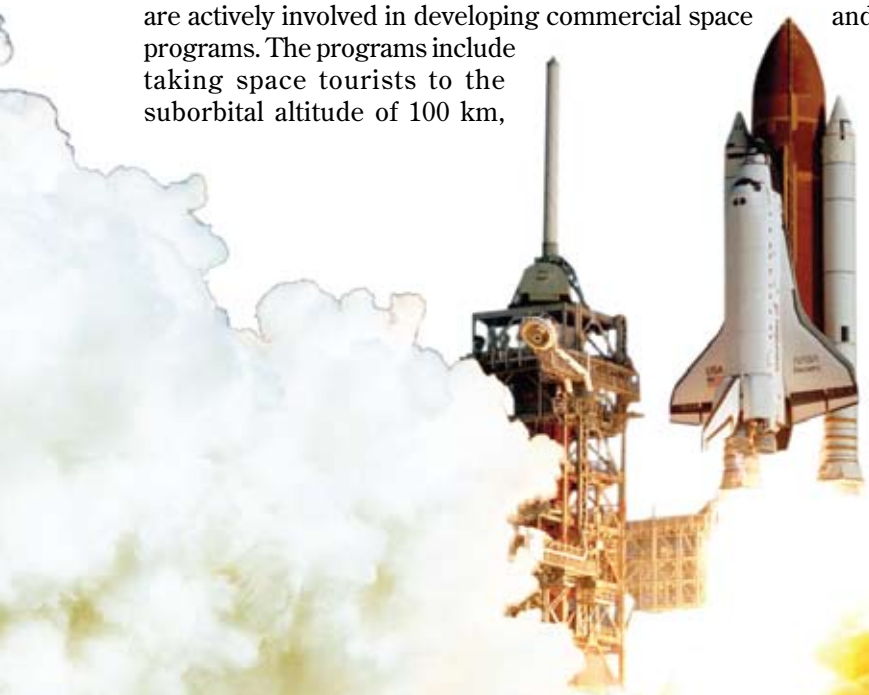
# Getting a crew into orbit

*by Bob Riddle*

Since the first rocket launch into Earth's orbit, the United States and Russia have led the world in developing the technologies to send people into space and were the only countries (until recently) with a crewed space program. However, other countries are now developing resources and applying technologies for the crewed exploration of space. Currently, there are three countries with crewed space programs—United States (NASA), Russia (RKA), and China (CNSA)—and other countries including Japan (JAXA), Ecuador (EXA), Malaysia (MNSA), India (ISRO), and Iran (ISA) are at various stages of development with an active crewed space program (but have not launched). Rocket launches to space have taken place at more than 20 launch facilities around the world, scattered at various latitudes, with the ideal locations close to the equator.

In addition to government-sponsored space programs, private companies such as Virgin Galactic and SpaceX are actively involved in developing commercial space programs. The programs include taking space tourists to the suborbital altitude of 100 km, ferrying crews and supplies to the International Space Station, and placing satellites in orbit.



## NASA and the last shuttle missions

This spring marks a milestone of sorts for NASA and our country's crewed space program with the launch of space shuttle *Discovery* (STS-133) in February, the space shuttle *Endeavour* (STS-134) during April, and a possible final mission this summer. STS-133 was originally scheduled for launch to the International Space Station (ISS) last November. Due to fuel tank problems, the launch was rescheduled for this month. Its planned 11-day flight will be its 31st mission to Earth orbit, and on this mission it will be delivering the Express Logistics Carrier 4, a Permanent Multipurpose Module, and other equipment and parts to the ISS.

*Endeavour's* 10-day mission will be our country's 134th shuttle mission, the 36th shuttle flight to the ISS, and possibly the last space shuttle flight for the United States until our country develops an alternate and efficient method for transportation of people and materials to Earth orbit and beyond. This past summer (2010), a final shuttle mission, STS-135, was approved by NASA and Congress and has been tentatively scheduled for launch by the end of June of this year. That mission, if followed through, is described as "launch on need"; if needed, it will transport a small crew of four plus extra supplies and equipment to the ISS. Following STS-135, our country's crewed space program will, for the time being, rely on the Russian space program for transporting crews to Earth orbit. With the European Space Agency, the Russians will also be transporting supplies and equipment to the ISS.

Even without the capabilities of the space shuttle, the ISS and crews will be transported and kept supplied as before. The Russian Space Agency will continue to send supplies and crew members using their Soyuz spacecraft. Soyuz, once docked at the ISS, will serve as the emergency escape vehicle for the ISS crew or as a "garbage truck" to haul away trash from the ISS. In the latter use, the spacecraft and its contents simply burn up as they reenter the Earth's atmosphere. The European Space Agency will also continue sending supplies and other equipment to the ISS onboard their *Ariane 5* spacecraft.

