



TECHNICAL MAGAZINE

Mach Book
2020-2021



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Vision of the institute

“Bharath Institute of Higher Education & Research (BIHER) envisions and constantly strives to provide an excellent academic and research ambience for students and members of the faculties to inherit professional competence along with human dignity and transformation of community to keep pace with the global challenges so as to achieve holistic development.”

Mission of the institute

- To develop as a Premier University for Teaching, Learning, Research and Innovation on par with leading global universities.
- To impart education and training to students for creating a better society with ethics and morals.
- To foster an interdisciplinary approach in education, research and innovation by supporting lifelong professional development, enriching knowledge banks through scientific research, promoting best practices and innovation, industry driven and institute oriented cooperation, globalization and international initiatives.
- To develop as a multi-dimensional institution contributing immensely to the cause of societal advancement through spread of literacy, an ambience that provides the best of international exposures, provide health care, enrich rural development and most importantly impart value based education.
- To establish benchmark standards in professional practice in the fields of innovative and emerging areas in engineering, management, medicine, dentistry, nursing, physiotherapy and allied sciences.
- To imbibe human dignity and values through personality development and social service activities.

B.Tech- Aeronautical & Aerospace Engineering

Vision of the Department

Department of Aeronautical Engineering will endeavor to accomplish worldwide recognition with a focal point of Excellence in the field of Aeronautics by providing quality Education through world class facilities, enabling graduates turning out to be Professional Experts with specific knowledge in Aeronautical & Aerospace engineering.

Mission of the Department

- To be the state of art Teaching and Learning center with excellent infrastructure and empowered Faculties in Aeronautical & Aerospace Engineering.
- To foster a culture of innovation among students in the field of Aeronautics and Aerospace with updated professional skills to enhance research potential for sponsored research and innovative projects.
- To Nurture young individuals to be knowledgeable, skilful, and ethical professionals in their pursuit of Aeronautical & Aerospace Engineering.

B.Tech- Aeronautical & Aerospace Engineering

Program Educational Objectives Statements (PEO)

PEO 1: Demonstrate a solid grasp of fundamental concepts in Mathematics, Science, and Engineering, essential for effectively addressing engineering challenges within the Aerospace industry.

PEO 2: Involve in process of designing, simulating, fabricating, testing, and evaluating in the field of Aerospace.

PEO 3: Obtain advanced skills to actively engage in research and development endeavors within emerging domains, while also pursuing further education opportunities.

PEO 4: Demonstrate efficient performance both as independent contributors and as valuable team members in diverse multidisciplinary projects.

PEO 5: Embrace lifelong learning and career advancement while adapting to the evolving social demands and needs.

Programme Outcomes (PO's)

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and Engg. Specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, research literature, and analyze engineering problems to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of

engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Dean Message

Winged Words is particularly important as it encourages the students to share the knowledge they have acquired. Writing articles for the magazine also improves the communication skills of the budding engineers of the Aeronautical department. It is common knowledge that representation of an idea is as important as, if not more important, than the idea itself. Winged Words represents a cloud with a silver lining for the world of technology. It aims to inspire and nurture upcoming engineers to bring a revolution in this ever-evolving world of technology. The magazine captures the current technological advancements. To conclude I would like to congratulate the faculty and the students of the editorial team on bringing out the Second issue of Winged Words

HOD Message

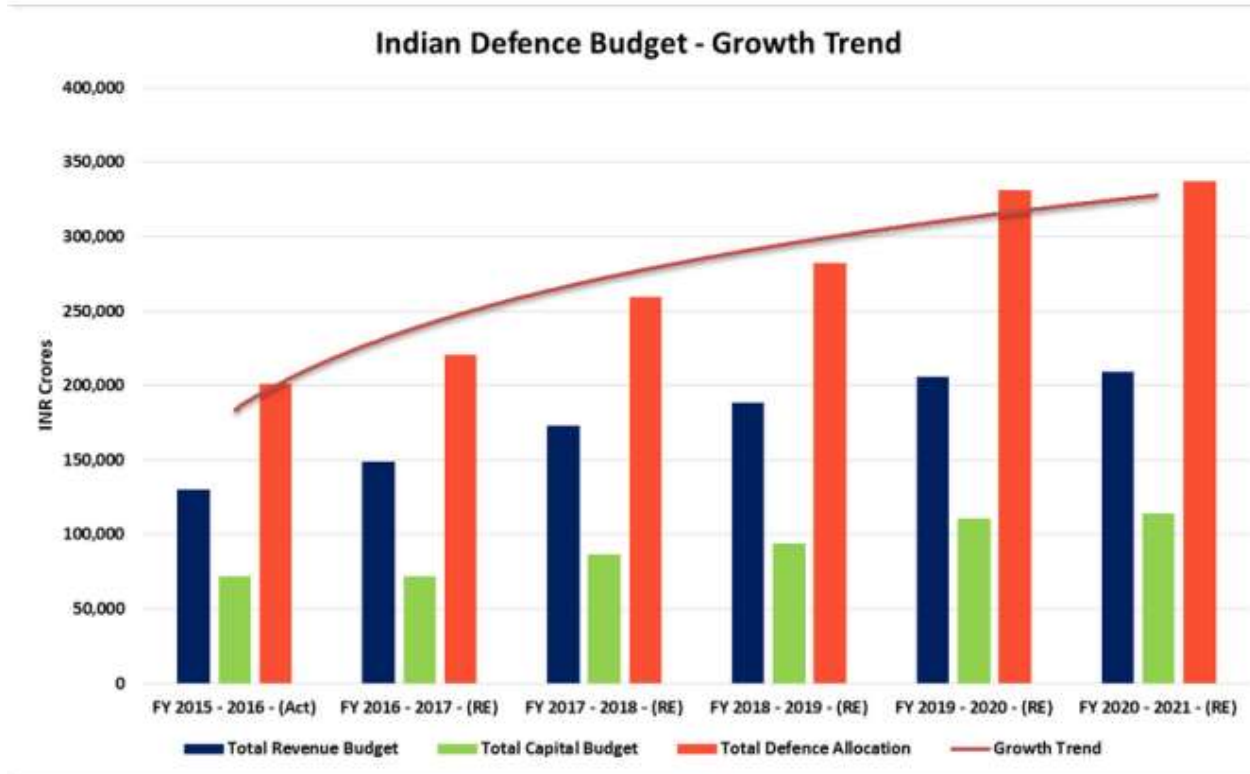
Congratulations to the students and faculty associated to magazine committee for successfully publishing this issue of departmental technical magazine Winged Words is creating platform which provides an opportunity to the students and staff to express their original thoughts on technical topics.

