Khalifa University Science and Tech Review

A quarterly science magazine published by Khalifa University

The Space Issue

GIVE US SOME SPACE

Stargazer

Khalifa University's Mohamed Ramy El-Maarry knows the cosmos. And a piece is named after him — **P34**

Lost in the light

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Weightless wellness

Medicine prepares for astronauts' health needs on long-distance journeys — **P54**

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Khalifa University Science and Tech Review

KUST Review is dedicated to publishing authoritative, reliable and accessible information about science, innovation and technology news and trends. Although we report on news from around the world, we highlight advances, innovators and topics of interest from the Middle East and North Africa region. Our mission is to spread knowledge of and enthusiasm for science and technology in the Arab world and beyond through responsible and trustworthy journalism.

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LETTER FROM
THE EDITOR

Certainly when people around the world think of technology innovations in the Middle East, they think of energy production. But space exploration is rapidly climbing on the list of the region's scientific accomplishments.

The United Arab Emirates in 2014 established the UAE Space Agency, and in less than a decade sent a probe to Mars and Emiratis Hazza Al Mansouri and Sultan Al Neyadi into space. And it has many more projects lined up at the gate.

The UAE has invested U.S.$817 million to support the space sector. Meanwhile, Saudi Arabia is also putting considerable resources into space research, promising to invest U.S.$2.1 billion in the sector to facilitate collaborations between government and private industry. Also in the region: Kuwait launched its first satellite in 2023; Oman has plans to build a spaceport; and Egypt has created a government agency to build and launch its own satellites.

Economic development is a key reason these governments are investing in space. But the pursuit of knowledge for its own sake and cooperation among the peoples of Earth to extend our reach to the stars fulfills a basic human drive as well.

That's why in this issue we examine space exploration. Senior science writer Jade Sterling looks at how space may be the final frontier for the law; editor Suzanne Condie Lambert writes about the 2D materials that might help humans build settlements on other planets; Maggie Kinsella delves into the troubling issue of space junk; and some of the MENA region's most talented amateur astrophotographers share images of the cosmos for a stunning photo essay.

You'll also find a special pull-out poster with a timeline of some of the UAE's past achievements in space and projects still to come.

Find these stories and more here, on our website (KUSTReview.com) and through our social media channels @KUSTReview.

As always, we invite you to be informed and stay curious.

Dr. Arif Sultan Al Hammadi
KUST Review Editor-in-Chief

IN THIS ISSUE

GIVE US SOME SPACE

Interest in space is, well, looking up, with more governments and companies funding research and missions to explore the cosmos and make use of the materials found there.

In this edition of *KUST Review*, we investigate some of the issues space exploration faces as well as some of the technology, materials and research that are paving the way.

In these pages you'll find stories about the 2D materials that might shield astronauts from radiation and the cold of space; how future explorers might be affected by the law; why the junk in Earth's orbit endangers future missions and much more.

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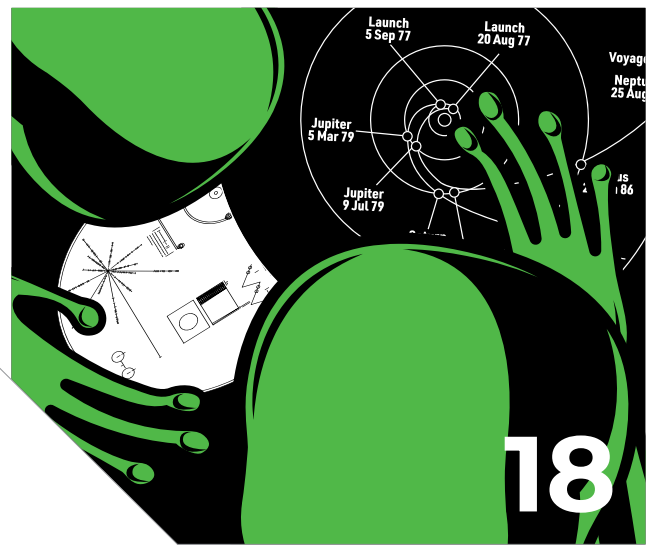

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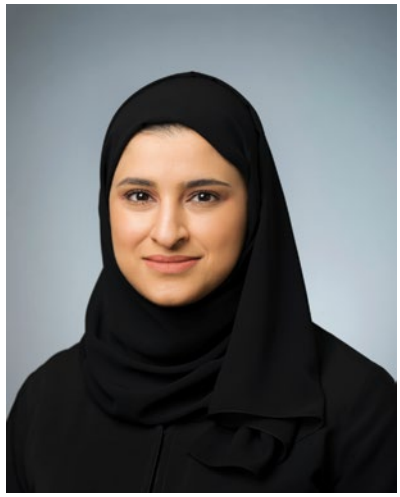
EYES ON THE SKIES

Her Excellency Sarah Al Amiri answered *KUST Review's* questions about how diversity strengthens her team, why a thriving space program benefits the nation and its people and more.

By: **Suzanne Condie Lambert**



CHAIR OF THE UAE SPACE AGENCY SAYS SUCCESS IN SPACE STARTS WITH ITS PEOPLE ON EARTH

Her Excellency Sarah Al Amiri chairs the UAE Space Agency and is minister of state for Public Education and Future Technology.

Q: The UAE Space Agency is unusual in the tech industry for having a high percentage (50 percent) of female employees. The Mars Hope mission team you led was 80 percent women. How have you encouraged female participation and other forms of diversity in the workforce? Have you seen any positive effects on the work?

I'm immensely proud of the job we've done as an agency in removing barriers to entry for team members regardless of their age, nationality, gender or beliefs. Since my childhood, I've always been very much deaf to challenges pertaining to gender, and this remains very much the case today. For me, it is less a question of gender and much more one of diversity.

The key to scientific achievement is to begin with interesting questions, and the driver of interesting questions is genuine variance in thought, perspective and experience – different people, from different backgrounds, with different ways of thinking. This has been integral to our achievements in recent years.

Q: How have the UAE's space endeavors benefitted the country's economy?

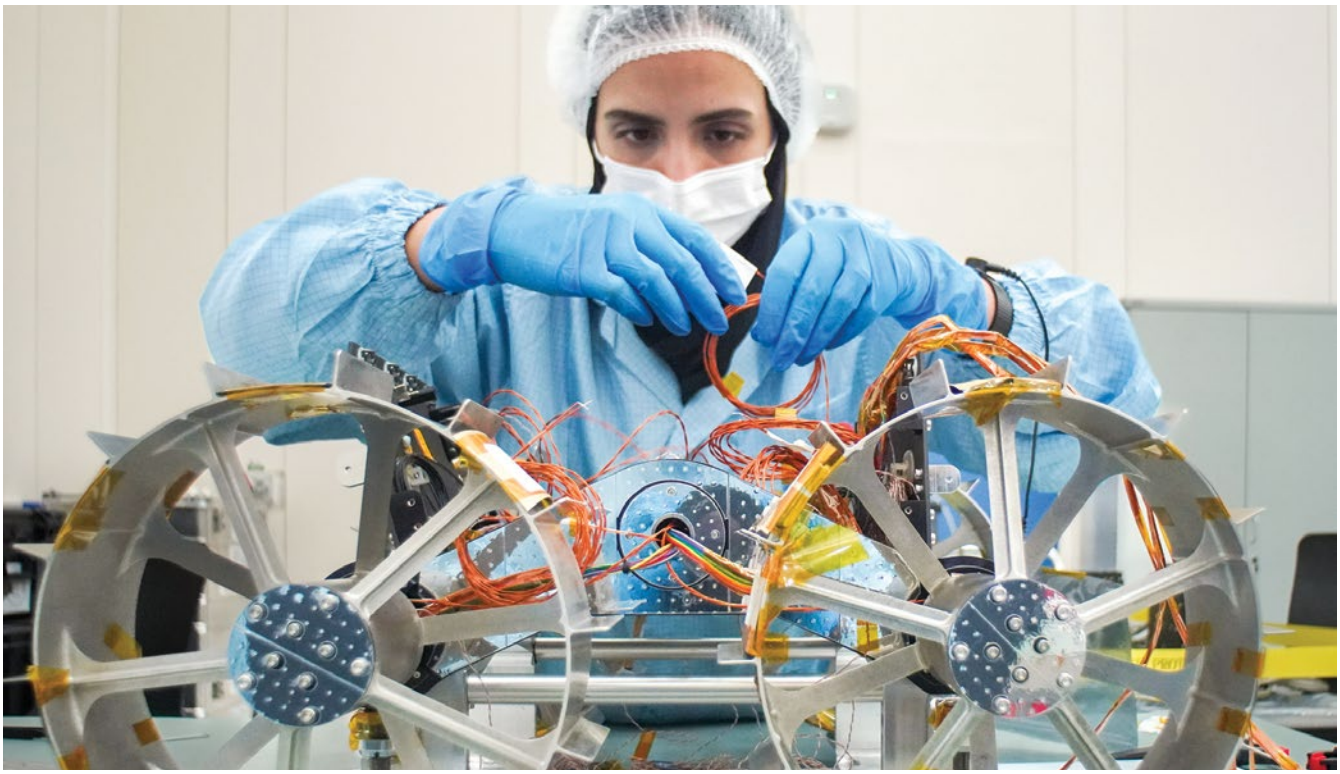
We have built the space sector directly into our nation's economy and its plans for future growth. By fostering an environment which pushes the boundaries of technology and science in space, we can unlock the enormous economic potential of the sector. From multinational businesses to start-ups to space entrepreneurs, we feel the UAE – through our technology, experience and capabilities – is the ideal place for private space companies.

For us, as an agency, to keep innovating and progressing, it's essential that we have a close, productive relationship with the private sector and wider space community.

As a tangible example of this, we recently announced the Emirates Mission to the Asteroid Belt, which will have a 50/50 split between public- and private-sector contribution to the mission.

Q: The asteroid-belt mission in 2028 will fly by Venus and survey seven asteroids. What do you hope to learn, and what are the biggest obstacles to success?

There is much to be learned from close inspection of this asteroid belt. Foremost, the mission will offer us greater insight into the origin of these asteroids, which in turn, could



teach us much about the history of the universe and life itself. By investigating the emergence of organic compounds on the asteroids, we can potentially better understand how water, and in turn life, came to be here on Earth.

The mission is, of course, immensely challenging from an engineering perspective, not least because it will span a distance more than 10 times that of our recent journey to Mars.

Q: The country clearly plans to be a leader in the space realm. How is the UAE encouraging the next generation of scientists?

Inspiring the next generation of scientists, and technologists, here in the UAE is always front of mind for me and is a natural synergy between my roles at the Space Agency and as a minister for public education.

As an agency, we host a youth council which aims to empower and support talented young Emiratis with an interest in space, as well as to ensure their perspectives are shared with us.

We are also working closely with schools and universities throughout the Emirates to ensure STEM pathways are open to all. The majority of the mission team for the Emirates Mars Mission was under the age of 35 – demonstrable proof that age is not a barrier here.

Q: International cooperation has been an important part of the UAE's space endeavors. Its astronauts train with NASA in the United States and it has worked with other international partners for such missions as launching the Rashid rover to the moon. Do you plan to continue such partnerships or is the UAE interested in building the facilities to provide more of these functions at home?

We pride ourselves on our collaboration with other nations, space agencies and international companies, and recognise that the future of space is very much a global opportunity.

International partnerships are key, not only because of the potential to share capabilities, technologies and experiences, but also to shape governance from a regulatory and policy perspective. This is particularly important for sustainability, commerciality and the avoidance of conflict.

Moving forward, we very much look forward to forging new partnerships as well as convening established and emerging space powers to further drive cooperation. ●

⊙ **ABOVE:** The UAE space program – with close links to the private sector and the international space community – is an important part of the nation's economic goals, Her Excellency Sarah Al Amiri says.

CREDIT: Mohammed Bin Rashid Space Center

LIFTING

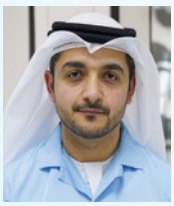
WHAT SHOULD BE OUR FIRST PRIORITY IN SPACE?

In 2021, the UAE's Hope probe reached Mars, just one of many missions launched by governments and private businesses in recent years looking to increase our understanding of our solar system and beyond. With all of this interest in space exploration, we asked our experts: What should be our first priority? Here's what they said.

RIGHT: The SpaceX Falcon 9 rocket carrying the Dragon cargo spacecraft lifts off from Launch Complex 39A at NASA's Kennedy Space Center.

PHOTO CREDIT: Freepik, NASA

OFF



Dr. Hamad Al Marzooqi was the project manager for the Emirates Lunar Mission and oversaw the computer and the imaging systems of the Rashid rover.

WORKING TOGETHER BENEFITS ALL OF EARTH'S PEOPLE

Space exploration has always been human-centric in nature. It has been the case in the past, it is what fuels the current space-exploration program, and it will continue to be in the future.

There were different drivers of space-exploration programs including political, economic and national defense in the past, and they will continue to be.

However, such drivers come and go, and what remains is the curiosity in all of us to explore the unknown and expand our knowledge.

What distinguishes us as humans is our persistence in asking questions from our childhood until adulthood, and such questions are the drivers of all scientific space-exploration programs.

Our ancestors looked at the moon, planets and the stars with awe and inspiration. Today, through our persistence in asking questions, we have become space explorers by sending spacecraft and rovers to the moon, Mars and other planets, eventually reaching the edge of our solar system.

Soon, we will be a space-faring species, and we will create our permanent presence on the moon and Mars. The "we" in the previous statements is not privileged to a nation, country, political region, ethnicity or religion. It includes all humans living on Planet Earth, and that is what should be the first priority in space exploration.

Space exploration is a challenging task, and it will not be feasible without working together as one species through international collaboration.

The International Space Station sets an excellent example of what can be achieved by setting our differences aside and working together. We need to take this example further and expand our international-collaboration efforts in future space-exploration programs.

We need to take advantage of the substantial advancements that are being made through different space programs and find solutions that are human-centric to improve the livelihood of humans living on this planet through technologies, knowledge, education and empowerment of underdeveloped and developing nations.

Our international space-exploration program should focus on advancing human knowledge, finding solutions for existing problems (global warming, inequality, poverty and global health system) and providing a brighter future for the next generation on Earth and other planets. ›››

⊙ **ABOVE:** At the Gagarin Cosmonaut Training Center in Star City, Russia, Expedition 61 backup crewmember Tom Marshburn of NASA signs in for the first day of crew qualification exams. Looking on are the other backups, spaceflight participant Sultan Al-Neyadi of the United Arab Emirates and Sergey Ryzhikov of Roscosmos.

PHOTO CREDIT: NASA

Ettore Perozzi is senior scientist at the Italian Space Agency (ASI) with a long-standing expertise in celestial mechanics, planetary science, space flight dynamics, education and public outreach.

AVOIDING THE FATE OF THE DINOSAURS

The long and winding roads that connect the neighborhood of the Earth to the outer regions of the solar system (and beyond) are well known in celestial mechanics.

It is also well established that asteroids and comets, often following chaotic orbital paths, are key to understanding the early phases of planetary formation – where we all come from.

Their dynamical mobility – leading to impacting the planets, falling into the sun or escaping to interstellar space – and their diversity in physical properties make them extremely interesting for planetary science as well as threatening objects in case of collision. They also present an opportunity for extraterrestrial mining.

Therefore, exploring asteroids and comets allows us to address at once three fundamental issues: unveiling the origin and evolution of the solar system, opening a potential new market for commercial space applications and providing vital information for civil protection.

Knowing the chemical composition and internal structure of a small celestial body en route to colliding with the Earth would allow us to develop a robust and reliable deflection strategy, thus helping humans avoid the fate of the dinosaurs.

When the body poses no danger, its pristine composition could provide precious reservoirs of extraterrestrial resources to compensate for the feared lack of key elemental abundances on our planet.

To date many successful space missions (Giotto, NEAR, Dawn, Rosetta, Hayabusa 2, Dart/LICIAcube, to name a few) have reached asteroids and comets. More are to come.

But in addition to the previous points, these celestial bodies represent ideal locations for the in-situ production of fuel and basic consumables, thus enabling routine long-range space exploration and, in the long run, sustaining the much-awaited human expansion in the solar system.

⊙ **ABOVE:** Knowing more about small celestrial bodies could help us deflect them.

⊙ **LEFT:** Photo of the Earth taken by the Visible/Infrared Imager Radiometer Suite (VIIRS) instrument on board the new Suomi NPP satellite

PHOTO CREDIT: NASA, Freepik, Shutterstock

Anton B. Ivanov is executive director for Beyond Space Exploration at the Technology Innovation Institute in Abu Dhabi, UAE.

EXPLORING NEAR EARTH ORBITS WILL AFFECT LIFE ON EARTH

We can distinguish two important priorities for the future in space exploration: Near-Earth orbits (LEO, MEO and GEO) and study of the solar system.

Safe exploration of near-Earth orbits (NEO) is important for a couple of reasons. These orbits are home to Earth observation communication and (global navigation) satellites. These assets play crucial roles in our everyday life, even though we don't notice their impact.

In the recent decade, we are seeing a big push toward creating large constellations, which will enable new applications, yet popular orbits will become very congested.

The number of active satellites and debris in orbit is rapidly increasing. This presents a significant safety risk to both human and robotic missions in LEO, and proper measures must be taken to mitigate these risks.

Exploration of the solar system, particularly Mars and the moon, is important for a number of reasons. Many governments and private companies are investing in missions to the moon, Mars and asteroid belt. In addition to technology advancement, we learn about the history of the solar system.

In conjunction with the growing number of discovered exoplanets, we can better understand whether life, as we know it, can exist outside the solar system.

Exploration of Mars and the moon can also serve as a stepping stone for human exploration of deeper space and inspire technologies that will find their place here on Earth.

Humanity has a natural curiosity to explore new places. Mars and the moon present great interest for establishing permanent future settlements.

It is unlikely that these settlements will solve problems, such as overpopulation and climate change. However, they will have a positive impact on human culture and society, promoting a sense of wonder and awe, fostering international cooperation and inspiring innovation.

⊙ **ABOVE:** The International Space Station (ISS) is backdropped over clouds, water and land.

⊙ **LEFT:** The Juno spacecraft captured this image of Jupiter's swirling clouds. This sort of exploration will continue to help humans understand more about the universe.

PHOTO CREDIT: NASA, MBRSC

Lost in the Night

Don't let light obscure the stars. Here's how you can help.

