ReEntry Breakup Recorder (REBR): Research Directions and Future Developments

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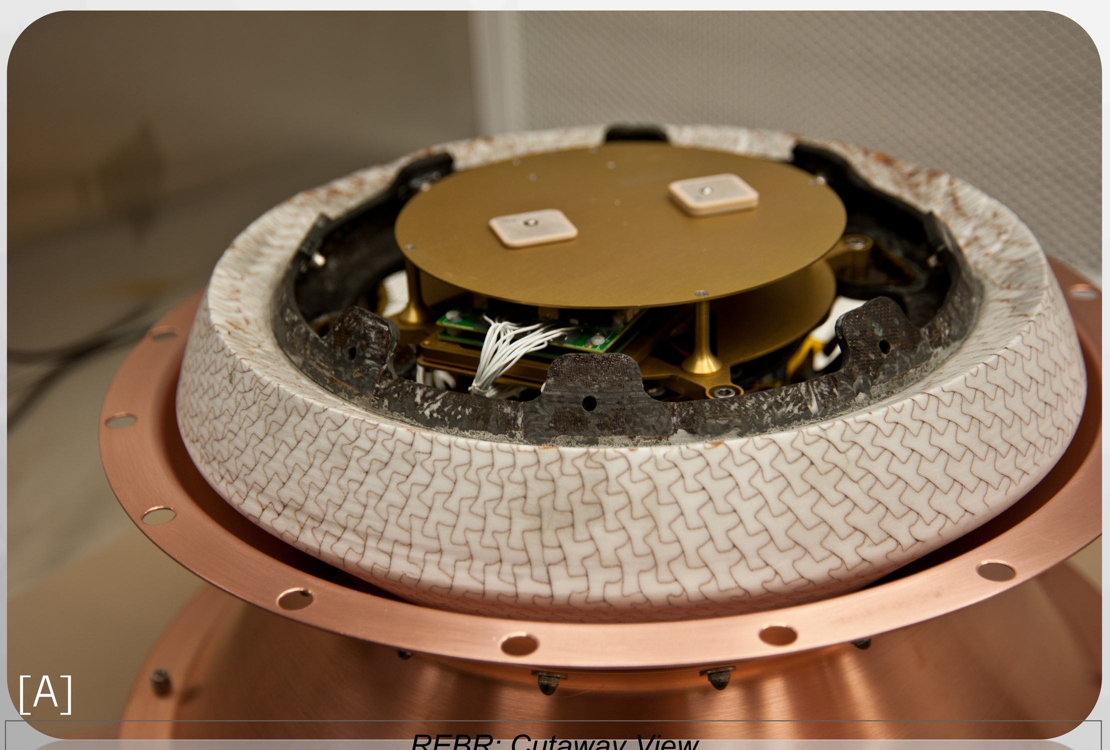
The Problem

The consequence of sending human-made objects into orbit is that most of those objects will return on earth. The obligation of safety requires that those objects land in unpopulated areas, such as the South Pacific. Originally, models predicted the majority of breakup events experienced by objects reentering the atmosphere would occur at high altitudes. The breakup of the space debris at these high altitudes would result in either the debris not surviving reentry or the debris impacting over a large area. During the 1970s though, it was discovered that breakup of reentering space junk occurred at much lower altitudes; thus the debris did not break up as previously hypothesized, not to mention the area that the space junk landed was smaller and theoretically easier to aim[1,2]. Another byproduct of low altitude breakup was that pieces of the debris were large enough to cause damage to property—and more catastrophically—people. On December 25, 1996, falling space debris struck a Chinese passenger plane, cracking the pilots' windshield, forcing them to make an emergency landing[3]. Potentially catastrophic examples such as this, as well as a growing amount/frequency of falling space debris, have significantly increased interest in the study of falling debris to validate numerical modeling of reentry breakup in order to ensure the future safety of people everywhere.

The Solution

In order to study the reentry and breakup of satellites, launch stages, etc., as well as develop more accurate mathematical models, Aerospace Corporation developed the ReEntry Breakup Recorder (REBR), launching the first in 2011. REBR is a small and autonomous device that measures and records temperature, acceleration, position, and other information pertaining to the reentry of debris. The whole assembly (see figures) is connected to a host vehicle (typically a single use resupply/waste craft) leaving the ISS before it is 'dropped' back to earth. The host vehicle is already destined for breakup, and once the vehicle has sufficiently broken up, REBR releases itself, having now gathered all relevant data. REBR will then self-stabilize for the remainder of its flight, and transmit all data via the Iridium network for download by ground control. Because the data is sent during flight, it isn't required that REBR be recovered, though, it has demonstrated survivability to water impact (no parachute), meaning REBR recovery is possible.



