INDIGENISATION OF UAVs BY INDIA AND ITS CHALLENGES

RK NARANG

The Indian armed forces were the first to acquire Unmanned Aerial Vehicles (UAVs) in India and their requirements have been predominantly met through imports. The Indian armed forces reportedly came out with a blueprint in early 2016 for the procurement of over 5,000 UAVs in the next 10 years, which is likely to cost US $3 billion.[1] India's Research and Development (R&D) organisations have been trying to develop UAVs for its armed forces amid various limitations and challenges. However, they have not been able to develop many successful UAVs for the armed forces and civil industry, despite having a well-developed aviation R&D and production set-up. The civil UAV industry is at a nascent stage. The development of the UAV industry is closely linked to the indigenous aviation development and manufacturing capability. The aviation industry comprises both military and civil aviation industry. Indian R&D agencies have been involved in the development of military aircraft. However, there has not been adequate emphasis on indigenously developing civil aircraft and ground systems under the 'Make in India' campaign despite its having enormous economic benefits.

The Public Sector Undertakings (PSUs) and private sector companies involved in indigenous development of manned and unmanned aircraft

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1. Vivek Raghuvanshi, "India Finalizes $3B Blueprint for UAV Fleets," March 20, 2016, http://www.defensenews.com/story/defense/air-space/2016/03/20/india-finalizes-3b-blueprint-uav-fleets/81637026/. Accessed on August 28, 2016.

The PSUs and private sector companies involved in indigenous development of manned and unmanned aircraft face enormous technological, regulatory and other challenges in India, which impede indigenisation.

face enormous technological, regulatory and other challenges in India, which impede indigenisation. Indian technical universities and colleges—a key component of the aviation eco-system—have not been adequately contributing in fundamental niche technologies in the aviation sector.

The persistent challenge for India has been to transform from being a net importer to an indigenous developer and exporter of aviation products, including UAVs. It is in this context that an understanding of UAV acquisition, development endeavours and the challenges faced in indigenisation of both military and civil aircraft and UAVs becomes important. This paper would endeavour to address two key questions: firstly, what is the status of India's UAV programme? And, secondly, what are the challenges being faced in the indigenisation of UAVs in India? It would also deliberate on the contribution of the PSUs, private sector entities, armed forces and academia in the indigenous development of UAVs in India.

INDIGENOUS UAV PROGRAMME

The UAV fleet of the Indian armed forces predominantly consists of the Searcher, Heron[2] and Harop UAVs[3], which are imported from Israel. India's indigenous UAVs are still in the development phase. India is a late entrant in the field of UAV development. Its indigenous target drone and UAV development programme is led by the Aeronautical Development Agency (ADA) of the Defence Research and Development Organisation (DRDO), which is primarily directed towards meeting the requirements of the Indian armed forces. India has developed target drones and micro and mini UAVs and is aspiring to develop

2. Dr Monika Chansoria, "Proliferated Drones: A Perspective on India," http://drones.cnas.org/reports/a-perspective-on-india/. Accessed on July 25, 2016.
3. Tekendra Parmar, "Drones in India," December 4, 2014, http://dronecenter.bard.edu/drones-in-india/. Accessed on August 1, 2016.

bigger and more capable Medium Altitude Long Endurance (MALE), High Altitude Long Endurance (HALE) and armed UAVs and Unmanned Combat Aerial Vehicles (UCAVs) indigenously. Its civil UAV industry is limited to a few individuals and companies, with a negligible presence in the Asian and global markets. The indigenous UAV development programmes are discussed below.

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TARGET DRONES

Missile Target Ulka

The Ulka is an aircraft launched supersonic missile target developed by DRDO, which is powered by a solid booster rocket. It can operate up to an altitude of 9 km and has a range of 70 km.[4]

Lakshya Pilotless Target Aircraft (PTA)

The Lakshya is a high subsonic reusable tow target system developed by the Aeronautical Development Establishment (ADE) of DRDO and was inducted in the Indian Air Force (IAF) in 2000.[5] It can carry two tow targets on wing mounted pylons, which trail the mother platform by 1.5 km. The Lakshya-2 is an advanced version of the Lakshya PTA, which can carry different payloads and has enhanced endurance.

4. *Unmanned Aircraft Systems and Technologies*, vol. 18, no. 6, December 6, 2010, http://www.drdo.gov.in/drdo/pub/techfocus/2010/dec10.pdf. Accessed on August 10, 2016.
5. "UAV Lakshya Hits the Target," December 12, 2015, http://www.newindianexpress.com/states/odisha/UAV-Lakshya-Hits-Target/2015/12/12/article3173665.ece. Accessed on August 26, 2016.

Fig 1: Lakshya Pilotless Target Aircraft[6]

Abhyas High Speed Expendable Aerial Target (HEAT)

Abhyas, a low cost, high speed, expendable aerial target system has been developed by the ADE, a lab of the DRDO, to provide a realistic threat scenario for the practise of weapon systems. It is powered by a 25 kg thrust engine and has an endurance of 30-45 minutes. It is equipped with an Acoustic Miss Distance Indicator (AMDI) to indicate the miss distance.

6. n.4.

Fig 2: Abhyas Expendable Target Drone[7]

MICRO AERIAL VEHICLES (MAVS)

The Council of Scientific and Industrial Research of the National Aerospace Laboratories (CSIR-NAL), in collaboration with DRDO and the Department of Science and Technology of the Government of India, had set up the Micro Air Vehicle (MAV) Aerodynamic Research Tunnel at NAL in June 2015—the first of its kind in India—to test fixed wing, flapping wing and rotary wing MAVs in the 500 mm wingspan category as part of India's National Programme on Micro Air Vehicles (NP-MICAV).[8]

7. "DRDO Abhyas High Speed Expendable Aerial Target (HEAT)," *Indian Armed Forces*, October 18, 2013, http://aermech.in/drdo-abhyas-high-speed-expendable-aerial-target-heat-indian-armed-forces/. Accessed on August 20, 2016
8. http://pib.nic.in/newsite/PrintRelease.aspx?relid=122523. Accessed on August 13, 2016.

They have developed the Black Kite, Golden Hawk and Pushpak MAVs and Indian Eagle (Imperial Eagle) and Slybird Mini UAVs.[9]

Fig 3: Golden Hawk Micro Aerial Vehicles[10]

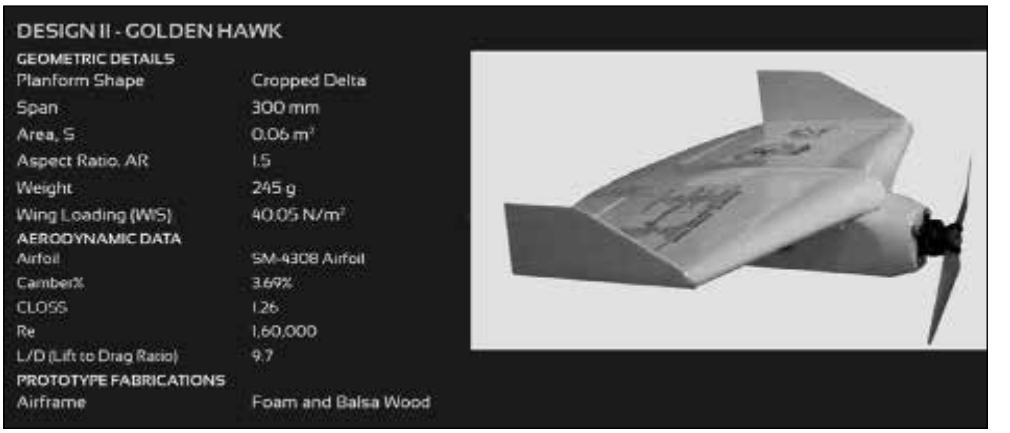


Fig 4: Pushpak Micro Aerial Vehicles[11]

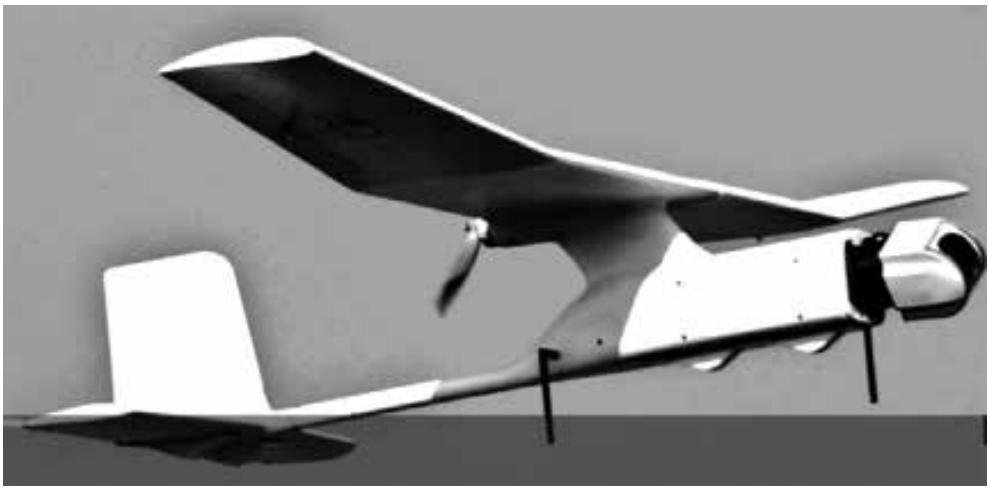
9. http://www.nal.res.in/pdf/MAV.pdf. Accessed on August 13, 2016.
10. "DRDO," http://www.drdo.gov.in/drdo/English/DRDO_BROCHURE_2015.pdf. Accessed on September 19, 2016.
11. Ibid.

