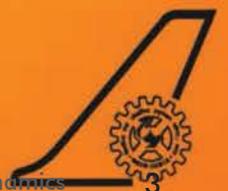


# ANNUAL REPORT 2020-21



Council of Scientific & Industrial Research  
NATIONAL AEROSPACE LABORATORIES

Experimental Aerodynamics



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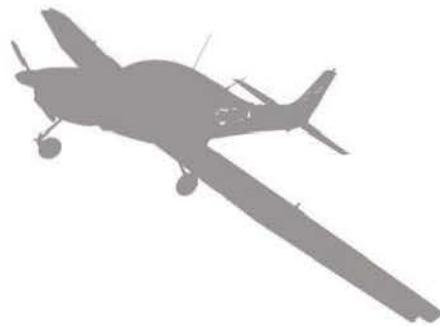
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*(a) Hansa NG - India's First all Composite  
Ab-initio Trainer Aircraft*

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**ANNUAL REPORT**  
2020 - 21

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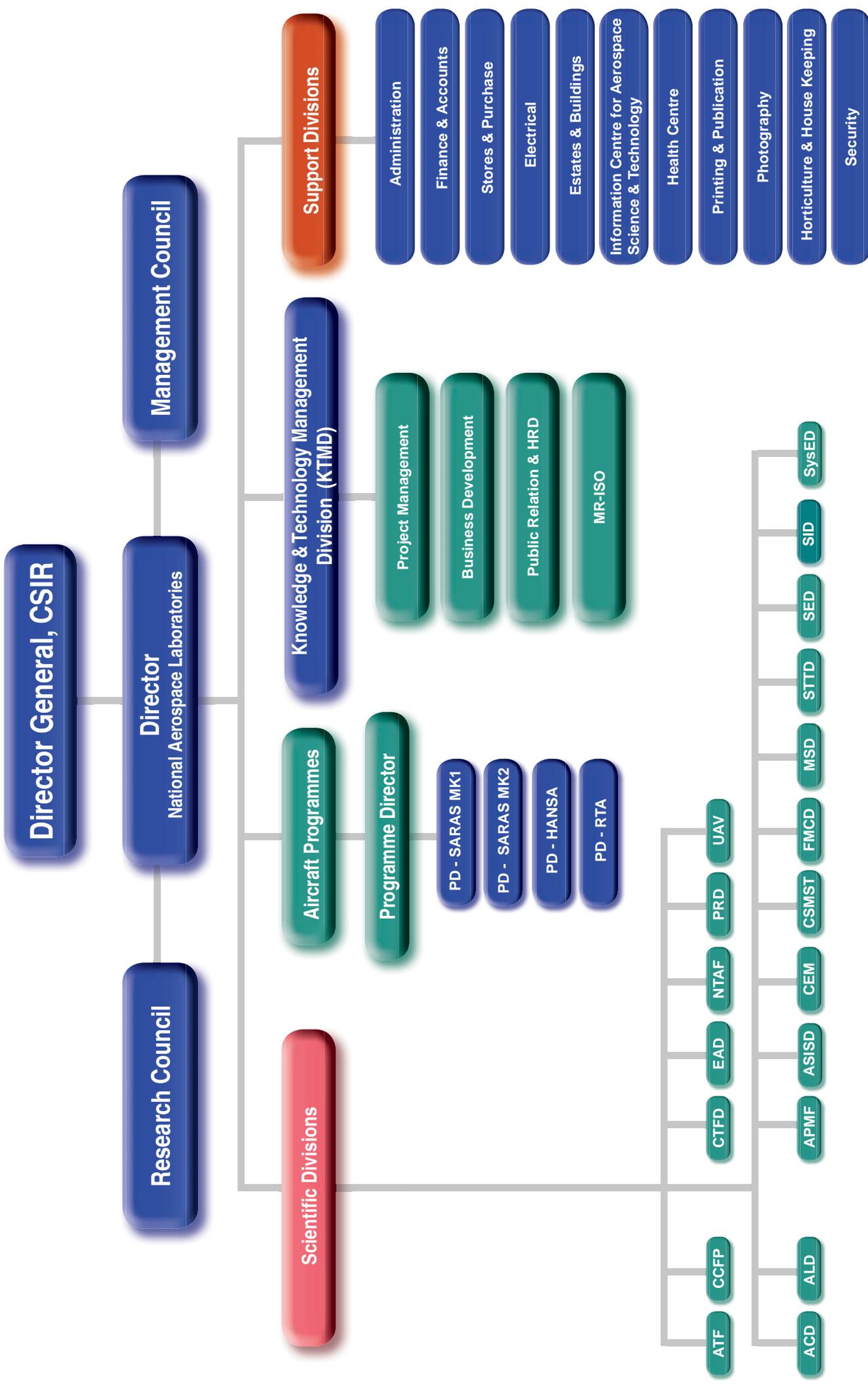
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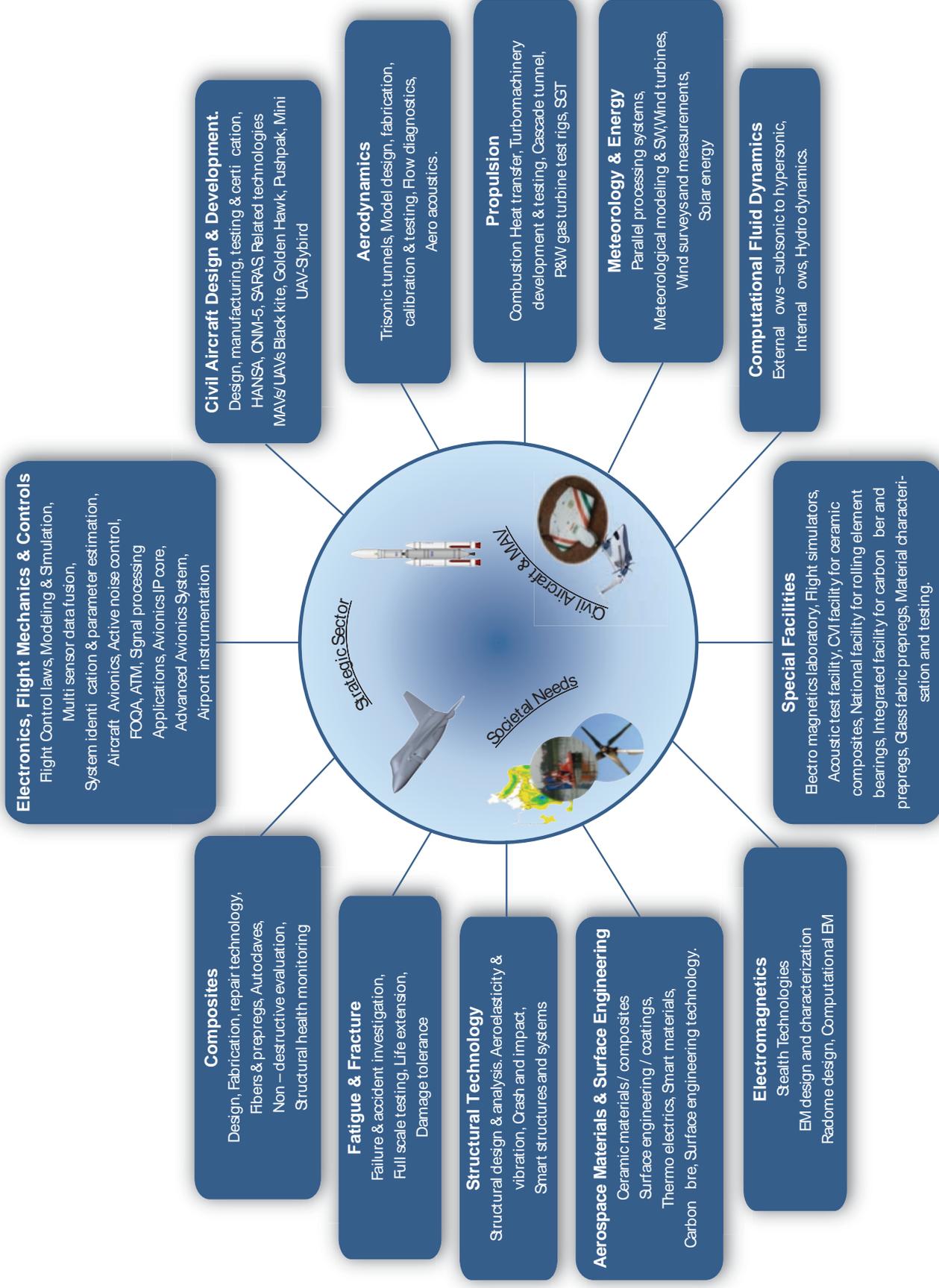
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सीएसआईआर-राष्ट्रीय वांतरिक्ष प्रयोगशालाएं  
**CSIR-National Aerospace Laboratories**

