मार्च
March
2026

खंड/Vol. : 51 अंक/Issue : 056

21-23/03/2026

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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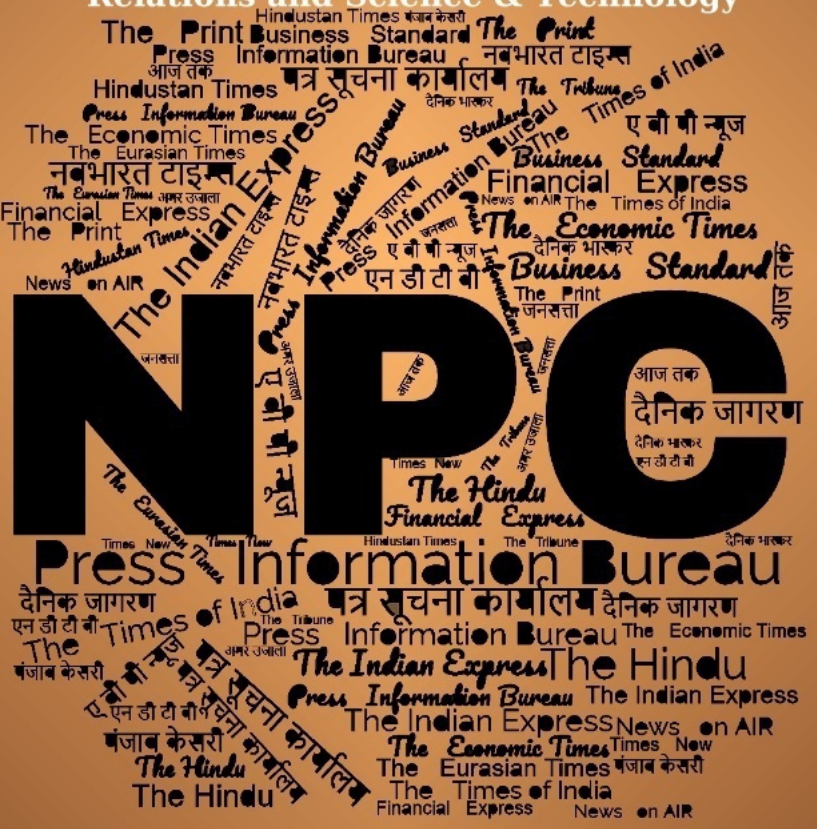

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Defence News

INDIAN NAVY SET TO COMMISSION ITS LATEST STEALTH FRIGATE 'TARAGIRI'

Source: Pnformation Bureau, Dt. 21 Mar 2026

In a ceremony that marks a defining moment for India's maritime sovereignty, the Indian Navy is preparing to commission its latest stealth Frigate, *Taragiri* (F41), on 03 Apr 2026. The ceremony at Visakhapatnam, scheduled to be presided over by the Hon'ble Raksha Mantri Shri Rajnath Singh, will serve as a powerful testament to the nation's journey toward becoming a completely self-reliant naval power.

As the fourth potent platform of the Project 17A class, *Taragiri* is not merely a ship; it is a 6,670-tonne embodiment of the 'Make in India' spirit and the sophisticated engineering capabilities of our indigenous shipyards.

Built by Mazagon Dock Shipbuilders Limited (MDL), Mumbai, this Frigate represents a generational leap over earlier designs, offering a sleeker form and a significantly reduced Radar Cross-Section that allows it to operate with lethal stealth. With indigenous content exceeding 75 percent, the ship highlights the maturity of a domestic industrial ecosystem that now spans over 200 Micro, Small and Medium Enterprises (MSMEs), contributing the GoI's *Aatmanirbharta* initiatives supports thousands of Indian jobs.

Driven by a Combined Diesel or Gas (CODOG) propulsion plant, *Taragiri* is designed for 'High-Speed – High Endurance' versatility and multi-dimensional maritime operations. The ship's weapon suite is world-class, featuring supersonic Surface-to-Surface Missiles, Medium Range Surface-to-Air Missiles, and a specialised Anti-Submarine Warfare suite. These systems are seamlessly integrated through a state-of-the-art Combat Management System, ensuring that the crew can respond to threats with split-second precision.

Beyond its role as a premier hunter of the seas, *Taragiri* is built for the complexities of modern diplomacy and humanitarian crises. Its flexible mission profile makes it ideal for everything from high-intensity combat to Humanitarian Assistance and Disaster Relief (HADR).

