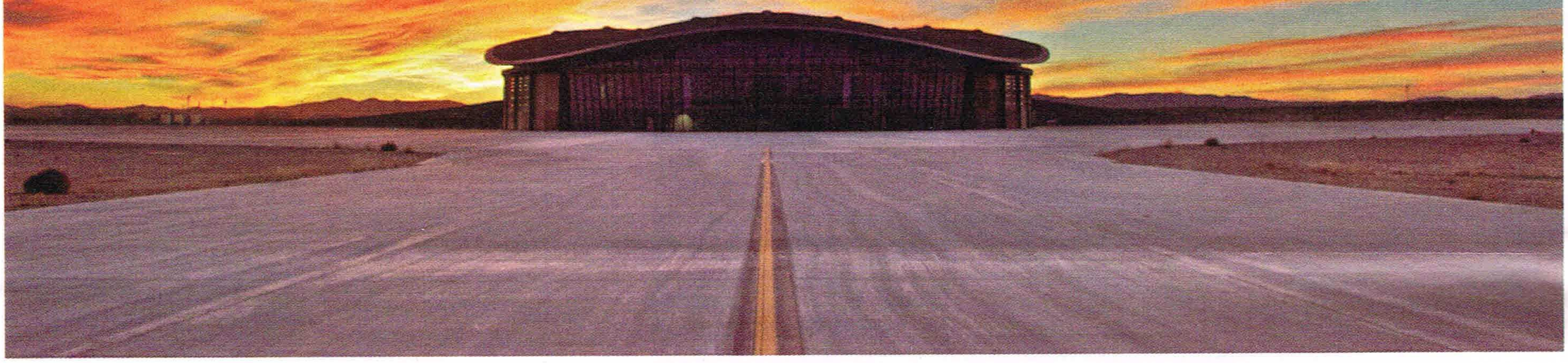
BOLDLY GO

THE COMMERCIAL SPACE FLIGHT INDUSTRY IS TAKING OFF, AND WITH IT A NEW ARCHITECTURAL TYPOLOGY: THE SPACEPORT

BY BILL MILLARD



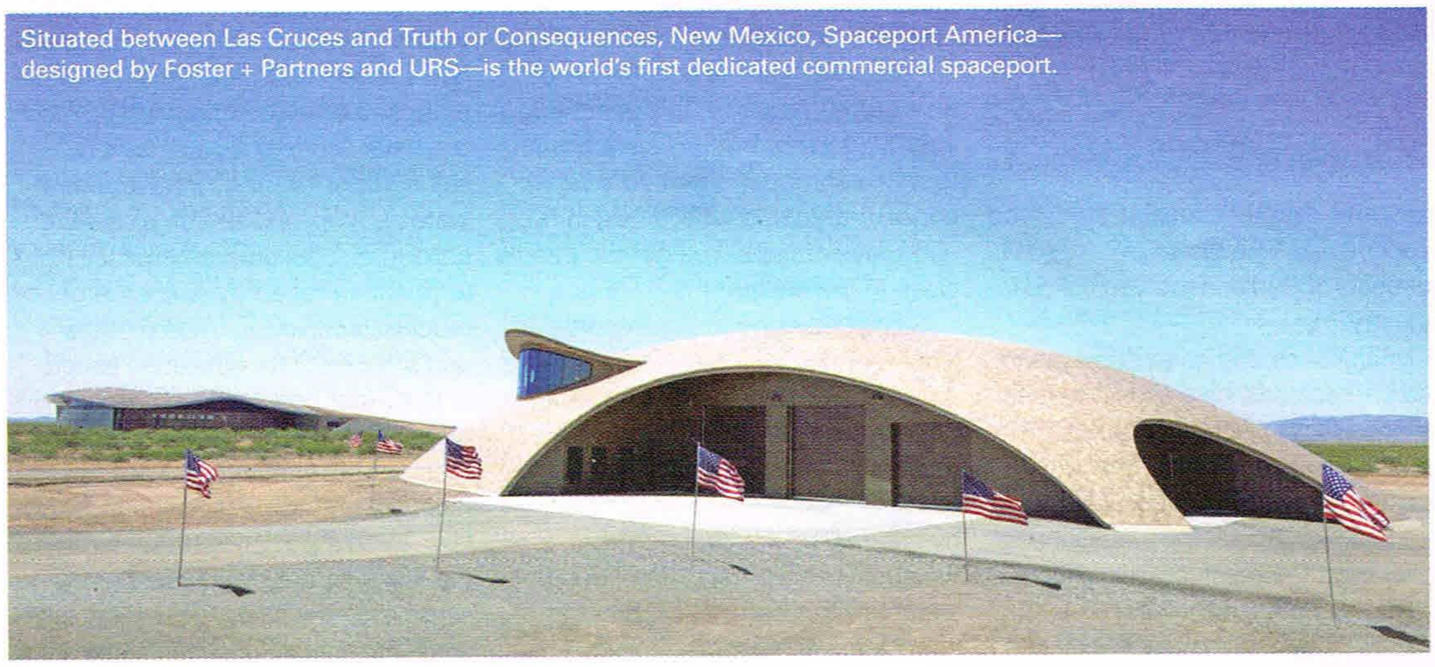
Quick: close your eyes and think of space flight. Where do the images come from? If you're of a certain age, they're from the Mercury, Gemini, and Apollo missions of the 1960s, the heroic era that culminated in a moon landing. For nearly everyone younger, they're from cinema and video: some iteration of *Star Trek, Star Wars, Battlestar Galactica*, and *2001: A Space Odyssey*. The visual vocabulary became a cliché long ago: sleek techno-biomorphic spacecraft straight out of William Gibson's Gernsback Continuum, zooming between Fullerian/Saarinenesque/Altoid space stations and CGI battle scenes, dodging the question of whether streamlined contours actually matter in environments with no atmosphere and, hence, no friction (they don't, as Thom Mayne once noted in reference to the Apollo Lunar Module that his Cooper Union building so uncannily resembles).