# Organization Chart



# CSIR-NAL'S Expertise and Core Competencies





The year 2020-21 was a difficult period as the Covid-19 pandemic affected the lives of millions of people all over the world as well as our country. The pandemic not only affected health of the people but also the businesses, economy, scientific activities and supply chain. Despite the challenges faced by our laboratory in mitigating the pandemic, I am proud to say that CSIR-NAL continued to make significant contribution towards S&T development in aerospace, strategic, health and social sectors for the nation. It is the combination of individual excellence and team work that has made the achievements and contributions possible.

On successful mitigation of the Covid-19 pandemic in the past year by our laboratory, it is my privilege to present the Annual Report of CSIR-NAL for the year ended 31st March 2021. The report summarizes the significant contributions made by the institution towards the technologies developed for Covid-19 mitigation in service of the nation and the development programs of the aerospace, strategic, health and societal sectors. I take this opportunity to acknowledge the efforts and contributions of the entire CSIR-NAL team responsible for the excellent outcome of the report.

## Highlights

The beginning of the financial year 2020-21 was greatly affected by the Covid-19 pandemic across the country. The country was facing severe shortage of Personal Protective Equipments (PPEs) and Health Assistive Devices (HADs) to mitigate the covid affected masses. Reposing faith on the scientific community, Government of India had called for quick development and deployment of indigenous technologies for the mitigation of pandemic. I am proud to say that, our laboratory quickly responded to the call of Government of India, developed and deployed

*Fig. 1 Personal Protective Cover all Suit - HINDKAVACH.*



in a record time of about a month, two major contributions namely “Personal Protective Cover all Suit -HINDKAVACH” for the frontline healthcare workers (Fig.1) and “SwasthVayu – BiPAP Non-invasive Ventilator” for the treatment of mild to moderate Covid 19 patients (Fig. 2) in various hospitals. I am happy to share that both the products have passed all the statutory tests, qualified in clinical trials. HINDKAVACH is certified by SITRA and SwasthVayu is certified by DGHS, Ministry of Health & Family Welfare, Govt. of India for use on covid-19 patients.

In the aerospace sector, significant achievements were made post approval of Saras Mk-2 project (19 seater LTA). The work on design & development activities towards performance optimization of aircraft configuration was taken up on priority to meet user/airlines

*Fig. 2 SwasthVayu - BiPAP Non-invasive Ventilator.*





Fig. 3 Rollout of Hansa NG. DG-CSIR, Chairman-HAL, JS-MoCA and other dignitaries witnessed the event.

requirement. As per the views expressed during configuration review meeting, it was decided to pursue the Tractor Configuration. Some of the major improvements are in the direction of reducing drag and improving handling qualities and control characteristics. Preliminary Design Review (PDR) has been completed and design activities are taken up on priority. The high fidelity test rigs are being realised. SARAS Mk2 is a unique aircraft for long and short airfield operations with maximum load factor.

The major achievement during the period was the roll-out of Hansa-NG on 31st March 2021 (Fig. 3). The event was a giant step taken by CSIR-NAL to reach out to industries and stake holders in furthering the ambitious "Make in India" programme of the government. Apart from stake holders, many flying clubs/flight training schools, production and MRO's like HAL, BEML, TASL, etc. have shown keen interest in Hansa-NG. On the occasion, a MoU was signed with IGRUA as a potential launch customer for

Hansa-NG (Fig. 4). Another memorable occasion was the showcase of Hansa-NG full size mock-up with glass cockpit and improved interiors during Aero India 2021 (Fig. 5). CSIR-NAL has received a good response from Indian Flying Club community and Lols have been received for more than 60 numbers of Hansa-NG aircraft from seven flight training schools. In the area of Regional Transport Aircraft (RTA) development, feasibility reports have been submitted to Ministry of Civil Aviation, Govt. of India. The aircraft is expected to have a payload in the range of 9550 kg. Discussions were held with private companies and proposal presentations made at the cabinet secretary level.

