At 65, NASA Still Challenges Science and Supports Cooperation and Peace

by Janet G. West

May 5—The U.S. National Aeronautics and Space Administration missions are many; its partners are around America and around the world; but NASA defines its one mission this way:

> NASA explores the unknown in air and space, innovates for the benefit of humanity, and inspires the world through discovery. [Its vision:] "Exploring the secrets of the universe for the benefit of all."

These are both lofty and reachable goals. NASA is fulfilling this purpose now and in the near future with a myriad of missions aiming to give mankind an increased understanding of our world, our Solar System, and the Universe.

NASA/ESA, A. Barth, J. Dalcanton

Interacting galaxies AM 1214-255, captured by the Hubble, published May 4, 2023. NASA offers projects online; anyone in the world can participate.

New Type of Citizen Scientist Needed

NASA provides a gigantic amount of information, interactive videos, and presentations to the public on websites, and in museums. We can look with awe at the miraculous images from the Webb and Hubble telescopes and other instruments; but the main reason that we can view them at all is the volunteer work of thousands of citizen scientists, many of whom have also made scientific discoveries. In collaboration with NASA scientists, they take the copious amounts of data downloaded from the various spacecraft (Parker Solar Probe, Webb Telescope, and others), and use computer programs and filters to render the data into recognizable images.

Citizen scientists come from all walks of life, and use their knowledge and expertise to push innovation and discovery forward. NASA freely offers projects online; anyone in the world can participate.

Scientists—like Johannes Kepler, Marie Curie and Albert Einstein—must often stand up to public opinion and assert the truth, even if they're the only one to do so. As such, they are models of what it means to be a citizen of a republic, and to take responsibility for providing a better world for our posterity.

Current history calls upon more and more of us to become "citizen scientists" and to enrich that vocation with that of becoming a citizen of our nation, and a citizen of the world. If our elected officials don't defend scientific progress and the American System economics that launched the American space program, then it is we who must seize our inalienable rights as articulated in the Declaration of Independence.

In considering how innovation, creativity and the discovery of new physical principles can lead to a greater energy throughput of the entire economy, perhaps NASA can play a pivotal role in the near future in the creation of a new economic and financial architecture which is currently emerging in the Global South.

Technologies from Space Missions

This article focuses on a few of the lesser known or less publicized missions, to demonstrate the breadth and depth of space science and research. Similarly, one could cite a few of the more than 1,000 new technologies resulting from space missions in NASA's 65

years. Many of our modern electronic devices, medical instruments and other useful tools are spinoffs from NASA technology; they include:

Kidney Dialysis: Dialysis machines were developed as a result of a NASA-designed chemical process to remove toxic waste from used dialysis fluid.

Water Purification: The technology for purifying water, used on the Apollo spacecraft, now is used to kill bacteria, viruses and algae in community water supply systems and cooling towers.

Infrared Camera: A sensitive infrared hand-held camera that observes the blazing plumes from the shuttle is also capable of scanning for fires. Designed by the JPL Center for Space Microelectronics in partnership with Amber, a Raytheon company, the camera can also be used for night vision and navigation.

Blood Diagnostic: NASA technology was used to create a compact laboratory instrument for hospitals and doctors' offices that more quickly analyzes blood, doing it in 30 seconds instead of 20 minutes.

Cordless Power Tool: A NASA requirement during the Apollo program, re-chargeable tools were developed to permit astronauts to do repairs in space.

Nuclear Magnetic Resonance (NMR): An image processing technology that was used to get a sharper view of Jupiter and Saturn (from Voyager) and Mars (from the Viking Probe) was later put to use by Michael Vannier, MD, a former NASA engineer, to enable NMR imaging to be a useful medical diagnostic.

Memory Foam, **Cochlear Implants**, **Magnetic Fluid Speakers**, and 1,000 more.

The Kepler Telescope—More Planets than Stars

The Kepler Mission was decommissioned in 2018, but was the first mission to discover exoplanets. It was specifically designed to survey our region of the Milky Way galaxy, which led to the discovery of hundreds of Earth-size and smaller planets in or near the habitable zone around their respective stars. The Kepler telescope was in deep space for nine years, revealing that our sky is filled with billions of planets—more planets than stars. A sizeable percentage of those could be promising cradles of life.

