Jet-Powered Go-Kart AND 9 OTHER WILD READER PROJECTS »

Popular Mechanics

SCIENCE AUTOMOTIVE TECHNOLOGY HOME OUTDOORS

POPULARMECHANICS.COM AUGUST 2008

INSIDE THE NEW AREA 51

MYSTERIOUS TEST FLIGHTS /// SECRET PROTOTYPES /// NEXT-GEN SPACECRAFT

HOW THIS DESERT OUTPOST BECAME THE HOTBED OF REBEL AEROSPACE

The Science of Fear

Build Your Own Speakers

MIT's Guru of Low-Tech Engineering

100 MPG!

Ten Contenders for the Mileage Prize

California's Mojave Air and Space Port is home to dozens of experimental aircraft, including this XCOR rocket plane.

SATURDAY MECHANIC:
TIME TO UPGRADE THOSE BRAKES P. 103

BACKYARD DIY:
HOW TO BLOW UP A ROCK P. 87

$3.99

08

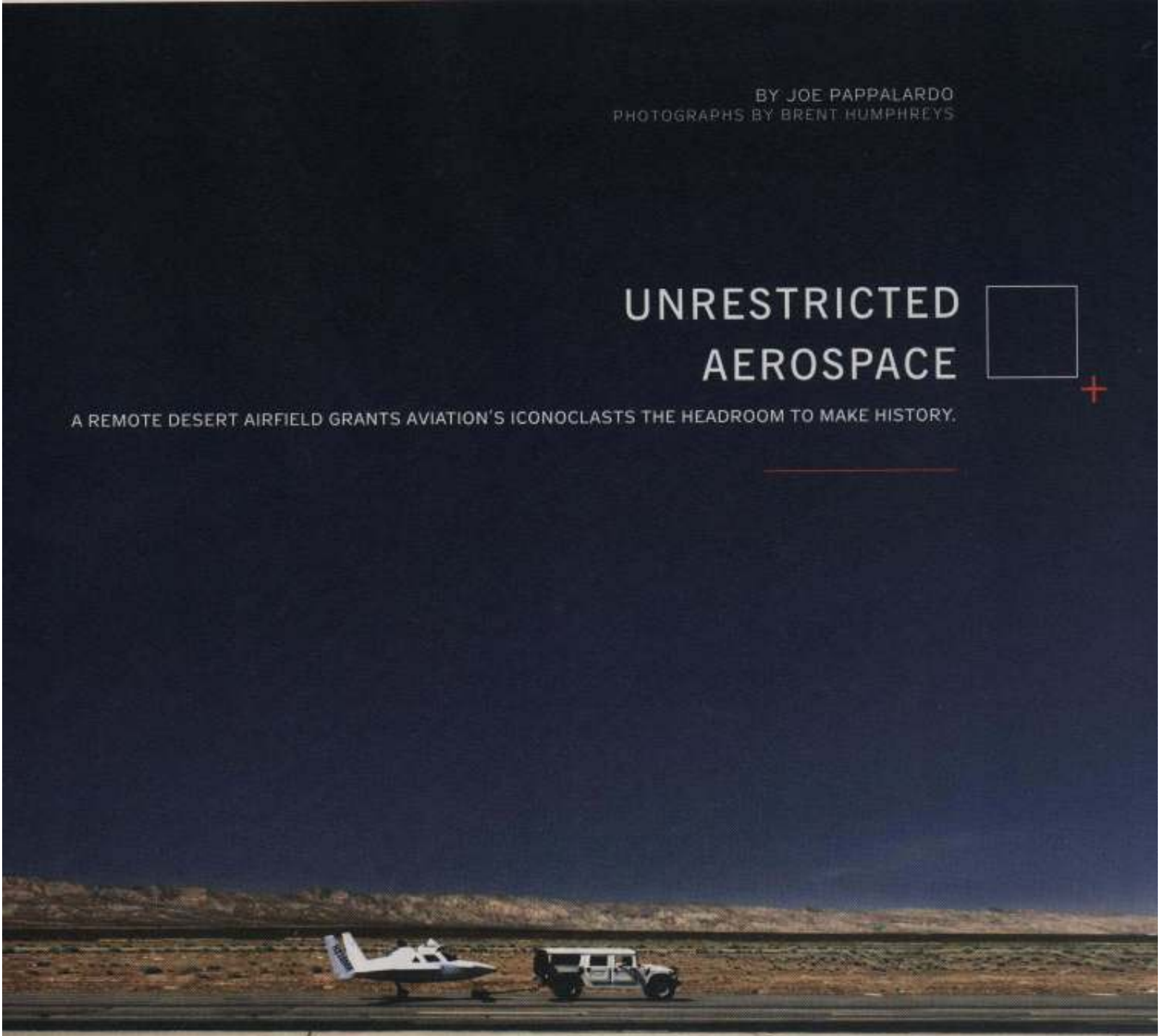
0 74470 08638 3


NO TRESSPASSING
THIS PROPERTY
IS A FEDERALLY
SECURED AIRFIELD

BY JOE PAPPALARDO
PHOTOGRAPHS BY BRENT HUMPHREYS

UNRESTRICTED AEROSPACE

A REMOTE DESERT AIRFIELD GRANTS AVIATION'S ICONOCLASTS THE HEADROOM TO MAKE HISTORY.



TWO TECHNICIANS IN COVERALLS stoop to push a gleaming white plane through open hangar doors into the bright sunshine of southern California's Mojave Desert. The tailless aircraft is about 18 ft. long with a rounded fuselage and sweptback wings, tips bent upward in pronounced winglets. A pair of canards stretches 13 ft. across the cone-shaped nose. A two-seat cockpit is slung beneath gullwing doors that look like they belong on a '54 Benz coupe. Basically, the aircraft is a rocket with wings.

The techs remove the cowling that covers the plane's engine, exposing slender helium tanks and intricate connections of frosted liquid oxygen fuel

Mojave's Air and Space Port hosts groundbreaking engineering once relegated to secret military sites like Nevada's Area 51.

lines. Two engineers in jeans and sneakers emerge from the hangar. Brandon Woodworth, 26, clipboard in hand, begins a brisk 100-item-plus diagnostic rundown.

"Check switch number nine to check thermocouples on the LOX tank," Woodworth says. "Any gripes?"

In tandem, the techs answer "no"—the temperature sensors on the liquid oxygen tank are functioning.

Woodworth nods. "Check switch number 10."

