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Technology & Military Disruption: Inbound from the Space Frontier

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The Forum presents innovative concepts and thought-provoking insight from air and space experts here in the United States and across the globe. In order to afford publishing opportunities for thoughtful perspectives, Mitchell Institute's Forum provides high visibility to writing efforts on issues spanning technology and operational concepts, defense policy and strategy, and unique interpretations of changing geopolitical relationships.

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Introduction

The modern Air Force was created in large part by funding early X-Planes, new launch systems, and the first satellites during the post-WWII era, despite declining defense budgets. Gen Hap Arnold, the first U.S. Air Force Chief of Staff, said, "Remember that the seed comes first; if you are to reap a harvest of aeronautical development, you must plant the seed called experimental research."[1] A U.S.–India partnership can help plant the seed to rapidly mature key space, air, and defense technologies while stabilizing the Indo-Pacific region with the only country in Asia that can stand toe to toe with China.

To counter the growing belligerence of China, both militarily in the Indo-Pacific region and economically around the world, the United States and India should establish a partnership to accelerate the growth of air, space, and defense technologies. Beyond advancing technology, key partnership goals should include:

1. Build a 21st-century economic engine benefiting both countries.

2. Develop high-speed space and air transportation, opening the space frontier for 21st-century commerce and bringing both nations and the world closer together.

3. Counter China's aggression by collaborating on national security, military intelligence, and counter terrorism efforts to facilitate peace and stability in the Indo-Pacific region.

One key technology that can be "harvested" is reusable rocket-powered Vertical Takeoff and Landing (VTOL) vehicles. A host of companies in the United States and around the globe, including Blue Origin, Rocket Lab, Stoke Space, and Relativity Space, are developing VTOL vehicles for space access, and SpaceX now routinely flies them. The

Chinese are also developing their Long March 9 VTOL vehicle.

Such VTOL vehicles can potentially enable point-to-point transportation around Earth as well; rocket-powered VTOL companies pursuing this technology include SpaceX, Beijing Lingkong Tianxing, and New Frontier Aerospace. Although still in their infancy, these VTOL vehicles offer inherent global reach capability. Indeed, properly matured and equipped, they have the potential to execute many Air and Space Force missions with aircraft-like operability, cost efficiency, and unprecedented speed.

The Escalating China Problem

China's growing military, economic, and political aggressiveness is a top concern of the United States Air and Space Forces. At the Air Force Association's 2021 Air, Space & Cyber Conference, then-Secretary of the Air Force Frank Kendall said his top priorities were "China, China, and China."[2] His was not a lone declaration as senior leaders in DOD and government continue to frequently voice similar sentiments.

Furthermore, the United States is not the only nation worried about China's aggressive behavior. Taiwan has major concerns due to China's blatant military harassment and reunification policy; India has been subjected to recurring border skirmishes due to China's increasingly expansionist policies; many poor nations borrowing funds from China's Belt and Road Initiative find themselves indebted to China; and China's buy-in to key seaports through their infrastructure initiative enables access and control of resource-rich regions, especially those in Africa and, increasingly, South America.[3] Far more nefarious "red light" signals include China's extensive export of fentanyl precursors, killing nearly 100,000 Americans per year, and continuing concerns about Chinese compliance with the Biological Weapons Convention, from the ambiguity of COVID-19 origins to ongoing "dual-use" civilian and military research.[4]

The world is already engulfed in wars, provocative displays of military strength by potential U.S. adversaries, refugee crises, political strife, and terrorism from enemies with no regard for the fundamental value of human life. If the United States and India work together, they can improve their mutual defense. The United States, the established superpower since WWII, and India, an emerging technological giant on the opposite side of the world, may seem an odd couple. However, they also share mature and stable governments, democratic values, educated technologists, able workforces, and a common interest in global security. With a nod to today's troubling global headwinds, the two governments have inked new pacts and are working on an increasingly united front, sharing intelligence and technology to support mutual defense needs.[5] India and the United States have strengths that complement one another. Building on these strengths, mutual defenses can be enhanced by expanding cooperative military and technology programs aimed at curbing foreign threats.