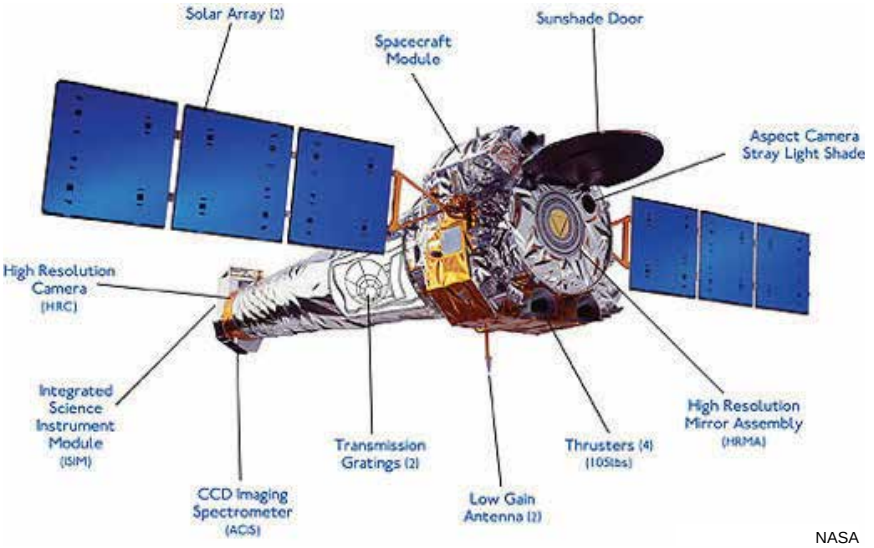
NASA's October 2018 press release quoted the Kepler mission's founding principal investigator, William Borucki, now retired from NASA's Ames Research Center:

> When we started conceiving this mission 35 years ago, we didn't know of a single planet outside our solar system. Now that we know planets are everywhere, Kepler has set us on a new course that's full of promise for future generations to explore our galaxy.

The Chandra Telescope

The Chandra X-Ray Observatory is named after the late Indian-American Nobel laureate, Subrahmanyan Chandrasekhar; he was known to the world simply as "Chandra" (which means "moon" or "luminous" in Sanskrit). The telescope was launched on the Space Shuttle *Columbia* in 1999. It specializes in the X-ray range of the light spectrum.

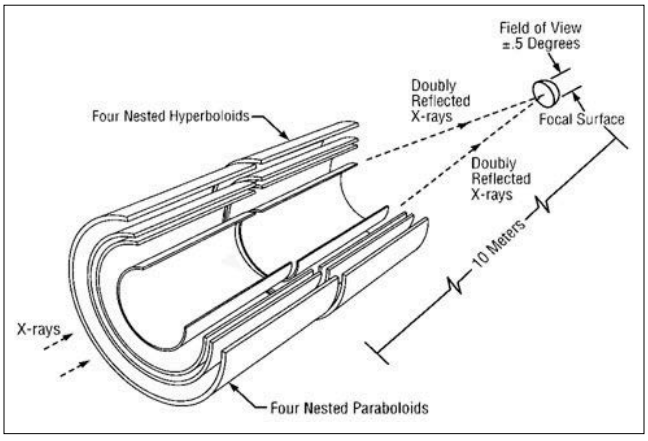
FIGURE 1
Chandra X-Ray Observatory



NASA

A normal telescope uses a large reflecting mirror, which generally focuses the incoming light onto a smaller, more focused mirror that transmits the image to the viewer. But, since X-rays are so energetic, they pass right through ordinary mirrors, Chandra has a special set of mirrors, called the High Resolution Mirror Assembly (HRMA).

The HRMA is made up of four pairs of slightly an-



NASA/Chandra

Chandra High Resolution Mirror Assembly

gled mirrors that subtly direct the radiation. The first mirror assembly is slightly parabolic and nearly parallel with the incoming X-rays. The second assembly is, again, slightly parabolic, and so forth; the entire assembly of mirrors is nested. This assembly gently guides the X-rays to the detector (see **Figure 1** and diagram).