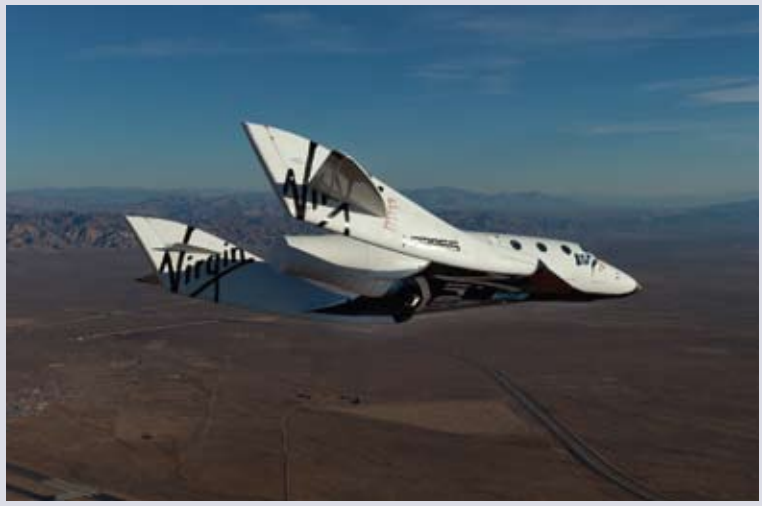
## Russian Space Agency

The Russian Federal Space Agency (RKA), or Roscosmos, and the National Space Agency of Ukraine (NSAU) came into being following the breakup of the former Soviet Union. Using what is considered to be one of the most dependable expendable launch vehicles, the Soyuz class rockets, the RKA mostly launches from the Baikonur Cosmodrome in Kazakhstan. The Baikonur Cosmodrome is not actually near the city of Baikonur, but is located several hundred miles southwest near the city of Tyuratam along the Syr Darya river. Using the Soyuz rocket, supplies are sent to the ISS onboard a Progress spacecraft, an expendable spacecraft capable of delivering approximately 2.5 tons of supplies (it does not carry crew members). The Soyuz spacecraft is launched on top of the Soyuz rocket and is the vehicle that is used by the RKA to transport crew members to the ISS. Each Soyuz spacecraft is docked at the ISS and may be used as an emergency escape vehicle should a need arise.

## China National Space Administration

The China National Space Administration has successfully placed six astronauts in space, beginning with Yang Liwei onboard the Shenzhou 5 rocket in October 2003. The majority of launches and all crewed launches have taken place at the Jiuquan Satellite Launch Center in north central China. China has at least three additional launch facilities: Xichang Satellite Launch Center, Taiyuan Satellite Launch Center, and Wenchang Satellite Launch Center. All are situated at lower latitudes and are primarily used for launching satellites into either a geostationary or a polar orbit.

**FIGURE 1** SpaceShipTwo




MARK GREENBERG AND VIRGIN GALACTIC

## Virgin Galactic

The private company Virgin Galactic successfully placed astronauts flying *SpaceShipOne* into space twice in 2004 as part of a worldwide competition. On its two 2004 flights, *SpaceShipOne* reached altitudes of 102 km and 112 km. In that competition, and in terms of the planned tourist flights in the near future, space is considered to begin at an altitude of 100 km.

The technology used by Virgin Galactic is radically different from that used in government space programs. Rather than relying on powerful rockets to launch astronauts into space from the ground, Virgin Galactic uses what is known as an air launch. For example, *SpaceShipOne* and its successor, *SpaceShipTwo*, are attached to the belly of a larger airplane and then carried to an altitude of about 15,240 m (50,000 feet) for release (Figure 1). Moments after being released, rockets are fired and the spacecraft climbs quickly to its prescribed altitude of 100 km, reaching speeds of approximately 4,023 km/hr. (2,500 mph) in the process. Following some time in suborbit, the spacecraft begins its descent back into the atmosphere in a manner similar to the space shuttle when it returns to the Earth's surface. However, based on the spacecraft design and the lower altitudes it flies, there are no heat-absorbing tiles.

## SpaceX

The SpaceX company is in the process of developing a series of launch vehicles capable of carrying payloads of various weights into Earth orbit. These include the Falcon 1, Falcon 9, and Falcon 9 Heavy. The first two are

intended for carrying lighter payloads than the Falcon 9 Heavy, and the Falcon 9 is nearly twice the diameter of the Falcon 1. The Falcon 9 Heavy will be capable of taking loads ranging from 19,500 kg (42,990 lbs.) to more than 32,000 kg (70,548 lbs.) into Earth orbit. To achieve this, the Falcon 9 Heavy will use a combination of the Falcon 9 rocket with two Falcon 9 first stages strapped on as boosters, much like the Solid Rocket Boosters used with the space shuttles. In addition to launch vehicles, SpaceX has also developed a spacecraft called *Dragon* that will primarily be used as a free-flying spacecraft to take crews back and forth to the ISS.

## European Space Agency

While not directly involved with sending crews into space, the European Space Agency (ESA) is actively involved with maintaining the ISS and providing an occasional crew member from the European Astronaut Corps to fly with the space shuttle or Soyuz spacecraft to the ISS. The ESA maintains a fleet of three heavy launch rockets, including the *Ariane 5* often used to carry supplies to the ISS. Launching from equatorial French Guiana, the *Ariane 5* is able to take advantage of the Earth's approximately 1,609 km/hr. (1,100 mph) rotational speed at that location and is capable of carrying up to 21 tons to orbit.