During the reporting period, the laboratory has partnered with M/s Bhor Chemicals, Mumbai for the indigenous development and certification of carbon fibre prepreg. A carbon fiber facility is being set-up with NAL technology for the requirements of various national programmes. CSIR-NAL's composite technology has received



Fig. 4 MoU was signed with IGRUA as a launch customer for Hansa-NG.

the prestigious CSIR Technology Award for Business Development and Technology Marketing 2020, for 'Successful commercialisation of Composite Technology towards Light Combat Aircraft (LCA) Tejas IOC series production' which is an apt recognition of the relentless effort of the ACD division (Fig. 6). Towards commercialization of composite parts developed for LCA, discussions with M/s HAL covering technical aspects, road map towards ToT to HAL for the 13 types of components/assemblies developed by NAL were completed and draft licence agreement has been finalised with HAL. With this arrangement, HAL will serve as an alternate vendor for the supply of components for

Fig. 5 Visit of General Bipin Rawat, PVSM UYSM AVSM YSM SM VSM ADC to HANSA NG mock-up at Aero India 2021.



Fig. 6 CSIR-NAL's bags CSIR Technology Award for Business Development and Technology Marketing 2020.





**Fig. 7 Industrial grade Autoclave fabricated by ToT Partner M/s. KRR Engg, Chennai for M/s. BEL, Bengaluru.**

next batch of 83 aircrafts for which HAL has received the order from Ministry of Defence, Govt. of India.

In the area of special technologies for aerospace, I am happy to inform that indigenously developed aerospace autoclave technology continues to benefit many industries after its successful commercialization in 2012. Till date, this technology has generated a revenue of Rs. 50.30 Crores. Presently, two industrial grade autoclaves are being commissioned at Dept. of Space, SDSC; SHAR and VSSC with the industrial partners. Also, industrial grade autoclaves for BEL, Bengaluru (Fig. 7) and Gopalan Aerospace, Bengaluru, have been delivered by ToT Partners.

In the societal sector, precision agriculture makes use of satellite and aerial imagery to monitor crop health. A modular Oct-Copter UAV system that can carry a maximum payload of 20 Kg and fly for the

endurance of around 20 min has been developed and field tested.

During the past year, the ToT Partners for Autoclave technology, SwasthVayu ventilator, Multizone Hot Bonder (MZHB), DRISHTI Transmissometer etc., have received many orders to the tune of Rs.50 crore, highest orders of commercialization in any financial year. The major orders were from BEL & Gopalan Aerospace for autoclave, SwasthVayu 1200 numbers orders DGHS, Govt. of NCT, Delhi and 66 number of orders from IAF for MAFI II programme being executed by ToT partner TASL. In yet another notable achievement, an indigenously developed NAL's Aviation Weather Monitoring System (AWMS) has been installed at the new runway of Kempegowda International Airport (KIA), Bengaluru.

In memory of late Prof. Roddam Narasimha, towards his long standing contributions to the development of aerospace science & technology, the Centre for Civil Aircraft Design & Development has been renamed as Roddam Narasimha Civil Aircraft Centre. The centre has been dedicated to the nation on 31st March 2021 in the presence Dr.Shekar C Mande, DG-CSIR and other dignitaries (Fig. 8).

A gist of significant contributions encompassing both civil, strategic,

health and societal sectors are presented in my report in the following categories.

### Contributions to the Civil Aviation Sector

The year 2020-21, saw CSIR-NAL continue its contributions to furthering the development of national aerospace sector. Team CSIR-NAL continue to build the organisation as a high-technology oriented institution focussing on advanced disciplines and delivering technologies and products towards 'Make in India' and "AtmaNirbhar Bharat" National Mission of the Government. One of the major milestones in the development of Saras Mk2, is the Preliminary Design Review (PDR). The aerodynamic configuration has been accepted by the PDR committee and further tasks related to Structural design, Systems requirements have been finalized. In the process of optimising the configuration, various intermediate versions were studied through several CFD and wind tunnel campaigns. Performance and stability-control characteristics of the aircraft were also evaluated at every step. Constant effort has been made to develop the simulator simultaneously and aero-data is updated and evaluated by pilots at regular intervals. Air loads were estimated using CFD for structural analysis. Feasibility of operations

**Fig. 8 The Centre for Civil Aircraft Design & Development has been renamed as Roddam Narasimha Civil Aircraft Centre. Tweet by Hon'ble Prime Minister Narendra Modi.**





**Fig. 9 Saras Mk II 19-seat Light Transport Aircraft.**



**Fig. 10 Hansa NG Aviation cockpit.**

at high altitude airfields like Leh, Kargil, Shimla, Kulu and Pakyong were studied and optimized for higher load factor. Cabin thermal analysis was carried out and oxygen requirement was fulfilled for such operation. Optimised tractor configuration was first reviewed by several system level sub committees and then by aircraft level PDR committee. Task teams are working on the suggestions of PDR committee and eventually towards the Critical Design Review. (Fig. 9)

Significant efforts were made towards the development of Hansa-NG (New Generation) aircraft with improvements such as glass cockpit, advanced fuel efficient Rotax 912iSc engine with better performance (increased range and endurance), optimized airframe, steerable nose wheel, electrically operated flaps, IFR compliance, improved ingress-egress, better interiors/ergonomics and external finish. CSIR-NAL has

**Fig. 11 Integrated Avionics and Display Computer (IADC).**



obtained Design Organization Approval (DOA) and Production Organization Approval (POA) under CAR 21 subpart G from DGCA to carry out Hansa-NG design and production. Fabrication and assembly of all airframe and system components are completed. Static testing of Air Frame has been completed successfully. Engine ground runs were carried out successfully. The first flight of Hansa-NG is planned during end of July 2021. (Fig. 10)

Towards the indigenous development, the laboratory has also successfully designed, developed and demonstrated the functionality

**Fig. 12 Drishti and AWOS at KIAL Airport, Bengaluru.**



of Integrated Avionics and Display Computer (IADC) Fig. 11. With the installation of NAL's Aviation Weather Monitoring System (AWMS), at Kempegowda International Airport (KIA), Bengaluru, the KIA has become the first airport in the country to install indigenous AWMS technology, developed by CSIR-NAL at both ends of the new runway. In addition, KIA has installed four Drishti transmissometers and has the unique honour of having NAL's 50th Drishti installed at its runway. It is very significant to announce that, KIA now has a total of six Made in India RVRs at both runways. (Fig. 12). Facilities like, High Fidelity Real-Time Simulator and the Avionics Integration Test Rig for Saras & Hansa (Fig. 13), Engine test bed for Saras Mk2 power plant ground test activities, and Virtual Reality cabin environment system for Saras Mk2 are being set up during the year. (Fig. 14).

