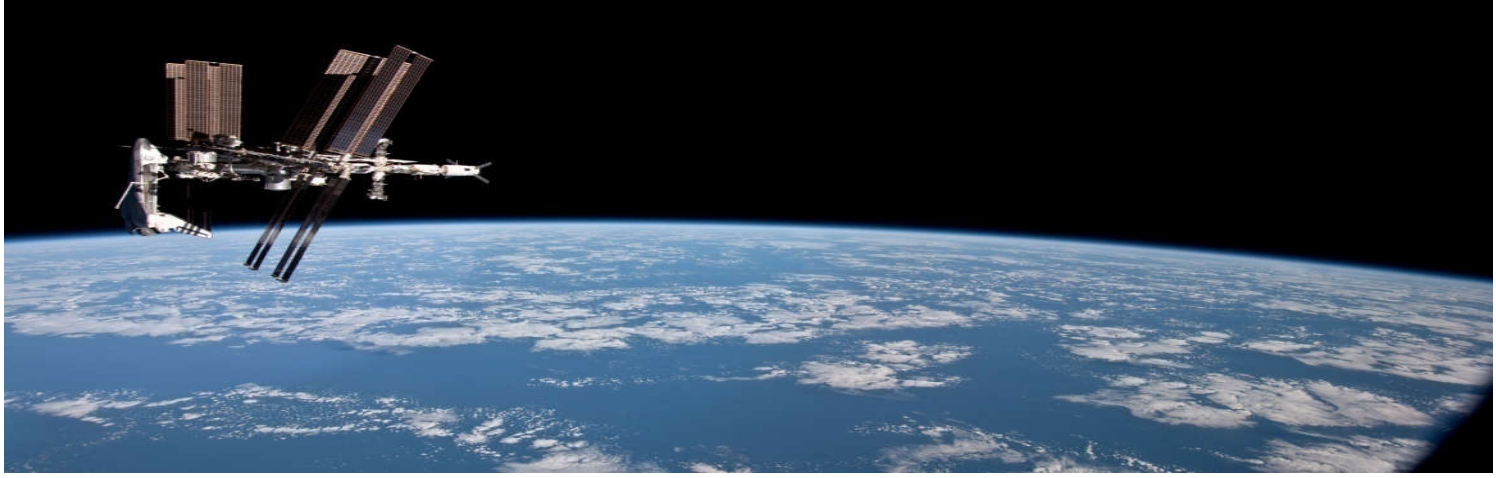

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Chang'e-4: A Mission with a Difference

Ajey Lele

In Chinese tradition, the full moon is a symbol of peace, prosperity, and family reunion. On the 15th day of the 8th month of the lunar calendar, the moon is full and for China, this is the period for the Moon Festival celebrations. The Chinese goddess of the moon is known as Chang E, the modern China has adopted this title for naming their probes to moon. China's space agency has evolved a very elaborate lunar programme and is found making a step by step approach, achieving limited, but important goals with every mission. On January 3, 2019, their fourth mission to moon called Chang'e 4 successfully landed on the far side of the moon. This is a very special mission, because with this, for a first time a satellite has been sent on the far side of the Moon, a region which is totally unexplored till date.

Some twelve years back, China made its first entry into the moon's vicinity. China's ongoing moon programme could be divided into two phases. The first phase was about carrying satellites into the moon's vicinity and taking observations to map the moon's surface. In this context, the first lunar spacecraft, Chang'e 1 orbiter, was launched on 24 October 2007, while the second orbiter, Chang'e 2, was launched on 1 October 2010. The second phase is all about the robotic equipment landing on the moon. Two missions (Chang'e 3 & 4) have been responsible for landing of rover and lander on the different locations on the moon. Chang'e 3 mission, which includes a lander and rover, successfully landed on the Moon on 14 December 2013 and on 03 January 2019, China's Chang'e 4 successfully landed on the far side of the moon.

The launch mass of Chang'e-4 spacecraft is about 3,780 kg. The mass of lander is about 1,200 kg and that of rover is 140 kg. As per the mission design, the rover is expected to explore the lunar surface for a period of three months while the lander's mission would last for a full year. The lander has released a rover, called Yutu-2 (Jade Rabbit) for performing experiments in the Von Karman Crater. This is a large lunar impact crater which is about 180 km in diameter. This basin is located within a very big impact crater called the South Pole–Aitken basin (2,500 km in diameter and 13 km deep).

