

**TWO YEAR
POST GRADUATE RESEARCH
PROGRAMME
IN
ENGINEERING OF
FLIGHT VEHICLES**

Prospectus 2010



**National Aerospace Laboratories
Bangalore**



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About National Aerospace Laboratories

National Aerospace Laboratories (NAL) a constituent institution of the Council of Scientific and Industrial Research (CSIR) under the Ministry of Science and Technology, Govt. of India, is a premier aerospace research and technology development organization of the country. Started as National Aeronautical Laboratory in June 1959 in New Delhi, NAL was shifted to Bangalore in March 1960 and started its operations in the stables of Maharaja's Palace on Jayamahal Road in Bangalore. Today, its activities and facilities are spread over three campuses located on the Airport Road and behind the HAL Airport. In 1993 it was renamed 'National Aerospace Laboratories' to reflect its multidisciplinary contributions to aeronautics and space sectors.

NAL has celebrated its Golden Jubilee during the year 2008-09. Over the last 5 decades, NAL has successfully contributed to the growth of aerospace activities in the country in particular to the projects of national importance in the defence and space sectors. This has been done through building up of expertise and establishing various facilities and needed. In the last decade, NAL has also taken up the mandate for the design and development of small civil aircraft for the national needs. As a result of its successful efforts and significant contributions, NAL has come to be recognized internationally as a major center for aerospace research and development activities.

NAL is the largest laboratory of CSIR and has strength of 1350 people including 330 scientists with 100 or more having Ph.D's. The mission of the laboratory is a good mixture of various activities, related to technology development, providing services to National programs and design and development of civil aircrafts.

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 and satellites, space systems
- **Civil aeronautics development (1994 onwards)**
Design and develop small and medium-size civil aircraft – Promote a vibrant Indian

NAL's activities in the area of aerospace have helped the strategic organizations (DRDO, ISRO, DAE, Defence Services etc.) in the country achieve success in their mission mode projects besides building up national technology strengths in the areas of civil aircraft design and development.

Major R&D Disciplines

NAL's core competence spans the entire aerospace sector with the ability to provide complete holistic technology solutions. NAL has had interaction with all the Indian aerospace organizations and has considerable visibility in India and abroad.

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

Brief work being carried out in the above disciplines in the various divisions is given below. These divisions mainly provide the critical scientific / technological inputs required of the design and development of many indigenous aerospace vehicles and also look into future S&T requirements of the country to create the necessary knowledge base and to develop further cutting edge technologies.

Advance Composites Division

The focus in the Advanced Composites Division (ACD) is on R&D efforts leading to innovative techniques for the design, development, fabrication, testing, evaluation & certification of airframe structural components using composite materials.

ACD has developed in-house expertise in the development of autoclave technology. ACD has been recognized as a Centre of Excellence in Composite Structures Technology by the Aeronautical Research and Development Board wherein new technologies such as composite stitching, automated tape laying and fiber metal laminates have been developed.

A newly evolved cost-effective Vacuum Enhanced Resin Infusion Technology (VERITY) has been developed for wing fabrication. Notable strides have been made in the new

and emerging areas of Structural Health Monitoring (SHM) and Adaptive Wing Structures based on Shape Memory Alloys (SMA).

Aerospace Electronics and Systems Division

Aerospace Electronics and Systems Division (ALD) has a core strength in design and development of flight critical systems with DO 178B safety critical software including Independent Verification and Validation (IV&V). Apart from this, division has a major programme on Active Noise Control for aircraft cabin and industrial applications. The division's focus is on the areas of aerospace electronics, active noise control, Electromagnetics and critical flight data analysis and validation.

