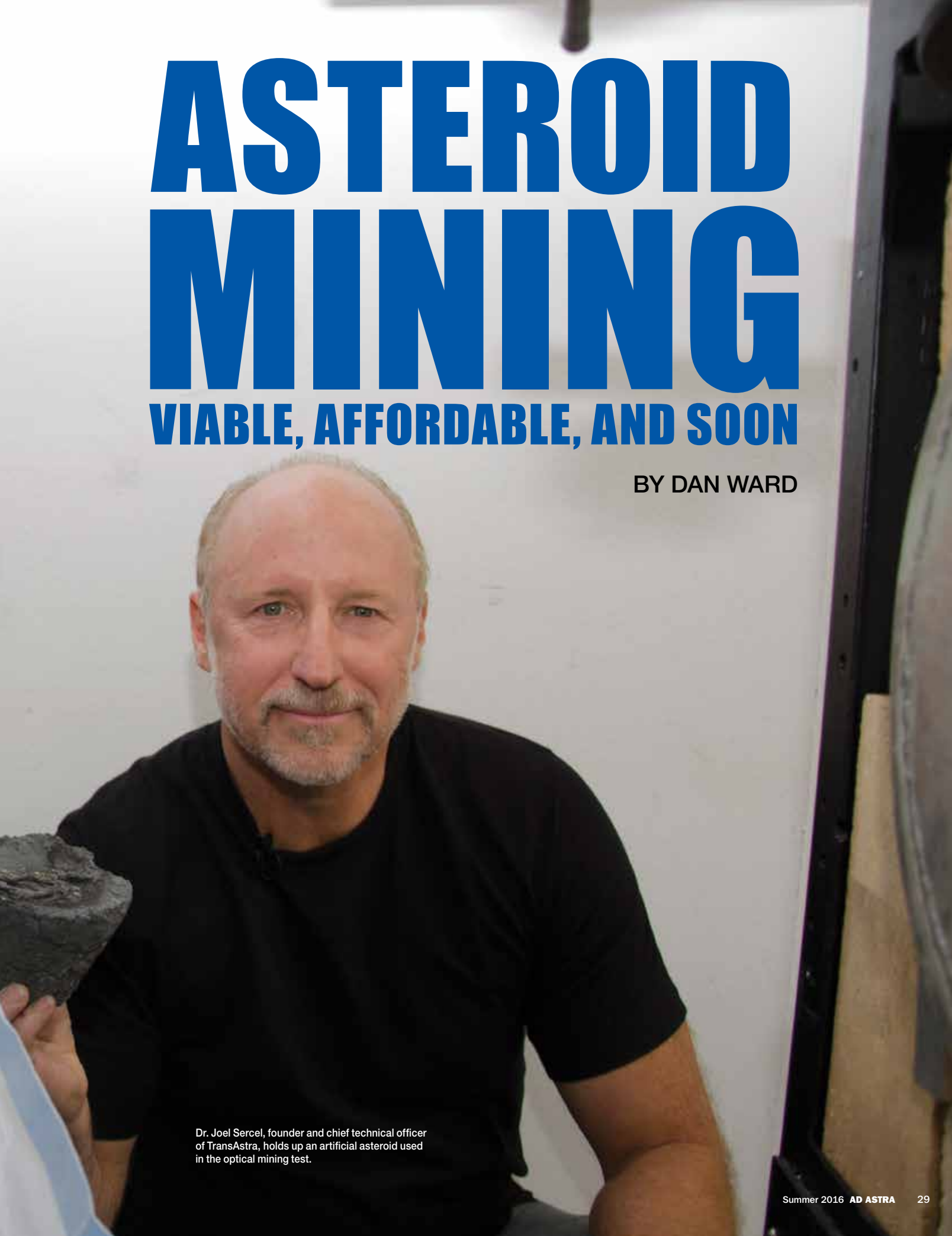
ASTEROID MINING

VIABLE, AFFORDABLE, AND SOON

BY DAN WARD



Dr. Joel Sercel, founder and chief technical officer of TransAstra, holds up an artificial asteroid used in the optical mining test.

In December of 1901, Rear Admiral George W. Melville, the U.S. Navy's chief engineer, published a paper titled "The Engineer and the Problem of Aerial Navigation." In the paper, Melville strenuously denied the feasibility of manned flight, calling the concept absurd. He went on to explain that even if it were possible, producing a flying machine capable of carrying a person would cost more than a battleship.

Exactly two years later, Orville and Wilbur Wright made their first successful flight. Total cost was less than $1,000—including their round-trip train fare between Dayton, Ohio, and North Carolina's Outer Banks. So much for Melville's prediction.