The magazine plays an instrumental role in providing exposure to the students to develop written communication skills and command over the language. It is a step towards building professional and ethical attitude in them. The entire journey of creating Winged Words is an outcome of rigorous effort made by students and faculty. Students not only gain the knowledge about the latest technological developments and advancements through reading and writing articles but they also develop verbal and written communication skills.

This issue has expanded its scope by introducing articles by major stakeholders. Apart from students and faculty, inputs have been collected from alumni, parents and industry experts. On concluding note, I would like to thank all the stakeholders for their involvement and encouragement and wish all the best for their bright future

Indian defence budget and market attractiveness

The Indian Aerospace and Defence market presents an attractive and significant opportunity for Indian and foreign companies across the supply chain. India has the 3rd largest armed forces in the world, and its Defence budget is about 1.62% of its GDP. India is one of the largest importers of conventional Defence equipment and spends about 40% of its total Defence budget on capital acquisitions. About 60% of its Defence requirements are met through imports. A report from the Stockholm International Peace Research Institute (SIPRI) which tracks global arms purchases has found that between 2015 and 2019, India accounted for 10% of global arms imports, followed by Saudi Arabia, the United Arab Emirates and China. Here is a glimpse of the Defence budget for the last 3 financial years categorized by the two main heads of Revenue Expenditure and Capital Expenditure.



DEFENCE OPPORTUNITIES

Defence has signed more than 180 contracts with the Indian Industry, as of December 2019. These contracts were valued over USD 25.8 Bn approximately. Favorable government policy is the one which promotes self-reliance, indigenization, and technology upgradation. The policies also aim at achieving economies of scale, including the development of capabilities, and for exports in the Defence sector. India's extensive modernization plans are with an increased focus on homeland security and growing attractiveness as a Defence sourcing hub. Defence production in India is gradually heading towards private sector participation. Between 2015-16 and 2018-19 (April-October), out of a total 188 contracts, 121 contracts have been signed with Indian vendors including DPSUs/PSUs/OFB and private vendors for capital procurement of Defence equipment. The equipment to be procured includes Helicopters, Naval vessels, radars, ballistic helmets, artillery guns, simulators, missiles, bulletproof jackets, electronic fuses and ammunition. The size of the opportunity is huge. The government is looking at achieving a turnover of Rs 1.7 trillion in military goods and services by 2025 and the SP model is envisaged to capitalize this opportunity and contribute to the Make in India initiative. The target also is to achieve export of Rs 350 billion (USD 5 billion approximately) in Defence goods and services by 2025. As per the acquisition plans of the three armed forces in the next 10 years, the industry is expected to acquire capital assets worth Rs 15 trillion.

AEROSPACE OPPORTUNITIES:

India's space program stands out as one of the most cost-effective in the world. India has earned worldwide recognition for launching lunar probes, building satellites, ferrying foreign satellites up and has even succeeded in reaching Mars. Till December 2019, a total of 319 foreign satellites from 33 countries have been successfully launched onboard Polar Satellite Launch Vehicles (PSLVs) by ISRO. With the ISRO undertaking the development of cutting-edge technologies and interplanetary exploratory missions, there is a tremendous scope in contributions to the realization of operational missions and new areas such as satellite navigation. The Union Cabinet of India has approved reforms in the Space sector which will boost private sector participation in the entire range of space activities. The Indian National Space Promotion and Authorization Centre (IN-SPACe) will provide a level playing field for private companies to use the Indian space

infrastructure and also hand-hold, promote and guide the private industries in Space activities through encouraging policies and a friendly regulatory environment. Such a thrust from the Government of India is intended to create investment opportunities for private companies in the Space sector in India. The Civil Aviation industry in India has emerged as one of the fastest growing industries in the country during the last 3 years. India has become the 3rd largest domestic aviation market in the world and is expected to overtake UK to become the 3rd largest air passenger market by 2024. To cater to the rising air traffic, the Government of India has been working towards increasing the number of airports. As of March 2019, India had 103 operational airports. India has envisaged increasing the number of operational airports to 190–200 by FY40. Further, the rising demand in the sector has pushed the number of airplanes operating in the sector. The number of airplanes is expected to reach 1,100 by 2027.