By: **Suzanne Condie Lambert**

When most people think of polluted skies, they often think of smog. But there's another source of pollution that disrupts natural wildlife patterns, damages human sleep, contributes to the increase of CO_2 in the air and obscures the stars at night. **Light.**

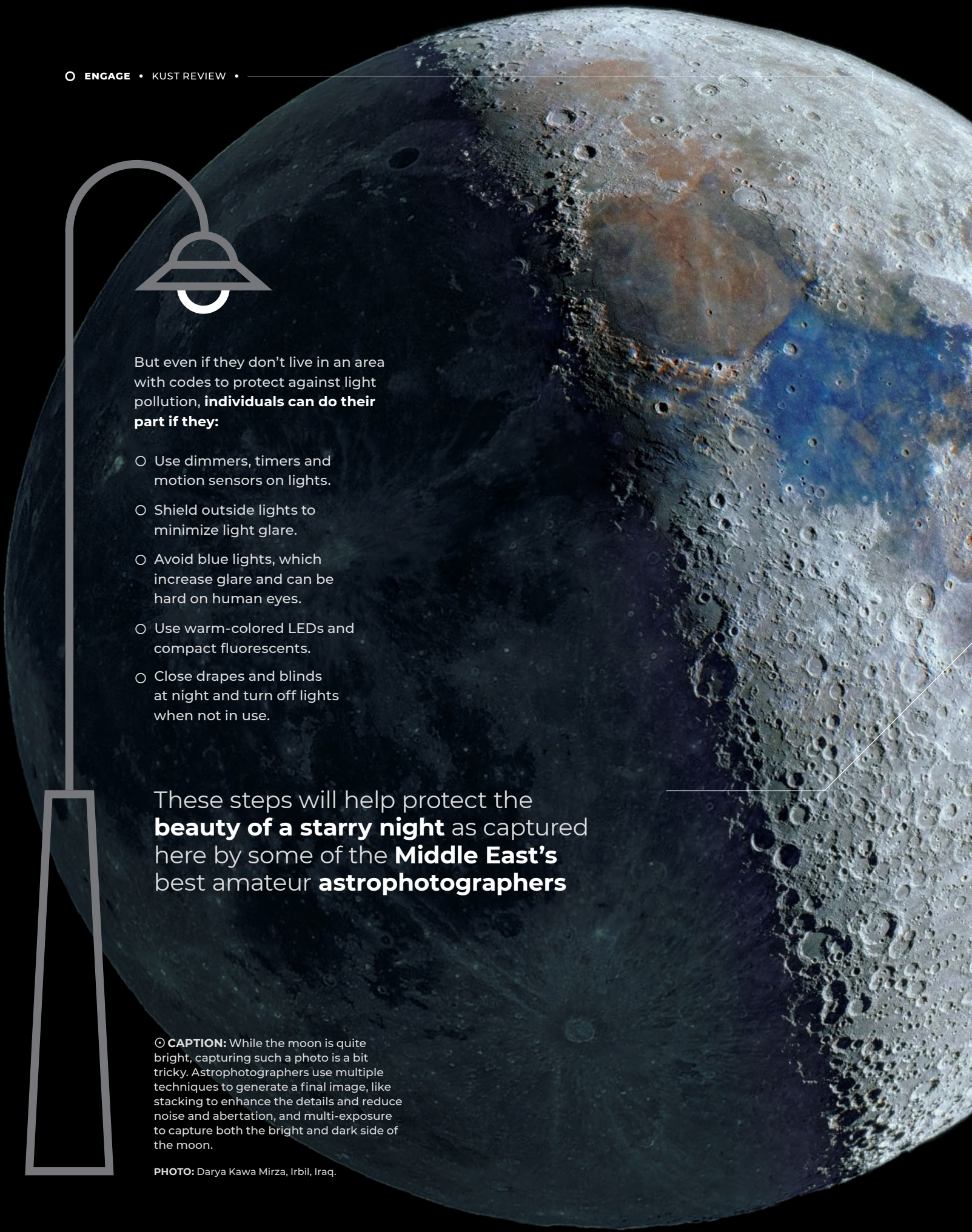
⊙ **CAPTION:** This photo is an excellent example of how much light pollution obscures the night sky. The bright areas below are city glows that can be visible from hundreds of kilometers away.

CREDIT: Apostolos Kyriazis, Abu Dhabi desert, UAE.

Streetlights, neon signs, car headlights and even the lamp at your window all contributve to light pollution. But there are things people can do as individuals and communities to prevent light pollution's harmful effects.

In 2001, Flagstaff, Arizona, home of the Lowell Observatory and the Pluto Discovery Telescope, became the first city designated as an International Dark Sky Place. The U.S. city instituted progressive codes to prevent unnecessary lighting and preserve the integrity of the night sky for casual stargazers and professional astronomers alike.

The Pacific island of Niue in 2020 became the first country to be designated as a Dark Sky Place, as defined by the International Dark-Sky Foundation. But the foundation isn't the only group promoting the concept. Oman's leadership, for example, in 2019 decreed the formation of the Western Hajar Reserve, southwest of Muscat. »»



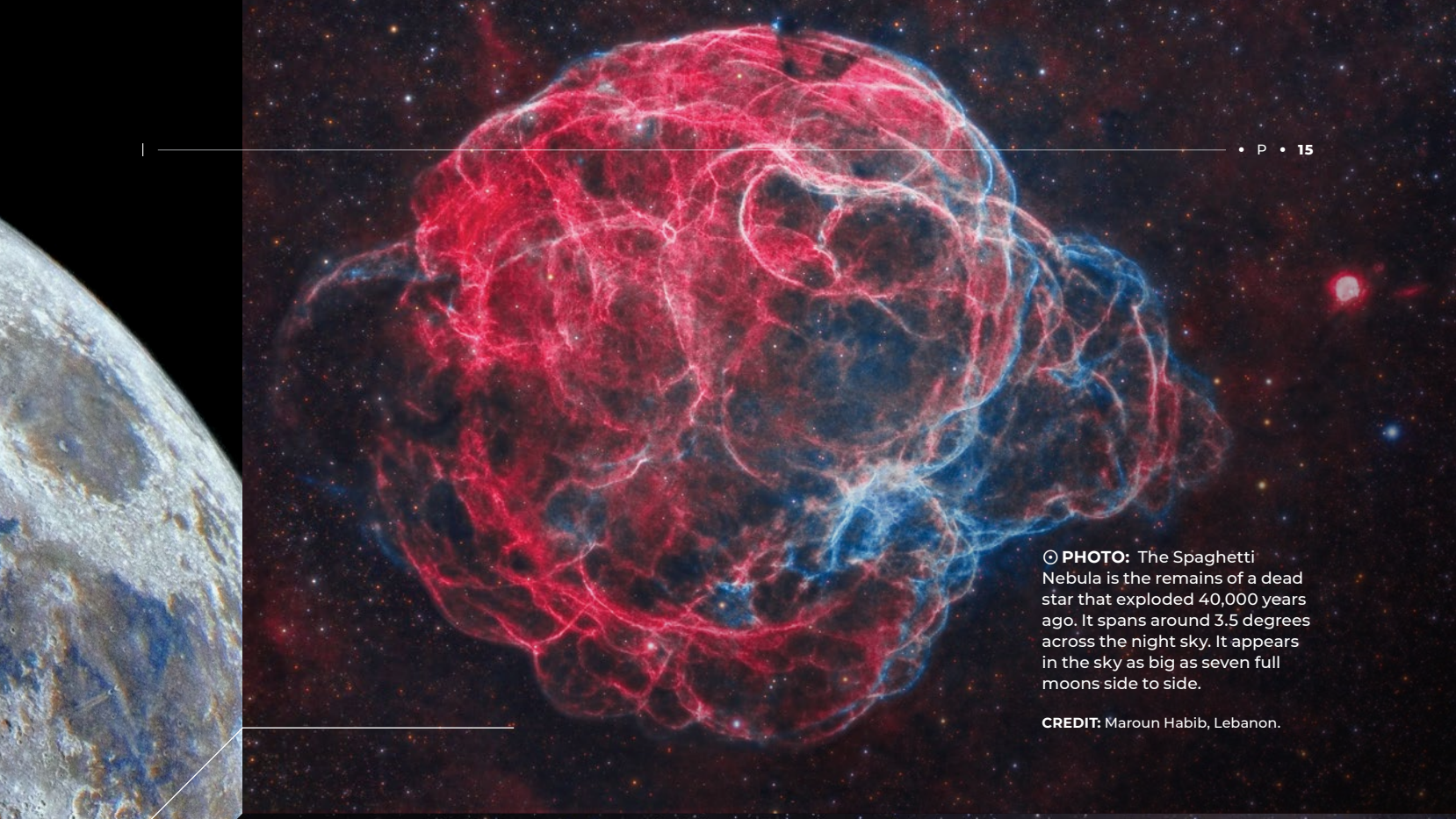
But even if they don't live in an area with codes to protect against light pollution, **individuals can do their part if they:**

- Use dimmers, timers and motion sensors on lights.
- Shield outside lights to minimize light glare.
- Avoid blue lights, which increase glare and can be hard on human eyes.
- Use warm-colored LEDs and compact fluorescents.
- Close drapes and blinds at night and turn off lights when not in use.

These steps will help protect the **beauty of a starry night** as captured here by some of the **Middle East's** best amateur **astrophotographers**

⊙ **CAPTION:** While the moon is quite bright, capturing such a photo is a bit tricky. Astrophotographers use multiple techniques to generate a final image, like stacking to enhance the details and reduce noise and abertation, and multi-exposure to capture both the bright and dark side of the moon.

PHOTO: Darya Kawa Mirza, Irbil, Iraq.



⊙ **PHOTO:** The Spaghetti Nebula is the remains of a dead star that exploded 40,000 years ago. It spans around 3.5 degrees across the night sky. It appears in the sky as big as seven full moons side to side.

CREDIT: Maroun Habib, Lebanon.

⊙ **PHOTO:** Our closest galactic neighbor, the Andromeda Galaxy (M31), is considered to be right next door on a cosmic scale, yet the light in this photo took over 2.5 million years to reach us. Talk about a blast from the past.

CREDIT: Abdullah Alharbi, Kuwait. This photo was awarded an **APOD (Astronomy Picture of the Day)** by NASA on March 22, 2023.

⊙ **PHOTO:** The NGC 2264 area has lots of star formations such as the Cone and Fox Fur nebulas and the Christmas Tree and Snowflake clusters.

CREDIT: Anas Albounni, Abu Dhabi desert, UAE.

⊙ **PHOTO:** Not all nebulas are created equal. Some emit light and some obscure it. In this case, the opaque dust clouds of the Horse Head and Flame nebulas obscure our view of glowing ionized gases. The brain's ability to identify shapes helps us name them.

CREDIT: Wissam Ayoub, Abu Dhabi desert, UAE. This photo was awarded an **APOD (Astronomy Picture of the Day)** by NASA on Nov. 3, 2021.

⊙ **PHOTO:** A composite image of the Milky Way core includes many nebulas such as the Lagoon and Trifid nebulas on the left and Rho Ophiuchi nebula in the Scorpius constellation on the right.

CREDIT: Amr Abdulwahab, White desert, Egypt. This photo was awarded an **APOD (Astronomy Picture of the Day)** by NASA on May 10, 2023.

⊙ **PHOTO:** M78, a nebula located in the Orion constellation, is a cosmic cloud of glowing gas and dust where new stars are born. When you look at it, you see the light from these young stars bouncing off the surrounding dust. It's a bit like a celestial nursery where stars are taking their first steps into the universe.

CREDIT: Arun Vijay & Souhayl Ben Khaled, Abu Dhabi desert, UAE.

SHOULD WE LIE TO ET?

Sending messages to the cosmos might lead to unintended consequences

By: **Jade Sterling**

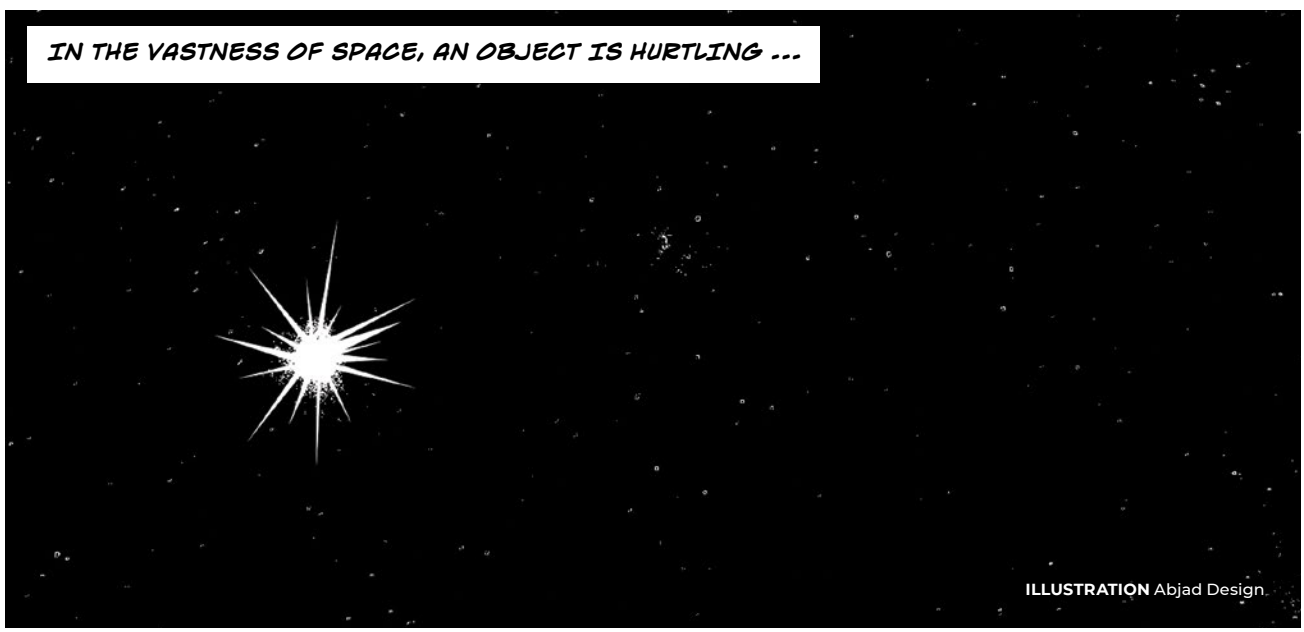


ILLUSTRATION Abjad Design

In a galaxy far, far away, a scaly green hand plucks a disk from the smoldering rubble of an unidentified spacecraft, shot down after attempts to communicate failed.

Earthlings would recognize a Voyager Golden Record immediately, but Carrex isn't sure what he's found yet. He has his ship's super computer scan the disk, and an image of human men running a track race flickers into view. Bach's Brandenburg Concerto No. 2 fills the air. How Carrex feels about this is anyone's guess.

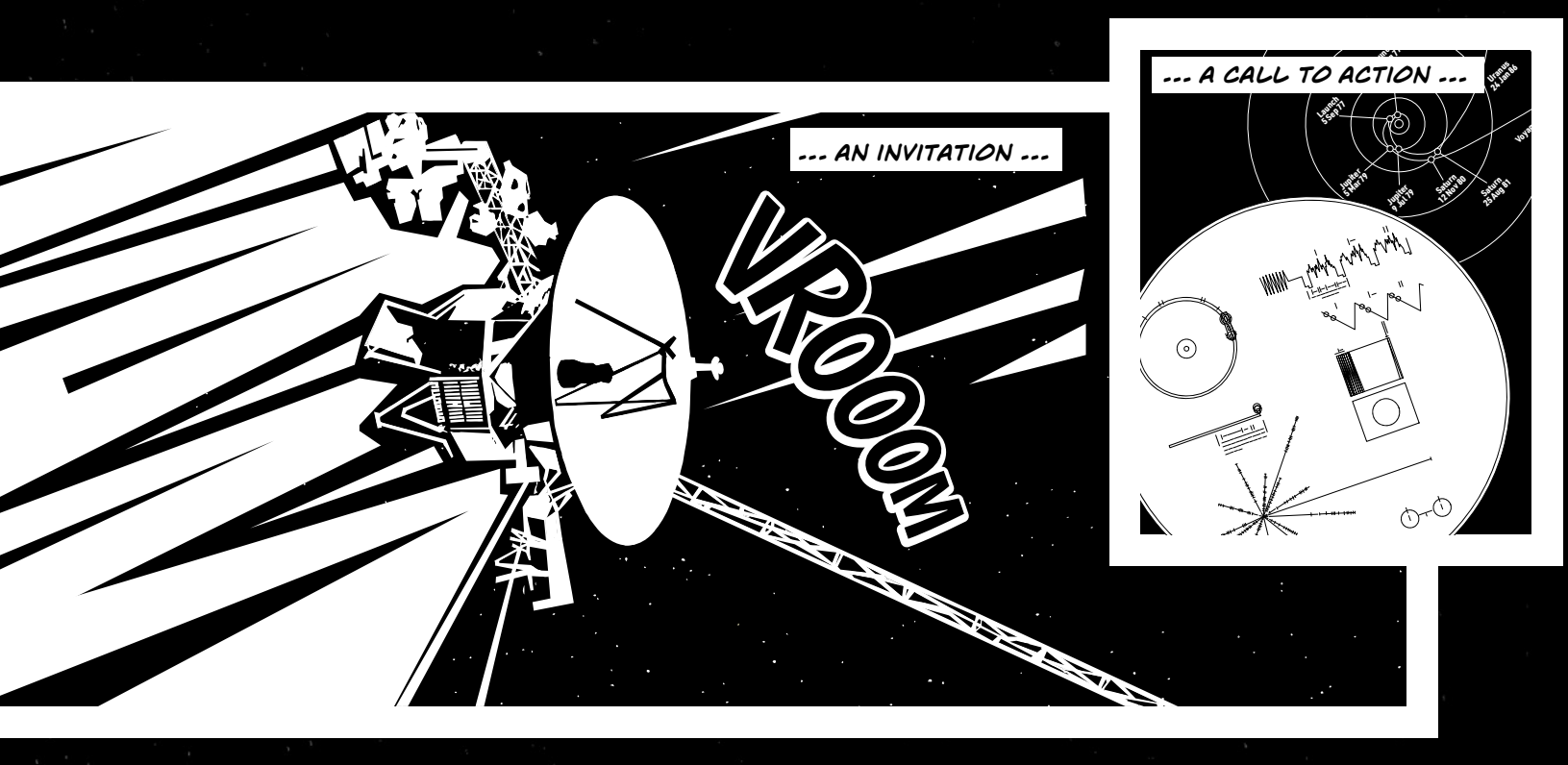
John Traphagan, professor emeritus at the University of Texas at Austin, isn't too keen on the music selected for the Golden Records, but is much more concerned about the images chosen.

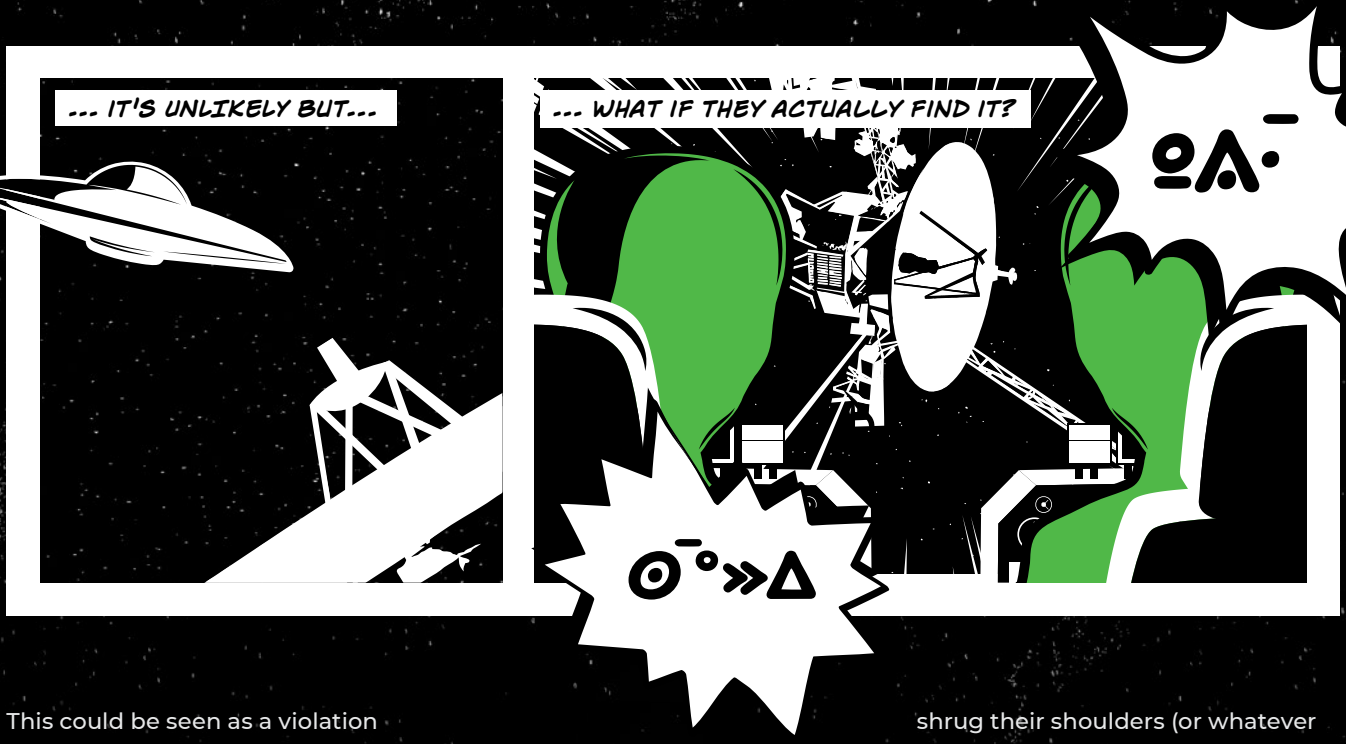
"The Voyager records are exceptionally biased toward presenting a picture of life on Earth as peaceful, devoted to the high arts (as defined by American intellectual elites) and engaged in noble activities such as space exploration," he writes in a 2021 article for Space Policy. "They covertly express what I term the 'Star Trek Imaginary' or a frame of thinking about space exploration to a potential interstellar traveler who happens upon one of the spacecraft.

