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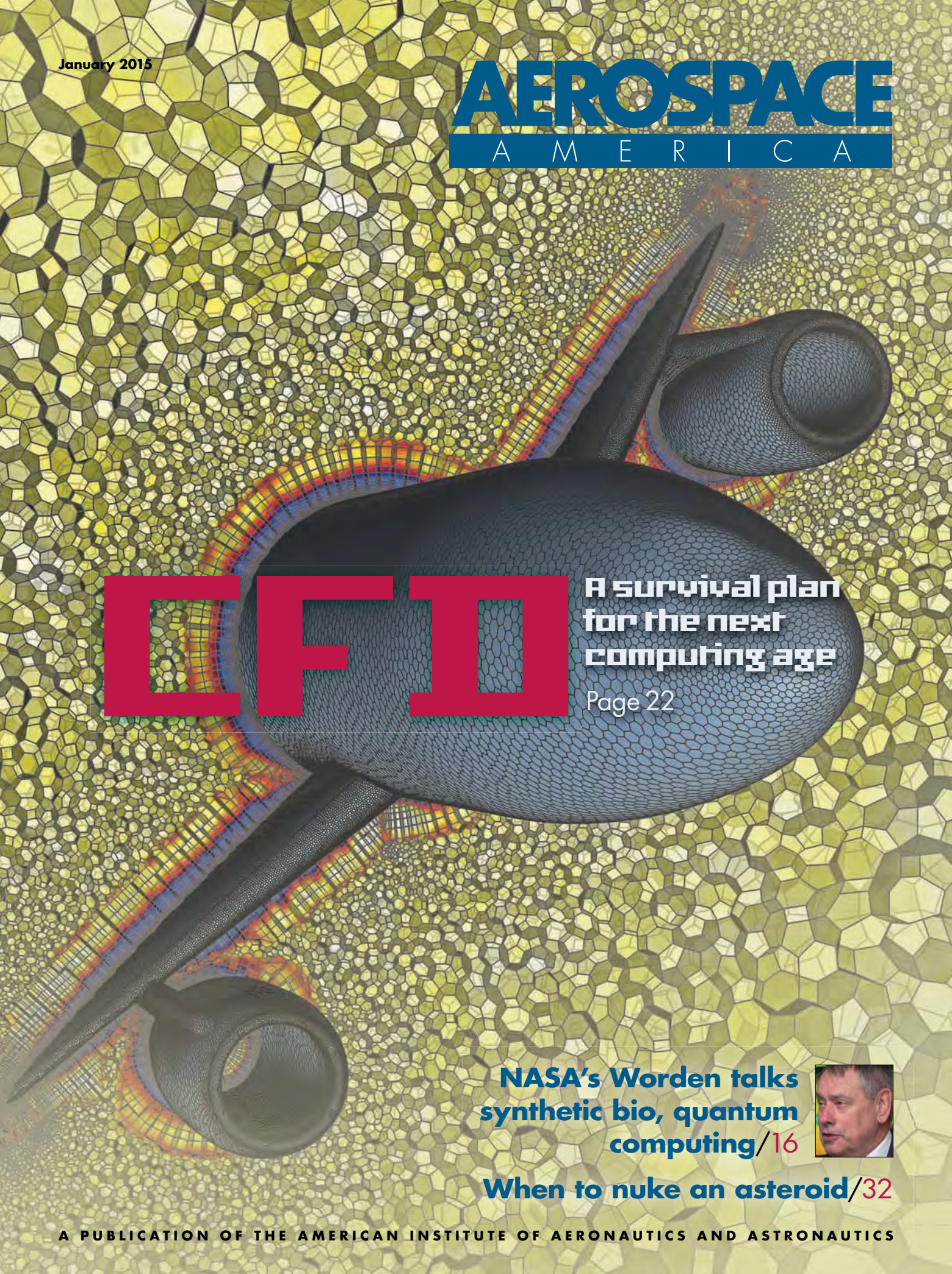

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Philip Butterworth-Hayes looks at the futures of the Rosetta and Philae spacecraft and what other space missions can learn about the use of social media.

Comet science

Will the sleeper awaken?

The first landing on a comet was fraught with tense moments that left the Philae robotic lander unexpectedly out of contact, and another nail-biting episode lies ahead.

The Philae lander held much of the world's attention Nov. 12 as it attempted to make history's first landing on a comet.

After its release from the Rosetta spacecraft and a seven-hour descent toward 67P/Churyumov-Gerasimenko, Philae ratcheted up the tension by contacting the comet not once, as planned, but three times. A harpoon meant to anchor the lander failed to fire, and the craft bounced twice before finally settling on the surface.

The lander contacted Rosetta, transmitting photos and other data from its instrument array. But Philae came to rest in a shadier area of the comet than anticipated, and the lack of solar energy forced the lander into hibernation on Nov. 15 when its primary battery ran out of power, according to the German Aerospace Center, DLR, which controls the lander for the European Space Agency's Rosetta mission.

