Council of Scientific and Industrial Research
National Aerospace Laboratories
Bengaluru 560017

Established in 1959, CSIR-NAL is a high-technology R&D institution focusing on advanced disciplines in aerospace and has a mandate to develop aerospace technologies with strong science content, design and bulld small and medium size civil aircraft and support all national aerospace programes.

- About Us
- Technologies for Industries
- Major Test Facilities
- Products


RTA


SARAS MkII


HANSA-NG


C-NM5


UAV

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Council of Scientific and Industrial Research
National Aerospace Laboratories
Bangalore, India

National Aerospace Laboratories (NAL), a constituent of the Council of Scientific and Industrial Research (CSIR), India, established in the year 1959 is the only government aerospace R&D laboratory in the country's civilian sector. CSIR-NAL is a high-technology oriented institution focusing on advanced disciplines in aerospace. CSIR-NAL has several advanced test facilities, and many of them are recognized as National Facilities. These are not only the best in the country, but are also comparable to other similar facilities in the world. CSIR-NAL has provided significant value added inputs to all the Indian national aerospace programmes. Its contributions over the last five decades have enabled it to create a niche for itself in advanced aerospace research and technology development. CSIR-NAL has also developed many critical technologies for the strategic sector and continues to support the mission-mode programmes of the country.

The Mandate

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

Major Focus / R&D Disciplines

Core competence of NAL spans practically the whole aerospace sector

- Civil aircraft design and development
- Micro Aerial Vehicle design and development
- Computational fluid dynamics
- Experimental aerodynamics
- Flight mechanics and control
- Turbo machinery and combustion
- Composites
- Structural design, analysis and testing
- Structural dynamics and integrity
- Surface modification
- Aerospace materials
- Aerospace electronics and systems
- Electromagnetics
- Meteorological modeling
- Wind energy

A Glimpse of the Significant Contributions to Indian Aerospace

A MILESTONE IN INDIAN CIVIL AVIATION

The HANSA Success - flying at four Indian flying clubs

The two seat aircraft, a pioneering ab-initio all composite design, was certified by DGCA in the year 2000 under JAR-VLA category. A total of 15 aircraft were built by NAL, out of which several are currently in use with various flying clubs in the country. Powered by Rotax 914 F3 Turbo charged engine with a AUW of 750 kg, it is capable of flying upto 10,000 ft altitude and has an endurance of 4 hours.

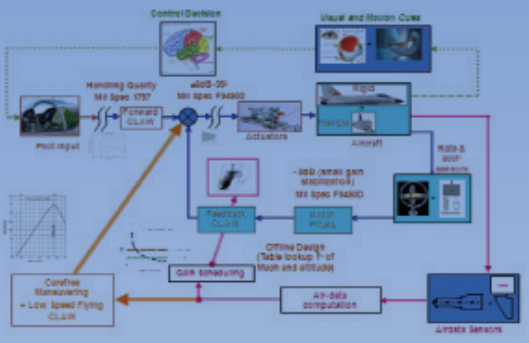
The SARAS - multirole light transport aircraft

SARAS, the 14 seat (7 ton class) multi role transport aircraft to be certified under FAR 23 category is being designed and built by CSIR-NAL. It had its maiden flight on May 29, 2004. Powered by 2x1200 SHP turboprop PT6A-67A engines (Pratt & Whitney) driving 5 blade MT-Propellers, SARAS is capable of flying up to 30,000 ft altitude (cabin altitude maintained at 8,000 ft) has an endurance of 5 hours and can operate from short air fields. It has been designed for multiple roles viz, executive transport, light package carrier, remote sensing, air ambulance etc. Indian Air Force is expected to be the launch customer for SARAS with HAL as the production partner.

Five Seat General Civil Aviation Aircraft (CNM-5) - the country's first public-private partnership

CNM-5, the five seat aircraft has the distinction of being the country's first public-private partnership (PPP) for development of civil transport aircraft. It is being developed by CSIR-NAL in collaboration with M/s Mahindra Aerospace Pvt. Ltd. (MAPL), Bangalore. CNM-5 had its first test flight on the 1st of September 2011 in Australia. CNM-5 is powered by a 300 HP piston engine driving a 3-blade propeller cruising at a speed of 160 knots with a maximum AUW (All Up Weight) of 1525 kg, capable of flying upto 10,000 ft altitude and endurance of 6 hours; glass cockpit is a customer option. It is an ideal aircraft for air taxi, air ambulance, training, tourism and cargo applications, and is proposed to be certified under FAR23 category.

SUPPORT TO NATIONAL PROGRAMS



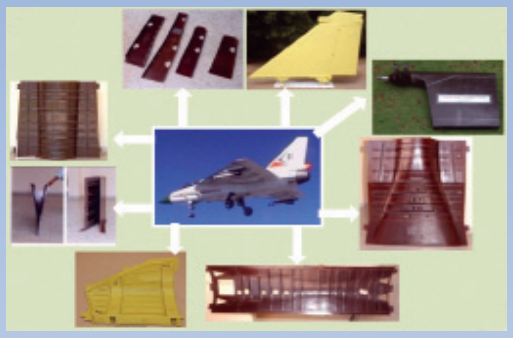
Flight control system structure

Aircraft Modeling and Control - understanding the dynamics of flight

- CSIR-NAL continues to lead the National Team effort on Design, Development and Certification of Fly-by-wire Flight Control Laws (Stability & Command Augmentation with Carefree Maneuvering, Autopilot, Autothrottle modes) and Fault Tolerant Airdata Algorithms for all Air force and Naval variants of the Light Combat Aircraft (TEJAS)
- Over 3100+ successful flights flown on nineteen different prototypes
- Sophisticated Parameter Identification techniques used to Validate and subsequently Update the wind tunnel generated aerodynamic database
- CSIR-NAL has carried out wind tunnel tests for LCA-TEJAS which resulted in aerodata generation & flight validation. Other significant contributions include: CFD analysis, flow diagnostic studies, aeroelastic model studies & dynamic response studies.
- The CLAW team led by NAL together with NFTC, ADA evolved safe and robust procedures for Ski jump launch of LCA Naval variant, successfully demonstrated during December 2014 from the shore based test facility at Goa.

Composite structures for TEJAS - forty percent of the TEJAS airframe is fabricated at NAL

- CSIR-NAL successfully led the National Team for the composite wing development for TEJAS
- Tejas airframe is 45% composites (mostly carbon-epoxy) by weight contributing to its reputation as the world's smallest light weight fighter aircraft
- CSIR-NAL has pioneered the development and fabrication of composite structures for the TEJAS aircraft using innovative and cost-effective fabrication technologies including co-curing/co-bonding construction. Co-curing technology has resulted in more than 20% savings in cost and about 15% reduction in weight
- Tie-up with Tata Advanced Materials Ltd., for supply of critical CFC components for the series production of LCA



CSIR-NAL developed composite parts for Tejas

Carbon Fibre Plant

Carbon Fibre

Carbon Fibre technology - achieving self–reliance

- India's First High-tech Carbon Fibre Plant of 400 TPA, established by Kemrock Industries, Vadodara with Technical knowhow from CSIR-NAL
- Type certified by Centre for Military Airworthiness and Certification (CEMILAC), Bangalore on September 21, 2011
- MoU with MIDHANI, Hyderabad for development of production technology for aeronautical grade carbon fibers
- Carbon fibre application: defense, wind energy, sports, transportation and infrastructure sectors

Technologies for Nishant UAV

- Wankel Rotary Combustion Engine Development: Successful test flights of a 55HP Wankel engine, design and developed in collaboration with VRDE for DRDO-ADE's Nishant UAV
- Structural Health Monitoring: Demonstration of Structural Health Monitoring technology using fibre optic sensors jointly with DRDO-ADE and Israeli MoD
- CEMILAC certificate for Limited Series Production accorded on 7 February 2013.

Maiden flight of the first ever indigenous rotary engine powering Nishant

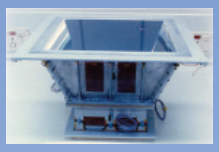
SHM system assembled on Nishant Wankel

Prototypes of Black Kite, Golden Hawk, Pushpak and mini UAV - Slybird

Development of Micro Aerial Vehicle (MAV) - for strategic & societal applications

- CSIR-NAL is playing a lead role in the National Program on Micro Air Vehicles (NP-MICAV) of DRDO/DST jointly with IIT-Bombay, IIT-Kanpur, Indian Institute of Science (IISc) and a few other academic institutions and private industries
- MAVs Black Kite, Golden Hawk and Pushpak with a 300 mm span, 300 gms weight and endurance of 30 mins have been developed. The MAVs carry a day light camera and provide an operational range of 2 Kms. User demonstrations have been carried out jointly with ADE and promotional flight demos given to Chhattisgarh Police, CRPF (Dhantawade), NSG (Manesar), Artillery Center (Deolali) and aerial survey of Muthangya Forest, Kerala Forest Department.
- Development of high altitude mini UAV - Slybird: 1.6m wing span, 1.3m length, 2 kg weight, operating range of around 10 km has been tested successfully at Leh/Ladakah (12,000 ft above sea level)

Acoustic Test Facility



Passive radiative cooler with the four polished mirrors

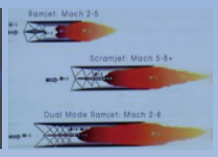
CSIR-NAL and India's Space Programme - a very fruitful association

- The Acoustic Test Facility (ATF) commissioned at CSIR-NAL for ISRO in 1986 has carried out acoustic tests on all of ISRO's launch vehicle stages (ASLV, PSLV, GSLV and RLV-TD) as well as satellites(IRS , INSAT series)
- CSIR-NAL has designed and developed a new ATF at ISITE, ISRO with 1500 cu.m reverberation chamber and nitrogen as the medium and a closed loop acoustic drive / control system
- Highly polished aluminum mirrors developed by CSIR-NAL help ISRO to get good satellite pictures
- CSIR-NAL has been supporting the programmes of ISRO including wind tunnel testing of all their flight vehicle models, structural analysis, flight dynamics and control etc.

NEW TECHNOLOGIES AND SYSTEMS

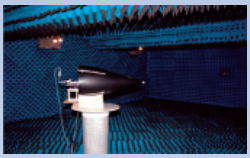
Supersonic Combustion for Hypersonic Vehicles - for advanced flight vehicles

- Advanced flight vehicles, will in future fly at hypersonic speeds using special engines called scramjets. NAL has successfully developed the vitally critical technology needed to burn fuels at supersonic speeds (around 1km/sec) in such engines



Airborne and Ground based radomes

12.88 m dia DWR



Electromagnetics Lab

Engineering radomes - protecting sophisticated electronic equipment

- Indigenous technology by CSIR-NAL for design and development of both airborne and ground-based radomes
- Technology transferred to HAL, Bangalore and BEL, Ghaziabad
- The Computational Electromagnetics Laboratory conducts studies related to radome design and characterization, radar cross section (RCS) evaluation of aerospace vehicles, antenna pattern analysis and metamaterials research

A new manufacturing process - for cost effective high quality composites

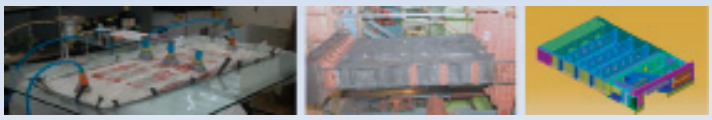
Vacuum Enhanced Resin Infusion Technology (VERITy)

- Lay dry preform on mould + Vacuum bag
- Resin infusion at just above room temperature
- Autoclave cure at low pressure and temperature
- Post cure in oven / autoclave
- JEC Asia 2013 Innovation Award for the innovative composite construction of horizontal tail bottom integrated skin of SARAS

SARAS wing, torsional box and trouser duct-top for LCA

Coduring and Cobonding Technology

- Uses Uni-directional Carbon Fiber Prepregs
- Layup Spar/rib/skin on a mould
- Inflatable bags as tooling
- Autoclave curing



Fully assembled wing test box

Design and Development of Autoclaves - for composite airframe manufacture

Mark IV *Mark III* *Mark II* *Mark I*

Industrial grade, high temperature (350°C) and high pressure (15 bar) autoclaves for demanding applications

- CSIR-NAL has built one of the largest indigenous autoclaves in the world (size 4x9 mts) with innovative features and an advanced control system. Autoclave supplied to HAL-Bangalore, ASL-Hyderabad, VSSC-Trivandrum and SHAR, Sriharikota for large size Autoclave.
- Cost effective Lab scale autoclave of 0.9m dia and 1 m length developed to cater the needs of R&D institutions and small scale industries. Lab scale autoclaves supplied to IIT-Kanpur, MIT-Manipal, and VSSC-Trivandrum
- PPP with private industries: UCE for manufacturing & marketing and Datasol for fabrication of systems

Actuator, Piezo ceramics sensor/ actuator for vibration control

Smart Materials, Systems and Structures

Smart (or multifunctional) materials such as Piezo Ceramics and Shape Memory Alloys are extremely attractive candidates for sensors and actuators. CSIR-NAL in its quest for advanced technologies is involved in the development of these materials and their applications in the aerospace sector.