The Voyager records do not represent an entirely honest representation of humanity or Earth; lying by omission is a form of dishonesty."

The Voyager Golden Records, which were sent into space in 1977 in the hopes of communicating with extraterrestrial life, contain a wide variety of information about human civilization and culture, including music, images and spoken greetings in multiple languages.

Traphagan argues this is ethically questionable. If we were to deliberately transmit false information about ourselves or our planet, we would be intentionally misleading potential alien beings. »»





This could be seen as a violation of the principle of honesty and integrity, and could lead to negative consequences for humanity if the extraterrestrials were to discover our deception.

"The disks paint an unequivocally rosy (at least from a human perspective) image of life on Earth — an exceptionally biased picture. The contents are at best quite misleading and at worst could be interpreted as intentionally deceptive.

This is where the problem with the approach taken by the team that created the records becomes significant. I can imagine at least three possible outcomes: the good, the bad and the ugly."

The good, in Traphagan's view, is a nonchalance: He says it's possible that a Carrex somewhere out there might explore the contents of the records, smile and move on. "It might even be the case that ET would not find it particularly important.

> **The Voyager records do not represent an entirely honest representation of humanity or Earth.**
>
> – John Traphagan

If they have the technology necessary to travel between star systems, they might just look at Voyager much in the way we look at a beaver dam — a mildly interesting, if unsophisticated, piece of technology by a somewhat intelligent species rather limited in its intellectual and engineering abilities.

"Perhaps there would be a little time spent looking over the spacecraft, but they might just shrug their shoulders (or whatever they have) and move on. It is always worth noting that it is a human conceit that members of a non-human civilization will necessarily be interested in talking to us."

However, if alien societies err to the imperialistic or belligerent, Traphagan worries the records send a very clear message: "There is easy prey on that planet situated here in relation to these 14 pulsars." He reminds us there is nothing on the record that would suggest a military capability on our planet, let alone thermonuclear bombs.

This is where the nuance in the question of whether or not we should lie to extraterrestrials comes in. There is an argument that because nothing on the records suggests we could or even would defend ourselves, it opens the door to exploitation by an alien intelligence.

But even the threat of alien invasion pales in comparison to Traphagan's "ugly" outcome. "Suppose our alien

travelers find the contents of the record interesting and decide they would love to visit this lovely planet, where people listen to good music, greet each other in happy ways, and live in peace and harmony.

What will they find when they arrive? Basically, all the stuff omitted from the record: the suffering, war, disease, pollution and exploitation that characterizes much of life on our planet.

The message of the Golden Record would look like a big lie, and it is fairly easy to imagine a huge, collective WTF running through those alien minds as they contemplate the intentions of a society that would send out incredibly deceptive messages about themselves."

Should we have sent the Golden Records in the first place? Traphagan certainly believes we created and launched into space a flawed and misleading message about the people sending it. The next question: If we do think we should be contacting aliens, who should create the message?

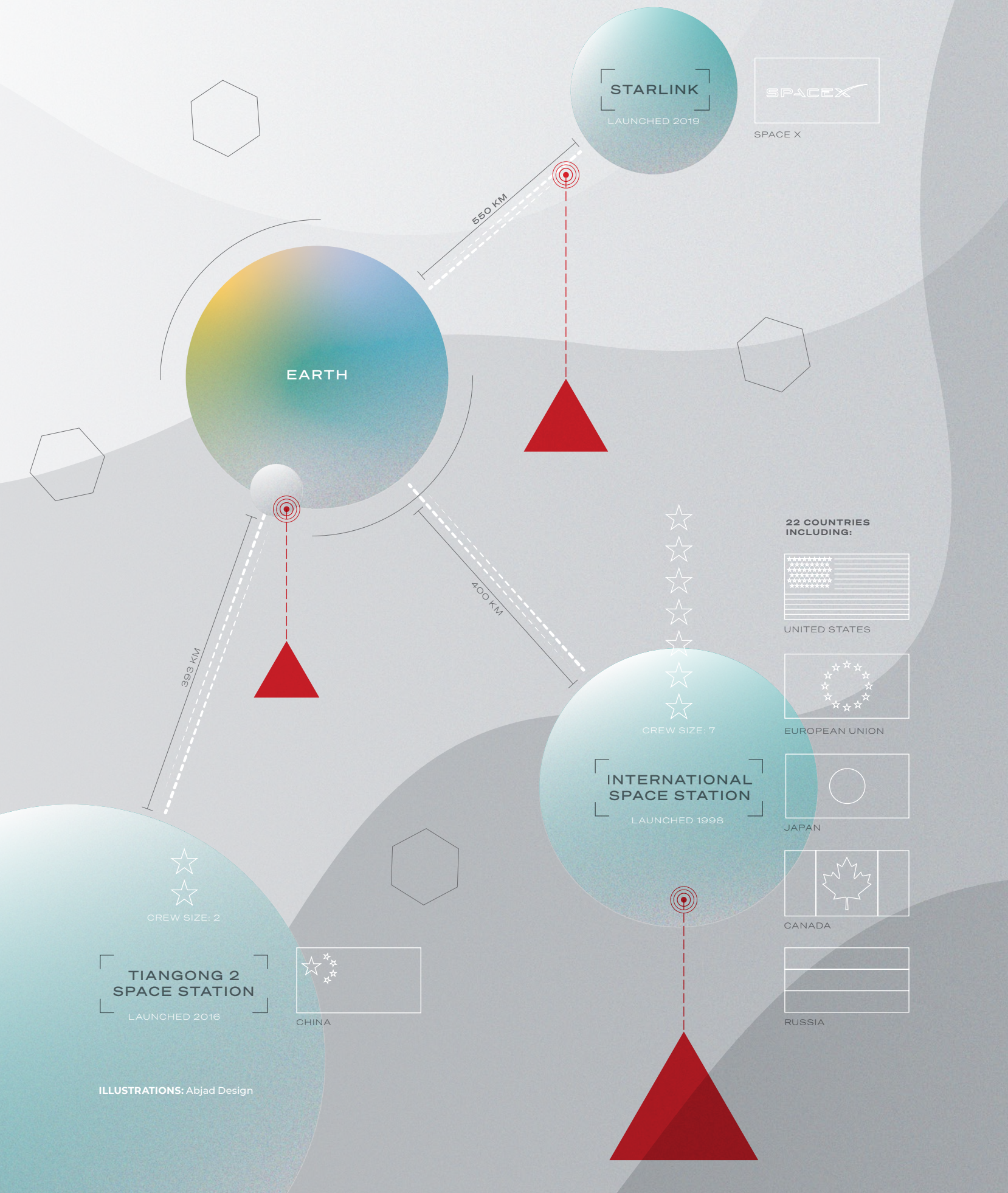
Kelly Smith, associate professor at Clemson University, likes the term "METI or REGRETTI." While SETI is the search for extraterrestrial intelligence, METI describes messaging them. REGRETTI should be self-explanatory. Smith's 2020 book, "Social and Conceptual Issues in Astrobiology," compiled articles exploring the "broader questions in astrobiology."

In his own chapter, he says debate about precisely what content should go into a message is largely beside the point as far as risk is concerned since any message will reveal both the location of Earth and the relative state of our technology.

"Any signal we send will contain at least two vitally important pieces of information: a) these guys are technologically backward, and b) they live right there," Smith says.

Perhaps attempts to communicate with extraterrestrial intelligence should not be led by astronomers or engineers, but by social scientists who specialize in intercultural communication. Perhaps we need space diplomats.

"Since we know nothing about aliens, parties on both sides of the debate are forced to rely on speculation of one form or another," Smith says. "For all we know, aliens might have motives that we have never encountered before. My argument is not that METI is a bad idea in general — I would personally love to push the transmit button and send a signal to every nearby system — just that we have not yet thought it through carefully and, until we do, we should err on the side of caution."



ILLUSTRATIONS: Abjad Design

SPACE INVADERS

Safeguarding our orbit from cyber threats

By: **Suzanne Condie Lambert**

Space was once a domain largely associated with government actions. Sovereign states were solely responsible for sending probes, satellites and crewed missions to Earth's orbit, the moon and beyond.

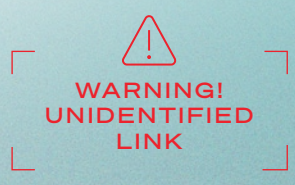
The technology was similarly segregated: Terrestrial and space systems were generally isolated from each other, creating a kind of "security by obscurity."

In recent years, however, private industry has launched into space, providing satellite services for telecommunications to the Earthbound that are projected to become a U.S.$1.4 trillion market by 2030.

These systems in space talk to the systems on the ground, and the scope is only growing. Cellphone users of tomorrow, for example, may be able to tap into satellites to seamlessly send messages when there is no terrestrial connectivity. Elon Musk's Starlink is a good, live example.

The World Economic Forum also points out that modern systems establish interfaces across "traditional trust boundaries," such as partners and customers. And more complex systems have more potentially exploitable attack surfaces.

With such growth and Earth-space network interconnectivity amid such other sectors as the military, aviation, emergency services and utilities, however, comes risk from those who might use those connections to steal, extort, sow chaos or wage war. »»



REAL-WORLD EXAMPLES

A series of cyberattacks in 2022, for example, targeted three wind farms operated by Germany-based companies.

A ransomware group supporting the Russian government said it was responsible for one of the attacks.

Christoph Zipf, a spokesman for WindEurope, a Brussels-based industry group, sees links to the Russia-Ukraine war.

Matthias Brandt, director of Deutsche Windtechnik, which maintains wind turbines and was one of the companies hacked, tells the *Wall Street Journal* that the renewable-energy sector will become an even more attractive target. "We need high IT security standards," he says.

Earlier the same year as the conflict unfolded, another attack linked to hostilities in the region targeted satellite modems, knocking out internet service in Ukraine and other parts of Europe for tens of thousands.

Ukrainian cyber official Victor Zhora called the hack "a really huge loss in communications in the very beginning of the war," CNN reports.

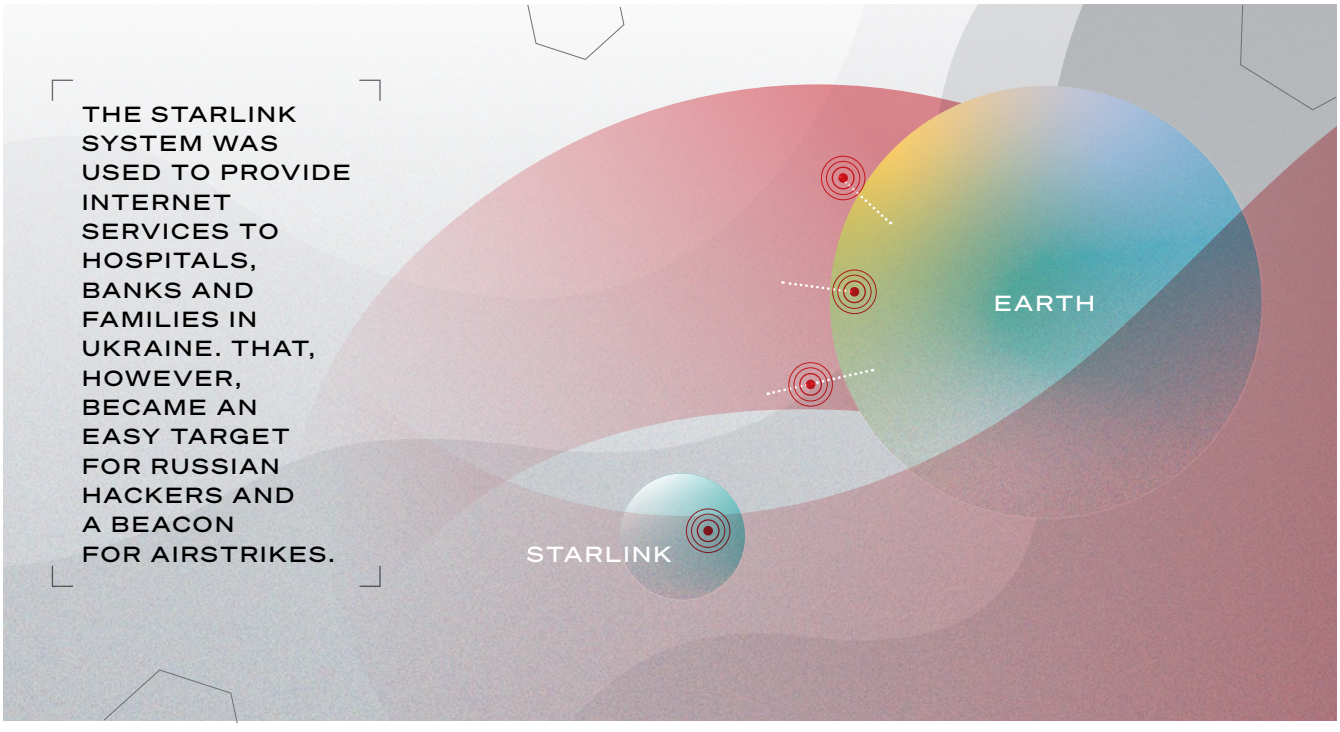
In response, SpaceX, which created the Starlink network of 3,335 active satellites, shipped truckloads of Starlink terminals to Ukraine in April 2022, providing hospitals, banks and families with internet access. The military also used the network, prompting Starlink to curb the country's use of the satellites for offensive drones.

By April 2023, the Washington Post was reporting on classified U.S. intelligence that concluded Russia was far more advanced in its plans to target the Starlink network than previously thought.

Additionally: "Starlink usage in Ukraine has been associated with Starlink users' uplink transmissions becoming beacons for airstrike," says Christina Pöpper, a professor of computer science at New York University-Abu Dhabi who focuses on information and communications security.

Space, it seems, has become an active theater in Earth conflicts. And the cyberattacks in this conflict could be a harbinger of many more such attacks to come. Even nations not involved in war have reason to be wary of cyberattacks in space, Pöpper tells *KUST Review*.

"(They) can have far-reaching implications, affecting various aspects of the lives of everyday people from communication and navigation to personal privacy, safety, economic stability and national security."



3 KINDS OF ATTACKS

Governments or rogue elements could target satellite systems in a number of ways. They can target services, rather than the satellites themselves, by hacking and GPS spoofing, as seen in the Ukraine conflict, denying millions access to essential services.They could also use anti-satellite weapons (ASATs) to target satellites in orbit.

Juliana Suess is a research analyst and policy lead for space security at the Royal United Services Institute, a defense and security think tank with headquarters in London. “ASAT attack consequences range from temporary and reversible to permanent and non-reversible,” she tells KUST Review.

> SPACE IS DIFFICULT.
> – Oxford University researchers

“The potential consequences are numerous. It needs to be borne in mind that a space system is made up of three basic elements — the satellite in space, the ground station on Earth and the links in between. All three are potentially vulnerable to attack.”

“For example, an adversary may take control (permanently or temporarily) of a satellite through hacking,” Suess says. “They may also disrupt (jam) or spoof the signal reaching or emanating from the satellite with temporary effect. A counterspace measure may also be to prevent a satellite from collecting information — for example by dazzling the sensors onboard of an Earth Observation satellite.”

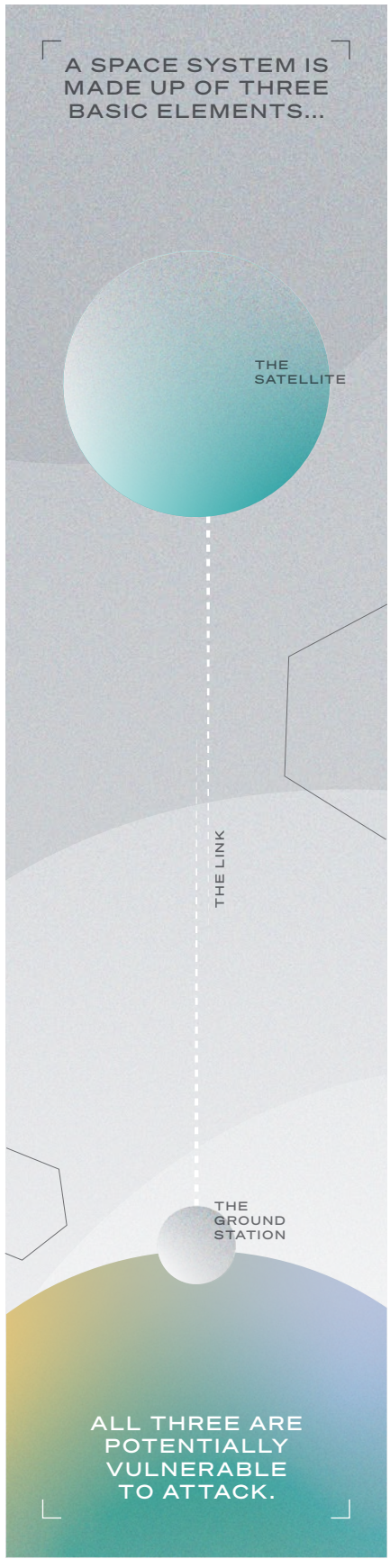
China, India and Russia have been criticized for testing physically destructive ASAT weapons on their own satellites. But such tactics are expensive, don’t guarantee success and can add to the growing problem of space debris.

The United Nations has approved a non-binding resolution calling for a halt to testing one type of such weapons, the debris-generating direct-ascent ASATs. It cited environmental issues and a desire to prevent an arms race in space. By April 2023, 13 countries, including the United States, Japan and Germany, had pledged to ban the tests.

“Space is difficult,” say Oxford University researchers in a paper published in IEEE. "A launch program alone does not guarantee the resources and precision required to operate a meaningful ASAT capability." And then there are cyber-ASATs.

These, the Oxford researchers say, “threaten the foundations of space's longstanding stability due to their high accessibility, low attributability and low risk of collateral damage.” In other words: They’re easy to use, hard to pin on the offender and probably won’t damage nearby satellites.

Without firing a rocket, the researchers say, belligerents could alter debris-collision forecasts to cause direct harm to space systems. “Cyber-ASATs are not merely a distant theoretical threat, but a real and present danger to the balance of power in space.” »»



MULTIPLE THREAT VECTORS

Threats, however, can be hybrid, warns NYU-AD's Pöpper.

"In reality, multiple threat vectors are often combined," she tells *KUST Review*. "Hacking and spoofing are part of cyber anti-satellite weapons.

We are dealing with whole infrastructures, so while spoofing satellite (GPS or other) signals typically happens during communication, hacking targets the satellites and satellite operation software, and cyber ASATs also encompass attacks (e.g., exploiting vulnerabilities) on ground control systems.

"Successful attacks can disrupt satellite communications, compromise control systems, manipulate data, and even disable satellites, potentially leading to loss of control, compromised missions, and significant disruptions to various sectors relying on satellite services."

> "Cyber-ASATs are not merely a distant theoretical threat, but a real and present danger to the balance of power in space."
>
> –Juliana Suess

A GOOD DEFENSE

So what are governments and businesses doing about the threat?

"There are a few defenses that can protect satellites — ranging from 'bodyguard' satellites (currently in the planning stage) that could accompany sensitive assets to simpler measures such as cyber defenses against hacking," says space-security expert Suess.

Pöpper, meanwhile, sees three tracks of interest:

- Develop and deploy secured space systems: "Recognize that space security is a real problem and thus support the development and deployment of secure space infrastructure, secure communication channels, integrity of satellite firmware and software, and satellite system hardening. There are many open research questions in this domain as well," she says.

- Collaborate and share information: "Share threat intelligence, best practices and lessons learned from previous cyber incidents to enhance the overall security of satellite systems."

- International cooperation and regulations: "Governments should collaborate internationally to establish common cybersecurity standards and regulations for space systems, promoting consistent security practices and enabling a coordinated response to cyber threats.

"I am aware that this can be a tricky ask beyond national boundaries, but the space industry in general has a long history of multi-national collaborations."