This method was part of the development of the X-ray laser for medical/biological uses, under the Strategic Defense Initiative program suggested to President Ronald Reagan by Lyndon LaRouche and by Dr. Edward Teller.

Over its history, some of Chandra's achievements have been:

- It discovered a rich cluster of young stars grouped in the constellation Orion; they were determined to be from 1 to 10 million years old, and were detected because they produce violent X-ray bursts, much different from our Sun (4.5 billion years old).
- Its images have allowed scientists to study the shock waves generated by supernovas, and its spectra have revealed the amounts and distribution of heavy elements expelled by the explosions.
- Its images of the Crab Nebula and Vela supernova remnants revealed spectacular rings and jets of high-energy particles created by rapidly rotating neutron stars.

The Fermi Gamma-Ray Telescope

This telescope was formerly called the Gamma-ray Large Area Space Telescope (GLAST), but after the instrument was launched in 2008, it was re-named in honor of scientist Enrico Fermi. It's in a low-Earth circular orbit at an altitude of 550 km (340 miles).

Since gamma rays have even greater energy than X-rays, they will pass through any material—mirrors are completely useless. Instead, the telescope uses its specially designed instruments to detect the gamma rays, especially gamma ray bursts—most of them thought to emanate from black holes. This information is then collected by the instrument and transmitted to Earth, where researchers can convert the data to images. Although it can detect these high-energy emissions, its resolution is very low, so it can point to a general area in the sky as the source of the gamma rays; most sources are still unknown.

Fermi carries two instruments: the Large Area Telescope (LAT) and the Gamma-ray Burst Monitor (GBM). The LAT is Fermi's primary instrument, and the GBM is the complementary instrument.

NASA's website explains how it works:

> The LAT [see **Figure 2**] has four subsystems that work together to detect gamma rays and to reject signals from the intense bombardment of cosmic rays. For every gamma ray that enters the LAT, it will have to filter out 100,000 to one million

FIGURE 2
Fermi Gamma-Ray Large Area Telescope

NASA/Kim Shifflet

cosmic rays, charged particles that resemble the particles produced by gamma rays….

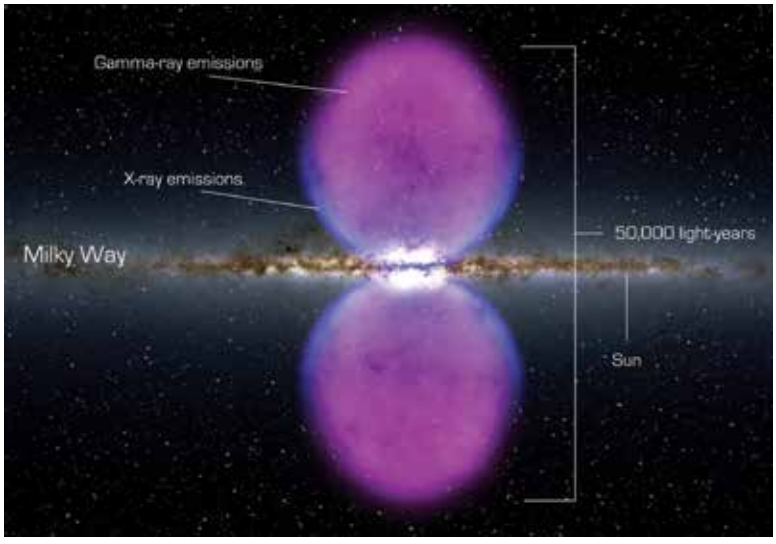
With its very large field of view, the LAT sees about one-fifth of the sky at any given moment.… The LAT is at least 30 times more sensitive than any previous gamma-ray instrument flown in space and has detected thousands of new sources.

A gamma ray enters the LAT. It first passes through the Anticoincidence Detector without producing a signal. The gamma ray interacts in one of 16 thin tungsten sheets. This interaction converts the gamma ray into an electron and a positron via pair production (governed by Einstein's equation $E=mc^2$). The Tracker uses silicon strips to measure the paths of the electron and positron, allowing the LAT to determine the arrival direction of the gamma ray. The electron and positron enter the Calorimeter, which measures the energies of the particles, and therefore the energy of the original gamma ray.