- Structural Health Monitoring using FBG sensors
- Piezo ceramics sensor / actuator for vibration control
- Shape memory alloy as control surface actuator / skin morphing / vibration damper
- Effecting repair – using SMA actuator
- Active Noise Control (ANC)

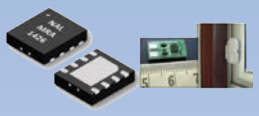
NiTi SMA wires, rods, tubes strips.

ANC system for fighter aircraft

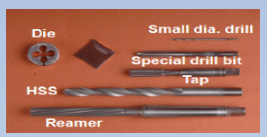
- NiTi-base shape memory alloys (SMAs) in the form of wires, strips, rods, ribbons and tubes suitable for Aerospace and Engineering applications have been developed at CSIR-NAL. Processing technology for commercial production of NiTi SMAs developed jointly with HAL, Bangalore and MIDHANI, Hyderabad.
- SMA wires developed can be used for variety of thermal actuator applications in the temperature range 25 to 200°C and the wires are available in the diameter range 1.5 to 0.1 mm
- NiTi Superelastic (SE) and Shape memory effect (SME) wires/strips developed for R&DE(Engrs.), DRDO, Pune for use in the development of SMA embedded CFRP/GFRP composites for impact energy damping applications

Surface engineering technologies - using nanotechnology to enhance component performance

- Superhard and tough coatings on cutting tools for high precision machining of difficult-to-cut materials. Cost effective plasma nitriding has been developed for cutting tools. Nanostructured solid lubricant coatings with friction coefficient <0.1 are useful for aerospace and automobile applications.
- Apart from cost effective the performance of the plasma nitrided tools is at par with WC tools
- Magnetoresistive thin film technology for automotive and sensor applications. NAL has a proven and patented technology to develop magnetic sensor chip. The sensors have wide band width operation, low power operation (mW), and miniature size (3mm x3mm) with low cost (<INR 20).
- Global Magnetic sensor market revenue estimated to be 2 billion US $. The technology will benefit Two Wheeler & Four Wheeler Automotive Companies in India

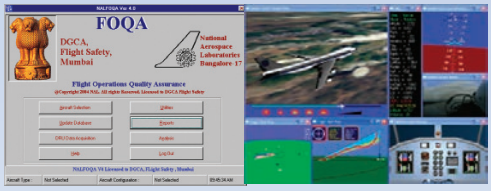


Gear Tooth Sensors based on Giant magnetoresistance (GMR)



High speed drill bits

Drishti installed at Indira Gandhi International Airport



Visualization and animation software

The Avionics challenge - success in electronics and instrumentation

- DRISHTI developed by CSIR-NAL is a fast-acting accurate transmissometer capable of handling both low (<25 meters) and high (>2000 meters) visibility accurately
- The DRISHTI systems have been installed at major airports in the country including Lucknow, IGI Airport, Delhi and NSCBI Airport, Kolkata. Suitable for CAT I,II,III A and B airports and it meets WMO and CAO regulations and has been issued International Class I certification (NOTAM). Partnership agreement with IMD for installation of 70 systems at all airports in the country.
- MoA with Tata Power Systems for supply 54 nos of Drishti for MoD's IAF airfields.
- CSIR-NAL's Flight Operation Quality Assurance software (NALFOQA) can monitor the flight performance of aircraft and has been used by Air India, Alliance Air, and DGCA for over a decade.
- Designed & developed Autopilot Hardware module version 4.2 (APV4.2). The hardware has been tested on five different platforms viz, SlyBird, Black Kite, Griffin, Pushpak and EasyStar.

Engine Instruments and Crew Alert System (EICAS) and a 3-axes digital autopilot system has been developed for SARAS aircraft

- EICAS has been cleared by DGCA for Aircraft Integration in February 2012. DO 178B Level A Software
- Potential for use in other aircraft programs in India and abroad
- State of the art Integrated Global bus Avionics Processing System (IGAPS) with ARINC 653 Time and Memory partitioned platform. ARINC 818, ARINC 664 based global bus interconnect. Dual Redundant design with Dual-Dual features. VITA 46- PCIx based backplane communication.
- First of its kind in India, indigenous design for civil aerospace.
- MoU with Tata Advance Systems for Indian and world wide marketing of IGAPS

Advanced civil aircraft cockpit

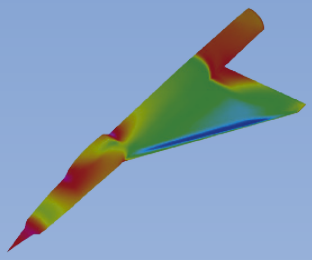
Autopilot Ver 4.2.

NAL Simulators

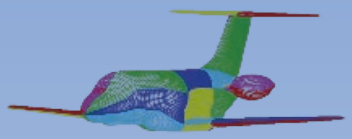
- Based on Matlab Simulink and Real Time Windows Target
- Model based design
- Rapid prototyping tool for control law evaluation and research
- Low cost

IGAPS integrated with the automated test station

EXPERTISE AND CAPABILITIES



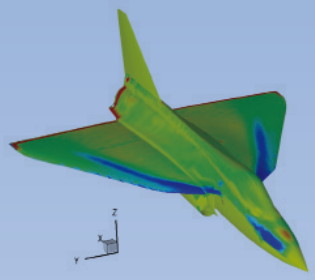
Pressure around fighter aircraft



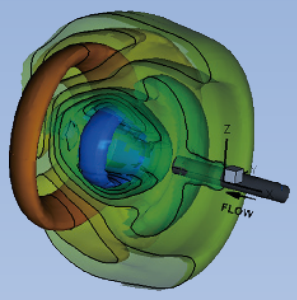
Multi-block grid around full SARAS aircraft configuration

The CFD advantage - to model and optimize the performance

- CSIR-NAL has used computational fluid dynamics (CFD) to model and optimize the performance of civilian and military aircraft, launch vehicles and missiles
- Some of the other novel studies in this area include internal flows in gas turbine engines, modeling of combustion, flow over wind turbine blades etc.



Surface pressure field on LCA TEJAS model using PSP



The BOS technique validated for fully 3-D flows

- At CSIR-NAL several advanced flow diagnostics techniques such as BoS, PIV, PSP etc. have been successfully developed and deployed
- The Background Oriented Schlieren (BOS) technique provides the capability for capturing the three dimensional density fields
- CSIR-NAL developed Pressure Sensitive Paints (PSP) used on wind tunnel models to map the whole-field pressure distribution
- DHVANI - Electronic Target for Marksmanship Training in Indian Army. This cost effective system bagged first major order for twelve lanes from HQ, Sothern Air Command (SAC) Thiruvanathapuram. The order executed through PPP consortium M/s Captronic Systems Pvt.Ltd

Dhvani System

Kanishka crash in 1985

Aircraft crash in 1990

Failure analysis and Accident investigations - asking why

- CSIR-NAL is recognized as India's premier organisation for carrying out failure analyses and accident investigations, and it has been doing this with distinction for more than 40 years
- More than 1500 accident cases have been investigated by the NAL team. The Air India Boeing 747 Kanishka crash in 1985 was due to a chemical explosion and NAL was closely involved in the investigation

Aerospace Structures - mastering the art and science of testing

- CSIR-NAL's full-scale fatigue test facility provides inputs that can lead to a substantial increase in the operational life of airframes of IAF's Gnat, Ajeet and MiG-21 Bis
- Over the years CSIR-NAL has built unique capability in the area of aeroelastic testing of SARAS and TEJAS aircraft, and the launch vehicles of ISRO
- CSIR-NAL has also successfully carried out ground vibration tests (GVT) on its SARAS, GA-10 aircraft, ALH, Jaguar, Mirage 2000 and other fighter aircraft

MiG-21 airframe testing

1/42 GSLV MkS model

MAJOR R&D FACILITIES AT NAL

- 1.2m Trisonic Wind Tunnel (M=0.2 to 4.0): Every Indian aerospace vehicle has graduated out of this wind tunnel. The NTAF has contributed immensely to all national programmes of DRDO, ISRO, ADA, HAL & NAL and has been performing reliably for over 50 years
- 0.6m Trisonic Wind Tunnel indigenously designed and built by CSIR-NAL
- Fullscale fatigue test facility
- Crashworthiness Forwerd Velocity Sled facility
- Large Scale Rotating Rig (LSRR) for Turbine and Compressor Aerodynamic Investigations
- Transonic Cascade Tunnel facility
- Micro air vehicle Aerodynamics Research Tunnel facility
- National Test Facility for Aerospace Bearings / Lubricants
- High speed combustor test facility (HSCTF)
- Jet Aeroacoustics Research facility
- Flight Simulators and Augmented Engineering Environment (AEE) for modeling and simulation
- Ceramic Matrix Composites through Chemical Vapour Infiltration
- High velocity air gun impact test facility
- The High Performance Computing (HPC) facility along with 4PI (C-MMACS) - fastest system in India
- Computational electromagnetics (CEM) facilities
- Versatile turbine test rig

1.2m Trisonic Wind Tunnel

Air gun impact test facility

Scramjet test rig

Augmented engineering environment

Technologies for the Society

The NALSUN technology - solar energy for water heating

- CSIR-NAL developed cost-effective Electrodeposited Black Chrome Coating. This technology has so far been transferred to many industries
- Commercially successful technology and plating requires room temperature (approx. 30°C) & normal current densities (approx. 10 to 30 Adm^{-2}). Service life of the coating is more than 20 years
- Widely patented (India, Australia, Canada, Europe and USA)

1.2 lakh litre per day system at M/s Godavari Fertilizers, Kakinada

Wind-solar hybrid System at CSIR-NAL

4 kW Wind-Solar Hybrid System (WiSH) for Agri-Pumps

- The present 1 kW class WiSH technology demonstrator system, installed at Renewable Energy Farm, Kodihalli Campus, NAL is of TRL 6 and is designed for remote hamlets.
- Under development - a WiSH system to deliver 4 kW in low wind regimes, at least eight hours in the day to drive agricultural pumps.