His Excellency Dr. Mohamed Al Kuwaiti, head of cybersecurity for the UAE, also sees the need for governments to work with businesses and other stakeholders.

"Cybersecurity is teamwork," he tells *KUST Review*, "and we have to involve everyone including government entities, industrial partners, academia and the community.

"That should be done at national and international levels."

HOW TO SAFEGUARD AGAINST THREATS:

DEVELOP AND DEPLOY SECURE SPACE SYSTEMS

COLLABORATE AND SHARE INFORMATION

ESTABLISH INTERNATIONAL REGULATIONS

CLEANING UP OUR SPACE

The human footprint is out of this world – and here's how we fix it

By: **Maggie Kinsella**

As the race to explore space intensifies, so does the problem of space junk. With millions of pieces of debris orbiting the Earth, scientists are sounding the alarm that the issue poses a serious threat to future space missions.

Earth's low orbit, 2,000 kilometers or less from the Earth's surface, is home to the vast majority of space debris. The debris consists of defunct satellites, upper launch stages, fragments from explosions and pieces left over when countries shoot missiles to take down their own satellites. Many pieces of debris are larger than tennis balls, and most no longer serve any functional purpose. Basically, there's a lot of garbage flying around up there.

And this garbage is flying at astounding speeds. Imagine you're driving home from work, traveling 80 kilometers per hour when a small stone flies up, striking your windshield. It makes a loud noise, and later you notice a crack in the windshield. The velocity of both objects — the car and the rock — determines the level of damage.

Now imagine you're traveling at over 25,000 kilometers per hour, and so is the stone. At this speed, collision with a stone would be catastrophic, but even something tiny can cause serious damage.

European Space Agency astronaut Tim Peak in 2016 noticed a crack in the observation window of the International Space Station. In a press release, Peak described a photo he took of the crack: "I am often asked if the International Space Station is hit by space debris. Yes — this is the chip in one of our cupola windows, glad it is quadruple glazed!"

The damage was caused by a rogue fleck of paint. »»

PHOTO CREDIT: NASA, Shutterstock

There are about 27,000 pieces of debris larger than 10 centimeters being monitored by the U.S. Department of Defense. More than 100 million smaller pieces fly around untracked. Any impact with other spacecraft, satellites or space stations could be devastating and in turn cause more debris, and so on and so on.

The chain reaction, theoretical at this point, is known as Kessler syndrome. Astrophysicist and one-time NASA scientist Donald J. Kessler proposed that at some point there will be so much debris in Earth's low orbit that it will continue to crash and create more debris, eventually becoming autonomous and unstoppable and making future space travel impossible.

Though Kessler syndrome is an extreme example, it's not impossible. John Crassidis, a professor at State University of New York and Buffalo State University, says he believes we will reach this point in this generation.

"I really think that we'll be in trouble in 50 years or less if we keep putting objects up in space like we are doing now," he tells *KUST Review*.

Though 50 years isn't far off, more imminent risks exist to satellites and other spacecraft in Earth's low orbit.

Crassidis, who works with NASA and the U.S. Air Force to monitor space debris, says the biggest risk is to humans — specifically to those doing extravehicular activities. "Debris is moving at 17,000 miles per hour. That can go right through a spacesuit, even a very tiny piece of debris," he says.

Other risks exist for active satellites in Earth's low orbit. This may not sound concerning but these satellites allow Earth dwellers to make calls on their iPhones, watch videos on TikTok, participate in Zoom meetings and make millions as YouTubers.

So, if these satellites are knocked out by debris traveling over 25,000 kilometers per hour, Gen X, millennials, and well, pretty much everyone, could be in for a trip — not to space — but back in time.

Among other concerns are for the 10 individuals living on active space stations. There are two inhabited space stations in Earth's low orbit — the International Space Station and China's Tiangong space station.

Space stations are protected by their outer shields from debris up to 1.5 centimeters in diameter, but other than that, it's either evacuate or duck. Thus far, both have proved successful solutions.

Russia in 2021 launched a rocket at one of its own satellites as a test, creating more than 3,500 pieces of debris and putting those living on the International Space Station at risk.

> **I really think that we'll be in trouble in 50 years or less if we keep putting objects up in space like we are doing now.** – Dr. John Crassidis

The astronauts were forced to move into their spaceship capsules docked on the station should they need to make a quick get-away.

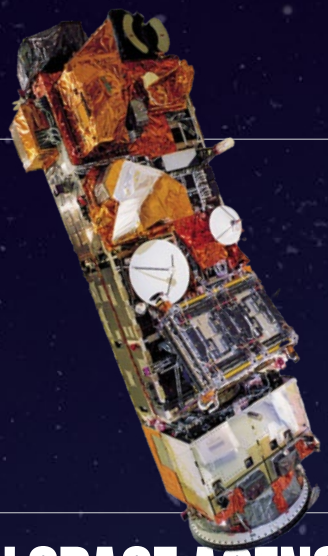
And in October 2022, the International Space Station had to be raised by 0.2 miles to avoid more fragments resulting from this test.

This evasive maneuver — with a price tag of about U.S.$1 million — was effective, but even a collision with a piece of debris between 1 and 10 centimeters in diameter could cause damage costing up to U.S.$2 million to fix.

Crassidis says this is only one of more than 20 maneuvers the space station has performed to avoid large pieces of debris.

Though moving the space station is currently a feasible — albeit expensive — solution, experts are concerned that with the increasing volume of debris each year, a safe space environment will cease to exist. ›››

PHOTO CREDIT: NASA, ESA, Shutterstock



34,000
PIECES OF SPACE JUNK

BIGGER THAN **10 CM**

2,000
DEAD SATELLITES

AND MORE INCLUDING PAINT FLECKS

THE LARGEST PIECE
8,200 KG

EUROPEAN SPACE AGENCY ENVISAT SATELLITE

WEIRD PIECES OF SPACE DEBRIS INCLUDE:

- A SPATULA
- A TOOLBAG
- A TANK OF AMMONIA
- STAR TREK CREATOR GENE RODDENBERRY'S ASHES
- ASTRONAUT URINE
- A CAMERA
- A PAIR OF PLIERS
- A GLOVE LOST ON THE 1965 GEMINI 4 FLIGHT

BUT WHAT IS THE SOLUTION?

While the United Nations holds guidelines for space-debris mitigation, there is no legislation in place to hold space explorers responsible for their mess. So, it's basically down to innovation and doing the right thing.

"We can't even get countries to follow United Nations Guideline Number 4: Avoid intentional destruction and other harmful activities. Our leaders need to start talking with each other. That's the first step, but not all countries are doing that. We (the Americans), the Europeans and other countries do follow many of the guidelines," Crassidis says.

So, while some governments are doing what they can to clean up their mess, start-up businesses are popping up to pick up the pieces. Take Japanese company Astroscale, for example.

PHOTO CREDIT: Shutterstock, Astroscale

RIGHT: Japanese company Astroscale is hoping to inspire a movement of space cleanup.

LEFT: Debris orbiting the Earth poses a risk to satellites, astronauts and future space missions.

Astroscale offers space-debris removal as a service. Space programs or private companies world-wide can hire it to collect debris and drag it into Earth's atmosphere to burn up.

Astroscale plans its first official removal mission to take place in 2025. The company is hoping to inspire a global movement of debris removal.

In the meantime, the European Space Agency has partnered with start-up Clearspace to launch a claw that will grab hold of space junk and pull it back into the atmosphere to burn up. The claw is expected to remove its first piece of debris in 2025.

Until these projects become regular practice, Crassidis' research focuses mainly on prevention by "trying to determine the characteristics of debris from unresolved images. These updated models can be used to better predict where the debris is in space, thereby helping to better determine the probability of collision with functioning satellites," he says.

Crassidis and his colleagues are also working on a plan to recycle space debris but, "This technology is 15 to 20 years away from being practical."

Crassidis says that one day there will be a practical and affordable solution to space debris.

"What is today's science fiction is tomorrow's reality. The best thing we can do is follow the U.N. guidelines, slow the growth of the debris, and then have technology catch up to clean it up," he tells *KUST Review*.

> **What is today's science fiction is tomorrow's reality.**
>
> – Dr. John Crassidis

THE SOLAR **CRADLE**

The story of how our planets were born

By: **Mohamed Ramy El-Maarry**

In the past few decades there has been a substantial leap in our understanding of how our solar system formed and how the planets came to be in the positions we see today.

Indeed, a bird's eye view of our solar system reveals a number of defining characteristics that intrigue scientists. The inner part of our solar system is dominated by small "rocky" planets including Earth. As we move out we encounter the gas and ice giants. Jupiter and Saturn are mainly composed of hydrogen and helium (similar to the sun's average composition), while the ice giants Uranus and Neptune show a high concentration of ices, or what scientists tend to call "volatiles."

When seen from above, all planets orbit around the sun in a counter-clockwise orientation and in nearly circular orbits. Furthermore, almost all planets rotate around themselves from west to east, in what we call "prograde" rotation. Any valid scientific theory or a model for the formation of our solar system needs to address these collective properties of our planetary system. Planets also host a vast collection of moons: Small planets have few or no moons while larger planets have tens of moons on average.

However, there are more pieces to the puzzle of our solar system! As we move beyond Mars to Jupiter, we encounter small bodies that similarly orbit the sun, called the asteroid belt. And if we continue farther out

beyond Neptune, we encounter an even larger collection of small bodies in what is called the Kuiper belt.

Scientists have built a solid model for how our solar system formed from a cloud of gas and cosmic dust called a nebula. Nearly 4.6 billion years ago, a rotating nebula started to gravitationally collapse on itself, leading to concentration of materials in the center. As gravity led to an increase in matter toward the center of the nebula, more grains and solid materials in that area collided and temperatures rose in the center of the nebula.

The hot center is where our sun was born. Furthermore, as mass concentrated in the center, the rotating nebula started to spin much faster, leading to a shift from a somewhat spherical cloud to a structure that would eventually become the "protoplanetary disk." In this disk, materials continued to merge with each other, forming larger blocks. The variations in temperature within the rotating disk are the main reason planets have different compositions.

In particular, the inner part of the disk was too hot for ices and other volatiles to condense from a gaseous state into a solid state, so planets in the inner system are relatively devoid of such volatiles. We also know now that the planets orbit around the sun in the same direction because this was the direction of the original nebula's rotation.

Small bodies are the remnants of this complex process. They are the spare "LEGO" parts of our solar system. When we study the asteroids, we gain more information about the physical and chemical conditions of the inner solar system, including Earth.

Similarly, when we study ice-rich small bodies in the Kuiper belt and beyond, we gain more information about the conditions at the outer edges of the early nebula. The great thing about small bodies is that rather than travel long distances to study them, we can rely on them coming close to Earth's backyard. But how does this happen?

Large planets, particularly Jupiter, have a massive gravity that occasionally pushes small bodies in the asteroid belt toward the inner solar system. This creates the family of near-Earth asteroids that have been visited by numerous space missions. Such bodies may even penetrate our atmosphere and land on Earth as meteorites. Neptune has a similar, yet weaker, effect and can attract bodies from the Kuiper belt, shifting their orbits inward till they get captured by the outer planets as moons, or upon encountering Jupiter in their journey inward undergo a shift in their orbit allowing them to visit the inner solar system as comets.

These ice-rich bodies allow us to study the outer solar system without needing to go there. When these comets enter the inner solar system, their near-surface ice may turn from a solid to a gas state, lifting surface dust along the way and forming a bright "coma" around the body that can aid in its viewing. Scientists can use remote sensing techniques to measure the composition of the ices.

Small bodies are essential parts of the puzzle to help us better understand our solar system. Small bodies can also offer viable economic prospects in the near future given the vast wealth of precious metals and ores they contain.

Near-Earth objects can also pose threats to human civilization if they are large enough and their orbits put them in a collision course with Earth. As such they are a target of planetary defense programs and constant monitoring by Earth-based telescopes. So don't expect our interest in small bodies to dwindle any time soon.

The International Astronomical Union (IAU) has named an asteroid after **Mohamed Ramy El-Maarry**, director of Khalifa University's Space and Planetary Science Center. Earlier known as 2002 CZ, it has been named **(357148) El-Maarry.**

⊙ **PHOTO:** This illustration is an artistic visualization of a new star surrounded by a protoplanetary disk.

CREDIT: NASA/JPL-Caltech

IMAGES: Shutterstock, Freepik.
GRAPHICS: Anya Lambert & Anas Albounni

The terrestrial law's

final frontiers

As the people of Earth move out into the universe, old precedents will guide emerging legal questions

By: **Jade Sterling**

Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means. — Outer Space Treaty

It's the year 2122. A space tug owned by the Weyland-Yutani Corp. and diverted by a distress signal has discovered a potentially valuable asset on a distant planet. But rival company Blue Sun says it registered an intellectual property claim on the planet's biological resources even though it had never sent teams there.

Who should prevail in court? The scenario may be set in the far future, but the law the decision might be based on is rooted in our past.

Individuals In Space

All countries have laws, rules and governing bodies determining what is legal — and what is not. Emigrate to a new country, adopt a new legal system. But what about moving to a new planet or space station? Under which — or whose — jurisdiction would your new home fall? Would there be one at all?

Maritime law could be one model to follow. When a ship is in international waters, the laws of the country of registration apply. An American cruise ship in the middle of the Pacific follows the American legal system. Should that ship drift into another country's territorial waters, it would fall under the jurisdiction of the country whose territory it is physically in.

Currently, a spacecraft is considered an extension of its country of origin. So while on your space shuttle bus to your new home on the moon, the maritime international waters model applies.

Upon landing, that's where things get complicated.

According to the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (more commonly known as the Outer Space Treaty or OST), "outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means." »»

Space belongs to no one — no law applies universally. Literally.

Enter "extraterritorial jurisdiction." According to this principle, people are subject to the laws of their home country even outside its territories.

When a person is in another country, that country's laws supersede the home country's laws — but when they aren't in any country, like on the moon, the home country's laws do apply.

Two people on the moon could be subject to different laws. The 1998 Space Station Agreement says, "Canada, the European Partner States, Japan, Russia, and the United States may exercise criminal jurisdiction over personnel in or on any flight element who are their respective nationals." Extraterrestrial jurisdiction applies.

Yun Zhao is head of the department of law at the University of Hong Kong. In an article for *Space Policy*, Zhao writes: "Objects and personnel inside space objects that are transported from Earth into outer space do not enter a legal vacuum during their sojourn; they continue in a confirmed legal relationship with the Earth.

This legal relationship is maintained and connected by registration."

The Convention on Registration of Objects Launched into Outer Space requires entities to establish and maintain the registration of space objects. It's maritime law again, just in the vastness of space instead of the waves.

According to Zhao, whether the space object is governmental or non-governmental is of no consequence: If an American company launches a spacecraft, it's an American spacecraft and any person on board is subject to American law. So far, fewer than 700 people have been to space. All planned to return — but what will govern those who choose to stay there?

Extraterrestrial Human Settlement

The China National Space Administration has been rapidly developing its space program, including a successful landing of a rover on the far side of the moon in 2019, and Mars in 2021. It has expressed interest in establishing a crewed lunar base and plans to send crewed missions by 2030.

> *Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty.*

The Russian space agency, Roscosmos, has a long history of space exploration and has expressed interest in establishing a lunar base in partnership with other countries.

NASA plans to send astronauts back to the moon by 2024 under the Artemis program, with plans for long-term space exploration and settlement. Within the next 100 years, the UAE aims to establish a human settlement on Mars.

Historical explorations on Earth have taught us that whoever gets there first lays claim to the land. But can this — and should this — apply to the extraterrestrial? For the most part, current space exploration is an international collaborative effort.

The challenges of exploring and utilizing space are immense and no single country can achieve them alone. By working together, countries can pool their resources, share expertise, and spread the risks and costs of space exploration.

Look up at the International Space Station, a prime example of successful international collaboration in space, an unlikely if not impossible endeavor if it weren't operated by a partnership of five space agencies: NASA, Roscosmos, the European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA) and the Canadian Space Agency (CSA).

Space exploration is inherently a global effort, and if this spirit of collaboration can continue, the Outer Space Treaty of 1967 could be enough to protect humankind's interests in space. As no one may claim ownership of any celestial body, everything in space becomes the common heritage of humanity.

Perhaps this will suffice. Certainly, president of the International Institute of Space Law and ESA's special advisor for political affairs Kai-Uwe Schrogl believes in it:

"Common heritage is the only thing that can save us," Schrogl tells *KUST Review*. "We can learn from our experiences here on Earth and develop these principles of common heritage for space. Look at Antarctica or deep-sea mining."

In 1960, U.S. President Dwight D. Eisenhower proposed that the principles of the Antarctic Treaty of 1959 be applied to outer space.

The signatories to the Antarctic Treaty (of which there were only 12 in 1959, but a further 17 signed by 2010) recognize "that it is in the interest of all mankind that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord."

Sounds familiar. There are many overlaps between the Antarctic Treaty and the Outer Space Treaty, which makes sense: They're both remote, extreme environments with potentially valuable resources, and lots of people want to explore, exploit and possibly make territorial claims. While only 50 countries have signed the Antarctic Treaty, 112 countries are party to the Outer Space Treaty, with another 23 signed but not ratified. This is encouraging to those with Schrogl's worldview of optimism and common heritage, but there may be a more earthly reason: The Outer Space Treaty started as the 1963 Limited Nuclear Test Ban Treaty, which prohibited nuclear weapons tests or detonations under water, in the atmosphere or in outer space. One hundred twenty-six countries signed that one.

However, as Schrogl points out to *KUST Review*: "We haven't seen anyone break the Antarctica Treaty, and we haven't seen anyone break space law." »»

Within the next 100 years, the UAE aims to establish a human settlement on Mars.

As for claiming land, the Antarctica example works again. During the Antarctic Treaty discussions, many countries wanted to claim part of the continent by virtue of their citizens having reached there first, with some claims overlapping.

The moon and Mars may offer more surface area to divvy up, but just like it was decided no country could claim sovereignty over any part of Antarctica, so too should the Outer Space Treaty hold up. Zhao agrees: "More than 50 years after the OST entered into force, it is justifiable to hold that the non-appropriation principle has successfully ensured the safe and orderly development of space activities."

Commercial Space Activities

The increasing commercialization of space is leading to new legal challenges, particularly in the areas of intellectual property and the use of space resources. Private companies like SpaceX and Blue Origin are playing an increasingly important role in space exploration, and there is a growing need for regulation of their activities.

This includes issues related to liability, intellectual property and the use of space resources. As private companies begin to exploit resources like water and minerals on the moon and other celestial bodies, clear legal frameworks will need to be developed to govern these activities.

For the University of Hong Kong's Zhao, intellectual property protection plays a significant role in promoting the sustainable development of space commercialization.

"Over the past few decades, the space sector has witnessed an accelerated speed of commercialization," Zhao says. "Due to the advancement of space technology and gradual reduced cost of space exploration, private entities are looking for new chances to participate in the development of space commercialization. However, existing policies and treaties fail to consider international intellectual property.

"Given that space exploration heavily relies on technology, which certainly requires intellectual property rights protection, the expansion of space commercialization further enhances such demand. Without an explicit and standing legal basis in space law that provides IP protection to private entities, they may be deterred from investing and thereby actively participating in commercial space activities.

"Space commercialization cannot be disconnected from IP protection. The essentially public nature of outer space law appears to clash with the private nature of IP law," Zhao adds.

At its core, IP law relates to the establishment and protection of intellectual creations, such as inventions, designs, patents and trademarks. IP law offers economic incentive because it allows people

to benefit from the information and intellectual goods they create, protecting their ideas and preventing copying.

For the companies charging ahead in an unclear framework, the Outer Space Treaty holds up.

"Article II of the OST also states that outer space cannot be appropriated by means of use," Zhao says. "Therefore, from a legal point of view, neither the scientific use nor commercial use of outer space will ever be sufficient to validate a territorial sovereignty claim.

Landing on the moon constitutes a 'use' of outer space, but it does not and can never constitute a 'national appropriation' that leads to territorial sovereignty. The major purpose of Article II was to protect outer space from the potential conflict which may be caused by territorial or colonization-drive[n] ambitions."

While he wants further clarification for the future, Zhao isn't too worried for those private entities going forth now: "In general, the IP regime we have now should be fine."