One of the most interesting experiments as a part of this mission was the one designed by the scientists from Chongqing University. This "mini lunar biosphere" experiment carried an 18cm bucket-like container holding air, water and soil. Inside this unit was carried cotton, arabidopsis – a small, flowering plant of the mustard family – and potato seeds, as well as fruit-fly eggs and yeast. The images sent back by the probe show a cotton plant has grown well, but so far none of the other plants had sprouted. Now, this experiment is over and sprouted cotton would decay in the container. This is for the first time in history a biological matter has been flown to moon. Earlier, plants have been grown on the International Space Station (ISS).

Chang'e-4 is a unique mission in many ways and one such aspect is international cooperation associated with this mission. Apart from the scientific community from China, there are instruments developed by scientists from Sweden and Germany too. The broad aim of the mission is to study the effects of low gravity on an Earth-like ecosystem, lunar environment, cosmic radiation and the interaction between solar wind and the moon's surface. The rover with its panoramic camera is presently investigating in detail about the

surface morphology and geological structure of the moon's surface.

Particularly, the study of this basin is very important because this is an area which has vast amount of water ice available. This area and some other craters in this region are permanently shadowed regions where no sunlight reaches. They are known to have deposits of hydrogen or water ice. India's Chandrayaan-1 orbiter and few American moon experiments based on their observations have inferred that there is water on the moon. Now, the experiments carried out by China could provide the actual proof of this finding.

Mission Chang'e-4 could be viewed as a very significant mission from the point of view of the future of China's moon agenda. It would help the rest in the world too, in regards to gathering important inputs to undertake future missions. So far, this mission has demonstrated that the biological matter could be grown on the moon. The mission is also expected to provide a definitive answer in regards to the extraction of water from the moon surface. It would also provide options for good landing sites/ safest landing spots for the future missions.

China's space agency is planning at least four more missions to moon in near future. The next mission which possibly could happen during 2019 itself, is being designed to bring back samples from the moon. Now for more than two decades, China is found playing a "(unannounced) catch up" game in space exploration with the US. There have been enough indications that they want to send a Chinese man or a women to space by 2030. They are found making a rapid progress in that direction. It would be of interest to see if Chinese human reaches to the moon first or some private sector company (possibly NASA supported) beats them in this unannounced human race for the moon.

Ajey Lele is a Senior Fellow with the Institute of Defense Studies and Analyses (IDSA).

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Resilience Thinking for Outer Space Security

Jessica West

It's no surprise that tensions are rising about security in outer space, because spacecraft are critical but vulnerable assets. The prevailing response in the West has been to rely on such familiar military strategies as deterrence.

Although to "deter and defeat threats in space" is the raison d'être of the proposed U.S. Space Force, deterrence should have only a limited role in military space strategy. Too much emphasis on deterrence risks fuelling an arms race in space. The essential "or else" premise of deterrence imbues it with offensive undertones and encourages confrontation.

Instead, we need to think more about resilience.

What is resilience?

The idea of resilience has informed military thoughts on space for some time. Core concepts in the 2015 U.S. White Paper Space Domain Mission Assurance: A Resilience Taxonomy includes protection, proliferation, disaggregation, diversification, distribution, and deception. Here the focus is on new space architecture. In this approach, space systems are designed to be less vulnerable to harmful interference. By mitigating vulnerabilities, the goal is to also bolster deterrence.

Designing satellite systems that are less vulnerable to disruption is laudable. But the benefits of resilience will be greater if we think beyond deterrence and system hardware.

While complimentary, resilience is a fundamentally different logic than deterrence. I liken resilience to a strategy of containment. Resilience is not about influencing the external environment to prevent certain effects or about reducing vulnerability per se. Instead, resilience involves mitigating the effects of disruptions that do occur and maintaining the core functions and identity of a system. It works by integrate the layers and components of a system into real-time surveillance and control practices to detect and contain disorder. It is both physical and social.

As a systems approach to defence, resilience can be scaled up or down. If we scale up, we can think beyond individual space systems to building global resilience in outer space.

Scaling up resilience

I manage and edit the Space Security Index series of reports. The focus of this project is the security of outer space as an environment that can be used by all safely and sustainably, free from threats. This approach to security is ripe for resilience thinking, because if humans want to continue to use outer space, we must learn to detect and control the effects of the many hazards found there.

To this end, a resilience approach enables an "all-hazards" response to dangers in space. While the risk of deliberate harm to space systems is real, operators face an array of potential disruptions and damage from space weather and debris, as well as accidental interference. These cannot be deterred, but they can be detected, and their effects contained. Likewise, resilience is useful in the face of deliberate interference, which can be difficult to distinguish and thus to deter.

