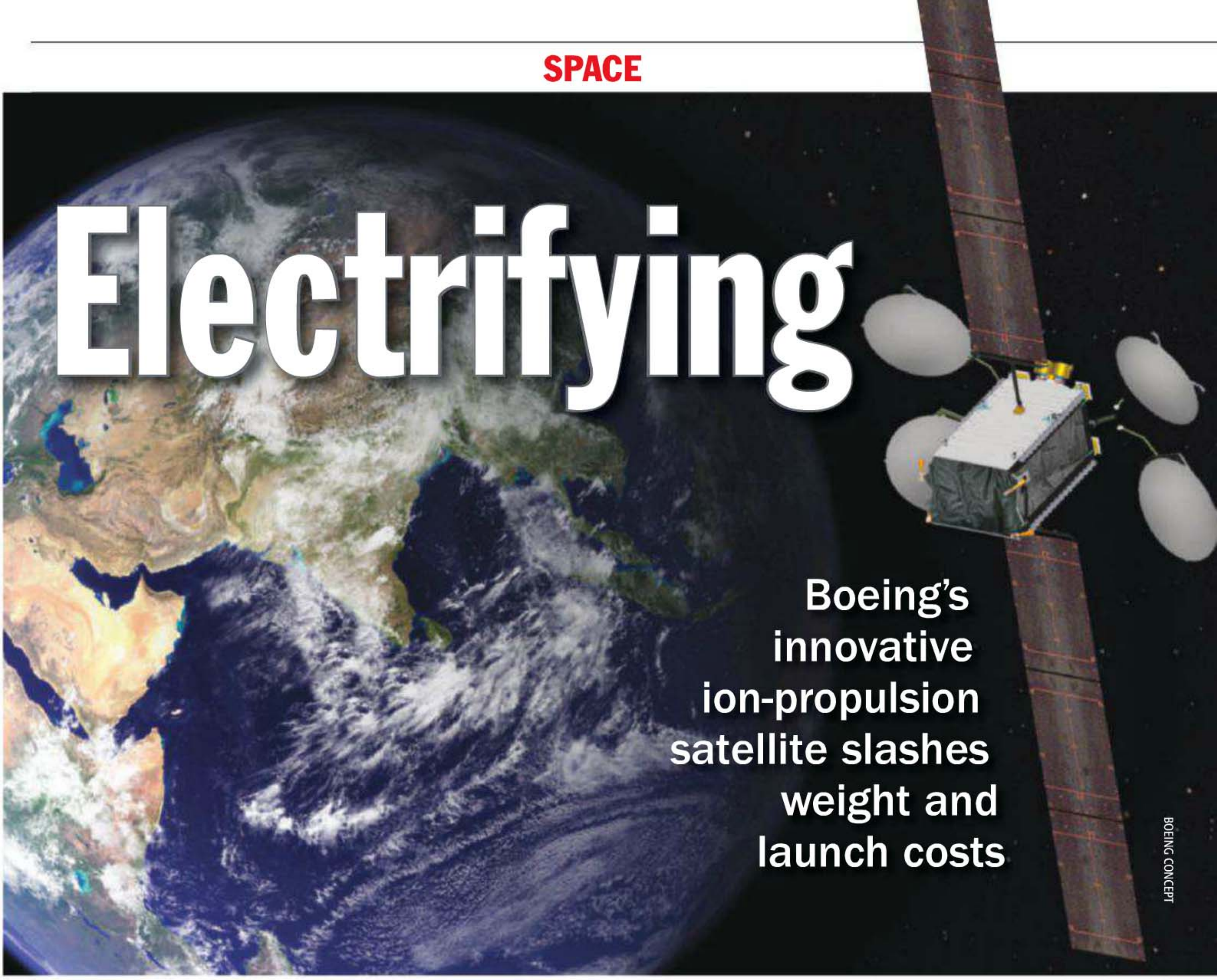
Electrifying

Boeing's innovative ion-propulsion satellite slashes weight and launch costs



BOEING CONCEPT

AMY SVITAK/WASHINGTON

It's no secret that Boeing's space systems unit is aggressively pricing bids in an effort to grow its commercial business segment as government spending flags. But even the most bullish observers were taken aback by an estimated $400 million deal just signed with Asia Broadcast Satellite (ABS) and Satellites Mexicanos (SatMex) to build the first all-electric commercial telecom spacecraft intended for launch to geostationary orbit.

