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समाचार पत्रों से चयनित अंश

Newspapers Clippings

डीआरडीओ समुदाय को डीआरडीओ प्रौद्योगिकियों, रक्षा प्रौद्योगिकियों, रक्षा नीतियों, अंतर्राष्ट्रीय संबंधों और विज्ञान एवं प्रौद्योगिकी की नूतन जानकारी से अवगत कराने हेतु दैनिक सेवा

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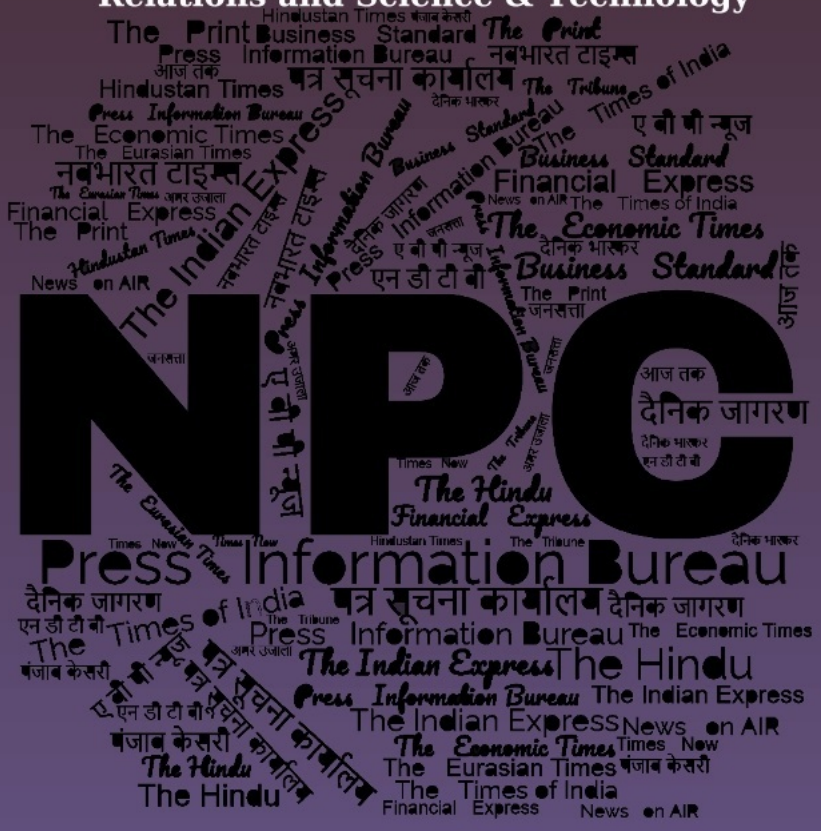

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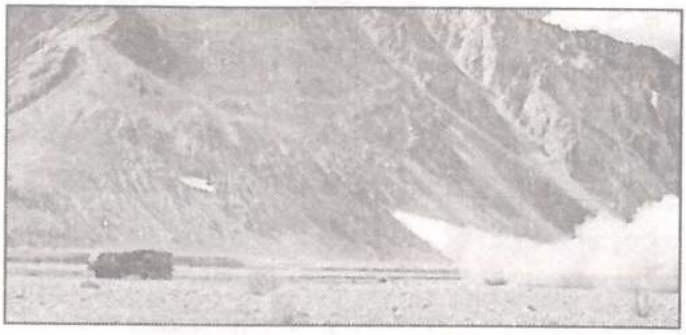
DRDO News

आकाश प्राइम मिसाइल का परीक्षण सफल

Source: Jansatta, Dt. 18 Jul 2025



भारत ने लद्दाख में आकाश प्राइम मिसाइल का सफल परीक्षण किया है। रक्षा मंत्रालय ने मंत्रालय ने बताया कि इस हथियार प्रणाली को समुद्रतल से 4,500 मीटर की ऊंचाई पर संचालित करने के लिए तैयार किया गया है।

इसमें कहा गया है कि यह उपलब्धि इसलिए भी महत्त्वपूर्ण है क्योंकि यह आपरेशन सिंदूर के दौरान भारत की स्वदेशी रूप से विकसित वायु रक्षा प्रणालियों के 'असाधारण प्रदर्शन' के बाद आई है। आकाश प्राइम मिसाइल भारतीय सेना के लिए तैयार आकाश हथियार प्रणाली का उन्नत संस्करण है। लद्दाख में मिसाइल का परीक्षण इसलिए महत्त्वपूर्ण है क्योंकि यह वास्तविक नियंत्रण रेखा (एलएसी) के करीब है।

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India tests new weapons system for China border

Source: The Times of India, Dt. 18 Jul 2025

The Army will soon begin inducting two regiments of the Akash Prime surface-to-air missiles designed for air defence in high-altitude areas along the frontier with China, with the force testing the new weapon system in Ladakh twice on Wednesday. The Akash Prime missiles successfully destroyed two high-speed unmanned aerial targets at an altitude of around 15,000-feet during the trials, which defence minister Rajnath Singh described as "a significant milestone and boost" for India's air defence capabilities, especially for high-altitude operational requirements.

The existing Akash air defence systems with the Army and IAF were extensively used against drones, loitering munitions and the like launched by Pakistan during the cross-border hostilities from May 7 to 10 under Operation Sindoor. Both Akash and Akash Prime have the capability to intercept hostile aircraft, helicopters and drones at a 25-km range, but the latter is the upgraded customised version for high-altitude areas above 4,500-metre with modified ground systems and radars as well as new radio frequency seekers in the missiles."