Space Debris

With more and more objects being sent into space, the amount of space debris is increasing rapidly. This debris poses a significant risk to both manned and unmanned space missions, and there is currently no comprehensive international legal framework to regulate its removal.

University of Hong Kong's Zhao points to the Outer Space Treaty: "Article VI makes states internationally responsible for their national activities in space, and Article VII makes states internationally liable for their launch of space objects into outer space and the damage caused thereof.

Sounds simple enough, and Kaitlyn Johnson, author of the Center for Strategic and International Studies report on key governance issues in space, calls space debris mitigation one of the best developed areas of space law.

"Space debris is a growing problem with almost every launch," she writes. "Many space experts acknowledge that without norms of behavior or debris removal missions, the space environment may be permanently damaged.

> *We haven't seen anyone break the Antarctica Treaty, and we haven't seen anyone break space law.*
>
> *Kai-Uwe Schrogl*

There are several international mechanisms, national policies, and industry efforts to curb the creation and proliferation of space debris, but despite this progress, few international standards or norms exist."

The few that do exist, Johnson adds, are out of date with today's technology and the proliferation of commercial satellites. She points out the recent near miss between an ESA Earth observation satellite and one of SpaceX's first satellites for its broadband internet provision plan. The U.S. Air Force tracked the two satellites, noting the chance of collision as 1 in 1,000. In the end, ESA chose to maneuver its satellite away from the SpaceX orbital path.

"In just this single example, it is clear that the lack of agreed international norms and processes for space-traffic management could have caused a devastating event in the space environment," Johnson writes. "A lack of defined international regulations means the choice of how to proceed is left to the satellite operators, but in cases where satellites are not operational, and cannot be maneuvered out of the way, all the international community can do is wait and watch."

P.J. Blount, IISL's executive secretary and lecturer in law for Cardiff University, firmly agrees the most pressing concern for policymakers is the safety of operations in Earth's orbit.

"At the moment, there is increasing congestion in parts of Earth's orbital space, which has been coupled with a proliferation of space debris," he tells *KUST Review*. "Space operations are coordinated through a variety of ad hoc frameworks, but as operators and objects increase these frameworks are strained under these burdens.

While understanding how resource activities may work out in the future is important, on-orbit congestion and the need for space traffic is a problem that the space industry faces today."

Johnson says 2019 saw the real start of united efforts to better coordinate space-debris management and space-traffic management measures. It started with the International Astronautical Congress in 2019, she says, where the international »»

space community collectively called for better space-situational awareness and the need to mitigate debris-creating events in the space domain.

Later that year, the 92 member states of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) approved 21 new guidelines for space sustainability.

These guidelines are voluntary and not legally binding, but Johnson says they signify a united effort to track all objects in space and to limit debris.

Part of this is the guideline encouraging increased communication between countries and non-governmental entities, and a United Nations information platform to manage space traffic.

2019 also saw the International Organization for Standardization (ISO) update its primary document on space-debris mitigation guidelines, making its compliance requirements stricter.

The ISO crafts and promotes international standardization for policy areas including food safety, health care, agriculture, commercial technology and space.

Compliance with ISO standards is generally accepted as industry best practice, and Johnson points out that several nations follow ISO guidelines and either write the standards directly into their national policies or use them as a basis for crafting unique policy.

Developing international guidelines and policies takes time, and Johnson worries that real efforts to protect the space domain will not occur until a major debris-creating event takes place.

However, she also highlights the strong industry and multinational consensus that protecting the space environment and focusing on efforts to mitigate the creation of debris should be an international priority.

What Lies Ahead

"The 1967 OST was made before the era of space commercialization," Zhao tells *KUST Review*. "It contains only general principles; there is a need to further clarify the application of these principles in our modern life with a lot of new development.

"There are loopholes in the current legal regime and an urgent need for the international society to negotiate to come up with some documents guiding new space activities."

Schrogl also highlighted the need to update and develop space law for the modern space race, but remains optimistic about the future: "The threat that member states (of the OST) go alone is omnipresent," he tells *KUST Review.*

"We have cases and cases where we see this on Earth but we have also seen over the last 50 years or so where respect for international law and the rule of law is growing.

"Wherever countries think 'I can be first,' they try and find loopholes or even use brute force, and we have to be realistic about that. But at the same time, if you look at it with a historical perspective, it's not so bad how, in particular, space law has been applied and respected."

So what does 21st century space law look like? For Zhao, expert in intellectual property law, IP is the main concern. He highlights scientific experiments carried out in space where no countries can claim sovereignty and says we'll need to determine the rules for IP claims for these results. For him, whether the national legal regime would apply to these situations is the big question.

Schrogl doesn't know what the future holds for space law but recognizes the sheer number of issues to be ironed out:

"Space law has expanded. From the beginning, it was meant to provide an understanding of the status of outer space and the status of the actors in outer space.

"This it did extremely well: It's a space for free use and non-appropriation, states are responsible and liable, and private actors can only act if they are authorized by the states.

"This holds true today. But space law's extension has to regulate the behavior of these actors. We need provisions for space traffic management to avoid accidents and collisions, for cleaning space debris, and for long-term sustainability."

Space law isn't standing still: There's COPUOS working to develop guidelines and principles for the exploration and use of space resources.

The International Institute of Space Law helps international organizations and national institutions cooperate to develop space law, and the International Astronautical Federation leads space advocacy across 75 countries. There are 11 academic journals dedicated to space law and policy.

And while Schrogl admits progress is slow, "we're building a new dimension of space law."

Mining the moon

Resources from space might help humans settle other worlds or power life on Earth

By: **Maggie Kinsella**

PHOTO: Anas Albounni

CAPTION: This photo might look a bit strange, yet those are the actual colors of the lunar surface (with a bit of a push to make them distinguishable and more visible). Those colors come from the minerals found there. Areas rich in iron, for example, have an orange tint, while areas rich in titanium have a blue tint.

CREDIT: Ritesh Biswas

THE space race of the 1960s was about which country would put boots on the moon first. While some of the frontrunners are the same, today's space race is quite different: Today it's about who might build on the moon first.

It's been more than 50 years since a human set foot on the moon. Now China and the United States are working toward habitable long-term structures. But why would we want to build on the moon?

Basically, it's a first-come, first-served situation. No one owns the moon — there is no border divide, no land-ownership dispute and no indigenous aliens to bargain with — it's all just there for the taking. So, it only makes sense that everyone wants to take it.

Though the Outer Space Treaty states no one owns the moon and no one can own parts of the moon, the rules for private companies are ambiguous. In 2020 the U.S. Trump administration produced an executive order that allows private companies to mine on the moon.

And now that we know the moon isn't made of cheese, players are hard at work to get pieces of what it is made of. It must be something spectacular for them to want it so badly, right? Sorry to disappoint, but with the exception of a handful of new minerals, it's really not much different from what we have here on Earth.

"The Earth and the moon are made out of the same stuff because the solar system was made out of the same stuff," says Ian Crawford, professor of planetary science and astrobiology at Birbeck University of London.

— Locally sourced materials

The problem is that stuff here on Earth doesn't help us build structures in space, and that's the long-term plan: Build on the moon without carting materials all the way from Earth or robbing Earth of its resources. "Gradually increasing access to lunar resources may help bootstrap a space-based economy from which the world economy, and possibly also the world's environment, will ultimately benefit," Crawford says.

— Progress is underway

NASA in 2022 announced it hired four private companies to mine the lunar surface. The first is Lunar Outpost, a company with a mission to settle humans on the moon.

Lunar Outpost charged NASA a dollar for the private company's rover to pick up a bit of lunar soil, take a snapshot of it and transfer ownership to NASA. This marked the beginning of commercializing lunar minerals. It also marked the first action in NASA's plan to build a long-term dwelling for humans on the lunar surface by 2030.

NASA's Artemis program launched its first phase to test its new mega-spaceship in 2022. It was uncrewed — by humans — and it successfully returned to Earth with all of its mannequins and stuffed toy Shaun the Sheep unharmed. Artemis II will take astronauts on a junket around the moon, and Artemis III will be the boots-on-the-moon finale with an ultimate goal of establishing habitable bases. »»

— Printing a place to live

But for those bases they'll need building materials. And they'll use modern technology to produce them. This is where 3D printing comes in.

NASA has toyed in the past with 3D printing on the International Space Station, using lunar regolith for research purposes. But in 2022 the agency announced it had awarded a U.S.$60 million contract to tech-construction company Olympus to construct a 3D laser printer that will build on the moon and Mars.

China, too, is pursuing 3D printing. According to a 2023 Reuters report, China is hoping to use the technology to 3D print a lunar station. Its 2028 mission has a robot tasked with constructing a brick from moon minerals. This race is on.

The Chinese space program also aims to mine the moon for exploration purposes. And while building a safe, sustainable shelter on the moon is paramount for all players, so is the discovery of possible energy sources.

The United States and Russia have discovered five new minerals on the moon. But China's 2020 lunar mission resulted in the discovery of a sixth: a phosphorus mineral named Changesite-(Y).

On Earth, phosphate plays an essential role in plant growth. While it is not known what the phosphate from the barrel-shaped moon crystals will reveal, it could be a possible energy source for those long-term lunar visits.

Scientists in China analyzing the Changesite-(Y) crystal determined it contains an isotope of helium-3, which is scarce on Earth.

— A better nuclear material?

This discovery could be an energy game-changer, says Gerald Kulcinski, director emeritus of the Fusion Technology Institute at the University of Wisconsin-Madison.

"The amount of energy in the helium-3 on the moon could produce all the electricity needed on the Earth for about 1,000 years," he says. Astronauts from the U.S. Apollo program discovered in 1970 that helium-3 is in almost every sample brought back from the moon, Kulcinski says.

40 grams of helium-3 could provide the energy equivalent of **5,000 tons of coal**

Helium-3 is effused by the sun and transported through the solar system by solar winds. But Earth's magnetic field repels helium-3; only a small amount penetrates the atmosphere.

The moon, however, has about 1 million metric tons of the material, Kulcinski tells *KUST Review*. The moon's resources could be a proverbial goldmine for nuclear energy. Experts say 40 grams (eight teaspoons) of helium-3 could provide the energy equivalent of 5,000 tons of coal.

Because helium-3 is not radioactive itself, it could provide safer and cleaner nuclear energy. "He-3 is one of the advanced fusion fuels that can release enormous amounts of energy without the drawbacks of greenhouse gases from fossil fuels or large amounts of radioactive waste from fission reactors," Kulcinski says.

— What else is there?

So if there are energy resources in abundance on the moon, surely, you might think, there are many other untapped assets there too.

Sadly, you'd be wrong, says Birbeck University's Crawford.

Though much of the moon is unexplored, Crawford says he believes there won't be any significant future finds to benefit us on Earth.

He contends this race is about what we can use while in space — whether it's a lunar station or a Jeff Bezos hotel in Earth's low orbit — and the media hype of the race is geo-politics at play.

"It's interesting and important from a scientific point of view, and though there are only 10 locations on the surface of the moon from which we've actually collected samples and analyzed them, I doubt there are going to be any big surprises that are going to be relevant," he tells *KUST Review*.

LUNAR ODYSSEY H2O

Charting a journey through the history of lunar water exploration

For centuries, scientists have theorized about whether water exists on the moon. From bountiful lunar oceans to arid, thirsty regolith, theories of water on the lunar surface have been extreme.

Today there is no longer any need for theory as the lunar surface provides the answer to the question: Can I get a drink of water on the moon? Follow the science as it reveals how early theories led to what we know today:

2023 China mission discovers tiny glass beads containing water in lunar soil where meteorites smash into the moon. There are billions, perhaps trillions, on the surface each no bigger than the width of two hairs.

2020 NASA confirms water on the sunlit surfaces as well.

2018 A team of scientists confirms ice rests inside craters at both lunar poles. The temperature here never rises above -250 degrees Fahrenheit.

2008 Re-examination of lunar soil samples reveals H2O molecules.

1969-72 Regolith collected by the Apollo mission turns up devoid of water.

1960s Scientists theorize the extreme cold of parts of the moon that never see the sun could be home to frozen water.

1892 American astronomer William Pickering suggests that because the moon has no atmosphere, any water would evaporate.

1645 First map of the moon is produced by Dutch astronomer Michael van Langren, suggesting the dark holes on the moon visible to the naked eye are oceans.

PHOTO CREDIT: Darya Kawa Mirza

SEEING SPACE

Graphene and similar materials could help solve some of **the biggest issues facing space exploration**

By: **Suzanne Condie Lambert**

"Space exploration is a material-science saga, because independent of the electronics and so forth, materials are the enabling technology for the challenges that exist in space."

That's according to Carlo Iorio, director of the Center for Research and Engineering in Space Technologies at the University of Brussels. And the game-changers he's most excited about: graphene and other 2D materials. "2D materials can be used and embedded for solving (many) different problems," he tells *KUST Review*.

Graphene might be the granddaddy of 2D materials, but it is relatively new, discovered in 2004, winning Andre Geim and Konstantin Novoselov a Nobel Prize in 2010 for its isolation. The material is a single layer of carbon atoms in a hexagonal pattern. It is tough, flexible, light and offers high resistance.

"The properties of graphene are exceptional in many ways," says Yarjan Abdul Samad, who earned his Ph.D. at Khalifa University, studied the properties of 2D materials as a postdoc at Cambridge University, and has recently returned to Khalifa as an assistant professor in aerospace engineering.

Samad says the discovery of graphene launched a tidal wave of 2D material research: "There are thousands of new 2D materials now under investigation because of the discovery of graphene. It's as if a new periodic table has erupted," he says. "Every property can be utilized for an application not possible for traditional materials.

"That keeps me intrigued. For me, especially when I look at the challenges of space, whether it's thermal management or radiation protection or long journeys, there are so many issues that need unconventional solutions. 2D materials are versatile and tunable to solve many problems," Samad says.

Here's a look at some of the issues of space travel and settlement Iorio and Samad say 2D materials might address: »»

RADIATION PROTECTION

Space radiation is often considered the top limiting factor of long-term space travel, with astronauts likely facing risks of cardiovascular and degenerative disease and cancer.

"I may be biased on this, but top of the list (of 2D applications) is radiation protection. Everyone is concerned about radiation and there have been many radiation-related incidents. So, how can we protect against radiation?" Samad asks.

"It's a very complex phenomenon, and conventional materials won't work against galactic cosmic radiation. We need to come up with an approach where we can have selective protection." Graphene and hybrid solutions might be the answer, he suggests.

Space radiation is also on the top of Iorio's list of 2D applications for space – "first and foremost," he says. Space shields will allow human exploration over long distances, he says. "At present it's fairly challenging to settle on Mars."

Samad worked with the UAE's Mohammed Bin Rashid Space Center on the Rashid Rover project that was presumed lost when its lander apparently crashed in April 2023.

But plans are underway for Rashid 2, and Samad says studying radiation's effects on 2D materials is under discussion. "(This) is one of the most pressing challenges, in my opinion," he says.

SUITS & HABITATS

Advanced materials are required for making temperature-resistant suits and structures for people to use on Mars or the moon, Iorio says.

2D material molybdenum disulfide will play a role in this specific challenge, he adds. 2D materials could also be useful in other construction applications.

Khalifa University is exploring rubber-based components with graphene to not only withstand the extreme temperatures but help the infrastructure sustain moonquakes, Iorio notes. "If it's rigid (the structure) will break. Imagine if the cracks allowed the oxygen to escape."

Transporting materials from Earth into space is expensive. But 2D materials are light.

And Samad sees potential for them to turn matter found on the moon or other worlds into building blocks for settlements.

"There could be composites or hybrid materials," he says. "There are many approaches that can be taken." And once the habitat is built, keeping it a healthy environment for human residents could also fall on 2D materials.

"Graphene and graphene oxide can play a role in materials that can prevent the spread of bacteria and foreign biological elements," Iorio says. "Imagine if an epidemic spread in a sealed human base. We're at the level of a sci-fi scenario."

IMAGES: unsplash, Freepik.
GRAPHICS: Anas Albounni, Khalifa University of scienceand technology.

THERMAL REGULATION

"How can we stand the lunar nights and what kinds of materials can help with that?" Samad asks.

2D materials show promise: Not only can they resist the extreme temperatures of space, they are excellent candidates to transfer the heat from, for example, a sun-facing side of a craft to the side facing away, where the temperatures could vary by 200 Celsius.

And because 2D materials are, well, 2D, they require little space, freeing up room for bigger habitats. "In space you have a lot of heat that is lost. So (2D) materials like MXenes have been used because they have a low infrared signature," Iorio says.

PROPULSION SYSTEMS

"Another application is the propulsion system for a rocket. 2D materials can easily be functionalized," Iorio says. One possibility: sails made from graphene membranes powered by light from the sun or lasers, freeing spacecraft to travel farther and longer without having to carry fuel on board.

The craft would also be lighter, nimbler and easier to launch. The European Space Agency says graphene has passed initial tests that show it is a viable candidate.

EARTHSIDE APPLICATIONS

What we learn from our space exploration attempts can be quite useful for us at home too, here on Earth. The problems graphene and other 2D materials solve in space can easily be transferred to Earthbound issues, Iorio says.

"The problem of scarcity that we solve in space will be used to solve the problem of rising scarcity anywhere," he says. Filters and membranes developed for recycling water on a moon base, for example, can help conserve resources on Earth. "The technology that we develop for space is capable of exploiting every single drop of water, which is the same goal of a sustainable economy," Iorio says. "There is also a scarcity of power.

"That means that the concepts we develop for space are to use the least energy. Regardless of how far we get in space, this will possibly be used on the ground to reduce energy consumption."

Samad sees advances in radiation protection eventually protecting data centers on Earth whose systems are vulnerable to cosmic radiation. Additionally, thermal management in spacecraft could eventually improve technology for trains and transportation in general.

"In the Emirates there is a growing interest in sustainability," Iorio says. "Despite the luxury of the lifestyle, there is more attention to sustainability, reducing the carbon footprint and so forth.

"I have been in developing countries but one of the things that strictly relates space exploration with sustainable development is they share the need to tackle the scarcity of resources."

BACK DOWN TO EARTH

8 technologies born of the space race and 3 inventions that weren't, but you thought were

By: **Jade Sterling**

The space race — the Cold War competition between the United States and the Soviet Union — brought innovations not just into the aerospace realm but into everyday life. Here are eight technologies that came out of that period — and three you thought came out of NASA but really didn't.