Vibration measurement is the most essential requirement at low frequency excitation which is commonly

**Fig. 13 System Integration Facility (SIF) for Saras Mk II.**





Fig. 14 Virtual reality system for SARAS Mk II.

used for overall health management of the aircraft. Piezoelectric (PE) accelerometers are widely used for vibration measurements for structural testing, flight testing and inflight vibration monitoring. Considering the in-house requirements, a ruggedized version (Prototype-2) of Piezoelectric (PE) accelerometer that suits the above requirements was designed and developed during this period (Fig. 15). The developed accelerometer has been tested on SARAS PT1N, was calibrated with inflight data acquisition system and has passed environmental tests and received NABL accreditation.

### Contributions to Strategic Sector

In addition to furthering the indigenous development for strategic sector, NAL's significant contributions to major national programs in this sector have enabled the strategic sector to achieve self-reliance and considerable savings to foreign exchange in terms of import of high-end technologies and services. CSIR-NAL's National Trisonic Aerodynamic Facility has completed 1028 blowdowns in the 1.2m and 254 blowdowns in the 0.6m wind tunnels during the year. The major



Fig. 15 Photograph of PE accelerometer with stud mount configuration.

users of the facility were DRDO, ISRO and CSIR-NAL. For ADA, wind tunnel tests were conducted on a typical combat aircraft configuration on the basic aerodynamic characteristics (Fig.16). The proposal for the 2.5m continuous trisonic and 1.75m blowdown supersonic wind tunnel facility has been recommended by the "Empowered Technology Group (ETG)" chaired by Principal Scientific Advisor to Government of India. The revised proposal based on the recommendations of ETG has been submitted to the Ministry of Finance and is under consideration.

CSIR-NAL continued its support to the LCA-Tejas Programme. Advanced Composites Division (ACD) - NAL continued to make contributions in the areas of design, fabrication and R&D of composite structures. The FOC order from HAL to supply 20 sets of composite parts/assemblies for the next batch of 20 aircrafts is being executed at M/s TAML under quality control of NAL. During the



Fig. 17 Test aircraft and instrumentation setup.

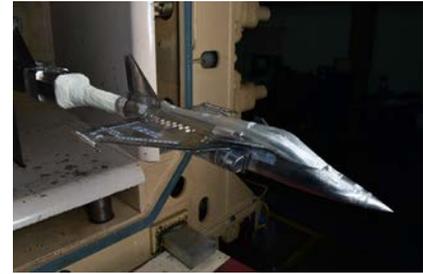


Fig. 16 A photograph of typical combat aircraft model mounted in 1.2m tunnel.

period with the existing tools, 9 sets of Centre fuselage parts, 6 sets of MLG doors both Aft and Fwd, 6 sets of Fin and Rudder assemblies were fabricated at the facility of production partner M/s Tata Advanced Materials limited under the QA coverage of CSIR-NAL and delivered to M/s HAL for the series production of LCA FOC aircraft.

For the AMCA program High Cycle Fatigue (HCF) data was generated for the indigenously developed Titanium alloy Beta21S (Titan 44A) material which intended to be used in AMCA airframe structural applications in high temperature zones. GVT based flutter analysis and store separation studies carried on Mirage 2000 aircraft. Further, Ground Vibration Testing (GVT) and GVT Based Flutter Analysis of Su-30 Mk-I Aircraft for Derby Integration was addressed and clearance was provided for captive trials as part of the DOS-30 (Derby on Su 30) programme. A total of 20 configurations were considered for clearance. Global elastic modes of the aircraft, store modes and control surface modes were analysed and tabulated. The test aircraft and the instrumentation are shown in Fig. 17.

A compact version of the MZHB that houses the accessories inside the equipment case was developed with wheels for ease of transportation. NAL's ToT licensee, M/s San Process Automation, Bangalore, has supplied Dual zone hot bonders (Fig. 18) customized for HAL's

requirement as well East Africa, Kenya. The MZHB facility was extended to LCA program for the repair of drop tank and engine bay cover. Failure analysis and accident investigation is a continuing activity of the Materials Science Division of CSIR-NAL for the past four and half decades and the activity has been designed to cater to the needs of the Indian Aerospace Organisations. During the year 2020-21, sixteen investigations involving incidents/accidents of aircraft, helicopters and ground equipment used for defence aircraft were referred to the laboratory for investigation by the various organizations like IAF, HAL & MoCA. In most of these investigations, the primary cause(s) of failures could be identified and after each investigation, recommendations were suggested for prevention of similar incidents/accidents in future. Towards contribution of indigenous technology for the strategic sector in stealth technology, a multi-layered FSS-based RASORBER has been designed with a transmission characteristic within the band associated with out-of-band absorption (Fig. 19).

### Contributions to Space Programmes

The Indian Space Programme has been ably supported by the CSIR-NAL's Acoustic Test Facility (ATF)

*Fig. 20 Test vehicle inter tank structure with EB.*

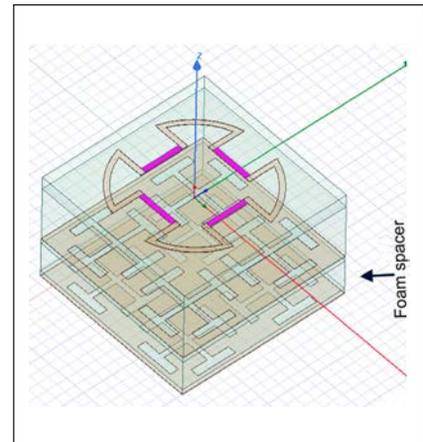


*Fig. 18 Dual zone hot bonder supplied to HAL Bengaluru.*

over the last three decades. During the current year, ATF has completed acoustic qualification of Test Vehicle Equipment Bay (EB) for testing certain critical components of the Gaganyaan Crew Escape system. ATF also qualified the Core Base Shroud of the Small Satellite Launch Vehicle which is one of the crucial subsystems of the highly modular small satellite launcher (Fig. 20). In addition, ATF also successfully completed the acoustic qualification of the Strap on Electro Mechanical Actuator Structure for the GSLV MkIII launcher. This would help in improving reliability and also provide advantages in payload capability in comparison with the Electro Hydraulic actuators used earlier. Further, unsteady pressure measurements were carried out on a scaled model of typical crew escape system test vehicle in the NAL's 1.2m wind tunnel. At Structural Technology Division, aeroelastic testing of GSLV MkII F10 configurations were carried out. A 1:42 scaled aeroelastic model of F10 vehicle was successfully designed, fabricated, and wind tunnel tested to assess the transonic buffet on the vehicle.