Various upgrades have been made in the Akash Prime system, designed by DRDO and produced by defence PSU Bharat Dynamics, based on operational feedback from the Army to improve its operational effectiveness. Wednesday's trials were conducted as part of the first production model firing to enable timely induction," an official said.

Under a Rs 8,160 crore contract in March 2023, the Army Air Defence (AAD) is now raising the two new regiments for the Akash Prime system, which also have a reduced footprint with 360° engagement capability, to add to its two existing Akash regiments. The IAF, in turn, already has 15 Akash squadrons ordered for Rs 10,900 crore, with more being in the pipeline, as reported by TOI earlier.

The DRDO has also developed the Akash-NG (new generation) weapon system, with an initial interception range of 30-km that will be progressively enhanced. Tested for the first time in Jan 2021, the Akash-NG consists of more compact missiles with advanced radio frequency seekers, launchers, multi-function radars, and command, control and communication systems."

The Akash-NG is a canister-based system for much greater operational flexibility. Each canister can carry six missiles. Once inducted, it will be a major force-multiplier to ensure that the kill or hit probability goes up further," another official said. The MoD said the improved Akash system "marks a major step forward for India's missile development programmes, which are now gaining increasing attention in the global defence market".

While Armenia was the first foreign customer for the Akash systems, India also offered them to the UAE when Dubai crown prince Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum visited India in April. The AAD, incidentally, is also slated to get three regiments of the new indigenous quick reaction surface to air missile (QRSAM) systems for Rs 36,000 crore. These highly-mobile QRSAMs, with interception ranges of up to 30 km, and the Akash systems will add to India's existing multi-layered air defence network that played a crucial role in thwarting multiple waves of Turkish-origin drones and Chinese missiles launched by Pakistan during Operation Sindoor.

https://timesofindia.indiatimes.com/india/india-tests-new-weapons-system-for-china-border/articleshow/122676664.cms

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Defence News

पृथ्वी-2 और अग्नि-1 मिसाइल का सफल परीक्षण

Source: Jansatta, Dt. 18 Jul 2025

भारत ने गुरुवार को ओड़ीशा के तट स्थित एकीकृत परीक्षण रेंज से कम दूरी की बैलिस्टिक मिसाइलों पृथ्वी-2 और अग्नि-1 का सफलतापूर्वक परीक्षण किया। रक्षा सूत्रों ने यह जानकारी दी। सूत्रों ने बताया, 'इन प्रक्षेपणों ने सभी परिचालन और तकनीकी मानकों को पूरा किया। ये परीक्षण सामरिक बल कमान के तत्वावधान में किए गए।'

अग्नि-1 का परीक्षण अब्दुल कलाम द्वीप से किया गया, जबकि पृथ्वी-2 का परीक्षण कुछ समय बाद चांदीपुर स्थित एकीकृत परीक्षण रेंज के लान्च पैड संख्या-3 से किया गया। अग्नि-1 मिसाइल की मारक क्षमता 700 किलोमीटर तक की है। इस मिसाइल का भार 12 टन है और यह 1,000 किलो के परमाणु हथियार को अपने साथ ले जा सकती है।

वहीं पृथ्वी-2 बैलिस्टिक मिसाइल को स्वदेशी तरीके से विकसित किया है। पृथ्वी-2 मिसाइल की मारक क्षमता 350 किलोमीटर है। पृथ्वी-2 500 से 1,000 किलोग्राम भार तक के हथियारों को लेकर जाने में सक्षम है। सतह से सतह पर साढ़े तीन सौ किलोमीटर मार करने वाली मिसाइल है।

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India test-fires nuclear-capable Agni, Prithvi missiles

Source: Hindustan Times, Dt. 18 Jul 2025

India on Thursday successfully test-fired nuclear-capable short range ballistic missiles Prithvi-II and Agni-I from an integrated test range off the Odisha coast, demonstrating its strategic deterrence capability. The test-firing of the missiles, conducted by the elite Strategic Forces Command, validated all operational and technical parameters, according to the defence ministry.

On Wednesday, India successfully test-fired indigenously developed Akash Prime missile in Ladakh that has been customised to operate at an altitude above 4,500 metres. The test-firing of the missiles came over two months after the May 7-10 military conflict between India and Pakistan. The Prithvi-II missile has a range of around 350 kms and it is capable of carrying a payload of up to 500 kgs. It can carry both conventional as well as nuclear warheads. The Agni-I missile has a range of 700-900 kms and it can carry a payload of 1,000 kgs. Both Prithvi-II and Agni-I missiles have been an integral part of India's nuclear deterrence.

"Short-range ballistic missiles Prithvi-II and Agni-I were successfully test-fired from the Integrated Test Range in Chandipur, Odisha on July 17," the ministry said in a brief statement. It said the launches "validated all operational and technical parameters. "These tests were conducted under the aegis of the Strategic Forces Command," the ministry said.

On test-firing of Akash missile, the ministry said it carries added significance as it follows the "exceptional performance" of India's indigenously developed air defence systems during Operation Sindoor. Akash Prime is an upgraded variant of the Akash weapon system built for the Indian Army. The test-firing of the missile in Ladakh assumed significance as it is close to the Line of Actual Control .