Unwanted cosmic-ray particles produce a signal in the Anticoincidence Detector, which tells the Data Acquisition System to reject the signal. The Anticoincidence Detector rejects 99.97% of the unwanted signals produced by cosmic rays that enter the LAT….

The Fermi telescope has given us new insights into how the Universe works: Fermi has shown that giant flares from super-magnetized neutron stars can be detected in galaxies beyond our own. Its measurements have provided important limits on new theories of gravity and on the nature of dark matter, the mysterious substance that seems to bind galaxies together. Fermi data revealed a vast new component of our galaxy known as the Fermi Bubbles [see **Figure 3**], a structure that spans 50,000 light-years and likely formed as a result of an outburst from the monster black hole at the center of our galaxy.

FIGURE 3
Gamma-Ray Bubbles



NASA/Goddard Space Flight Center

The gamma-ray bubbles ("Fermi Bubbles") are regions rich in gamma-ray emissions above and below the disk of the Milky Way, discovered by the Fermi telescope.

The Juno Mission to Jupiter

As NASA describes Juno's mission:

> On August 5, 2011, NASA's *Juno* spacecraft embarked on a 5-year journey to our Solar System's largest planet—the gas giant Jupiter. Its mission: to probe beneath the planet's dense clouds and answer questions about the origin and evolution of Jupiter, our Solar System, and giant planets in general across the cosmos….
>
> Juno's discoveries have revolutionized our understanding of Jupiter and Solar System formation. During the prime mission's 35 orbits of Jupiter, Juno collected more than three terabits (375 gigabytes) of science data and provided dazzling views of Jupiter and its satellites, all processed by citizen scientists with NASA's first-ever camera dedicated to public outreach. Juno's many discoveries have changed our view of Jupiter's atmosphere and interior, revealing an atmospheric weather layer that extends far beyond its clouds and a deep interior with a diluted, or "fuzzy," heavy element core….
>
> Unlike Earth, Jupiter's giant mass allowed it to hold onto its original composition, providing us with a way of tracing our Solar System's history. Juno is measuring the amount of water and ammonia in Jupiter's atmosphere and helping to determine if the planet actually has a solid core, directly resolving the origin of this giant planet and thereby the solar system. By map-

FIGURE 4

NASA/JPL-Caltech/SwRI/MSSS, Björn Jónsson

Complex colors and structure of Jupiter's clouds, imaged by NASA's Juno, July 5, 2022.

FIGURE 5

NASA/JPL-Caltech/SwRI/MSSS, Björn Jónsson

The same image of Jupiter's clouds, enhanced in color and contrast by citizen scientist Björn Jónsson in Iceland.

bits. This was the most detailed map yet, and revealed a magnetic anomaly near Jupiter's equator, which was named the Great Blue Spot.

Juno has recorded changes in Jupiter's magnetic fields just over the last five years. The Great Blue Spot is slowly drifting eastwards, and will lap the planet in about 350 years.

The new magnetic field map also enables scientists and researchers to make comparisons with Earth's magnetic field. Jupiter's magnetic field is about 10 times stronger than Earth's; the data suggests to the mission team that "dynamo action"—the mechanism by which a celestial body generates a magnetic field—in Jupiter's interior occurs in metallic hydrogen, beneath a layer expressing *helium rain*.

> ping Jupiter's gravitational and magnetic fields, Juno is revealing the planet's interior structure and measuring the planet's diluted heavy element core….

From a May 7, 2023 article, "Jupiter's Complex Colors Revealed in Stunning Images from NASA's Juno Spacecraft," in the online *SciTechDaily*:

> Citizen scientist Björn Jónsson from Iceland created these two images [see **Figures 4** and **5**] using raw data from the JunoCam instrument aboard the spacecraft. *Juno* was about 3,300 miles (5,300 kilometers) above Jupiter's cloud tops, at a latitude of about 50 degrees at the time the raw image was taken. North is up.