Now the question is: Will Philae wake up?

"I'm very confident that Philae will resume contact with us and that we will be able to operate the instruments again," said Lander Project Manager Stephan Ulamec on the DLR website in November.

Ulamec predicted a spring awakening, European time. When the controllers attempt to reconnect with the lander, it's sure to be another tense moment in one of the most dramatic space science missions in recent years.

A main goal of the Philae landing was to conduct in situ analyses of soil samples to determine whether comets might have delivered water and organic compounds to Earth. A soil-sampling drill was activated on Philae during its 60 hours of operation and data was transmitted before the battery ran out of power, but scientists must analyze the data to determine whether a sample was examined in its gas chromatograph.

"We currently have no information on the quantity and weight of the soil sample," Fred Goesmann of the Max Planck Institute for Solar System Research was quoted on the DLR website as saying.

As Philae sleeps, observations of the comet will continue to arrive from the Rosetta spacecraft, which is orbiting P67 at a height of 30 kilometers.

"We will deal with some of the main aspects of Rosetta science in the next 14 or so months: examining how the comet evolves in time as it passes through perihelion — its closest approach to the sun — in

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A mosaic of four images from Rosetta's navigation camera shows comet 67P/Churyumov-Gerasimenko on Dec. 7.

ESA

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and *social media*

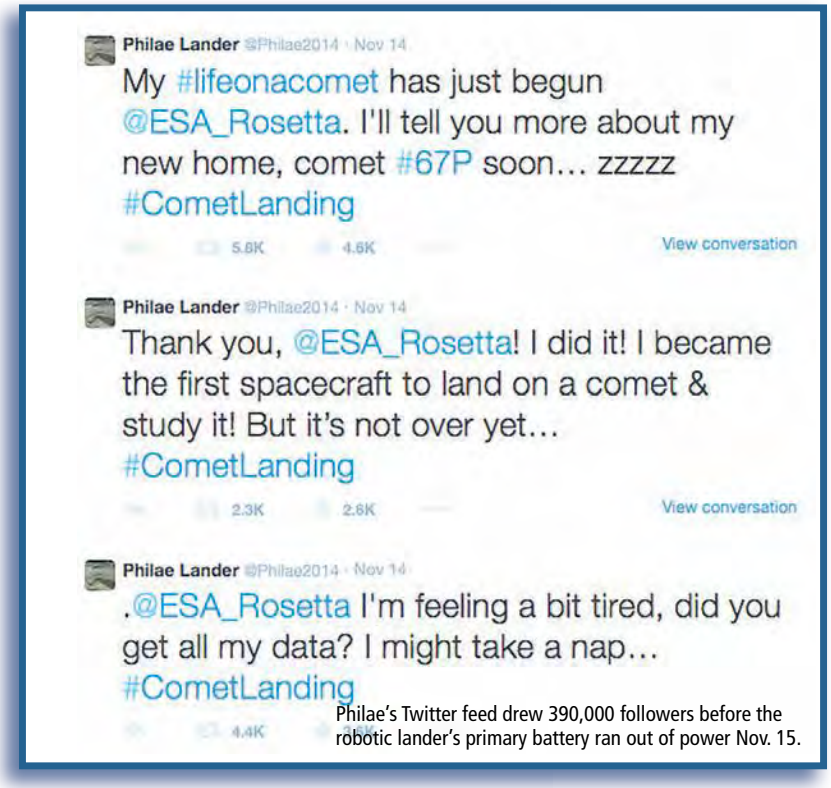
Going viral

When the Philae robotic lander was released from the Rosetta spacecraft and began its descent onto comet P67/Churyumov-Gerasimenko in November, interest on Earth extended beyond the European Space Agency's operations center in Darmstadt, Germany. On Twitter, tweets about Philae grew from fewer than 10,000 on Nov. 10 to about 60,000 the next day and peaked at over 125,000 on the 12th, the day of the landing, according to Topsy Labs, a social media search and analytics company.

Philae's social media surge was aided by the fact that the lander and Rosetta had their own Twitter feeds, which allowed their personalities — "Ready when you are, @ESA_Rosetta. Give me a little nudge?" — to shine throughout the mission. By the time Philae went into hibernation on Nov. 15, its account had nearly 390,000 followers.

Giving Rosetta and Philae their own Twitter accounts — the feeds were actually the work of teams at ESA and the German Aerospace Centre, DLR — was in keeping with a now common strategy by space agencies to engage the public in space missions. NASA's Curiosity rover on Mars, for instance, has a Twitter feed with 1.75 million followers. By raising the public's interest in space science the agencies hope to also increase support for funding future missions.