And so it goes through six pages of procedures. Then the crew tests the igniter, which emits a throaty burp, calibrates the fuel flows and tops off the tank with liquid oxygen cooled to minus 297 F. White mist curls from the nozzle as the gas boils off in the hot sun.

Meanwhile, an interloper on a Harley-Davidson pulls up on the road that parallels the chain-link fence along the airport perimeter. Standing on tiptoe, he holds a digital camera above the fence and begins squeezing off shots of the exotic rocket plane 15 yards away. The crew ignores him. "He probably couldn't recognize anything proprietary even if he could get a picture of it," says Reuben Garcia, 34, crew chief and composite materials ace.

The shooter stows the camera, mounts his Harley and roars off. Whether tourist or aviation paparazzi, he has come to the right place to capture images from the cutting edge of aerospace. The city of Mojave—a low-rise community of 3800 people, 100 miles north of Los Angeles—doesn't look like much. The dusty main drag has two traffic lights, a cluster of fast-food franchises and one decent roadhouse, Mike's, where a mix of miners, bikers and pilots drink, shoot pool and watch motor sports on ESPN. The desert winds blow tirelessly.

But on the northern edge of town, that chain-link fence marks the boundary of the Mojave Air and Space Port, which sprawls across 3300 acres of desert. A control tower stands sentinel over three runways, the longest of which extends more than 2 miles out into the scrubby flats. Weathered hangars, some dating back to World War II, line the main runway.

What goes on inside—and above—these nondescript hangars makes Mojave the growing hub of global aerospace research and development. Bizarre aircraft, secret Pentagon programs and private spaceships take shape in these aluminum-sided buildings. Most hangar doors are shut tight. The few that are cracked open offer glimpses of pressurized tanks, technicians and mechanics in oil-smeared overalls and smooth white fuselages, emblazoned with black tattoos mandated by the Federal Aviation Administration: Experimental.

