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IN REVIEW



TWO BAD DAYS
Questioning conventional wisdom after Antares, Virgin Galactic/Page 4

This year saw continued efforts toward expanding human economy throughout cislunar space. While there is still no clear development or unified planning of integrated infrastructure components to enable future space settlement, small steps are being made toward that big goal.

The **International Space Station** continues to be the primary focus of commercialization. Cargo deliveries in the past year included two flights by the SpaceX Dragon and two by the Orbital Sciences Cygnus vehicle under the Commercial Resupply Services contracts. A third Cygnus resupply mission failed in October when the Antares launcher exploded shortly after liftoff. NASA has issued a preliminary request for proposals for continuation of commercial cargo deliveries through CRS2.

In September, NASA announced that it had awarded **Commercial Crew** contracts to SpaceX and Boeing for the next phase of vehicle development through initial flights starting in 2017. SpaceX is offering a crewed version of the Dragon cargo vehicle and Boeing is developing its CST-100 capsule. Sierra Nevada, which offered its Dream Chaser winged vehicle, was not selected for the program, but the company intends to continue development of the vehicle.

Management of ISS as a **National Laboratory** by the Center for the Advancement of Science in Space, or CASIS, is yielding impressive research results. For example, the capability to crystallize proteins in weightlessness reveals previously unknown protein structural features, enabling development of new drugs, at least one of which is now in testing. A rodent research facility will initially enable studies for 30 to 60 days, and eventually 180 days with either mice or rats. Research from this facility is expected to include studies of disease, testing of drugs, and better understanding of bone and muscle loss in space. The Hyperspectral Imager for the Coastal Ocean has demonstrated clear imaging of algae blooms, which aids understanding of environmental effects on water quality. Long-term experience in space enabled by CASIS can lead to the products that will eventually show how to make profits by manufacturing in space, a prerequisite to large-scale habitation.

Direct progress toward **space manufacturing** is being accomplished by Made In Space Inc. with the creation of a 3-D printer that arrived on ISS in September. The company recognizes this is just a first step, with plans being developed for a permanent Additive Manufacturing Facility on ISS.

Another possible path toward space commerce is suggested by a DARPA request for information on development of **robotic servicers** for spacecraft inspection and relocation in and near geosynchronous Earth orbit. The agency is trying to learn whether commercial on-orbit satellite servicing could become financially self-sustaining.

Interest in **space solar power** continues to grow. The U.S. Department of Energy's website, for example, featured a "Space Week" with the message that "solar power directly from space may arrive sooner than you think." Conferences brought experts together several times during the year, with strong interest in Japan and China. A book by John Mankins, "The Case for Space Solar Power," suggests a roadmap for operational solar power satellites within 20 years, driven by a business model and recognizing that the timeline will be flexible.

Also newly published is "Space Elevators: An Assessment of the Technological Feasibility and the Way Forward," resulting from a study by the International Academy of Astronautics. The goal is more affordable access to space. The book acknowledges that the biggest challenge is a producible material with "strength, length and perfection needed to enable a 100,000km long tether. Almost all other issues ... have either been resolved in space before or are close to being space ready today." ▲

Small steps toward space commerce

by Anita Gale, Ron Kohl and Mike Snyder

The Space Colonization Technical Committee promotes the development of advanced concepts, science, and technology to enable and enhance permanent human presence in space.



Made In Space's zero-gravity 3-D printer.

Made In Space