Air Ferry system - for rural applications

- An air-ferry is a buoyant, self-propelled, multi-terrain vehicle that depends primarily on air thrust for propulsion
- Air ferry system for deployment in rural areas for river crossings, rescue mission operation etc.
- Aam Rath made up of bamboo material base vessel, with 33hP aero-engine; and Lal Hamsa with FRP base vessel and 17hP aero-engine

Aam Rath-6 seat

Lal Hamsa-3 seat

INTERNATIONAL COLLABORATIONS

Long Term Cooperations

- DLR, Germany
- CAE, China
- P&W, USA
- CRIAQ, Quebec, Canada
- MDB, Russia
- Czech Academy of Sciences
- Astronautics Corp., USA

Collaborative / Sponsored Projects

- Boeing, USA
- P&W, Canada & USA
- BELL Helicopters
- CAE, CANADA
- UKIERI, UK
- ALCOA, USA
- RMIT, Australia
- NCA&T University, USA

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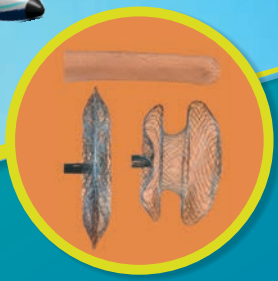
CSIR-NAL

Technology Profile @ CSIR-NAL



CSIR-National Aerospace Laboratories
Bengaluru

Overview

National Aerospace Laboratories (NAL), a constituent of the Council of Scientific and Industrial Research (CSIR), India is the only civilian aerospace R&D laboratory in the country. Started on June 1, 1959 in Delhi, it moved to Bengaluru in 1960 and later on to its own two campuses (Kodihalli and Belur) in Bengaluru. CSIR-NAL is a high-technology oriented institution focusing on advanced disciplines in aerospace and has a mandate to develop aerospace technologies with strong science content, design and build small and medium size civil aircraft and support all national aerospace programmes. CSIR-NAL's committed efforts over the last five decades have resulted in achieving expertise and core competencies in most of the disciplines of aeronautics. It has always readily accepted challenges and delivered programme critical products and technologies and has become the preferred destination for almost all the mission-mode aerospace programmes in the country. The major aerospace programmes of ISRO & DRDO have significant contributions from the laboratory. CSIR-NAL's developmental work in strategic areas has helped the country in overcoming the technological denial regimes. The laboratory's significant contributions both in civilian and strategic sectors have resulted in the development of new technologies and systems, which are also of interest to industries. To mention few key technologies and systems developed/being developed are of interest to industries include; the new generation 2 seat Hansa aircraft with alternate material, digital glass cockpit, steerable nose with increased endurance and range for pilot/cadet training, SARAS 19 seat LTA for civil and military applications, CNM5 – 5seat aircraft for air taxi, tourism and cargo, Suchan mini UAV for surveillance, carbon fibre airframe components using innovative and cost-effective fabrication technologies, 55 hp/65 hp/30 hp Wankel engine for UAVs, radomes for airborne and weather applications, indigenous autoclaves for composite airframe manufacture, Detection and Hit

Overview

Visualization using acoustic N-wave Identification (DHVANI) & Acoustic Based Hit Identification & Analysis System (ABHIAS) for locating bullet hits on targets for the Indian Army, DRISHTI - an airport runway visibility assessor system developed is a fast and accurate transmissometer, advanced display system for aircraft cockpits, ARINC 818 IP core for high speed avionics solutions,, Flight Operation Quality Assurance (FOQA) software as a key tool for aviation and is being used by many Indian aircrafts for over a decade, NiTi Shape Memory Alloy for engineering and bio-medical applications, GMR Sensors for automotive applications, Multi Zone Hot Bonder for composite repair, Chromate free corrosion resistant coating for aerospace & automobile applications, Tape casting technology for ceramic substrates, and so on. Many technologies have been developed for societal applications. NALSUN solar selective coating for industrial and domestic solar water heaters, wind turbines of 1.5 - 30 kW capacity for wind energy harvesting, coatings for cutting tools to enhance wear resistance and improved tool life are some of the significant achievements with societal impact. As can be seen above, CSIR-NAL has contributed significantly to indigenous technology and product development and has been the backbone of many national aerospace programmes. This booklet provides a detailed view of CSIR-NAL technologies and systems which are of benefit to the Indian industries for possible collaboration in indigenous production and furthering Make in India.

Shri Jitendra J Jadhav
Director, CSIR - NAL

Contents

C-CADD

AERO THERMAL SCIENCES

STRUCTURAL AND MATERIAL SCIENCES

Contents

SYSTEMS ENGINEERING

SOCIETAL MISSIONS

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.

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

C-CADD

HANSA - NG Aircraft

Glass Cockpit (fully loaded version)

Improved Engine Cowling Design

New generation Hansa aircraft called Hansa-NG is being developed by incorporating state of the art technologies and design improvements in the present type certified Hansa-3 aircraft based on operator's feedback and inputs received from the Light Trainer Aircraft Users.

CSIR-NAL and M/s Mesco Aerospace Ltd have collaborated and took up the joint development of Hansa-New Generation (NG) aircraft project titled Design, Development and Certification of Hansa-NG aircraft.

Apart from incorporating the design improvements such as glass cockpit, steerable NLG, heated Pitot, LED type lights, improved ingress/egress, it is also proposed to enhance the aircraft performance (range & endurance) & production rate by installing the advanced Rotax 912 iSc Sport engine with aerodynamically efficient cowling and latest JIPREG manufacturing process.

Year of Development :

2000 – Hansa 3, 2020 - Hansa-NG

Applications

- Ab-initio Flying Training at Flying Training Schools
- Hobby Flying

HANSA - NG Aircraft

Salient Technical Features

- New MIP with Glass Cockpit
- Advanced Fuel Efficient Engine along with improved cowl
- Increased Range & Endurance
- Landing Gear Wheel Fairings & Optimized Bottom Fairing
- Steerable Nose Wheel
- Electrically Operated Flaps, Heated Pitot Unit & LED Lights
- IFR Certification
- Improved Manufacturing Process
- Improved Cockpit Ingress/Egress & Provision for Baggage
- Better Cockpit Aesthetics & Ergonomics
- Endurance - 6 hrs
- Range - 500nm(926km)

Level/Scale of Development : TRL-7

Intellectural Property Rights (IPR) :

Hansa-3 Aircraft is certified by the Director General of Civil Aviation, under FAR-23, amendment 23-42 using the requirements of JAR-VLA dated 26th April 1990, including amendment VLA9//2/1.

India Type Certificate No. 7-12/94-RD-TC-1 dated 1st February 2000.

Hansa-NG : To be certified under CS-VLA.

Commercialization

Collaboration with Mesco Aerospace Limited, for design, development, certification, production and marketing of Hansa-Next Generation

Available in Market

Hansa-3

- Currently in use at flying club and IIT-Kanpur.
- CSIR-NAL is the holder of the Type Certificate and is the Original Equipment Manufacturer.
- If there is a demand, CSIR-NAL can take up low volume production and make it available.

Techno-Economics

Cost of indigenously developed Hansa–NG aircraft is estimated to be around Rs. 70-80 Lakh as compared to the imported aircraft with similar features costing Rs. 100-135 Lakh. There is an immediate requirement of 70-80 training aircraft in the country.

CNM-5 Aircraft

Multi-Mission General Aviation Aircraft: C-NM5 Joint Development by CSIR-National Aerospace Laboratories and Mahindra Aerospace Pvt. Ltd.

The NM5 is a single-engine low wing five-place airplane with a fixed tricycle landing gear that can be used in multiple roles like air-taxi, training, touring, executive transport, cargo carrier, etc. It is being designed to be an affordable, easy-to-operate and easy-to-maintain light aircraft that can be customized to suit a variety of operational needs. The NM5 will offer a cabin that can readily be reconfigured, thereby maximizing its utility to the operator. Equipment options and performance parameters will enable it to function as a luxurious four place executive transport as well as an economical cargo carrier for back-country use.

The design objective is for NM5 to combine the utility of older generation aircraft, the safety and reliability embodied by the current airworthiness requirements, and the interior fit and finish of modern luxury aircraft in its class.

Aircraft is designed to meet the airworthiness requirements of FAR part 23 under Normal Category.

CNM-5 Aircraft

Year of Development : 2011

Level/Scale of Development : TRL-7

Applications

- Air Taxi
- Training
- Tourism
- Cargo
- Executive Transport

Salient Technical Features

- VFR/IFR, Day/night flight operations
- Advanced Avionics and Glass Cockpit
- Spacious & reconfigurable cabin with 3 Doors for multi-role capability
- Max. altitude - 10000 ft, Endurance - 6 hrs
- Range - 1300 km, Max. Cruise Speed - 296 km/hr

Airframe

All metal construction with composite cowling and fairings

Power plant

Lycoming IO-540 engine /Diesel Cycle Engine, 300bhp, 3-bladed constant-speed propeller

Avionics

AMS, NAV / COM / GPS, CDI, Transponder, and ELT

Intellectural Property Rights (IPR) :

IPR will be jointly owned by CSIR-NAL & Mahindra Aerospace Pvt. Ltd. (MAPL)

Commercialization

Collaboration with Mahindra Aerospace Pvt. Ltd., for design, development, certification, production and marketing of the aircraft.

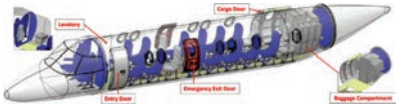
Available in Market

Under development

Techno-Economics

- As per the PWC report 2017 on small fixed wing aircraft market in India, Flying Training Organisations (FTOs) are actively looking to replace the old 2-6 seat aircraft. The study found that there is a steady growth in the requirement of small fixed wing aircraft. The 5, 10, 15 and 20 year CAGR for 2 to 6 seat fixed wing aircraft are 2%, 5.8%, 5.6% and 6.2% respectively.

SARAS NG Aircraft



SARAS aircraft was originally conceived as a 9-14 seat commuter in a pusher turbo-prop configuration in early 1990's at CSIR-NAL.19-pax production version of SARAS meets all regulatory requirements of a Light Transport Aircraft. Different layouts in terms of arrangement of seats, luggage and a lavatory compartment were explored within the existing fuselage shell. Final configuration with 17-19 seats and several improvements in basic airframe configuration and significant weight reduction are proposed. The design aims to achieve low operating empty weight, low drag and high aerodynamic efficiency, good stall characteristics, control and handling qualities. In addition, the aircraft systems will be comparable to current industry standards which include a full-glass digital cockpit and power assisted control systems.

- Designed to meet FAR 23 requirements
- Pressurised cabin
- Low cabin noise (<80 db)
- Operable from semi – prepared runways
- Operable from hot and high altitude airfields

SARAS NG Aircraft

Year of Development : *4 years from To*

Level/Scale of Development : TRL - 6

Applications

- 19-Seater Multi Role Light Transport Aircraft, ideal for commuter connectivity under UDAAN Scheme for variety of applications like air taxi, executive transport, disaster management, remote sensing, aerial search/survey, coast guard, border patrol, air ambulance and other community services.

Salient Technical Features

- Improved aerodynamic efficiency and useful load
- Reduced pilot work load with hydraulic boost
- State of the art general systems with pressurized cabin
- Full glass cockpit: EFIS - Four PFD / ND / MFDs
- Comm / Nav suite: VHF-VOR and radio, ADF, DME, ILS
- TAWS: Terrain Avoidance Warning System
- FMS: Flight Management System
- TCAS: Traffic Collision Avoidance System
- Auto pilot and Weather Radar

Commercialization

Under development. Certification by 2024.

Techno-Economics

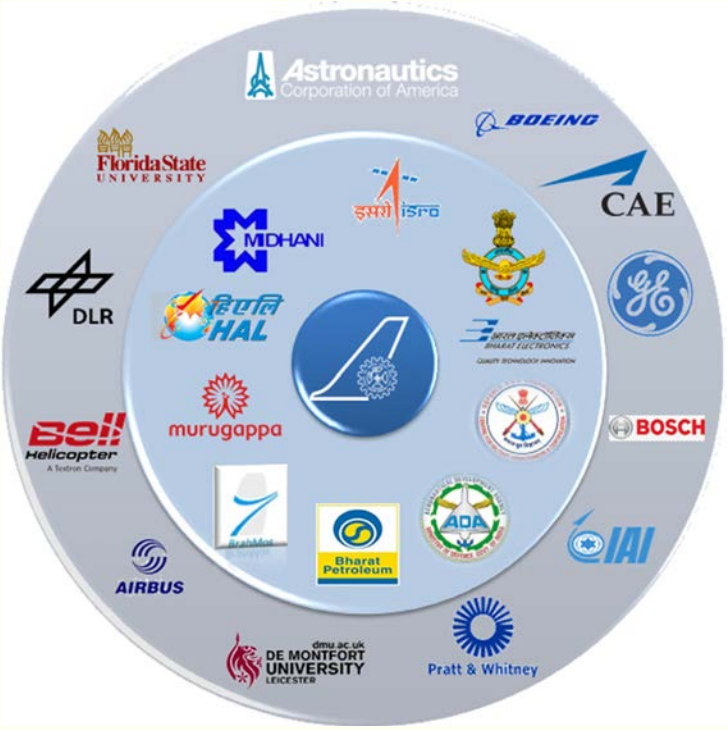
Passenger commutation, VIP Transport etc. - Civil Aviation

- It is estimated that between 120-160 multi-role light aircraft in different versions are required for India over next 10-15 years.
- HAL has projected a market potential for at least 200 numbers 19 seat aircraft of Do-228 class.