The Indian Navy continues to grow as a combat-ready, cohesive, credible, *Aatmanirbhar* force, safeguarding the seas for a *Viksit, Samriddha Bharat* guarded by ships designed by Indians, built by Indians and operated by Indians. *Taragiri* stands ready for a promising future as a beacon of rising maritime power and an ironclad guardian of our blue frontiers.

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Modern-day warfare transcends borders, robust military supported by prepared citizens must to secure national interests: Raksha Mantri

Source: Press Information Bureau, Dt. 21 Mar 2026

Present-day warfare transcends borders, with national security encompassing economic, digital, energy, and even food security," said Raksha Mantri Shri Rajnath Singh as he underscored the need of a robust military supported by prepared citizens capable of standing shoulder-to-shoulder to protect the nation under any circumstances. Virtually addressing the Raising Day celebrations and the Diamond Jubilee of Sainik School, Ghorakhal in Uttarakhand on March 21, 2026, he asserted that the nature of conflicts has undergone a paradigm shift as a nation can today be weakened through economic, cyber, space and information warfare, which demands every citizen to remain vigilant & prepared at all times.

While the Government, under the leadership of Prime Minister Shri Narendra Modi, is leaving no stone unturned to equip the defence forces with niche weapons & technologies, Raksha Mantri emphasised that the citizens, especially the youth, need to develop mental toughness and intellectual clarity through discipline & determination to help the nation tackle any and every situation. Referring to the concept of VUCA (Volatile, Uncertain, Complex and Ambiguous), he exhorted the students to develop their own version of VUCA *i.e.*, Vision, Understanding, Courage and Adaptability, to navigate modern challenges effectively.

Highlighting the steps taken by the Government towards ensuring that a larger number of youth imbibe the values essential for nation-building, Shri Rajnath Singh stated that recently a decision was taken to establish 100 new Sainik Schools across the country in the Public-Private Partnership model. He added that another initiative includes increasing the number of vacancies within the National Cadet Corps (NCC). "Earlier, the NCC had an intake capacity of 17 lakh cadets; this has now been expanded to 20 lakh," he said.

Raksha Mantri described the decision of admission of girls into Sainik Schools as historic and revolutionary, which is bolstering the country's 'Nari Shakti'. These girls will, in the times to come, become the torchbearers of 'Nari Shakti' and scale new heights across various sectors, he said.

Extending his greetings to students, faculty, alumni and their families on Sainik School, Ghorakhal completing 60 years of dedicated service to the nation, Shri Rajnath Singh expressed confidence that the students will continue to uphold the highest standards of discipline and dedication, bringing pride to their families, institution and the nation. "Over decades, the school has sent more than 800 students to the National Defence Academy and over 2,000 candidates to the Armed Forces through various entry schemes such as Combined Defence Services Examination and Air Force Common Admission Test. He hoped that the institution will continue to produce leaders who contribute meaningfully to nation-building. The distinguished alumni of the school, including General Officer Commanding-in-Chief, Western Command Lt Gen MK Katiyar, are a source of inspiration to the students, he added.

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MSMEs and start-ups are safeguarding national interests by strengthening defence capabilities & contributing to self-

reliance vision: Raksha Rajya Mantri at National Defence Industries Conclave 2026

Source: Press Information Bureau, Dt. 20 Mar 2026

The National Defence Industries Conclave (NDIC) 2026, organised by the Department of Defence Production (DDP) on the theme *'Advanced Manufacturing Technologies'*, concluded at the Manekshaw Centre, New Delhi on March 20, 2026, after two days of extensive discussions on advanced manufacturing technologies and industry participation in defence production. The conclave brought together MSMEs, Defence Public Sector Undertakings (DPSUs), private defence companies, innovators, policymakers and academia to deliberate on strengthening India's defence manufacturing ecosystem and accelerating the adoption of emerging technologies.

The valedictory session was graced by Raksha Rajya Mantri Shri Sanjay Seth. In his address, Raksha Rajya Mantri highlighted the critical role of MSMEs, start-ups & innovators in strengthening India's industrial base and contributing to the vision of Aatmanirbharta in defence. He also commended them for strengthening the capabilities of the defence forces, thereby safeguarding the nation from different kinds of threats.

Shri Sanjay Seth described the MSMEs and start-ups as the brand ambassadors of innovation, who are playing a central role in making India a global defence manufacturing hub and Viksit Bharat, as envisioned by Prime Minister Shri Narendra Modi. Extending the Government's full support in this endeavour, he expressed confidence of achieving the target of Rs 50,000 crore worth of defence exports and Rs 03 lakh crore worth of defence production by 2030.