The tenant in the faded blue hangar housing the rocket plane is XCOR Aerospace, a Mojave-based outfit that in 2003 invented a helium-powered rocket-fuel pump for a Defense Advanced Research Projects Agency project. Most rockets require pressurized tanks to drive propellant to the engine. In XCOR's system, helium generates the pressure that drives the pump that pulls kerosene from unpressurized wing tanks and LOX from a fuselage tank. The design has complicated plumbing, but it frees engineers to dream up a wide range of weight-conscious flying machines with unusual aerodynamics. The nascent Rocket Racing League (which plans to field flying teams that will scream around courses at 300 mph) hired XCOR to design its fleet.

Rocket test stands, tough enough to endure tens of thousands of pounds of thrust, are studded with precise sensors. Aerogel that resembles silver foil insulates tanks of liquid oxygen.

The contract pays the rent, but XCOR has its sights on a bigger prize. The company will incorporate lessons learned from the project into the design of a suborbital spacecraft scheduled to launch in 2010 with a pilot and a paying passenger onboard.

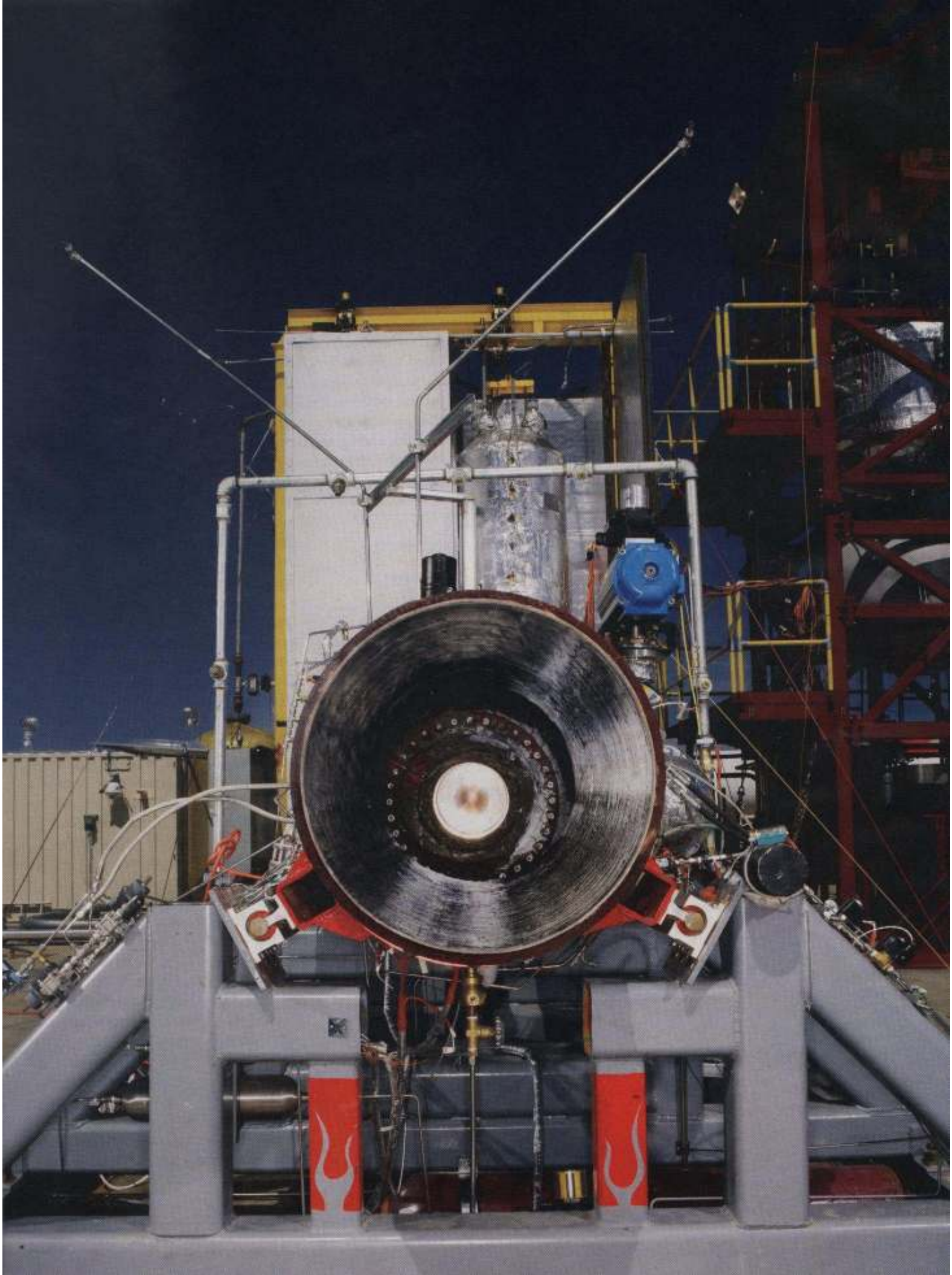
XCOR is not the only company at Mojave hoping to turn spaceflight into a private business. Just 50 yards from the company's headquarters stands a row of hangars leased by Scaled Composites, the firm founded by legendary aerospace pioneer Burt Rutan. Scaled's long line of radical aircraft includes Voyager, which in 1986 became the first plane to fly around the world nonstop and unrefueled. Rutan's biggest coup: the $10 million Ansari X Prize he won in 2004 when *SpaceShipOne* became the first private craft to take a pilot into space, blasting 335,000 ft. above Mojave twice in six days. Behind closed hangar doors and blacked-out windows Scaled is building new space tourism vehicles for its partner, Richard Branson's Virgin Galactic.