The division has developed the first full life cycle DO 178B level A civil certification for SARAS Stall Warning System (SWS) with indigenous design and development of software. Extensive work has been done in the area of Flight Data Analysis and Animation, NAL Visualization and Animation Software (NALVAS) and its integration with the NAL Flight Operations Quality Assurance (NALFOQA) software. Scientific investigations are pursued in the areas of Active Noise Control and Signal Processing to utilize and expand the capabilities to serve the application requirements aptly backed by concurrent applied research activities. The establishment of NAL-Microwave Anechoic Chamber (NAL-MAC) is one of the major achievements of the division.

Acoustic Test Facility

The Acoustic Test Facility (ATF) is a national facility for acoustic environmental qualification testing of satellites, launch vehicle stages and their subsystems for the ISRO. The ATF has a 1100 cu.m. reverberation chamber in which a maximum sound pressure level of 157 dB (controlled) can be generated. ATF has conducted more than 120 tests. In addition to acoustic testing, ATF has the following capabilities.

ATF has developed a jet noise generator capable of producing high frequency random noise in the range above 2 kHz, where no generators are available. This device is ideally suitable for simulation of spacecraft/launch vehicle subsystem acoustic environment in reverberant chambers due to the random nature of acoustic energy generated instead of discrete frequency energy. This also finds applications in high frequency noise environment testing for aerospace and automobile industries.

Centre for Civil Aircraft Design and Development

The charter and focus of C-CADD is to bring under one roof the civil aircraft development project optimally utilising the available resources. It is also tasked with to plan in advance other projects such as 5 seater general aviation aircraft, regional aircraft and study airworthiness and certification aspects and liaison with DGCA.

It produced 12 HANSA aircraft for delivery to DGCA and CASA Australia and is currently working on a five seater General Aviation aircraft development jointly with private industry (Mahindra Aerospace Technologies) launched in 2006.

Computational and Theoretical Fluid Dynamics Division

The Computational and Theoretical Fluid Dynamics Division has been engaged primarily in the development and application of Computational Fluid Dynamics (CFD)

software for the simulation of complex fluid flows. The emphasis has been in terms of both the complexity of the flow physics as well as geometrical complexity. There has also been a smaller but significant effort in the development of theoretical and analytical techniques for the analysis of certain categories of flow problems.

Presently, the Division is involved in many activities including CFD analysis for the design of a 500 kW wind turbine, aerodynamic shape optimization, studies on turbulence models, transition and large eddy simulation, unstructured grid and grid-free computations for complex applications, theoretical methods for surface waves, grid generation for aircraft configurations, and flutter prediction in turbo-machinery. The Division is also supporting the SARAS project in analyzing the propeller effects as well as analysis of aerofoils and high-lift devices for the RTA project.

Experimental Aerodynamics Division

In the Experimental Aerodynamics Division, a major emphasis has been to understand the physics of complex flows by the use of novel flow diagnostic techniques and generation of aerodynamic data for the development of advanced design concepts and flow modeling. The division strives to carry out innovative research in Aircraft and Spacecraft Aerodynamics, Civil Aircraft R&D, and Flow Diagnostics.

The division is now actively involved in several areas with a focus towards emerging requirements of the country's aerospace programs. Some of these are: high-lift research for the new Regional Transport Aircraft, low-Reynolds number aerodynamics for micro-aerial vehicle (MAV) design, base-flow and nozzle studies for launch vehicle aerodynamics, intake design for hypersonic vehicles and applications of flow diagnostics to understand flow mixing in gas turbines. Additionally the first ever facility in the nation for jet aeroacoustic studies has been set up in the division.

Flight Mechanics and Control Division

The division is actively engaged in Research, Development and Technology advancements in the areas of Flight Control and Flight Simulation, Modeling and Parameter Estimation, Multi Sensor Data Fusion and Air Traffic Management. Design of the SARAS Autopilot is a major program and the SARAS Flight Training Device for Pilot training is also being set-up in the division in partnership with a private company.

The current emphasis in national and international aeronautical research and development is towards micro and mini unmanned air vehicles. To meet these requirements, research and development is being initiated in the area of simulation, modeling and control of small air vehicles.