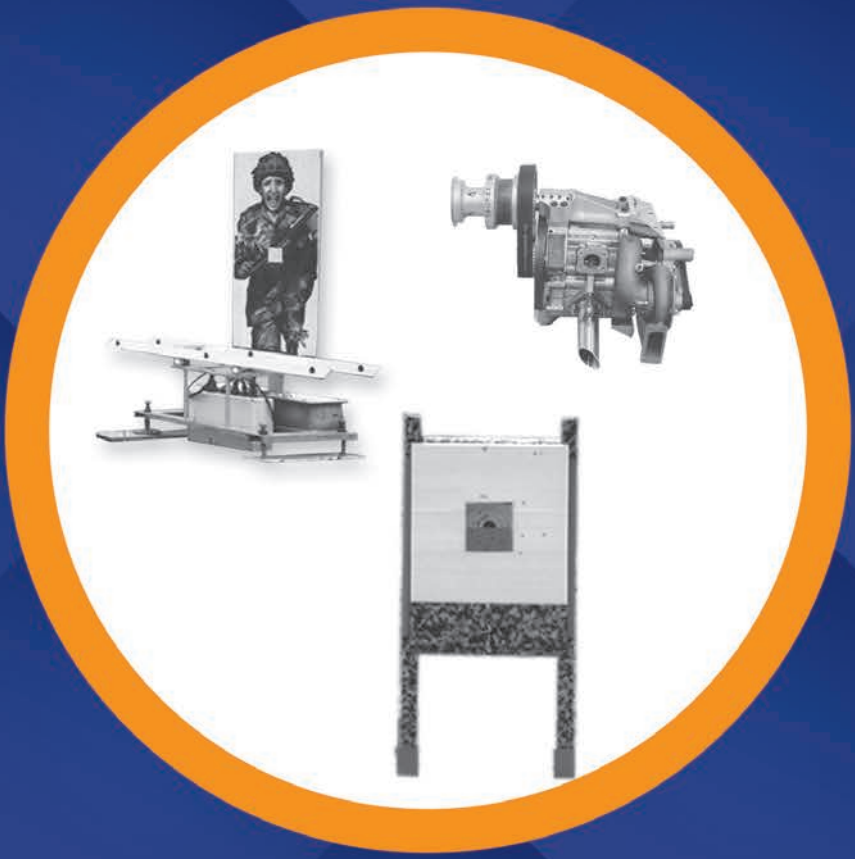
Troop Transfer, Paramilitary Surveillance, Casevac etc. - Military Aviation.

- The Indian Airforce (IAF) has given their initial induction of 15 aircraft. It is expected that another 25-30 aircraft may be required in the next 10-15 years.

Collaborations and Interactions



AERO THERMAL SCIENCES



Location of Bullet on Target System

Detection and Hit Visualization using Acoustic 'N'- wave Identification (DHVANI)

Marksmanship training requires positive and negative reinforcement of shooting techniques immediately after each shot is fired. CSIR-NAL developed 'DHVANI'–"Detection and Hit Visualization using Acoustic 'N'-wave Identification" - a Location of Bullet on Target System (LOBOTS) is an indigenous, cost effective electronic target training system for perfecting soldier marksmanship skills by accurately determining the location of bullet impact on the target during training. It works for all supersonic weaponry used by Indian Armed and paramilitary forces.

Year of Development : 2014

Applications

- Automated system to detect bullet using supersonic acoustic detection and localization of hits on target by acoustic time delay estimation methods
- Real time and precise system, catering for individual to tactical level of exercise settings.
- Tailor made for Indian Armed Forces with high degree of ruggedisation to meet Mil Grade Standards. Configured out of COTS item to ensure low post sale maintenance cost.

Location of Bullet on Target System

Salient Technical Features

- Automated Range Control with database management
- Variable firing positions without any re-calibration
- Exercise as per SAO 12/S/85 and facility for user defined exercise setting
- Seamless wireless network with Ethernet enabled network
- Roaming Firing Point Officer (RFI) and Firer End Display Interface (FEDS)
- Interactive and User Friendly GUI
- Power on self-diagnostic and real time diagnostic during exercise
- Pop Up Target System with Self-Healing Targets and simulation units for illumination, smoke and flash
- Unit level package for firer management and performance evaluation outside the range
- All weather-proof carbon fiber composite sensor bar.
- Accuracy within 5mm on 5.56mm bullet

Level/Scale of Development : TRL-9, Production Version

Intellectual Property Rights (IPR) : In process of patent application

Commercialization

Exclusive License to Bharat Electronics Ltd (BEL), Bengaluru

Available in Market

Systems for twelve lanes supplied to HQ, SAC, Thiruvanathapuram

Techno-Economics

- System meets or exceeds the specification of all comparable systems available internationally
- The cost of the system is currently about 60% of comparable systems
- The target customers are Indian Army, Navy, Air Force, NSG, BSF and all security groups using rifles with supersonic ammunition.
- Estimated demand about 16000 units for 2000 shooting ranges with an average of 8 lanes per range
- Typical life of this system is about 7 years. Life cycle costs are far lesser than imported systems due to availability of local spares and expertise.

Location of Bullet on Target System

Acoustic Based Hit Identification and Analysis System (ABHIAS)

CSIR-NAL developed ABHIAS is an indigenous, cost effective electronic target training system for perfecting soldier marksmanship skills by accurately determining the location of bullet impact on the target during training. It works for all supersonic and subsonic weaponry used by the Indian armed forces, paramilitary forces and police forces.

Year of development : 2017

Applications

- Acoustic based detection and localization of hits on target by acoustic time delay estimation methods
- Real time and precise system, catering for individual to tactical level of exercise settings.
- Tailor made for Indian Armed Forces with high degree of ruggedisation to meet Mil Grade Standards.
- Configured out of COTS item to ensure low post sale maintenance cost.

Location of Bullet on Target System

Salient Technical Features

- Caters to both supersonic and subsonic weaponry
- Variable firing positions without any re-calibration
- Exercise as per SAO 12/S/85 and facility for user defined exercise setting
- Seamless wireless network with Ethernet enabled network
- Range Firer Instructor (RFI) and Firer End Display Interface (FEDS)
- Ergonomically designed all weather-proof carbon fiber composite target frame
- Innovative mechanism for quick target change
- Interactive & User Friendly GUI

Level/Scale of Development : TRL-9, Production Version

Intellectual Property Rights (IPR) : Nil.

Commercialization

Exclusive License to Bharat Electronics Ltd (BEL), Bengaluru

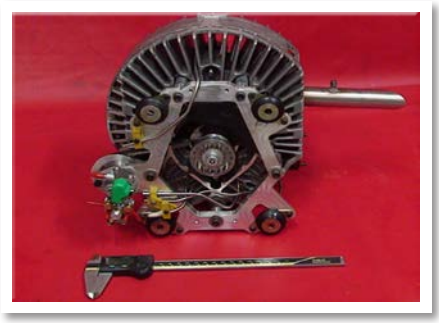
Available in Market : Discussion with perspective customers

Techno-Economics

- System meets or exceeds the specification of all comparable systems available internationally
- The cost of the system is currently about 60% of comparable systems
- The target customers are Indian Army, Navy, Air Force, NSG, BSF and all security groups using rifles, LMG, and close quarter weapons
- Estimated demand about 16000 units for 2000 shooting ranges with an average of 8 lanes per range
- Typical life of this system is about 7 years. Life cycle costs are far lesser than imported systems due to availability of local spares and expertise.

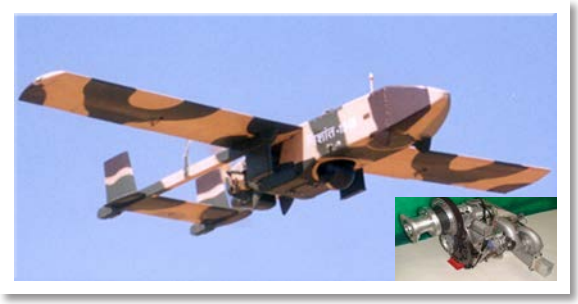
Wankel Rotary Combustion Engine

30 hp, 55 hp and 65 hp Wankel Rotary Engine



First Prototype 30 hp Wankel Rotary Engine

Indigenous 65 hp Wankel Rotary Prototype Engine



NISHANT UAV maiden successful flight with indigenous 55 hp Wankel Rotary Engine

Wankel Rotary Combustion Engine (WRCE) has gained considerable interest as a viable power plant for small aircraft and Unmanned Aerial Vehicles (UAVs) due to its inherent advantages on many counts. CSIR-NAL has established considerable expertise in analysis, materials, manufacture and operation of Wankel engines over the past two decades.

Wankel Rotary Combustion Engine

Year of Development :

30 hp Wankel Engine : Technology is developed in December 2018

55 hp Wankel Engine : Engine first flight demonstrated on March 2009. Certification completed in 2016

65 hp Wankel Engine :Technology demonstrated in December 2016. Two prototypes were delivered for flight trails on PANCHI UAV in 2018

Applications

- Unmanned Aerial Vehicles
- Hybrid vehicles as Range Extenders
- Compact Generators
- Powered Hang Gliders
- Outboard Motors

Salient Technical Features

- High power to weight ratio
- Simplicity in design due to less number of components
- Fewer moving parts
- Low noise and vibration
- Smooth power output
- Ease of balancing

Level/Scale of Development :

30 hp Wankel Engine : TRL-4, First prototype engine is developed for design validation and is in progress.

55 hp Wankel Engine : TRL-8, Prototype engines successfully flight tested on the NISHANT UAV.

Center for Military Airworthiness and Certification (CEMILAC) cleared the technology for Limited series production on 7 February 2013.

Provisional clearance for flight testing is granted on 13 January 2016.

65 hp Wankel Engine : TRL-5, Technology is demonstrated on the ground through the first prototype engine.

Center for Military Airworthiness and Certification (CEMILAC) and Directorate General of Aeronautical Quality Assurance (DGAQA) coordinated second and third prototype engines and undergone extensive ground testing as stipulated by the certification agencies and completed the acceptance testing.

Second and third prototype engines were delivered for flight testing on the PANCHI UAV.

Intellectual Property Rights (IPR) :

30 hp Wankel Engine: Held by CSIR-NAL

55 hp Wankel Engine: Jointly held by CSIR-NAL and DRDO

Wankel Rotary Combustion Engine

65 hp Wankel Engine: Held by CSIR-NAL

Commercialization

55 hp Wankel Engine: Technology is given to DRDO for defense applications and limited series production of 20 engines were completed.

Available in Market

55 hp Wankel Engine: Currently in use for strategic sector. Not available in the market.

Techno-Economics

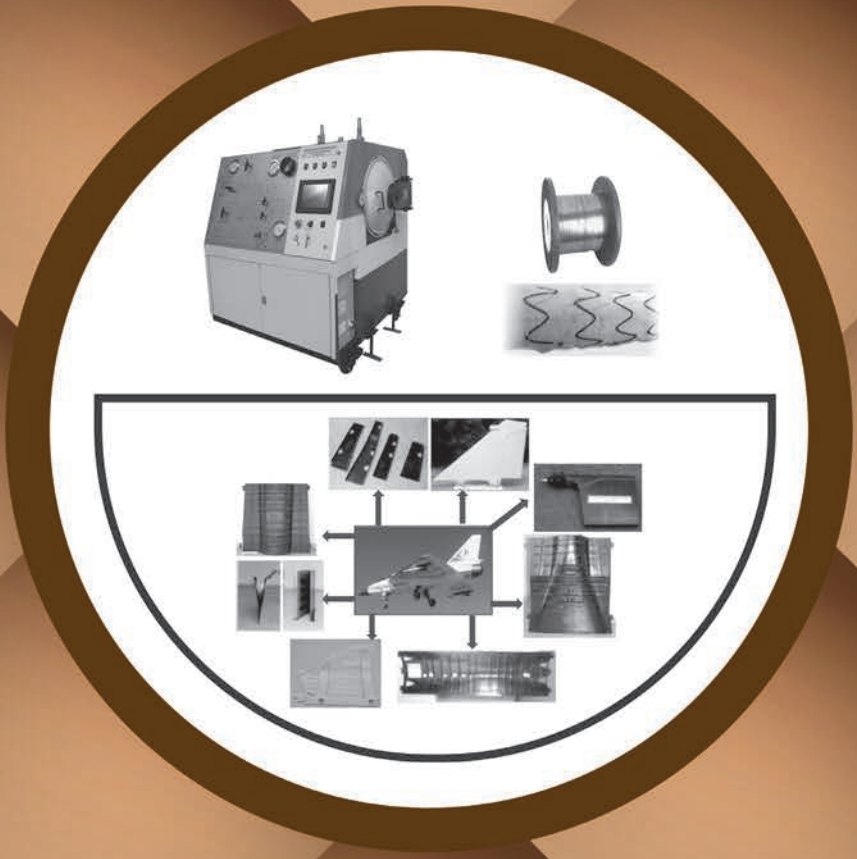
55 hp Wankel Engine:

- Indigenous engine cost is about 40 percent lower than the imported similar class of engine
- Spare parts cost is much lesser than the imported parts
- Foreign exchange saving for the country
- Lot of time saving due to delay in import and export license clearance from authorities.