"India on July 16 achieved a significant milestone by successfully destroying two aerial high speed unmanned targets at high-altitude in Ladakh by Akash Prime, the upgraded variant of Akash weapon system for the Indian Army," the ministry said in a separate statement. It said the weapon system is customised to operate in altitude above 4,500 metres and has latest upgrades including indigenously developed radio frequency seeker.

"Based on the operational feedbacks from users, various upgrades are made to improve the operational effectiveness, demonstrating the advantage of the ecosystem created for the indigenous weapon system," the defence ministry said. Defence Minister Rajnath Singh complimented the Indian Army, the Defence Research and Development Organisation , and the industry on this "remarkable achievement", it said.

https://www.hindustantimes.com/india-news/india-test-fires-nuclear-capable-agni-prithvi-missiles-101752772445999.html

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Indian Navy’s eastern fleet ships reach Singapore to bolster naval ties in Southeast Asia

Source: The Hindu, Dt. 18 Jul 2025

Indian Naval Ships Delhi, Satpura, Shakti, and Kiltan arrived in Singapore to a warm welcome from the Singapore Navy and the Indian High Commission.

According to the Indian Navy, the visit is part of the Indian Navy's operational deployment to Southeast Asia and aims to strengthen maritime ties with Singapore through various engagements and activities. Naval Ships reached under the Command of RAdm Susheel Menon, Flag Officer Commanding Eastern Fleet.

One of the Indian Naval Ships, under the Command of Flag Officer Commanding Eastern Fleet of the Indian Navy Rear Admiral Susheel Menon, arrive in Singapore on July 16.

Professional interactions with the Republic of Singapore Navy, discussions with academia and engagements with the community, that reflect the shared values of both nations, are planned during the visit, the Indian Navy added.

Indian Navy and Republic of Singapore Navy share operational relations spanning over three decades of cooperation, coordination and collaboration with regular visits, exchange of best practices and reciprocal training arrangements. The current deployment underscores the strong linkages between the navies.

https://www.thehindu.com/news/national/indian-navys-eastern-fleet-ships-reach-singapore-to-bolster-naval-ties-in-southeast-asia/article69824093.ece

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India, France ignite next-gen jet engine pact in ₹61,000 crore strategic thrust

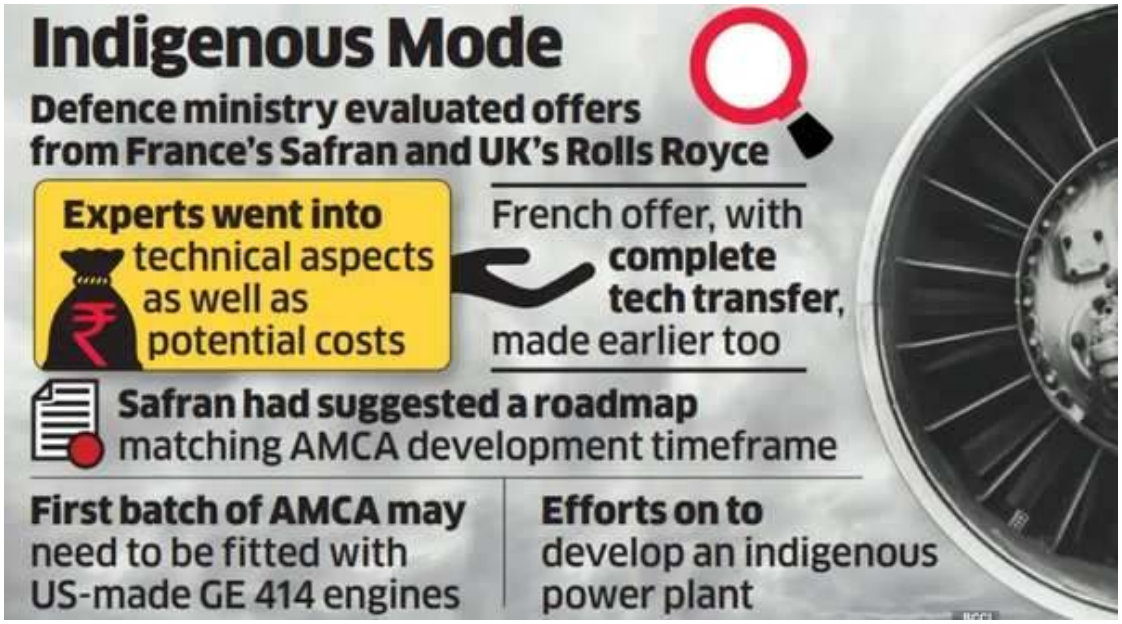
Source: The Economic Times, Dt. 18 Jul 2025

The defence ministry has recommended a collaboration with France to develop next-generation fighter jet engines, marking a breakthrough for the mega project that will bring advanced manufacturing and design technologies and is a key step towards self-reliance.

Sources said after a consultative process, which included feedback from stakeholders and a technical committee that went deep into all aspects of fighter jet engine manufacturing, a decision

has been taken to recommend a collaboration with France, as the proposal was found to be more beneficial for India.

Under the ₹61,000 crore project, India will jointly develop a 120kn fighter jet engine that will be used for future platforms, including the advanced medium combat aircraft (AMCA). Defence minister Rajnath Singh has been a key driver behind plans to develop an indigenous fighter engine and its manufacturing ecosystem in India.