MINI UAVS

Indian Eagle and Sly Bird

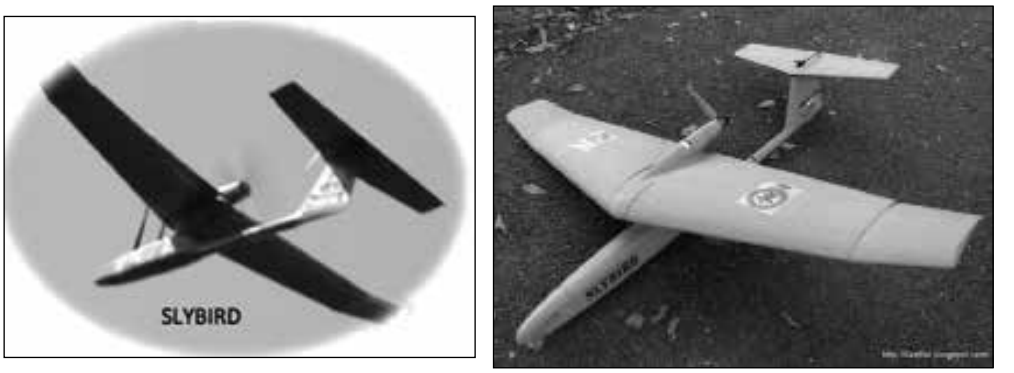
The Indian Eagle (also known as the Imperial Eagle) and Sly Bird mini UAVs weighing around 2 kg and having an endurance of approximately one hour, were test flown at Bangalore in January 2012. These were developed to meet the short-range small UAV requirements of the Indian Army, Police and National Disaster Management Agency (NDMA).[12]

Fig 5: Indian Eagle, Mini Aerial Vehicle[13]



12. "Testing the Eye in the Sky," January 27, 2012, http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/testing-the-eye-in-the-sky/article2835797.ece. Accessed on August 20, 2016.
13. http://www.newindianexpress.com/states/karnataka/Desi-Air-Vehicles-Ready-for-Mass-Production/2014/09/30/article2455232.ece. Accessed on August 13, 2016.

Fig 6: Slybird Mini UAV[14]



Netra Quadcopter

The police, paramilitary forces, NDMA and civil users in India are using the 'Netra', a quadcopter mini UAV, developed by DRDO.[15]

Fig 7: Netra UAV[16]

14. http://www.nal.res.in/pdf/MAV.pdf. Accessed on August 13, 2016.
15. https://www.iitbombay.org/news/Current/dighi-defence-setup-to-lead-robotics-project. Accessed on August 10, 2016.
16. http://indiandefenseresearch.blogspot.in/2012/01/india-current-future-uavs-ucavs.html. Accessed on August 10, 2016.

TACTICAL UAVS

Nishant and Panchi

The Nishant is a vehicle mounted battlefield surveillance and reconnaissance UAV, which can be equipped with Electro-Optical/Infrared (EO/IR) payloads for target acquisition and tracking. It was launched in 1995 with an investment of Rs 90 crore. Four Nishant UAVs were supplied in 2013.[17] However, there were apprehensions that the launcher of the Nishant UAV, which comprises a truck with a railing system, could give away its position to satellite or aircraft reconnaissance, compromising the safety of the UAV and its support systems during operations. Therefore, a wheeled version of the Nishant UAV, named Panchi, was developed, which was successfully tested in 2014.[18] Also, the Panchi, being lighter in weight, would have carried greater payload than its predecessor, the Nishant. However, delivery of eight more Nishant UAVs was cancelled in November 2015.[19]

Fig 8: Nishant Tactical UAV[20]

17. "After Crashes, Army set to Junk Nishant UAVs," November 20, 2015, http://timesofindia.indiatimes.com/india/After-crashes-Army-set-to-junk-Nishant-UAVs/articleshow/49853186.cms. Accessed on August 28, 2016.
18. Hemant Kumar Rout, "DRDO Conducts Maiden Test Flight of Panchi UAV," December 25, 2014, http://www.newindianexpress.com/nation/DRDO-Conducts-Maiden-Test-Flight-of-Panchi-UAV/2014/12/25/article2587210.ece. Accessed on August 10, 2016.
19. n. 20.
20. n. 12.

Fig 9: Panchi (Wheeled Version of Nishant) UAV[21]

Rustom-I

The Rustom series of UAVs is being developed in three variants i.e. Rustom-I tactical UAV, Rustom-H MALE and Rustom-II armed UAV. The Rustom-I owes its existence to the initiative of the National Aerospace Laboratory (NAL)[22] scientists. NAL has been involved in developing trainer and transport aircraft for civil aviation and micro UAVs. The Rustom-I UAV is named after the late Dr Rustom B Damania and is being developed by ADA of DRDO. Dr Rustom was a scientist at NAL, who had a passion for building aircraft and was the driving force behind many indigenous aircraft designs, including the Hansa-2[23] and Hansa-3[24] trainer aircraft[25] and Light Canard Research Aircraft (LCRA).[26]

The Rustom-I is an all-composite UAV, which is based on the LCRA. It is powered by a single Lycoming engine and flew its first flight on October 16,

21. Ibid.
22. NAL comes under the Ministry of Science and Technology, India
23. Srinivas Bhogle, "Rustom Shouldn't Have Gone so Soon", October 3, 2012, https://bademian.wordpress.com/2012/10/03/rustom-shouldnt-have-gone-so-soon/. Accessed on October 15, 2016.
24. Hansa-3 became India's first indigenously designed all composite single engine propeller driven trainer aircraft, which was certified by DGCA in 2001.
25. Type Certificate, February 1, 2001,http://dgca.nic.in/TC/Hansa-3.pdf. Accessed on November 29, 2016.
26. Maneck Bhujwala, "India Drone Airplane Named After a Zarathushti Rustom," December 7, 2009, http://www.parsinews.net/india-drone-airplane-named-after-a-zarathushti-rustom/862.html. Accessed on October 15, 2016.

2010.[27] The Rustom-I has also served as a test-bed for various technologies to be incorporated in the larger and more capable Rustom-H and Rustom-II (armed) variants. India has made some progress in weaponisation of indigenous UAVs as the trials are being carried out to arm the Rustom-I MALE UAV with the HELINA Anti-Tank Guided Missile (ATGM). The Automatic Take-Off and Landing (ATOL) capability was indigenously developed and demonstrated on the Rustom-I in May 2015.[28]The ATOL capability will improve automation, enable UAVs to take off and land at night, and could remove the requirement of an external pilot.[29]

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Fig 10: Rustom-I

27. "A Long Flight of Unmanned Independence," p. 12, https://www.joomag.com/magazine/sps-aviation-issue-8-2015-vol-17-issue-5/0197551001401100021?page=14. Accessed on August 13, 2016.
28. Saurav Jha, "India is Finally looking to Enter the era of Armed Drones," May 23, 2015, http://www.news18.com/blogs/india/saurav-jha/india-is-finally-looking-to-enter-the-era-of-armed-drones-10879-995842.html. Accessed on August 13, 2016.
29. Ibid.

The Tactical Airborne Platform for Surveillance-Beyond Horizon-201 (TAPAS-BH 201), the first prototype of the RUSTOM – II, flew its first test flight on November 16, 2016, from the Aeronautical Test Range (ATR), Chitradurga, which is 250 km from Bangalore.

MALE/ HALE UAVS

Rustom-II

The Rustom-II MALE UAV being developed by DRDO is aimed at replacing the Heron UAVs.[30] Hindustan Aeronautical Limited (HAL) and Bharat Electronics Limited (BEL), with HAL being the prime integrator of parts built by BEL and other private players, would jointly produce the Rustom-II. The Defence Electronics Application Laboratory, Dehradun, has developed the data links, which comprise a critical part of the UAV.[31] HAL, BEL and DRDO have jointly invested $46 million in this. The third and fourth airframes of the Rustom-II, meant for the validation phase, are already undergoing trials. The fifth to eighth airframes to be offered for user evaluation had been ordered in 2015. The ninth to fifteenth airframes would be built from the production line some time in 2017-18.[32] All the three Services have placed a consolidated demand for 75 Rustom-II UAVs.