Raksha Rajya Mantri listed out the number of steps taken by the Government to increase the participation of the private sector, especially MSMEs and start-ups. He stated that the all-time high allocation of Rs 7.85 lakh crore to the Ministry of Defence in the Union Budget 2026-27 provides an opportunity to the MSMEs and start-ups to make the nation self-reliant.

Speaking on the occasion, Secretary (Defence Production) Shri Sanjeev Kumar gave a broad overview of the discussions and sessions organised as part of the two-day conclave. He stated that these sessions provided a platform for MSMEs to engage directly with DPSUs, industry leaders and policymakers, helping identify opportunities for collaboration, technology development and supply-chain integration.

The Secretary (DP) emphasised that the conclave facilitated extensive interaction between government, industry and academia, helping identify technology gaps, capability requirements and opportunities for collaboration across the defence manufacturing value chain. He added that the discussions reinforced the importance of innovation, advanced manufacturing and MSME participation in strengthening India's defence production capabilities and enhancing global competitiveness.

Technical Discussions

Over the course of two days, the conclave hosted multiple thematic and domain sessions covering key areas of defence manufacturing including:

- Artillery guns, small arms and infantry weapons
- Defence metallurgy, special alloys and precision manufacturing
- Advanced materials and defence composites
- Naval platforms and shipbuilding technologies
- Armoured vehicles and logistics platforms
- Ammunitions, explosives and propellants
- Missile systems and air defence technologies

- Defence Maintenance, Repair and Overhaul (MRO) and lifecycle support

Several iDEX and DRDO-led sessions focused on emerging technologies such as:

- Smart Manufacturing and Industry 4.0
- Guidance, Control and Navigation Systems
- Propulsion and Mobility Technologies
- Advanced Materials and Composites
- Semiconductor Manufacturing for Defence Systems

Industry Exhibition

The exhibition organised alongside the conclave served as an important platform for showcasing the capabilities of India's defence manufacturing ecosystem. It featured stalls from 20 large defence companies, along with 24 participation from Indian and international companies demonstrating advanced manufacturing technologies in areas such as automation, artificial intelligence, robotics, additive manufacturing and smart materials. The exhibition also showcased initiatives of the Department of Defence Production and its associated organisations, highlighting policy reforms and innovation platforms aimed at strengthening India's indigenous defence industrial base.

The NDIC 2026 marks another significant step towards advancing the Government's vision of Aatmanirbhar Bharat in Defence and building a robust, globally competitive defence manufacturing ecosystem.

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INDIAN NAVAL SHIP TRIKAND CONCLUDES PORT CALL AT PORT VICTORIA, SEYCHELLES

Source: Press Information Bureau, Dt. 22 Mar 2026

Indian Naval Ship Trikand, a stealth frigate of the Indian Navy, has departed from Port Victoria, Seychelles, on 20 Mar 2026 on completion of an enriching port call.

Captain Sachin Kulkarni, Commanding Officer of the ship, called on senior Government functionaries and the High Commissioner of India to Seychelles. The ship also handed over critical spares and essential stores to the Government of Seychelles.

INS Trikand participated in the first tri-services edition of Exercise Lamitiye 2026, along with members from the Indian Army and Indian Air Force and the Seychelles Defence Forces (SDF). This marks the maiden participation of the Indian Navy in Exercise Lamitiye.

During the harbour phase, Visit, Board, Search and Seizure (VBSS) training was conducted onboard, which also included joint boarding drills. This was followed by the sea phase of the exercise, during which the ship exercised with *SCGS Le Vigilant* and undertook joint boarding operations at sea by a team comprising of Indian Navy Marine Commandos and Special Forces of SDF. This was followed by landing of Army troops of the Indian Army and the Seychelles Defence Forces on Praslin Island. Maj Gen Michael Rosette, Chief of Defence Forces, SDF, Brig Jean Attala, Deputy Chief of Defence Forces SDF, along with other senior officers embarked INS Trikand for the sea phase to witness conduct of the exercise.

The exercise provided an opportunity to enhance interoperability and strengthen maritime cooperation between India and Seychelles. *Lamitiye*, meaning 'friendship' in Creole language, reflects the historic ties between the two nations.

The port call reflects India's vision of *MAHASAGAR* - Mutual and Holistic Advancement for Security and Growth Across Region, and reinforces the Indian Navy's commitment to remain the *Preferred Security Partner* and *First Responder* in the Indian Ocean Region.