A Magnetic Great Blue Spot

One of Juno's tasks was to map Jupiter's magnetic field, which it did by collecting data during its 32 or-

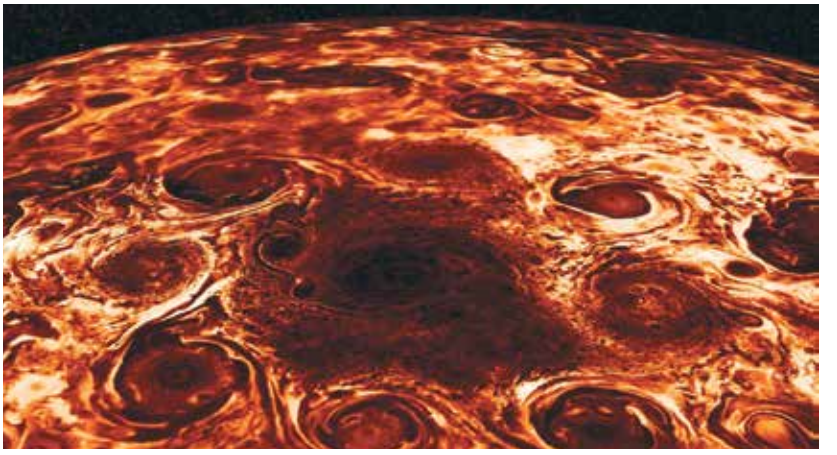
NASA observed, regarding another citizen scientist:

> Lia Siegelman [from] Scripps Institution of Oceanography at the University of California, San Diego, [noticed] that the cyclones at Jupiter's pole appear to share similarities with ocean vortices she studied during her time as a doctoral student.
>
> "When I saw the richness of the turbulence around the Jovian cyclones, with all the filaments and smaller eddies, it reminded me of the turbulence you see in the ocean around eddies," said Siegelman. "The simplified model of Jupiter's pole shows that geometric patterns of vortices, like those observed on Jupiter, spontaneously emerge, and survive forever. This means that the basic geometrical configuration of the planet allows these intriguing structures to form."

Stable vortices and filaments such as observed on Jupiter, have also been observed in the very small in fusion reactions, and on a cosmic scale in galaxies and nebulae. [See **Figure 6**.]

There are two complementary European missions to that of Juno planned in the near future. One, the Europa Clipper mission, is scheduled to launch in October 2024 to study one of Jupiter's moons, Europa, which, evidence suggests, has an ocean of liquid water. The second is the European Space Agency's JUICE mission (JUpiter ICy Moons Explorer), which was launched April 14, 2023 to make multiple flybys of Jupiter's satellites and go into orbit around one of them, Ganymede.

FIGURE 6
Jupiter's Stable Storms at Its North Pole



NASA/JPL-Caltech/SwRI/ASI/INAF/JIRAM

Mars Odyssey: the Oldest Mars Orbiter

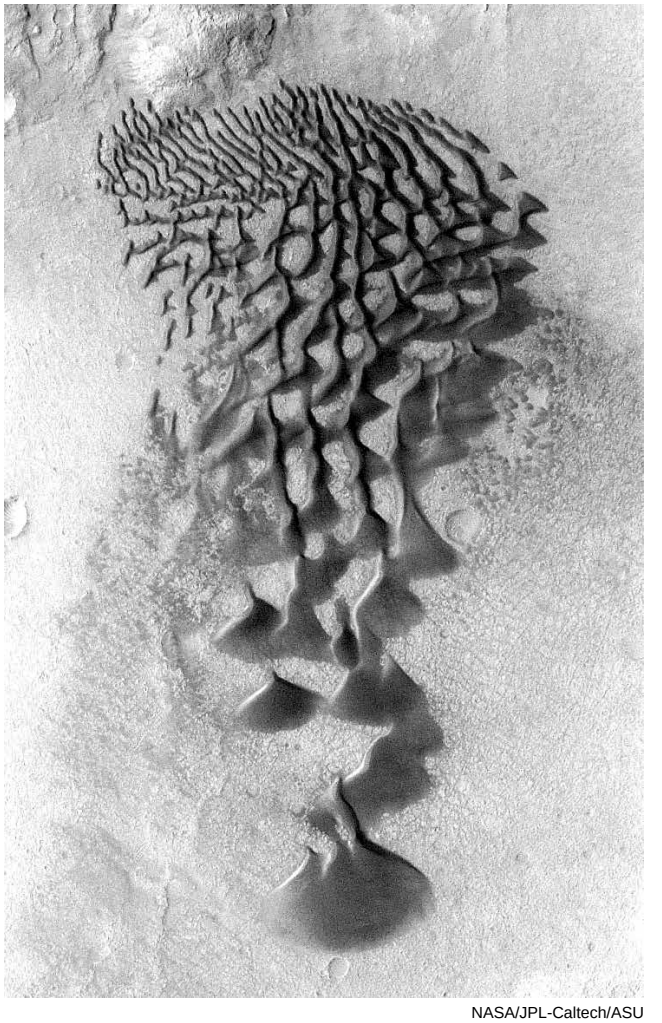
NASA's *Mars Odyssey* was launched in April 2001, and was inserted into its Mars orbit in October 2001. Its mission was to make the first global map of Mars's surface, showing the distribution and amounts of many minerals or chemical elements that make up the Martian surface. This primary science mission was completed in August 2004, and its extended operations continue to the present.

