NEW SPACE FRONTIERS

Venturing Into Earth Orbit and Beyond

Piers Bizony

NEW SPACE FRONTIERS

venturing into earth orbit and beyond

ZENITH
PRESS

First published in 2014 by Zenith Press, an imprint of Quarto Publishing Group USA Inc., 400 First Avenue North, Suite 400, Minneapolis, MN 55401 USA

To find out more about our books, visit us online at www.zenithpress.com.

ISBN: 978-0-7603-4666-2

Library of Congress Cataloging-in-Publication Data

Bizony, Piers, author.
New space frontiers : venturing into Earth orbit and beyond / by Piers Bizony.
pages cm
ISBN 978-0-7603-4666-2 (hardback)
1. Space flight--Technological innovations--Forecasting. 2. Outer space--Exploration--Forecasting. 3. Astronautics and state--Forecastng. I. Title.
TL790.B56 2014
629.4'10112--dc23
2014018427

Layout: Spaced Design Ltd.

On the front cover: *NASA/Sierra Nevada Corporation*
On the back cover: *World View Enterprises, Inc.*

Printed in China

10 9 8 7 6 5 4 3 2 1

NEW SPACE FRONTIERS

milestones in human space flight

APRIL 12, 1961
Russian pilot **Yuri Gagarin** becomes the first man in space, completing one orbit of the Earth aboard a Vostok capsule.

FEBRUARY 20, 1962
John Glenn makes the first U.S. manned orbital flight aboard Mercury 6, completing three orbits before reentry and splashdown.

MARCH 18, 1965
Soviet cosmonaut **Alexei Leonov** makes the first spacewalk from Voskhod 2, a Vostok-style craft adapted for two crewmen.

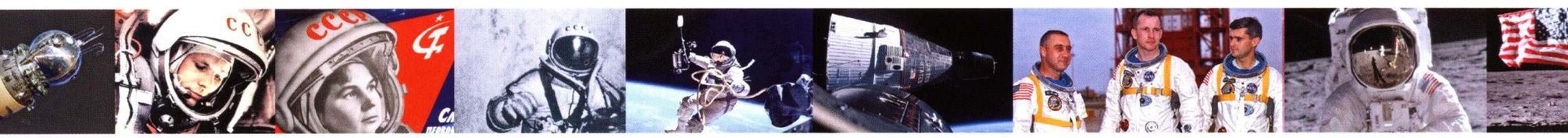
MARCH 16, 1966
Gemini 8 links with a previously launched unmanned Agena target vehicle, making the first firm orbital docking between two spacecraft.

APRIL 23, 1967
The Soyuz 1 spacecraft is launched, but multiple failures cause the death of Soviet cosmonaut **Vladimir Komarov**.

JANUARY 16, 1969
Two Soviet spacecraft, Soyuz 4 and Soyuz 5, rendezvous and dock. Crews **transfer between ships** in orbit for the first time.

APRIL 13, 1970
An explosion damages **Apollo 13**. The astronauts use the lunar module to slingshot around the Moon to speed their return to Earth.

JUNE 6, 1971
Soyuz 11 launches successfully, docking with Salyut 1, but the three cosmonauts are **killed during reentry** because of an air leak in the cabin.



MAY 5, 1961
NASA's "Freedom 7" Mercury capsule launches on a Redstone rocket for a suborbital flight, making **Alan Shepard** the first American in space.

JUNE 16, 1963
Valentina Tereshkova of the U.S.S.R. becomes the first woman to fly into space, aboard a Vostok capsule.

JUNE 3, 1965
Ed White becomes the first American to walk in space during Gemini 4. He floats almost free of the capsule, attached by an umbilical cable.

JANUARY 27, 1967
Gus Grissom, **Roger Chaffee**, and **Ed White** of Apollo 1 suffocate from smoke inhalation when their capsule catches fire during a launch pad test.

DECEMBER 21, 1968
Apollo 8 launches on a Saturn V prior to becoming the first manned mission to fly into deep space and orbit the Moon.

JULY 20, 1969
Apollo 11's lunar module Eagle crew lands on the Moon. **Neil Armstrong** and **Buzz Aldrin** walk on the lunar surface.

APRIL 19, 1971
A Proton rocket launches the **first small space station**, the U.S.S.R.'s Salyut 1, from the Soviet-controlled "cosmodrome" at Baikonur in Kazakhstan.

May 14, 1973
A Saturn V rocket launches **Skylab**, NASA's first space station, built from an adapted Saturn V stage. Three crews visit between 1973 and 1974.

April 12, 1981
Space Shuttle *Columbia* lifts off from Cape Canaveral, beginning the **first orbital mission** for NASA's new rocket plane.

June 18, 1983
NASA astronaut **Sally Ride** becomes the first American woman to fly into orbit aboard Space Shuttle *Challenger*.

January 28, 1986
Shuttle *Challenger* explodes 73 seconds after launch, killing the crew of seven and grounding the shuttle fleet for more than two years.

February 20, 1986
The Soviet Union launches the first element of the multi-module **Mir space station**, which would remain operational for fourteen years.