### Health Sector and Societal Mission

CSIR-NAL has made significant contributions in the area of Health and Societal Mission. The achievements in the year are truly noteworthy. I would like to place on record the



*Fig. 19 Schematic of FSS-based Rasorber.*

dedication and commitment of CSIR-NAL team in quickly bringing out the healthcare products despite of lockdown period and threat of the covid-19 disease. The first is the PPE coverall suit "HINDKAVACH" for covid-19 frontline workers and the second is the "SWASTHVAYU" a non-invasive BiPAP ventilator for treating covid-19 patients. Both the technologies have been transferred to industries for commercial production which has resulted in quick deployment of about 1500 SwasthVayu units to hospitals of NCT- Delhi, Ramgarh & Chatra-Jharkhand, Bhopal-Madhya Pradesh, Mysore, Hyderabad and more than 2 lakhs units of PPE coverall to Hindustan Latex Limited (HLL), Jaslok Hospitals etc.

The laboratory has taken up collaborative R&D work with Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum for development of three specific products, viz., (i) Aortic Stent Grafts (ASG), (ii) Atrial Septal Defect (ASD) occluder and (iii) Flow Diverter Stent (FDS). Biocompatibility and functional studies on these implants have been completed at SCTIMST. Technology transfer agreement for commercial production of ASD occluder and FDS was executed with M/s Biorad Medisys Pvt. Ltd., Pune. The Surface Engineering Division has developed many technologies which include: a cost-effective

indigenous thermally compensated low-range magnetic pressure sensor for medical ventilators, environment friendly sprayable solar absorber coating, thermal insulation paint for aircraft application, etc.

With an increase in the practical application of UAV's in the agricultural industry and to provide an end to end solution in the agricultural domain (from crop monitoring to pesticide spraying) UAV division has developed a modular Oct-Copter UAV system that can carry a maximum payload of 20 Kg and fly for the endurance of around 20 min. The Oct-Copter has a provision to house either a hyperspectral camera for crop health monitoring or a fertilizer. First field demonstration of NAL's Oct-Copter has been carried out for the farmers of Alur APMC, Bangalore. (Fig. 21). Realizing the need of automated weed clearing system for the protection and rejuvenation of lakes, BBMP Bangalore has come forward to join hands with NAL for the design & development of JALDOST Mk2 version. The collaborative project has been initiated along with industry partner with BBMP as the stake holder for realizing Jaldost Mk2 in a short period of one year.

### R&D Performance Indicators and Technology Licensing

The R&D performance indicators of the laboratory during the year are noteworthy. CSIR-NAL was awarded 52 new Sponsored projects costing Rs. 58.20 crores, 5 Grant-in-aid projects costing Rs.3.10 crores and 10 Technical services projects costing Rs.2.55 crore during the financial year 2020-21 from external agencies. NAL's external cash-flow was Rs. 91.52 Crores. This year a total of Rs.236.27 crore CSIR grant (excluding central administration grant of Rs.87.12 crore) was allocated to the laboratory by CSIR and



Fig. 21 First field demonstration of NAL's Oct-Copter at Alur APMC, Bengaluru.

thus the ECF earnings stand at about 38 %. I am happy to share that the total LRF realized is Rs. 46.71 crore for the year 2020-21.

During the year, NAL has licensed five technologies with a cumulative license fee of about Rs.4.75 crore. These technologies will also fetch royalty varying from 2-5% on the sales of the product by the licensee using NAL's technology. The major ToTs include: Drishti transmissometer to TASL, Bangalore; SwasthVayu - BiPAP non-invasive ventilator to six MSMEs; Indigenous resin for manufacturing carbon fiber prepreg to Bhor Chemicals, Mumbai; Piezo -Electric PVDF films to Ajay Sensors, Bangalore and GMR based pressure sensor to Hydro Fluidic Technologies. Further, four new collaborative projects with industry on 'Risk and Cost Sharing Model' have also been initiated. The new programmes in the current year are; Sensors for Automotive applications with M/s Rotary Electronics, JALDOST Mark II for BBMP, Bangalore with M/s Sri Vari Engineering, Design & performance improvements of small wind turbines with M/s Wish Energy Solutions, and Manufacturing of components for Archimedes wind turbine with M/s Archimedes Green Energy. Under the collaborative projects the total investment by industries was Rs.18.20 crore and cash flow in 2020-21 was Rs.4.2 crore including Transfer of Technology (ToT) fee of Rs.1.62 crore.

The year witnessed signing of 86 MOUs / NDAs with external agencies, the major ones amongst them include 28 for executing the various activities of ongoing Saras MKII programme, 20 for Defence Category like DRDO & ISRO, and 15 for marketing of Covid-19 technologies. In the reporting period, NAL's IP portfolio increased by filing of 4 new patent proposals, 1 copyright and 1 trademark. Also 7 Indian patents, 2 Foreign patents and trademark for SwasthVayu were granted during the year. The total number of publications was 180, with 143 journal papers and 37 conference papers.

### Participation in Aero India

CSIR-NAL participated in the Aero India 2021 by putting up a brilliant exhibition stall. CSIR-National Aerospace Laboratories showcased SARAS Mk2 IADC & Virtual Reality (VR) and HANSA full-scale mock-up. Mr.Rajnath Singh, Hon'ble Minister for Defence released the tractor version of SARAS Mk-2 brochure and the curtain raiser for Hansa-NG full-scale mock-up (Fig. 22). Business meetings were held with HAL, Flying Clubs, BEML, IAF, TASL etc. Flying clubs have shown keen interest in Hansa-NG aircraft and UAVs. For the first time in the Aero India history, hybrid event in Virtual Platform has been organised and the NAL virtual stall has been adjudged as the best stall by the organisers. The event was very successful in terms of participation with NAL receiving LOIs for about 40 numbers of Hansa-NG aircraft. MoU was signed during the event with BEML for collaboration on advanced composites and UAV development and NDA was signed with TASL for possible cooperation on productionization of Hansa NG.