The Tactical Airborne Platform for Surveillance-Beyond Horizon-201 (TAPAS-BH 201), the first prototype of the Rustom–II, flew its first test flight on November 16, 2016, from the Aeronautical Test Range (ATR),[33] Chitradurga, which is 250 km from Bangalore. The Rustom-II prototype was simultaneously tested by the Centre for Military Airworthiness and Certification (CEMILAC) and Directorate General of Aeronautical Quality Assurance (DGAQA), which are the designated organisations for

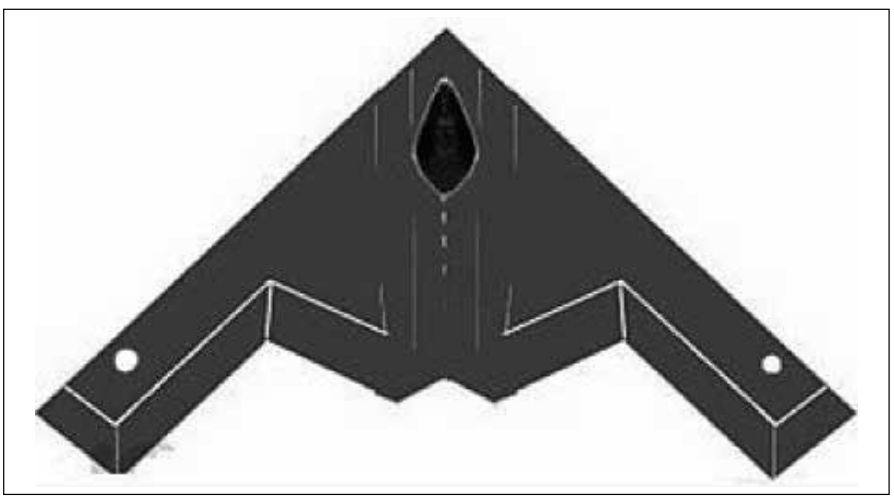
30. R Swaminathan, February 2015, http://www.orfonline.org/wp-content/uploads/2015/02/OccasionalPaper_58.pdf. Accessed on July 26, 2016.
31. Jha, n. 32.
32. Neelam Mathews, "India's Own MALE UAV To Fly Soon," November 5, 2015, http://www.ainonline.com/aviation-news/defense/2015-11-05/indias-own-male-uav-fly-soon, accessed on August 13, 2016.
33. ATR is India's newly developed flight test range for the testing of UAVs and manned aircraft.

certification of military aircraft in India.[34] The Rustom-II was subjected to technology denials, which added to the delays in the project.[35]

UCAVS: AURA AND USAV

The Indian Unmanned Strike Air Vehicle (USAV), which was earlier known as the Autonomous Unmanned Research Aircraft (AURA) would be a stealthy UCAV, which would carry weapons internally and be able to release Precision Guided Munitions (PGMs). It is likely to be powered by a jet engine without an afterburner, which could be a derivative of the indigenous Kaveri engine.[36] Its flight control system and data links will be designed by ADE and Defence Electronic Application Laboratory (DEAL), Dehradun.[37] The project has completed the concept evaluation stage and is being considered for design and development.

Fig 11: Artistic Impression of Aura/ Ghatak UCAV[38]



34. "Successful Maiden Flight of Rustom-II," November 16, 2016, http://www.drdo.gov.in/drdo/English/dpi/press_release/ rustamII_161116.pdf. Accessed on December 2, 2016.
35. Jha, n. 32.
36. Joseph Noronha, "A Long Flight to Unmanned Independence," *SP's Aviation*, no. 7, 2015, http://www.sps-aviation.com/story_issue.asp?Article=1437. Accessed on August 13, 2016.
37. n. 4.
38. Kalyannaidu000001 - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=30991572. Accessed on October 15, 2016.

The micro UAVs were ready for production by the end of 2014; however, HAL has not yet commenced commercial production of micro and mini UAVs. This indicates the inability of the PSUs to convert indigenous designs into successful products.

NRUAV

The joint project between Hindustan Aeronautics Limited of India and Israel Aircraft Industries (IAI), Malat, of Israel to develop the Naval Rotary Unmanned Aerial Vehicle (NRUAV) for the Indian Navy was launched in 2008. However, the present status of this rotary wing UAV is unknown.[39]

PRODUCTION OF UAVS

HAL has signed a Memorandum of Understanding (MoU) with ADE and NAL for mass production of micro, mini and MALE UAVs. It may be recalled that NAL has designed micro and mini UAVs and is also involved in the development of the Rustom-I UAVs.[40] The micro UAVs were ready for production by the end of 2014; however, HAL has not yet commenced commercial production of micro and mini UAVs. This indicates the inability of the PSUs to convert indigenous designs into successful products.[41]

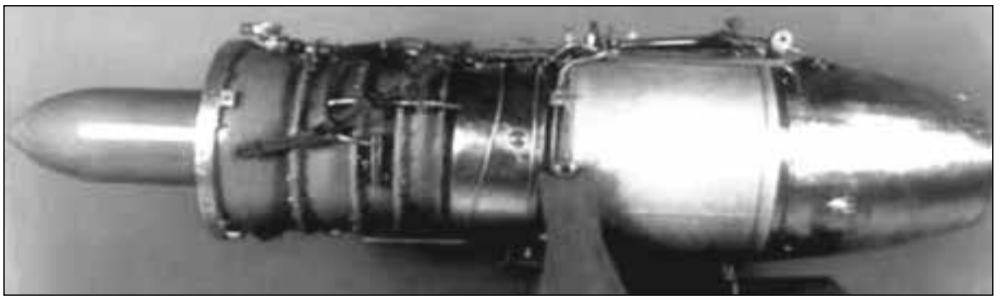
ENABLING TECHNOLOGIES

DRDO, in collaboration with the defence PSUs and private partners, has indigenously developed many enabling technologies in the process of development of UAVs and these include:

- Jet engine for the Lakshya PTA (PTAE-7).
- 55 HP Wankel engine for the Nishant UAV.
- Flight control software for UAVs.

39. PTI, "India, Israel Developing Unmanned Helicopter," April 2, 2008, http://timesofindia.indiatimes.com/world/middle-east/India-Israel-developing-unmanned-helicopter-/articleshow/2918496.cms?referral=PM. Accessed on August 10, 2016.
40. Furquan Moharkan, "Manning Unmanned Aerial Vehicles," May 30, 2016, http://www.deccanherald.com/content/549359/manning-unmanned-aerial-vehicles.html. Accessed on September 5, 2016.
41. Anantha Krishnan M, "Desi Mini UAVs Ready for Production," November 30, 2014, http://icast.org.in/news/2014/sep14/sep30IEa.pdf. Accessed on October 30, 2016.

Fig 19: Indigenous PTA Engine (PTAE-7)[42]



- Software enabled capabilities, which include automated launch, manual and assisted take-off and landing,[43] auto-pilot functions, autonomous flight during data link loss, flying at low level under high G conditions, semi-autonomous and autonomous flight and return home capability.
- UAV simulator.

DRDO has developed the Global Positioning System (GPS) Aided Geo-Augmented Aerial Navigation System (GAGAN), which is a planned implementation of a regional Satellite-Based Augmentation System (SBAS) for navigation as well as for vertical guidance, and which will assist UAVs to land safely. It also launched the Geo-Synchronous Satellite-7 (GSAT-7), a dedicated military communication satellite for the Indian Navy, which can be used to control UAVs.[44]

PUBLIC-PRIVATE PARTNERSHIP

The Research and Development Establishment (Engineers) (R&DE), a Pune-based lab of the DRDO, had collaborated with the Indian Institute of Technology (IIT), Mumbai, to develop the 1.5 kg 'Netra' quadcopter mini UAV.[45] The technology of the Netra was later transferred to the Mumbai-

42. n. 4.
43. http://www.drdo.gov.in/drdo/pub/techfocus/2010/dec10.pdf. Accessed on July 11, 2016.
44. Madhumathi D.S., "Indigenous Aero-Engine Stays on Radar, says DRDO Official," May 29, 20316, http://www.thehindu.com/todays-paper/tp-national/indigenous-aero-engine-stays-on-radar-says-drdo-official/article8661571.ece. Accessed on August 1, 2016.
45. https://www.iitbombay.org/news/Current/dighi-defence-setup-to-lead-robotics-project. Accessed on August 10, 2016.

based start-up Idea Forge[46], a company formed by four IIT, Mumbai (Powai), alumni, Rahul Singh, Ashish Bhat, Ankit Mehta and Vipul Joshi in 2012 for its production.[47]

PRIVATE SECTOR INITIATIVES

India's private start-up companies like Garuda Robotics, Idea Forge, Airpix, Edall Systems and Aurora Integrated Systems have preliminary reach in UAV technology[48] and are dependent on foreign suppliers for semi-conductors, lithium polymer batteries, collision avoidance systems, engines, etc. Some of the Indian companies have come up with enabling technologies for UAV operations despite various challenges. A case in point is Zen Technologies Limited, a private company, which has indigenously developed simulators for UAVs.[49]

CHALLENGES FOR INDIGENOUS UAV PROGRAMMES

India's indigenous R&D journey has been a roller coaster ride, with many promising starts and unexpected ends. Some of India's aviation indigenisation projects have shown tremendous promise in recent years. However, India has been unable to produce cutting edge aviation products despite having an extensive network of laboratories and research centres. Some of the constraints faced by the R&D agencies, PSUs and private sector entities are deliberated upon in the succeeding section.

46. Shashwat Gupta Ray, "UAV Netra Gets into Production," January 6, 2012, ahttp://www.sakaaltimes.com/NewsDetails.aspx?NewsId=5559164217083274887&SectionId=4924098573178130559&SectionName=Top%20Stories&NewsDate=20120106&NewsTitle=UAV%20Netra%20gets%20into%20production. Accessed on August 28, 2016.
47. Sanjay Vijaykumar, "IdeaForge to Raise $10m Series A Funding," December 23, 2015, http://www.thehindu.com/news/cities/mumbai/business/ideaforge-to-raise-10m-series-a-funding/article8020460.ece. Accessed on August 28, 2016.
48. n. 3.
49. VS Chandra Shekhar, Zen Technologies Limited, 11th International Conference on Energising Indian Aerospace Industry, September 5, 2016.

R&D Organisations and PSUs

DRDO, defence PSUs and other R&D agencies of India play an important role in the indigenisation of defence aviation technologies. They are often criticised for their failure to deliver, inefficiencies, lax work culture, and exceeding timelines and cost estimates despite having a huge infrastructure and substantial allocation of funds. [50] However, development of advanced aviation technologies, including UAVs, is an unknown area, venturing into which requires a high level of research, funding and government support. These entities often have to face bureaucratic difficulties for funding of their projects. The weaknesses, challenges, and opportunities for PSUs are discussed in the subsequent section.

India's private start-up companies like Garuda Robotics, Idea Forge, Airpix, Edall Systems and Aurora Integrated Systems have preliminary reach in UAV technology and are dependent on foreign suppliers for semi-conductors, lithium polymer batteries, collision avoidance systems, engines, etc. Some of the Indian companies have come up with enabling technologies for UAV operations despite various challenges.

