Flight Opportunities in Research and Technology (H-FORT) grant budgets primarily fund the development and construction of instrumentation. A side effect of this approach is that mission operations, including data collection and data processing, tend to be severely under budget (or unfunded). In order to satisfy the requirements of modern missions, we recommend a new funding source for mission operations. This funding source is increasingly vital going forward as new missions collect exponentially more data compared to past missions. Similarly, to take full advantage of underutilized historical datasets, we recommend adding another funding source to analyze these valuable datasets. Without these funding sources, mission datasets will, in the best case, be significantly underdeveloped and underutilized, and more likely, will fall dramatically short of their required scope.
Introduction:

Recently the space physics community leaned heavily on smaller missions such as balloons, rockets, and CubeSats. The primary benefits of these missions include relatively cheap and rapid development, opportunities for larger constellations, technology development, and a pathway for PI training and development. The data collected from these missions often provide insights into regions of the geospace system which are hard to access, especially when this data is combined with other platforms. However, the downside of these missions is the limited funding for data collection and data processing. The limited funding leads to, in the best case, datasets that are significantly underdeveloped and underutilized, or more commonly, fall dramatically short of their required scope. A compounding effect is the lack of funding for data analysis of historical datasets. If the collected dataset does not get processed in a timely manner, that dataset may become ineligible for many proposal calls and become obscure. In essence, the goal is to avoid re-discovering old knowledge or prevent expending precious resources to repeat existing observations that, if only had been duly analyzed, would have allowed us to progress by leaps and bounds.

Recommendation 1: Mission Extensions for CubeSats

NSF and NASA currently fund the development and construction of instruments flown on balloons, rockets, and CubeSats, via calls such as the NSF’s Ideas Lab, NASA’s Heliophysics Low Cost Access to Space (H-LCAS) or NASA’s Flight Opportunities in Research and Technology (H-FORT) programs. These projects have moderate-sized budgets that primarily fund the development and construction of scientific instrumentation. Frequently, funding for the mission operations, including data collection and data processing, tends to be eaten up by excessive hardware development costs, inflation, and other unforeseen scheduling issues. As a result, once the mission flies, the science team often has limited funds to continue mission operations—operations that are critical to gathering the data necessary to achieve closure of the mission’s science goals.

NSF’s twin FIREBIRD-II CubeSats are an example of how a new funding line focused on continued operations would be highly beneficial [Crew et al., 2016]. After they launched in early 2015, the funding to operate the CubeSats ended. As a result, FIREBIRD-II was, and still is, operated by volunteer students. Without a funding mechanism—or students willing to work for free—there is little incentive to operate FIREBIRD-II. The continued operations of FIREBIRD-II has resulted in the training of numerous engineers and researchers, including two PhDs [Shumko 2019, Johnson 2022]. The FIREBIRD-II data collected since the end of it’s funding lifetime have also resulted in many peer reviewed publications and advancements to our understanding of energetic electron precipitation and its role in inner magnetospheric dynamics [Breneman et al., 2017, Shumko et al., 2017, Capannolo et al., 2019, Johnson et al., 2020, Capannolo et al., 2021, Duderstadt et al., 2021, Johnson et al., 2021, Kawamura et al., 2021,
In cases similar to FIREBIRD-II (for example AC-6, REACH, ELFIN, BARREL) a *mission operations* grant will go a long way to get the most science return, and provide equitable opportunities for students to gain experience and be paid for their work.

**Recommendation:** add a new proposal calls at NSF and NASA to support mission operations for current missions that demonstrate a compelling scientific need to continue data collection and processing beyond the primary mission.

This new grant could be similar to NASA’s Heliophysics Data Environment Enhancements (HDEE) grants, but instead of archiving and processing data sets, this new call will focus on collecting and processing raw data. Basically the idea is to avoid re-discovering old knowledge or prevent expending precious resources to repeat existing observations that, if only had been duly analyzed, would have allowed us to progress by leaps and bounds instead.

**Recommendation 2: A new proposal call for historical missions**

Historically, NASA’s Guest Investigator and Supporting Research grants focused on current missions. However, much can be learned from historical data sets (e.g., Shumko et al. 2021). By providing a means to fund data analysis from these missions, we will be able to push the science frontier with questions that were unimagined when these missions were conceived.

However, its potential is being hamstrung by not being able to have new funding available for scientists to more actively use this valuable dataset in new proposal calls.

Additionally, the heliophysics and space weather communities would greatly benefit by being able to more actively and consciously use archival data in submitted proposals. The Combined Release and Radiation Effects Satellite (CRRES) and Van Allen Probe data are just one example. There were about two solar cycles between the two radiation belt missions, and with no radiation belt mission “on the books” there could easily be two more solar cycles before we once again collect this valuable data. As with the pause between CRRES and Van Allen Probes, research will continue, Ph.D ’s will still be written on inner magnetospheric dynamics, and papers will be published. However, instead of a subfield only surviving, it could continue to grow if there is a concerted effort to continue to fund analysis of these historical data sets.

**Recommendation:** Add new NASA and NSF proposal calls which focus on historical data and data from rockets, CubeSats, and balloons.

**Conclusion:**

Our two recommendations are two potential solutions to get the most out of our investments. The first recommendation aims to ensure that we continue to collect valuable data from these missions, while the complementary second recommendation aims to ensure that we get the most out of underutilized historical datasets. Each of these recommendations requires new funding that is ultimately more cost effective than building new hardware.

When hardware is successful in producing high-quality and unique data on the ground or on orbit, assuming this is duly evaluated and demonstrated, then it would behoove the funding agencies to ensure full utilization of these data by funding operations and data processing from these missions. The reason is that these unique datasets can result in science that may complement larger programs and lead to discoveries that would otherwise be impossible. In other words, big science can come even from small missions, if only appropriate funds are judiciously expended on the operations and science analysis side of those that have been proven to produce high quality observations worthy of such investments.

**References:**

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