Space opportunity

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Private Sector

To achieve the goal of self-reliance in the Defence sector, continuous efforts are being made to increase indigenization, wherever technologically feasible and economically viable. In May 2001,

the Defence Industry sector, which was hitherto reserved for the public sector, was opened up to 100% for Indian private sector participation, with Foreign Direct Investment (FDI) up to 26%, both subject to licensing. However, recently the Department of Industrial Policy & Promotion, Ministry of Commerce & Industry vide Press Note No. 5 (2016 Series), has allowed FDI under automatic route upto 49% and above 49% wherever it is likely to result in access to modern technology or for other reasons to be recorded. Post liberalization of the Defence sector in 2001, the first instance of opportunity was sighted in the DPP 2006 with the introduction of Make category, which was exclusively reserved for Indian private companies. We are now looking at a decade of development since 2006 in the private industry and here are some of the companies which have proved themselves in Defence manufacturing.

The TATA Group:

The Tata group is leading the 'Make in India' charge in the Defence & Aerospace spaces and is a key private sector player in the industry. In Aerospace, Tata has emerged as a global, single-source supplier for a number of important fixed wing and rotary wing programmes. In the Defence domain, as a trusted partner to the Ministry of Defence (MoD), armed forces and Defence Research and Development Organization (DRDO), Tata is playing an increasingly important role in Defence programmes of strategic importance. Going forward, the group is focused on, partnering global OEMs for 'Make in India' programmes for fighters, helicopters, transport aircraft and weapon systems and land systems; building unmanned systems; supporting other critical aerospace & Defence programs for the Indian Defence sector, and setting up world-class aero engine components manufacturing facilities. **BUSINESS HIGHLIGHTS** Tata group announced the consolidation of five Aerospace and Defence businesses into a single entity to be known as Tata A&D. It will be amongst India's largest private Aerospace and Defence players post consolidation, moving beyond providing individual products to developing integrated offerings and executing larger and more complex products.

Tata Advanced Systems Tata Power SED

Tata Advanced Material Limited (TAML)

TAL Manufacturing Solutions Ltd (TAL)

Tata Motors Limited

Mahindra group

Airbus Helicopters has awarded a contract to Mahindra Aerostructures to make airframe parts for the AS565 MBe Panther. These parts will be produced at the Mahindra facility in Bengaluru. They will be shipped directly to the Airbus Helicopter production line in Marignane, France where they will be integrated with the rest of the airframe assembly and will form a critical part of the Panthers sold worldwide. The contract positions Mahindra Aerostructures as the first Indian company to receive a direct manufacturing contract from Airbus Helicopters as a Tier 1 supplier. Annual procurement of Airbus Group from India exceeds USD 500 million from over 45 suppliers in 2015. It supports more than 6000 local jobs. Due to this supply chain, every Airbus commercial aircraft produced today is partly 'Made in India'. In March 2014, Mahindra Defence Naval Systems (MDNS) inaugurated its new underwater systems and naval applications manufacturing facility in Chakan, near Pune. MDNS is a wholly owned subsidiary of Mahindra Defence Systems, which is part of the USD 16.7 billion Mahindra Group. In July 2016, Boeing Co. and Mahindra Defence Systems formally opened a centre to provide C-17 training services to the Indian Air Force. In Feb 2017, Mahindra Aerostructures, a Mahindra Group company, signed an agreement with Segner SAS of France to collaborate on airframe manufacturing.

LARSEN & TOUBRO (L&T)

L&T is one of India's leading companies for supply of Defence Equipment and Systems in the private sector, with over 30 years of experience in this field. They provide indigenous, design-to-delivery solutions across the Defence spectrum – from land-based weapon launch systems, air Defence and artillery systems and upgrades, to naval weapon launch systems with fire control solutions, bridging systems, communication, avionics, C4I and missile systems. L&T won the tender in a global bid for manufacture of guns, which originally fell within the expertise of the OFs. L&T in partnership with the South Korean firm, Samsung Techwinwon, was awarded a contract for over a billion dollars for the supply of 100 howitzer artillery pieces to the Indian Army. In Feb 2017, L&T and the UK-based MBDA, one of the leading global players in missile systems set up a joint venture (JV) to develop and supply missiles and missile systems to meet the grow

potential requirements of the Indian armed forces. MBDA is jointly held by Airbus Group (37.5 %), BAE Systems (37.5 %), and Leonardo (25 %). The Joint Venture Company is named 'L&T MBDA Missile Systems Ltd'.

DYNAMATIC TECHNOLOGIES LIMITED

DYNAMATIC TECHNOLOGIES LIMITED designs and builds highly engineered products for Automotive, Aeronautic, Hydraulic and Security applications. With futuristic design, engineering and manufacturing facilities in Europe and India, they are able to meet customers' exacting requirements on 6 continents. Their facilities which are located in India (Bengaluru, Chennai, Coimbatore, Nasik), United Kingdom (Swindon, Bristol) and Germany (Schwarzenberg), are lean, green and clean, and designed to support neighboring communities as well as the environment. With three design laboratories in India and Europe, Dynamatic Technologies is a leading Private R&D Organization, with numerous inventions and patents to its credit. The Company and its Subsidiaries employ around 50 scientists and 500 engineers with expertise in Mechanical Engineering, Advanced Computer Aided Engineering, Materials & Metallurgical Engineering, Fluid Dynamics and Defence & Aerospace Research. Most recently, Dynamatic has built the first front fuselage for the FOC version of the Tejas Light Combat Aircraft (LCA). This is the first time a complex fuselage section for a supersonic fighter aircraft has been built by a private sector company