Flosolver Division

The charter and focus has been to use state-of-the-art processors and other hardware available to keep developmental cost low, make the best use of available sequential software to obtain quick returns on hardware investments, secure the maximum possible raw computing power for a unit investment, keep in pace with the technology development and achieve concurrent application software.

The Flosolver Unit carries out work in the field of integrated development of hardware and software for meteorological computing. Studies in many exciting new directions such as multi-precision computing, coupled models, innovative inter-connect strategies, high performance visualization are being planned. It is evident that the hardware and software developed will find direct use in “flow solvers” used for aerospace applications.

Fibre Reinforced Plastics Division

The Fibre Reinforced Plastics Division as the country’s premier and multifaceted R&D center indigenized wide spectrum of composite products for the aerospace, non-aerospace and societal sectors, using cost effective home grown technologies, supported through concurrent applied research programmes. The FRP Division continues to perform with its committed motto “simplistic technologies even for high-end composite products”, with emphasis on economy and environment. Today, the “cutting-edge technologies” also imply “cost-effective technologies”, meaning “the technologies while serving the very purpose of their development, should also offer spin-off benefits, to compensate for their rapid obsolescence on one hand, and serve the socio-economic cause on the other.

The Division is well equipped with sophisticated material characterization equipments like DSC-TGA, DMA, FTIR, Curing ovens, INSTRON-UTM, DYNATUP-Impact tester, as well as a dedicated Environmental test facility for qualification of aerospace and non-aerospace components. The FRP Division has initiated R&D activities for the development and application of nano-structural composites, conductive composites, metal-fibre composites, rapid manufacturing technologies incorporating machine impregnated just-in-time prepregs (JIPREGS).

Materials Science Division

The activities of the division is directed towards development of materials for aerospace applications, characterization of materials and rendering materials related engineering and technological services to aerospace community. The division is engaged in synthesis and processing of metallic materials, ceramics, polymers and fibers. One of the major activities of the division is failure analysis and accident investigation and testing and qualification of materials.

The focus of activities of the division is currently functional and smart materials. Development of products using Shape Memory Alloys is being pursued actively. Products like wires of different diameters, couplings, links, etc. have been developed from shape memory alloys. Preparation of high quality piezo ceramic powders is being carried out on a pilot plant level. Efforts are also on to develop high figure of merit thermoelectric materials, thermoelectric coolers and generators. Novel processing techniques like mould less casting of ceramics are being developed. In the area of high temperature structural materials for aerospace applications, development of ceramic matrix composites is in progress. A major activity of the division is the development of several grades of carbon fibres. A new state of the art Runway Visibility Range Measurement System – Drishti has been commissioned in several airports.

National Trisonic Aerodynamic Facilities

The charter of NTAF is to provide quality experimental aerodynamic data in the range of Mach numbers 0.2 to 4.0, required for the national aerospace programmes such as the Light Combat Aircraft programme of DRDO, Launch vehicle development programmes of ISRO, the SARAS aircraft of NAL and aerospace vehicles being developed by other User organizations. The focus is on experimental technique developments and measurements of aerodynamic force, moment, steady and unsteady pressures as well as mechanical design of models and support systems required to meet the requirements. The 1.2m trisonic blowdown wind tunnel is the main workhorse for all the major national aerospace programmes.

The current activities of NTAF are focused on data generation for the LCA of ADA, RLV of ISRO and HSTDV of DRDO. Special systems needed for these missions are being designed, developed, fabricated and tested.

Propulsion Division

The Propulsion Division is involved in applied research pertaining to Turbomachinery, Combustion and Heat Transfer, Mechanical Aspects of Turbomachinery as well as in the Design/Development of Propulsion and Energy Systems. It gives R&D support to the country's National Aerospace Programmes being carried out at the Gas Turbine Research Establishment (GTRE), Defence Research and Development Laboratory (DRDL), Vikram Sarabhai Space Centre (VSSC) and the Liquid Propulsion Systems Centre (LPSC) besides taking up grant-in-aid projects from the Aeronautical Research & Development Board. International collaborative programmes with Pratt & Whitney, USA and Canada are also being carried out.