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भारतीय नौसेना को मिलेगा एक और युद्धपोत तारागिरी

Source:NavBharat Times, Dt. 23 Mar 2026

जंग के बाद नेवी ने बढ़ा दी थी तैनाती

इंडियन नेवी को मिलेगा एक और वॉरशिप 'तारागिरी'

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■ नई दिल्ली : पश्चिम एशिया में जंग के बीच इंडियन नेवी को एक और वॉरशिप मिलने जा रहा है। 3 अप्रैल को रक्षा मंत्री राजनाथ सिंह की मौजूदगी में नेवी में स्टील्थ फ्रिगेट तारागिरी कमिशन होगा। ये प्रोजेक्ट-17 A क्लास का चौथा वॉरशिप है। 6670 टन का ये वॉरशिप मेक इन इंडिया की स्प्रिट और शिप बिल्डिंग में भारत की काबिलियत का भी उदाहरण है। बताया गया कि इस फ्रिगेट में पुराने फ्रिगेट के डिजाइन से मुकाबले काफी बदलाव किए गए हैं।

नेवी पश्चिम एशिया में जंग छिड़ने के बाद हॉर्मुज जलडमरूमध्य (स्ट्रेट) के ईस्ट में अपनी तैनाती बढ़ाई है। ओमान की खाड़ी एरिया में नेवी के तीन से ज्यादा वॉरशिप तैनात है।

रडार को भी देगा चकमा: नया वॉरशिप ज्यादा स्लीक है, जिसकी वजह से ये रडार की पकड़ में कम आएगा। स्टेल्थ होने की वजह से ये छिपकर प्रभावी तरीके से ऑपरेट कर सकता है। नेवी के प्रवक्ता कैप्टन विवेक मधवाल ने कहा कि इस शिप का 75 पर्सेंट से ज्यादा हिस्सा स्वदेशी है और ये दिखाता है कि भारत में औद्योगिक नेटवर्क काफी मजबूत हो गया है। ये वॉरशिप कंबाइंड डीजल या गैस प्रपल्शन सिस्टम से चलता है और इसकी रफ्तार तेज है, ये लंबे वक्त तक ऑपरेशन करने में सक्षम है।

75 पर्सेंट से ज्यादा हिस्सा स्वदेशी है शिप का

हर तरह के मिशन के लिए तैयार: इसे हर तरह के समुद्री मिशन के लिए तैयार किया गया है। इस वॉरशिप में आधुनिक और ताकतवर हथियार लगे है। इसमें सुपरसोनिक सतह से सतह पर मार करने वाली मिसाइलें, मध्यम दूरी की सतह से हवा में मार करने वाली मिसाइलें और पनडुब्बियों से निपटने के लिए खास सिस्टम है। इन सभी को एक आधुनिक कॉम्बेट मैनेजमेंट सिस्टम से जोड़ा गया है, जिससे क्रू किसी भी खतरे का तुरंत और सटीक जवाब दे सकता है।

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रक्षा सचिव ने कहा- बजट में **10%** की बढ़ोतरी काफी है लेकिन...

Source:NavBharat Times, Dt. 22 Mar 2026

रक्षा सचिव ने कहा- बजट में 10 पर्सेंट की बढ़ोतरी काफी लेकिन...

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संसद की स्टैंडिंग कमिटी के सामने किया युद्ध के बदलते स्वरूप का जिक्र

FILE

नई दिल्ली : रक्षा सचिव ने रक्षा मामलों की संसद की स्टैंडिंग कमिटी को युद्ध के बदलते स्वरूप के बारे में बताया और कहा कि वे रक्षा बजट में हर साल 20 पर्सेंट बढ़ोतरी की सिफारिश करें, तो हमारे लिए अच्छा रहेगा। रक्षा सचिव ने कहा कि हमने फाइनेंस कमिशन के सामने पांच साल की डिमांड रखी है और हर साल करीब 20 पर्सेंट की बढ़ोतरी मांगी है। संसद की स्टैंडिंग कमिटी के सामने रक्षा सचिव ने कहा कि वित्त वर्ष 2026-27 के लिए रक्षा मंत्रालय को कुल 7.85 लाख करोड़ रुपये का बजट मिला है। उन्होंने कहा कि इस साल ऑपरेशन सिंदूर के संदर्भ में खासकर कैपिटल बजट में हमने 20 पर्सेंट की बढ़ोतरी मांगी थी। फाइनेंस मिनिस्ट्री ने 24 पर्सेंट की बढ़ोतरी दी। रक्षा सचिव ने कहा कि क्षमताओं को बढ़ाने में अभी जो गैप है उनकी पहचान सर्विसेज (आर्मी, नेवी, एयरफोर्स) ने की है। उसके हिसाब से 10 पर्सेंट से ज्यादा की बढ़ोतरी आधुनिकीकरण के लिए काफी है लेकिन युद्ध के बदलते स्वरूप को देखते हुए हर साल 20 पर्सेंट बढ़ोतरी की मांग की है।

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With 7th regiment, army expands pinaka fleet

Source: The Times of India, Dt. 23 Mar 2026

With 7th regiment, Army expands Pinaka fleet

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New Delhi: With increased security threat along the western and northern frontiers, especially after last year's conflict with Pakistan, the Indian Army has added another Pinaka regiment and is preparing to induct one more by the end of the year, it is learnt.