Comparison of CSIR-NAL's Indigenous Wankel Rotary Combustion Engines

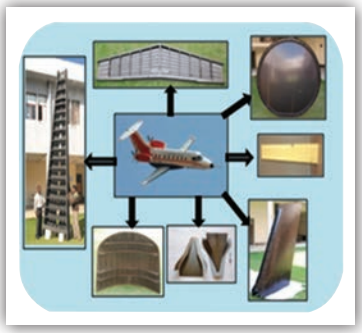
	55 hp	65 hp	30 hp
Type	Single rotor Wankel engine		
Thermodynamic cycle	Otto cycle		
Power (ISA-sea level)	55 hp (41 kW) @ 8000 rpm	65 hp (48 kW) @ 8000 rpm	30 hp (22.4 kW) @ 7000 rpm
Max propeller speed	4000 rpm (Reduction drive)	4000 rpm (Reduction drive)	7000 rpm (Direct drive)
Cylinder capacity	324 cc	397 cc	216 cc
Compression ratio	9.2	9.2	9.2
Housing Cooling	Water-Glycol mixture	Water-Glycol mixture	Ram air
Rotor cooling	Air cooled	Air cooled	Ram Air
Lubrication	Total loss forced lubrication system	Total loss forced lubrication system	Total loss forced lubrication system
Ignition	CDI system	CDI system	CDI system
Fuel used	AV GAS- 100LL/ Gasoline	AV GAS- 100LL/ Gasoline	AV GAS- 100LL/ Gasoline
Fuel supply	Carburetor- Diaphragm type	Carburetor- Diaphragm type	Carburetor- Diaphragm type
Specific fuel consumption	335 to 365 g/ kWh (0.55 to 0.60 lb/ hp/ h)	335 to 365 g/ kWh (0.55 to 0.60 lb/ hp/ h)	335 to 365 g/ kWh (0.55 to 0.60 lb/ hp/ h)
Engine installed weight	35.6 kg	41 kg	< 15 kg
Status	Development Completed	2 Nos. Prototype Engine delivered to DRDO for flight testing	Under development

Structural and Material Sciences



Manufacturing of Cocured Composite Structures for Aircraft

Composite parts of LCA



Composite parts of SARAS aircraft

Manufacturing of primary aircraft composite structures for fighter aircrafts, transport category aircrafts and UAVs with autoclave moulding technology.

Year of Development : 1990-2018

Application

- Structures like wing, horizontal and vertical tails, fuselage shells, control Surfaces like rudder, elevator, aileron, flaps etc. developed for LCA-Tejas and SARAS aircrafts. Parts developed for LCA have entered Series Production.

Salient Technical Features

- Autoclave processing of prepregs is a well-established technology in the aircraft industry. It offers excellent reliability and part quality mandated for airworthy parts. This technique remains a benchmark for competing processes. Parts with fiber loading of 58-60% and void content less than 1% can be produced using this technology.
- CSIR-NAL has developed cocuring technology indigenously to realize highly integral structures for aircraft programs. The primary benefits of co-curing are reduction in part count, elimination of fasteners, reduced assembly and associated costs and elimination of stress concentration zones due to fastener holes, elimination of fuel

Manufacturing of Cocured Composite Structures for Aircraft

leakage etc. The total structure is realized in shorter time compared to the traditional fastened structure.

- More than fifteen LCA aircrafts have taken to skies with composite structures manufactured at CSIR-NAL and extensive flight testing has been done with composite parts performing excellently.
- Some of the structures developed have won prestigious awards in international forums like JEC Asia innovation awards in 2013, 2015 and 2016.

Level/Scale of Development :

TRL: 10, Proven through successful demonstration of autoclave moulding technology both on civil and fighter aircrafts.

Intellectural Property Rights (IPR) :

Patent Not Applicable

Commercialization

For the LCA program,

- CSIR-NAL has transferred the technology to HAL
- CSIR-NAL has tied up with Tata Advanced Materials Ltd. as production partner for the supply of critical composite parts for series production.
- Moreover, the technology can be commercialized based on the specific structure that needs to be developed.

Available in Market

Autoclave processing of prepregs is a well-established technology in the aircraft industry. However, its application to develop cocured and integral parts and the associated tooling is available with a very limited companies globally.

CSIR-NAL developed technology used in LCA Tejas and SARAS aircraft.

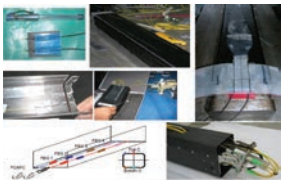
Techno-Economics

- Cocuring technology is one such approach wherein more than 50% of expensive fasteners can be eliminated and assembly time is reduced.
- Composites materials bring in overall reduction in life cycle costs of a particular component by reducing the need for frequent inspection, insensitivity towards corrosion etc.

Parts	Reduction of part count due to co-curing
LCA Fin	200 parts to 15 parts
LCA Rudder	50 parts to 6 parts
LCA Centre Fuselage	500 parts to 44 parts
LCA undercarriage Doors (Aft and Fwd)	40 parts to 5 parts

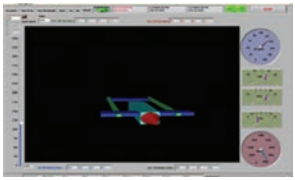
Impact : Co-curing technology has resulted in more than 20% savings in cost and about 15% reduction in weight.

Structural Health Monitoring Technology for Composite Structures using Fiber Optic Sensors

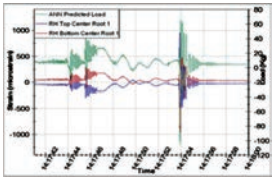


Fiber Optic Sensor Integration

Sensor Interrogation



GUI Software for Data Acquisition



Data Analyses & Reporting

Structural Health Monitoring (SHM) Technology leading to systems capable of continuously monitoring structures for damage.

Year of Development : 2010 flight trial testing started

Applications

- Online and offline strain measurement
- Damage and load estimation using strain profile
- Impact event monitoring and detection

Salient Technical Features

- Expertise in robust sensor installation for under manufacturing and built-up composite structures
- Expertise in integrating the COTS fiber optic sensor interrogators with other subsystems for synchronized data acquisition during testing
- Real time sensor measurement, data acquisition and reporting with in-house developed software modules

Level/Scale of Development : TRL – 4, Successful technology demonstration

- At ground level for complex

Structural Health Monitoring Technology for Composite Structures using Fiber Optic Sensors

composite test box structures having multiple spars, ribs and skins

- At flight levels for inflight strain measurement on 2-Seater HANSA aircraft and Nishant UAV

Intellectural Property Rights (IPR): QuickVIEW© Indian Copyright granted on 24 December 2013 vide no. SW-7582/2013

Commercialization

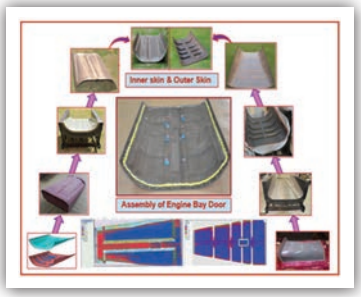
Development stage

Available in Market : Not Applicable

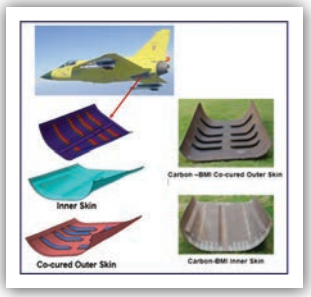
Techno-Economics

- Structural Health Monitoring (SHM) Technology leading to systems capable of continuously monitoring structures for damage

Manufacturing of High Temperature Resistant Co-cured Composite Structures using Carbon-BMI Prepreg



Exploded View of Engine bay door assembly of LCA-TEJAS



Developmental approach to realize co-cured Engine bay door assembly

Most of the composite structures for the aircraft have been developed using carbon-epoxy prepreg material system, which can withstand maximum service temperature of 120°C temperature. Hence this material system cannot be used in the hot zones like Engine vicinity areas. Carbon-Bismaleimide (BMI) materials are used on some of the most important and complex high performance application ranging from military programs such as US Air Force F 22 to Formula-1 race cars.

Year of Development : 2011-2018

Application

- Carbon-BMI materials technology is useful for emerging aircraft engine programs for the development of Composite fan blades, fan cases etc. This development opens a new segment in the composite processing technology, where composite can be used up to service temperature of 230°C in any engineering sector.

Salient Technical Features

- Autoclave processing of prepregs is a well-established technology in the aircraft industry. It offers excellent reliability and part quality mandated for airworthy parts using carbon-epoxy prepregs. Similar level of confidence was achieved by developing Engine Bay Door (Middle) of LCA-TEJAS for the first time in the country using Carbon-BMI prepreg.

Manufacturing of High Temperature Resistant Co-cured Composite Structures using Carbon-BMI Prepreg

- Most of the airframe manufacturers uses carbon-BMI prepreg to manufacture simple monolithic skin and ribs and then assembled by fasteners, where they lost composite real advantages like reduction in part count, elimination of fasteners, reduced assembly elimination of stress concentration zones due to fastener holes and elimination of fuel leakage etc.
- First time co-cured engine bay door was developed and undergone qualifications tests and cleared by relevant regulatory authorities for flights.

Level/Scale of Development : TRL-10, Proven through successful demonstration of autoclave moulding technology and static structural testing of Carbon-BMI Engine Bay Door of LCA TEJAS.

Intellectural Property Rights (IPR): Not Applicable

Commercialization

- Currently used to fabricate simple skins and less contoured parts due to BMI resin property at curing temperature. However, its application to develop cocured and integral parts and the associated tooling is available with a very limited company globally.

Available in Market : Used in LCA-Tejas

Techno-Economics

- Realized that the savings in weight and performance can be maximized using cocuring technology. This results in large reduction of fabrication cycle time, cost and weight.
- Co-cured structures have fewer fasteners which results in shorter assembly cycle time and also reduce sealing issues.
- Composite materials are the materials of choice for the designer today. It is not only sufficient to reduce the weight, but to make it cost effective.

Process Technology for continuous preparation of Carbon Fiber (NAL-CF1)

Characterized by high tensile strength, high stiffness, fatigue resistance and light weight, carbon fibers are the preferred reinforcement material in the advanced composites in aerospace and other high performance structural applications.

Year of Development : 2015

Applications

- Carbon fiber composites in aircraft structures such as wings, rudder, elevator, aileron, flaps etc. in SARAS and TEJAS
- As composites in heat shields in Re-entry vehicle structures

Salient Technical Features

Fully Integrated Technology
(Acrylonitrile → PAN copolymer → Special acrylic fiber → Carbon fiber)

- Polymer production at 35 kg/h rate
- Precursor fiber spinning at 5 TPA
- Conversion of Precursor fiber to Carbon fibers at 5 TPA

Level/Scale of Development : TRL6.

- Pilot plant scale employing continuous processes at rates suitable for development/ small scale production.
- Standard modulus grade carbon fibers NAL-CF1 is certified by CEMILAC for aerospace application.

Process Technology for continuous preparation of Carbon Fiber (NAL-CF1)

Intellectural Property Rights (IPR): The technology is not new and internationally it is out of patent regime.

Commercialization

Currently working with a public sector enterprise and a Government agency to set up production plant with CSIR-NAL technology.

Available in Market: No

Techno-Economics

- The cost of production is sensitive to production capacity. For strategic and defense 300 tons per year will be quite viable.
- For general industrial applications, a capacity of 1000 to 1200 tons per year will be commercially viable.

Autoclave – Industry Grade, Lab Scale and Desktop

Industrial grade Autoclave

Lab scale Autoclave

Power panel for Industrial grade Autoclave

Desktop Autoclave

NAL's expertise in designing and building Aerospace Grade Autoclaves is evident from the number of autoclaves that are in operation in the country right from the Desk top to Lab scale to Industrial grade.

Lab scale and Desk top Autoclaves are very popular in Academic institutions

Industrial grade autoclave were supplied to Defence and Space establishments. Nations Largest autoclave (5.5m dia and 10m length) is under fabrication for VSSC, Trivandrum.

Autoclave – Industry Grade, Lab Scale and Desktop

To cater to the thermoplastic composites processing requirements, an high temperature (425 deg C and high pressure (15Barg) Autoclave is developed. Presently, one such autoclave is being supplied to IIT Delhi.

The technology has been transferred to several MSMEs in the country. These industries have generated a revenue of about 40 crores as on date.