### Honour's and Awards

On the honours and awards front, the year 2020-21 was quite



*Fig. 22 Shri. Rajnath Singh Hon'ble Minister for Defence releasing Saras MkII Brochure and CSIR-NAL Virtual Stall.*

significant for the laboratory, major achievements are:

- NAL won the CSIR-Technology Award for "Successful Commercialization of Composite Technology towards Light Combat Aircraft (LCA) Tejas IOC series production".
- Dr. S Raja, Head STTD was elected Fellow of the Indian National Academy of Engineering,
- Dr. Harish Barshilia, Head SED was elected Fellow of the National Academy of Engineering,
- Dr. Indu Elizabeth, SED received "CSIR-Young Scientist Award" in Engineering Sciences, and
- Dr. Hema Singh, CEM has won IEEE-Women Technologist Award.

In addition, many scientists of our laboratory have received research

and association fellowships, members/senior members of prestigious societies/institutes, won other individual/group awards, appointed as editorial board members and reviewers of national and international journals, received best paper awards etc., I congratulate all of them on their success.

For all the achievements of the laboratory I would like to acknowledge and sincerely thank the support and cooperation of members of the Research Council, Management Council of CSIR-NAL, DG-CSIR, and staff of CSIR Head Quarters, New Delhi. I also acknowledge the support received from our various stake holders; DRDO, ISRO, DGCA, ADA, HAL, Air HQ, ARDB, DST, DAE, Defence Services, MoES, IMD MoCA and others including international bodies for continuing

to repose their faith in us and by sponsoring several R&D projects. Much of our achievements have been made possible due to efforts, cooperation, advice and confidence shown by these agencies.

Finally, I wish to acknowledge and thank all scientists and other staff members of CSIR-NAL for their continued commitment towards the achievements of the organisation.

**Jitendra J Jadhav**  
**DIRECTOR**



## Mission

- Development of national strengths in aerospace sciences and technologies, infrastructure, facilities and expertise.
- Advanced technology solutions to national aerospace programmes, fighter aircraft, gas turbine engines, defense systems, defense services, launch vehicles & satellites, and space systems.
- Civil aeronautics development (from 1994). Design and development a small and medium-sized civil aircraft - To promote a vibrant Indian civil aviation.



## Mandate

- NAL's mandate is to develop aerospace technologies with a strong science content, design and build small and medium – sized civil aircraft, and support all national aerospace programmes.



## Research Council

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Mr Vijeesh T  
Scientist, Flight Mechanics and Control Division

Mr M S Pradeep, PTO, APMF

Controller of Finance & Accounts, CSIR-NAL

### Member Secretary

Controller of Administration, CSIR-NAL



## Major R&D Discipline

- ❖ Computational fluid dynamics
- ❖ Experimental aerodynamics
- ❖ National Trisonic Aerodynamic Facilities
- ❖ Flight mechanics and control
- ❖ Propulsion
- ❖ Composites
- ❖ Structural design, analysis and testing
- ❖ Structural dynamics and integrity
- ❖ Surface modification
- ❖ Aerospace materials
- ❖ Aerospace electronics and instrumentation
- ❖ Civil aviation
- ❖ Parallel processing computers
- ❖ Meteorological modeling
- ❖ Wind energy
- ❖ Manufacturing technology
- ❖ Information systems
- ❖ Electromagnetics

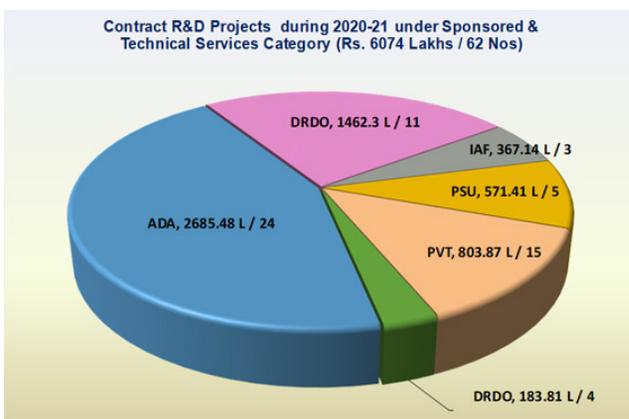
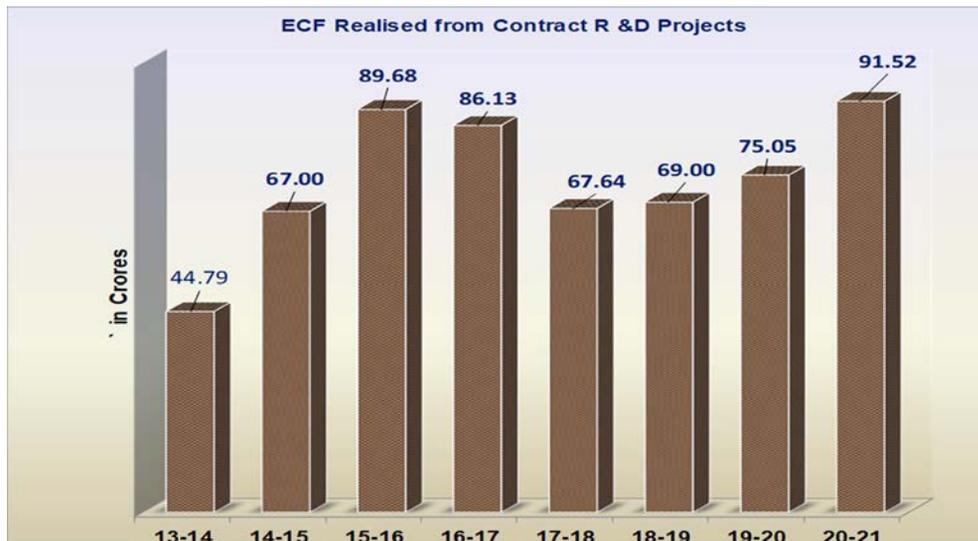
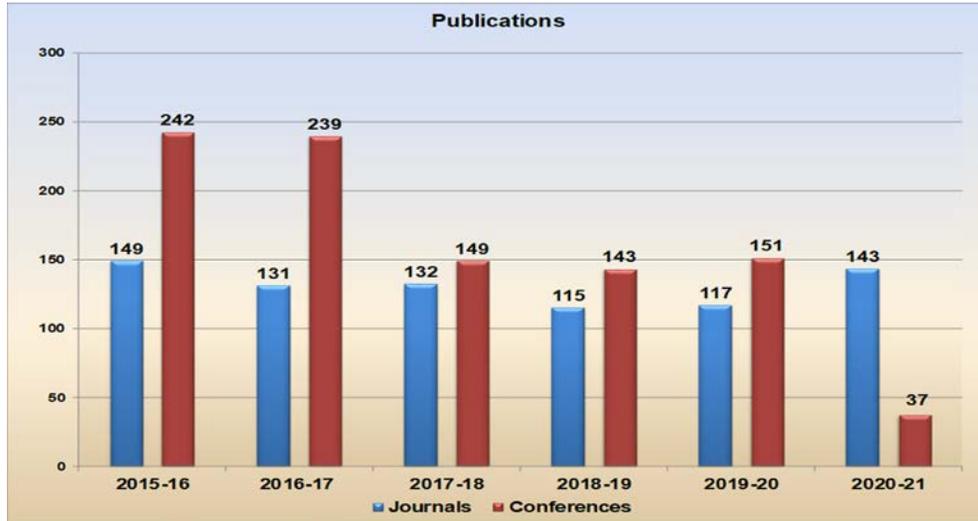