The *Odyssey Orbiter* is actually a communications relay for landers on Mars, including the Mars exploration rovers *Spirit*, *Opportunity*, and *Curiosity*, and the *Mars Phoenix Lander*.

Mars Odyssey is making the first global map of the amounts and distribution of chemical elements and minerals that make up the Martian surface. It helped construct the most accurate global map of Mars, using 21,000 images from the THEMIS (Thermal Emission Imaging System) instrument. (See **Figure 7**.) Years ago it identified large amounts of hydrogen in the soil, implying the presence of ice possibly a mile (1600 meters) below the planet's surface; subsequently, in 2008, mission scientists revealed that *Mars Odyssey* had found evidence of salt deposits in 200 locations in southern Mars, left behind in places where water was once abundant.

Mars Odyssey's images also help identify potential landing sites for spacecraft.

FIGURE 7
Sand Dunes Imaged by *Mars Odyssey*



NASA/JPL-Caltech/ASU

Deep Space Network: Tracking, Communicating, Defending Earth

The Deep Space Network (DSN) is a system of powerful antennae that track and communicate with several deep space missions, particularly the James Webb Space Telescope, the *New Horizons* spacecraft, and the *Voyager 1* and *Voyager 2* spacecraft.

The Jet Propulsion Laboratory website, which shows in real time which antenna is communicating with which spacecraft, explains the Deep Space Network's mission:

> The antennas of NASA's DSN are the indispensable link to robotic explorers venturing beyond Earth. They provide the crucial connection for commanding our spacecraft and receiving their never-before-seen images and scientific information on Earth. The DSN consists of three antenna facilities spaced at equal distances from each other (about 120 degrees apart in longitude) around the world, operated through the Network Operations Control Center at JPL:
>
> • The Goldstone Deep Space Communications Complex near Barstow, California
>
> • The Madrid Deep Space Communications Complex near Madrid, Spain
>
> • The Canberra Deep Space Communication Complex near Canberra, Australia
>
> The strategic placement of these sites permits constant communication with spacecraft as our planet rotates. Before a distant spacecraft sinks below the horizon at one DSN site, another site can pick up the signal and carry on communicating. All three complexes consist of at least four antenna stations, each equipped with large parabolic dish antennas and ultra-sensitive receiving systems capable of detecting incredibly faint radio signals from distant spacecraft….
>
> For example, the Deep Space Network operates the Goldstone Solar System Radar, the world's only planetary radar system. The Goldstone Solar System Radar conducts a variety of planetary science investigations, and it is a critical element of NASA's planetary defense activities.

FIGURE 8

NASA

Bill Nelson: "There is a very professional, competent relationship between the U.S. and ... the Russians with regard to space." Here Donald K. Slayton and Alexey A. Leonov aboard the Soyuz *Orbital Module, July 17, 1975.*

A video provides "360°" exploration of the telescopes of the Deep Space Network.