Development Challenges

PSUs, in the past, either could not persist with successful aviation designs or were unable to increase the production rate due to various reasons. HAL has produced the Light Combat Aircraft (LCA) and Advanced Light Helicopter (ALH) successfully; however, it is still facing challenges in meeting the aspirations of customers, who demand regular improvements and upgradation of technology. The indigenously designed UAVs are also facing similar challenges and may not become successful products unless an enabling environment is provided. The challenges being faced by some of these newly designed UAVs are deliberated upon below.

50. Vipul Singh, Co-founder and CBDO of Aarav Unmanned Systems Pvt Ltd, in an email dated September 20, 2016.

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Micro and Mini UAVs: The future of indigenous micro and mini UAVs is uncertain. The micro and mini aerial vehicles were ready for mass production in 2014[51]; however, HAL is yet to commence commercial production of micro and mini UAVs.

Nishant and Panchi Tactical UAVs: DRDO's Nishant UAV project, initiated for the Indian Army in 1995, was cancelled in 2015 after delivering four UAVs.[52] The cancellation of the Nishant and Panchi tactical UAVs projects points towards the limitations of existing technologies, failure to upgrade them, and difficulties faced in developing enabling technologies in order to meet the aspirations of the users.

Rustom-I and II: The Rustom-I has a proven airframe and engine. It has carried out several test flights successfully, and integration of payloads, including weapons, is in progress. However, no firm orders have been placed for the Rustom-I. The Rustom-II, a truly indigenous design, had faced overweight challenges. The airframe weight of the Rustom-II, like most development projects, had increased from the estimated 1,700 kg to 2,400 kg (5,300 lb), which has impacted the planning and development calculations, and necessitated fitment of larger engines viz. Austro Engine AE300 diesels (rated at 170 Horse Power – HP). However, DRDO is aiming to reduce the All Up-Weight (AUW) after the delivery of the first 24 UAVs.[53]

51. Krishnan M, n. 46.
52. http://economictimes.indiatimes.com/news/defence/drdos-two-decade-old-nishant-uav-programme-crashes-indian-army-cancels-further-orders/articleshow/49809095.cms. Accessed on July 12, 2016.
53. Mathews, n. 36.

Engine Development

The development of engines for its flying machines has been weak area for India. Lack of indigenous engines had resulted in the early decline of many promising indigenous aircraft designs, including the famous Hindustan Fighter-24 or HF-24 (Marut), which was designed in 1960 and was considered to be one of the best airframe designs of its era. The plan for indigenous development of engines has not achieved much success. Therefore, it is prudent to understand the engine development challenges in order to overcome past weaknesses.

Manohar Parrikar, the former Indian defence minister, unveiled a 25 kN engine built by HAL for its trainer aircraft at Bengaluru in late 2015. However, it may be recalled that HAL had developed a 25 kN engine for the upgraded version (Mk-II) of its trainer aircraft Kiran in the late 1970s. When development of the engine for the Kiran Mk-II was nearing completion, it was decided that the 30 kN Orpheus 703 engine of the HF-24 be de-rated to 25 kN for use on the Kiran Mk-II. Had India preserved its earlier 25 kN engine and upgraded it at regular intervals, we could have used this engine not only to upgrade our trainers but exported it to other countries. The redevelopment of the 25 kN engine in 2015 indicates the inability of India's R&D agencies to preserve indigenously developed technology.[54] India had initiated a programme for the development of the Kaveri jet engine for the indigenous LCA in collaboration with France. However, the project faced hurdles midway due to differences with the French partner. India is now planning to use the Kaveri engine without the afterburner for its Ghatak UCAV, which is in the development and testing phase.

India needs a wide variety of engines, including turboprop engines for its tactical and MALE class of UAVs. DRDO's Vehicles Research and Development Establishment (VRDE), has collaborated with Tech Mahindra to develop a 165-210 HP engine, which will power future Rustom UAVs. However, this too would be a new engine and its

54. Ajai Shukla, "Engine of Indigenisation", December 21, 2015, http://www.business-standard.com/article/opinion/ajai-shukla-engine-of-indigenisation-115122101122_1.html. Accessed on September 30, 2016.

When development of the engine for the Kiran Mk-II was nearing completion, it was decided that the 30kN Orpheus 703 engine of the HF-24 be de-rated to 25kN for use on the Kiran Mk-II. Had India preserved its earlier 25 kN engine and upgraded it at regular intervals, we could have used this engine not only to upgrade our trainers but exported it to other countries.

capability cannot be predicted at this stage.[55] India would have to develop efficient and more capable smaller engines for mini and micro UAVs. More of such indigenous endeavours are needed and successful designs preserved and upgraded regularly to reduce dependence on foreign suppliers and achieve a higher level of self-reliance in engine technology.

CONVERTING DESIGNS INTO PRODUCTS

The cancellation of the Nishant and Panchi tactical UAVs, lack of orders for the Rustom-I, and delay in the commencement of the commercial production of micro and mini UAVs indicates the challenges being faced in converting indigenously designed products into successful designs. The delay in the test flight of the Rustom-II UAV was due to design challenges and technology denials, which, in turn, could delay its commercial production and induction into the armed forces. Delays and failures are part of the indigenisation process. The inability of the R&D organisations and PSUs to convert an idea or design in the aviation domain into a successful product can be attributed to the following gaps:

- Lack of enabling technologies and facilities like engines, metallurgy, latest machines for design, testing equipment, laboratories, etc.
- Unavailability of the latest production processes, low production capacity, inadequate participation of the private sector, etc.
- Obsolescence of technology and failure to ensure timely product upgradation during its entire life span covering the development, production and operational utilisation phases, which can last several decades.

55. Jha, n.32.

Technology Development Vs Production

HAL, BEL and other PSUs appear to be having greater focus on production, which is attractive from the point of view of increasing their market share. The PSUs are following a two-pronged approach for increasing production:

- Increasing rate of production of indigenous products by involving the private sector; and
- Forming joint ventures with global aviation leaders for advanced technologies, which have not yet been developed in India.

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There is a general perception that R&D laboratories and PSUs are resorting to acquisition of critical enabling technologies and sub-systems from domestic and foreign vendors and Original Equipment Manufacturers (OEMs) and assembling them, with only little technological development or technology gain. Such perceptions need to be nipped in the bud by DRDO and the PSUs by ensuring a transparent system of sharing information on the progress of various projects, especially those involving foreign OEMs.

Business Models

Aviation observers feel that products developed by the PSUs in India are sometimes incorrectly priced from the business and economic viability points of view. The method of costing of indigenous designs for transfer of technology to the private sector has been a weak area of the public sector R&D agencies. Sound and economically viable business models need to be worked out to ensure that they are able to generate revenue for the design as well as for the production agencies.[56]

56. Panel Discussion at 11th International Conference on Energising Indian Aerospace Industry: The Changing Environment" at New Delhi, on September 2, 2016.

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Economy of Scale

Lack or uncertainty of orders for indigenously designed products from users results in lack of enthusiasm from the private sector to invest in procuring indigenously designed technologies. The numbers ordered by the Indian armed forces and Central Armed Police Forces (CAPFs) are normally small and based on their unique requirements, which adversely impacts the economic viability of the design and development projects. Most private sector entities are reluctant to accept indigenous designs for production, which have no economic viability in the long run. The fewer numbers ordered by the users do not provide enough incentive to designers to continue upgrading such systems, and, as a result, such systems soon become obsolete. All these aspects need to be addressed if the indigenous aviation industry, especially the PSUs, have to compete at the global level.

Product Support

Some of the aviation platforms and systems designed indigenously by the Indian R&D agencies have struggled to become successful designs due to the inability of the production agencies to provide timely, assured and robust product support for the entire life cycle of the product.

PRIVATE SECTOR IN INDIGENISATION

Unrealistic Expectations

The aviation sector requires research and development of complex systems involving high investments. There is a growing perception that the private sector would be able to transform India's aviation sector and undertake all activities varying from core research to production of advanced aircraft and other weapon systems. However, this is a misconception as the private sector works on the economic models

and may not be able to sustain itself in the high-risk research and development programmes in the niche technology sector, which is full of uncertainties and prone to failures. Therefore, it may not be feasible for the private sector to undertake core research and development without reasonable certainty of success. However, the private sector thrives on its efficiency in production and applied research, which can be effectively utilised in increasing the production rate and in providing specialised systems and sub-systems to the integrators.

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CHALLENGES FOR MSMEs AND START-UPs

India has set up a Ministry of Micro, Small and Medium Enterprises (MSMEs)[57] considering the importance of these sectors. However, MSMEs and start-ups continue to face challenges with respect to their integration in the aviation eco-system. MSMEs contribute 45 percent of the industrial output and 40 percent of the total exports of India. They can play a significant role in the growth of the aerospace sector, including UAV development.[58] The start-ups ride on new ideas and their academic and professional excellence to provide innovative technological solutions in niche fields. They are, however, constrained by financial challenges and the absence of an enabling environment. They sometimes do not get clear and complete information regarding where they can contribute, the modalities for registration with aviation production organisations, and absence of a time limit for approval

57. "Ministry of Micro, Small and Medium Enterprises", http://msme.gov.in/mob/home.aspx. Accessed on September 4, 2016.
58. "Challenges to MSME", https://www.indiansmechamber.com/challenges_to_msme.php. Accessed on September 4, 2016.