☐ THE NEW AREA 51

Aerospace history is often made in isolated places where risky designs and radical procedures can be tested beyond the inhibiting scrutiny of patrons and public officials. Places where mistakes won't crash into tract housing or shopping malls. The most famous test ground was the U.S. Air Force base at Groom Lake, Nev., a secret facility that inspired iconic nicknames—the Ranch, Dreamland, Area 51 or, simply, "the remote location." For all the mystery and alien-conspiracy hype, Groom Lake legitimately secured its place in history as the birthplace of revolutionary aircraft such as the high-flying U-2 spy plane, the supersonic SR-71 Blackbird and the stealthy F-117 Nighthawk.

At its apogee during the Cold War, Groom Lake was a top-secret site where huge defense contractors worked on classified military planes. Mojave has inherited a whiff of that Dreamland secrecy. Airport officials admit cryptically that some tenants work on "black" government projects. "There's a lot of stuff that goes on I don't want to know about," says Jim Balentine, president of the airport district's board of directors. "We have tenants who don't even want to disclose who they are."

ON THE WEB > Take a tour of Mojave—and see videos of rocket-powered aircraft in flight—at ***popularmechanics.com/futurespace***.



Mojave qualifies as the new Area 51 not because of large military contractors—there's only one here—but because it has lured a critical mass of small, entrepreneurial private-sector players to a freewheeling testbed that's open to anyone with the funding, brainpower and ambition to devise a new way to fly—within the atmosphere or above it.

No homeowners encroach on the deliciously long runways. Tenants can access otherwise reserved military airspace and a supersonic flight corridor, thanks to an agreement with Edwards Air Force Base, 20 miles to the east. The world-renowned, civilian-run National Test Pilot School provides a steady stream of cockpit jockeys. All this helps to make Mojave the place to go for designers with experimental aircraft to test. Long-time Mojave residents become almost jaded about seeing exotic, one-off flying machines overhead. "We look at this place as the best-kept secret in the business," says Marie Walker, longtime resident, owner of a small composite parts manufacturing firm and another member of the airport's board. "We can see the future from here."

Engine tests may be routine for some companies at Mojave, but safety remains the top priority. During this firing, Protoflight's crew ignites an engine with 15,000 pounds of thrust from a building 2000 ft. away.

THE SPACEPORT THAT DAN BUILT

Mojave's earliest airport was scraped into the desert in 1935 to serve the surrounding gold and silver mines. The government appropriated it during World War II as a Marine auxiliary air station, where Corps pilots received gunnery training. When the Marines pulled out in 1961, the airfield might have slowly reverted to sagebrush if not for an aviation-obsessed rancher. Dan Sabovich, who liked to fly his V-tail Beechcraft Bonanza from his own strip on his spread near Bakersfield, Calif., had a vision for the underutilized facility. He imagined Mojave as a civilian test-flight center that would cater to experimental aviation and be run by its own elected officials who could shield the airfield from political interference and protect its spirit of adventure. Sabovich had the political savvy to match his outsize vision; in 1972, after enduring several years of his intense lobbying, the state created Mojave's special airport district.

Sabovich ran the airport until 2002; he died in 2005. But the marriage he envisioned between public spirit and private enterprise lives on. Today, most of the airport district's board of directors are tenants, pilots or both.