Advanced Technological Solutions for a Sustainable Future

Today, a revolution advancing civil and military space technology is changing what satellites the United States builds, how it launches them, and even how it operates them. The revolution is not limited to space systems, as many of the underlying technological trends impact military and civil aviation as well. Transformational technology trends include additive manufacturing, artificial intelligence, quantum computers, and advanced energy sources. These underlying technologies are enabling revolutionary distributed satellite constellations and autonomous uncrewed aerial systems (UAS), to name a few.

However, this paper focuses on the benefits of cooperating to mature reusable rocket-powered VTOL vehicles and high-speed global-reach aircraft. These technologies can enable the U.S. and India to lead the world into an era of both economic expansion in space and a stable political detente in the Indo-Pacific region.[6]

Revolutionary transportation technology is on our doorstep. VTOL rockets can open the space frontier and enhance global connectivity with fast worldwide access for emergencies, security breaches, disaster responses, military operations, and a better life for all.[7] To be sure, further resources, scientific collaboration, and business case initiatives are needed to help realize these goals. As with the introduction of all historical transportation systems, from trains to ships to aircraft, support from the government can incentivize and facilitate the growth of this nascent industry.

A key benefit of VTOL rockets is that they can dramatically lower the cost of space access or rapidly travel over intercontinental distances. Whether flying ballistically or inside the atmosphere using waverider configurations employing "boost-glide" and cruise flight, these next-generation aircraft offer global reach without aerial refueling. The physics and engineering for their construction and operations portend a revolution in transportation technology. For example, comparing the Starship Raptor scaled to the same thrust as the Boeing 777 GE90 turbofan engines, the Full Flow Stage Combustion rockets are up to thirty times lighter and take up to twenty times less volume.[8] Other rocket advantages include up to a hundred times lower parts count, dramatically lower dry weights when installed in VTOL vehicles like Starship, and much lower bulk propellant cost vs jet fuel at Wall Street Henry Hub prices.[9] Indeed, most VTOL companies are pursuing liquid oxygen and natural gas/methane or hydrogen-based systems. Bulk costs for the former are 3 to 5 times less than jet fuel at Wall Street Henry Hub prices, and if they are synthetically manufactured or sourced from renewable natural gas, they are eco-friendly with a path to carbon-neutral operations.[10]

Once fully matured, the high payload-to-dry-weight ratio of rocket-powered VTOL vehicles, which is a key measure of productivity for commercial aircraft, can potentially outperform today's cargo jets. Comparing the Boeing 777 and the Starship Super Heavy, the latter potentially delivers more cargo ton-miles per dry weight lb. However, without successful flight tests, including operability and reliability data, such comparisons must be treated as only potential advantages. A U.S.–India partnership can help advance this technology, including operability and reliability, both for access to space and global transportation. SpaceX has reduced the cost of space launch by another order of magnitude. Starship, designed from the get-go for full reusability, could reduce costs another order of magnitude.[11]

A robust U.S.–India partnership should focus on space access and high-speed aircraft; however, it can include other defense and civil technologies. Likewise, the mutual advantages of a technology partnership are not limited to how the technologies are used but also to how the two governments can facilitate their adoption and growth.

If the United States and India choose, they can together incentivize the development of expansive commerce on the space frontier while facilitating technologies for high-speed flight and mutual defense with many civil applications. This partnership includes a deterrent value in the escalating challenges posed by Chinese, North Korean, and Russian aggression in Asia—as well as the unarticulated cooperation between these potential adversaries. Moreover, bolstered

by large and highly skilled workforces, the collaboration can evolve to support essential military logistics and rapid crisis response throughout the region. Disruptive economic progress, mutual and regional military security, a burgeoning space economy, and the protection of freedom of the space frontier are worthy goals urgently needed to expand economic progress and counter the growing belligerence in the Indo-Pacific region.