With the operationalisation of one more regiment, the Indian Army now has seven Pinaka rocket launcher regiments deployed along its borders with Pakistan and China. "The eighth regiment has received more than half its equipment. It should become operational before the end of 2026," a source said.

Two more regiments are likely to be operationalised next year, which will take the total number of Pinaka regiments in deployment to 10. The Army has a long-term goal of 22 regiments, equipping them with newer, longer-range guided versions.

In Aug 2020, the Army signed contracts with Bharat Earth Movers Ltd (BEML), Tata Power Company(TPCL) and Larsen & Toubrofor supply of six Pinaka regiments at an approximate cost of Rs 2,580 crore.

Developed by DRDO, Pinaka is India's premier indigenous multi-barrel rocket launcher.

While early versions had a range of 40 km, newer variants such as Guided Pinaka and Long-Range Guided Rocket have extended ranges of up to 120 km, making the system a critical asset for deep-strike operations.

RAZING ENEMY INFRA IN MINUTES

- A Pinaka regiment typically comprises three batteries. Each battery operates six Pinaka launchers, giving a regiment 18 launchers
- Two additional launchers are generally maintained for training and wartime replacement
- A single battery of six launchers can fire 72 rockets in about 44 seconds
- Named after Lord Shiva's divine bow, it is designed for rapid, high-volume fire to saturate large areas and neutralise enemy troop concentrations, logistics hubs and infra within minutes
- System is mounted on a high-mobility Tatra or Tata truck, featuring 'shoot and scoot' capability that allows it to quickly relocate after firing
- Armenia is the first country to have purchased and received the Pinaka launcher system

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How Ukrain's front line became a laboratory for drone innovation

Source: The statesman, Dt. 23 Mar 2026

How Ukraine's front line became a laboratory for drone innovation

AGENCIES
Kharkiv, 22 March

The night air in eastern Ukraine is crisp, and a myriad of stars scatter above a small crew of soldiers watching for Iranian-designed Shahed drones that Russia launches in waves.

Such teams are deployed across the country as part of a constantly evolving effort to counter the low-cost loitering munitions that have become a deadly weapon of modern warfare, from Ukraine to the West Asia.

While waiting, the crew from the 127th Brigade tests and fine-tunes their self-made

interceptor drones, searching for flaws that could undermine performance once the buzzing threat appears.

When Shahed drones first appeared in autumn 2022, Ukraine had few ways to stop them. Today, drone crews intercept them in flight with continually adapting technology. In recent years, Ukraine's domestic drone interceptor market has burgeoned, producing some key players who tout their products at international arms shows. But it's on the front line where small teams have become laboratories of rapid military innovation - grassroots technology born of battlefield necessity that now draw international interest.

President Volodymyr Zelenskyy says US allies in the West Asia have approached Ukraine for help in defending against Iranian drones, the same type that Russia has fired by the tens of thousands in the 4-year-old war.

Iran has also used the same drones in retaliation for joint US-Israeli strikes, at times overwhelming far more sophisticated Western-made air defences and highlighting the need for cheaper and more flexible countermeasures. "It's not like we sat down one day and decided to fight with drones," said a pilot with Ukraine's 127th Brigade, sitting at his monitor after completing a preflight check. "We did it because we had nothing else."

Moments earlier, the pilot carefully landed his interceptor drone to avoid damaging it.

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Science & Technology News

Scientists find ways of understanding role of molecular clouds near Milky Way disc in star formation

Source: Press Information Bureau, Dt. 20 Mar 2026

Scientists tracing small molecular clouds located near the Milky Way disc have "seen" the skeleton of the magnetic field surrounding them for the first time to better understand its role in star formation.

For decades, astronomers have known that gravity pulls molecular clouds inward to form stars, while internal pressure pushes them outward. But there is a third, silent player in this tug-of-war: the Magnetic Field.

L1604 and L121 are small molecular clouds, modest stellar nurseries with L1604 lying toward the Galactic anticenter and L121 toward the crowded Galactic center.