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of registration of applications despite numerous initiatives by the government.[59]

Financial Constraints

Start-ups and MSMEs often come up with innovative and unique designs and technological solutions, which can meet the requirements of the armed forces as well as provide them a technological edge. However, they are expected to pledge a certain minimum amount of capital to be eligible for supplying products to defence PSUs, which they may not have. They also face difficulty in raising the working capital after winning the contracts. The MSMEs and start-ups need a variety of licences viz. Defence Industrial Licence, Explosives Handling Licence, UAV Licence, ISO Certification, etc. and need to possess expensive test equipment, storage facilities, etc. in order to meet the compliance criteria and be eligible for supplying their products to the armed forces and other government agencies. This makes the task of the MSMEs and start-ups extremely difficult and economically challenging.

R&D, IPR and Royalty

The innovative indigenous components, systems and sub-systems are developed by private sector companies while supporting R&D agencies like DRDO, NAL, etc. However, these designs are subsequently transferred by the R&D agencies to the PSUs for production. There is a feeling among the individual developers and private sector companies that the Intellectual Property Rights (IPRs) of the systems and sub-assemblies designed and developed by them are not adequately protected, as they do not get assured orders for production of those systems.[60] Also, they have to compete with others during the tendering process initiated by the

59. n.61.
60. Ibid.

production agencies, i.e. PSUs, despite having indigenised those products or sub-assemblies for the R&D agencies. They are sometimes coaxed to sell their rights to the PSUs, citing the limitations of regulatory policies.[61]

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Certification and Acceptance of Innovative IDDM Products

Indian companies and individuals developing innovative and exclusive aerospace products and designs indigenously are unable to get certification if the demand for such products is either not raised by the armed forces or such products do not exist. This is due to non-availability of a designated agency with the requisite technical expertise to assess Indigenously Designed, Developed and Manufactured (IDDM) as well as innovative products, evaluate the extent of indigenisation, and certify them. As a result, they are forced to sell their innovative designs and products to global aviation giants. A case in point is Verdant Telemetry and Antenna Systems Pvt Ltd, an Indian start-up founded by Louis George and Kuruvila George at Cochin in 1997,[62] which supplies airborne and shipping antennae to leading aerospace and defence organisations. Its antennae are installed on the Searcher and Heron UAVs and C-130 transport aircraft, purchased by India. However, it initially struggled to sell its products in India.[63] Indian start-up companies feel that they are at a disadvantage vis-à-vis

61. Vipul Singh, Co-founder and CBDO, Aarav Unmanned Systems Pvt. Ltd in email dated September 15, 2016.
62. "Mangement Team", http://www.verdanttelemetry.com/management_team.php. Accessed on October 16, 2016.
63. Interaction with Gowtham Hebbur Gurumurthy, Sr Technical Officer, Verdant Telemetry and Antenna Systems Pvt Ltd, 8th International Conference on Aerospace Industry: Challenges and Opportunities, India Habitat Centre, New Delhi, September 1-2, 2016.

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foreign suppliers for doing business in India.

Need to Review Defence Acquisition Plan

The MSMEs and start-ups feel that they are not able to adequately contribute in indigenisation as they do not benefit much from the existing 15-year Long-Term Perspective Plan of the Indian armed forces, which does not provide specific capabilities, technologies and products required in a finite period. They have been demanding formulation of annual and five-year acquisition plans by the defence forces. Formulation of annual and five-year acquisition plans would enable the MSMEs and start-ups to anticipate the requirements of the armed forces and align their development/ business plans with them. This would enable them to contribute constructively and effectively in indigenisation.

Role of the Armed Forces

There is reluctance among the users to procure indigenously developed equipment, which is considered outdated and does not meet the requirements of the armed forces and security agencies. On the other hand, it is impossible to indigenously develop the best from the word go. The moot point is how to attempt indigenisation and, at the same time, meet the requirements of the armed forces and security agencies.

The Indian armed forces have vast experience in operating a wide variety of flying platforms, including UAVs. It has been seen among the leading military aircraft exporting countries that their armed forces play an important role during the design and development phase of the manned and unmanned flying machines. However, in India, most aviation projects are initiated by the

R&D agencies like DRDO, NAL and/ or HAL, and the armed forces are not involved during the conceptualisation or design stage. As a result, the R&D organisations are deprived of valuable inputs during the critical inception/ drawing stage.

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ENHANCING THE SCOPE OF THE PROCUREMENT EXECUTIVE

The Dhirendra Singh Committee had recommended that the Procurement Organisation of the Ministry of Defence (MoD) be placed outside the Government of India (GoI) ministry structure to overcome existing limitations.[64] The mandate of the proposed Procurement Executive outside the GoI ministry structure would be limited to procurements by the MoD. It would not have the mandate to synergise aviation and other acquisitions of the other ministries, CAPFs and agencies of the GoI. The procurement by various agencies within the country, if combined, could provide India with a huge leverage to seek transfer of technologies, manufacturing of equipment and/or shifting of assembly lines of equipment and sub-systems to India from the OEMs. Similarly, there is merit in integrating the civil and military aviation (including UAVs) industry under 'Make in India' as enhanced numbers for production and reduced cost could yield disproportionate economic benefits by becoming a major source of job creation, revenue generation through their export and, in turn, mitigate the military aviation products' development costs. Therefore, an independent common procurement agency, if established, would synergise the procurement of the products by the armed forces, ministries and other agencies in order to optimise the technological gains and reduce the cost of procurements.

64. Para 6.6 of Report of Committee of Experts for Amendment to DPP 2013 including formulation of Policy Framework, July 2015, http://www.mod.nic.in/writereaddata/Reportddp.pdf. Accessed on January 2, 2017.

CIVIL AVIATION INDIGENISATION: THE UNEXPLORED POTENTIAL

The civil aviation sector has not been considered for 'Make in India' or indigenisation. The indigenous development of civil aviation aircraft and ground systems has enormous economic and technological potential with possible military applications, which has remained unexplored so far. India, with a size of $16 billion, is the ninth largest civil aviation market in the world and is likely to become the world's third largest aviation market by 2020 and the largest by 2030.[65] India's civil aviation companies in both the public and private sectors, have placed orders or are likely to place huge orders for buying/ wet lease of passenger planes (about 850 aircraft), which include 100 jet planes by Spice Jet in a $12 billion deal in 2016,[66] 250 aircraft by Air India, 100 aircraft by Vistara,[67] 75 aircraft by Jet Airways,[68] 250 aircraft by IndiGo,[69] 72 aircraft by GoAir, to name a few.[70] In addition to this, the Indian Air Force, CAPFs, some state governments and other private operators operate commercial civil aircraft. These are huge numbers and if the government provides a common platform to these airlines to integrate their requirements and acquisitions, India would be in a stronger position to bargain and acquire civil aviation manufacturing, Maintenance, Repair and Overhaul (MRO) and other technologies.

65. "India all set to Become the World's Third-Largest Aviation Market by 2020, says New Study," September 4, 2016, http://scroll.in/article/805518/india-all-set-to-become-the-worlds-third-largest-aviation-market-by-2020-says-new-study. Accessed on September 4, 2016.
66. "SpiceJet's 100-Plane and $12 Billion Blockbuster Deal: Foreign Media," July 13, 2016, http://www.ndtv.com/india-news/spicejets-100-plane-and-12-billion-blockbuster-deal-foreign-media-1430821. Accessed on September 04, 2016.
67. PR Sanjai, "Airline Companies Seen Ordering New Aircraft on Sturdy Passenger Traffic Growth: Capa", June 3, 2016, http://www.livemint.com/Industry/XUpiGZTKnIsbCK6w8zDKAM/Airline-companies-seen-ordering-new-aircraft-on-sturdy-passe.html. Accessed on September 4, 2016.
68. Robert Wall, "Boeing Bags Order for 75 New 737s From India's Jet Airways," November 9, 2015, http://www.wsj.com/articles/boeing-bags-order-for-75-new-737s-from-indias-jet-airways-1447054496. Accessed on September 4, 2016.
69. Anurag Kotoky, "IndiGo Confirms $27 Billion Order to Buy 250 Airbus Planes," August 17, 2015, http://www.bloomberg.com/news/articles/2015-08-17/india-s-indigo-confirms-order-to-buy-250-airbus-a320-neo-planes-idfkj8wd. Accessed on September 4, 2016.
70. "Budget Carrier GoAir to Purchase 72 A320neo Aircraft from Airbus," July 13, 2016, http://economictimes.indiatimes.com/industry/transportation/airlines-/-aviation/budget-carrier-goair-to-purchase-72-a320neo-aircraft-from-airbus/articleshow/53183199.cms. Accessed on September 4, 2016.

India's endeavours in developing commercial civil aviation aircraft have not borne fruit so far. The high powered committee for National Civil Aircraft Development (NCAD), set up by the Council for Scientific and Industrial Research (CSIR) in May 2010, had recommended the launching of a civilian aircraft development project.[71] Its past endeavours in developing civil passenger aircraft did not achieve the desired success. The civil trainer and transport aircraft designed by NAL, a laboratory under the Ministry of Science and Technology, did not succeed due to the inability to convert indigenous designs into commercially successful products.

India, with a size of $16 billion, is the ninth largest civil aviation market in the world and is likely to become world's third largest aviation market by 2020 and the largest by 2030.

There is no known programme to indigenously develop civil aviation products like simulators, radars, landing and approach aids and other ground systems (for commercial users in the aviation sector) by the R&D laboratories in India. The indigenous development of such systems would help in reducing the cost of procurement, maintenance and operation of Indian civil airliners, with a possibility of technological benefits percolating down to military aviation. India lacks civil UAV manufacturing capability. Indian public sector R&D agencies do not have any known programme for indigenous development of civil UAVs.