HARAT FORGE

Kalyani Strategic Systems Ltd entered into a JV with Saab Group for manufacturing of surface-to-air missile (SRSAM) system and very short-range air Defence (VSHORAD) air Defence programmes. In Feb 2017, Kalyani Group, the owners of Bharat Forge, finalized a JV partnership with Rafael Advanced Systems. The initiative will enable the development and production of high end technology systems within the country. This will include a wide range of technologies and systems, like Missile Technology, Remote Weapon Systems and Advanced Armor Solutions. The proposed JV will produce Spike Anti-Tank Guided Missiles (ATGM). Kalyani Strategic Systems (KSSL), the Defence arm of Kalyani Group and Israel Aerospace Industries (IAI) signed a memorandum of understanding to incorporate a JV company in India, at the Aero-India exhibition

in Bengaluru. As part of the MOU, IAI and KSSL are aiming to expand their presence in Indian systems and ground to ground & ground to sea munitions

KIRLOSKAR

“Marine & Defence” division was formed exclusively to cater to the requirements of Marine and Defence sector including the Indian Public Sector Undertaking (PSU) Shipyards, Indian Navy, Indian Coastguard, Indian Army, Indian Air force, Ordnance Factories, Civil & Marine Ships, MES and all other Defence establishments. Their facilities are approved by IRS for production of Marine grade products. They are also registered vendors for pumps and valves for the Indian Navy, DGS & D, and registered with DGQA. They have had the privilege to be associated with the Indian Navy. They have supplied AC sea water and chilled water pumps for INS Viraat, INS Ranjit, INS Ranvijay & Salvage pumps for INS Makar Survey Ship.

VEM TECHNOLOGIES

Established in 1988, VEM Technologies Pvt. Ltd. has a significant experience in providing technological solutions to the Defence and Aerospace Industry. Over the years, VEM developed expertise in wide range of technological domains ranging from connectors to missile systems and has successfully executed many important projects of national interest, using its highly reliable state of the art manufacturing, assembly and testing facilities. VEM is one of the most reliable technological partners for the Defence and Aerospace Industry. VEM was awarded with the “Best Technology Award for the Servo System” by DRDO. VEM has transformed itself into a prominent player for system integration of missiles and aircrafts by developing know-how and expertise in various technological fields like Composites, Mechatronics, Electro-optics, RF & MW, Power Electronics and Micro-electronics. With the help of the expertise in all these fields, VEM successfully develops, manufactures and integrates major systems for Aerospace and Defence Industry

ANANTH TECHNOLOGIES

Ananth's Aerospace division since 1992 has been one of its core strength and differentiators. The division's capabilities span both the embedded software, hardware and system design. Through their services and solutions, Aerospace companies achieve faster time-to-market with quality products, cost effectively. They offer best-of-breed design solutions in aerostructures, aero-engine

for Aircraft Original Equipment Manufacturers (OEMs) and suppliers. Core areas of expertise also include systems design and development including Avionics, RF and Microwave communication systems, Telemetry systems, power modules, DC-DC converters, PCM encoders, and more.

ALPHA DESIGN TECHNOLOGIES PVT. LTD

Alpha is set up to utilize the Government of India's policies for liberalization of Indian economy and opening of Defence Production to Private Sector Industries. Alpha responds in a very unique and innovative manner to the needs of India's Defence and para military markets. Established in Bengaluru, India's high-tech metropolis, the company is structured to offer technical support, indigenous assembly/manufacture facilities and technology integration services for a wide range of products to Indian and international organizations

GOPALAN AEROSPACE

Gopalan Aerospace is a fast paced, innovative Aerospace composite Design, Development and Manufacturing company. Their expertise lies in Precision Engineering, Sheet Metal Fabrication, Heavy Parts Manufacturing and Aerospace Composites. They also manufacture Aerospace interiors parts and more in order to cater to the increasing Aerospace equipment and other heavy engineering needs of India. Established in Bengaluru, Gopalan Aerospace was conceptualized to enable and contribute to the country's rapidly changing Aerospace industry. A domain which was sparsely populated by only a few large players is now open to new, more progressive, faster moving entrants

SCOPE OF THE PRIVATE SECTOR

- Annual rise in the Defence budget of India
- Clarity on items requiring ILs, single window for application to obtain ILs and streamlined procedures
- Large capital expenditure projection. The government has estimated that around 33% of its Defence budget for the year 2020-2021 is to be spent on capital acquisitions of Defence equipment.
- Large imports - scope for indigenization
- Delisting of several items from export clearances

- New thrust to Buy and Make (Indian), and Make categories of procurement in DAP
- Increased scope for transfer of technology due to procurement categorizations in DAP
- Increased FDI cap in automatic route and governmental route subject to certain conditions
- Level playing field with the public sector - removal of exemptions granted to public sector companies and undertakings for payment of customs and excise duties
- Increased flexibility to FOEMs in discharge of offset obligations in terms of change in IOPs, timeframe and products & services. The government has estimated a net amount of contractual offset obligation of around \$4.5 Billion over the next 5-6 years

Tamil Nadu & TN Defence Industrial Corridor

TAMIL NADU DEFENCE INDUSTRIAL CORRIDOR The formal launch of the Tamil Nadu Defence Industrial Corridor was done by the then Defence Minister Nirmala Sitharaman in Trichy on 20th January 2019. This southern Defence corridor is also called the “Tamil Nadu Defence Production Quad”, since the nodal cities namely, Chennai, Salem, Hosur, Tiruchirappalli and Coimbatore form the quadrilateral. Independently, each of these cities already supports well defined tiered manufacturing clusters, which cater to a variety of industries, from automobiles to heavy industries. These manufacturing hubs also have a fairly developed ecosystem like the Ordnance Factory Boards, DRDOs, and other Defence Public Sector Units.