Personal visions of space travel are less likely to suggest NASA's more prosaic space shuttle (or, lower on the aerospace-iconography ziggurat, *The Jetsons*). Yet commercial spaceports, a critical step toward a future when space is open to every George and Jane, have moved from speculation to actual construction over the past decade. If the space-travel industry follows the path these ports' proliferation implies, those humbler models will be closer to reality.

Spare-no-expense public projects with single-use rockets that discard launch stages into the ocean, manned by larger-than-life rocket jocks who joined the astronaut/cosmonaut elite through military training, have given way to economical carrier craft ("motherplanes") taking off horizontally on regular runways, ferrying light reusable vehicles full of relatively unheroic civilian passengers. Tourism and eventual routinization, in other words: the passing of the torch from people with the Right Stuff to people with plenty of the green stuff.

Though it's easy to view rocket-borne millionaires as the ultimate dilettantes, some longtime aerospace observers see tourism as an essential phase in the evolution of the field. Consultant/engineer Derek Webber, executive director of Spaceport Associates, has analyzed the business models and regulatory climate for passenger space flight, managing Futron Corporation's ASCENT study of space markets for the National Aeronautics and Space Administration (NASA)'s Marshall Space Flight Center. After decades in the communications satellite industry, he believes that space tourism could grow far larger. "It's an enormous potential market," he said, "because if each person is considered as a payload, you've got potentially tens of thousands of payloads per year, whereas in normal commercial space you have about 80 payloads a year... globally." Envisioning a wide range of "horses for courses"—spaceports tailored to particular purposes—and looking to suborbital tourism as the path to commercial viability as general space transportation matures and expands, Webber compares the brewing space boom to the barnstorming era in the early history of aircraft. "Go back to the Wright brothers. They started something, and they didn't know where it was going to lead."