Approaching these challenges collectively can generate greater resilience. We can see elements of this approach that are already in place, such as interoperability agreements between providers of global navigation services, which help to contain the effects of disruptions to individual capabilities. By emphasizing cooperation and data sharing,

mutual resilience could also facilitate arms control and conflict prevention measures.

Resilience and arms control

The relationship between resilience and arms control is complicated. When embedded in a narrow, national approach to deterrence, resilience might be seen as an attempt to achieve invulnerability and thus reduce the incentive for arms control. But this shouldn't be the case.

A resilience framework cannot mitigate all risk. There are limits to the ability to detect and contain emerging threats and disruptions. Space systems are particularly susceptible to the application of external force. The resulting debris could damage swaths of the space environment. Arms control and efforts to de-escalate the risk of conflict in space remain essential. However, a focus on resilience could make such efforts more appealing by alleviating concerns linked to limited modes of monitoring and verification. The starting point is space situational awareness (SSA).

System surveillance – particularly the ability to detect an anomaly or disruption early – is critical for resilience. In space, this is done via sensors on individual spacecraft, and through SSA of the whole space environment—an incredible task. The United States has by far the most advanced capability, and engages in extensive but selective data-sharing. A global approach to surveillance remains elusive, even though it would contribute significantly to the resilience of outer space activities, providing more comprehensive data for early warning to all actors, and facilitating the ability to objectively identify and respond to suspicious behaviour or hardware in space.

More global approaches are emerging for SSA in relation to asteroid early warning and space weather mitigation. This logic should extend to human made hazards. Just as "eyes in the sky" are critical for early warning capabilities linked to nuclear deterrence and arms control, "eyes on the sky" are a critical step for building resiliency that can contain conflict in space.

New thinking

Threats in space are many, complex, and often indiscriminate. Thinking about resilience – the ability to detect and contain the effects of disorder and disruptions – is necessary. While clearly a part of national defence strategy in outer space, there is an opportunity to leverage this concept to bring new thinking to the security of outer space and the collective challenges that we face in this domain.

Jessica West is a Program Officer at Project Ploughshares, where she serves as the managing editor for the Space Security Index project.

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The Space Activities Bill- Does it deliver?

Ashok G. V.

Understanding the legal context of the Space Activities Bill

The organisational hierarchy for India's space program remains unique, reflecting the government's sense of priority for India's space ambitions. By virtue of the allocation of business rules, the office of none other than the Prime Minister, through the Department of Space, remains at the top of the organisational hierarchy. Within these organisational structure, numerous policies such as SATCOM Policy, SATCOM Norms, Remote Sensing Data Policy and Technology Transfer policy were formulated. Lacking the means to impose sanctions on those who flout, the status of these policies as a law is debateable. The structure of this hierarchy and the allocation of business rules suggest a deliberate effort on the part of the Indian state to refrain from over regulating the sector, a laudable effort, supported by precedents in other industries where absence of regulation unleashed innovation.

However, in the world of globalisation, experiences with international liability have necessitated the need to reflect on the wisdom of deregulation. As was demonstrated in the Devas case, the liability that India suffered in the arbitration was the product of a BIT enforcement action in International Arbitration, based on the allegation that the allocation and cancellation of Indian state resources to Devas was arbitrary. Absence of well-defined policies often lends credence to allegations of arbitrariness and can be as counter-productive to the state as it is to the industry. From the perspective of the industry, while there is little to complain, considering how ISRO and Antrix have supported space tech start-ups in the country, the challenges space tech start-ups have faced in attracting investments reflects investor caution and some would argue, poor investor sentiment. While this is true to any industry that is novel and unprecedented, the right policy around the sector can mitigate the crisis created by poor investor sentiment and thus help emerging start-ups. A policy statement that is clear and qualifies as law can improve predictability of investment transactions, estimate the cost of investment transactions, facilitate the flow of international capital thus assuring returns on investments and enable investors to accurately gauge their rights and provide mechanisms for enforcing investment obligations.

Reviewing the Space Activities Bill

The question therefore is simply this- Does the space activities bill provide to the state and to the industry, the missing links necessary to mitigate international liability and improve investor sentiment respectively? The Space Activities Bill gets many things right- it reflects India's international obligations so far as space activities are concerned, it provides a mechanism for enforcing those obligations by defining offences to address transgressions in space and provides for appropriate punishment for the same. A combined reading of Section 3 and Section 5 suggests that, though per se, they do not provide the clarity on the critical question of who will be eligible to be the licensed operator of space activities and what barriers of entry such space aspirants will face, as the question of timelines for granting of licenses and the licensing fee. However, the very fact that the law requires the government to evolve such mechanism, by itself, reflects the intention of the state to set up a transparent and clear procedure for licensing the right to conduct business activities in or in relation to space.