The technology—which uses lightweight xenon-fueled ion thrusters rather than conventional chemical propulsion to maneuver a spacecraft into position—is promising. Imagine cutting in half a satellite's weight, and subsequently its launch costs, which can top $100 million depending on the size of the spacecraft. All-electric satellites could potentially save fleet operators hundreds of millions of dollars in annual launch expenditures, with potentially no impact to their satellites' capability or performance.

The downside is that while most commercial communications spacecraft are expected to be on station and making money within a few weeks of launch, new all-electric satellites could spend up to six months using slow pulses from ionic propulsion systems to maneuver into their final orbital slot—months when the spacecraft is not generating any revenue. This might not pose a problem for large operators with established revenue streams who can accommodate the lag in revenue as they incorporate new satellites into fleet-replenishment programs. But it could put small companies at a disadvantage as they sacrifice up to half a year's income waiting for the spacecraft to enter service.

In either case, employing an all-electric spacecraft requires getting an early start on the capital-spending cycle to accommodate the lengthy orbit-raising process.

"It is easier for a company with a large fleet that has to anticipate replacement satellites several years in advance to tolerate the several months it takes for an electric satellite to reach position once it has separated in orbit," says Romain Bausch, chief executive of Luxembourg-based SES, the world's second-largest fleet operator by revenue.

Boeing's use of xenon-ion propulsion for geostationary transfer and station-keeping distinguishes its 702SP as the industry's first all-electric satellite.

Bausch, who believes the ionic propulsion technology is now ready to enter the commercial field, says SES intends to issue a tender for an all-electric spacecraft in the coming year, once it completes the procurement process for a conventional satellite planned for service over Asia.

But while Boeing is discussing the new platform with several companies, including SES, the partnership that pushed this ground-breaking technology into the commercial realm was forged by two small regional operators that say the bulk buy allowed Boeing to keep costs low while affording an opportunity to commercialize a technology in which the El Segundo, Calif.-based manufacturer has been investing for several years.

"We think this might expand the market quite a bit," says Steve O'Neill, president of Boeing Satellite Systems International, who spent the past five months negotiating the deal. "The total cost to market will be significantly different for a satellite operator than it is currently."

Today, most geostationary telecom satellites are dropped off in an equatorial parking orbit after separating from their launch vehicles. From there, it takes several days using chemical propulsion systems to circularize a path more than 22,000 mi. above the equator. To facilitate the orbit-raising process and maintain orbital position over its 15-year operational life, these satellites are fueled with a substantial amount of liquid chemical propellant, accounting for 50% or more of the satellites' total weight and adding millions to the cost of launch.

In some cases, however, satellites save on weight by using xenon gas to power the thrusters used for orbital station-keeping. Boeing currently flies 18 such satellites for commercial and government customers. But electric propulsion has never been used to provide the heavy-lifting required to carry a satellite from transfer orbit to its final geostationary position. Except, that is, when accidents happen.

For example, the U.S. Air Force Advanced Extremely High Frequency (AEHF) and the European Space Agency's Artemis data-relay satellites both were forced to limp into final orbit using electric thrusters following failures of their main propulsion systems.

Jim Simpson, vice president of business development at Boeing Space and Intelligence Systems, acknowledges the inherent risk associated with new technology developments and admits the ABS and SatMex satellites are likely to spend 4-6 months circling the Earth before reaching their final orbits. "That's why it's important to reduce the cycle time relative to development and build of the satellite," he says, adding that the first two spacecraft are slated to launch as early as the fourth quarter of 2014.