Year of Development : 2010

Applications

- Manufacture of composite structures for strategic aerospace, automobile, education and allied sectors

Salient Technical Features

- Fail safe and easy to operate
- Auto, semi-auto and manual modes of operation
- Davit arm/ Hinged door with lock ring less design
- Pressurised motor with health monitoring
- PC, PLC, Front –end controllers and Recorder based C&I architecture
- Multiple level safeties
- Heater power steering logic
- Advanced insulation system for minimal energy losses
- Identification and management of single point failures
- Advanced process control software with remote monitoring
- Master and stand by computer control

Level/Scale of Development : TRL-9
Successfully commercialized.

Intellectural Property Rights (IPR):
Patent under process

Commercialization

Industrial grade and Lab scale Autoclaves:

- KRR Engineering, Chennai and
- Unique Chemoplants Equipments (UCE), Mumbai.

Desktop Autoclaves:

- Milvus Aero solutions, Bangalore
- Datasol India Pvt., Ltd, Bangalore
- Lakshmi Engineering Works, Chennai

Autoclave – Industry Grade, Lab Scale and Desktop

Available in Market : Autoclave supplied to :

Industrial Grade : ASL-Hyderabad, VSSC-Trivendrum, ADE-Bengaluru, SHAR - ISRO Sriharikota

LAB Scale : IIT-Kanpur, IIT-Bombay, IIT-Delhi, IIT-Hyderabad, MIT-Manipal, ISAC-Bengaluru

Desktop: IIT-Chennai, IIT-Guwahati

Techno-Economics

- About 70% of the cost of imported autoclaves.
- NAL autoclave technology is comparable with that of international manufacturers.
- Several Autoclave orders were won against international bidders.

Autoclave Specifications

Sl. No.	Specifications	Mark-IV	Mark-III	Mark II	Mark I	Desktop	LabScale
1	**Diameter (for working space)**	4400 mm	2000 mm	2800 mm	1800 mm	450 mm	900 mm
2	**Length (for working space)**	9000 mm	4000 mm	5200 mm	4000 mm	500 mm	1000 mm
3	**Maximum Pressure**	7 Barg	15 Barg	7 Barg		7 barg	7 barg
4	**Maximum Temperature**	250 °C	350 °C	250°C	200°C	200°C	200°C
5	**Heating rate**	0 to 5 °C per min	0 to 4 °C per min		0 to 5°C per min	0 to 3° C per min	0 to 3° C per min
6	**Cooling rate**	0 to 3 °C per min.				1° C per min	3° C per min
7	**Total power rating (3 Phase,** 415 V (typical)**)**	1230KW	292KW	277KW	123 KW	7 kW single phase	23 kW

Radomes for Airborne and Weather Applications

Jaguar nose cone composite radome

DWR Radome at Kochi, Kerala

DWR Radome installed at Bhuj,Gujarat

Radome is a structural and weatherproof enclosure protecting the radar antenna while causing minimal attenuation to the radar signals. Fibre reinforced polymer composite materials have emerged as the designers' choice for radomes due to their unique properties of high specific strength/stiffness, electromagnetic (EM) transparency, light weight and non-corrosiveness. These materials can be moulded into different geometries as required and become cost effective based on the choice of appropriate processing techniques. NAL has developed cost competitive manufacturing technologies for airborne and ground based weather radomes of strategic significance. Nose cone radome of Jaguar maritime aircraft & Spherical radome for Doppler weather radar are the outcome of the indigenous effort that have culminated successful technology transfers to industry.

Radomes for Airborne and Weather Applications

Year of Development :

2014– Airborne Nose Radome
2013–Ground Based Weather Radome

Applications

- Airborne Nose Radome for fire control radar of Jaguar Maritime Fighter Aircraft fleet (IAF).
- Ground Based Radomes for protection of Doppler Weather Radars of IMD which includes the Indian coastline and hilly regions of the North-East.

Salient Technical Features

- The Airborne nose cone radome has been developed using a novel Resin Injection Technology (RIT) that includes development of contoured fabric pre-forms and closed mould pressure assisted high temperature resin injection. The radome has successfully met the stringent airworthiness qualification standards of CEMILAC, DRDO and has been flight tested.
- The Ground Based Weather Radome is a spherical radome of diameter 12.88m. It has 66 polygonal panels fabricated using PolyUrethane (PU) Foam core glass epoxy sandwich composite. A cost-effective wet lay-up and Room Temperature vacuum bag moulding process has been adopted. The Radome is designed to withstand 250 km/h wind speed with gusts upto 300 km/h.

Level/Scale of Development : TRL - 9

- Technology tested in real/ field trials at full scale.
- CEMILAC airworthiness certification obtained & radomes are in service of IAF since 2008.

Intellectural Property Rights (IPR):

Patent NA

Commercialization

- ToT of Airborne Radomes to HAL, Bangalore completed in 2013.
- ToT of Weather Radomes to BEL, Navi Mumbai completed in 2014.

Available in Market

Airborne Radome: 7 production radomes have been manufactured at HAL till date.

Radomes for Airborne and Weather Applications

Weather Radome: The manufacturing facility has been established at BEL Navi Mumbai and awaiting orders from IMD.

Weather radomes are installed at SHAR-Sriharikota, Bhuj - Gujarat, Kochi - Kerala, Gopalpur - Orissa, Cherrapunji - Meghalaya

Techno-Economics:

For Airborne Radomes:

- Unit cost: Rs.11 Lakhs at ToT stage. Further cost reduction expected with HAL taking up production of 50-60 nos.
- Saving of precious foreign exchange of nearly 200% vis-à-vis the imported Israel radome.

For Weather Radomes:

- Unit cost: Rs.116 lakhs approx. at ToT stage. Further cost reduction expected with production of 30-40 Nos. by BEL.
- Saving of foreign exchange of minimum of 30% vis-à-vis imported US radomes and also allows deployment in strategic locations.

Multi Zone Hot Bonder

Hot bonder is a special purpose equipment that enables in situ bonded repair of Aircraft / Helicopter structures, wind turbine blades and other advanced composite structures. Multi zone hot bonder enables bonded repairs, simultaneously at multiple locations, while maintaining the temperature uniformity. Using this feature one can carry out, large and complex repairs along with test coupons with very good cure quality.

Year of Development : 2018

Applications

- To perform in situ repair / hot bonding of composite structures used in aircraft, helicopter, UAV, Wind turbine blades, automobile etc.
- Complex and multiple repairs along with test coupons
- Thermo-forming of foams for aircraft structures

Multi Zone Hot Bonder

Salient Technical Features

- High performance and cost effective repair kit
- Advanced features for complex and multiple repair
- 7" Colour touch screen (PLC-HMI) controller
- 2 simultaneous repairs with independent 12-zone temperature control
- Maximum temperature: 230°C (for silicon heater blankets)
- Menu driven program to create, run, view Cure Cycles (CC)
- Online and offline reporting / printing
- Hold, modify and continue or extend CC
- Power interruption management

Level/Scale of Development : TRL-9

Intellectural Property Rights (IPR) : Nil

Commercialization

Non-exclusive ToT licenses have been taken by M/s SAN Process Automation, Bengaluru and M/s Ajay Sensors, Bengaluru.

Availability in Market

- A tender for 7 numbers was submitted by ToT licensee.
- Budgetary estimation was provided to IAF, Nasik and Navy, Goa

Techno-Economics

- Cost saving of over 30% on initial procurement and over 50% on maintenance compared to imported system.
- Serves as an important import substitution for the strategic sector.

Nickel-Titanium (NiTi) shape memory alloy (SMA) products for engineering and biomedical applications

Photograph of Ni-Ti braided mesh using 80 µm diameter wire

NiTi SMAs finds wide usage in a variety of smart systems and devices pertaining to engineering and biomedical fields

Year of Development : Commerical production 2018

Applications

- Engineering applications: sensors and actuators, frangibolt, pin-puller, pipe coupling, vibration dampeners, etc.
- Biomedical applications: orthodontic arch wires, guide wires, stent-grafts, flow diverters, bone staples, etc.

Salient Technical Features

- Indigenous technology for fabrication of NiTi SMAs in various product forms (wires/strips/rods)
- Technical know-how for processing of alloys with shape memory effect and superelastic behavior

Level/Scale of Development : TRL-8

- The process technology for NiTi SMA fabrication has been successfully demonstrated in industries in commercially viable scale
- Technical know-how is ready for transfer to industries Production Version

Intellectural Property Rights (IPR) :

- Process know-how developed indigenously
- No patents filed
- IPR with CSIR-NAL

Commercialization

Licensing of the process technology to MIDHANI, Hyderabad for commercial production

Nickel-Titanium (NiTi) shape memory alloy (SMA) products for engineering and biomedical applications

Available in Market

- NiTi semi-finished products (Plates / Rods / Strips / Wires / Springs) for Engineering applications are manufactured and sold by M/s MIDHANI, Hyderabad using CSIR-NAL Process Technology

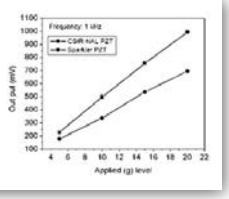
Techno-Economics

- M/s MIDHANI, Hyderabad is the only producer of NiTi SMA in India with CSIR-NAL Process Technology
- India has a huge market potential (> 1000 crore) for NiTi SMA products with an annual growth rate of 10 to 14%.

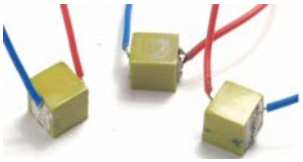
Development of PZT powders, fabrication of PZT multilayered stacks, bimorphs, unimorphs and ring shaped products

PZT Powders

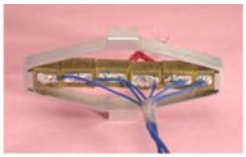
PZT Rings for accelerometer application



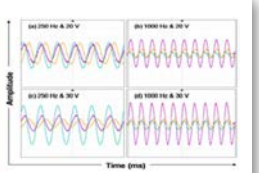
Linearity of output voltage at different "g" level of PZT rings



PZT Multilayered Stacks



Amplified Stack Actuator



Frequency response of ASA

Lead Zirconate Titanate (PZT) powder is a piezoelectric material. These materials produce electric charges on application of mechanical stress, therefore, used for sensor applications. Similarly, these materials undergo dimensional change when subjected to an electric field, therefore, used for actuation applications. PZT is a synthetic piezoelectric material with high piezoelectric charge coefficient (d_{33}). PZT powder is used for fabrication of various types of components such as in the form of rings, circular discs, rectangular and square shaped plates, multilayered (ML) stacks, unimorphs, bimorphs etc. These devices are widely used for many engineering applications such as aerospace vibration control, precision fluid flow control, underwater sonar transducers, accelerometers, force transducers, vibration sensors, vibration energy harvesting etc. At CSIR-NAL, PZT powders of high piezo properties were prepared by wet chemical route with piezoelectric charge constant (d_{33}) > 500-700pC/N.

Development of PZT powders, fabrication of PZT multilayered stacks, bimorphs, unimorphs and ring shaped products

Year of Development : 2002-12

Application

- PZT devices are used for aerospace vibration control, accelerometers, force transducers, vibration sensors, precision closing and opening of valves, sonar transducers, vibration energy harvesting etc.

Salient Technical Features

- A process for preparation of PZT powders with high piezoelectric charge constant (d_{33} > 500-700pC/N).
- Prepared by wet chemical route, therefore, minimum variation in piezo properties from batch to batch.
- Fabricated PZT multilayered stacks by tape-casting technique.
- Amplified stack actuators (ASAs) of varied displacement (max. displacement achieved: 173μm at 175V).
- Fabricated PZT rings having linear output voltage at different "g" (up to 20)

Level/Scale of Development : TRL-7

- PZT powder: 1-10kg/batch
- PZT multilayered stack: Lab scale

Intellectural Property Rights (IPR) : Nil

Commercialization

Non-exclusive licensing of NAL's PZT powder technology to M/s IPA Pvt. Ltd, Bengaluru for commercial sale of PZT powders/products.

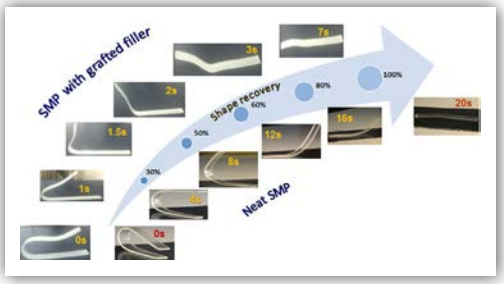
Available in Market

The products are generally imported.