As magnetic fields are invisible, the research team from Aryabhatta Research Institute of Observational Sciences (ARIES) an autonomous institute of Department of Science and Technology (DST) and Assam University used R-band polarimetry with the ARIES Imaging Polarimeter (AIMPOL) on the 104-cm ARIES telescope at Nainital to measure how starlight from distant stars becomes polarized as it passes through dust in the molecular clouds. When starlight hits dust grains aligned by a magnetic field, the light vibrates in a specific direction. By mapping thousands of these light waves, the team "saw" the skeleton of the magnetic fields surrounding L1604 and L121 for the first time.

The researchers found two very different personalities. The two clouds also lie at very different distances- L1604 at around 816 parsecs and L121 nearly seven times closer at just 124 parsecs. The L1604 cloud is highly dense and more massive and has enough material to possibly form many new stars. L121 is located toward the center of the Galaxy. It is less dense and less massive than L1604, but has a stronger magnetic field. Moreover, its magnetic field morphology appears more orderly, suggesting it hasn't yet been warped by the violent gravitational collapse that characterizes more active star-forming regions.

By calculating the magnetic field strength the scientists found that both clouds are firmly sub-critical, meaning the magnetic fields are comfortably strong enough to resist gravitational collapse across the full body of both clouds. The magnetic fields are not "just barely" holding on -they dominate over both gravity and turbulence, with magnetic energy exceeding turbulent kinetic energy, which in turn exceeds gravitational energy at the envelope scale. However, in the dense cores nestled deep within these clouds, gravity may be quietly gaining the upper hand, making these cores the true cradles of future star birth even as the surrounding envelope remains magnetically protected.

This story isn't just about two clouds; it’s about the "recipe" for a star. By showing exactly how magnetic fields wrap around and permeate these small clouds, the study reveals that magnetism is the invisible hand that slows star formation, preventing the galaxy from turning all its gas into stars at once.

L1604 and L121 are now more than just dark spots on a map; they are active laboratories where we can watch the fundamental forces of the universe, gravity and magnetism, dance in a delicate, million-year-long embrace.