Why India? A Rapidly Emerging & Influential Superpower

India has always been the gateway to Asia. Modern Asia holds 60 percent of the world's population and 40 percent of global gross domestic product, which is projected to grow to 50 percent by 2040.[12] India is also one of five nuclear-weapon states in Asia, six if nearby Israel is included. Packed close together with many adjacent borders and both ancient and modern rivalries, the region is a powder keg. A U.S.–India partnership based on routine and low-cost access to space and high-speed flight will not only promote strong economic growth but also help stabilize the Indo-Pacific region.

The modern multipolar world, with its proliferation of dangerous government and non-government actors alike, calls for partnerships with like-minded allies to enhance national security and regional stability, underpinned by economic growth. Since winning back its independence in 1947, India has methodically built the industrial and technological foundations of a modern nation state. Indeed, India is poised to reestablish its former greatness and help lead the world into the 21st century. India will bring many strengths to a U.S.–India partnership. Key strengths include:

- A long-standing commitment to democratic principles, equality, and freedom.
- A thriving and growing culture of free enterprise with a Gross Domestic Product in the top five worldwide and the fastest growing major economy in the world.[13]
- Political and economic stability with a robust and growing military capability.
- A massive population equivalent to that of China.[14]
- A high-tech work force thanks to decades of prioritizing Science, Technology, Engineering & Mathematics (STEM) education.
- A large start-up ecosystem with some of the top innovators worldwide.[15]
- A large, educated workforce, much of it composed of U.S.-educated Indians, many of whom migrate to the United States and help build enduring economic and cultural ties between the two nations.
- A nuclear arsenal that is designed and maintained to ensure peace.

Ongoing Chinese aggression along Indian borders and throughout the region makes this an opportune time to forge a more formal U.S.–India partnership. Although not the only goal, a key partnership objective should be to counter China's authoritarian domination and increasingly aggressive military actions in both the Indo-Pacific region and throughout the world. A little background will set the stage for the partnership that should be forged.

Modern India and China have a long history of border disputes dating back to the early 20th century, resulting in multiple conflicts and military standoffs. Recent

tensions have escalated due to China's assertiveness in the region, leading to border confrontations. Since 2020, India and China have been locked in an ongoing military standoff in Ladakh, with Chinese incursions and armed skirmishes in Pangong Tso and the Gogra-Hot Springs areas. India and the United States are already working on an integrated deterrence strategy focused on interoperability and seamless software connectivity to enhance coordination in the event of a flare-up on the India-China border.[16]

India's rapidly growing and high-tech aerospace capabilities have been highlighted by many international contracts and agreements over the past year. France's Airbus and India's multinational conglomerate TATA Group partnered to build the C295 transport aircraft, breaking the public sector monopoly.[17] India and the United States agreed to manufacture fighter jet engines tailored for the Indian Air Force.[18] India also ordered 31 MQ-9B Reapers from the United States.[19] Meanwhile, semiconductor giants like Micron, Applied Materials, and AMD, along with Foxconn and Vedanta, are investing in semiconductor manufacturing in India.

India brings considerable and growing prowess to the space enterprise as well. As of July 2023, the Indian Space Research Organization had launched 431 satellites for 34 nations.[20] As a signatory to the Artemis Accords with NASA, India is committed to exploring the space frontier. The Indian Space Research Organization (ISRO) and NASA are planning to launch the first Indian astronaut into space to visit the International Space Station.[21] India's recent unmanned missions to the Moon and Mars, Chandrayaan and Mangalyaan, respectively, used indigenously developed parts like cryogenic engines, batteries, adapters, and software, signaling India's self-sufficiency with respect to technology, talent, and resources—truly impressive feats for a new space entrant.

Mangalyaan spent an astounding eight years in Mars orbit transmitting data home, and in 2023, Chandrayaan-3 accomplished the first landing at the lunar south polar region, discovering water and a host of minerals essential to establishing a self-sustaining lunar base. Chandrayaan's landing leapfrogged India to a new status—the fourth nation to successfully land on the moon and, equally significant, pushed lunar exploration forward.[22] Importantly, the Chandrayaan-3's total mission cost was a mere $75 million. NASA's own MAVEN orbiter cost $582 million, and even Russia's failed Luna-25 moon landing attempt cost $133 million.[23]

Since then, India has raised its sights to a crewed spaceflight mission called Gaganyaan planned for 2027.[24] To make it happen, they need environmental control and life support technology to keep the crew alive. While the United States could contribute significant data and research toward this and future efforts, cooperation is challenging due to current U.S. international traffic in arms regulations. Nonetheless, such cooperation is ideal for demonstrating a forward-leaning U.S.–India partnership.