Section 7 (2) of the bill stipulates limited grounds for refusing an application for a license, with the intention of ensuring licensees don't jeopardise public health, remain compliant with international obligations and do not adversely prejudice national interests. Since these are the only disqualifying criterion prescribed within the draft legislation itself, it would be reasonable to expect the Indian state to promote and advance the cause of space tech start-ups in the country by ensuring low barriers of entry. To give further credit to the bill, it also illustrates the terms and conditions of such license under Section 8, thus providing already, a semblance of clarity and predictability of what space tech businesses must undertake to ensure they are able to conduct business in or in relation to space.

While the practicality of investigating, prosecuting and establishing the offences laid down in the bill is debateable, the process of such criminal law sanctions are an inevitable character of a domestic space law, as it gives the state the basis to enforce international and domestic space law obligations upon the private sector. Notwithstanding the utility of the offences stipulated in Chapter V of the bill, the Indian state will have to develop the capacity, infrastructure and the expertise necessary to enforce it. However, space tech businesses must be mindful of the penalties prescribed and accordingly invest in suitable safety measures and quality control processes.

The way forward

The Bill will still have to be approved by both houses of the Indian Parliament before it assumes the character of an enforceable legislation. Even past that process, what the industry must closely monitor is the mechanisms for licensing and regulating private sector activities in or in relation to space, that the Government will have to evolve in terms of Section 3 and 5 of the Bill. Those mechanisms based on the law, will not only have a more significant and measurable impact on the industry, but it will also enable state agencies to engage the private sector in a manner consistent with international investment laws. Coupled with the establishment of a special purpose vehicle, India appears to be serious about ensuring flow of technology from the state sponsored space program to the private sector. Two state driven enterprises Antrix and NewSpace India Ltd., dedicated to the cause of taking the state space program to the private sector, reveals a positive statement in favour of the industry. The potential for these two agencies to compete with each other to drive the cause of unleashing a domestic space economy for the private sector, can result in more reforms and progress than a policy can achieve. At the very least, the setting up of these two agencies provides a framework for interpreting the vision and specific provisions of the space activities bill.

The Government of India has truly delivered on its promises improving the factors for enabling ease of doing business in space. Antrix and ISRO, despite the lack of a clear pro private sector policy, have forged excellent relationships with new space companies, providing space entrepreneurs, both the platform and the support necessary to set up sustainable businesses in the country. The Space Activities Bill can augment that support and encouragement and greatly improve investor sentiment in the Indian space sector. If the setting up of the Special Purpose Vehicle is anything to go by, the Indian space tech businesses have much to celebrate and to hope for, for the Government is clearly inclined to unleash the private sector initiatives in space.

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FROM THE MEDIA

India's 40th communication satellite GSAT-31 launched successfully

India's 40th communication satelliteGSAT-31 was successfully placed in orbit on Wednesday by an Ariane5 rocket from French Guiana. The satellite will cover both the mainland and islands of the country and provide communication services such as DTH, ATMs connectivity and emergency communication, etc.

Source:Business Standard, February 6, 2019

ISRO Opens Rocket Launch Viewing Facility For First Time In Andhra

The Indian Space Research Organisation (ISRO) is, for the first time, opening its launch complex at Sriharikota to common people to view rocket launches live. People can now enjoy watching with their naked eyes the lift-off of the 44-metre-tall and 320-tonne heavy PSLV rocket into the sky from the coast of the Bay of Bengal at Sriharikota in Andhra Pradesh, some 105 km north of Chennai.

Source:NDTV, March 29, 2019

First ever India-Japan Space Dialogue: Both countries to focus on surveillance and maritime awareness

At the first ever India-Japan Space Dialogue, space agencies of the two countries, Indian Space Research Organisation (ISRO)and Japan Aerospace Exploration Agency (JAXA), focused on Surveillance and Maritime Domain Awareness (MDA) of the waters in the East China Sea, the South China Sea and the Indian Ocean. With China already making impressive strides in the space sector, both India and Japan are getting closer and seeking higher cooperation in critical sectors.

Source:Financial Express, March08, 2019

India will launch electronic intelligence satellite Emisat on April 1

India on April 1 will launch an electronic intelligence satellite Emisat for the Defence Research Development Organisation (DRDO) along with 28 third party satellites and demonstrate its new technologies like three different orbits with a new variant of PSLV rocket, ISRO said on Saturday.