## Collaborations and Interactions



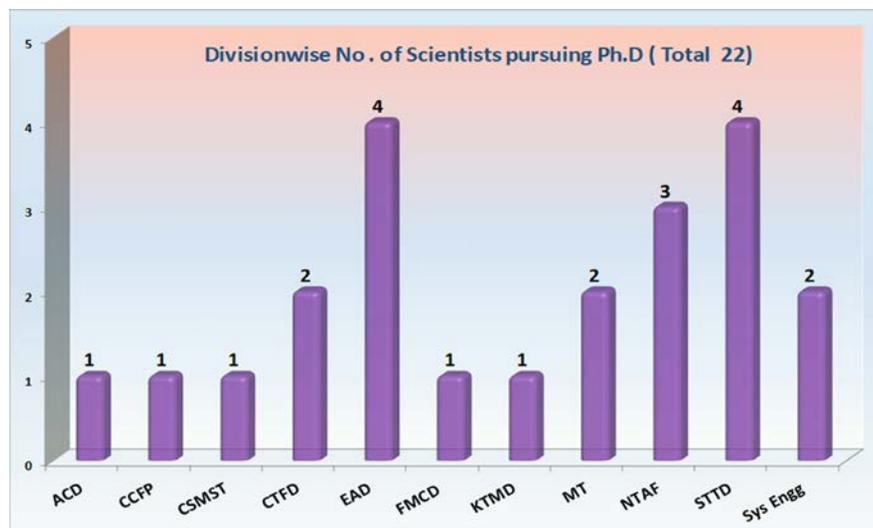
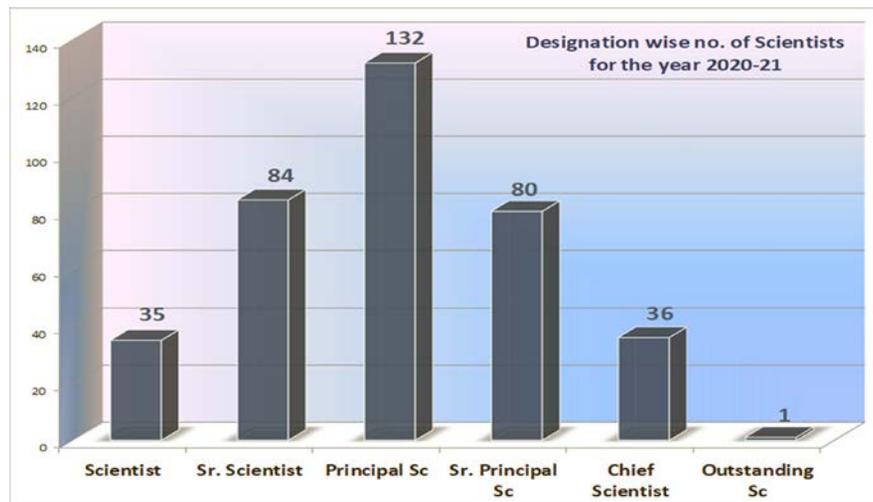
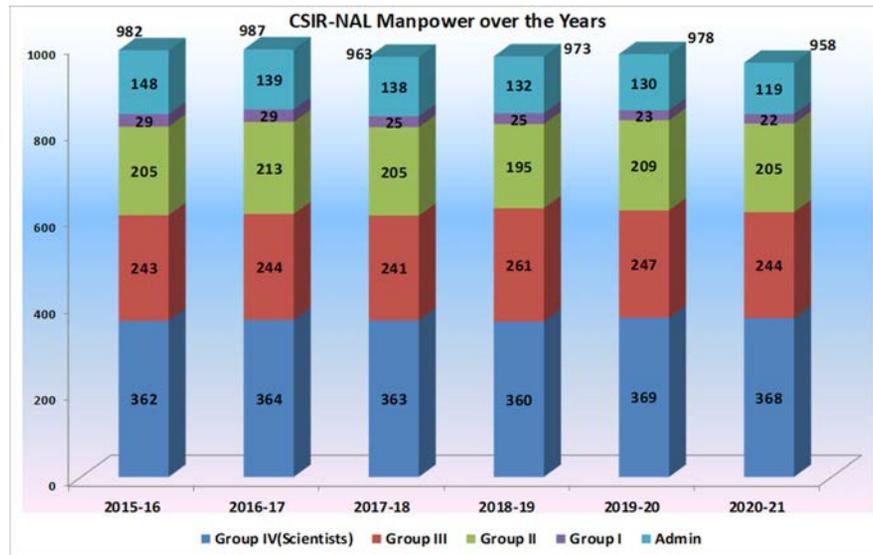