Finally, India has the third-largest start-up ecosystem in the world, and it is emerging as a growing hub for air and space technology startups. Several innovative companies are developing advanced aerospace solutions, including launch vehicles and rocket engines. A U.S.–India aerospace partnership would open India's high-quality, low-cost aerospace products to U.S. ventures, as well as critical technical talent and broader market and capital accessibility to companies in both countries.[25]

In the past few years, India has grown into an impressive partner for future space and high-tech endeavors. From very humble beginnings, it has taken years of grit and passionate scientists, both men and women, to bring India to the precipice of space leadership. Few other countries can provide the support

and expertise needed to exploit and successfully commercialize the tremendous potential of a U.S.–India partnership to rapidly advance air, space, and defense technologies.

A Strategic Alliance Aimed at Fostering an Enduring Peace

The government tools to make the partnership thrive do exist, but commitments are needed by both governments on both the defense and civil fronts. One caution: The tools should not be used to pick winners in the emerging industry, but rather to foster a competitive industrial base with many participants from which innovation springs. The partnership can largely be built on dual-use civil and military needs, kickstarting economic growth through collaborative efforts in multiple fields. The table below highlights potential approaches and their desired impacts. Wherever practical, quantifiable metrics should be agreed upon to measure both partnership participation and ongoing progress.

Steps to translate plans into tangible reality. Potential actions to implement the partnership include ministerial-level meetings to set national priorities, resolve disputes, and affirm partnership objectives; regular discussions on strategic, economic, humanitarian, and global security matters that facilitate the partnership; response teams to address national or global crises; and joint action committees to address partnership concerns, communication protocols, and processes. Military action officers could support these diplomatic efforts by:

1. Developing realistic military and natural disaster response scenarios, as well as the joint responses required to save lives and facilitate peace.

2. Establishing communication protocols and command structures to smooth coordination between U.S. and Indian forces.

3. Modernizing compatibility of equipment, communications, and operations, to include expanding basing options where needed.

4. Conducting extensive training and joint military exercises to familiarize forces with operations, roles, and objectives.

5. Sharing intelligence data and collaborating on cybersecurity efforts to protect national infrastructure, data, and intelligence.

Although not sufficient, the above actions provide a roadmap to a partnership that can serve as a vital anchor in Asia. The partnership will facilitate regional stability while forging a path to future military and commercial collaboration. Space, air, and defense technologies are at the core of the proposed partnership, and the partnership will also plant the seed for future military capabilities and collaboration.

Build on the History of Growing U.S.–India Military Collaboration

The partnership should build on the success of past collaborations. An example is the annual Indo-U.S. Vajra Prahar joint special forces exercise. The exercise focuses on the sharing of best practices in joint mission planning and operational tactics, cooperation, and interoperability.[26] Another intermittent air forces–centric exercise, Cope India, focuses on honing critical skills, strengthening relationships, and exchanging knowledge.[27]

The exercises include joint planning and simulated warfighting between special forces and air forces. For the former, key areas of emphasis are counterterrorism and combat drills in the Himalayan terrain. Mountain operations are an area of concern due to the potential for foreign incursions on both India's eastern and northern flanks. The extreme altitude and weather conditions also serve to test the mettle of U.S. and

Indian forces and their equipment. For the latter exercise, the focus is on showcasing best practices for formation and low-level flying, reduced-distance landing operations, and personnel and mass-container airdrops. Both exercises highlight the U.S. and Indian determination to preserve a free and open Indo-Pacific region.

Another key focus of such joint exercises is practicing air mobility support, like cargo and troop insertion/extraction missions. One day, these operations could benefit immensely from partnership technologies. One example is regional and global-reach VTOL rockets, which deliver larger payloads when operating at higher altitudes.