ACADEMIA IN INDIGENISATION

According to the 2012 report of the Planning Commission Working Group on the Aerospace Sector, India, with over 380 universities, 11,200 colleges and 1,500 research institutions, has the second largest pool of scientists and engineers in the world.[72] India lags behind in fundamental research due to

71. "Plan Panel to Allocate Rs 5,000 Crore to Develop Civilian Plane", January 22, 2012, http://www.thehindu.com/news/national/plan-panel-to-allocate-rs-5000-crore-to-develop-civilian-plane/article2822788.ece. Accessed on September 9, 2016.
72. "Report of the Planning Commission Working Group on Aerospace Sector", 2012, http://planningcommission.gov.in/aboutus/committee/wrkgrp12/wg_aerospace%20_sector.pdf. Accessed on September 3, 2016.

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inadequate investment in higher technical education. Despite having made reasonable progress in the economic field, India is still dependent on other manufacturers of the world for fundamental technologies varying from cars, computers, aviation, defence and other high technology industries. The low level of fundamental research can be gauged from the fact that most of the cars in India run on imported engines.

The engineers being trained in India are not given adequate practical training on the design, development and production aspects of the aerospace sector during their M Tech and PhD curricula. The engineering colleges do not possess an adequate state-of-the-art infrastructure and funding or a conducive environment to enable young engineers to innovate in the aviation sector at an early stage. They have to undergo practical training at aviation production factories and R&D agencies before they can contribute. The practical training cannot be imparted to engineers through the skilling programmes, which are aimed at training technicians. These engineers do very well when they study abroad, where they get practical training in colleges as well as by working with leading aerospace aviation giants like Boeing, Lockheed Martin, Airbus, etc. There is a need to provide the same environment to the students of leading IITs and engineering colleges within India.

ACADEMIA, PSUs AND PRIVATE SECTOR COLLABORATION

The involvement of academia in core aerospace research and development is limited due to the constraints of infrastructure, funding and absence of collaboration with R&D organisations of the government and the aviation industry. There is an increasing realisation among the PSUs and other R&D organisations of India that academic institutes can play a significant role in the development of innovative and cutting edge aerospace products. Secretary,

Department of Defence R&D and Director General DRDO, Dr S Christopher signed a Memorandum of Understanding with the Jadavpur University, Kolkata to establish the Jagdish Chandra Bose Centre for Advanced Technology (JCBCAT) to undertake research in cutting edge technologies in June 2016.[73] The Defence Institute of Advanced Technology (DIAT)[74] conducts M Tech and PhD courses on defence technologies for DRDO scientists, service officers, officers from defence industries and fresh engineering graduates[75]. It complements the research and development efforts of the DRDO laboratories.[76] However, such collaborations are isolated their scope limited and they may not be able to bring transformational changes in the R&D culture unless a national level programme is launched to develop world-class technologies.

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The lack of collaboration among the academic institutions, PSUs and aerospace industry can be better understood if we examine the way projects are undertaken in academic institutions. IIT, Bombay, and Birla Institute of Technology and Science (BITS), Pilani, carried out a study titled, "Design and Fabrications of Solar Powered Unmanned Aerial Vehicle" in July 2014 and

73. "DRDO-Academia Partnership is Taking Shape in Kolkata", June 24, 2016, http://timesofindia.indiatimes.com/good-governance/west-bengal/DRDO-academia-partnership-is-taking-shape-in-Kolkata/articleshow/52897474.cms? Accessed on August 10, 2016.
74. An autonomous organisation under the Department of Defence Research and Development, Ministry of Defence, India.
75. Defence Institute of Advanced Technology, Pune, http://diat.ac.in/index.php?option=com_content&view=article&id=82&Itemid=142. Accessed on August 12, 2016.
76. "DIAT Complements DRDO Labs, says Parrikar", May 31, 2016, http://timesofindia.indiatimes.com/city/pune/diat-complements-drdo-labs-says-parrikar/articleshow/52523384.cms. Accessed on August 10, 2016.

came up with a design and proposal for the fabrication of a solar powered mini UAV.[77] The model solar powered UAV, weighing 1.8 kg, was flown for two test flights in strong winds and cloudy conditions by rookie trainee engineers of the IITs. The duration of both test flights was curtailed due to emergency/crash landings. The result could have been much better if these IIT students had collaborated with experienced aviation experts from the design and development organisations. This also brings out the issue of aerospace research being carried out by leading academic institutions without adequate access to aviation development labs and industrial production facilities. There is a need to increase collaboration among academic institutions, aviation R&D laboratories and aviation industrial production facilities in order to improve the level of practical training as well as involving them in R&D.

R&D, PSUs AND PRIVATE COLLABORATION

Mr. T Suvarna Raju, chairman of HAL, during a seminar in September 2016, had called for greater involvement of the private sector in aerospace indigenisation. He invited private sector companies to participate in the supply of components and assemblies for the Hindustan Turbo Fan Engine-25 (HTFE-25), a 25 kN indigenous aero-engine,[78] ALH, LCA and other aerospace projects of HAL and the Indian Space Research Organisation (ISRO). He was concerned about the underutilisation of registered companies as only 50 to 60 companies out of 2,500 registered were effectively participating in the sub-contract work for HAL.[79]

MSMEs and private sector companies, on the other hand, feel that PSUs are trying to encroach into their area of work rather than focussing on developing niche capabilities and producing strategically important and sensitive equipment. There is also a view that HAL and other PSUs have not been able to understand the concerns and difficulties of the MSMEs and other

77. "Design and Fabrications of Solar Powered Unmanned Aerial Vehicle", July 2014, http://www.umic-iitb.org/summer14/solar_uav.pdf. Accessed on August 23, 2016.
78. Boost for 'Make in India': HAL's 25 kN Aero Engine Completes Inaugural Run; Can be Used for Trainer Aircraft", December 14, 2015, http://economictimes.indiatimes.com/news/defence/boost-for-make-in-india-hals-25-kn-aero-engine-completes-inaugural-run-can-be-used-for-trainer-aircraft/articleshow/50173767.cms. Accessed on October 15, 2016.
79. n.61.

private sector companies. The underutilisation of registered companies by HAL is being viewed as the failure of PSUs to tap the potential of private sector entities.

There is need to increase collaboration among academic institutions, aviation R&D laboratories and aviation industrial production facilities in order to improve the level of practical training as well as involving them in R&D.

Another challenge for public-private partnerships has been the inconsistent approach of the R&D organisations and PSUs for transfer of technology of indigenously designed products to private sector entities. Mini UAVs are likely to have both military and civilian applications, and transfer of technology of mini UAVs to private sector entities would have been a logical step. However, the decision to transfer the designs of micro and mini UAVs by NAL to HAL, a public sector company, some time in 2014-15,[80] and not to a private sector company, indicates the challenges in public-private partnerships. HAL, on the other hand, is yet to commence production of micro and mini UAVs.

The uncertainty about who is going to produce indigenously designed products creates doubts as well as competition between private and public sector entities, which is avoidable. Therefore, there is a need to carry out a holistic assessment and work out the modalities for delineating products to be manufactured by the private as well as public sector entities. The production of strategically important and sensitive products could be entrusted to the PSUs and other products to private sector entities by an independent agency for greater efficiency and improving the rate of production.

OTHER CHALLENGES

Absence of Civil-Military Integration

The integration of design and development of aerospace products for civil and military aviation has not received due consideration in India.

80. Krishnan M, n.46.

The absence of a programme for indigenising commercial civil aircraft, fewer aircraft required for the military and aspirations to procure proven platforms adversely impact the economic viability of indigenous aviation development programmes.

The absence of a programme for indigenising commercial civil aircraft, fewer aircraft required for the military, and aspirations to procure proven platforms adversely impact the economic viability of indigenous aviation development programmes.

Lack of Synergy Among Stakeholders

There are many agencies involved in the design and development of civil and military aerospace products. NAL of the Ministry of Science and Technology has been involved in developing civil aviation technologies. DRDO and HAL of the Ministry of Defence have been developing and producing military aviation products. The Ministry of Civil Aviation (MoCA), Airport Authority of India (AAI) and Directorate General of Civil Aviation (DGCA) do not generally get involved in developing enabling technologies for civil aviation. In addition, the private sector is slowly entering civil and military aviation. However, all these entities are working as individual organisations, with little coordination and synergy, despite many attempts to do so, which is not helping the cause of indigenisation and 'Make in India'.

CERTIFICATION AND QUALITY ASSURANCE

The Centre for Military Airworthiness and Certification (CEMILAC) and DGCA are responsible for certification of military and civil aviation products. The Directorate General of Aeronautical Quality Assurance (DGAQA) and DGCA are responsible for quality assurance in the defence and civil aviation sectors respectively.[81]

CEMILAC: CEMILAC is a certification agency for military aviation products in India, which initiates certification only on receipt of a requirement

81. n.77.

from a user viz. the Indian armed forces. However, it does not provide certification to innovations or start-ups that intend to develop futuristic technologies.[82]CEMILAC would need to gear itself to provide certification for the same without having received the requirement from the users. Similarly, users would need to work out a methodology to integrate innovators in their future acquisition plans to stay ahead in niche technologies.

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DGCA: The level of involvement of DGCA in certification for the civil aviation sector has much scope for improvement. DGCA does not normally undertake research and development of technologies or for building capability to undertake such tasks. It normally adopts standards set up by the European Aviation Safety Agency (EASA)/ Federal Aviation Administration (FAA)/ International Civil Aviation Organisation (ICAO). There is need to change this approach and DGCA needs to consider adopting a proactive approach in developing capabilities and technologies.