The current activities include the development of active magnetic bearings, micro-gas turbines, Wankel engines for UAVs, novel afterburners, advanced ramjet/scramjet combustors, advanced compressors, ultralight helicopters, micro-air vehicles and the testing of synthetic aviation lubricants and rolling element bearings. The collaborative R&D programmes with Pratt & Whitney Canada & USA on gas turbine technologies, specifically related to turbomachinery aerodynamics, combustors and heat transfer are being actively pursued.

Structural Technologies Division

Structural Technologies Division is primarily in Research and Development Programmes in Structural Design, Analysis, Testing and Certification of Aerospace/Mechanical Structures. The specific areas of emphasis are aeroelastic modeling and testing of aerospace vehicles, development of numerical techniques like Finite Element Method with smart material concepts for structural control, state-of-art analysis, testing, design and optimization of aerospace vehicles/structures, impact & crashworthiness studies, evaluation of mechanical properties of aerospace materials, evaluation of airworthiness & flight safety including Full Scale Fatigue Test (FSFT) and Structural Integrity Assessment.

The expertise of the division is in designing scaled wind tunnel models and design & development of indigenous large Autoclave systems. The division has made significant contributions in design and analysis of ground based, airborne and missile radomes. Smart structure activities for development of multi channel active

vibration control system using smart actuators for aerospace applications and investigation of structural health monitoring concepts for aeroelastic instability and active vibration control for Launch vehicle components are also being studied.

Surface Engineering Division

Surface Engineering Division (SED) devotes itself to develop know-how in surface technologies. The main thrust of SED is aerospace and engineering applications. SED works on import substitution in sensitive and critical areas to provide self-reliance. Besides, SED works on development of innovative technologies driven by the user industries. The division also undertakes research on thrust areas such as nano-scale architecture and energy sector.

Current activities of the division are: development of sunshield mirror with ultra low roughness, evaluation and certification of the pressure sensitive paint developed in SED, development of plasma nitriding and plasma ion immersion implantation processes for the surface modification of Ti-6Al-4V alloy, Ni-SiC composite coatings for trochoid of Wankel engine, development of plasma sprayed coatings for solid oxide fuel cell applications, development of electrodeposited composite coatings with higher thermal stability, electroless coatings of nickel-based binary and ternary alloys and composites, development of sputter-deposited solar selective coatings, development of high wear-resistant coatings for machining of difficult-to-machine materials.

Wind Energy Division

The Wind Energy Division is mainly involved in the design/development of small and medium-scale wind turbines. The special driver of this programme is the application of NAL's aerospace technology to wind turbine development. The Division also has facilities for wind monitoring, wind resource assessment and micro-siting.

The Division has evolved a comprehensive indigenous methodology and created a design database for the development of low cost small and medium-scale wind turbines, specially suited to the Indian wind environment of relatively low wind speeds and dusty conditions. A number of small scale wind turbines, both for power generation and water pumping have been built. A Savonius machine (150W) for electricity generation has been installed in Antarctica.

Other Important Divisions :

Knowledge and Technology Management Division

The mandate of the Knowledge and Technology Management Division is to ensure easy and smooth operation of all the management activities of NAL. It is comprised of four groups.

The Project and Business Management Group (PBMG) carries out both technical and financial management including project planning, costing/budgeting, project monitoring of both externally funded and internal projects, IPR, technology transfer and project evaluation

Public Relations and Resources Management Group (PRRMG) manages Public Relations - including visitor services, event management, training and coordination.