December 2, 1993
Astronauts aboard *Endeavour* lift off for a mission to repair and upgrade the **Hubble Space Telescope**, bringing it to full working condition.

November 20, 1998
Russia's Zarya control module, the first segment of the **International Space Station**, is launched into orbit.

May 6, 2001
American entrepreneur **Dennis Tito** returns to Earth aboard a Russian Soyuz spacecraft after becoming the first privately funded space voyager.

February 1, 2003
Shuttle *Columbia* disintegrates as it re-enters the atmosphere. All crew members are lost. Loose insulation had punctured a wing during lift-off.

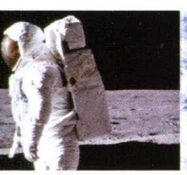
October 15, 2003
Yang Liwei becomes China's first "taikonaut" aboard the Shenzhou spacecraft. China becomes the third nation capable of human space flight.

October 4, 2004
Scaled Composites's ***SpaceShipOne*** piloted rocket plane wins the X Prize by flying into suborbital space twice within two weeks.

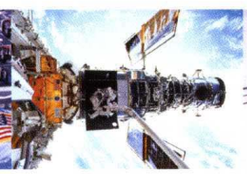
July 8, 2011
Shuttle Atlantis, carrying supplies for the International Space Station, launches for the 135th and **final mission** of the Space Shuttle era.

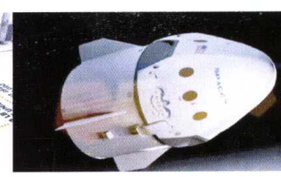
June 29, 2012
The first **Orion spacecraft** arrives at NASA's Kennedy Space Center for final checks, heralding a new era in human space flight.

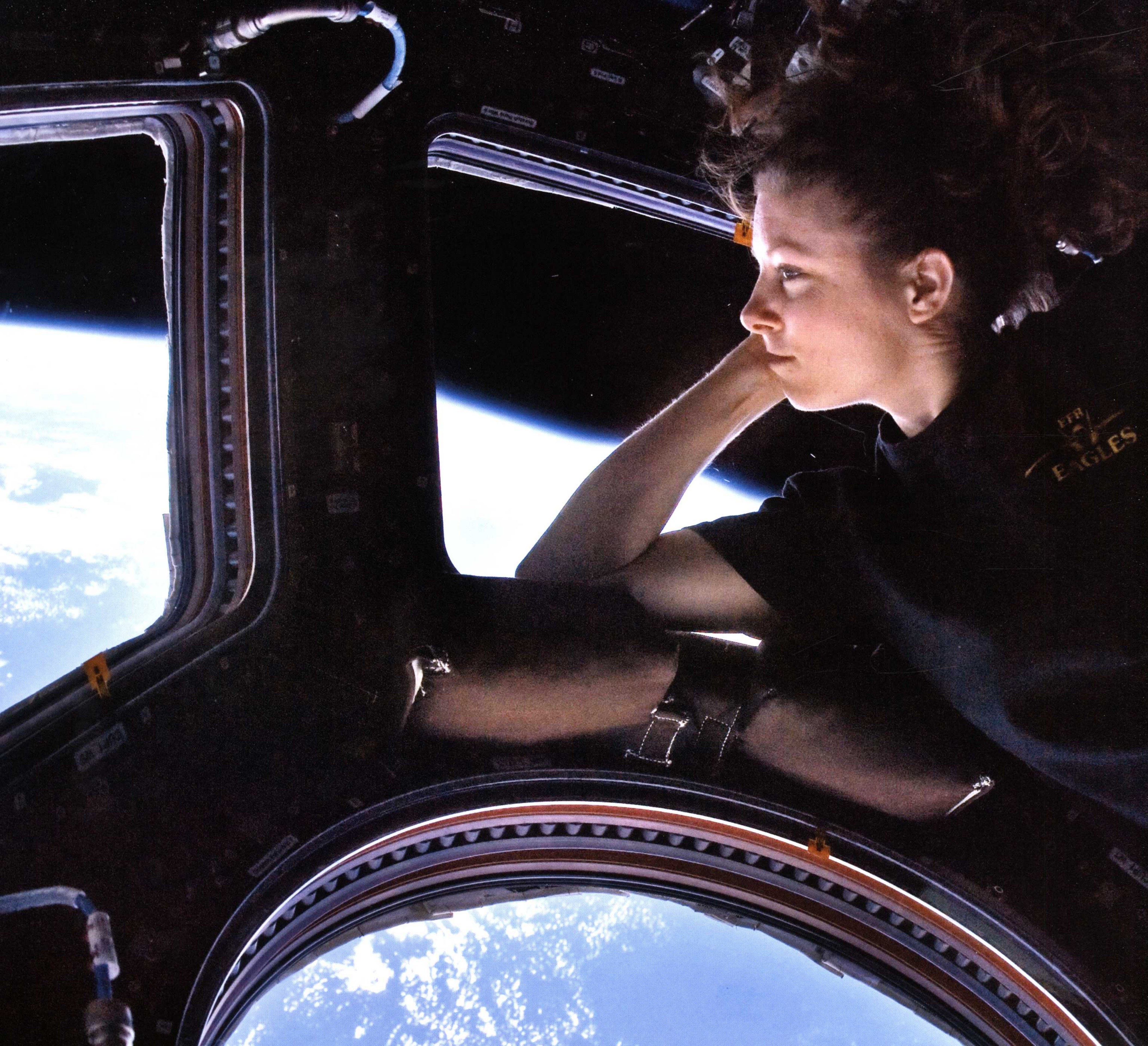
May 29, 2014
Elon Musk's **SpaceX** company unveils the first privately built crew transport capsule, the Dragon V2, due for first flight in 2017.