The ministry evaluated offers from France's Safran and UK's Rolls Royce, with experts going into the technical aspects as well as potential costs. The French offer, with complete technology transfer, had also been made earlier, with Safran suggesting a roadmap that would match the development timeframe of AMCA.

As things stand, the first batch of AMCA may need to be fitted with US-made GE 414 engines, while efforts will go on parallelly to develop an indigenous power plant. An engine is at the very core of a fighter aircraft and few nations around the world have mastered the technology. By conservative estimates, India will require well over 250 next-generation engines in the coming decade.

At present, all Indian fighter jets are powered by foreign-origin engines. A significant cost of a fighter goes towards engine and its maintenance. India has made efforts to develop its own engine under project Kaveri but it could not lead to a conclusion as the engine was not found to generate adequate thrust. A derivative of the Kaveri is now being developed to power unmanned combat aerial vehicles.

India is also in talks for technology transfer with the US for the GE414 INS6 engine that will be used to power the Mk2 version of light combat aircraft. Negotiations have not yet been concluded, with India looking for over 80% tech transfer including coating for the hot end of the engine as well as crystal blades and laser drilling tech.

https://economictimes.indiatimes.com/news/defence/indo-french-next-generation-fighter-engine-collab-gets-minimum-thrust/articleshow/122670184.cms?from=mdr

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एके-203 राइफल्स 31 दिसंबर को बन जाएगी 'शेर'

Source: NavBharat Times, Dt. 18 Jul 2025

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■ कोरवा (अमेठी): यूपी के अमेठी जिले के कोरवा में भारतीय सेना के लिए असॉल्ट राइफल AK-203 बन रही है। भारत और रूस का ये जॉइंट वेंचर है इंडो-रूस राइफल्स प्राइवेट लिमिटेड (IRRPL), अभी यहां जो राइफल बन रही हैं उसमें 50% स्वदेशी कंटेंट है लेकिन इसी साल 31 दिसंबर को यहां जो राइफल तैयार होगी उसमें 100% स्वदेशी कंटेंट होगा और फिर स्वदेशी AK-203 का नाम होगा 'शेर'। इसकी टेक्नॉलजी रूस ने ट्रांसफर की है।

पहली बार AK-203 फैक्ट्री में मीडिया की एंट्री हुई। नवभारत टाइम्स ने यहां विजिट किया। यहां फैक्ट्री में 121 अलग-अलग पॉइंट्स हैं। एक राइफल इन 121 प्रक्रिया से होकर गुजरती है और तब तैयार होती है। अगले साल तक यहां हर दिन 600 राइफल बनने लगेंगी, यानी हर 100 सेकंड में 1 राइफल। भारतीय सेना के मेजर जनरल एसके शर्मा IRRPL के सीईओ और एमडी हैं। उन्होंने बताया कि अगले साल से हर साल 1 लाख 50 हजार राइफल्स तैयार होंगी, जिसमें से 1 लाख 20 हजार आर्म्ड फोर्सेस को मिलेंगी और बाकी 30 हजार एक्सपोर्ट और डोमेस्टिक यूजर्स के लिए होंगी।

- 3.8 किलो वजन वाली राइफल
- 400 से 800 मीटर रेंज
- अलग अलग साइट्स लगाने की सुविधा
- 30 राउंड वाली मैगजीन
- सटीकता ज्यादा

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HAL receives first set of wing assemblies for LCA Mk1A from L&T

Source: Press Information Bureau, Dt. 17 Jul 2025

The first set of wing assemblies for Light Combat Aircraft (LCA) Mk1A, produced by Larsen & Toubro, was handed over to Hindustan Aeronautics Limited (HAL) in Coimbatore, Tamil Nadu on July 17, 2025. Secretary (Defence Production) Shri Sanjeev Kumar attended the event virtually as General Manager (LCA Tejas Division) Shri M Abdul Salam received the assemblies on behalf of HAL from Precision Manufacturing & Systems Complex unit of L&T.

In his address, the Secretary (Defence Production) commended the efforts of HAL and L&T towards achieving self-reliance. He hailed HAL for spearheading collaboration with different private sector partners, nurturing them and ensuring enhanced capability. He expressed confidence in meeting the requirement of the production target for LCA Tejas. He called for expanding horizons and focusing on reducing dependency on other countries.

CMD, HAL Dr DK Sunil, who was present during the handing over, termed it as a testament to years of dedicated hand-holding and a shared commitment to excellence from HAL and L&T. “HAL

is working with suppliers, both large and SMEs, as an initiative towards achieving Aatmanirbharta in the aerospace and defence sector. HAL has effectively built a parallel aircraft structural assembly line in the private sector which will help in capacity augmentation of the LCA Tejas program," he said.

Senior Vice President & Head, L&T Precision Engineering & Systems Shri Arun Ramchandani said L&T is set to supply four wing sets annually, with plans to scale up production to 12 sets per annum through advanced assembly processes and automation, he added.