Create a Collaborative Environment from which Future Opportunities Can Grow

As mutual trust and respect grow, both sides of the partnership may decide to expand into new areas of cooperation, like defense pacts, counterterrorism operations, the sharing of additional military technologies, and perhaps even basing rights during crisis and peacetime.

Defense treaties could offer many advantages that benefit both the United States and India. For example, they could simultaneously promote the U.S. goal of regional stability and the Indian goal of solidifying the defense of its borders. However, neither party is currently willing to work on such a pact. Collaboration needs to be built on a basis of trust that stems from a history of shared values and collaboration. Building a stronger U.S.–India partnership in other areas can help build the relationship and open a path to future collaborations like mutually advantageous defense treaties.

Terrorist attacks in the seas adjacent to India may offer an opportunity for future cooperation. U.S. and Indian forces, working together, could potentially police the violence, whether from Somalian piracy or the escalating Houthi terrorism against merchant marine vessels.[28] India's proximity to the region offers key advantages if both nations choose to work together on future antiterrorism initiatives.

Another area of potential future collaboration is India's development of a modern navy. India is developing a nuclear-powered aircraft carrier, expanding its fleet of support vessels, and increasing the number of its ships and submarines able to launch modern missiles.[29] While India plans

Approaches/Tools	Desired impact(s)
Bilateral civil & defense R&D investments	Increase and coordinate air, space, & defense investments. Goals: improved operability, reliability, and safety of high-speed global reach, access to space & aircraft technology.
Public-private partnerships	Expand civil commercial off the shelf (COTS) and military programs by leveraging commercial sector investments.
Build and fly experimental air & space vehicles	Demonstrate unique military capabilities, leveraging the commercial sector where appropriate. Goal: reinvent air & space forces as the U.S. Air Force did at its birth with X-Planes, launch vehicles, and satellites.
Establish loan programs	For low-risk or proven dual-use technology, foster innovation by facilitating rapid scaling to advanced demonstration and production.
Foreign military sales	Expand availability and interoperability of U.S. arms to India, and qualify Indian corporations to produce high-quality, low-cost systems for the United States.
Modernize U.S. international traffic & arms regulations	Protect essential military technology while facilitating commercial investment. Goal: outrun adversary technological competition.

to indigenously expand and modernize its fleets, a U.S.–India partnership could help develop interoperable equipment that enhances cooperative military operations in the Indo-Pacific.

Establishing U.S. military bases in India has never been acceptable to India, nor has it been desired by the United States. It may never happen. However, the changing geopolitical threat environment and advancing technology produced by the partnership may open new opportunities. While global-reach aircraft may not require permanent bases, they can benefit from access to jointly built bases during a crisis, whether for disaster response or mutual defense.

The potential of a U.S.–India partnership extends well beyond the above scenarios. Many other possible futures abound, but all depend on taking a first step toward that level of close collaboration. A collaborative partnership between the United States and India that advances defense technologies, like a revolutionary high-speed flight initiative, stands to not only drive robust economic growth but also contribute to the stabilization of the Indo-Pacific region. India's growing mastery of air and space technology and a burgeoning ecosystem of tech-focused startups are a foundation upon which such an enduring partnership can be built.

Summary

A U.S.–India partnership should be formalized and strengthened around air, space, and defense technologies. The partnership can harness the collective expertise, innovation, and resources of both countries to address emerging challenges, ensure a robust defense posture, and foster a safer world. As Gen Bennie Schriever, the father of modern U.S. space systems, said, "Today the kind and quality of systems which a nation develops can decide the battle in advance and make the final conflict a mere formality—or can bypass conflict altogether."[30] Details of how the partnership will operate need to be discussed and implemented to facilitate bilateral technological, political, economic, and military relations. A strong partnership will build a 21st-century economic engine, mature technologies for mutual defense, and facilitate the development of high-speed air and space transportation. It will open the space frontier, bring the world closer together, and perhaps deter future conflicts in the Indo-Pacific region. India has always pursued collaborative endeavors instead of confrontational postures. The United States and India need to try a new approach together—step one is a collaborative technology partnership. ✪

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