Two years after the airport district was founded, Burt Rutan, a young aeronautical engineer from California Polytechnic, arrived to set up the Rutan Aircraft Factory. "Trouble was, I could not afford a hangar," Rutan once told a reporter. "Dan let me have a hangar at no charge. If he had not, I doubt that Voyager would have been built."

Other aviation companies followed in Rutan's slipstream—airplane rehab artists, kit-plane makers, plane storage specialists, flight-test gurus and composite parts manufacturers.

Then, in the mid 1990s, rocketeers began to arrive. One of the first was Rotary Rocket, a company founded by Gary Hudson to develop a low-cost, manned, reusable spacecraft, *Roton*. Hudson hired Rutan's outfit to help build a

Desert Players

Innovators and new firms make Mojave an aerospace hotspot.

1: Nemesis Air Racing
Designs and sells kit airplanes based on Nemesis—the most successful craft in air-racing history.

2: Scaled Composites
Creates experimental aircraft, including some designed to carry paying space tourists.

3: Flight Test Associates
Stores, maintains and reactivates airplanes for clients and offers various flight-test services.

4: XCOR
Develops rocket-powered propulsion systems, components and vehicles, from racers to spaceships.

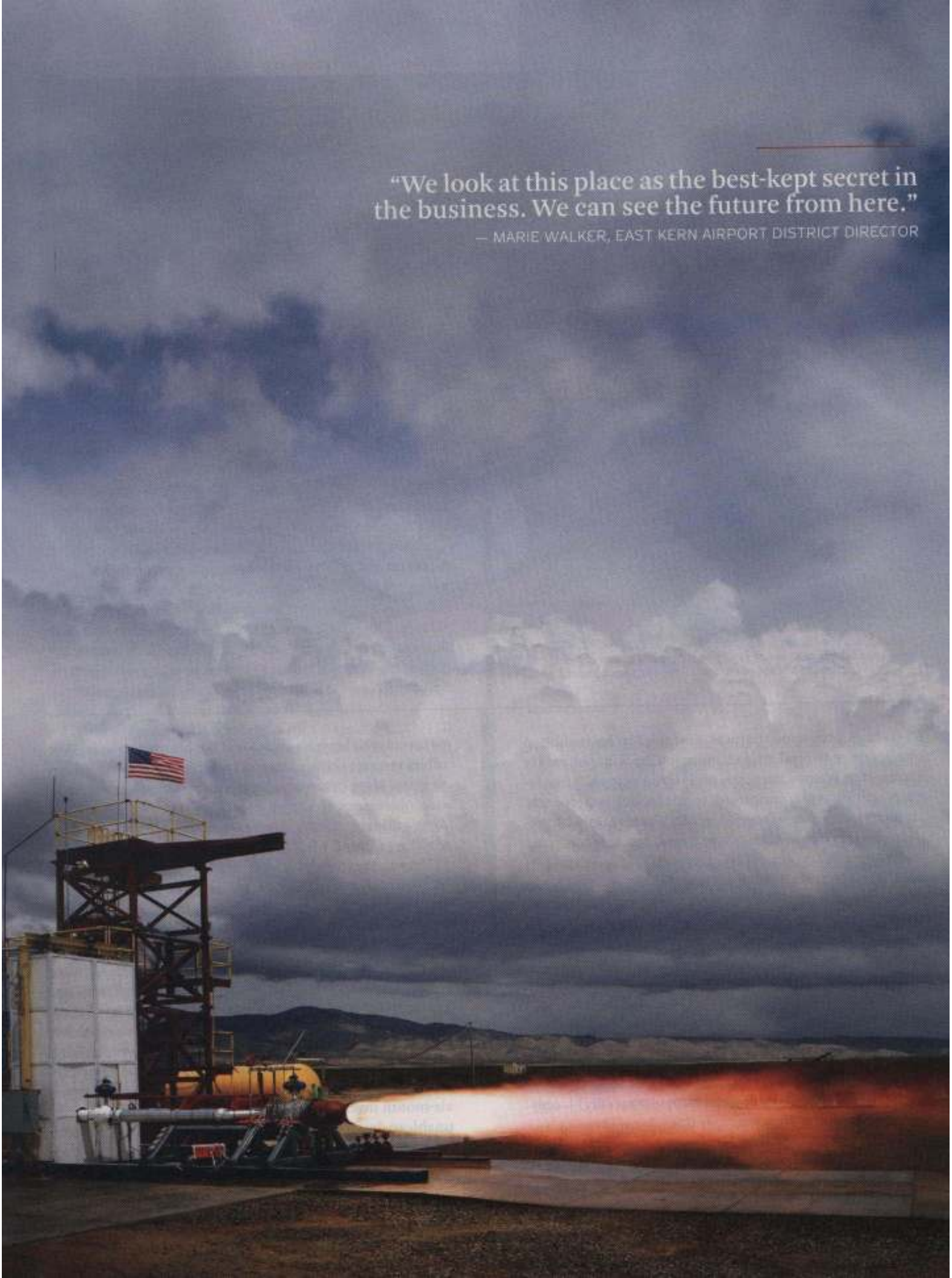
5: Protoflight
Designs and tests rocket engines including one for a Pentagon project to launch satellites from planes.