Till date, the LCA Tejas Division has received structural modules of Air Intake Assemblies from Lakshmi Machine Works, Rear fuselage assembly from Alpha Tocol, Loom Assemblies from Amphenol, Fin & Rudder Assemblies from Tata Advanced Systems, Centre Fuselage Assembly from VEM Technologies and Wing Assemblies from Larsen & Toubro for the LCA Mk1A.

https://www.pib.gov.in/PressReleasePage.aspx?PRID=2145547

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Drones to the fore: Challenge for India to stay ahead

Source: The Tribune, Dt. 18 Jul 2025

INDIA's Operation Sindoor sent a strong message to Pakistan in retaliation to the Pahalgam terror attack. It was undoubtedly a stunning display of aerial superiority, but there is no room for complacency. Chief of Defence Staff (CDS) Gen Anil Chauhan has hit the nail on the head: today's warfare has to be fought with tomorrow's technology, not with yesterday's weapon systems. It's all about remaining ahead of the curve — any nation that fails to do so will imperil its security. The CDS has rightly observed that UAVs (unmanned aerial vehicles) have emerged as a "transformative force" in the rapidly evolving landscape of non-contact warfare.

What makes drones so lethal is their ability to quickly spot and hit targets such as key defence installations. India was able to neutralise most of the drones used by the Pakistani armed forces during the recent conflict mainly because of its robust air defence system. However, it is inevitable that Pakistan's close allies will supply it with superior UAVs to keep the pot boiling. This threat makes it imperative for India to scale up indigenous development of UAVs and Counter-Unmanned Aerial Systems that are tailor-made for Indian conditions and needs.

India can draw lessons from the drone-intensive conflict in eastern Europe, where Ukraine has made the most of UAVs to undermine Russia's advantage in terms of troop strength, artillery and tanks. This strategy has forced Russia to sharpen its focus on UAV technology. It is estimated that both nations are churning out drones at the staggering rate of millions per year. Ukraine's rise as a powerhouse of drone production should inspire India to become self-reliant in a field where cutting-edge innovation is the name of the game. No matter what purpose they are used for — strike operations, surveillance, decoys — these flying machines are here to stay. And the challenge for India is to ensure that its drones and counter-drone systems are better than those of the enemy.

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Science & Technology News

भारत को मिलेगी पृथ्वी की बेहतर निगरानी की नई शक्ति

Source: Dainik Jagran, Dt. 18 Jul 2025

- इसरो और नासा मिलकर 30 जुलाई को लांच करेंगे 'निसार' सेटेलाइट
- एक सेंटीमीटर तक की सटीक फोटो खींचेगा, अपनी तरह का पहला उपग्रह

जागरण ब्यूरो, नई दिल्ली : अंतरिक्ष सेक्टर में भारत-अमेरिकी सहयोग के तहत इसरो और अमेरिकी अंतरिक्ष एजेंसी नासा की संयुक्त परियोजना, नासा-इसरो सिंथेटिक अपर्चर रडार (निसार) उपग्रह 30 जुलाई, 2025 को आंध्र प्रदेश के श्रीहरिकोटा स्थित सतीश धवन अंतरिक्ष केंद्र से लांच होने के लिए तैयार है। 1.5 बिलियन डॉलर की लागत वाला यह मिशन पृथ्वी की सतह की निगरानी में अभूतपूर्व बदलाव लाने वाला है। रूस-यूक्रेन युद्ध, ऑपरेशन सिंदूर और उसके बाद इजरायल-ईरान युद्ध ने यह साबित किया है कि पृथ्वी पर नजर रखने वाले सेटेलाइट की रणनीतिक अहमियत अब काफी बढ़ गई है।

नासा के मुताबिक निसार दुनिया में अपनी तरह का पहला उपग्रह है जो प्रत्येक 12 दिनों पर पृथ्वी की पूरी भूमि व बर्फीली सतहों को स्कैन करेगा। यह एक सेंटीमीटर तक की सटीक फोटो खींचने व प्रसारित करने में सक्षम है। इसमें एल-बैंड व एस-बैंड रडार लगाया गया है जिन्हें विश्व में सर्वोत्तम माना जा रहा है। यह प्राकृतिक आपदाओं की रीयल-टाइम निगरानी में मदद करेगा।

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Complex greenhouse gas dynamics in the Central Himalayas revealed

Source: Press Information Bureau, Dt. 17 Jul 2025

Indian scientists have, for the first time, captured high-resolution, continuous online measurements of key greenhouse gases in the Central Himalayas highlighting how both environmental factors and human activities jointly impact greenhouse gas levels in this sensitive ecosystem.