The following are some of the key highlights of the launch:

Investments of approximately INR 3,100 crores have been announced in the Tamil Nadu Defence Corridor

An established TIDCO Aerospace park with 250 acres (expandable to 500 acres)

An Aircraft MRO (Maintenance Repair Overhauling) facility in Krishnagiri and an upcoming MRO facility in Chennai will further catalyze industry growth

An Advanced Computing & Design Engineering Centre (ACDEC) for Aerospace Industry in TIDCO Aerospace & Defence Park will offer cutting edge technology and state-of-the-art infrastructure to support incubation and innovation in the Aerospace Industry. Most of the investment will come from the Defence Public Sector Units (DPSUs), such as Ordnance Factory Board (OFBs), Bharat Electronics Limited (BEL), Bharat Dynamics Limited (BDL), Bharat Heavy

Movers Limited (BEML), and Mazagon Dock Limited (MDL). OFB will be investing Rs 2,305 Crores, BDL will invest Rs 150 Crores, MDL will be setting up incubators in IIT Chennai with an investment of Rs. 15 Crores, and BEML is planning to set up a spares manufacturing facility with an investment of Rs. 40 Crores.

Tamil Nadu Industrial Explosives Limited has signed an MoU with Bharat Electronics Limited for reviving its defunct factory for producing ammunition and to set up a Centre of Excellence for ammunition related technologies

An Aerospace division is being established by BHEL in Ranipet with an investment of Rs.200 crore

Land acquisition has commenced for the satellite launch station of ISRO at Kulasekarapattinam in Thoothukudi District. This launching station will be established at an estimated investment cost of Rs.1000 crore

A feasibility study by TIDCO through IIT-Madras for developing Ulundurpet airstrip as an Aviation Technology Development complex including UAV Testing, Flight Academy, Aeromodeling, etc is in progress

The private sector companies have also announced their investment plans. The Bengaluru headquartered Alpha Design has announced an investment of Rs 100 Crores, while the TVS Group will be investing Rs 50 Crores, with plans for manufacturing tactical combat gears for soldiers. The Chennai headquartered Data Patterns with plans for Transfer-of Technology (ToT), will invest Rs 75 Crores. Aerospace Engineers based at Salem also plans to invest Rs 105 Crores

L&T MBDA Missile Systems Ltd, a JV between Larsen & Toubro and France's MBDA, have obtained the provisional approval for their SEZ unit in Coimbatore from Government of India, for producing missile weapon systems

Lockheed Martin's has announced their intention to invest in the corridor and also mentioned of the impressive expertise and capabilities of companies like Lakshmi Machine Works (LMW) and some others, which measure up to be their supply chain partners

The Defence Minister also launched by video conferencing, the “CODISSIA Defence Innovation and Incubation Centre” to support the MSMEs, Start-up, and existing companies, to encourage their participation and indigenous contribution to the Defence industry

DRDO handed over the model of Arjun Mark-1A to Mr Saurabh Kumar, Director General of Ordnance Factories (DGOF) and chairman of the Ordnance Factory Board. The release also said that the Arjun Mark-1A is much superior to the earlier version in terms of firepower, mobility and protection features

According to the TN Govt, Govt has identified about 1,000 acres of land in Manapparai, 1,300 acres in Krishnagiri, 1,000 acres in Dharmapuri and 900 acres in Hosur

ANALYSIS OF CLUSTERS IN TN DEFENCE CORRIDOR AND ITS STRENGTHS

Chennai: The capital city of the state is also the automobile capital of South Asia. It is home to Armored Vehicles and Ammunition Depot – AVADI has been a military base since the colonial times. Heavy Vehicles Factory (HVF), EFA-Engine Factory Avadi, Combat Vehicles Research and Development Establishment (CVRDE), Central Vehicle Depot (CVD), The Ordnance Depot [OD], Unfit Vehicles Park [UVP] and the Ordnance Clothing Factory (OCF) exist within the limits of Avadi. A Maintenance Repair Overhauling (MRO) complex is being planned in Chennai which will emerge as the preferred MRO destination. Aerospace Park in Sriperumbudur (Vallam - Vadagal) with an Advanced Computing and Design Engineering Centre (ACDEC) is being set up to form a strong base for supporting large OEMs

The city also boasts its advantage of having the largest port in India which connects with the busiest trade routes in the Indian Ocean.

- Trichy: One of Trichy’s unique advantages is the usage of state-of-the-art tools and technology in SMEs that specialize in laser cutting of tungsten, a material which is widely used in the making of ships and submarines. Heavy Alloy Penetrator Project (HAPP) Trichy pioneers in the manufacture of Tungsten and other heavy alloys primarily for Defence applications. Trichy also houses Bharat Heavy Electricals (BHEL). The Ordnance Factory of Trichy (OFT) specializes in the manufacture of rifles, grenades etc

- **Coimbatore:** The entrepreneur rich city is a strong base for foundry, machining, tooling and forging. It also has a large base for auto-ancillaries manufacturing in the country. It is an education hub with a large number of Engineering and Industrial Training Institutes supplying technical talent to the nation. Termed the “Manchester of South India” it pioneered the industrial development in India. Currently, over 14,000 MSMEs support the supply chain across foundry, motor & pumps, auto-components and tooling sectors
- **Salem:** Strategically lying at the heart of the Defence quadrilateral and equidistant from the four Nodal cities of the Defence corridor, Salem has rich deposits of minerals such as bauxite, magnesite, granite and calcite, and is a hub for making power grids and steel, which form the foundation for the shipping industry. Salem is also a focus state for Power Grid
- **Hosur:** Hosur is a prominent city along the Chennai -Bengaluru Industrial Corridor. Heavy Engineering and Automobile majors across the globe have set-up bases. Hosur is a powerhouse in the auto corridor. Often missed out in the Defence quadrilateral is the proximity of the corridor with Bengaluru, the IT hub of the world. Bengaluru is right at the doorstep of Hosur and Defence corridor. Electronics, embedded systems and software controls are critical to Engineering systems and proximity of Bengaluru is a bonus to the already well-placed Quadrilateral.