## The future

Despite the temporary setback in our country's crewed space exploration program, there will continue to be missions requiring crews to orbit Earth and beyond. Under the NASA Authorization Act of 2010, NASA should have its own heavy launch rocket and crew vehicle developed by 2016. Private companies will continue to explore space, as well. At the time of this writing, SpaceX had launched a Falcon 9 rocket carrying a *Dragon* spacecraft into orbit. That mission successfully concluded with the safe return of the *Dragon* capsule several orbits later. A tentative launch to the ISS is scheduled to take place by the summer of 2011.

To date, only a few hundred people have been into space, and there are many more—including me—who would like this experience! Currently, however, space travel is limited to qualified astronauts and the tourist with $20 million for a ride to the ISS on a Russian Soyuz spacecraft. Leading the charge to make this an affordable experience is Virgin Galactic, which has offered space flight at a dramatically reduced price: There are presently more than 300 space tourists who have already made their flight reservation at a cost of $200,000. What may really push the development of crewed space exploration and bring the costs down will be the demand by the general public—not only for suborbital flights, but also for extended stays in space—a weekend at an orbiting hotel, for example. Space exploration will continue, despite the challenges. As the saying goes, the meek shall inherit the Earth—the rest of us will get space. ■

### Questions for students

1. Why are rocket launches mostly done toward the east? *(Launching toward the east adds the rotation speed of the Earth to the liftoff speed of the shuttle. The closer to the equator, the greater the rotational speed. In other words, the shuttle is already moving at approximately 1,448 km/hr. [900 mph] toward the east from the latitude of the Kennedy Space Center [28°]. From 45° at Baikonur, the rotational speed is approximately 1,126 km/hr. [700 mph]. Because of this speed difference, it requires less energy to carry the same weight load from 28° than from 45°. What this means is that a heavier load may be launched.)*
2. What is the speed that a shuttle would gain from Earth rotation if launched at your latitude? *(To determine the Earth rotation at any latitude, you need the circumference at that latitude. The circumference at any latitude is calculated by multiplying the cosine of the latitude times the Earth's equatorial circumference of 40,055 km [24,889 miles]. Divide by 24 hours to get the speed in either miles or kilometers per hour. See Resources [Riddle 2010] for more information.)*
3. Have students examine the locations of the various launch facilities to learn about their respective geographic features and location.

## February

| | |
|---|---|
| 1 | Very thin waning crescent Moon near Mercury |
| 3 | New Moon |
| | STS-133 *Discovery* launch to ISS |
| 4 | Mars in solar conjunction |
| 6 | Thin waxing crescent Moon near Jupiter |
| 9 | Draconids meteor shower peak |
| | Asteroid Apophis closest to Earth |
| 11 | First quarter Moon |
| | Moon near the Pleiades open star cluster |
| 15 | ATV-2 launches to ISS |
| 17 | Neptune in solar conjunction |
| | Waxing gibbous Moon near Regulus |
| 18 | Full Moon |
| 23 | *Glory* launches into orbit |
| 24 | Last quarter Moon |
| 25 | Mercury in superior conjunction |
| 28 | Thin waning crescent Moon near Venus |

## Visible planets

**Mercury** will move behind the Sun toward superior conjunction and will not be visible until next month as an evening planet.

**Venus** will remain visible over the southeastern horizon, rising two to three hours before the Sun.

**Mars** will be on the opposite side of the Sun and will not be visible this month.

**Jupiter** will shine brightly over the southwestern horizon at sunset.

**Saturn** will rise before midnight and will be visible over the southwestern horizon at sunrise.

### *Resources*

*Ariane* rocket—*www.esa.int/esaMI/Launchers_Access_to_Space/ASEVLUOTCNC_0.html*

Asteroid Apophis—*http://neo.jpl.nasa.gov/apophis*

ATV-2 cargo vessel—*www.skyrocket.de/space/doc_sdat/atv.htm*

Baikonur Cosmosdrome—*www.kosmotras.ru/en/bayconur*

*Cassini* equinox mission—*http://saturn.jpl.nasa.gov/mission/introduction*

Glory—*www.nasa.gov/mission_pages/Glory/main*

Riddle, B. 2010. Scope on the skies: March measurements. *Science Scope* 33 (7): 86–89.

Soyuz rocket—*www.aerospaceguide.net/soyuz_launch_vehicle.html*

Space launch facilities—*www.spacetoday.org/Rockets/Spaceports/LaunchSites.html*

SpaceX—*www.spacex.com*

STS-133 *Discovery*—*www.nasa.gov/mission_pages/shuttle/shuttlemissions/sts133*

STS-134 *Endeavour*—*www.nasa.gov/mission_pages/shuttle/shuttlemissions/sts134*

Virgin Galactic—*www.virgingalactic.com*

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