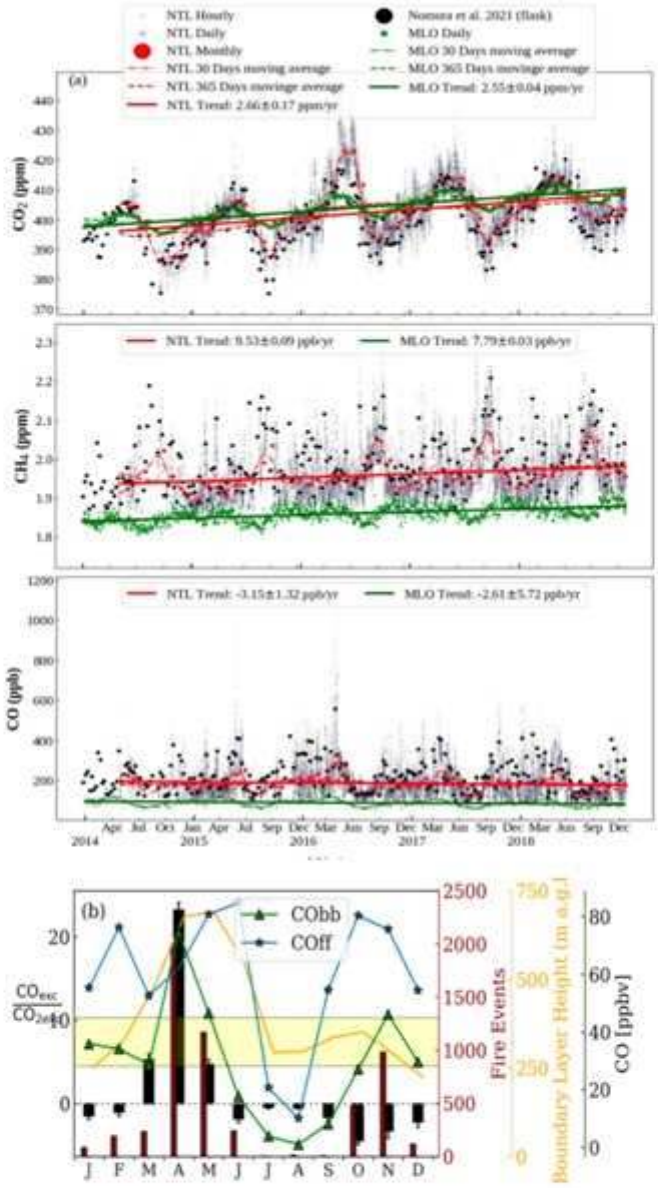

***Fig. (a)** Trend in CO2, CH4, and CO at Nainital (NTL) and Mauna Loa, a background site, during 2014–2018. **(b)** Monthly variation in excess CO/CO2, ppb/ppm with CO from fossil fuel combustion (COff) and from biomass burning (CObb), fire events over the Northern Indian region (24-35° N, 70-89° E) and boundary layer height at the site location. The yellow highlighted region denotes the emission ratios reported for fossil fuel emissions and biomass emissions.*

Ground observations with diurnal variability over the Himalayas are crucial to validate climate mitigation efforts, build accurate emissions inventories and better forecasting.

In a study performed by the Aryabhatta Research Institute of Observational Sciences (ARIES), an autonomous research institute under the Department of Science & Technology (DST), Government of India, Scientists from the Institute collected data over five years at a high-altitude research site in Nainital.

Dr. Priyanka Srivastava and Dr. Manish Naja found how natural processes and human activities together shape greenhouse gases – carbon dioxide (CO_2) and methane (CH_4) and carbon monoxide (CO) in the Central Himalayan region. The observations fill a critical gap in ground-based atmospheric data for South Asia's mountain regions, which have long been underrepresented in global climate monitoring.

The unique vantage point of this Himalayan site in Nainital allows researchers to disentangle the effects of biospheric uptake, regional emissions and complex meteorological patterns that shape the region's air quality and climate.

The research reveals that greenhouse gas concentrations in the Central Himalayas are generally higher than those at other remote background sites, highlighting the influence of emissions from both local and upwind sources. However, these levels remain lower than those typically found in urban and semi-urban settings.

The data shows pronounced daily and seasonal cycles, with carbon dioxide reaching its lowest levels during daylight hours due to active photosynthesis, while methane and carbon monoxide tend to peak during the day as mountain winds transport pollutants upward from lower elevations.

Seasonal patterns are also evident: carbon dioxide concentrations rise in spring, coinciding with increased biomass burning and limited vegetation cover, while methane levels are highest in autumn, likely linked to agricultural activities such as rice cultivation. Carbon monoxide peaks in late spring, suggesting a strong influence from regional pollution transport during this period.

Long-term trends point to a steady rise in both carbon dioxide (2.66 ppm per year) and methane (9.53 ppb per year). These trends are even higher than those at Mauna Loa (a background site), underscoring the growing impact of anthropogenic emissions in the region. In contrast, carbon monoxide shows a gradual decline (3.15 ppb per year), possibly reflecting improvements in combustion efficiency or changes in regional emission sources.

The study found that factors like solar radiation, temperature and the atmospheric boundary layer —essentially the cap on how high pollutants can rise—are just as important as agricultural practices or urban emissions in shaping these gas patterns.

These comprehensive, high-resolution observations provide an essential baseline for validating satellite data, refining emissions inventories and improving atmospheric models.

By disentangling these influences, the research gives policymakers and climate modelers a powerful tool-- localized, high-resolution data that tells the real-time story of South Asia's changing climate and offer valuable guidance for climate mitigation strategies and policy development in South Asia.

https://www.pib.gov.in/PressReleasePage.aspx?PRID=2145544

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A foothold in the Cosmos

Source: The Indian Express, Dt. 18 Jul 2025

THE SAFE RETURN of Group Captain Shubhanshu Shukla from the International Space Station as part of the Axiom-4 mission, where he was the pilot among the four-member crew, marks a watershed moment not just for Indian human spaceflight, but for the entire strategic arc of India's space programme.

For the first time since Rakesh Sharma travelled on a Soviet spacecraft in 1984, an Indian has completed a complex scientific mission, in a journey to and from the ISS, spending more than two weeks aboard, this time under the banner of international partnership and indigenous resolve.