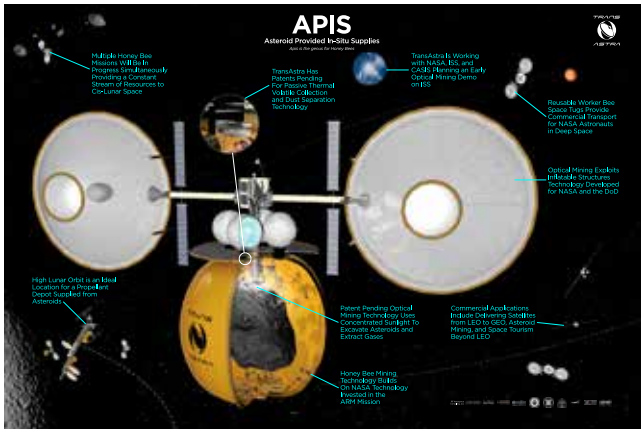
The erroneous belief that technological breakthroughs incur enormous costs is common across a variety of industries. In projects ranging from space missions to medicine to military technology, there is a widespread assumption that innovations require massive investments simply because previous investments were made. Fortunately, there is a counter-thread of thrifty innovators like the Wrights who consistently prove the predictions wrong by orders of magnitude, creating new markets and destroying old ones.

One such innovator working today is Dr. Joel Sercel, a rocket scientist whose new company, Trans Astra, aims to make asteroid mining a commercially viable enterprise in the very near future, in large part by re-evaluating common economic assumptions and taking a lower-cost approach than space missions typically use.

Asteroid mining was a popular topic for science fiction stories as far back as the 1940s. Inspired in part by these stories, scientists and engineers like Sercel have been talking about asteroids as a source of raw materials for decades. Although the necessary technology has existed for some time, nobody has quite managed to make the economics work out. While near-Earth asteroids contain a tantalizing quantity of interesting and valuable materials, the effort involved with retrieving those materials is generally expected to come with a pretty big price tag, so asteroids are dismissed as being out of reach or simply uneconomical.

That is where Trans Astra comes in, with an inventive proposal to use a fleet of small, inexpensive spacecraft capable of extracting volatile chemicals from carbonaceous chondrite asteroids. Rather than a single big leap, Sercel developed an iterative approach, using a series of stepping stones to advance from rudimentary mining to full-blown manufacturing.

The operation of the first phase concept is ingeniously simple. A small, low-cost vehicle called a Honey Bee captures an asteroid in an inflatable bag. The spacecraft's reflectors then direct highly concentrated sunlight onto the rock. This heats the stone, causing it to release water and other volatiles in the form of gases which are captured by the Honey Bee.



Visual overview of APIS: Asteroid Provided In-situ Supplies.

Sercel calls the process of using light to extract resources "optical mining," and it has several technical and economic benefits. The most obvious is that it uses free energy from the Sun to do the physical mining. This reduces the vehicle's power needs and does away with mechanical drilling components, reducing cost and weight. Drilling with light means there are no physical drill bits to break, get dull, or malfunction, which saves money in development, testing, and maintenance, in addition to launch weight.

Initial tests in 2015 using the solar furnace at White Sands Missile Range showed that the optical mining extraction approach is sound. Using a simulated test sample, Sercel was able to demonstrate that highly concentrated sunlight can "drill holes, excavate, disrupt, and shape an asteroid." While the experiment showed the optical mining procedure to be possible, the effect of wind and gravity limited the test performance parameters. Fortunately, the lack of gravity and atmospheric disturbances in space actually make optical mining easier and more effective than Earth-bound experiments.

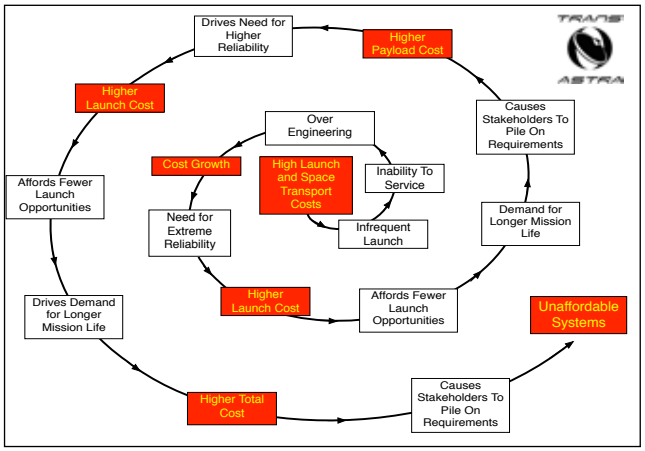
Let's look at some numbers: Up to 120 tons of water could be harvested from a typical asteroid over a period of a few months and stored as ice. This water would then be available to use as spacecraft propellant, provided to astronauts for drinking, or split to produce oxygen. According to a NASA Fact Sheet, today's cost to orbit is approximately $10,000 per pound, so extracting 120 tons of water from an asteroid represents a launch cost saving of $2.4 billion.