Media and Publicity Management Group (MPMG) organizes exhibitions, management of NAL Museum, Press and Media, supports publication and dissemination of technical and popular periodicals documenting NAL's R&D effort and offers photography and videography services

Management of Information Systems Group (MISG) undertakes the Design, Development and maintenance of ERP packages, development and maintenance of MIS on intranet and Web-Based information.

Information Centre for Aerospace Science and Technology

The Information Centre for Aerospace Science and Technology (ICAST), a state-of-the-art centre with expertise, infrastructure and services caters to the information requirements of the Indian aerospace community in particular and the engineering and technical community in general. ICAST is well known for its exhaustive and rich collection of books, journals and specifically technical reports from NASA, DLR, ONERA, NLR, UTIAS etc, in addition to 50,000 meeting papers of 375 AIAA conferences. The centre offers Online, Web and CD-ROM based literature search services including access to e-journals, News clipping services, Online Public access Catalogue, Union Catalogue of Serials held by CSIR/ Aerospace Libraries. More than 6,000 e-journals from major publishers like IEEE, AIAA, Springer, Wiley, CUP, ASME, ACM, AIP, RSC are accessible through CSIR consortia. Books online from Springer, CUP, Reference Works from Credo are accessible, as are major databases like Web of Science, Aerospace database and J-Gate.

Innovative Delopments

- Successful development of SARAS Prototypes PT1,PT2-a 14 seater multi-role transport aircraft
- Design and development of HNSA (all composite, 2-seater for day/night operations. DGCA type certified aircraft)
- Technology for production of autoclaves
- State-of-the art transmissometer DRISHTI for measurement of runway visibility at airports as a safety aid
- Manufacture of the fibres and prepregs of strategic importance – R&D in aircraft and space grade fibres
- National Test Facility for rolling element bearings
- Design of India-specific wind turbines
- Hardware and software for weather forecasting relevant to India
- Design and Development of supersonic combustors
- Failure analysis and accident investigation
- Software for flight quality assurance and incident / accident analysis (NALFOQA/NALVAS) for airlines
- Cost-effective rapid resin injection moulding technology for nose radomes of fighter aircraft
- Low cost Vacuum Enhanced Resin Infusion Technology (VERITy) for advanced composites components
- Advanced flow computation and visualisation techniques
- Smart materials and structures (sensors and actuators)

- Nano surface coated mirrors for passive cooling of IR sensors in satellites
- Active noise control for aircraft/helicopter cabins
- Development and validation of the Tejas (LCA) flight control law
- Public – Private partnership to jointly design, develop and certify small general aviation light aircraft (NMS-100) with 4 to 5 seats.

Thrust Areas

- Cutting edge technologies in aerospace
- Centre of Excellence in Flight Mechanics and Control
- Advanced technology solutions for national programmes
- Micro Air Vehicles for strategic / civilian use.
- Production of SARAS aircraft for IAF and other customers
- Development of a regional transport aircraft of 70 -90 seater with turboprop / fan engines under the 11 FYP to promote regional air transportation / economy.

Contributions to National Projects

NAL has contributed enormously to virtually all the national projects in both the aeronautical and the space sectors. Among the significant contributions of NAL are:

- Leadership of National Team for CFC Wing
- Advanced Composite Structures
- Carbon Fibers
- Leadership of National Team for Flight Control Law Development
- Wind Tunnel Models & Testing – Aerodynamic Data Generation
- Material / Box level Testing and Characterization for Certification
- CFD Analysis
- Surface coating
- Noise measurement & control
- Flow Diagnostics Studies
- Aeroelastic Model Studies
- Dynamic Response Studies
- Acoustic test facility
- Sunshield Mirrors for IR Sensor Cooling on Satellites
- Composite Radome for DWR
- Thermo - Structural – Aeroelastic Analysis for RLVTD
- High Speed Combustor Design and Testing
- Transonic Buffet Studies on Launch Vehicle Models
- SATCOM Applications
- Special Carbon Fibers

Collaborations and Partnerships

NAL has developed collaborative programs with various Aerospace organisations and R&D institutions abroad mainly to foster the growth of R&D activities and technology developments.