2020 global aerospace and defense industry outlook

While defense continues to soar, commercial aerospace is experiencing a short descent

After a strong year in 2018, the global aerospace and defense (A&D) industry has experienced a descent in 2019. While the defense sector has continued to soar, growth in the commercial aerospace sector has slowed. In 2020, the A&D industry is expected to get back to its growth trajectory with the commercial aerospace sector recovering from its decline in 2019. The defense sector has sustained its growth in 2019 as security threats have intensified, requiring governments worldwide to continue increasing their defense budgets. Defense expenditure is expected to grow between 3 and 4 percent in 2020 to reach an estimated US\$1.9 trillion,¹ as governments worldwide continue to modernize and recapitalize their militaries. Most of the growth will likely be driven by increased defense spending in the United States, as well as in other regions, such as China and India. The commercial aerospace sector has experienced a decline in deliveries in 2019 due to

production-related issues in certain aircraft models. Order backlog of commercial aircraft has also decreased from the 2018 peak levels of about 14,700 aircraft to slightly more than 14,000 at the end of August 2019. This was a result of order cancellations and a drop in new orders. However, commercial aerospace sector growth is likely to recuperate from 2020 onward as the long-term demand for commercial aircraft continues to remain robust, with nearly 40,000 units expected to be produced over the next two decades.

Military expenditures are on the rise as security threats continue to intensify:

Demand for military equipment is on the rise as governments across the globe focus on military modernization, given increasing global security concerns. The uncertainty and sustained complexity of the international security environment worldwide is likely to boost global defense spending over the next five years. Global defense spending is expected to grow at a CAGR of about 3 percent over the 2019–2023 period to reach US\$2.1 trillion by 2023.⁴ While the US administration's increased focus on strengthening the military is expected to be a key growth driver for defense spending in 2020, other large nations, such as China, Russia, and India, are also likely to embark on higher spending on defense equipment. US foreign military sales (FMS) also remained steady as global threats persisted, and this is likely to continue to add to the robust performance of the defense sector. In 2018, US FMS rose 33 percent to reach US\$55.7 billion, and in the first nine months of 2019 achieved US\$44.2 billion, with a likelihood of reaching the 2018 total.⁵ Strong US FMS continues to boost export opportunities for defense contractors in the United States. However, a strengthening dollar could dampen growth in FMS as some of the European defense exporting nations could become more price competitive. In Asia, higher defense spending by major regional powers such as India, China, and Japan will likely contribute to global sector growth. In Europe, members of NATO are also increasing defense budgets to reach a defense spending target of 2 percent of GDP. Apart from this, ongoing geopolitical tensions in the Middle East are creating a strong demand for military equipment. Increasing global defense spending would continue to create opportunities for defense contractors and their supply chains. To meet the increased demand and improve production yields, defense companies should leverage highly agile production that adapts to changes in demand, including digital technologies. For instance, adopting smart factory initiatives could drive 10–12 percent gains in factory utilization and labor productivity without major capital investment.

Commercial aircraft backlog is declining from peak levels while regional jet demand is taking off

The commercial aircraft order backlog continues to be high, at about 14,000 unfilled orders through September 2019. However, the backlog declined from 2018 peak levels of about 14,700 aircraft due to order cancellations and lower-than-expected new orders. While original equipment manufacturers (OEMs) have been pushing the envelope in creating state-of-the-art aircraft—which are fuel-efficient, connected, and highly automated—many are still grappling with production-related issues. Specifically, OEMs are continually aiming to increase production rates and pushing suppliers to ramp up, and the sector is facing production-related challenges with certain aircraft models. Consequently, OEMs are experiencing order cancellations and delays in taking deliveries from their primary customers, airlines. Aircraft deliveries are estimated to be lower in 2019 compared to 2018, largely due to the decrease in production rates for certain aircraft models. In 2020–2021, deliveries are expected to be back on track as Boeing announced its goal to have the 737 MAX back in service by January 2020. Moreover, with China’s narrow-body aircraft deliveries anticipated to begin in 2021, the current duopoly may raise production rates further between now and 2021 to capture China’s domestic aircraft backlog before C919 deliveries begin. As a result, commercial aircraft production is projected to be about 1,900 aircraft in 2020, up from an estimated 1,450 aircraft in 2019.¹² The outlook for the regional jet market remains robust, as forecasts anticipate more than 5,000 regional jets will be required over the next 20 years. This is expected to primarily be driven by an aging fleet and demand from Asia-Pacific, the Middle East, and Latin America, as they continue to expand regional connectivity. Over the last two years, the regional jet market experienced some major tie-ups—Airbus’s acquisition of majority ownership in Bombardier’s C-Series aircraft program, Boeing’s proposed deal to buy Embraer’s passenger jet unit, and Mitsubishi Heavy Industries’ proposed acquisition of Bombardier’s CRJ regional jet program. These program realignments could allow supply chain and manufacturing consolidations, resulting in reduced production costs. The commercial aerospace aftermarket landscape is also evolving, due to a changing aircraft fleet mix, pressure on airlines to reduce maintenance costs, and the emergence of new advanced technologies. This is resulting in an increased aftermarket opportunity for the overall commercial aircraft value chain, including OEMs. With the increasing aircraft backlog and production rates, OEMs are focusing on expanding aftermarket revenues by seeking partnerships and exploring new business lines to

diversify. For example, Boeing's 2018 services revenue stood at about US\$17 billion, and it aims to triple its service revenue to US\$50 billion in the next five years