6: National Test Pilot School
Hosts students from around the world; the largest civilian-run school of its kind.

7: BAE Flight Systems
Converts F-4 Phantoms into remote-control targets and modifies all types of aircraft.

BURT RUTAN	GARY HUDSON	STU WITT
Founder of Scaled Composites. Opened his first airplane design firm here in 1974.	Founder of Protoflight and other rocket firms. Brought private spaceflight to Mojave in 1997.	General manager of the airport. The former F-16 test pilot took over from Dan Sabovich in 2002.

DIAGRAM BY **INTERNATIONAL MAPPING**



"We look at this place as the best-kept secret in the business. We can see the future from here."

— MARIE WALKER, EAST KERN AIRPORT DISTRICT DIRECTOR

Birds of Mojave

Four reasons why visitors to the airfield always look up.

Nemesis NXT

Jon and Patricia Sharp's 350-hp sport class airplane, available to customers, can cruise at 325 mph and climb 3000 ft. per minute. The airplane is based on one that Jon flew to break 16 world speed records.

White Knight Two

Scaled Composites will use this airplane to haul a craft carrying six tourists to 50,000 ft. From there, the craft will detach and blast into space. The secretive company plans to start test flights later this year.

F-4 Phantom

BAE Flight Systems rewires these Vietnam-era airplanes to be flown by remote control as targets for Air Force pilots. Before they fly the Phantoms to Florida for their final missions, company pilots test them in the Air Force airspace near Mojave.

Proteus

Scaled Composites built this twin-turbofan aircraft for high-altitude missions. It can haul 2000 pounds of payload to 60,000 ft. and stay there 14 hours. Its completed missions include atmospheric research and NASA-sponsored radar tests.

63-ft.-high prototype that was designed to be launched like a conventional rocket, boosted by a novel rotary engine that burned kerosene and liquid oxygen. After reentry, pilots were supposed to make helicopter-style landings using nose-mounted rotors. The ungainly, bullet-shaped craft made a few short hops, but the company itself never really got off the ground, finally folding in 2001 when contracts failed to materialize.

In November 2006 the *Roton* prototype was moved from the outskirts of the airport to a small park near the port's entrance. Some might see the awkward-looking rocket's prominent position as a kind of joke—a monument to failure. But Mojave's veteran rocketeers are more likely to see it as a tribute to audacity. "When the *Roton* was relegated to an obscure corner of the airfield, I used to feel like I had wasted three years of my life," says Hudson, who still operates rocket companies at Mojave. "Now that it's been moved, I feel pride when I see it. Prior to Rotary, few people spoke about commercial human spaceflight, only satellite launching. Now everyone does."

In 2004 the FAA certified Mojave as a spaceport, which means private firms here can launch craft into orbit. Stuart Witt, the current general manager of the airport, is trying to preserve Sabovich's mission. Like his predecessor, Witt offers cut-rate rents to startup companies, allowing them to grow. Most tenants today are subcontractors and sub-subcontractors, living off corporate patrons like Middle Ages guildsmen. "We need places like Mojave to be the kindling ground where it's okay to take risks," Witt says. "That was Dan Sabovich's genius. He saw that."