Long Term Cooperations

- DLR, Germany
- CAE, China
- P&W, USA

Collaborations

- RMIT, Australia
- Boeing, USA
- P&W, Canada
- BELL Helicopters
- NC A&T University
- UKIERI, UK
- ALCOA, USA
- Florida State University, USA

Interactions

- CRIAQ, Quebec, Canada
- Bombardier, Canada
- Province of Bavaria, Germany

New Challenges, New Opportunities

Keeping in pace with increasingly globalised aerospace R&D scenario, NAL is exploring new model and structures to fulfill its mandate in the following areas during the 11th Five Year Plan (2008 – 2012). NAL will leverage its diverse and multidisciplinary resource base to the research needs of the national and international aerospace community, and society at large.

- Advanced flow diagnostics
- Advanced structural technologies
- Advanced wind turbines
- Aeroacoustics
- Air traffic management
- Aircraft systems
- Automatic target recognition
- Civil aviation
- Computational sciences
- Crashworthy structures
- Damage tolerant designs
- Data fusion
- Enhanced and synthetic vision
- Flow control
- High performance computing
- High temperature materials and coatings
- Hypersonic propulsion
- Integrated vehicle health management
- Low Reynolds number aerodynamics
- Micro aerial vehicles
- Morphing structures
- Multidisciplinary design optimization
- Multifunctional materials
- Nanotechnology
- Next generation composites
- Precision weather forecasting
- Small gas turbines
- Surface modification
- Ultra – light systems
- Vibration and noise control

Amenities

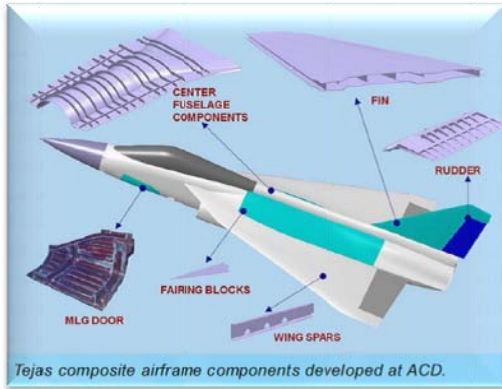
- **Sports**

NAL has number of sports activities both for outdoor and indoor games. It has a cricket ground, where number of matches under Karnataka state cricket association are played; tennis court, a basket ball court and a volley ball court. For indoor games facilities for playing shuttle badminton, table tennis and carrom are available. These facilities are extensively used by NAL staff members during lunch break and after office hours during the weekdays.

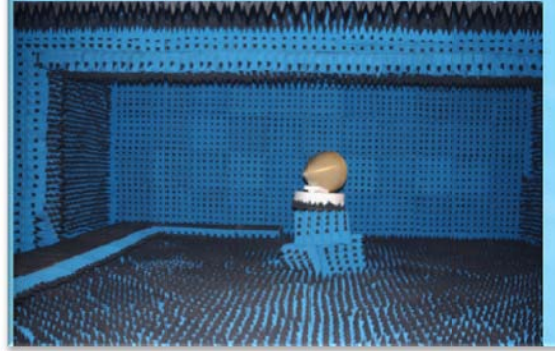
- **Health Center**

A health center catering to the employees of the laboratory exists on the campus. The center has five doctors, and operates during the weeks days. Doctors are available at the campus for 24x7 hours.