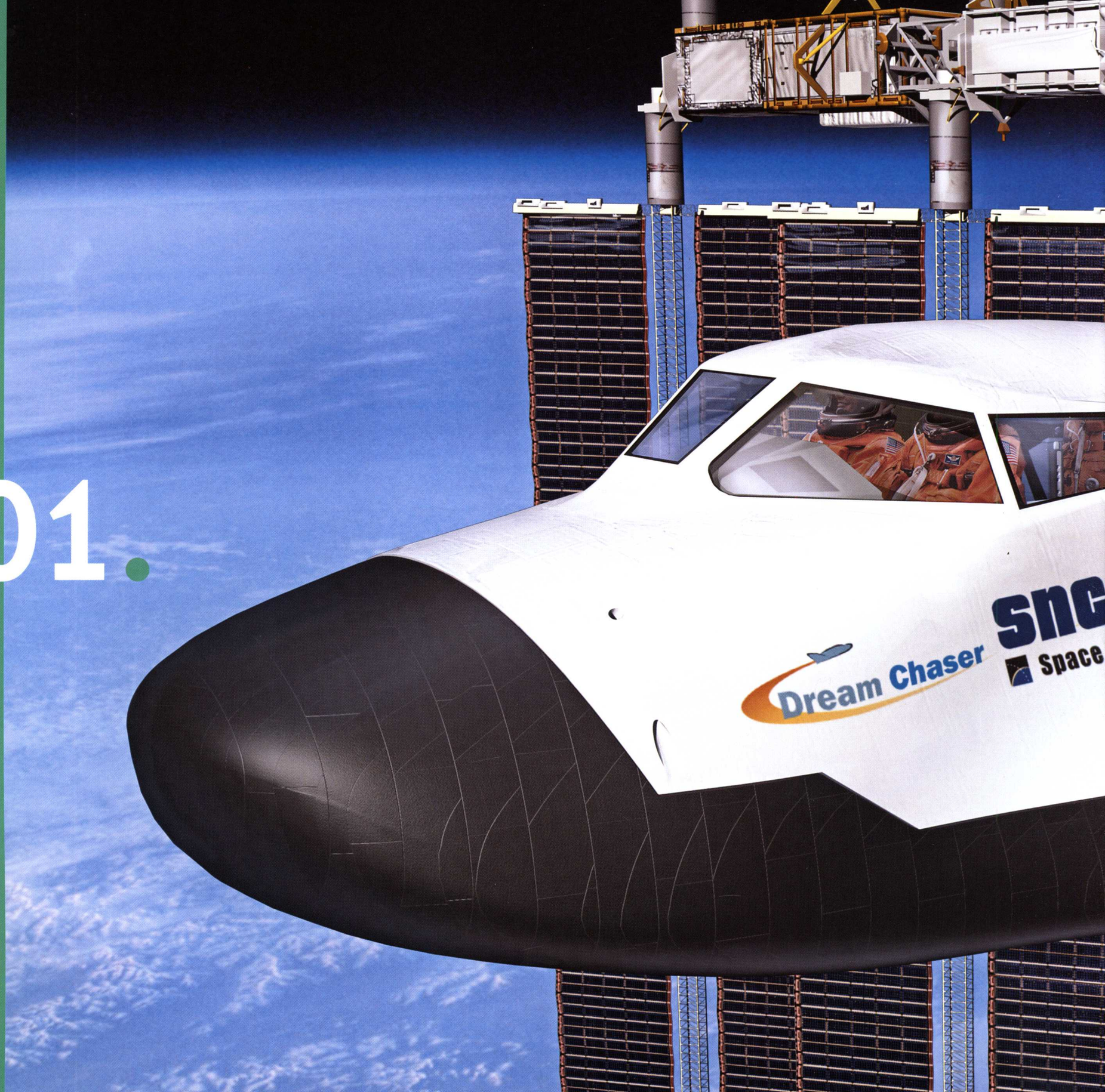


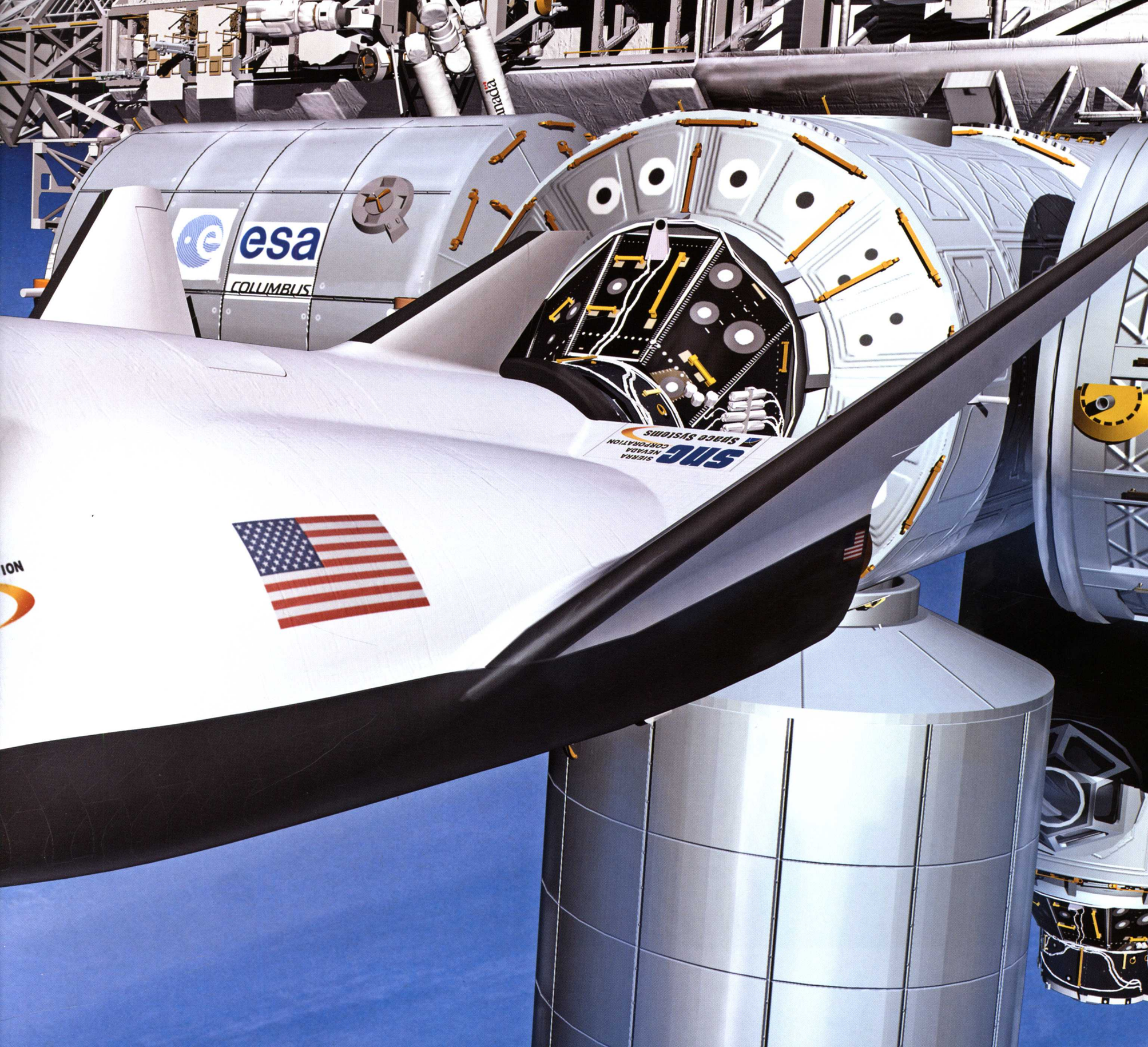



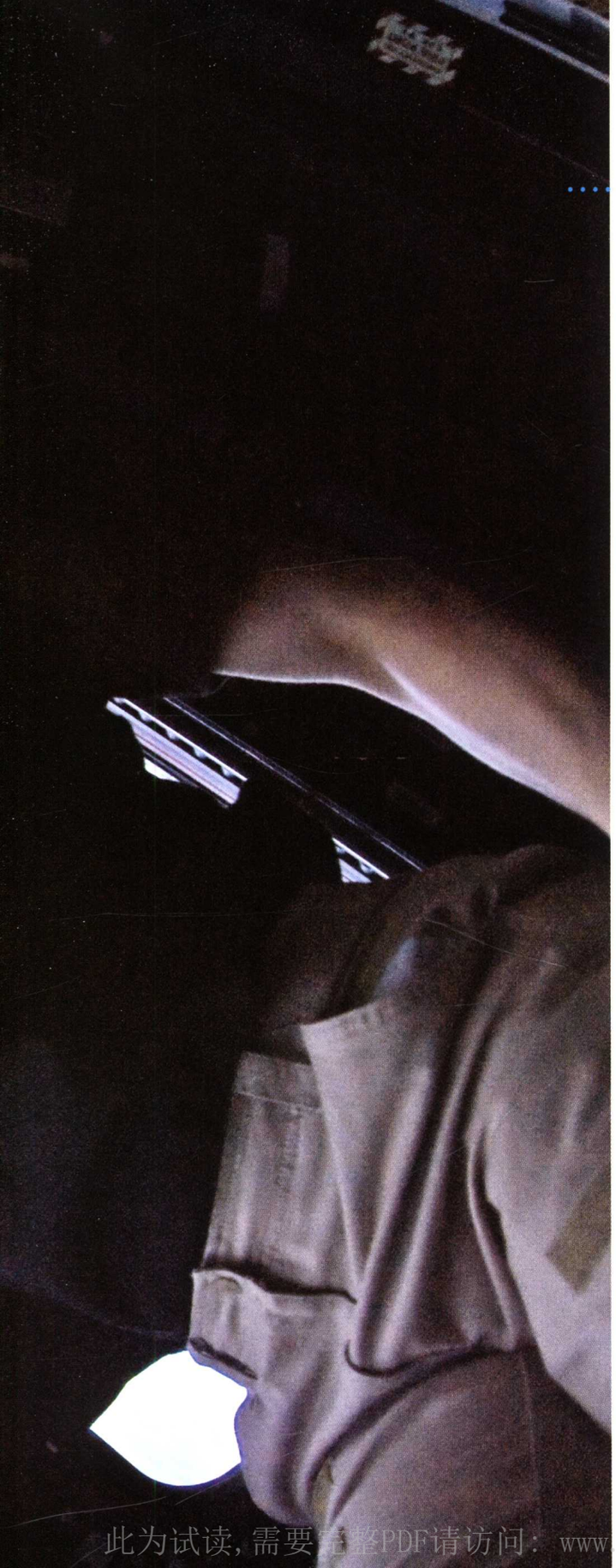



EAGLES

01.




esa
COLUMBUS
SNC
SIERRA NEVADA CORPORATION
SPACE SYSTEMS



contents

An artist's impression of an *Orion* spacecraft mated to a European-built ATV service module.