The successful conclusion of the Axiom-4 mission, marking another milestone in the burgeoning era of commercial human spaceflight, resonates far beyond the confines of Earth's orbit. For India, a nation rapidly asserting its prowess in the global space arena, this achievement offers invaluable lessons and a powerful impetus, particularly for its ambitious Gaganyaan mission and the grander vision for its future ventures in space.

Axiom-4's journey underscored several critical advancements that are reshaping the space landscape. It highlighted the increasing reliability and capability of private-sector space transportation. This mission, executed with professionalism and a clear focus on its objectives, reinforced the growing accessibility of the low-Earth orbit for a multitude of purposes, from cutting-edge scientific research and technological demonstrations to the nascent but rapidly expanding commercial ventures.

Many Indians were following the mission, among them the young people in schools and colleges across the country, who were born long after Sharma's heroic journey. For them, in addition to the importance of the Indian role model who achieved this rare feat, the journey also showcased the efficiency and necessity of international collaboration, even in commercially driven missions, where diverse expertise works together towards shared objectives.

For India's Gaganyaan mission, which aims to send Indian astronauts into space on an indigenous vehicle, the insights gleaned from Axiom-4 are profoundly relevant. While ISRO's approach is distinctly national, the global landscape of human spaceflight is increasingly collaborative and increasingly driven by the commercial sector.

Axiom-4's experience provides a rich case study in several key areas. Of primary and critical importance is crew training and preparation. Observing how commercial astronauts from various professional backgrounds, who are not necessarily all career military pilots, are rigorously trained and seamlessly integrated into a complex mission profile offers valuable perspectives. India can meticulously refine its own astronaut selection and training methodologies by studying these models. This includes incorporating best practices for physiological adaptation to microgravity and psychological conditioning for isolation. Both simulation-based drills and real-time problem-solving scenarios can enhance the preparedness of Indian "vyomnauts".

Mission operations and logistics present another vital area of learning. Managing a human spaceflight mission involving multiple international partners and commercial entities, as Axiom-4 successfully did, provides an invaluable blueprint for streamlining complex operational flows. This encompasses pre-flight preparations and launch sequences to in-orbit activities, rendezvous and docking procedures, and the critical re-entry and recovery phases. Understanding the intricacies of communication protocols, real-time decision-making under pressure, and robust contingency planning, can significantly help ISRO anticipate potential challenges and optimise its own mission control strategies for Gaganyaan.

Equally important are the areas of technology validation and integration. While Gaganyaan is built upon ISRO's formidable indigenous capabilities and decades of expertise, Axiom-4's reliance on established commercial launch and crew vehicles (like SpaceX's Falcon 9 and Crew Dragon), and its focus on specific in-orbit scientific and commercial objectives, demonstrates how new technologies can be rapidly integrated, tested, and validated in the space environment. This could inspire India to explore strategic partnerships for certain sub-systems or adapt specific commercial methodologies for its own technological development and validation processes.

If it hasn't already, the public visibility and success of this mission will inspire and strengthen international collaboration. As the global space community becomes more interconnected, missions like Axiom-4 highlight the benefits of pooling resources, expertise, and technological capabilities. This mission's success will certainly accelerate private-sector participation, demonstrating the viability and potential profitability, encouraging more Indian companies to invest in space infrastructure, services, and human spaceflight support. This could lead to a thriving ecosystem of Indian suppliers, manufacturers, and service providers for future missions.

The transition from short-duration missions like Gaganyaan to a continuous human presence requires mastering complex logistics, radiation protection, and psychological support for astronauts, all areas where these new transnational collaborations can offer insights. Axiom Space's declared long-term goal of building its own commercial space station, intended to succeed the ISS, is a bold undertaking. ISRO has already declared India's ambitions to deploy the Bharatiya Antariksh Mission. It plans to, perhaps in the following decade, send Indians to the Moon, maybe even build a base on its surface. Observing the progress of Axiom's efforts, including the challenges they encounter, and the solutions they devise in developing and integrating modules into the ISS, will provide rare invaluable foresight for India.

In essence, the successful conclusion of Axiom-4 is not just a triumph for commercial spaceflight; it is a beginning for the space ambitions of a nation such as India. It underscores that human spaceflight is no longer solely the domain of a few state-funded agencies but is evolving into a more dynamic, collaborative, and commercially viable enterprise. One can only hope that these ventures will also support purely scientific projects such as the planned ISRO missions to look for life by studying the atmospheres of extra-solar planets, or detect gravitational waves from space.

By meticulously studying its successes and drawing pertinent lessons, India can not only ensure the triumphant realisation of Gaganyaan, but also confidently chart a course for an even more ambitious and impactful future in the cosmos. The stars, it seems, are increasingly within reach, and India is well-positioned to seize its moment.

The writer is vice-chancellor and professor of Physics, Ashoka University. Views are personal

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How our space mission is studying muscle loss

Source: The Tribune, Dt. 18 Jul 2025

TV VENKATESWARAN
VISITING PROFESSOR,
IISER MOHALI

INDIA rejoiced when astronaut Shubhanshu Shukla returned to Earth after the Axiom-4 mission to the International Space Station. But as he was helped into a wheelchair, we were reminded of the harsh toll space travel takes on the human body. Microgravity turns muscles to jelly in weeks. Just like prolonged bed rest weakens patients, space makes even strong astronauts stumble like toddlers.