[A]

REBR: Cutaway View

Current Research

Currently, REBR is solely focused on measurement and analysis of re-entry breakup in order to validate numerical models. However, its design and low overhead cost allow for many other capabilities. Our goal is to repurpose REBR into a system that is capable of wide-spectrum experimental analysis, and potential payload delivery (e.g. from the ISS). By altering the location of analysis components currently contained within REBR, REBR can be reorganized in a way that will allow for the possibility of introducing several other test instruments. This would allow for further testing in additional areas of study, such as heat shielding, [internal] heat transfer, structural analysis, and impact analysis. We would accomplish this by creating an array of data ports; with each port serving to connect all instruments to a centralized chipset. This design would allow a vast variety of tests to easily be completed, in addition to still obtaining the original breakup analysis data—which means every experiment run with REBR in the future will still generate much needed reentry data for numerical model validation. With this new capability to "pick and place" test components, space is saved and further capabilities can be realized.

[B]

REBR: Exploded View

In addition to instruments gathering data, independent experiments (that fit the dimension requirements) could be incorporated into REBR's [soon-to-be] available compartments. Because REBR makes a stop at the ISS after launch before reentry, and because of market desire to test launch and re-entry durability of various materials (e.g. lenses, etc.), several opportunities arise for REBR to carry additional experiments. Standard dimensions could be created for REBR's compartments to allow experiments to be designed specifically to fit in REBR. This dimension standardization expands REBR's capability from in-house testing to third party involvement. By doing so, revenue can be generated by those willing to "rent space" inside of their REBR experiment, and further research can be conducted that was previously unavailable in an economical manner.

Because of all the effort of making, essentially, a standardized REBR kit design that allows for payloads with standard dimensions [of both instrumentation and test subjects/materials], we have decided to dub this new version of REBR as REBR-UPS, which stands for ReEntry Breakup Recorder—Universal Payload System.

Future Applications

The creation of the REBR-UPS kit will greatly influence the methods experiments are completed by research institutions and other bodies. Much like the invention of the CubeSat made projects in space practical for universities, smaller institutions, and the like, REBR-UPS will allow these same institutions the ability to run experiments within their means—with respect to both finances and facilities. The relatively low overhead cost of building REBR-UPS will likely attract more than just those in the academic spectrum, but also private companies. The reality of private company interest in this concept is real. In fact, in 2012, the developers of REBR, Aerospace Corporation, entered into a licensing agreement with Terminal Velocity Aerospace (TVA), LLC because of TVA's desire to commercialize REBR in a way befitting of the emerging industries regarding "reentry debris safety and utilization of space"[4]. With interest already being shown in the original REBR, it isn't hard to imagine that REBR-UPS will one day find its niche as well.

NASA Kentucky Space Grant Consortium and EPSCoR Programs

NASA

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References:

[1] – Ailor, William, Joseph A. Carroll, Daniel J. Rasky, and Rex Ridenoure. "Pico Reentry Probes: Partnership Pushes Evolution." *AIAA Space 2006 Conference.* (2006): n. page. Web. 31 Jan. 2013.

[2] – Cozmuta, I., "Perspective on Small Payload Flight Experiments," *AVT-199 Specialists Meeting on "Cat- alytic Gas Surface Interactions"*, 2012.

[3] – Ailor, William, and Paul Wilde. "Requirements for Warning Aircraft of Reentering Debris." *3rd International Association for the Advancement of Space Safety Conference.* (2008): n. page. Web. 31 Jan. 2013.

[4] – Weaver, Michael A., and William H. Ailor. "Reentry Breakup Recorder: Concept, Testing, Moving Forward." *AIAA Space 2012 Conference and Exposition.* (2012): n. page. Web. 31 Jan. 2013.

[A] – Web. 31 Jan 2013. <http://blogs.esa.int/atv/files/2011/06/REBR51255-16.jpg>.

[B] – Web. 31 Jan 2013. <http://www.spacesafetymagazine.com/wp-content/uploads/2012/12/REBR-schematic.jpg>.