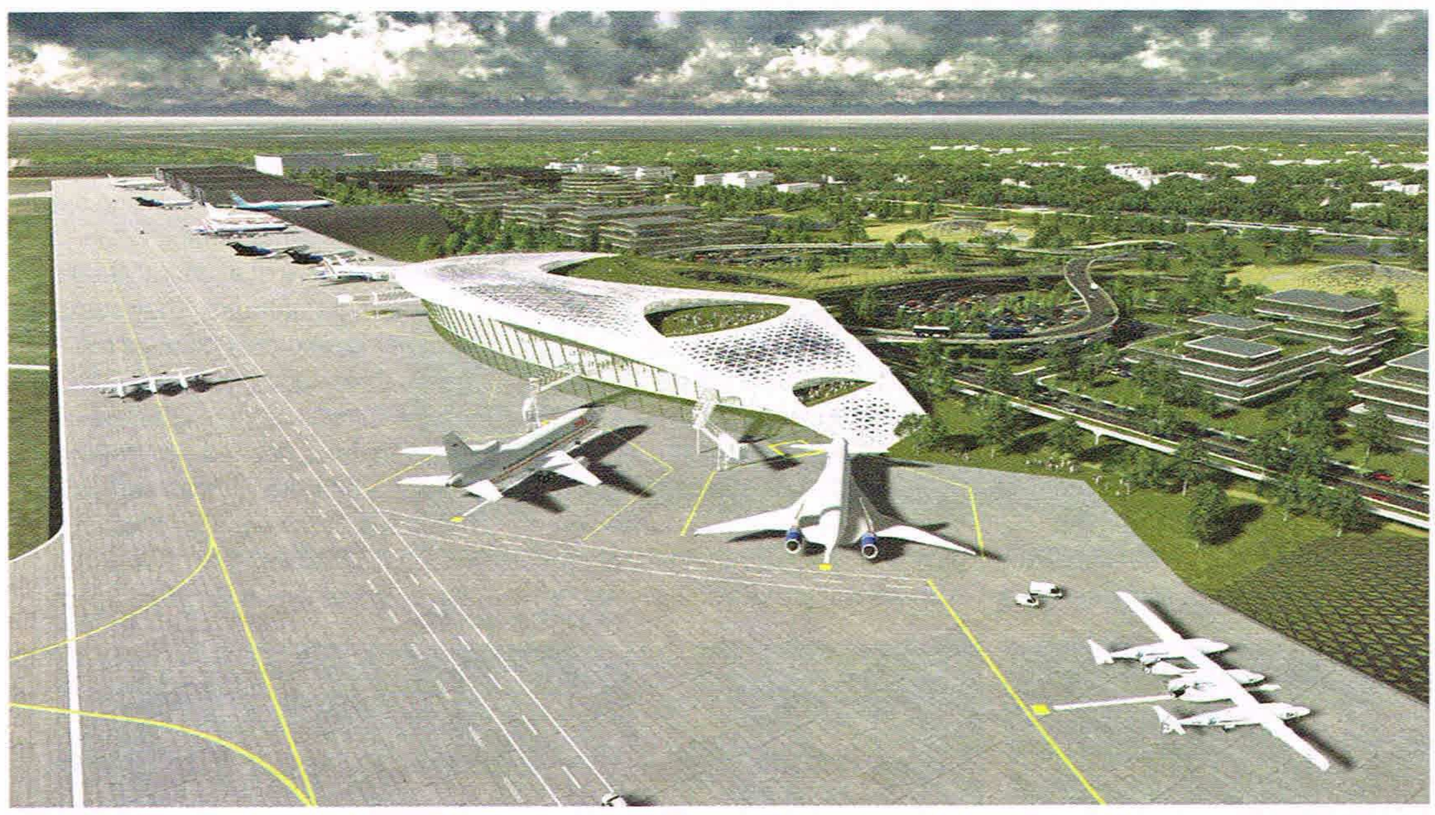
One thing is certain: wherever this industry is headed—back to the moon, to a future Martian settlement, to the Martian moons Deimos and Phobos (an exploratory possibility that some at NASA Goddard Space



Situated between Las Cruces and Truth or Consequences, New Mexico, Spaceport America—designed by Foster + Partners and URS—is the world's first dedicated commercial spaceport.