We Need More 'Handshakes in Space'

It is a paradox that we've created scientific instruments that can see far into the distant past, but here on Earth, we the people do not seem to recognize what is currently staring us all in the face: the imminent danger of thermonuclear war.

In the past, NASA was one of the instruments by which the United States and the Soviet Union, and later Russia, were able to collaborate in scientific endeavors, in spite of political tensions existent at the time.

At the height of the 1962 Cuban Missile Crisis, when nuclear weapons based in Cuba were on a hair-trigger to launch, U.S. President John Kennedy and Soviet Premier Nikita Khrushchev went to extraordinary lengths to pull the world back from the brink of nuclear war.

In 1975, even during the Cold War, there was the docking of the American *Apollo* spacecraft with the Soviet *Soyuz* capsule—an event watched by millions around the world on TV. The International Space Station has been host to Russian cosmonauts over the years, both sides consistently expressing joy and respect as they work alongside each other (see **Figure 8**). Today, no such relationship exists, nor even a "hotline" between the United States and Russia.

When Sputnik was launched by the Soviet Union in 1957, its beeping signal was set at a frequency which the Soviet scientists knew would be capable of being detected by Western scientists. Like musicians, scientists speak a common language, even with all of their disagreements.

NASA Administrator Bill Nelson testified at the Senate Appropriations Subcommittee hearing on April 17, 2023, and emphasized that U.S.-Russian cooperation in space could be "a template for the future." Space should be the model of cooperation between the two adversaries. According to Interfax, he stated:

> There is a very professional, competent relationship between the U.S. indeed and other international partners, and the Russians with regard to space. Not only between the cosmonauts and the astronauts onboard the International Space Station.... Not only that, but also the fact that there is a mission control of Americans and Russians—in Moscow, as well as Houston. And it is all working.

The Russian news agency TASS reported Nelson recalling the 1975 Russian-U.S. *Soyuz-Apollo* experimental flight, saying:

> That set the tone for the civilian space program between otherwise two enemies, two political and geopolitical enemies.... And so then, we designed and built together the International Space Station.... If we can continue peacefully working together in space, maybe that's a template for the future.

In the Spirit of Westphalia

Perhaps a step toward a new basis for a ceasefire and diplomatic talks to begin between Russia and Ukraine would be to turn to the great Ukrainian-Russian scientist, Vladimir Vernadsky. (See the presentation on Vernadsky elsewhere in this issue.) He is well known and respected in both nations, and contributed enormously to the scientific community of both. Vernadsky was born in Russia, and his family lived in Ukraine; he spoke both Russian and Ukrainian, and encouraged the revival of Ukrainian culture and language. Under the appropriate conditions, the common history between these two nations, and common "father of biogeophysics" could lay the groundwork for a new understanding.

And there is a towering scientific thinker, whose philosophical outlook could be a foundation for a new strategic doctrine between the United States and Russia, aligned with the idea that human beings are fundamentally good.

We can look back to the 17th Century, to Gottfried Wilhelm Leibniz, the great German scientist, philosopher and statesman, born July 1, 1646. He was not only a friend of Peter the Great (1672–1725), but was influential in the formation and development of the St. Petersburg Academy of Sciences and Arts.

It was also Leibniz's science and philosophy which shaped the thinking of Benjamin Franklin, influenced Alexander Hamilton, and instilled in our Declaration of Independence the principle that our inalienable rights include "Life, Liberty and the Pursuit of Happiness…," not "Life, Liberty and Property" as promulgated by John Locke and Adam Smith.

Perhaps a grand exposition and dialogue between our nations on this common scientific and philosophical outlook could be the basis for a new form of peaceful collaboration between America and Russia. Looking forward to July 2026, it would be appropriate for both Russia and the United States to celebrate not only the 250th anniversary of the founding of the United States of America, but also to recognize and celebrate the 380th anniversary of the birth of Gottfried Leibniz.

The future of billions now living on our planet is in jeopardy, as is the future of billions as yet unborn. Let us turn our scientific and technological advances, informed by the wonder and joy of the amazing images from our Universe, to undertake one of the greatest missions of all: To bring humanity, finally, to fulfill its true nature, to become adult, and take our place in the Universe as a meta-terrestrial species.