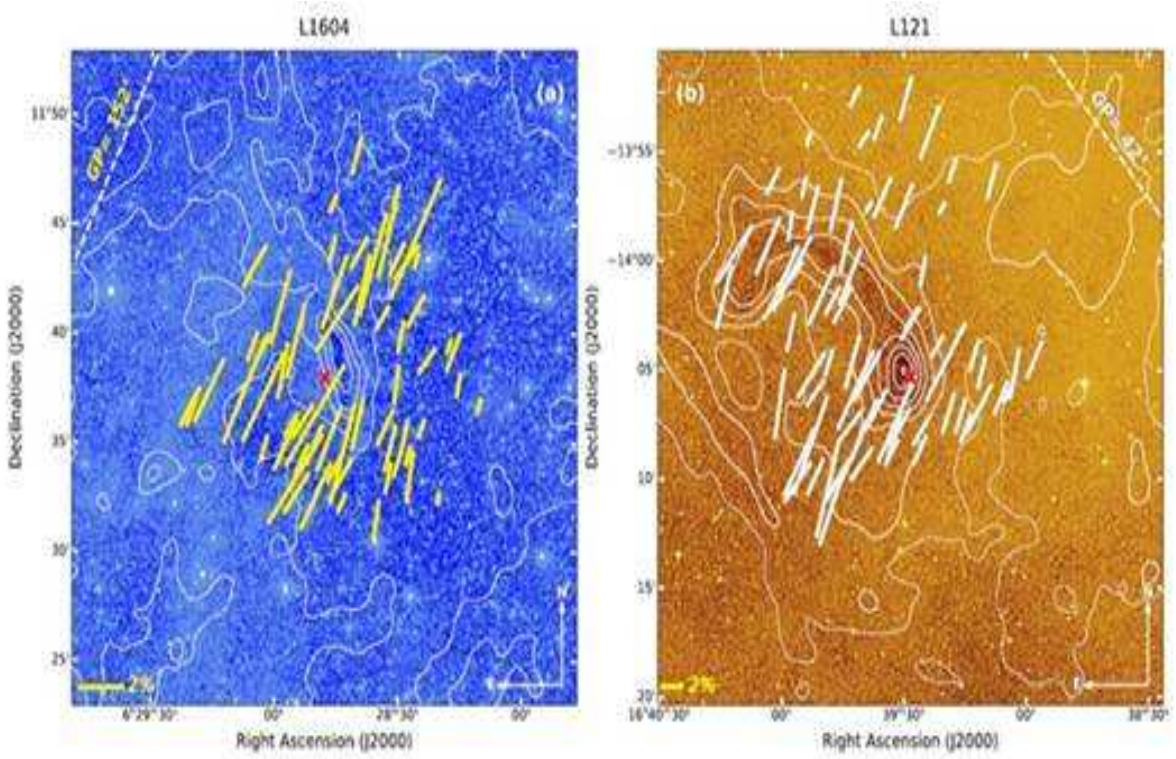

Fig: *Polarization maps of dark clouds L1604 and L121. Solid lines represent the polarization vector corresponding background stars overlaid on the composite DSS images of the respective clouds. The orientation of the Galactic Plane (GP) is marked with a dashed line. The cross denotes the central position of each cloud. Contours of the Herschel SPIRE 500 μm dust continuum emission are over plotted.*

Publication link: https://academic.oup.com/mnras/article/545/4/staf2228/8382486?login=true

News Link : https://www.pib.gov.in/PressReleasePage.aspx?PRID=2243030&reg=3&lang=1

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ISRO forcesink telemedicine agreement

Source: The Tribune, Dt. 20 Mar 2026

ISRO, forcesink telemedicine agreement

TRIBUNE NEWS SERVICE

NEW DELHI, MARCH 20

The armed forces and the Indian Space Research Organisation (ISRO) have signed a memorandum of understanding (MoU) to expand satellite-based telemedicine facilities for troops stationed in forward areas.

The MoU covers maintenance of existing telemedicine nodes and the addition of new ones for the armed forces. Both sides reviewed the current infrastructure and discussed a roadmap for next-generation telemedicine systems.

The collaboration aims to provide critical medical care to soldiers deployed in remote, high-altitude and inaccessible border regions where conventional healthcare is unavailable.

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Tipping Point : How earth may go into a hot loop ?

Source: The Times of India, Dt. 22 Mar 2026

TIPPING POINT: HOW EARTH MAY GO INTO A HOT LOOP

New Research Shows If Changes To The Greenland Ice Sheet, Amazon Forest Or Atlantic Currents Breach Thresholds, The Planet May Enter A 'Hothouse Trajectory' Of No Return

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We know the planet has been warming for decades. Now, a group of scientists wants us to understand something more unsettling: higher temperatures can further trigger the process of warming, leading to a chain of events that, once started, we may not be able to stop.

For thousands of years, human civilization has lived in a relative climate calm. Seasons shifted, monsoons came and went, glaciers grew and shrank slowly. Agriculture flourished. Cities rose. That stability, scientists now say, is slipping.

"We are leaving the stable conditions of the Holocene," authors of a new study published in One Earth write, referring to the last 11,700 years during which human societies developed. The paper's lead authors include climate scientist William J Ripple and Earth system researcher Johan Rockstrom.

Researchers from institutions including Oregon State University and the Potsdam Institute for Climate Impact Research lay out what they call the risk of a "hothouse Earth trajectory" — a pathway in which the climate system tips past a point of no return, locking the planet into temperatures far higher than anything seen in human history, even if we stop burning fossil fuels tomorrow.

How warming feeds itself

Think of the climate as a thermostat that can, under certain conditions, start turning itself up. When Arctic ice melts, for instance, the white surface that once reflected sunlight back into space is replaced by dark ocean water, which absorbs heat instead. More heat melts more ice, and a more ice-free ocean absorbs more heat. And warming accelerates without help from humans.

Scientists call these "amplifying feedback loops", and they have identified dozens of them — from thawing permafrost releasing stored carbon, to dying forests that can no longer absorb carbon dioxide, to changes in cloud cover that let more solar energy through. Each loop is a mechanism by which warming begets more warming.

What makes the new paper striking is how it joins these individual loops to a wider theory of catastrophic, self-sustaining change.