COURTESY SPACEPORT AMERICA

This proposal for a Houston Spaceport to be built at Ellington Field was designed by Nejc Trost of Trost & Associates and Sam Ximenes of Exploration Architecture Corporation. It provides flexible facilities for flight operations, research and development, business incubation, and a museum.



COURTESY TROST AND ASSOCIATES

Flight Center have studied), or only to the checkbooks of indulgent hedgefundistas and celebrities—its trajectory leads through a quiet airfield on 18,000 acres between Las Cruces and Truth or Consequences, New Mexico. Here, a state agency, the New Mexico Spaceport Authority (NMSA), operates the world's first dedicated commercial spaceport. Spaceport America, with a terminal designed by Foster + Partners and URS, is not just photogenic but substantially operational; its first-phase construction was completed in 2013, and its vertical-launch component (it supports both horizontal and vertical takeoffs) has hosted 20 launches since 2006. Virgin Galactic, the furthest-flung branch of entrepreneur/adventurer Richard Branson's empire, is its anchor tenant. In May 2013, the port added Elon Musk's firm SpaceX, which will launch the Grasshopper test rocket, a vertical-takeoff, vertical-landing (VTVL) design that Spaceport America's executive director Christine Anderson describes as "the Holy Grail... that will cut costs 100-fold in the vertical space industry."

Uniquely among its existent peers, and perhaps providing a prototype for its speculative ones—globally, there are still more of the latter than the former—Spaceport America expresses a recognition that since the business model and the theatricality are intertwined, success in the sky requires balanced attention to practicality and spectacle on the ground. It marks the first realized case of the commercial spaceport as a distinct building typology.

X Prize leads to New Mexico

Space-flight privatization began with the 1980 founding of the French satellite firm Arianespace and accelerated after businessman Dennis Tito's self-financed International Space Station visit on a Russian Soyuz rocket in 2001. The Ansari X Prize— $10 million offered by telecom tycoons Anousheh and Amir Ansari to the first nongovernmental team that could deliver a manned reusable spacecraft to the Kármán line, the 100-km (62-mile) altitude accepted as the border between Earth's atmosphere and outer space, twice within two weeks—gave the effort a boost.

Mojave Aerospace Ventures, a partnership of aerospace designer Burt Rutan's Scaled Composites firm and Microsoft cofounder Paul Allen, won that competition in 2004 with SpaceShipOne, a carbon-fiber craft whose folding-wing design allows a high-drag feathered configuration for re-entry and a glider configuration for landing. SpaceShipOne, which launched from the motherplane White Knight at California's Mojave Air and Space Port, now hangs in the Smithsonian's National Air and Space Museum. Its successor, SpaceShipTwo, large enough to carry two pilots and six passengers (all with window seats), is undergoing testing as Virgin Galactic's demonstration craft for a maiden flight carrying Branson and his two adult children from the New Mexico port and back, with White Knight Two (*VMS Eve,* after Branson's mother) as carrier. Though Virgin Galactic has kept details quiet and revised its timetable several times, Webber speculates that the Bransons' ride may occur as early as late 2014.

The convergence of the X Prize, the appearance of Virgin Galactic, and the energetic promotion by NMSA, said Spaceport America's project architect Grant Brooker, senior partner at Foster + Partners, created an optimal opportunity for the firm to apply its signature high-tech, high-efficiency approach to a new realm of transportation infrastructure. It wasn't a hard sell—more a case of "'You had me at spaceport,' really. Any conversation that begins, 'We really want to build a *spaceport* in America,' that's definitely a project we want to do. This is not an expensive facility; this is not a very big facility; but we were trying to make something that was very concentrated and where, [as] in the early days of flight, you get the people close to the equipment."