Innovation in space technologies driving toward modernization

The global commercial space sector is likely to see steady investments in new and existing space technologies and services, with funding coming primarily from governments and venture capital. Currently, revenues in the commercial space market primarily come from manufacturing of satellites used for earth observation and communications, and launch vehicles used to place these payloads in orbit. While new space technologies and services are likely, most are expected to continue to be in the proof-of-concept phase and will thus likely require additional funds and development before providing broader commercial services and economic returns. Existing commercial space service providers will likely continue to evaluate their business models and technology to prepare for shifts in the market but are not expected to make significant changes beyond research and development (R&D) until new products and services are proven. 2020 may be a year of firsts for significant milestones on the way to grow the space ecosystem, laying the foundation for more significant change in the earlier part of the next decade. However, due to the generally nascent stage of development defining much of the emerging commercial space sector and the cautious approach adopted by established commercial space companies, 2020 is unlikely to produce significant changes in the commercial space sector. An increased focus on the modernization of military space missions and the resiliency of space capabilities is likely to continue. New government appreciation for threats posed by anti-satellite (ASAT) weapons has caused a sharp increase in concern over the military use of near-Earth space. Based on the ASAT threat, the United States and other countries are increasing investments in research, technology, and commercial services, as well as altering organizational strategies to improve the resiliency of their military space capabilities and capacities. We have already seen the US government push for innovation and modernization result in new acquisition authorities, substantially increased sources of government funding, and the design of new space-based military concepts of operation. Over the next year, these investments and organizational changes should be expected to continue, but significant changes to the military use of space, i.e., placing non-satellite weapons into space, remains unlikely, and the deployment of new military space concepts will not occur until later in the decade.

Oradea, Romania, www.jeanu.com software: Photoshop, 3ds max, Vue d'Esprit

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Long-term A&D industry growth drivers are shaping M&A activity

M&A activity has been strong since 2015 and is expected to be shaped further by growth drivers in areas such as C5ISR (Command, Control, Communications, Computers, Combat Systems, Intelligence, Surveillance, and Reconnaissance), commercial aerospace MRO, unmanned and autonomous vehicles, hypersonics, and the need to achieve scale. The impact of the US Presidential elections in 2020, the focus on achieving quality excellence in aerospace manufacturing, and a potential economic slowdown will be added considerations in M&A. While popular wisdom may suggest that it is less likely that the megadeals the sector experienced in the recent past will continue, given the strain in overcoming regulatory hurdles, disruptive M&A that can further unlock value also remains a distinct focus. For instance, we witnessed the merger of two major communications and electronics contractors, and more recently, the mergers of two A&D giants—one of the largest deals in the history of aerospace and defense. As the A&D supply chain focuses on transformation for cost and scale effectiveness, further industry consolidation is possible as some of the smaller companies may not be able to meet the increased financial, program management, skills, risk-taking, and investment requirements. Consolidation by parts family, i.e., components, aero-structures, electronics, and interiors, is expected to continue as companies focus on gaining economies of scale. Apart from this, large prime contractors may use acquisitions to gain access to new and advanced technologies as well as to expand global reach.

Regional perspectives

The United States continues to be the primary growth driver for the A&D industry; however, increasing passenger growth worldwide and a complex international security environment could result in several other regions and countries contributing to industry performance. Asia and the Middle East are driving growth in both commercial aerospace and defense sectors, whereas Japan is expected to be a key market primarily for the defense sector. In Europe, NATO members, such as France, are reportedly targeting to increase defense spending as the United States constantly encourages NATO countries to increase military spending to 2.0 percent of GDP.

CHINA

China, the fastest-growing aviation market globally, could require 8,090 aircraft over the next 20 years, worth about US\$1.3 trillion, with nearly 75 percent being single aisle aircraft. The robust aircraft demand is also likely to create a US\$1.6 trillion opportunity for aftermarket services for its aircraft fleet over the 2019–2028 period. China continues to remain the second-largest defense spending nation after the United States, with a 14 percent share in global defense spending. However, China's 2019 defense spending growth, at 7.5 percent year over year to US\$177.6 billion, is lower than the 8.1 percent growth in 2018 and much below the double-digit increases in prior years.

FRANCE

France allocated US\$48 billion to the 2019 defense budget, which is a 4.7 percent year-over-year increase and 1.8 percent of its GDP.²² France plans to boost its defense spending by 40 percent by 2025 as it aims to meet the NATO target of “2 percent of GDP” spent on defense. The defense ministry is targeting to increase defense spending of approximately US\$2 billion per year between 2019 and 2022 and US\$3.5 billion each year during the 2023–2025 period.

GERMANY

Germany increased the 2019 defense budget by 10 percent over 2018 to US\$53 billion (€47.3 billion), the largest increase since the Cold War. The country expects to further increase its budget to US\$56.4 billion (€50.3 billion) for 2020, however, falling short of the 2 percent NATO target. By 2024, Germany aims to increase its military spending to 1.5 percent of GDP and achieve the 2 percent of GDP target by 2031.