The world's greatest space agency NASA is preparing a vehicle that will extend humanity's reach further into space than ever before. Meanwhile innovative private companies are building new systems for reaching Earth orbit.

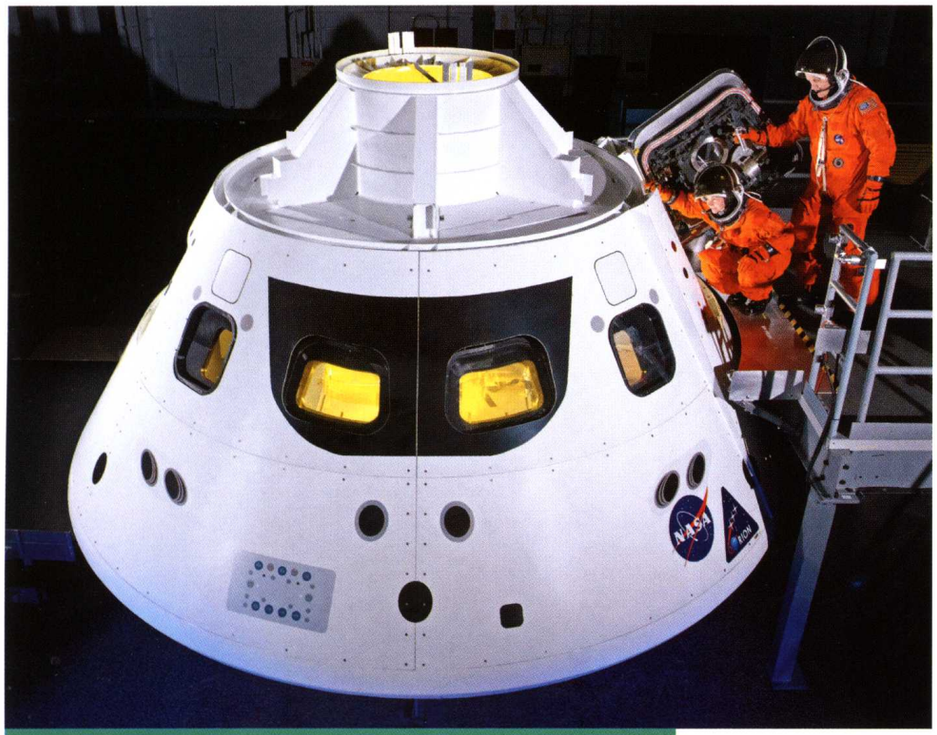
ESCAPE **FROM PLANET EARTH**

We are on the verge of a new era in space exploration. For the first time in history, private access to space is becoming almost routine. At this same time, NASA seems to have lost some of its former momentum, waiting for America to make up its mind about the broader future of the national space program. Tough choices lie ahead. The good news is that those choices can be based on a swiftly expanding set of technical possibilities, and mission options.