Orbital refueling stations would allow other spacecraft to haul less fuel out of Earth's gravity well, thus reducing their weight—and cost—at launch. But Trans Astra is aiming higher than that. Reducing the cost and barriers of space launch is part of a larger vision of establishing a "transcontinental railroad" in space, to transport people, equipment, and supplies across distances that were previously difficult, dangerous, and expensive to cross. Just as the 19th century's transcontinental railroad transformed America into an economic and military superpower, efficient asteroid mining has the potential to create easier, lower-

cost access to the final frontier and profoundly transform humanity's future.

While the technology involved is impressive and important, the economic aspect of Trans Astra's work might be more important than their scientific and engineering achievements. In fact, talk about Trans Astra's technology almost immediately goes to the business case, a relative rarity among rocket scientists who tend to prefer debating the technical merits of various trajectories, control systems, and propulsion methods.

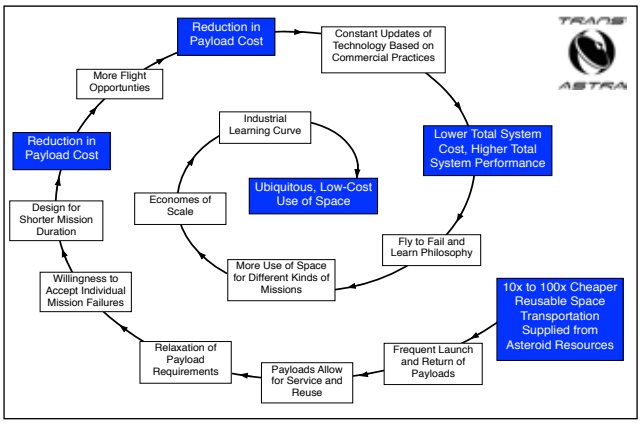
According to Sercel, one of the reasons space missions are so astronomically expensive is that "space launch has never been optimized for cost." Instead, government space agencies have focused on addressing technical and operational aspects of the problem, often relying on the self-fulfilling prophecies of experts like Melville—their beliefs about cost lead to excessive budgets, which are then spent with bureaucratic efficiency. Large budgets lead to large spending, which reduces launch frequency and causes further cost growth. The result is an economic death spiral.



Impact of high costs on launch frequency, requirements, and further cost growth.

Sercel argues that space exploration need not follow this path. As part of the growing entrepreneurial space community, which includes companies like Blue Origin and SpaceX, Trans Astra is setting out to drive space costs down by orders of magnitude. In part this is through the use of emerging technologies like additive manufacturing and mechatronics. It also involves addressing previously ignored market forces and re-examining long-standing assumptions about cost, launch frequency, and complexity. The idea is to reverse the previous spiral and instead follow a path that leads to lower costs and more frequent launches.

The cost of space launch is a significant barrier today, as it has been ever since space flight began. Making space missions more affordable fundamentally changes the game. It changes who can play, how we play, and even what the rules are. This change will initiate not only the economic development of space but also the transformation of humanity from a terrestrial species to a spacefaring one.



Reduced costs lead to more opportunities, developments, and learning, further driving costs down.

Sercel's plans and calculations show that asteroid mining is technologically and economically feasible in the near future. He projects that Trans Astra can be ready for its first orbital test in three years, with actual mining operations underway within 10 years. NASA has already made some initial investments in this effort—Sercel previously received a NASA Innovative Advanced Concepts grant and is a NIAC Fellow. He is now proposing NASA apply the Commercial Orbital Transportation Services (COTS) model to building in-space infrastructure, setting the foundation for a public-private partnership where the government funds the early stage technology development, while industry funds the effort to build and operate the vehicles.

The key to making all this happen goes back to Melville's prediction about how much an airplane would cost, and the Wright brother's low-cost approach. While a certain amount of investment is clearly necessary to spur new projects and developments, innovation is not primarily a function of investment. Rather, economically efficient innovators who challenge the status quo assumptions about cost and who leverage speed, thrift, and simplicity can often deliver breakthrough capabilities much sooner and less expensively than conventional wisdom predicts. Asteroid mining is not easy and it is not free. There are technical, political, operational, and economic questions that still must be answered. But if Sercel is correct, the resources contained within NEOs are easier to reach than they appear, and once a concerted mining operation is underway, it just might change everything.

Lt Col Dan Ward, USAF (ret) is the author of "The Simplicity Cycle: A Field Guide To Making Things Better Without Making Them Worse" and "F.I.R.E.: How Fast, Inexpensive, Restrained, and Elegant Methods Ignite Innovation." He holds three engineering degrees, was awarded the Bronze Star, and is a Cybersecurity Fellow at the New America Foundation.