INDIA

Growth in low-cost carriers and rising passenger traffic is expected to result in a demand for about 2,300 aircraft over the next two decades, valued at US\$320 billion in India. The majority of these aircraft (more than 80 percent) will likely be single-aisle aircraft, with a seating capacity between 90 and 200. India is emerging as one of the major countries in space exploration. The country recently launched a civilian moon mission—Chandrayaan-2—and is also working on a manned

space mission, Gaganyaan. India continues to increase its defense spending, with a defense budget of US\$44.6 billion for 2019–2020, up 9.3 percent. Over the next five years, India plans to spend US\$130 billion to modernize armed forces and strengthen combat capabilities

JAPAN

Japan's passenger traffic is expected to grow at about 3.0 percent over the next 20 years. Growth in low-cost carriers (LCCs) is likely to drive demand for narrow-body commercial aircraft—LCCs account for 17 and 26 percent of domestic and international seat capacity, respectively, compared to 9 and 3 percent in 2011. Moreover, Japan's two major airlines are expanding their network to Southeast Asia to capture the solid demand from the region, which is expected to contribute to passenger traffic growth in the near term. The country is also developing its first mid-sized commercial aircraft, which is expected to challenge the existing commercial aircraft duopoly. To strengthen its military, Japan announced a defense budget of US\$50.3 billion for 2019–2020, up 1.2 percent, marking the eighth consecutive annual increase; however, it remained below 1.0 percent of GDP. Japan is also developing a domestically designed sixth-generation twin-engine stealth fighter, F-3, with a first-flight target of 2030. It is developing the F-3 aircraft primarily to replace older F-2 single-engine fighter aircraft fleet as well as to complement its existing fleet of F-35 aircraft.

RUSSIA

Russia is developing a commercial aircraft, MC-21, and the country anticipates this aircraft to be competitively priced to gain market share.³⁶ MC-21 has already received 175 orders; however, most of these orders are from Russian airlines and leasing companies. Due to a slowing economy, Russia's defense spending declined 3.5 percent in 2018 to US\$61.4 billion, which led to Russia slipping out of the top five defense-spending nations for the first time since 2006.³⁸ Defense spending as a percentage of GDP was at 3.9 percent in 2018, higher than that of the United States (3.2 percent in 2018)

THE MIDDLE EAST

Over the 2019–2038 period, passenger traffic in the Middle East is anticipated to grow at 5.1 percent CAGR, which could create a demand for 3,130 new aircraft, worth US\$725 billion. In the Middle East, wide-body aircraft are expected to account for nearly half of the total aircraft demand as the region caters to high-volume flights to Asia and Europe and also operates ultra-longhaul flights. Defense spending declined 1.9 percent in 2018 to US\$145 billion, despite high levels of arms imports and ongoing military intervention in Yemen by Saudi Arabia, which is the top military spender in the region. Six out of the top ten countries with the highest military expenditure as a percentage of GDP are in the Middle East—Saudi Arabia, Oman, Kuwait, Lebanon, Jordan, and Israel.

THE UNITED KINGDOM (UK)

The UK's defense budget of US\$49 billion (£38 billion) stood slightly above 2 percent of GDP and has declined from about 4 percent at the end of the Cold War era.⁴⁴ However, the UK's defense committee has been recommending increasing the budget to 3 percent of GDP to strengthen the country's armed forces. The potential impact of Brexit creates uncertainty for the UK A&D industry—for example, the risk of disruption in supply chains or new tariff structures when the UK renegotiates trade agreements with the EU and other nations.

What's on the horizon beyond 2020?

Technological developments and innovation continually shape the A&D industry. Some of the significant developments that are likely to have implications in the medium-to-long-term include:

Electric propulsion aircraft: While aerospace manufacturers have built more fuel-efficient aircraft over the last few decades, rapid growth in air travel demand has continued to result in an increase in carbon emissions by the aviation industry. With technology evolving rapidly, there are several companies globally that are developing electric propulsion systems, which would reduce carbon emissions, make flights quieter, and decrease costs. Electric propulsion systems could also support the emerging urban air mobility (UAM) ecosystem, consisting of passenger drones, most of which are likely to be either electric or hybrid-electric. Apart from large aerospace propulsion companies, such as Rolls-Royce and Safran, there are various technology startups also involved in the development of electric propulsion engines.

Urban air mobility: The development of UAM vehicles is expected to accelerate over the next decade. However, there are significant challenges that would need to be ironed out.⁴⁶ Most importantly, there would need to be the formulation of regulations for pilotless vehicles, airworthiness certifications, and the use of airspace. Implementing efficient energy management systems, onboard sensors, collision detection systems, and other advanced technologies would also need to address the technological challenges.⁴⁷ In addition, the industry should build takeoff and landing zones, parking lots, charging stations, and vertiports to support the infrastructure needs of UAM.⁴⁸ Apart from this, creating a robust air traffic management system integrated with other modes of transport would be needed to enable smooth operations of UAM vehicles.⁴⁹ Lastly, the industry would require a flawless operational and mechanical safety record to overcome psychological challenges associated with the idea of flying in an unmanned aircraft.⁵⁰ To address these challenges, vehicle manufacturers have begun testing vehicles, ecosystem participants are collaborating on developing a robust regulatory framework, and technology is advancing swiftly.

Automated flight deck: Although commercial aircraft manufacturers are increasingly relying on automated flight controls, including automated cockpits, the commercial aerospace sector is aiming to transition to fully automated flight decks. Such a transition will likely reduce the number of crew members in the cockpit, resulting in lower costs for airlines. Moreover, automated flight decks would also address the growing pilot shortage issue currently faced by the aviation industry, which will likely be accentuated in the future as the commercial aircraft fleet continues to grow.

Technology investments required to make major shifts in the A&D industry

With higher production requirements for both commercial aircraft and defense equipment, it is important for A&D companies to adopt new and advanced manufacturing technologies. As A&D customers become more demanding in terms of delivery schedules and customization, industry players are expected to increasingly need highly agile production and predictive quality controls. By investing in digital technologies, the industry could be at the forefront of manufacturing, enhancing productivity and efficiency.

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