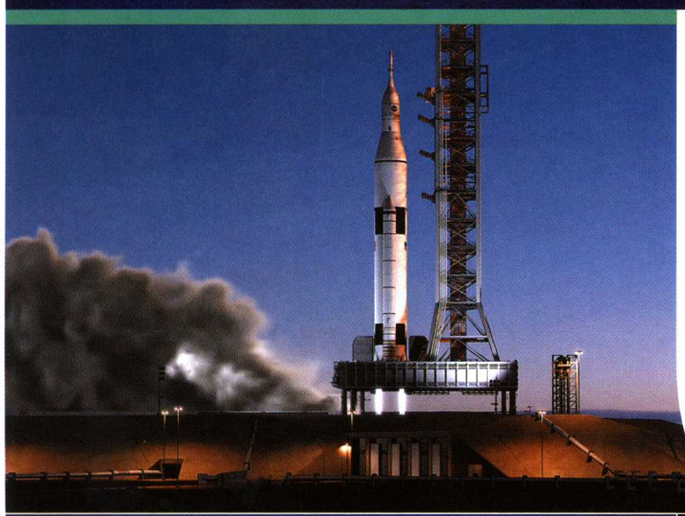
The journey forward starts on the basis of some difficult backward steps. The space shuttle fleet has retired after thirty years of service. The surviving orbiters, *Atlantis*, *Endeavour*, and *Discovery*, and the glide test prototype, *Enterprise*, are now on display in museums. Our memories of the shuttle system are a mixture of pride and sadness. The first ascent to orbit by *Columbia* in April 1981 thrilled the world, but in January 1986, *Challenger* exploded just seventy-three seconds after liftoff, and all seven crew members were killed. Faulty booster seals and poor management within NASA (the National Aeronautics and Space Administration), the United States' space agency, were blamed for an avoidable disaster. Then the story of space travel and exploration improved, with the repairs to the Hubble Space Telescope and the assembly of the International Space Station (ISS). Americans once again regarded the shuttle with pride, and perhaps even took it for granted. The shuttle at its best was an adaptable workhorse, an incredible machine capable of transporting astronauts and payloads together.

But as is often the case, pride came before a fall. In February 2003, *Columbia* disintegrated during reentry. Another crew was lost. A suitcase-size piece of thermal insulation foam had peeled off the huge external fuel tank shortly after launch and hit the orbiter's left wing on its leading edge, making a small but ultimately catastrophic hole. Two weeks later, as *Columbia* hurtled through the atmosphere at the end of its mission, hot gases rushed into that hole, destroying internal controls and melting the underlying metal airframe.

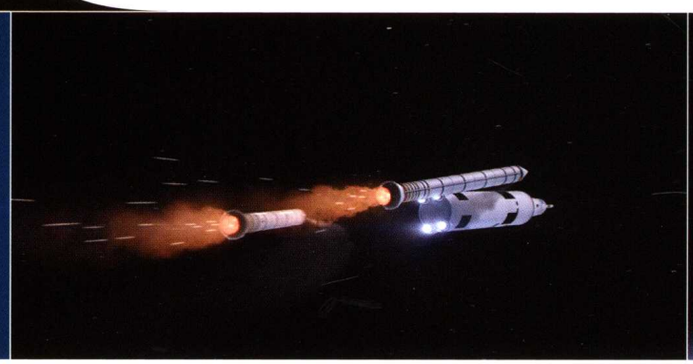
President George W. Bush responded to this catastrophe during a televised visit to NASA headquarters in Washington in January 2004. "Today I announce a new plan to explore space and extend a human presence across our solar system," he said. The first goal was to return the remaining shuttle fleet to operational status and finish the construction of ISS. No surprises there, but as his speech

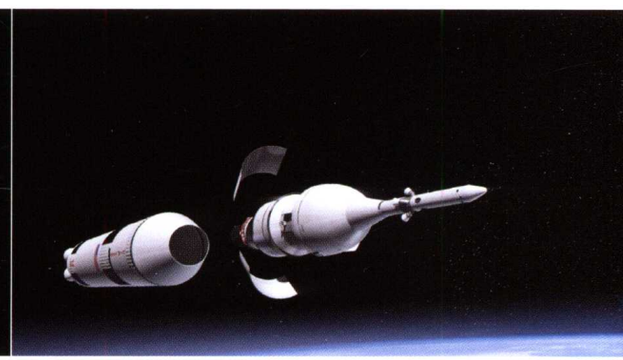


Astronauts prepare to enter an *Orion* engineering mockup to test the capsule's interior layout and seating arrangements.



An *Orion* mission using a Space Launch System rocket will echo the scale and grandeur of a 1 960s Saturn V launch, but will exploit modern hardware and computing power.