## S&T Performance Indicators



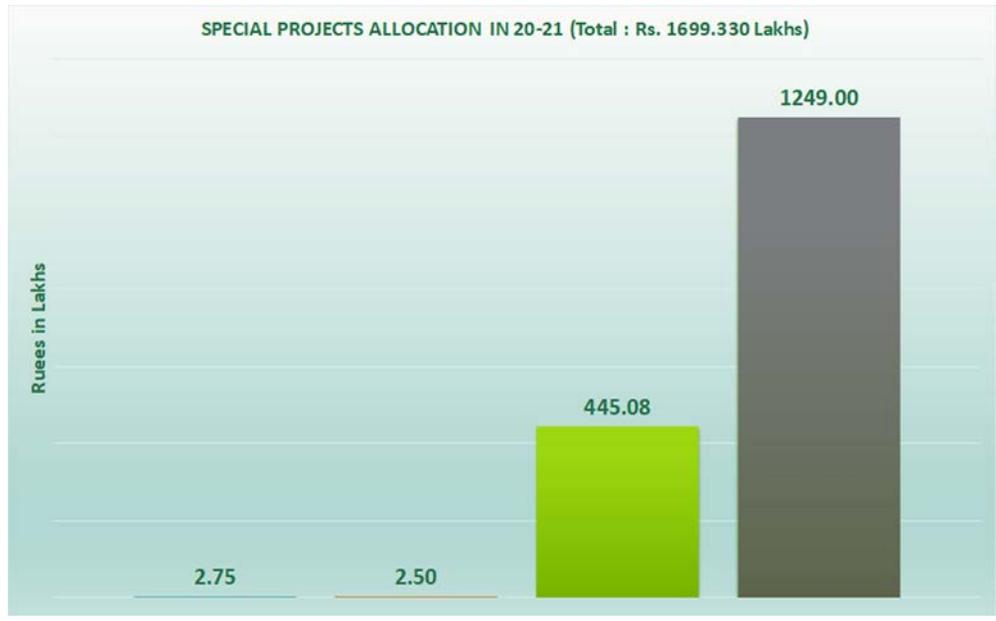
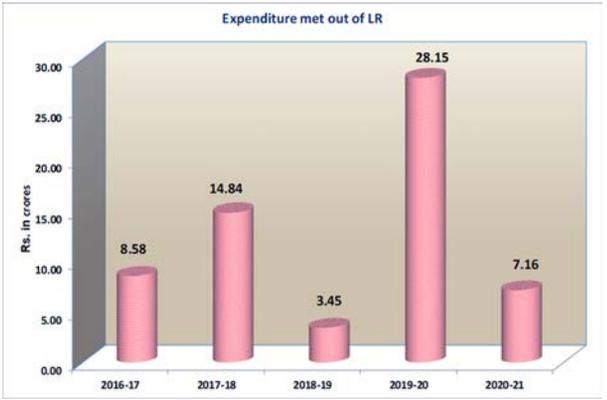
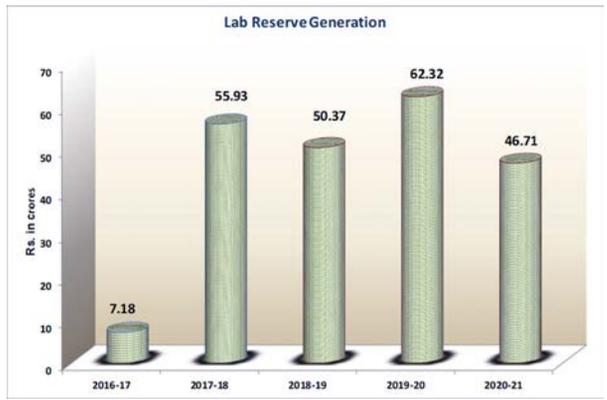
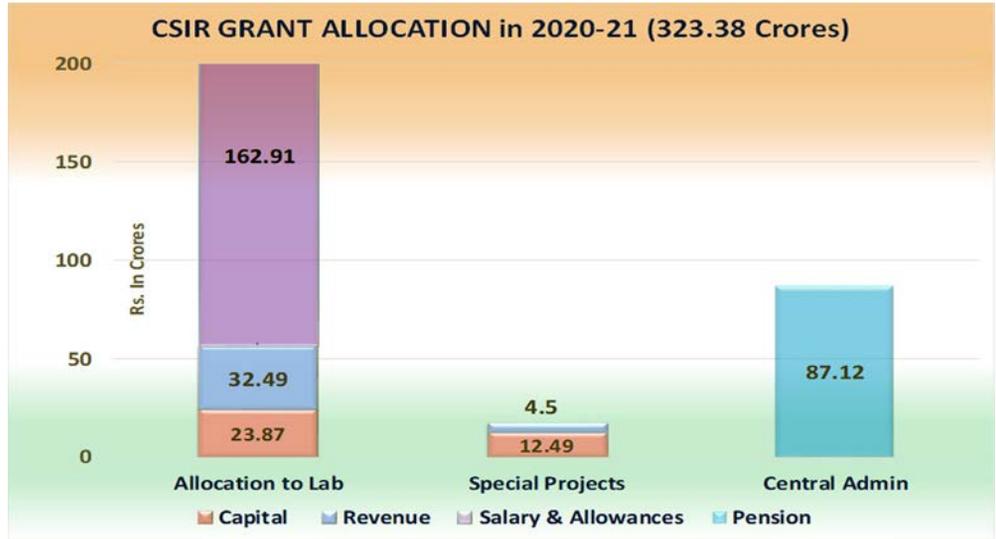


# Human Resource Indicators

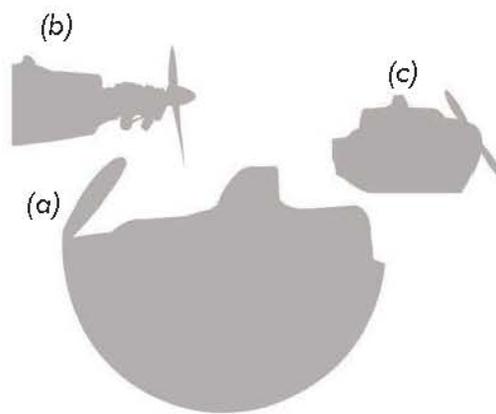




# Financial Performance Indicators



## Back Cover



- (a) *Hansa NG full glass cockpit with modern avionics*
- (b) *Hansa NG is powered with 100 hp Sport engine*
- (c) *Hansa NG cockpit view*

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