To further reduce the cost of the system, ABS and SatMex have purchased a co-manifested launch atop a medium-class Falcon 9 operated by Space Exploration Technologies (SpaceX) of Hawthorne, Calif. Although the payload-carrying capacity of the ABS and SatMex satellites puts them squarely in the medium-class range of around 4,000 kg (8,800 lb.), each spacecraft is designed to weigh less than 2,000 kg using Boeing's new 702SP platform, the name the company has given to this product line using all-electric propulsion.

Boeing says these satellites are designed to launch atop any of the world's main commercial vehicles, though the Falcon 9 may be especially attractive for its ability to accommodate two 702SP spacecraft in a stacked configuration inside the rocket's 5-meter-dia. (16.4-ft.) payload fairing.

"That's a very interesting changing of the game when you have two satellites at 2,000 kg or less that you can put on a Falcon 9," O'Neill says. "Given the differential price of the Falcon 9, it does begin to change the equation."

The new technology may also be welcomed by Europe's Arianespace consortium, whose heavy-lift Ariane 5 typically needs to match two spacecraft—one large and one medium—for commercial launches. Adding the option of a low-weight 702SP, Arianespace could accommodate larger primary payloads co-manifested with a single all-electric spacecraft without exceeding the rocket's total capacity of more than 9,000 kg to orbit.

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The new technology has long-term implications for the industry, not the least of which is that equatorial launch sites, such as the Guiana Space Center operated by Arianespace, would no longer boast a decisive advantage over a spaceport located far from the equator. Given a modest supply of lightweight xenon fuel, an all-electric satellite could easily make up the distance it must travel from the equator if it is launched, for example, from Baikonur Cosmodrome, Kazakhstan, or Cape Canaveral.

The emergence of ion-propelled satellites could also inform the future architecture of the Ariane rocket itself. European governments are scheduled this year to determine which path to take in developing the rocket line, a choice that could mean adding more capacity to the Ariane 5 or designing a modular next-generation launcher. Given the two options, an all-electric commercial product line would appear to argue in favor of the latter.

For the moment, Boeing is the only commercial satellite builder that has an all-electric product ready for sale. But not for long. Evert Dudok, chief executive of Astrium Satellites, says his company is working on an all-electric product. And John Celli, president of Space Systems/Loral, which in recent years has been the most active satellite manufacturer on the commercial market, says his company will have an "efficient" all-electric product ready for commercial sale within a year.

"Right now it's in qualification," he says, adding that Loral is concerned existing customers could be turned off by the lengthy orbit-raising process that all-electric satellites require. "You're looking at maybe five or six months, so we're trying to reduce that substantially."

Other leaders of satellite manufacturers—including Reynald Seznec, chief executive of Thales Alenia Space, and Joseph Rickers, vice president of Lockheed Martin Commercial Space Systems—say they are interested in the technology, but matching Boeing's prices could be a challenge.

"We certainly have electric propulsion, but not at that price point you saw today," says Rickers. "The jury is out on that."

Even Boeing says the ABS/SatMex deal would have been difficult to close if the order had involved fewer than four spacecraft. "There are economies of scale with four," O'Neill says, adding that developing and launching spacecraft in pairs is more cost-effective than one-offs. This means that unless other midsize fleet operators join forces on a major procurement program, such price points may be available only to larger operators.

Besides reducing weight, all-electric spacecraft offer the opportunity to add payload capacity and boost performance. "The more you use electrical propulsion, the lighter the spacecraft becomes and the more payload you can put on it," Simpson says, adding that the ion-propulsion satellites can accommodate 47 active transponders and generate 3-8 kw of power. "You're getting quite a significant value proposition, up to 7.5-8 kilowatts of capacity, but it's much more economical from a launch perspective."

Simpson says the project could serve as an incubator for the direction Boeing hopes to take all of its satellite platforms. Ultimately, he sees it as an opportunity to win additional government business for U.S. Air Force and classified satellite programs.