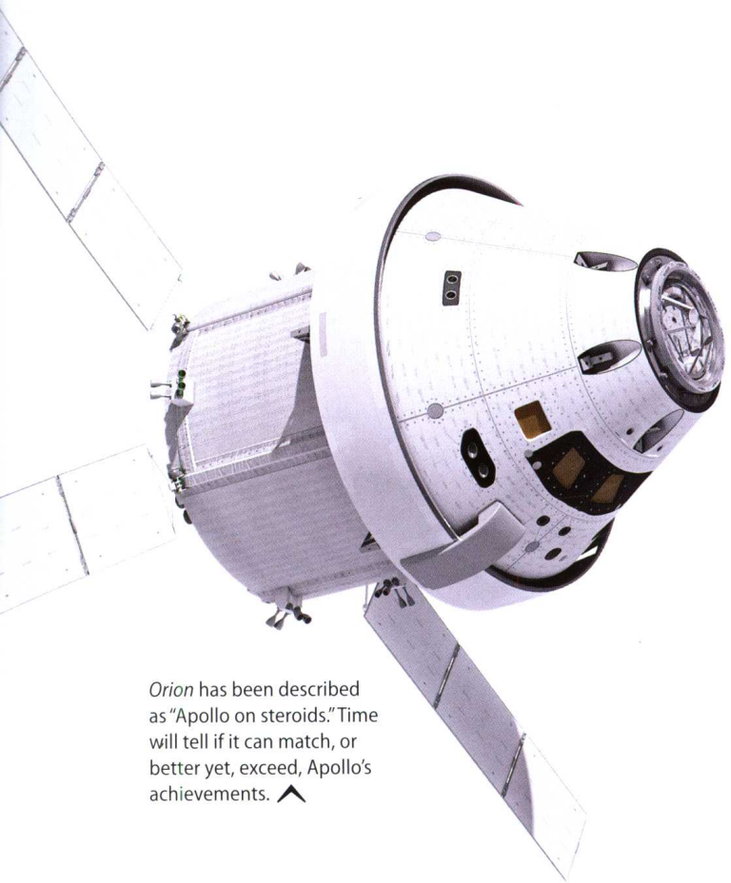




continued, radical new ideas emerged. "Our second goal is to develop and test a new spacecraft, the Crew Exploration Vehicle, by 2008, and to conduct the first manned mission no later than 2014. Our third goal is to return to the Moon. Using the Crew Exploration Vehicle, we will undertake extended human missions to the Moon as early as 2015, with the goal of living and working there. With the experience and knowledge gained on the Moon, we will be ready to take the next steps of space exploration: human missions to Mars and to worlds beyond."

NASA set to work on a new, wingless spacecraft design, with the crew compartment positioned at the top of the launch stack, thereby ensuring that any stray debris peeling away from the flanks of the rocket below would not endanger the crew. The cone-shaped capsule, commonly known as *Orion*, exploits reliable reentry techniques perfected back in the 1960s for Project Apollo. The *Columbia* accident investigators concluded that it is too risky to carry astronauts in the same part of a spacecraft that also contains the propulsion systems, because of the risk of launch failures and the danger of damage to the crew compartment. Investigators noted that the Apollo capsules were remarkably safe. The tough, compact command modules could always be instantly separated from other modules or rockets in the event of failures. When *Apollo 13* suffered an explosion on the way to the Moon in April 1970, the rear service module with the rocket engine was blown wide open, yet the capsule itself was unharmed and returned its crew safely home to Earth.

The space shuttle had no way of separating its crew compartment from the rest of the system. This may always be a problem for any space plane that does not have a separate escape module. NASA has returned to the capsule concept, including an escape rocket that can pull the capsule clear of a wayward launch vehicle. An



Orion has been described as "Apollo on steroids." Time will tell if it can match, or better yet, exceed, Apollo's achievements. ^

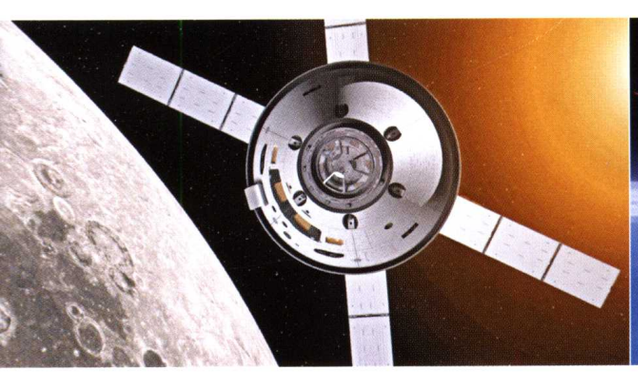
improvement in crew safety was just one aspect of a new vision for NASA. *Orion* was incorporated into a grand vision of Moon-Mars exploration, using a fleet of rockets and landers. The program as a whole was called Constellation. Robert Seamans, NASA's deputy administrator in the Apollo era, was one of a dozen enthusiastic veterans called upon to advise *Orion*'s designers. "I served on what they called the 'Greybeard Committee,' all these old hands who knew how we'd reached the Moon first time around. Astronaut John Young was there, and he'd flown in Gemini, plus Apollo, and he'd commanded the first space shuttle flight. We didn't fool around. They put us in a room from eight until five. They brought in food because there was no break for lunch. What we came up with is amazingly similar to what we did with the Apollo." Indeed, NASA officials described their Moon plans as "Apollo on steroids." The proposal, which still exists as a detailed engineering concept, features a lunar landing craft, the *Altair*, carried to orbit unmanned aboard a heavy-lift rocket. Then the *Orion* and its crew locate it in Earth orbit, make a docking and head to the Moon. On arrival, *Altair* detaches from *Orion* and drops toward touchdown. At the end of its surface stay, the lower part of *Altair* stays behind while the upper module blasts back into lunar orbit, makes a rendezvous with *Orion* and transfers its crew. Then *Orion* heads back to Earth for an Apollo-style reentry and splashdown.