Siting decisions for spaceports, at least for now, rank remoteness above accessibility. Keeping uninvolved populations safe from errant rockets, Webber points out, is a vital consideration in licensing decisions by the Federal Aviation Administration (FAA), favoring ocean-side or desert sites. Spaceport America, Brooker said, offers a "geographical advantage held by no other location in the States, which is the proximity of the White Sands missile base," creating a large commercial no-fly zone. Additional benefits of the location include impressive desert views, a 12,000-foot runway, and the prevailing westerly winds, which the building employs in a geothermal system, channeling air beneath large earth berms via long tubes for cooling and delivery into the mechanical plants, making the HVAC system more efficient. A broad, blanket-like roof of thin-shell concrete keeps direct sunlight from penetrating the building and provides additional thermal mass. Although flight is obviously energy-intensive, environmental performance is an important priority for the port; the terminal is not carbon-neutral, but it is designed to attain LEED Gold, Anderson reports. The site offers an incremental advantage over sea-level areas: "We're also at altitude," she adds. "We always say, 'The first mile is free,' because we're at 4,600 feet, so that means more payload, less fuel."

The curves of the low-slung, symmetrical, steel-framed facility can be read as a horseshoe crab or a manta ray as easily as a parked spacecraft or winged alien; it references both Earth and space. "We wanted something that really felt that it was almost tethered," Brooker continues, "floating above the landscape, *in* the landscape. That gave us an aesthetic straight away. We like that it hovered, but we weren't consciously trying to drive anything that looked futuristic." Internally, it circulates observers on a viewing bridge close to the hangar space without disrupting the facility by placing them right in the vaults with the equipment, a decision that Brooker calls the most important design-stage change in a competition proposal that otherwise remained consistent. Lifting the walkway allowed the architects to join the control and training vaults as one large "superhangar" with enough clearance for carriers and jets to pass below.

Galleries for spectators are among the earthbound considerations that make an active spaceport more than a launch site. Astronauts are the most prominent people a port serves, but they are outnumbered by terrestrial onlookers whose purchases of souvenirs, hot dogs, lodging, and other goods, Webber has concluded, will be a key part of any private spaceport's revenue stream. This far from other settlements, Anderson pointed out, "we had to build a small city," self-sufficient in basic infrastructure: water, power, and sewer, plus a fire department, security, emergency flight termination capability, and emergency medical technicians. Aware of the port's potential for education aimed at the wider population as well as preparatory training for the passengers themselves, she notes its secondary function as a kind of science museum. "We hired a company from Florida that did a lot of EPCOT and Disney activities," she said. "Education is an undercurrent, but it's a fun experience,

Spanish firm Luis Vidal + Architets' proposal for Spaceport Colorado, near Denver. **Below right:** A flyover of Virgin Galactic's SpaceShipTwo beneath the WhiteKnightTwo motherplane.

COURTESY LUIS VIDAL + ARCHITECTS

so you're going to learn more about commercial space; you're going to learn how spacecraft fly, and kids can build model rockets and fly them there. That's our other business line." Other spaceports, she said, supplement their central business in different ways. Mojave, for example, is also a wind power center and an intermodal transportation hub with cargo-transfer capabilities to rail and trucking.

In other respects, private spaceports are less complicated than airports to design, build, and operate. Space tourists for the foreseeable future return to the liftoff point rather than traveling elsewhere on Earth. Until enough of these facilities exist to make point-to-point flights an option, there is no need for baggage handling, passport control, or customs. And certainly not in-flight food: with accelerating forces of 3-6G during re-entry, plus a zero-gravity flight segment that reminds some passengers why NASA's reduced-gravity aircraft acquired the nickname "Vomit Comet," space tourism is best experienced under fasting conditions.

First, single points; eventually a network

Spaceport America is one of eight licensed spaceports in the United States, including the longtime manned-launch monopolist, Cape Canaveral. Most are either vertical-launch facilities, mainly handling satellites, or repurposed existing airports (decommissioned military fields in the case of Jacksonville Cecil in Florida and Mojave north of Los Angeles); only one, Spaceport Systems International's California Spaceport at Vandenberg Air Force Base in Lompoc, operates with no governmental funding. Wallops Island, Virginia's Mid-Atlantic Regional Spaceport, has not taken on passenger missions but may hint at long-range ambitions through its acronym. Legislatures in Texas, Colorado, and Wisconsin have mounted efforts to join the "spaceport states" (Alaska, California, Florida, and Oklahoma).