Risk is always in the air at Mojave. And in this business, the word means more than a failed public relations campaign or burst market bubble. In July 2007, at the rocket test range in a remote corner of the airfield, Scaled conducted a cold-flow test—one that does not include igniting a rocket—on a new engine component for *SpaceShipTwo*. Three seconds into the test, a pressurized tank of nitrous oxide exploded, killing three people and injuring three others. The FAA and California work safety regulators descended on Mojave. "It was one inspection after another," says Bob Rice, the port's operations director. After a six-month investigation, federal and state inspectors were unable to determine the exact cause of the accident. "We all learned something," Witt says. "It was an eye-opener to see government in action and, in many ways, overreaction."

In late 2007 the FAA briefly threatened to rescind

Mojave's spaceport license. Instead, after inspecting the facilities, the agency instituted safety-related amendments to the license. In January 2008, the state levied $25,000 in fines on Scaled Composites. "We had done a lot of these tests with *SpaceShipOne*," Rutan later said. "We felt it was completely safe."

☐ PHANTOMS AND LEGENDS

Fortunately, the average work day at Mojave is far less dramatic. Amid the futuristic space planes and experimental prototypes, it's not uncommon to see a Vietnam-era warplane wheeled onto a runway. In a large hangar on the outskirts of the airfield, BAE Flight Systems rewires F-4 Phantoms to serve as remotely operated targets for live-fire air-to-air missile training in Florida. Essentially, the Phantoms are being prepared for suicide missions.

Inside a small hangar at the opposite end of the flight line from BAE, Jon and Patricia Sharp store their carbon-fiber kit plane, the Nemesis NXT. Patricia, who makes handcrafted composite parts, impales tennis balls on the super-sharp wingtips of the prop-driven prototype to prevent workshop bloodletting. The Sharps' previous racer broke so many speed records that the Smithsonian's Air and Space Museum mounted it as an exhibit.

A few hangars away, JoAnn Painter and her husband Wen are trying to fix the radio in their fixed-wing Pietenpol Air Camper before an afternoon flight. Wen is a legend at NASA's Dryden Research Center, one of a cadre that revolutionized wingless flight. JoAnn, who sits in the cockpit wearing vintage aviator goggles and helmet, is the vice president of the airport's board of directors and the retired owner of a flight instruction school.

Above their heads, a bright white airplane circles in the azure Mojave sky. It's an experimental warplane called Ares, designed by Scaled Composites in the 1980s to replace the Air Force's tank-busting A-10 Warthog. One side of the airplane has an air intake; the other, a similar-size gap to house a 25 mm cannon. The military passed on the plane, but here it is flying again, for reasons known only to secretive Scaled.

☐ A PLACE TO LAUNCH

At the rocket test range, not far from where the Scaled explosion occurred, a half-dozen 20-something engineers and technicians from Protoflight, a Mojave-headquartered company that designs rocket engines, scramble over a 35-ft.-high test stand. They are readying hardware for the next milestone in a complex Pentagon project. The goal: launch satellites from C-17 or C-5 cargo airplanes at altitudes so high as to be virtually undetectable to the various nations that normally track all U.S. satellite launches.

Protoflight junior engineer David Mitchell, 24, chose to come to Mojave after graduating from California Polytechnic, at San Luis Obispo, to gain hands-on experience. Protoflight recruited another employee, Terry Palmer, from an Ace hardware store in town after he impressed engineers with his plumbing advice—valued expertise for anyone dealing with liquid-powered engines. Software engineer Lyle Menzel sums up the staff's attitude: "Most places you get to work hardware on a project maybe once or twice in a career. You just don't get"—the double-tap booms of an unseen jet going supersonic interrupt him—"this at the larger companies."

Airplanes like this Boeing 707-330C get second lives inside the Mojave workshop hangar of Flight Test Associates; the company refurbishes airplanes for its clients to lease or resell.

Just before noon, Protoflight's crew gathers in a trailer-size, prefab building they call the control room, 2000 ft. from the stand. Three staffers sit in front of monitors running live video and audio feeds from the test site. Observers stand behind the seated staff, peering over shoulders. Today's test is ready to begin.

The building rumbles as the engine ignites, blasting 15,000 pounds of thrust across the stand's concrete platform. On the screens, a 30-ft. plume of orange fire cuts through the air. After 20 seconds at full flow, the flame disappears. In the command center there are no cheers, no backslapping, just the well-honed professionalism of staffers following protocol—shutting off fuel lines, processing data from engine sensors. For the young Protoflight crew, it's another day at Mojave. **PM**