Techno-Economics

- Low cost of development of PZT powders and products, therefore, commercially viable.
- Strategic material, therefore, its import may be restricted.

Bio-compatible Shape Memory Polymer



Shape memory response behaviour of Neat SMP and SMP with grafted filler

The in-house developed Bio compatible shape memory polymer (SMP) made of tBA – PEGDMA matrix (70 wt% tBA: tert-butyl acrylate +30 wt% PEGDMA: polyethylene glycol dimethacrylate) with addition of grafted hydroxyapatite (HAp) filler has improved mechanical properties and shape recovery rates when compared to acrylate based neat SMP and SMP composites. The addition of grafted HAp filler has increased the tensile strength by 40% and shape recovery rate by 185% when compared to the neat SMP. It also exhibits a higher cell viability compared to the neat SMP making it better for bio-medical applications.

Year of Development : 2017-2018

Application

- Morphing structures, Biomedical devices, orthopedic slab, artificial bone etc.

Salient Technical Features

- Recovery strain 99%, Bio-compatible to skin and bone, Tg = 35° to 55°C

Level/Scale of Development :

TRL-6, Industry standard

Intellectural Property Rights (IPR) :

Indigenously developed in the country

Commercialization

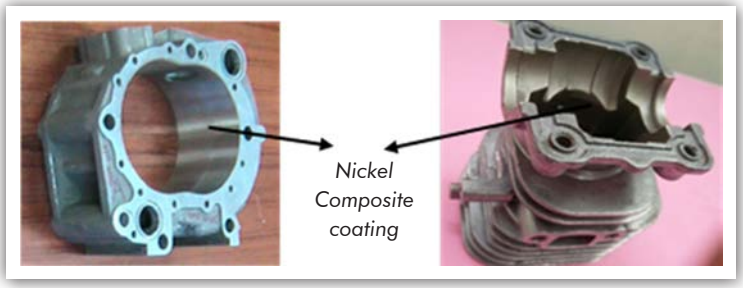
Ready for commercialization

Available in Market : Under discussion with Industry for production and Marketing

Techno-Economics

- Biocompatible and Biodegradable Shape Memory Polymers have huge potential in Medical Application.

Wear resistant nickel based composite coating for aerospace and automobile applications



Coated Trochoid of Wankel (rotary) engine *Coated reciprocating engine*

Aluminium alloys are being adopted in IC engines for strategic and automotive applications. However, due to the inherently poor wear resistance of these alloys a protective coating is required to enhance the performance of the engines. A nickel based composite coating has been developed through simple electrodeposition process which is comparatively cheaper in comparison to the other methods adopted for depositing such wear resistant coatings. The result is a co-deposited composite coating with a high hardness, due to the presence of carbide particles thereby resulting in enhanced wear resistance. Nickel based composite coating of thickness in the range of 50 to 300μm can be deposited on both rotary and reciprocating engines.

Year of Development : 2004-2009

Application

- Used in rotary and reciprocating engines of light weight aircrafts, UAV's, micro UAV, hang gliders and automobiles.

Salient Technical Features

- The coating has a microhardness of >400 VHN for a thickness of ≥100 microns.
- The coating is obtained by a simple and economical chemical method and hence, there is flexibility in thickness and properties.

Level/Scale of Development : TRL-7

- Coated on Trochoid of CSIR-NAL's indigenous 55hp and 65hp Wankel Engines and flight tested successfully in UAV-NISHANT. Tested on automobile engines.

Wear resistant nickel based composite coating for aerospace and automobile applications

Intellectural Property Rights (IPR) :

Ni-SiC composite coating for rotary and reciprocating engines. Patent Application number : 945/DEL/2014

Commercialization

Proven on prototypes. Yet to be commercialized

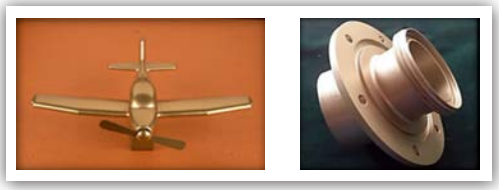
Available in Market

Currently the coating is being imported from U.S or U.K.

Techno-Economics

- The total demand of Aluminium in the auto sector of India is likely to be 11 mn tonne by 2030. Aluminium and its alloys inherently possess poor tribological properties hence, the composite coating is mandatory for all the moving parts.

Eco-Friendly Process for the Preparation of Corrosion Resistant Sealed Anodized Coatings on Aircraft Aluminium Alloy



Anodized model components

Outdoor Exposure study (for 18 months) of anodized aluminum alloys at Coastal area- Mandapam Camp, Rameshwaram

A chromate free pretreatment process for the corrosion protection of aerospace aluminum alloy.

Year of Development : 2015

Application

- Aluminum alloy structural components

Salient Technical Features

- At present no chromate free technology is available for the corrosion protection of AA 2024 alloys used in aircraft applications.
- An indigenous and cost effective process has been developed.
- The coating system is chromate free corrosion protective system for aluminum alloys with societal impact.
- This process can also be used in automobile sectors.

Level/Scale of Development : TRL-7
Panels (10"X3") qualified for > 3000 h of continuous salt spray test as per ASTM B117.

- Process Clearance from CEMILAC (RCMA (F&F-FOL)/NAL/223-06/443/C-01/2018/01; dated 07/05/2018) has been obtained.
- Collaborative efforts are in progress between CSIR- NAL and ARDC, HAL to establish 5000 Ltrs anodization facility at ARDC, HAL.

Eco-Friendly Process for the Preparation of Corrosion Resistant Sealed Anodized Coatings on Aircraft Aluminium Alloy

- Discussions held with various divisions of HAL and ADA for Type Approval of the process by CEMILAC.

Intellectural Property Rights (IPR) : An improved process for the preparation of corrosion resistant sealed anodized coatings on aluminum alloy, INDIAN PATENT (App. No. 159/DEL/2015); US Patent No. U.S 15/543,153.

An International patent application pending (no. PCT/IN2016/050003 filed on 6 January 2016).

Commercialization

Establishing the scale up plant for this process is in progress. Organizations like ADA and AR&DC, HAL have shown interest for this process technology apart from M/s Airbus and M/s Boeing Industries.

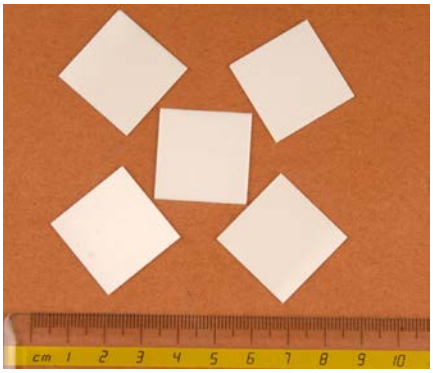
Available in Market

Not available in the market.

Techno-Economics

- Chromate-free coating systems to be in place by 2026 as per NASF forecast.

Tapecasting Technology for Ceramic Substrates



Alumina ceramic substrates are in great demand in the country for space and electronics industries and they are being imported. Zirconia substrates find application in the fabrication of solid oxide fuel cells (SOFC) and oxygen sensors. CSIR-NAL has developed alumina and zirconia substrates. The properties of indigenously developed alumina ceramic substrates exceed the benchmarked specifications. The technology has been transferred to M/s. Carborundum Universal Ltd. (CUMI) and CUMI has successfully commissioned an industrial scale tapecasting facility for the production of ceramic substrates.

Year of Development : 2014 - 2015

Applications

- Electronics Industry
- Aerospace Sector - high temperature co-fired ceramics, thermal knife and oxygen sensor
- Energy Sector - Solid oxide fuel cells

Salient Technical Features

- 100-650 µm thick alumina and yttria stabilized zirconia (YSZ) tapes with <90 nm roughness

Level/Scale of Development : TRL-6
Technology transferred to M/s. Carborundun Universal Ltd. (CUMI), Hosur, June 2018

Tapecasting Technology for Ceramic Substrates

Intellectural Property Rights (IPR) :

2338/DEL/2015.
Indian patent (Filed) 30/07/2015

Commercialization

Commercialization by M/s. CUMI

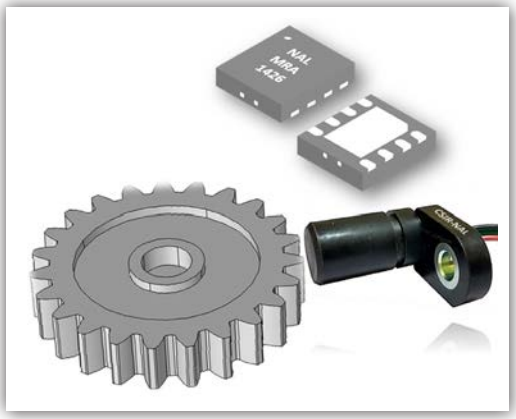
Available in Market

Under production by
M/s. Carborundum Universal Limited

Techno-Economics

- Sales of space electronics substrates will increase by USD USD 8.68 Billion by 2022.

NAL MRA 1426/1427 GMR Magnetic Sensor



The MRA 1427/1426 magnetic sensor utilizes Giant magneto-resistive (GMR) technology, where highly sensitive unshielded GMR elements are configured in a form of single Wheatstone bridge. The Wheatstone bridge generates a differential output voltage with respect to magnetic field gradient along the sensor's sensitive direction. Each resistor has 4-5 kΩ nominal resistance and output of the bridge is purely ratiometric with the power supply voltage. Due to our unique technology and design, MRA 1427 is highly sensitive and has the ability to detect signals at the wide air gap. The excellent thermal and voltage stability makes it suitable for challenging environments.

The MRA 1427 GMR sensor available in 8T-DFN package with dimensions 3 mm x 3 mm x 0.75 mm.

Year of Development : 2010-2016

Applications

- Gear tooth speed sensing
- Direction and motion sensing
- Linear and rotary speed sensing
- Linear and rotary position sensing

NAL MRA 1426/1427 GMR Magnetic Sensor

Salient Technical Features

Chip type:

8T DFN package

Sensing element configuration	:	Wheatstone bridge configuration
Bridge resistance	:	6.4±5% kΩ
Input voltage	:	1-30 V
Field Range	:	5-100 G, unipolar
Saturation of GMR Sensor Elements	:	±300 G
Single Resistor Sensitivity	:	0.033%/G
Temperature Coefficient of Resistance	:	0.033 Ω/°C
Temperature dependence of GMR	:	-0.03%/ °C
Operating Temperature Range	:	-70 to 130 °C

Level/Scale of Development : TRL-8
Scaled to 4 inch Si wafer

Intellectural Property Rights (IPR):
Patent filed in India - 3689/DEL; 1221/DEL; 449/DEL

Commercialization

Ready for commercialization

Available in Market

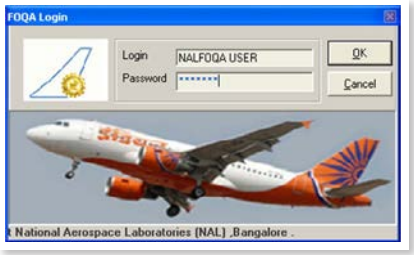
Available with Jayashree Electron Pvt. Ltd. for automobile applications.

Techno-Economics

- As per the market analysis, the overall magnetic revolution sensor market revenue would be 279 million US$ with a corresponding volume of 1347 million units by the year 2016.

Systems Engineering

NAL FOQA flight data analysis system



Black Box Analysis for all aircrafts. NALFOQA is used for flight data analysis by engineering, operations and flight safety apart from certification agency itself.