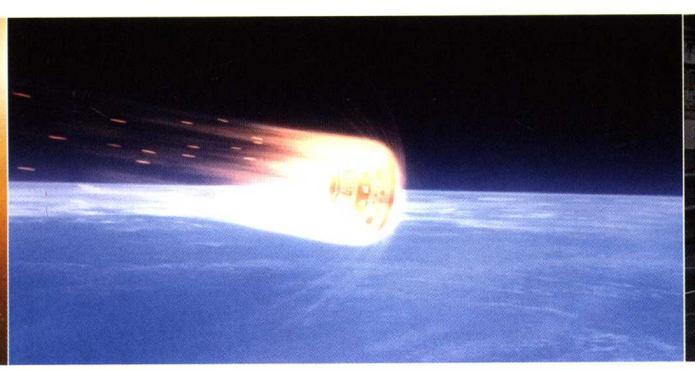
There are other significant reasons for reinventing the capsule concept. The shuttles dropped down from low Earth orbit at less than 17,500 miles per hour. *Orion* capsules coming home from deep space missions will slam into the upper atmosphere at nearly 25,000 miles per hour. Winged shuttles cannot sustain that kind of shock. *Orion* uses a blunt and rounded heat shield that is more than capable of surviving high reentry speeds. Why not simply slow an *Orion* as it approaches Earth? Fuel for a powerful braking burn would have to be carried all the way into deep space and back again, thereby incurring a weight penalty. Most compelling of all, no one would wish to see an engine failure endanger a crew in the last hour of a mission. An *Orion* can hit the atmosphere without having to fire any rocket engines for a braking burn. This is a valuable safety feature.

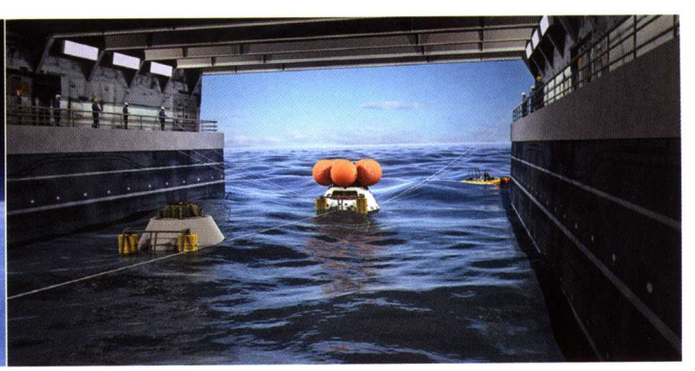
Development of flightworthy *Orion* systems has continued more or less smoothly ever since President Bush first lent his support to the vehicle. However, even before the banking crisis and credit crunch in the first decade of the 2000s, NASA's plan for a return to the Moon looked ambitious. A year or so after Barack Obama entered the White House in 2009, his administration proposed resetting NASA's priorities yet again: skipping the Moon, putting Mars on the back burner, and aiming instead for an asteroid rendezvous by the mid-2020s. Predictably in hard economic times, NASA had to scale back its ambitions in response to budget constraints. The rocket architecture was adjusted, although the capsule design stayed essentially the same. After all, *Orion* was conceived from the outset as a multipurpose vehicle. As a consequence, design and construction work on this component has proceeded more or less steadily. The capsule taking shape today is America's new national crewed spacecraft. How deep into space it will eventually travel has yet to be determined. A giant new rocket for *Orion* is under development: the Space Launch System (SLS). This will be similar in scale and power to the Saturn Vs that propelled Apollo to the Moon.

Virgin Galactic

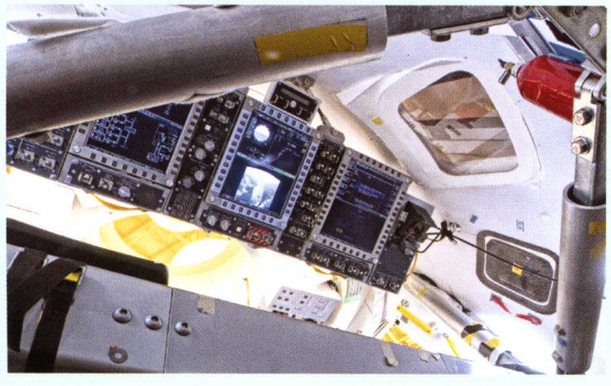
There is nothing new about the idea of flying civilians into space. In the late 1960s the now-defunct Pan Am airline held out the promise of routine access to orbit, while bold plans for a resort on the Moon were presented by







Engineers at the Lockheed Martin company prepare the first *Orion* for flight. ^



Orion's instrument panel uses flat screen displays to simplify the layout. <

The Space Launch System (SLS) will be assisted at lift-off by solid rocket boosters developed from space shuttle technology.

EUROPEAN SUPPORT FOR ORION

New economic realities have stimulated fresh ideas about international cooperation in space, building on the diplomatic and cultural legacies of ISS. The Orion capsule will be supported by a service and propulsion module that–in all but a few interface details–has already proved its capabilities in flight. The 20-ton Automated Transfer Vehicle (ATV) is the most complex spacecraft ever developed in Europe. Until recently, its main task was to deliver eight tons of crew supplies, propellant and scientific equipment to ISS at intervals of approximately 15 months.The ATV had three times the payload capability of its Russian counterpart, the Progress cargo vehicle.

Although no one was launched aboard an ATV, astronauts wearing regular clothing could board once it was docked. Each ATV became an integral part of ISS for up to six months. During that time, an ATV's engines could be used to reboost ISS's orbit, compensating for atmospheric drag. Technology derived from this hardware is about to have a new lease of life. NASA's Orion spacecraft will be attached to an ATV service module, as depicted in this illustration.