Overseas, along with Russia's Baikonur (actually in Kazakhstan), three in China (Xichang, Wenchang, and Jiuquan), and the Guiana Space Centre, used by the European Space Agency (ESA), proposed ports can market their services with appeals to local features as well as expertise. Webber notes that Spaceport Sweden in Kiruna, already experienced in ESA rocketry, may be able to offer passengers the chance to fly through the aurora borealis. The proposed Caribbean Spaceport in Curaçao features Dutch leadership in both architectural design (by the Amsterdam firm D/DOCK) and engineering, along with a tropical location; XCOR Aerospace, which markets two-person flights, one passenger plus pilot, on its Lynx spaceplane (a horizontal-launch vehicle with no motherplane), has bruited the idea of moving these operations from Mojave to the Curaçao port as early as 2015. The Japan Aerospace Exploration Agency (JAXA) joined the commercial market with a satellite launch from the island-based Tanegashima port in 2012; Space Adventures, the tourism firm that has put Tito and six other civilians into orbit to date, is reportedly vetting sites in Japan, Australia, Singapore, and Dubai along with U.S. ports for a suborbital-flight port and training center. Abu Dhabi, not to be outdone, may get a passenger spaceport within two years in a partnership between Branson and local investors. A global spaceport network, giving Virgin Galactic and XCOR somewhere to go besides up, is conceivable.

For the proposed Spaceport Colorado, to be located at Front Range Airport, a small general-aviation facility near Denver, planners called in Luis Vidal, an internationally recognized airport design specialist and principal of Madrid-based Luis Vidal + Architects. Vidal sees the spaceport typology evolving out of airports, with distinct requirements. "The trend concerning the 'air side' is trying to use preexisting aerodromes, while in the 'land side' new buildings should be developed to adapt to the new demands," he suggested. For tourism, crafting the experience is paramount: "A need will arise to create a unique space focused on preparing the passenger before the trip, and then after the trip, another place to guide and receive this new experience would be required." Spaceports will also serve as technology development centers, he believes, particularly for studies performed in microgravity environments, calling for laboratories and research facilities, along with "extreme confidentiality requirements, very different [from] those of a conventional cargo terminal."

From his work on the Colorado project, Vidal sees functionality and modularity as essential design principles for the emerging typology. The Front Range spaceport, "actually a conventional aerodrome with a regular runway," is the only one to his knowledge that will include both spaceport and general-aviation uses. He also goes against the grain in advocating site choices closer to cities and commercial airports to facilitate connections for passengers and proximity to spacecraft manufacturers; he is confident that "an evolution of the current aviation safety protocols would be sufficient to guarantee the same levels of safety." As for aesthetics, he acknowledges that science-fiction visionaries are implicit influences on most spaceport architecture to date—"but we have to realize that sci-fi is now. These flights will soon be as common as taking a plane."