Satellite technology and GPS

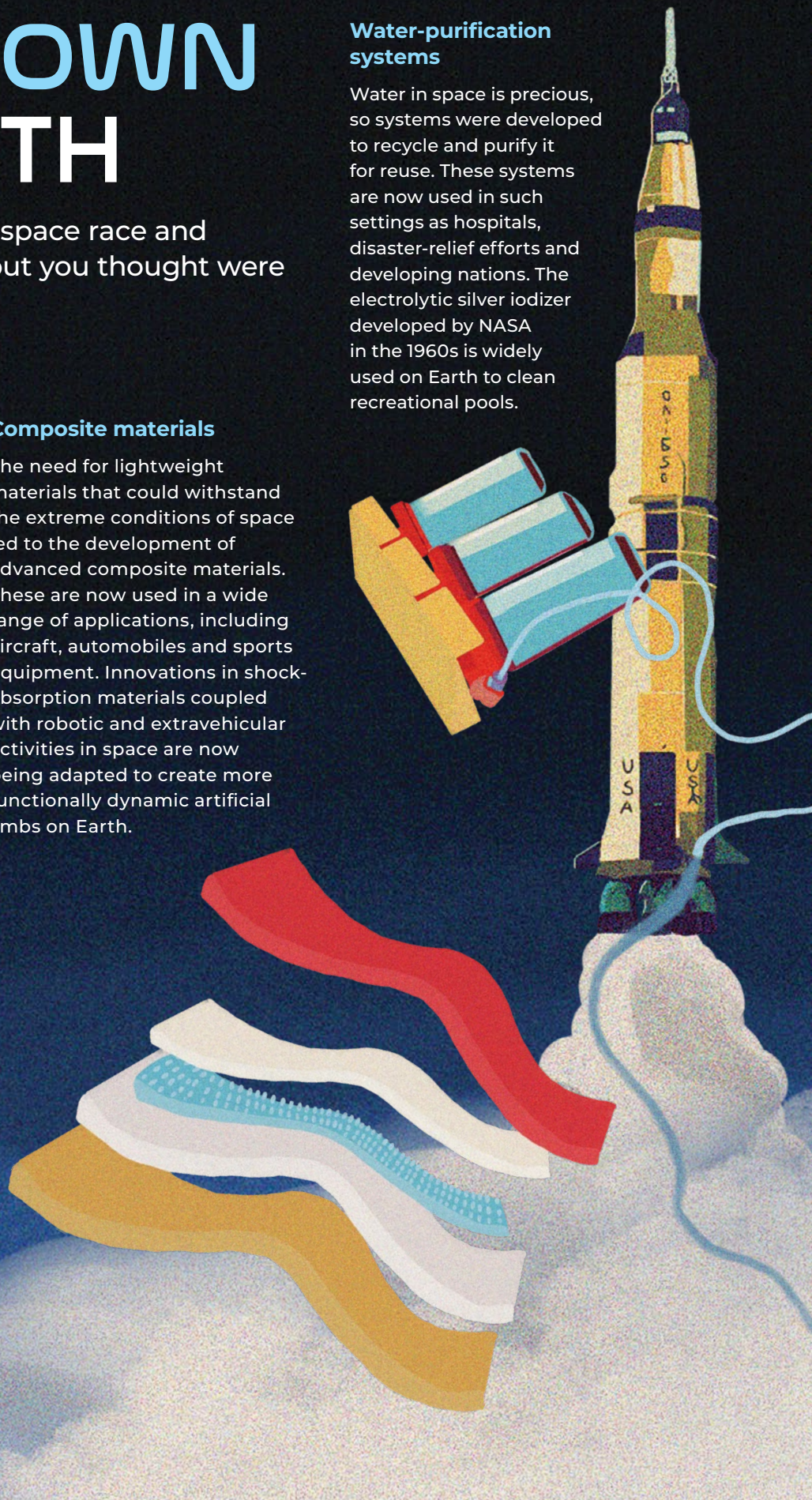
Satellites were developed as a way to communicate with spacecraft and relay information back to Earth. Today, satellites are used for a wide range of purposes, including communication, navigation and weather forecasting. The Global Positioning System (GPS) was developed to navigate and track the position of spacecraft. Now, the average consumer uses GPS for navigation, while farmers use it for precision agriculture. By combining GPS location data with readings from sensors on farming machinery, farmers are able to determine crop yields in different areas of their fields.

Composite materials

The need for lightweight materials that could withstand the extreme conditions of space led to the development of advanced composite materials. These are now used in a wide range of applications, including aircraft, automobiles and sports equipment. Innovations in shock-absorption materials coupled with robotic and extravehicular activities in space are now being adapted to create more functionally dynamic artificial limbs on Earth.

Water-purification systems

Water in space is precious, so systems were developed to recycle and purify it for reuse. These systems are now used in such settings as hospitals, disaster-relief efforts and developing nations. The electrolytic silver iodizer developed by NASA in the 1960s is widely used on Earth to clean recreational pools.



Smartphone cameras

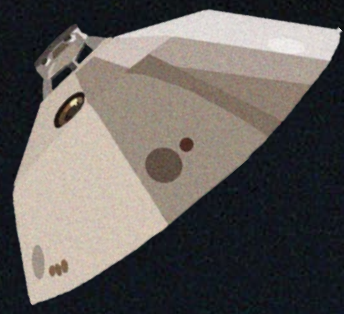
Experiments miniaturizing cameras for use in space led to the active pixel sensor now used in the standard smartphone camera. Today's smartphones also employ embedded web technology used onboard the International Space Station to conduct experiments remotely over the internet.

Insulation materials

To combat extreme temperatures in space, NASA developed insulation from aluminized polyester called Radiant Barrier, used today in home insulation. Plus, the foil blankets draped over athletes at the end of a grueling event evolved from a lightweight insulator NASA developed to protect spacecraft and people in space.

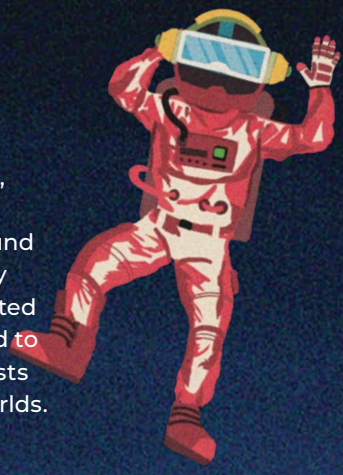
Medical equipment

The space race led to the development of medical equipment that monitored astronauts' health during long-duration missions. Plus, digital imaging technology developed for use in space helped create CAT scanners and radiography.



Wireless headsets and virtual reality

Astronauts need to float free, hence the development of wireless headsets. Earth-bound high-resolution virtual-reality systems use the head-mounted panoramic display developed to let astronomers and geologists study 3D images of other worlds.



Internet of Things

From embedded web technology came the Internet of Things: remote wireless connectivity between devices in smart homes, smart cities and wearable technology.

3 things NOT invented for space

Urban myths link NASA to many materials and gadgets. In fact, the agency didn't invent Teflon, Velcro or the powdered-drink mix Tang. Teflon had been around since the 1930s, Velcro since the 1950s and Tang was on the market just as NASA was finding its feet.

Mercury astronaut John Glenn drinking Tang in orbit as part of an experiment did, however, do a lot for the brand. NASA may not have invented these products, but it helped to popularize them. Having your product associated with astronauts and the space race connected it with science and discovery.

ILLUSTRATION: Abjad Design

WEIGHT LESS WELLNESS

By: **Maggie Kinsella**

ILLUSTRATION Abjad Design

Medicine prepares for astronauts' health needs on long-distance journeys

Astronaut health care — prior to, during and post mission — has historically been served by specialized medical doctors called "flight surgeons." While the name suggests surgeries are taking place in the air, it is rather misleading. But with longer space missions on the horizon, flight surgeons may soon be aptly named.

The role of flight surgeons, or aerospace medicine specialists, is varied but they are primarily responsible for the care of crews whether they are flying in space or in the air.

The current protocol is to stabilize the patient and send him or her back to Earth for medical intervention. That won't work for a seven-month journey from Mars, so is it time for flight surgeons to up their game with actual surgery? What could go wrong? Doing surgery. In space. In microgravity.

The problem: There is little knowledge and even less experience. To date, there have been only minor procedures in space. But there is a lot of research focused on medical obstacles to deep-space, moon and Mars missions to come.

PREVENTING BLOOD LOSS

Innovations are underway to prevent blood or other fluids escaping the surgical site in microgravity conditions.

A surgical fluid management system developed by the astrosurgical team at University of Louisville in the United States was tested in 2021 aboard a Virgin Galactic flight. The technology, funded by NASA's program to prepare for long missions, is basically a dome that fits over the surgical site to contain fluid. It is fitted with specific points where surgical instruments can be inserted without fluid escaping.

The fully automated test included injecting a blood-like fluid into the dome and manipulating the pressure within it to control bleeding. But the technology is multi-faceted and included tests of its irrigation abilities, suction and ability to vacate fluids from the dome. The dome keeps fluid in but also protects the surgical site from contaminants.

George Pantalos, head of the University of Louisville's astrosurgery team, said the device operated as expected. "There was a little bit of variation in how things worked compared to gravity on Earth, but they weren't showstoppers by any means."

The team is also working on ways to allow non-surgeons to perform emergency surgeries as well as a space-saving 3D printer that will print recyclable surgical tools.

SURGICAL ROBOTS

Another potential path to success: robotic surgeries. Remotely operated surgical robot MIRA (Miniature In-Vivo Robotic Assistant), created by Virtual Incisions' Shane Farritor, will make a jaunt to the International Space Station for testing in 2024.

The tiny MIRA robot will conduct small surgical-type functions inside a small compartment with simulated materials.

Robotic surgeries contain the internal organs and bodily fluids while reducing contamination. They also offer less invasive procedures with quicker recovery time, which means lower risk of infection – especially important considering microgravity's damaging effects on the human immune system.

MICROGRAVITY AND WOUNDS

Microgravity also appears to have an effect on wound healing. Current research indicates slowed cellular growth and decrease in collagen fibers. A 2022 paper published in *Nature* suggests that time spent in space leads to a reduction in red blood cell count in astronauts — a condition known as anemia. Oxygen-rich red blood cells are instrumental in building tissue for wound healing.

Space anemia was originally thought to be caused by initial exposure to microgravity resulting from bodily fluids shifting upward. Further research, however, shows that the anemia is present during and after exposure. This also should be considered for surgical aftercare on long-term missions. These are only a handful of challenges.

Then there is the matter of who is going to perform such surgeries. Currently medical officers on board spacecraft aren't doctors — they are flight crew with 60 hours of medical training. Flight surgeons monitoring the health of astronauts currently do so from the ground.

Flight surgeons for astronauts aren't typically astronauts themselves or surgeons for that matter. If flight surgery is in your path, however, you are in for a bit of a long haul. On top of a four-year degree, four years of medical school and three years of residency, it will be another two years of specializing in space medicine to reach the final »»

frontier, says NASA flight surgeon Rick Sheuring in an interview with the University of Strathclyde in Glasgow, Scotland. That's a 13-year journey, plus astronaut training. But it could just land you on the cutting edge of space-medicine development.

THE CURE

Though many of these developments are in process, Dr. Sergi Vaquer Araujo, intensive care medicine specialist and leader of the European Space Agency's space medicine team, says there will be limits to what can be done. This means astronauts will have to accept that there are health issues that simply can't be properly addressed in space. But some conditions can be anticipated and prepared for.

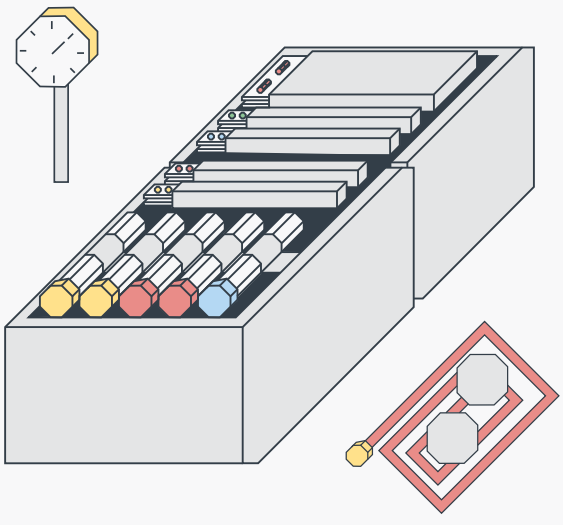
Vaquer Araujo's team works closely with NASA to prepare a kit that will address as many likely emergent scenarios as possible. Not necessarily open-cavity surgeries, but treating illnesses and performing procedures, such as suturing small wounds or extracting teeth, that have been performed on the International Space Station.

"Imagine a micrometeorite penetrates the vehicle and penetrates the chest of an astronaut, for instance, and then not having the tools to manage that. That would be a pity, and the person dies because I didn't have the tools," Vaquer Araujo says. What tools to take to space can be a high-stakes guessing game. "That's a very frustrating thing, but one has to be also realistic, and if you cannot have everything you need to assess the chances of that happening and if the chances are low, you need to take a gamble," he tells *KUST Review*.

He says astronauts are well aware of the risks, but as a doctor, there are still ethical concerns with sending people on a mission without every possible means to maintain their health and safety.

The European Space Agency and NASA have different approaches to how they build their medical kits, but they are complementary. The organizations continue to work to combine them. The philosophy goes something like this: It's not what happens, it's what the body needs to solve the problem.

"For example, if I'm bleeding, what I need is to stop the bleeding and administer fluids. But if I have septic shock, meaning I have a completely uncontrolled infection, I also need fluid and I will also need the same tools for both things to know the status," he says.



"What this all means is when you're in a critical medical situation and conditions escalate to a failure of a system, those failures are diagnosed with almost the same tools. So, our approach is to try to find all those commonalities and build our kit, so at least we have something to treat those commonalities. So, you do not think whether this could be a micrometeorite that penetrates the chest — you just know that if you have insufficient lung function, you will need oxygen," Vaquer Araujo says.

OTHER THINGS TO CONSIDER

He is encouraged by the fact that the ESA's kit and NASA's are in line up to 90 percent now. They also agree that at this stage, major surgery in space is not feasible. And the challenges of microgravity are not necessarily the major concerns.

For complicated open surgeries, a full operating room is imperative, which means more space in space is required. But this space would also require an amount of flammable oxygen that would put the entire crew at risk. Also to consider are the sterilization capabilities, which Vaquer Araujo believes is the biggest concern.

You also need the skill of an actual surgeon on board, but what if that surgeon is the patient? And what type of medical doctor do you put on board as the surgeon? What if you place an internal medicine doctor in the field and there is a trauma issue? And that "surgeon" spends the two years prior to the mission training as an astronaut but not treating patients — what risks does two years away from practicing pose?

The list of questions is unending. The cure, it seems, is time, innovation and a lot of money.

WHAT HAPPENS TO THE HUMAN BODY IN SPACE?

On Earth, we spend our days walking from room to room, home to car, car to office, running around the office, exercising and running errands. Every single step includes flexion and extension at the hip, knee and ankle, involving 200 muscles. Strong muscles contribute to bone density health. The stronger a muscle is, the more it pulls on the bones it's attached to, making them stronger.

This also means the weaker the muscles, the weaker the bones. So imagine if you were just floating about your day and not using any of the muscles or joints your body was designed for. What might happen to those muscles? And those bones?

According to NASA, lengthy stays in space can lead to muscle atrophy (loss) — a condition that astronauts aim to avoid with intensive strength-training sessions during missions on the International Space Station. Astronauts on a mission from five to 11 days can lose up to 20 percent of their body's muscle mass. Short-term missions don't have much impact on bone-density loss but longer missions do — and the effects are really noticeable upon return to Earth.

The normal weight bearing on the skeletal system on Earth can be a shock to weakened bones and would put them at higher risk of breakage and for osteoporosis. This risk factor continues to be an obstacle for long-term space stays for astronauts, with a monthly average of 1 to 2 percent bone mineral density loss. The World Health Organization says that an osteoporosis diagnosis is based on a 25 percent deficit on the average bone density of a 30-year-old. And osteoporosis is not reversible.

The International Space Station orbits the Earth at 400 kilometers from sea level and can be reached in anywhere from four hours to several days. NASA estimates a journey to Mars will take approximately seven months. This means by the time astronauts reach Mars, they could experience a 20 percent mineral loss.

But flight surgeons counter this with rigorous cardiovascular exercise and resistance training up to two hours daily. And after a six-month stay on the International Space Station, astronauts return with minimal loss. Dr. Sergi Vaquer Araujo of the European Space Agency says the hydraulic resistance machines to maintain muscle mass and strength enable the astronauts to walk very quickly after their return to Earth.

"They all lose bone, but the amount is always within a very big safety margin that would classify as a normal human bone mineral density," Vaquer Araujo tells *KUST Review*.

"All in all, what I'm trying to say is that if you look at the commonalities on how to treat those three things, bone, muscle and heart and vessels, they all benefit from exercise, our main drug, and we treat it as a drug.

"So that means what we're doing in space works for six months, the one-year mission (on the Russian and American side) showed that, yes, it (effects of time in microgravity) is more pronounced, but still is within manageable ranges."

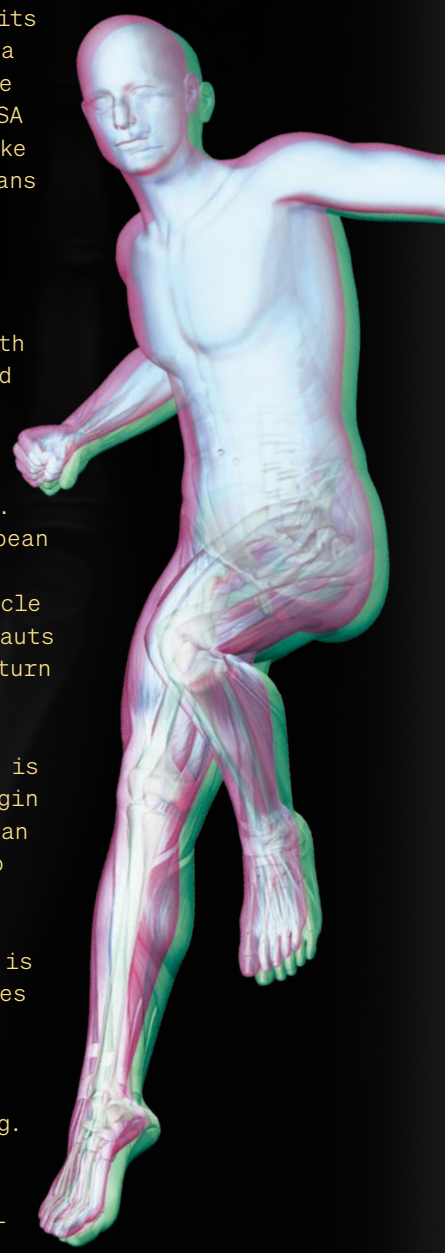
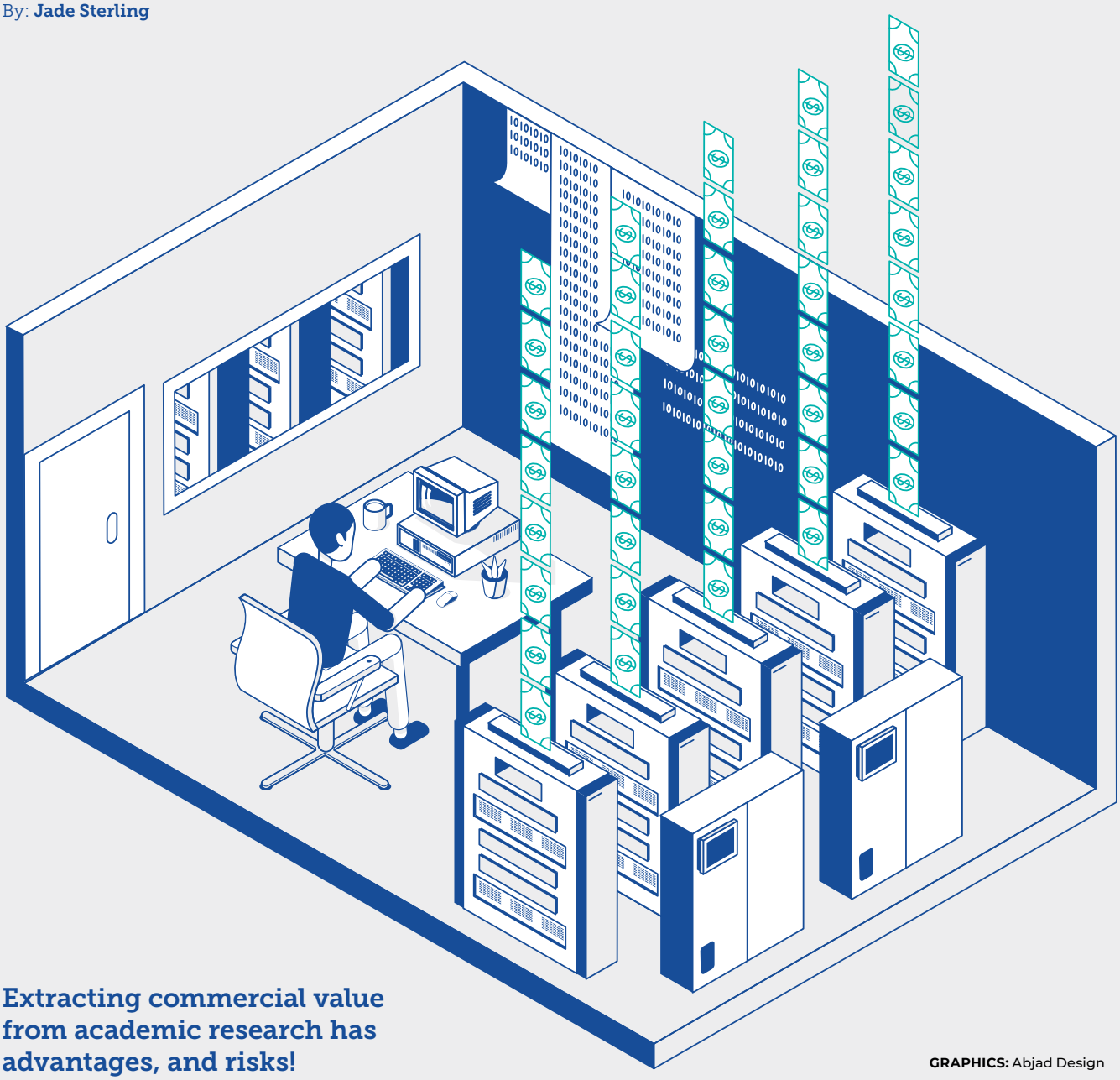


PHOTO FREEPIK

Researchers, Start Your Companies!