There is a need for upgrading the capability of DGAQA and DGCA for certification of military and civil aviation products.[83] The need for strengthening CEMILAC and DGCA was also highlighted in the report of the Planning Commission working group on the aerospace sector in 2012.[84]

Certification of IDDM Products: Indian companies undertaking indigenous design, development and manufacture of aerospace products do not get preferential treatment. There is neither a designated independent agency with the requisite experts to assess the technical and technological indigenisation nor is there any laid down criterion to assess IDDM products.

82. Mr G Gouda, Scientist G, Group Director (Propulsion), CEMILAC, during the 11th International Conference on Energising Aerospace Industry, held at Delhi on September 1, 2016,
83. n.86.
84. Ibid.

IDDM products designed by public sector and private sector companies lose out to the established players as the indigenous products are in the development phase and may not be able to match the global standards in absolute terms but could hold a promising future in terms of indigenisation and strategic autonomy. The existing system favours the established players as indigenous designs are considered for induction only if they meet all the Qualitative Requirements (QRs) and become L1. Therefore, indigenously designed products do not receive the desired support in the absence of laid down criteria and an empowered committee of experts to assess the indigenisation contents.

The absence of an independent agency, which is competent to assess the indigenisation content in the IDDM products and approve acquisitions without going through the established norm of Request for Information (RFI), Request for Proposal (RFP), etc. is an area which makes it difficult for innovators and developers to produce new designs, products or technologies indigenously. Often, private sector and PSU laboratories develop some of the best or new enabling technologies but fail to compete with the leading aviation giants, as they are unable to develop a complete product due to technological and other difficulties. These technological innovations, if preserved, can provide a giant leap to the indigenisation effort. Such technological innovations of the PSUs end up in their historical records and private sector entrepreneurs often sell their innovative designs and products to aviation giants or become their sub-contractors. India has been losing many such enabling technologies to foreign OEMs due to a lack of a mechanism to harness these innovations.

TRIAL AND TESTING SITES[85]

There is inadequate infrastructure, i.e. laboratories and test facilities, etc. for developing the indigenous aerospace industry, in both the public and private sectors. In order to overcome these limitations, DRDO is building an Aviation Test Range (ATR) at Challakere in Chitradurga district of Karnataka, about 200 km from Bangalore. The test range will facilitate testing

85. Jha, n.32.

of fighter aircraft, UAVs, Airborne Warning and Control Systems, etc. The inauguration of ATR, initially planned for mid-2016, has been delayed.[86] The test range would have an aerodynamic test facility, an engine test facility and a test range for aircraft, helicopters and UAVs. An engine test facility was planned to be set up at Rajanukunte near Bengaluru.[87]

Often, private sector and PSU laboratories develop some of the best or new enabling technologies but fail to compete with the leading aviation giants, as they are unable to develop a complete product due to technological and other difficulties.

The above facilities would meet the requirements of the PSUs and government controlled R&D agencies. However, they do not meet the requirements of the private sector and start-ups. There is need to earmark certain areas where MSMEs, start-ups and other private sector entities can utilise these facilities to design, develop and test UAVs and other aviation products.

SKILL DEVELOPMENT: INITIATIVES AND CHALLENGES

Another problem faced by the Indian UAV manufacturers is lack of adequate skilled labour.[88] Their products do not match global standards in terms of quality and they are not able to keep the cost competitive in the regional and global markets. India's aerospace development programmes have faced several challenges in recruiting engineers and technicians for designing and producing aviation products. The requirement of engineers and skilled technicians was met by a combination of retired armed forces technicians and some civil institutes providing training on these skills. However, the rapid expansion of civil aviation, commencement of MRO services, sub-contract work of aviation leaders in India, resurgent PSUs,

86. "Challakere: DRDO's Test Range May Open in June", May 26, 2016, http://www.deccanchronicle.com/nation/current-affairs/260516/challakere-drdo-s-test-range-may-open-in-june.html. Accessed on August 13, 2016.
87. "DRDO to Open 5,000-acre Aeronautical Test Range in Chitradurga by Mid-Year", May 26, 2016, http://www.defencenews.in/article/DRDO-to-open-5,000-acre-Aeronautical-Test-Range-in-Chitradurga-by-mid-year-5416. Accessed on August 13, 2016.
88. Vipul Singh, Co-founder of Aarav Unmanned Systems Private Limited, delivering a lecture at UAS2016, organised at India International Centre, New Delhi, on August 18, 2016.

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etc. increased the requirement of skilled engineers and technicians, which the existing set-up is finding difficult to match up to. This created the need for training a greater number of cabin crew, ground support services and cargo handling staff. The initiatives taken by the government and private sector, especially under the skill India programme, are covered below.

Aerospace and Aviation Sector Skill Council (AASSC): AASSC was set up under Section 8 of the Companies Act, 2013, on September 12, 2014, at Bangalore with HAL, Bangalore Chamber of Industries and Commerce (BCIC) and Society of Indian Aerospace Technologies and Industries (SIATI) as promoters under the National Skill Development Programme. KPMG Advisory Services Private Limited was appointed by AASSC on April 16, 2016, to prepare a roadmap and develop National Occupational Standards (NOS) for job roles by October-November 2016 in the following sub-sectors:[89]

- Aerospace Design and Development.
- Aerospace Manufacturing and Assembly.
- Airline Operations.
- Airport Operations.
- Airport Operations, Cargo and Ground Handling.
- Maintenance, Repair and Overhaul (MRO).

Private Sector Initiatives: Boeing, Tata Advanced Materials Limited Aerospace Facility and Nettur Technical Training Foundation (NTTF) announced a three-year diploma course in aerospace manufacturing technology (advanced composites) under their skill development programme to train frontline workers for the aerospace industry in March 2016. NTTF is

89. "Aerospace and Aviation Sector Skill Council", http://www.aassc.in/about-us/aassc-3/. Accessed on September 3, 2016.

a partner in the National Skills Development Corporation.[90]

Ministerial Initiatives: The Airport Authority of India (AAI), National Skill Development Corporation (NSDC) and National Skill Development Fund (NSDF) signed a tripartite Memorandum of Understanding (MoU) for setting up skill development centres in the aviation sector in June 2016.[91]

Challenges in Skill Development: The above skill-oriented programmes are primarily aimed at meeting the requirements of civil aviation and do not address the indigenous design, development and manufacturing aspects. The programmes of AASSC are ambitious; however, some of the key programmes are still in the planning stage and appear to be moving very slowly in addressing crucial aspects like skilling in the design, development and manufacturing domains under the 'Make in India' initiative. Another significant aspect of skill development is non-availability of literature and resources in high-end technology. Indian universities and selected private sector entities need to be made partners for developing and producing high-end technology products in order to develop an R&D culture.

ASSURED ORDERS

Indian private sector entities are reluctant to buy indigenous designs from the public sector design (R&D) agencies for mass production since there are no assured orders. It has been seen that countries like the US and China have developed their indigenous industries by providing whole-hearted support to indigenously designed products and placing assured orders with the production agencies. The defence industries of the US and China also face technological challenges, costs overruns, etc., which are addressed through increased funding on R&D, collaborations, etc. The US Air Force (USAF) and People's Liberation Army Air Force (PLAAF) are predominantly equipped with indigenously produced fighters, bombers, transport aircraft

90. "BOEING, TATA, NTTF Announce Skills Program for Aerospace Sector", March 28, 2016, http://www.boeing.co.in/news-and-media-room/news-releases/2016/march/boeing-tata-nttf-announce-skills-program.page? Accessed on September 3, 2016.
91. "Strategic Partnership Between Ministry of Skill Development and Entrepreneurship and Ministry of Civil Aviation to Boost to Skill Initiatives in Aviation Sector", June 8, 2016, http://pib.nic.in/newsite/PrintRelease.aspx?relid=146064. Accessed on September 3, 2016.

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and helicopters despite their limitations. The US laws prohibit procurement of arms from foreign vendors. Similarly, surety of business is likely to motivate Indian entrepreneurs, MSMEs and other private sector entities to invest in defence manufacturing and applied research, and take calculated risks.[92]

DELAYS AND COST OVERRUNS

The cost overruns due to delays in the completion of the projects are a major cause of concern for most developers as well as users. The delays in completion of the projects can be attributed to, firstly, technological challenges, and, secondly, change of QRs by the users. The French Director General for Armament (DGA[93]) is the single agency, which is technically qualified and responsible for procurement of armaments for the French defence forces. The French government has introduced the "Responsibility Principle" to address the issue of cost overruns and delays. In this system, whoever fails to meet contractual obligations—whether the manufacturer (or contractor) or government (the armed forces are responsible for, say, change of QRs)—pays for the escalation of costs.[94] The cost overruns had reduced with the introduction of this system.

ABSENCE OF UAV REGULATIONS

Impact of Ban: The private industry has seen a marked reduction in small UAV development programmes since the imposition of the ban on operations of civil drones by the DGCA in October 2014. The DGCA came up with Draft Guidelines for obtaining the Unique Identification Number and Operation of

92. Singh, n.55..
93. Direction générale de l'armement
94. "Committee of Experts for Amendments to DPP 2013 including formulation of Policy Framework," http://www.mod.nic.in/writereaddata/Reportddp.pdf. Accessed on January 17, 2017.