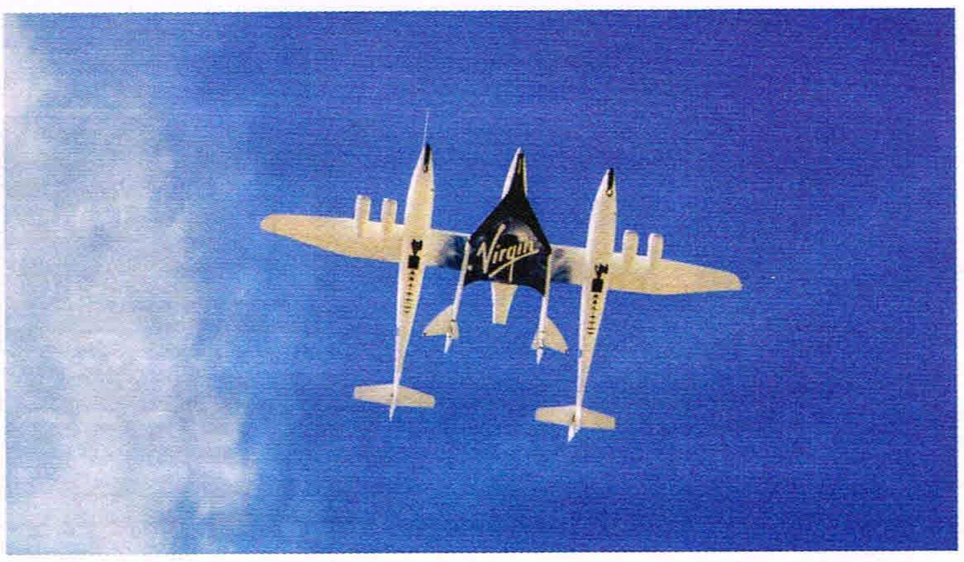
A similar conviction that space travel will eventually become routine animates the world's first academic program in the field, the University of Houston's Sasakawa International Center for Space Architecture (SICSA). The proposed spaceport at Houston's Ellington Airport draws on this center's expertise: Nejc Trost of the Slovenian firm Trost & Associates, author of *Chase for Space* (Faculty of Architecture, Ljubljana, 2011) and a graduate student at SICSA, worked with recent alumnus Sam Ximenes of Exploration Architecture Corporation to design this facility, which the Houston Airport System unveiled last fall before an annual meeting of the Commercial Space Federation. Ellington is a deactivated Air Force field a few miles from NASA's Johnson Space Center—and closer than central Houston to the Gulf of Mexico, so that rockets can minimize flight over populated areas. The proposed complex is designed as "a frame that can be modified," said Trost, "flexible according to the growth of the industry." It allows for flight operations, research and development, business incubation, and promotion of the general public's interest in aviation and space through an onsite museum.

Trost, who has flown in zero gravity himself on a Russian "vomit comet" training plane, does not flinch from recognizing that flight can be both thrilling and nerve-wracking. The design for Ellington aims to calm edgy passengers by combining natural and futuristic elements, merging the landscape of the six-acre site with gently emerging diagridded surfaces: dominant Fullerian geometries for the terminal and museum amid a verdant campus and business center. "At the same time," he said, "we pushed the open area inside the terminal, so you see a large green patch growing inside the building. This was the plan; for nature and technology to mix next to space vehicles in the hangar. So one of the main considerations in the spaceport terminal is a roof has to have a feeling of floating. We want to encourage a feeling of the passengers, when they go through the spaceport, to give them similar experience to the space travel." Trost also wants the facility to be prepared for an eventual transition from suborbital tourism to orbital transportation. "Point-to-point is definitely the next step, after suborbital flights have been proven as safe," Trost said, "but the speeds are very high, even higher than Concorde, and much higher orbit. So you need thermal protection, and it's a completely new aviation skill." Houston's concentration of aerospace expertise, he believes, is a strong argument for developing the nation's ninth spaceport there.

Integrating rockets and their infrastructure into the global transportation network is admittedly blue-sky speculation in a non-metaphorical sense. With figures as visible as film stars signed on among Virgin Galactic's early customers, contingencies that could delay or derail the whole endeavor are obvious (no one discussing these ports and projects mentions Icarus, let alone Challenger). Yet Brooker places the field in historical context. "Jet travel doesn't begin with an enormous airport complex capable of handling 80 million passengers a year. It begins with a few incredibly brave people piloting small craft, trying them out on small fields, and then expanding the technologies from that knowledge that they're gaining."

Webber, a veteran and an optimist, summarized: "In the essence, it's a very American idea, space tourism. It's people wanting to push the boundaries, take some risks, have some fun, and other people wanting to make a buck out of it. Nobody believed it; it was impossible; but now the giggle factor is gone. Everyone knows it's going to happen in different places around the world and in the U.S. It's just a matter of how successful. Will the forecasts turn out to be correct? Once a few have done it, will they be disappointed? Will they say, 'Ah, it wasn't that great'? Or will they say 'Wow: it was transforming'? Every astronaut I've talked to—and I've talked to a lot of them—they always just tell you that they want to go up again."

BILL MILLARD IS A CONTRIBUTOR TO *AN, OCULUS/EOCULUS, ARCHITECT, ARCHITECTURAL LIGHTING, LEAF REVIEW, ICON, CONTENT,* AND OTHER PUBLICATIONS.



DEREK WEBBER