It might be an uphill struggle. In a 2014 survey of interest in science and technology issues, the U.S. National Science Board said that, while 40 percent of Americans said they were "very interested" in news about new scientific discoveries, "[i]nterest in other issues that touch on S&T ranged from a high of 58% for 'new medical discoveries' to a low of 23% for 'space exploration.'" A 2010 survey by the European Commission found that 30 percent of Europeans were "very interested" in new scientific discoveries.



Philae's Twitter feed drew 390,000 followers before the robotic lander's primary battery ran out of power Nov. 15.

Agencies are also looking beyond social media to build interest in space exploration. NASA and The Planetary Society invited people around the world to submit their names to be placed on a microchip aboard OSIRIS-Rex, the sample-return mission to asteroid Bennu in 2016. In 2013, 9-year-old Michael Puzio from North Carolina won a contest to the name the asteroid with his Bennu entry — it was previously known as 1999 RQ36 — beating more than 8,000 other entries. Industry is also trying to engage the public. In 2014, Boeing launched "Beyond Earth," an

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Adept use of social media helped Europe's Philae scientists focus the world's attention on a 100-kilogram spacecraft more than 300 million miles away. It's an increasingly common stategy for space agencies hoping to build public support for exploration missions.

Going viral

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online educational effort that has included live chats with astronauts and discussion pages about government funding decisions. And with important new space science and exploration missions on the horizon, agencies can be expected to look for even more ways to connect to the public.

Manned missions are likely to remain a spending priority for the largest space programs, according to a July report by Euroconsult, the space sector analytical firm. Worldwide government spending on manned spaceflight is predicted to rise from $10.99 billion in 2013 to $17.5 billion in 2023. During the same period, spending on space science and exploration is expected to climb from $5.6 billion to about $8 billion.

The Rosetta mission cost the European Space Agency $1.7 billion. To sustain that kind of spending, space agencies are working hard to inspire academics, students and the public to support continued government investments in the science of space.

Upcoming science missions that offer opportunities to ignite public enthusiasm include:

• **New Horizons** is set to begin a five-month flyby study of Pluto and its moons in summer 2015. The NASA spacecraft became active Dec. 6 after the last of 18 planned hibernation periods since its 2006 launch.

• **ExoMars**, a two-part mission by the European Space Agency and Russia's Roscosmos, is set to launch an orbiter and stationary lander in January 2016, which would arrive at Mars nine months later. That would be followed by the launch of a rover in May 2018, set to arrive in January 2019 to search for signs of primitive microbial life, past or present, on the planet.

• **InSight**, NASA's Interior Exploration using Seismic Investigations, Geodesy and Heat Transport mission to Mars, is on track for a March 2016 launch. The aim is to better understand the processes that shaped the rocky planets of the inner solar system, including Earth, more than 4 billion years ago, using a stationary lander with a robotic arm that will deploy surface and burrowing instruments.

• **Juno** will reach Jupiter in July 2016 and enter into an elliptical polar orbit 5,000 kilometers above the planet's atmosphere. Launched in 2011, the NASA spacecraft is expected to provide new information on the planet's origins, structure, atmosphere and magnetosphere, and determine whether it has a solid planetary core.

• **OSIRIS-Rex**, NASA's Origins, Spectral Interpretation Resource Identification, Security-Regolith Explorer, is scheduled to launch in September 2016 and rendezvous with the near-Earth asteroid Bennu in 2018. The mission calls for the spacecraft to approach the asteroid, use a robotic arm to retrieve a sample of material — which will have changed little since the formation of the solar system 4.5 billion years ago — and return it to Earth in 2023.

• **James Webb Space Telescope**, NASA's orbiting infrared observatory, is planned to launch in October 2018 to search for the formation of the earliest galaxies as well as exoplanets that may resemble Earth.

• **JUICE**, the ESA's Jupiter Icy Moons Explorer, aims for a 2022 launch and 2030 arrival to explore several of the giant planet's icy moons.

Sleeper

(Continued from page 39)

August 2015. We will be able to observe how the comet changes in appearance from now to then, measure volume changes," Rosetta project scientist Matt Taylor tells me in an email.

Philae managers are counting on the intensifying sunlight to get Philae functioning again. Before it powered down, DLR controllers managed to rotate the lander so that its largest solar panel is aligned toward the sun, and they expect that will help revive the craft. For the comet, the rising temperature will create a resurgence of outgassing, with streams of gases such as water vapor, carbon monoxide and ammonia pouring out of its nucleus. Mission controllers want to monitor this process, at least for a short time, from the surface of the comet via Philae as well as watching from Rosetta.

"We will see activity increase and then subsequently wane, from kilograms of material to hundreds of kilograms of material being lost per second from the comet," says Taylor. "We will be doing this from a ringside seat, starting at about 20-kilometer gravitationally bound orbits now, up to February, when outgassing will overcome gravity and we will resort to quick flybys of the nucleus."

The Rosetta mission began in 2004 with the spacecraft's launch on an Ariane 5 rocket and it is set to end on Dec. 31, 2015.