By: **Jade Sterling**



Extracting commercial value from academic research has advantages, and risks!

GRAPHICS: Abjad Design

The domain google.com was registered on Sept. 15, 1997. Prior to that, Google's founders, Larry Page and Sergey Brin were a couple of computer science doctoral candidates at Stanford University.

Take two theses, one algorithm, an initial prototype that used nearly half of Stanford's entire network bandwidth, and a patent citing another patent that turned into the Chinese search engine Baidu, and you've got Google, a trillion dollar tech company. And it all started with a university research project.

The university research community has always been under outside pressure — political, economic and institutional — that has had the potential to impact, for better or worse, the nature and direction of academic research. In recent years, a new type of pressure has descended on university-based research: increased emphasis on the commercialization of research.

Commercialization is the process by which a product or service is introduced to the market. It is the entrepreneurial push that translates research discoveries and new technologies from laboratory to market. Universities around the world offer incubation and accelerator programs and assistance to commercialize the research conducted in their facilities.

This makes sense: Research that can be used to solve pressing problems or improve quality of life is most impactful when in the hands of those who can benefit from them. To reach these people, research needs to hit the market. Additionally, taking innovations to market also provides an economic benefit. Whether it be through licensing technology to other companies or developing startups, commercialization provides new revenue streams.

A Crucial Role

"Universities play a crucial role in society as producers and transmitters of knowledge," says Parimal Patel, University of Sussex. "In recent years, the discussion about whether universities can encompass a third mission of economic development, in addition to research and teaching, has received greater attention. Many have argued that within the remit of the third mission, university-industry research collaborations are extremely important mechanisms for generating technological spillovers. At the same time, many governments have introduced an increasing range of policies encouraging the involvement of universities in technology transfer."

Things have not always been so. Licensing of inventions by academics became prevalent only in the early 20th century: In 1908, Frederick Cottrell received a patent to reduce industrial pollution, and in 1925, the University of Wisconsin-Madison founded its technology-transfer office to disseminate Harry Steenbock's discovery that irradiating food to increase vitamin D could treat rickets. Quaker Oats requested that technology, and the office licensed it in 1927. The U.K. established the National Research Development Corp. in 1948, leading to the first hovercraft in the 1950s, but it took until 1985 for an increase in academic entrepreneurship to appear.

Things changed in the U.S. with the 1980 Bayh-Dole Act. Formerly known as the Patent and Trademark Act Amendments, the Bayh-Dole Act created a uniform patent policy among the federal agencies that fund research, motivating more and more universities to become actively involved in the transfer of technology from lab to market. In the US in 2018, approximately U.S.$2.94 billion in licensing revenue was generated directly from technology transfer. Now, there's another push. »»

The Arab World Enters The Chat

Sami Bashir, director of Khalifa University's technology management and innovation office, says it is increasingly evident that universities in the Middle East want to make their mark in the world of research and development through sponsored research and technology transfer.

"In recent years, there has been a great emphasis in the Arab world for universities to incorporate an 'economic development mission' within their strategic vision and operation so as to contribute towards their local and regional economies," Bashir says. "Innovation and entrepreneurship have become cornerstones for the vision of new economies in this region.

Universities are viewed as promising outlets that not only provide scientific discoveries, but can also create business opportunities in the form of technology-based startups."

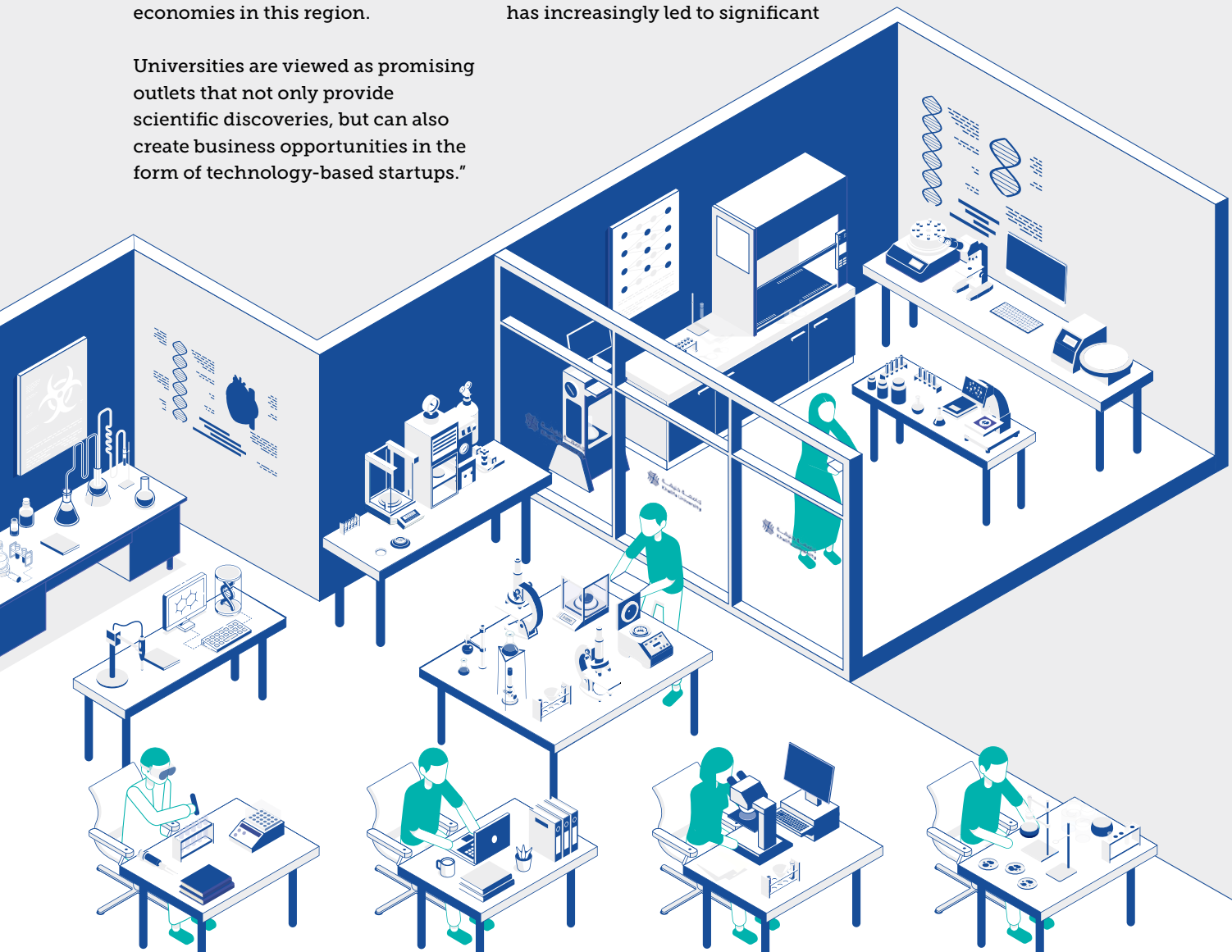
Dwindling Resources

Bashir says he believes the drive for economic benefits from scientific research stems from the global economic downturn and the drop in oil prices.

He says most Arab countries have relied on natural resources, such as oil and minerals, to support their economies, but these resources face scarcity and environmental challenges that would slow or hinder their economies in the near- and long-term.

Accordingly, he says, research and education funding has increased in most Arab countries. "Technology patenting and commercialization has increasingly led to significant advances in cutting-edge research, focusing primarily on innovations in life sciences, information technology, and software and data management," Bashir says. "Unfortunately, the existing regulatory framework does not suit development of new technologies, nor the creation of technology-based startups, but this is changing.

"Additionally, universities are steadily being regarded as more relevant to the technology marketplace and easy to do business with. As a result, more universities have begun to create formal research-administration or technology-transfer offices to support translation of business ideas into viable technology products or processes."



Not Everyone Is a Fan

Ubaka Ogbogu, associate professor in the Faculty of Law at the University of Alberta, Canada, says the increasing push to commercialize university research has emerged as a significant science-policy challenge, with socio-economic benefits but also potential risks that are not as often considered.

"Studies of research-policy trends suggest that the commercialization ethos and associated pressures are unlikely to relent anytime soon and may, in fact, become the central or defining mission of university-based research," Ugbogu said. "These studies also show that the push to commercialize is almost always presented as an unqualified social good that warrants broad governmental and institutional focus and support. Conversely, its risks and challenges are largely absent from policy statements and discussions."

A 2014 Pew Research Center survey of members of the American Association for the Advancement of Science found that 47 percent believed the pressure to develop marketable products was having an undue influence on the direction of their research, while 69 percent viewed a focus on projects expected to yield rapid results as having a similar influence.

Hyun Ju Jung and Jeongsik Lee, both at the Georgia Institute of Technology, reviewed nanotechnology patents filed between 1996 and 2007 in a study conducted in 2014, finding that the "government-initiated emphasis on commercialization" of U.S. university research "may undermine open paths towards novel technologies and hinder explorations of unknown fields."

Narrowing Research Scope

The government-initiated emphasis in this case came in the form of the National Nanotechnology Initiative (NNI), a U.S. government science and technology program launched in 2000. Jung and Lee consider the NNI a policy intervention that targeted the commercialization of technology with a focused research direction to promote national economic growth.

They found that since the NNI was implemented, U.S. universities have benefited from increased interest — and funding — from industry but have narrowed down their research scope. This ultimately reduces their discovery of potential novel technologies, meaning they are less likely to generate technological breakthroughs — which "appear[s] to be inconsistent with the NNI's objectives," as the authors say.

Nanotechnology may be a narrow area to focus on, but these findings do suggest that a focus on commercialization forces a narrow focus for research.

Ogbogu was hardly surprised: "Several studies have found associations between commercialization activity and data withholding, the erosion of collaborative research relationships, and an unwillingness or reluctance to engage in certain research trends, such as open science initiatives, which conflict with the financial considerations that underlie the pursuit of commercialization."

A Positive Impact Through Knowledge

One important aspect of knowledge sharing is the capacity to move research results from the laboratory into new or improved products and services in the marketplace. Commercialization of research is an important part of how science makes it to the public, which Ogbogu acknowledges. »»

"It is a primary means through which medical products and services reach the market and consumers, which can, in turn, advance public health."

He's not wrong: A study by Boston University found 153 drugs and vaccines were developed by public research institutions between 1981 and 2011. The COVID-19 mRNA vaccine originated from research at a University of Pennsylvania bench.

Consider also, that sharing knowledge from a university in an open-access manner would result in another company springing up to profit from its usage. If a company will exist or a license could be issued anyway, why shouldn't a university benefit directly? This is where the publish-versus-patent argument comes in.

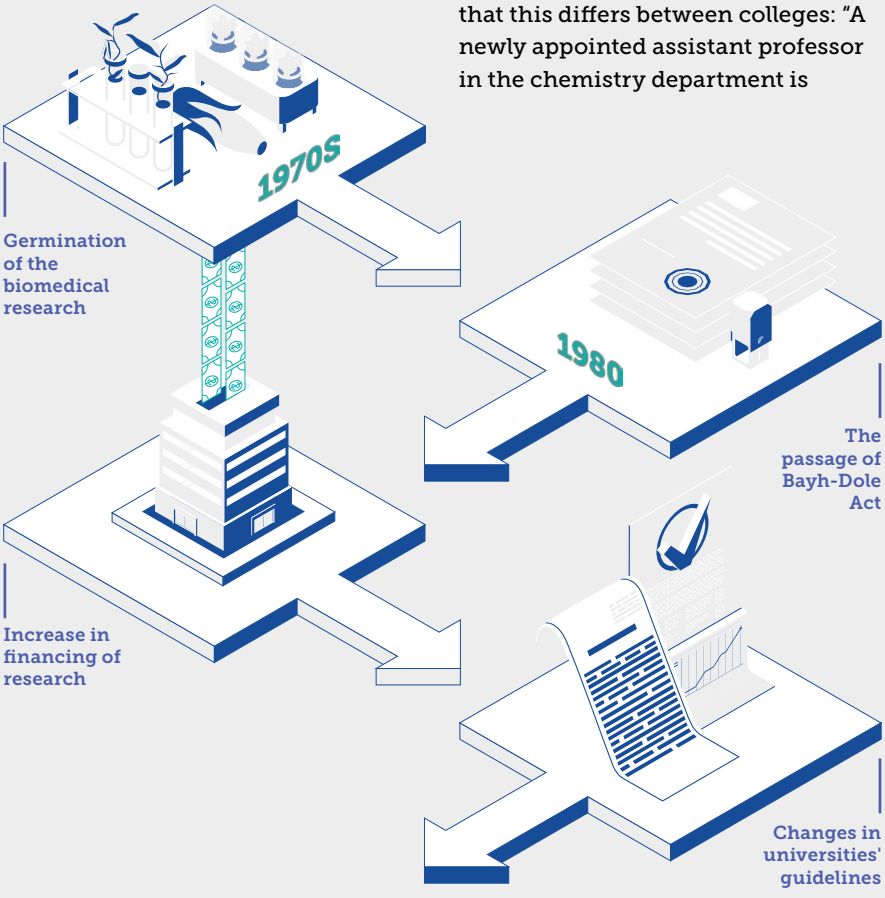
Publishing Dilemma

In most jurisdictions, a patent cannot be obtained if an invention was previously known or used by other people in the U.S. Understandable, but publishing results counts as making an invention known. To be awarded a patent, you have to file your application before you publish, speak about or present your work.

In a publish-or-perish world, however, researchers can hardly afford to not publish papers, present at meetings or discuss their work.

Gangotri Dey works in Cornell University's technology-transfer office, focusing on the physical sciences.

She recognizes that the main goal of most of the university's inventors is to publish their work in peer-reviewed journals but highlights that this differs between colleges: "A newly appointed assistant professor in the chemistry department is more eager to publish, whereas a person from an engineering college will likely think of patenting their invention before it is sent out for publication."



In Dey's experience, of the academics who do file and secure a patent, less than 10 percent are licensed to companies, with life sciences and the medical school securing the most funding.

The physical science division brings in less than 10 percent of the total revenue, showing that market success also tends to be field-specific and university goal-oriented. The other issue is the timeline.

"A typical patent takes about four years to be issued," Dey says. "This varies and some fields are so heavily backlogged it may take ten years to get a patent. I assume there is no peer-review journal article that takes this long! My biggest concern though is that we are comparing apples to oranges in this scenario.

"A peer-reviewed journal article should be for the basic science that needs to be communicated to the public that is paying for this research with their taxes.

"A patent is filed to benefit the public from a ready product. You can win a Nobel Prize for an invention, but you might not be able to patent that same invention. In my view, you can't compare the two."

Best of Both Worlds

So is it possible to have the best of both worlds? At the Khalifa University technology-transfer office, Bashir says with a laugh: "That's where we come in!"

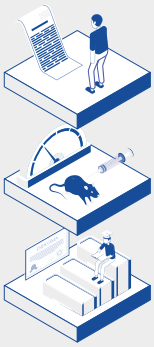
Time to visit your local TTO, folks.

The Shift to Startups

In recent years, there has been a paradigmatic shift toward commercializing technology through startups, rather than patents. University inventions tend to need substantial development before they are ready to go to market, and universities are now trending toward funding these startups. Potential is evident: Stanford University alone birthed Google and HP.

Thomas Astebro, professor of entrepreneurship at HEC Paris, says the dramatic increase in the rate of university spinoffs can be attributed to the germination of biomedical research in the 1970s; the passage of the Bayh-Dole Act in 1980; increased financing of research by industry; changes in university guidelines and behavior; and changes in the scientific ethos of faculty and researchers.

Creating companies takes extensive work, expertise and focus, and academic institutions are not historically designed or optimized for this. Those that can shift focus quickly and create and support startup companies built around innovations designed within their walls can increase the likelihood that those innovations make an impact. Just as university research creates many innovations, universities can also participate in the startup-creation process in many ways.



Lack of guidelines and policies

Considering universities as "houses of wisdom"

Technology readiness levels 1-2 / 9

Local Challenges

"We can and should learn from the experiences of universities in the U.S. and Europe, but the adoption of impactful technology-transfer models in the Arab world must be established through our own learning and experiences in ever-changing operating environments," Bashir says.

He says he believes universities in the Arab region experience challenges that can be categorized as internal and external, with the most pressing being the adoption of intellectual-property policies.

Among internal challenges, most universities seem to lack policies and guidelines that clarify the rights of researchers whose discoveries are commercialized.

The lack of such policies renders researchers more apprehensive in disclosing inventions to their universities or technology-transfer offices, Bashir says, which in turn reduces the chance of research commercialization.

Additionally, universities in the Middle East have been traditionally viewed as *beit al hikma*, or "houses of wisdom" — entities that provide academic scholarly activities, not industry-relevant applied research and development.

Establishing progressive external industry partnerships will be essential for attracting industry funds to university research activities and enhancing the delivery of research results to market.

"The biggest challenge is we mostly deal with technology readiness level one or, at maximum, level two," says Dey. Technology readiness levels are used to assess the maturity of a particular technology, with Level 1 the lowest and Level 9 the highest.

When a technology is at level one, scientific research is just beginning to be translated into future research and development, while Level 2 occurs once the basic practical applications have been applied to those research findings. Level 2 is very speculative as there is little to no experimental proof of concept for the technology.

"University research does not easily translate into a patent, product or company at such an early stage," adds Dey. "But this problem can be partially mitigated with more industry-university collaborative research or sponsored research projects."

As far as external challenges, the issue of patent or IP law comes top of the list.

"Patent law in general has been enacted only recently in the Arab world; for instance, in Saudi Arabia in 1985," Bashir says.

"In most cases, the patent system was established to protect technologies and businesses coming from outside and not home-grown inventions and technologies.

"It's clear that the patent legal framework here needs modernization and reforms to accommodate for the registration and protection of research discoveries coming out of universities.

"Technology transfer is not a stationary model. It is a dynamic and progressive model and continuously needs evaluation, assessment and modernization to be relevant and fit for purpose."

COVER: Three AI tools were used to create the images for this story: Midjourney to create the pictures; Topaz Gigapixel AI to scale them up; and Photoshop's experimental beta version to expand the height and width.

IMAGES: AI generated, *KUST Review*
CREDIT: Prompts & design by Anas Albounni, *KUST Review*

This artwork did not come from **a human brain,** *did it?*

Artificial intelligence could be the **future of creativity,** but the tool should be used with care — By: **Suzanne Condie Lambert**

If you were active on social media in the final months of 2022, odds are good you noticed a spike in avatars of your friends as fairies or anime characters or figures from a high-fantasy video game.

The images were from a company called Lensa, which uses artificial intelligence to turn selfies into art. And they had more than the social-media influencers buzzing.

The technology set off a new wave of debate about the role of artificial intelligence in art as well as ethical issues involving racism, stolen images and revenge porn. But others look ahead to a future where AI assists artists instead of competing with them.

The Lensa app, which uses the Stable Diffusion deep-learning model to render images in various art styles, was not the first use of AI technology to disturb artists worried about being replaced by computers.

In 2018, a piece of digital art called Edmond De Belamy, which was generated by a machine-learning algorithm, sold at a Christie's art auction for U.S.$432,500, well above its U.S.$10,000 estimate, setting off alarm bells among creatives fearing for jobs and the nature of art itself.

A similar cry erupted in September 2022 when Jason M. Allen won first prize in a digital category at the Colorado State Fair's annual art ›››

competition with an AI-generated piece called Théâtre D'opéra Spatial. Allen used Midjourney, which translates text descriptions into digital artwork (and has been used to produce images in *KUST Review*). But both images show that computer-generated art has more human involvement than the AI tag and Christie's promotional language for Edmond De Belamy ("This portrait … is not the product of a human mind") might lead you to believe.