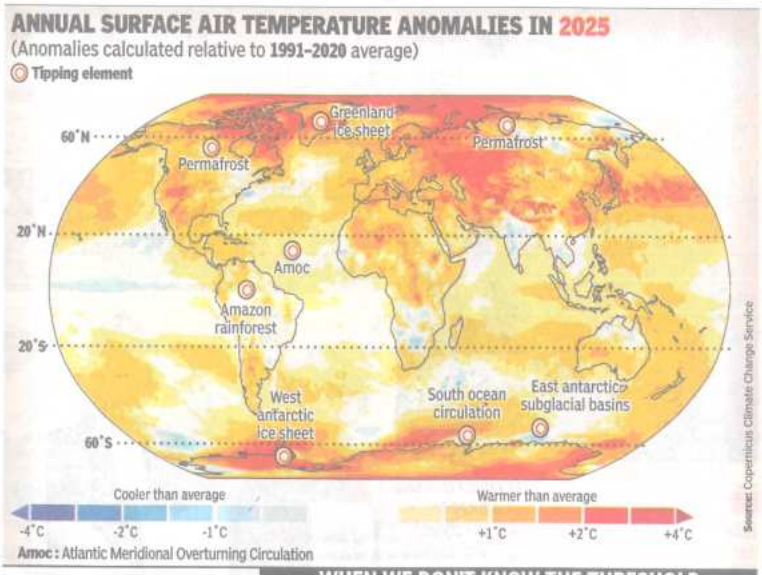
Tipping Elements

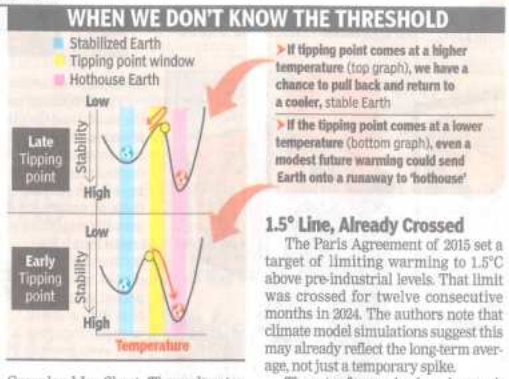
Scattered across the planet are what scientists call "tipping elements" — large parts of the Earth system that can, when pushed past a certain temperature threshold, shift abruptly and permanently into a new state.

Sixteen such elements have been identified. The Greenland Ice Sheet is one. The Amazon rainforest is another. The Atlantic Ocean's great overturning current — the conveyor belt of water that keeps northern Europe relatively mild — is the third. The concern is not that each of these will tip independently; it is that they are connected. Trigger one, and it may push others closer to their own thresholds.

The paper describes a chain of events that illustrates the point. Rising greenhouse gas emissions warm the Arctic, melting sea ice and the Greenland Ice Sheet. The meltwater pours into the Atlantic and disrupts ocean currents that alters rainfall patterns across the tropics. Parts of the Amazon dry out. Dying trees release carbon that warms the planet further. And the cycle continues.

"Such tipping cascades have the potential to drive self-sustaining climate change," the authors write.





1.5° Line, Already Crossed

The Paris Agreement of 2015 set a target of limiting warming to 1.5°C above pre-industrial levels. That limit was crossed for twelve consecutive months in 2024. The authors note that climate model simulations suggest this may already reflect the long-term average, not just a temporary spike.

The rate of warming has also accelerated. In the mid-twentieth century, the planet was warming at roughly 0.05° per decade. The current rate is approximately 0.31° per decade — six times faster.

At that pace, the paper suggests, we could cross 2° of warming before the middle of this century. There is a complicating factor. For decades, industrial air pollution — the aerosols produced by burning coal and oil — has had a cooling effect, masking some of the warming caused by greenhouse gases.

As the world shifts away from the dirtiest fuels, that masking effect fades. The result could be an additional 0.5° of warming.

ALARM BELLS

- Since 1970s, global mean surface temperature has risen at a decadal average of 0.2°C, the fastest in the past decade
- In 2024, global temperature exceeded 1.5°C above pre-industrial age
- 2025 was the third-warmest year on record

What We Don't Know

The paper is careful not to claim certainty. The precise temperature at which each tipping element flips is unknown. Some may be further away than feared; others may be closer than some current models suggest.

The Greenland Ice Sheet, one study cited here indicates, may be vulnerable to tipping at somewhere between 0.8° and 3.4° of warming. Uncertainty, the authors say, is not a reason to wait. If anything, it is the opposite. "Uncertainty about where tipping thresholds lie is therefore not a reason for delay, but a compelling reason for immediate precautionary action," they say.

Where We're Headed

Current national pledges and policies, assessed by the UN Environment Programme, put the planet on track for peak warming of roughly 2.8° by 2100. In 2024, global energy-related CO^2 emissions rose to a record 37.8 billion tonnes, according to the International Energy Agency (IEA).

Atmospheric CO^2 has reached 422.5 parts per million, about 50% higher than the pre-industrial age. Scientists stop short of predicting a hothouse outcome. What they are doing is insisting the risk be taken seriously by those who set policy. There is, they note, an important distinction between a "hothouse trajectory" and a "hothouse state". A trajectory is a direction of travel that can still, in theory, be interrupted. A state — a planet of extreme, sustained heat and seas many metres higher — is where that trajectory ends.

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