Source:Live mint, March 24, 2019

Chandrayaan 2 To Carry NASA Laser Instruments To Moon

Chandrayaan-2 is India's second moon mission which will be launched in April. Chandrayaan-2 will carry laser instruments that are owned by NASA. The laser retro reflector arrays will help the scientists to take precise measurements of the distance to the Moon. The entire surface will be populated with as many laser reflector arrays as possible, according to US space agency officials.

Source:NDTV, March 26, 2019

ISRO experts to receive training for Gaganyaan project in France: CNES

Experts from ISRO will start receiving training for the 'Gaganyaan' project at the Toulouse Space Centre in France from this month, French space agency CNES said Wednesday.

The experts will also be trained at CADMOS, the centre for development of microgravity applications and space operations, and the MEDES Space Clinic in France, it said.

Source: Livemint, March 06, 2019

ISRO Launches Young Scientist Programme

In order to inculcate and nurture space research fervour in young minds, the Indian Space Research Organisation (ISRO) on Friday announced Young Scientist programme. "Under this one-month programme selected students, mostly 8th standard passed out students, will be given lecturers and access to research laboratories," said Chairman, ISRO, Dr K Sivan.

Source: NDTV, January 18, 2019

China to Deploy ASAT Laser by 2020: pentagon report

China's military is expected to deploy a laser weapon capable of destroying or damaging U.S. military satellites in low earth orbit in the next year, the Pentagon's Defence Intelligence Agency disclosed in a report on space threats.

Source:Freebeacon, February 15, 2019

ISRO launches Human Space Flight Centre in Bengaluru

The Human Space Flight Centre (HSFC), the hub of ISRO's future manned missions, was inaugurated at ISRO headquarters in Bengaluru on Wednesday, the space agency has said. Announced on August 15 2018, the country's first crewed mission is set to happen by 2022, the 75th year of Independence. A full scale model of Gaganyaan's crew module was also unveiled as former ISRO chairman K. Kasturirangan inaugurated the new centre in the presence of ISRO Chairman K. Sivan, former chairmen and centre directors.

Source: The Hindu, January 30, 2019

ISRO selects 10 firms for transfer of Lithium-ion technology

The Indian Space Research Organisation has selected ten companies for transfer of its Lithium-ion cell technology. The selected firms are- Amara Raja Batteries Limited, Chittoor,Bharat Electronics Limited, Pune, Carborundum Universal Limited, Kochi, Exicom Tele-Systems Limited, Gurgaon, GOCL Corporation Limited, Hyderabad;

Source:Business Standard, January 30, 2019

SpaceX launches unmanned US space capsule from Florida

A SpaceX rocket with an unmanned crew capsule blasted off on Saturday for the International Space Station, in a key milestone for Elon Musk's space company and NASA's long-delayed goal to resume human spaceflight from US soil later this year.

Source:The Times of India, March 02, 2019

ISRO puts world's lightest satellite into orbit

ISRO's rocket launch on January 24 was mainly to put into orbit a 740-kg satellite named Microsat-R that will be used to take high-resolution photographs of the earth. This satellite will be used by the Indian Defence research team. The satellite was launched using the Polar Satellite Launch Vehicle (PSLV) and was successfully placed into orbit.

Source:Deccan Chronicle, January 25, 2019

China's Moon Landing: Lunar Rover Begins Its Exploration

Hours after a space probe from China made humanity's first landing on the far side of the moon, sending images of its surroundings back to Earth, the spacecraft deployed a rover on Thursday to take still more photographs and scan the surface of terrain never before traversed.

Source:New York Times, January 03, 2019

China's space station gets the green light in surprise announcement

In a surprise move, the China Manned Space Engineering Office (CMSEO) announced it will be starting the process of building its own space station sooner than expected. It expects to launch the first mission imminently and aims to have a space station completed by 2022.

Source:Digital Trends, March 07, 2019

Japanese space probe touches down on asteroid to collect samples

A Japanese space probe named after a falcon, Hayabusa 2, has touched down on an asteroid more than 300 million km (186 million miles) from Earth on a mission to seek clues about the origins of life, Japan's space agency said on Friday.

Source:CNBC, February22, 2019

Japan Taps Toyota to Build Futuristic Moon Rover

Japan wants to build the ultimate moon rover for astronauts and has tapped Toyota to help develop a futuristic, off-road, lunar vehicle that could potentially launch in 2029. The Japan Aerospace Exploration Agency announced Tuesday (March 12) that it is working with vehicle manufacturer Toyota to develop the moon rover of the future – a massive vehicle powered by fuel cells with a maximum range of a whopping 6,213 miles (10,000 kilometres).

Source:SPACE, March 19, 2019

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