Unlike skin cells, muscle cells are not replaced; instead, they repair themselves using special satellite cells that patch up tiny tears caused by movement, keeping muscles strong.

When we do not move much for a long time, such as during bed rest, the body's signals to repair muscles become weakened. Then, muscles start breaking down faster, lose their strength and get tired easily. It is similar to how a rubber band becomes weak if not used for an extended period of time. This slow weakening is identical to what occurs in diseases like muscular dystrophy or in old age, when muscles become weaker. While muscular dystrophy is genetic and more severe, prolonged bed rest or ageing causes muscle loss through inactivity, poor energy production and inflammation.

While astronauts float through their spacecraft and conduct daring spacewalks, their antigravity muscles, the very muscles that usually fight Earth's gravity daily, go unused. These postural muscles, including calves, thighs, back and core, work constantly to maintain your posture, whether you are standing, sitting or walking. They are your built-in support system, with endurance-focussed muscle fibres designed for sustained activity against gravity's pull.

Microgravity mimics that brief, weightless sensation in your stomach when an elevator begins descending, your body and the elevator drop together for a split second before the descent smoothens out. In space, astronauts experience this feeling continuously. Gravity has not disappeared (Earth's pull is still at work), but their spacecraft is in a perpetual, controlled free-fall around the planet. Like an elevator that never stops dropping, this endless fall creates the illusion of weightlessness, known as microgravity. In space, the antigravity muscles do not have to work much and they become lazy and weak, just like during bed rest. That is why astronauts find it challenging to walk when they return home.

From astronauts to bedridden patients to the elderly and those with muscular dystrophy, maintaining muscle strength is a constant challenge. While exercise remains the gold standard, researchers are now asking: Could flavonoid-rich foods do more than just slow muscle wasting, might they actually help rebuild and strengthen muscles? Early studies hint at this possibility, but the evidence is far from conclusive.

Flavonoids are natural compounds — found in foods such as berries, apples, onions, green tea and dark chocolate — known for their health benefits. They might help keep skeletal muscles healthy by acting like tiny helpers inside your muscle cells. Flavonoids can boost mitochondrial biogenesis, assisting cells to create more mitochondria, the "powerhouses" that produce ATP, the energy muscles need to work. More mitochondria mean stronger, more energetic muscles. Plus, flavonoids act as antioxidants, combating harmful molecules called reac-

tive oxygen species (ROS) that damage muscle cells during stress, exercise or ageing. By neutralising ROS, flavonoids protect muscle cells, potentially keeping them stronger.

The Axiom-4 Myogenesis-ISRO experiment, led by Arvind Ramanathan's group in Bangalore, studied how weightlessness in space affects muscle growth and tested whether plant-based flavonoid nutrients could help prevent muscle wasting. They used special lab containers called BioCells, like tiny high-tech "cell homes", to grow human muscle stem cells. These containers function like mini-labs in space, allowing researchers to feed the cells, alter their liquid environment and preserve samples for study. Unlike regular lab dishes, BioCells can mimic how cells naturally attach or float, making them ideal for space experiments.

During the Axiom-4 mission, a set of BioCells containing human muscle stem cells was placed under Shukla's care. Over eight days in microgravity, he administered differentiation media every 48 hours to stimulate the stem cells' development into muscle fibres. Think of these muscle precursor cells as raw clay, the differentiation media acts like a potter's skilled hands, using precise biochemical signals such as growth factors to shape them into functional muscle fibres. The experiment tested multiple flavonoid combinations, different BioCell wells received distinct cocktail formulations, while control groups received no flavonoids.

For ground-based comparison, Ramanathan's team maintained an identical set of BioCells in their inStem lab. They repeated the experiment by giving the same mix of nutrients and flavonoids at the same time as was done in space. They watched how the muscle cells grew both in the lab and on International Space Station.

Shukla has safely returned to Earth with the space-exposed samples, which will be shipped to inStem. The scientists will compare them with the ones grown on Earth. They will use special methods to study them. RNA sequencing will reveal how microgravity impacts genes that facilitate muscle repair and support energy production in cells. Proteomic profiling will help track changes in proteins that maintain muscle strength and stimulate energy production. High-resolution microscopy and functional assays will be be used to study differences in cell structure, proliferation and differentiation capabilities. The Earth-based cultures, grown identically but under normal gravity, serve as the baseline to isolate microgravity-specific effects.

This study aims to advance our understanding of muscle degradation by revealing key molecular mechanisms and evaluating how metabolic supplements affect mitochondrial function and muscle regeneration through comparative analysis of treated and untreated cells. The findings may lead to new therapeutic approaches for sarcopenia, muscular dystrophy and disuse atrophy.

Space gives a unique chance to study muscles. In microgravity, astronauts lose muscle quickly — what takes years on Earth can occur in a few weeks in space. This enables one to observe how muscle cells cease to repair and become weak.

Earth-based simulations, such as bed rest or laboratory models, cannot fully replicate space conditions, as they fail to reproduce the unique disruption of cellular energy production (mitochondrial function) and repair signalling pathways that occurs in microgravity. By studying these processes in actual microgravity, researchers gain clearer, more reliable insights into muscle deterioration and recovery mechanisms, benefiting both space medicine and terrestrial healthcare applications.

The blind receive sight, the lame walk — not by miracles, but through meticulous science.

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