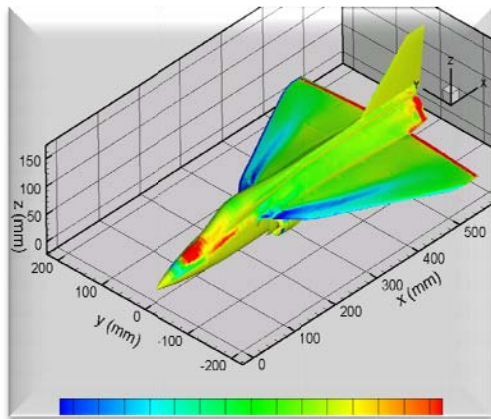
Some of the activities of the laboratory in pictorial form:



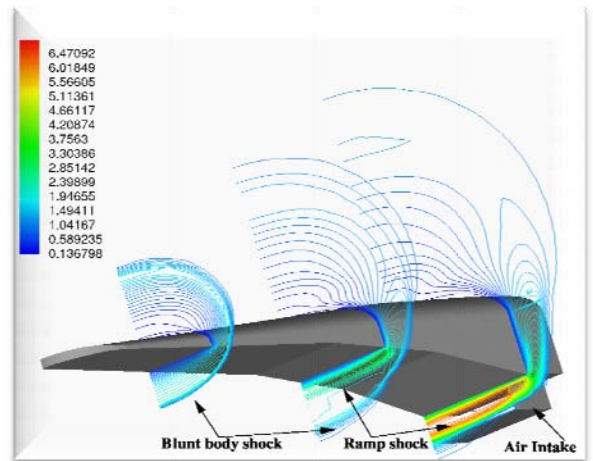
NAL-Microwave Anechoic Chamber (NAL-MAC).



SARAS PT-1 in flight



Surface pressure map on TEJAS model using Pressure Sensitive Paint



Computed density contours at different inlet sections of HRV



Artificial feel Six Degrees of Freedom
Departure and Spin Studies



The 128 processor Flosolver Mk 6



Mark-1 Radome for DWR



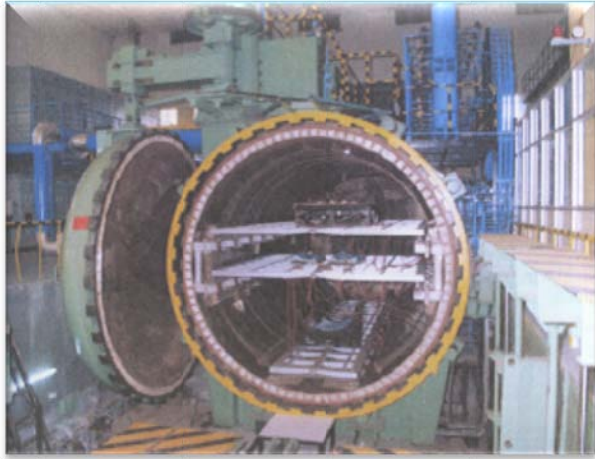
Integrated Facility for Carbon Fibre production



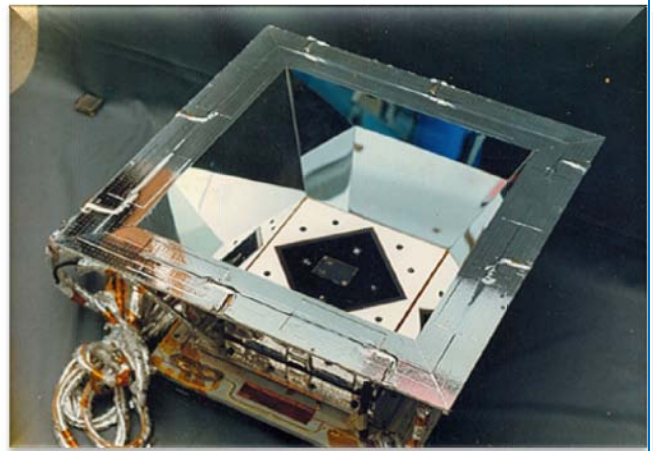
Captive Trajectory System for studies on
stores separation from aircraft models



High Speed combustor test facility



4m x 8m Autoclave designed and developed for HAL



Photograph of sunshield mirrors



NAL-Sangeeth wind turbine blades being tested at Kethanur wind farm

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