Both pieces were products of humans: Edmond De Belamy by a Parisian art collective called Obvious. Both were initiated, selected, printed and promoted by those humans. And humans created the code that built them, infusing the final works with human aesthetics, biases and potential moral issues.

Humans behind the code

Remembering that it's humans, not soulless code, ultimately behind the AI product is important to keep in mind, says Ziv Epstein, a Ph.D. student in MIT Media Lab's Human Dynamics group who has an eye on the emerging technology.

"When we talk about AI as a creator instead of a tool, it undermines credit and responsibility to the artists involved in the creation of AI art," Epstein tells *KUST Review*. "Anthropomorphizing AI can undermine our capacity to hold people responsible for the wrongdoings of sociotechnical systems when an AI system commits a moral transgression: The perceived agency of the AI could be a sponge, absorbing responsibility from the other human stakeholders.

"We must be careful how we talk about AI and fight the current conceptualization of AI, typified by corporate-metaphysical circuit brains or embodied androids, lit by blue light and here to take your job. These narratives are not neutral and often cut along lines of power."

Baked-in biases

A wrongdoing Epstein might have in mind: Among initial users of the Lensa avatar generator, some people who wear hijabs and/or have dark skin reported that their images seemed to have more glitches than others' or didn't look much like them. And this cuts to deeper issues of racism and sexism baked into the code and reported on frequently in recent years.

A piece of **digital art** called Edmond De Belamy, which was **generated by a machine-learning algorithm,** **sold** at a Christie's art auction for **U.S.$432,500.**

"AI bias in art hurts Black and other communities of color in two very specific ways," says Mutale Nkonde, founder and CEO of AI for the People and a UN advisor on AI and human rights.

"The app Lensa used AI to create 'artist' impression avatars for users and a beauty filter that made non-white women appear more European.

"This may seem innocuous, but there is data that shows algorithmic recommendation systems used within the image-sharing app Instagram has been found to increase mental-health complaints among young girls because it amplifies images of women with unhealthy bodies.

"This could be true of women with non-European features who watch their physical appearance being erased and devalued," she tells *KUST Review*.

"This ethnic erasure contributes to the sales of skin-lightening creams in countries in Asia, Africa and the Gulf region and could result in women in these regions engaging in even more self-harming behavior.

"The second concern is the data privacy of the people using these apps in order to work," Nkonde says. "Users have to upload pictures, and in doing so give the company their biometric data which could be shared and/or sold to data brokers and then used to develop technologies like facial recognition.

"Facial-recognition systems in the West being used by law-enforcement agencies have problems recognizing people with dark skin and have led to the wrongful arrest of Black men." Again: Blame the humans behind the code.

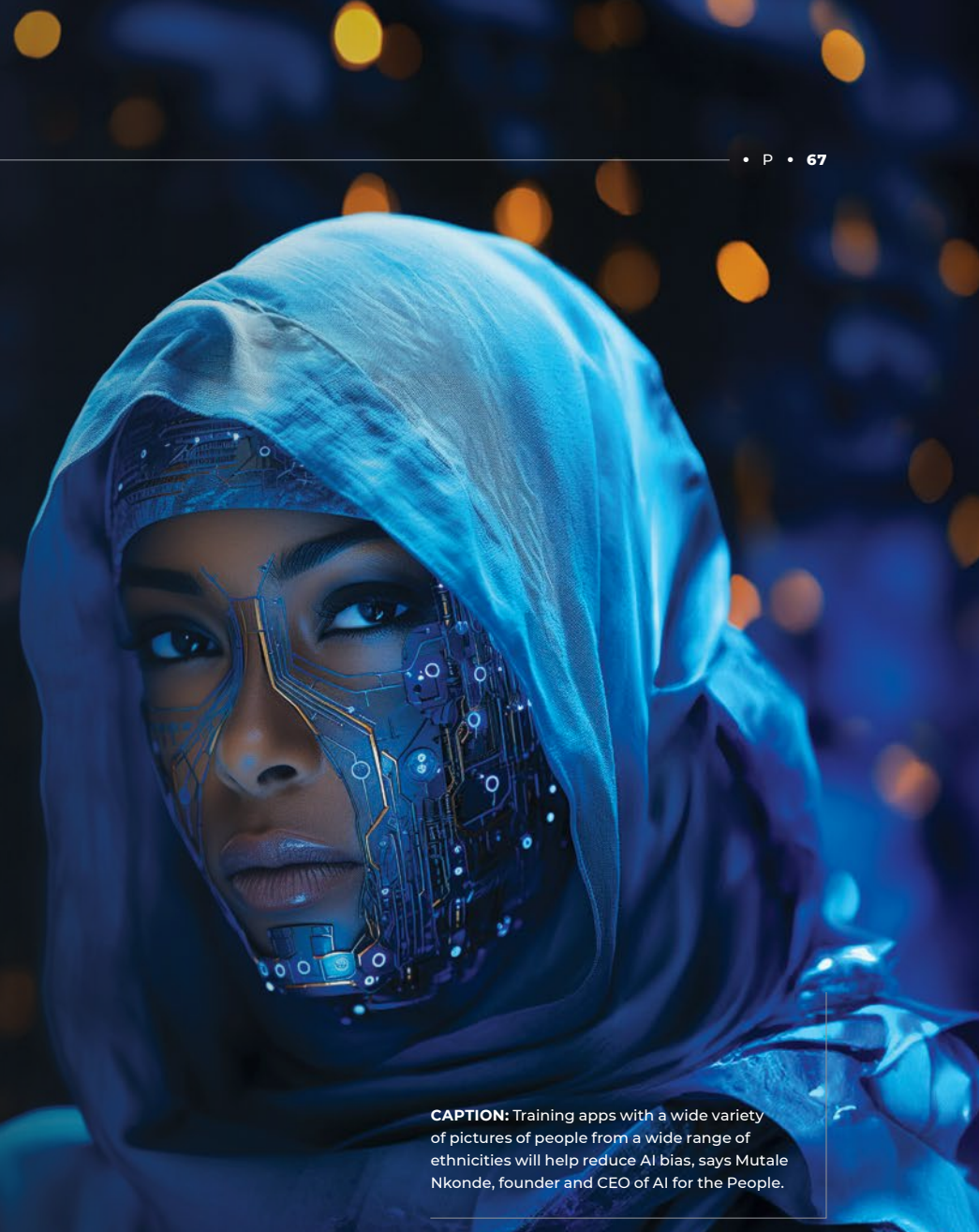
Expanded datasets

Nkonde sees a solution, however. "The best way to reduce these biases is by expanding the training datasets used to develop each app.

In terms of the Europeanization of visual culture that means training those apps with a wide variety of pictures of people from a wide range of ethnicities. That way an Arab woman using it will be given an image that shows her unique beauty," she says.

Without expanded datasets, apps and AI risk reflecting – and perhaps amplifying – biases. "The Stable Diffusion model was trained on unfiltered internet content. So it reflects the biases humans incorporate into the images they produce," Lensa says in its FAQ.

That unfiltered content used to train the model is also concerning to artists who fear their work is being used without their consent – and may damage their livelihoods by allowing the masses to replicate their style without paying for it.



CAPTION: Training apps with a wide variety of pictures of people from a wide range of ethnicities will help reduce AI bias, says Mutale Nkonde, founder and CEO of AI for the People.

Artists worry

One of them is Greg Rutkowski, a Polish artist whose high-fantasy digital illustrations of defiant wizards and rampaging orcs are familiar to fans of such games as Dungeons & Dragons and Magic: The Gathering.

His style was commonly requested on Stable Diffusion before the model in November 2022 changed its code to make it harder to copy specific artists' styles. "It's a cool experiment," he says of the people who used his name as a prompt. "But for me and many other artists, it's starting to look like a threat to our careers," he tells the *MIT Technology Review*.

Artists have countered with a site called Have I Been Trained, which allows creatives to search for examples of their own work among the 5.8 billion images scraped from the internet, including sites such as Pinterest, to train Stable Diffusion and Midjourney.

Some groups have responded by banning AI-generated art, including online artist community Newgrounds and visual-media company Getty Images, which cited fears of future copyright claims as laws eventually catch up with technology. Among the laws catching up with the accelerating technology: The United Kingdom in November 2022 announced plans to criminalize the sharing of pornographic deepfakes, often created as a form of revenge porn victimizing primarily women who don't know their faces have been digitally attached to others' bodies.

At the same time it changed its code to make copying styles harder, Stable Diffusion also introduced changes that make creating pornographic content more difficult. AI systems Midjourney and DALL-E 2 had previously banned adult-content creation. But other systems remain accessible to deepfake abuses. »»

A promising tool

Still, some creators remain optimistic about AI-assisted art. Alexander Reben used a machine-learning algorithm called GPT-3 to slough off a creative slump during the early months of the COVID-19 pandemic.

The algorithm, a language model trained by OpenAI like ChatGPT, which came later, writes original text – essays, news articles, even dad jokes – from a prompt. Reben played with the tool until he learned he could prod it to write the sort of text one might find on a label next to a piece of art on a gallery wall.

Reben pored through the outputs until he found some he liked, then created in real life the art they described. A whimsical story about an anonymous art collective known as The Plungers that created art with actual toilet plungers, for example, became an IRL installation as part of a series the AI titled "AI Am I?"

"As technology becomes more of an extension and amplification of our minds – just as a wrench is an extension of our hands and amplifies our physical ability – AI becomes more of a collaborator rather than a calculator," he writes for BBC.com. "Unlike creative tools of the past, such as Photoshop, photographs or pigments, we are now working with tools that seem to have generative imagination, but perhaps no 'taste.' The human in the loop adds an important curatorial role in determining the 'good' versus 'bad.'"

Or as AI-avatar creator Lensa says in a tweet: "As cinema didn't kill theater and accounting software hasn't eradicated the profession, AI won't replace artists but can become a great assisting tool."

> When we talk about **AI as a creator instead of a tool,** it undermines **credit** & **responsibility** to **the artists involved in the creation of AI art.**

Architecture student Qasim Iqbal, for example, uses Midjourney to visualize his designs. "With Midjourney primarily being a text-to-image generator, it encourages you to summarize and define ideas through words and teaches you to be specific," he tells *My Modern Met*. He says it helps him "test concepts, ideas and directions for projects," but "it should never be the originator of the idea."

Collaborators, not competitors

Others are embracing the technology by trading the pen or the brush for the word to create visual art. This is the emerging domain of "promptology" or the "prompt engineer," using a new set of skills to coax a desired image out of the models with carefully crafted text.

And then there is the utility of the technology for, well, anyone. NightCafe, launched in 2019 and named after Vincent Van Gogh's The Night Café, is one of the systems looking to fulfill the tech's promise of democratized art: "We create tools that allow anyone — regardless of skill level — to experience the satisfaction, the therapy, the rush of creating incredible, unique art," it says, with the caveat that it does not seek to "make artists redundant."

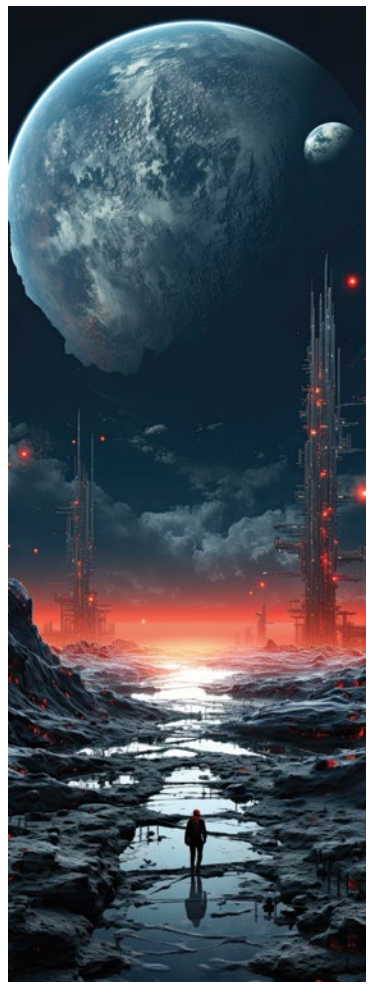
But for the "but is it art?" crowd, there's still opportunity to invest skill, thought, talent and effort beyond the push of a button to create with AI tools.

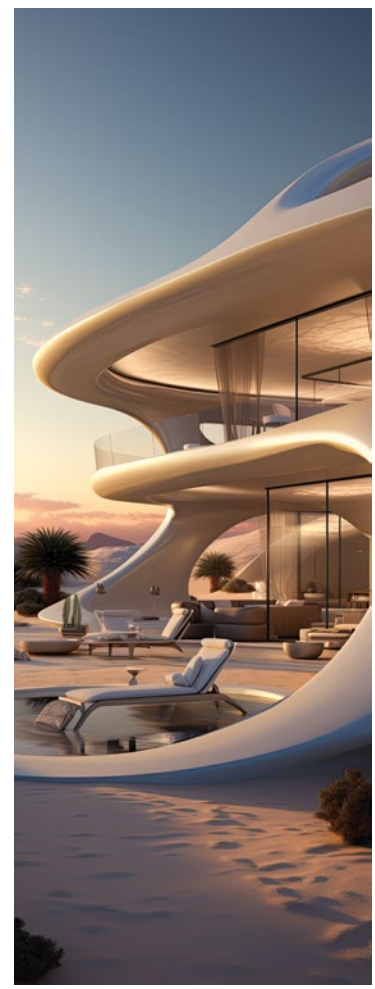
Allen, the Colorado State Fair winner, spent 80 hours on Midjourney and sifted through 900 images before he settled on a picture to print on canvas. Other artists take much longer for their process, investing considerable time and brainpower to learn the technology and make tweaks to the code for the specific result they seek.

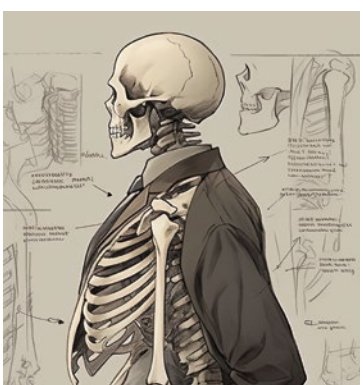
"Using machine learning is such a steep learning curve for me," says Jake Elwes in the paper "AI and the Arts: How Machine Learning Is Changing Artistic Work."

"I understand enough of the technology to use it and hack it, but I'm not writing algorithms myself, so it often takes months of research to work out how to use a model and get it to do what I want it to do.

"To be able to see some of my artistic voice coming through a black box or a ready-made, and then find an interesting way of subverting it. It's a long process, not something you can just play with lightly." The same might be said for the technology itself.







CAPTION: AI training encompassing billions of images allows tools to produce a wide variety of styles. Artists, however, are concerned that their work has been scraped from the internet without their consent, possibly threatening their livelihoods.

DUBAI WELCOMES ROBOT COPS

and more...

Dubai is embracing robot technology, with AI machines taking on such work as policing, serving ice cream and dancing for tourists.

By: **Maggie Kinsella**

Dubai began its foray into robot security in 2017 when a robot became an active member of the Dubai Police Force. The robot was purchased to be a greeter, providing information and alleviating daily administrative work. Dubai police say robots will make up 25 percent of the force by 2030.

"The integration of emerging technology into the police force is a multifaceted endeavor that goes beyond simply deploying robots," Maj. Gen. Khalid Nasser Alrazooqi of the Dubai Police Force tells *KUST Review*.

"It also involves educating officers and the community on how to effectively utilize this new technology. Ultimately, the key to unlocking the full potential of these technological advancements lies in the hands of the people who use them."

The police robots, from Russian company Promobot, are part of a line of machines that can be used as medical assistants, consultants, concierges or even educators. The robots are being used in 43 countries. Dubai uses robots for security purposes in a variety of venues.

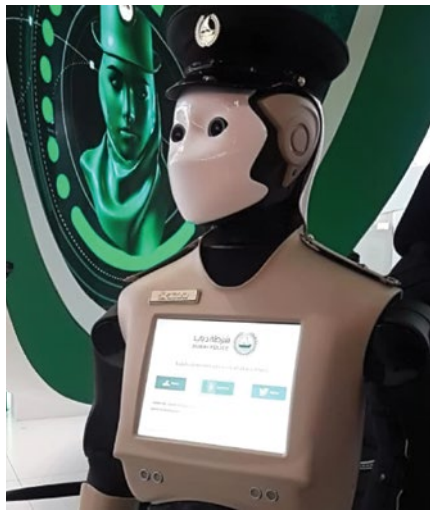
In 2022 the Dubai police employed robots equipped with artificial intelligence to patrol the Dubai World Cup, a thoroughbred horse race held annually in the Gulf city since 1996.

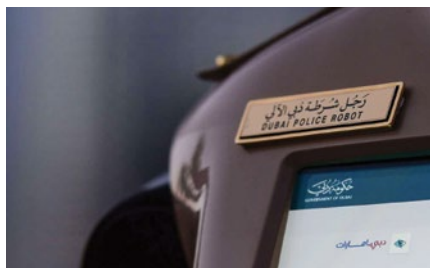
"Public events are always a great opportunity to test the engagement with our robots and take a step towards human-centric integration. We are always looking for ways to improve and expand our use of robotics and emerging technology in policing," Alrazooqi says.

The robots were tasked with weapon detection; facial recognition; scanning license plates; and observing human behavior. But robots are being used for more than police work in the emirate.

It was announced in 2022 that Dubai would soon be home to a "supermodel cybercafé" in which a robot that looks like a supermodel will serve customers.

The autonomous robot, named Donna, was created in the image of Diana Gabdullina, a supermodel from Eastern Europe. It will serve ice cream and coffee and chat with customers.





IMAGES: Robots do perform administrative tasks for the Dubai Police Force. They also helped patrol the Dubai World Cup.

CREDIT: Dubai Police Force

Other venues around Dubai are also embracing robot workers. Tanuki restaurant at the Dubai Mall has a robot that takes orders, recommends menu items, uses facial recognition to remember customers and performs a dance that the restaurant team choreographed. The dance often draws a crowd.

Dubai's residents and visitors can probably expect to see more robots in other areas soon. Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum, the crown prince of Dubai, in 2022 launched the Dubai Robotics and Automation Program. Over the next decade, the program expects to provide 200,000 robots for such sectors as logistics, services and industry.

NEXT ISSUE

Artificial intelligence: Where do we go from here?

AI technology is moving fast. In the **next issue of the *KUST Review*** we examine what it means to live in a world increasingly run by machines and software.

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HUBBLE VS JWST

Space telescopes, working above the blurring effects of the Earth's atmosphere, give observers a **better view of the universe**. Two of the most famous space telescopes are **the Hubble** and **James Webb telescopes**. Here's how they compare:

The Hubble and James Webb telescopes captured images (Hubble above, JWST below) of the same target: **NGC 3324 in the Carina Nebula**. The Webb telescope resolution is **100 times stronger** than Hubble's, which shows in a **clearer, more defined image** when placed **side by side**.

Expected time in service
Discoveries and goals
Wavelength range
Primary mirror
Launch
Orbit
Cost

HUBBLE

- **Through the 2020s**
- Helped pin down the age of the universe to 13.8 billion years; discovered Pluto moons Nix and Hydra; created a 3D map of dark matter
- Primarily **optical** and **ultraviolet wavelengths**
- Primary mirror is **2.4 meters**
- **April 24, 1990**
- **Low-Earth orbit**, approximately **525 kilometers** from the Earth
- The mission has cost about **U.S.$16 billion dollars**, not counting the cost of space shuttle missions to deploy and service the telescope

JAMES WEBB

- Cost **U.S.$10 billion**. There will be no missions to service the telescope
- Orbits the sun **1.5 million kilometers** from the Earth at the second Lagrange point or L2
- **Dec. 25, 2021**
- Primary mirror is **6.5 meters**. The larger mirror is able to collect more light, allowing the telescope to see further away, and consequently, farther back in time
- Primarily in **infrared wavelengths**
- Motivated by results from the Hubble mission, it studies the origins of the universe, galaxy formation and planetary systems
- **20 years**

PHOTOS: NASA