Unmanned Aerial Systems (UAS) in April 2016.[95] The operation of civil UAVs continues to remain banned and final rules were still awaited at the time of writing. The growth of the civil UAV industry has stagnated since then. According to Vipul Singh, a UAV start-up co-founder,

> Most of the UAV companies in India are start-ups, which have been badly hit by the ban on civil UAV operations and lack of regulations and guidelines for undertaking R&D, testing and trials of UAVs. The delay in releasing the guidelines has adversely impacted the investment eco-system in terms of funding the start-ups for UAV development. The start-ups, which had developed UAVs indigenously prior to the ban, were unable to commercialise them and move to the next level. This is demotivating private investors to invest in this domain.[96]

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The ban on civil UAV operations in India is having an adverse impact on the private sector's participation in R&D as well as on the growth of the civil UAV industry.

ADVERSE IMPACT OF COLLABORATIONS AND JOINT VENTURES

Collaborations and joint ventures can only support indigenisation or 'Make in India', if they are planned and executed to achieve well-defined objectives, which support indigenisation. Collaborations and joint ventures with foreign OEMs, without specifying clear objectives, could prove counter-productive and their likely impact is deliberated upon in the succeeding section.

Developer to Integrator: The emphasis on collaboration/joint ventures could encourage PSUs to collaborate with leading aerospace

95. Guidelines for obtaining Unique Identification Number (UIN) and Operation of Civil Unmanned Aircraft System (UAS), April 2016, http://www.dgca.nic.in/misc/draft%20circular/AT_Circular%20-%20Civil_UAS(Draft%20April%202016).pdf. Accessed on October 25, 2016.
96. Vipul Singh, Co-founder and CBDO, Aarav Unmanned Systems, email dated October 24, 2016.

manufacturers in producing aerospace products in India and achieving 'Make in India'. However, this could result in Indian PSUs shifting their focus from developing core technologies to becoming integrators of imported technologies.

Meagre Technology Gains: Many foreign OEMs are wooing Indian private and public sector companies for joint production to meet the requirements of 'Make in India' while retaining the core technology. In a joint venture, the Indian company would normally be assigned the task of providing low-end technology support like assembly of the product, MRO services, providing maintenance support and acting as a point of contact for channeling spares from the foreign OEM. Therefore, there is unlikely to be significant technology gain in real terms in joint ventures.

Scuttling of Indigenous Project: India was the first country in Asia to produce supersonic jet aircraft (the HF-24 Marut), which was first conceived in 1967 and had served in the IAF during the 1970s. The Marut's design was based on the 3,770 kgf Bristol Siddeley Orpheus after-burning engine. However, the British discontinued production of the engine and India had to be content with the non-after-burner Orpheus 2,200 kgf engine, thus, making the Marut significantly underpowered.[97] India's efforts to procure engines from other aerospace companies were not successful and it was instead offered licensed production of the MiG-21 fighter aircraft. As a result, the Marut was shelved after limited production, and the technological gains made in its design and development were lost in due course. The licensed production, on the other hand, normally involves assembly of aircraft, and the gains are limited to acquiring production technology and processes.

India is again in a similar situation but with an advantage of having a huge economy and its R&D agencies developing a wide variety of aircraft, UAVs and other systems indigenously, which have the potential to become successful products if persisted with. With this background,

97. Larkins D'Souza, "LCA Tejas is not India's First Indigenous Fighter Plane: A HF-24 Marut Story", July 7, 2016, http://www.defenceaviation.com/2016/07/lca-tejas-is-not-indias-first-indigenous-fighter-plane-a-hf-24-marut-story.html. Accessed on September 30, 2016.

many aerospace companies are now ready to collaborate and form joint ventures with PSUs for joint production of manned and unmanned aircraft. The PSUs could be tempted to enter into such agreements in order to produce products without following the unpredictable and difficult path of indigenisation. However, such collaborations and joint ventures may not result in adequate technology gains as the collaboration partners are unlikely to transfer critical technologies. As a result, the country would continue to remain dependent on foreign OEMs.

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Joint ventures and collaborations could result in shelving of indigenous projects or make them economically unviable due to the reduced demand. The technological gains made during the design and development process could be lost. Joint ventures and collaborations, without clear-cut technology gains at the national level, could prove to be counter-productive. This may give a false sense of indigenisation and is not a desirable outcome of the 'Make in India' initiative.

PROPAGANDA AGAINST INDIGENOUS PROJECTS

Aviation projects the world over take decades to mature and such projects, being complex in nature, often face several technological challenges during the design and development phase. If such indigenous projects show significant progress and are viewed as competitors to the products developed by global aviation giants, they are subjected to aggressive propaganda against them. Indigenous projects are shown in a bad light by pointing out their isolated failures to create a public opinion against continuation of R&D in indigenous projects.

India's policy of 'Make in India' needs to take into consideration economic, technical and strategic issues. No country or company would shift its production facilities unless it is compelled to do so. Also, India needs to have a roadmap which identifies machinery, technologies and other capabilities that it aims to acquire.

TECHNOLOGY DENIALS

India's journey to indigenisation has not been without technology denials. India's endeavours in UAV development were dependent on the US for some critical parts. The US State Department had withdrawn export licences for certain components ((MOOG rotary actuators by the MOOG Group, USA) on Missile Technology Control Regime (MTCR) grounds, which were critical for the Rustom UAVs. As a result, India was forced to indigenise these components, which were in the testing stage in 2015. The restrictions helped India indigenise these critical components but at the cost of delays in the projects.[98]

LIMITATIONS OF 'MAKE IN INDIA'

Mr. T Suvarna Raju, chairman HAL, emphasised that formulation of favourable policies like increasing the Foreign Direct Investment (FDI) limit from 26 percent to 49 percent and 100 percent with the approval of the Indian government has not attracted many foreign OEMs to invest in 'Make in India', indicating the limitations of investment in this strategically important high technology sector. The regulatory, contractual and other systematic gaps are exploited by the foreign OEMs to avoid meeting the obligations of indigenisation under the 'Make in India' initiative. Mr. Raju had advised foreign OEMs to focus on 'Make in India'.[99] India's policy of 'Make in India' needs to take into consideration economic, technical and strategic issues. No country or company would shift its production facilities unless it is compelled to do so. Also, India needs to have a roadmap, which identifies machinery,

98. Jha, n.32.
99. n.61.

technologies and other capabilities that it aims to acquire. India needs to show the will to accept or reject proposals which do not meet the 'Make in India' criteria.

The demand for UAVs is rising in both the military and civil sectors. The Indian armed forces need a wide variety of UAVs, which include micro, mini, tactical, MALE, HALE, rotary UAVs and UCAVs.

However, the problem of 'Make in India' is not limited to foreign OEMs. India's R&D organisations, PSUs and the private sector too have some challenges as well some weaknesses, which need to be addressed. The lack of coordination among various stakeholders creates gaps between indigenous R&D endeavours and manufacturing. Users normally assess the complete products and do not assess indigenisation of enabling technologies. There is no certainty that indigenously designed products would be selected for induction by the armed forces. There is no independent agency which assesses the level of indigenisation before clearing procurement from foreign OEMs. It needs to be understood that delays and technological challenges are inescapable realities in pursuit of developing indigenous capability. Also, there is no joint mechanism to assess the weaknesses of indigenously designed products, and efforts are required to overcome them by acquiring enabling technologies to make them compliant with the users' requirements rather than going for outright purchase.

SUMMATION

The demand for UAVs is rising in both the military and civil sectors. The Indian armed forces need a wide variety of UAVs, which include micro, mini, tactical, MALE, HALE, rotary UAVs and UCAVs. There would be a requirement of sensors and weapons of different weights and sizes for carriage by these UAVs. However, the indigenous UAV industry is finding it difficult to meet the requirements of the Indian armed forces, which could result in the armed forces importing them and thereby increasing India's dependence on foreign suppliers. The civil UAV operators are procuring UAVs from foreign vendors as well as by assembling UAVs by

The PSUs need to come up with sound business, marketing and product support strategies to become competitive in this sector. India should be prepared to deal with adverse propaganda and ensure that indigenous aviation development programmes are not shelved.

integrating components, sub-assemblies and developing software indigenously. The lack of indigenous capability in certain essential technologies is a major limitation of the indigenous UAV manufacturing industry, which is resulting in continued dependence on foreign suppliers.

The lack of skilled manpower and enabling technologies in the aviation sector adversely affects the quality of indigenously manufactured components and sub-assemblies, which do not match the global standards. The ongoing skilling initiatives do not provide practical and result oriented training to engineering students for developing cutting edge technologies indigenously. The other challenges faced by the PSUs and R&D agencies include retaining bright researchers, and technology denials, during the process of developing elusive technologies. The collaborations and joint ventures with leading aviation giants often end up as assembled in India without much technological gains.

The smaller quantity of orders adversely impacts the economic viability of products, which has been a major hurdle in involving the private sector in the indigenous production. India has been unable to plug the gaps in the three critical phases of product development: first, between the conceptualisation of an idea and the designing of the product; second, between the design and the commercial production; and, third, between the commercial production and meeting the aspirations of the users. These gaps do not allow indigenous designs to become commercially successful products. Improving coordination among the various stakeholders involved in the above three stages is of utmost importance to revitalise the aerospace eco-system. In addition, weak business models and poor product support weaken the credibility of the indigenous products. The PSUs need to come up with sound business, marketing and product support strategies to become competitive in this sector. India should be

prepared to deal with adverse propaganda and ensure that indigenous aviation development programmes are not shelved. Factors like vitalising academic institutions, collaboration among various stakeholders, etc. need to be addressed. Transformational changes may be needed for addressing these challenges and for achieving synergy among various stakeholders i.e. government ministries, DRDO, R&D agencies and PSUs. The non-availability of an empowered and independent council to carry out technical evaluation of indigenous content in IDDM is one of the major hurdles in harnessing the potential of indigenous innovators towards achieving indigenisation and succeeding in the 'Design and Make in India' campaign.