Year of Development : 2000

Applications

- The software package proven in the industry for more than a decade
- Currently the software is being used by Air India (Delhi & Mumbai), Alliance Air and DGCA

Salient Technical Features

- Modular design with easy to use GUI based application
- Can be configured for any aircraft with any configuration of words per second (WPS)
- Multi-level security protection with password.
- Software is active protected with node locked license
- Easy to use GUI where customer can debug problems and solve
- Can be configured for fixed wing and rotary wing aircrafts also

Level/Scale of Development : TRL-10

Intellectual Property Rights (IPR) : The software has copyright in India

Commercialization

Ready for technology transfer

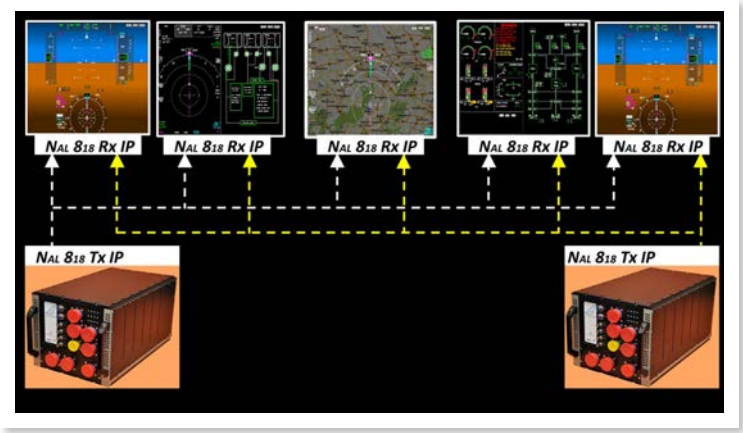
Available in Market

NALFOQA software package proven in the industry for more than a decade

Techno-Economics

- NALFOQA can be commercialized and has large potential in India and other countries.
- NALFOQA has potential to be used for any type of aircraft.
- Every License of imported software cost at least 3 times and RE is too high

ARINC 818 FPGA based IP Core



CSIR-NAL has initiated "Design, development and certification of ARINC 818 FPGA based IP-Core" compliant to DO254 guidelines and requested CEMILAC to help certification of the same. CEMILAC has taken good initiative to start the DO 254 process for FPGA based IP core to establish the process, guidelines and complete framework to certify the IP cores in the country. CEMILAC has approved the FPGA IP Core certification. This is the FIRST TIME in the country to design, develop and certify Complex Electronics Hardware (CEH) ARINC 818 IP core compliant to DO 254 DAL A.

Year of Development : 2015

Applications

- Avionics Display Computer, Cockpit display Unit, Camera and Video Storage.

Salient Technical Features

- Transmission IP-Core and Reception IP-Core
- Supports links speeds of 1X, 2X, 3X, 4X(based on bandwidth requirement)
- Compatible with range of resolution VGA, XGA, SXGA, SXGA+ pixel resolution
- 24 Bit RGB color support

ARINC 818 FPGA based IP Core

- User data transmission and reception along with each video
- All weather-proof carbon fiber composite sensor bar

Level/Scale of Development : TRL-4

- The Technology has been realized and demonstrated on FPGA Spartan 6
- DO254 based certification process under progress

Intellectual Property Rights (IPR) : None, Import substitution

Commercialization

Semi-Commercial. The IP core is being certified for DO 254 by CEMILAC. Discussions are ON for international collaboration with M/s Astronautics USA for FAA certification and marketing Council of Scientific and Industrial Research – National Aerospace Laboratories (CSIR-NAL), Bangalore and M/s. Paras Defence and Space Technologies Limited, Mumbai, entered into agreement for the collaborative development of ARINC 818 Avionics Display.

Available in Market

Available with one international vendor

- Costing around $500000
- Without IP rights
- Configured for single configuration (single resolution/feature)
- Without source
- Usage licensing policy

Techno-Economics

- Indigenized FPGA IP of ARINC818 standard can be integrated onto the any avionics display system modules across different aircrafts.

DRISHTI Transmissometer - A runway visibility measuring system and Aviation Weather Monitoring System (AWMS)

Drishti and AWMS at Kannur International Airport

Drishti gives runway visibility information to pilots and **AWMS** gives information on weather parameters like Wind speed, Wind Direction, Pressure, Humidity, Temperature and Dew Point on the runway.

The weather sensors are mounted on a Frangible - Flexible 10 meter eco friendly free standing mast with provision for ease of maintenance of sensors.

The above parameters are very essential for airports aiding safe landing and takeoff operations of Aircrafts.

Year of Development : Drishti - 2015, AWMS - 2017

Applications

- Drishti and AWMS are Mandatory systems for Airport operations.
- Drishti measures visibility on the runway and is reported to pilots through Air traffic control room.
- AWMS measures all the weather parameters required for airport operations wherein the weather sensors are mounted on a 10 meter Mast as per the requirement of International Civil Aviation organization.

DRISHTI Transmissometer - A runway visibility measuring system and Aviation Weather Monitoring System (AWMS)

Salient Technical Features

DRISHTI

- Base Line : 30m
- Measurement Range of Visibility : 10 - 10000 m
- Reporting Range : MOR :10-3000m RVR: 50 - 2000 m
- Drishti has been given International Class I Certification.

AWMS

- Measurement Range of Parameters
  Pressure : 600 to 1100 hpa
  Temperature : -40 to +60°C
  Relative Humidity : 0 to 100%
  Wind Speed : 0 to 100 knots
  Wind Direction : 0-360°
  Visibility : 10 -10000 m
- Meets ICAO & WMO requirements

Software for Drishti and AWMS :

In Industry standard LabView Platform for data acquisition, computation with self diagnostics and also with provision for web enabling.

Communication

- Dual mode of Communication both through cable and WiFi
- Secured - encrypted -Bi Directional communication through concept of Virtual Private Network.
- The data of both AWMS and Drishti are web enabled with METAR and MET Report as per ICAO standards.

Level/Scale of Development : Drishti and AWMS : TRL-10, Production
Level - Field tested Product with International Certification

Intellectural Property Rights (IPR):
Patent : 1 filed (patent application No.2251/DEL/2015), 3 in filing process
Copyrights : 21
Trade Mark : Sanctioned

Commercialization

Production level

Will be installed in all the Civilian Airports of the country under Partnership agreement signed between CSIR-NAL and ESSO-IMD on 20th May 2014.

Under Memorandum of Agreement (MoA) with Tata Power SED for Indian Air Force Airbases signed in Feb 2016.

Available in Market

Drishti
Civilian Airports :
47 nos of Drishtis are installed in 21 international Civilian Airports in the country

DRISHTI Transmissometer - A runway visibility measuring system and Aviation Weather Monitoring System (AWMS)

Indian Air Force Airbases :

54 Systems are installed in 18 IAF Airbases

AWMS

3 systems working in 3 International Airports. (Bhubaneshwar, Mangalore and Kannur International Airports)

Techno-Economics

- Drishti is 1/4th the cost of similar Imported equipment.
- AWMS is 1/2 the price of the imported system
- Has saved foreign exchange to the country
- Rugged System and easy maintenance .

SUCHAN mini UAV

Suchan is an all-composite, lightweight, modular mini UAV designed and developed by CSIR-NAL. It is designed to meet high altitude operation requirements and has a ceiling altitude of 5000 m ASL. Indigenously designed and developed this mini-UAV is a far more cost efficient solution than other UAVs.

Year of Development : 2017

Applications

- Surveillance Application
  - Raster Scan Survey of large areas
  - Static and Moving Object Tracking
  - Detection, Recognition and Identification of Objects
- Geospatial Mapping Applications
  - Open Cast Mines
  - Sand Ridges
  - Agricultural Mapping
  - Other Civil Applications

Salient Technical Features

Parameter Specifications

Wing Span	:	1.85m
Length	:	1.5 m
Weight	:	~5 kg
Range	:	8-10 km
Endurance	:	60 - 90 minutes
Speed	:	10-20m/s

Operating Altitude : 500 m AGL, 15,000 ft ASL ceiling altitude

Autopilot : PSOC based Controller Auto Pilot developed by NAL In-house developed Control laws

GCS : In-house developed software hosted on Rugged, Waterproof Lap-top Mission planning, Video relay / recording

SUCHAN mini UAV

Payloads:

- Interchangeable Daylight or Thermal Camera with Gimbal control
- Mapping Payload

Launch and Recovery :

Hand-Launch and Belly Landing

Portability :

2 Man portable system

Level/Scale of Development : TRL-8

Actual System complete and flight qualified through test and demonstration in the test sites.

Intellectural Property Rights (IPR) : In the process of obtaining Design Patent and Trademark: **SUCHAN**

Commercialization

Ready for commercialization and Transfer of Technology.

Available in Market

Other competitive UAVs are available in the market but at three to four times the cost.

Techno-Economics

General

- Cost effective system for surveillance and mapping applications

Agricultural & Mapping

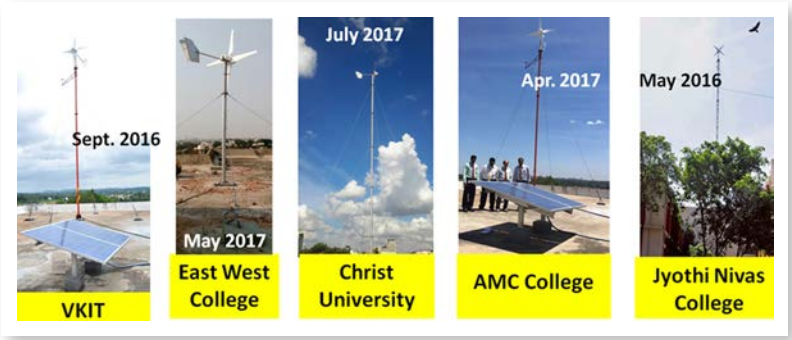
- Accelerate Crop Inspection from the sky, thereby reducing cost by manual inspection.
- Crop analysis is done within hours and disease crops can be identified quickly and action taken. Reduces time & cost for manual survey and pesticide application.
- Mapping of large areas and cities for planning. Reduces time and cost.

Surveillance

- Reduces manpower for perimeter monitoring and surveillance (target detection and tracking)
- Two man operable system.

SOCIETAL MISSIONS

Wind Solar Hybrid (WiSH) System



5 WiSH systems installed and commissioned under PPP mode by CSIR-NAL with M/s ARES Pvt. Ltd., Bengaluru

(900 W Wind + 500 W Solar PV) WiSH systems

10 kW NALWIN Wind Turbine

1 kW, 10 kW and 20 kW WiSH systems are designed, developed and demonstrated to cater to energy requirements at different levels (individual houses, cluster of houses, large community level dwellings).

Year of Development

- 1 kW WiSH system – 2016
- 10 kW WiSH system – 2017
- 20 kW WiSH system – 2018

Wind Solar Hybrid (WiSH) System

Applications

- 1 kW WiSH – Teaching aid for educational institute, remote small hamlets and off grid situations.
- 10 kW WiSH – Agri pump application, domestic lighting
- 20 kW WiSH – Community level energy solution

Salient Technical Features

- 1 kW WiSH
  - State-of-the-art light weight rotor with advanced aerodynamic design & eco-friendly composite blades
  - In-house developed controller.
  - Superior performance for low speed Indian wind regimes, compared to international counterparts.
- 10 kW WiSH
  - Indigenous 5 kW Wind + 5 kW Solar Hybrid system for rural India
  - Versatile for hybridization with other local energy sources
  - Eco friendly CFRP based blades
  - Simple Tail vane direction control mechanism
- 20 kW WiSH
  - Indigenous 10 kW Wind + 10 kW Solar Hybrid system for community level populace
  - Active Yaw directional control mechanism
  - Integrated controller-cum-inverter for outdoor application
- Alternator based design for low cut-in.

Level/Scale of Development

- 1 kW WiSH – Commercially available : TRL-8
- 10 kW WiSH – Technology Demonstration : TRL-8
- 20 kW WiSH – Technology Demonstration: TRL-6

Intellectural Property Rights (IPR):

- 1 kW WiSH – To be filed
- 10 kW WiSH – To be filed
- 20 kW WiSH – To be filed

Commercialization

- 1 kW WiSH – Licences to M/s ARES, Bengaluru
- 10 kW WiSH – Technology available for ToT
- 20 kW WiSH – Technology available for ToT

Available in Market

- 1 kW WiSH – Yes
- 10 kW WiSH – No
- 20 kW WiSH – No

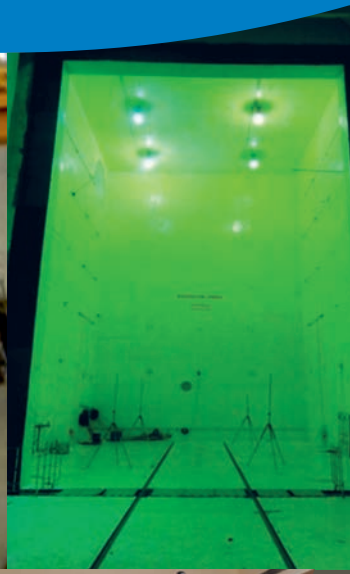
Techno-Economics

- 1 kW WiSH – Affordable for colleges, O&M available
- 10 kW WiSH – Low O&M cost due to tiltable tower
- 20 kW WiSH – Low cost technology for rural community.

CSIR-National Aerospace Laboratories
P B No1779, HAL Airport Road, Bengaluru-560017
www.nal.res.in

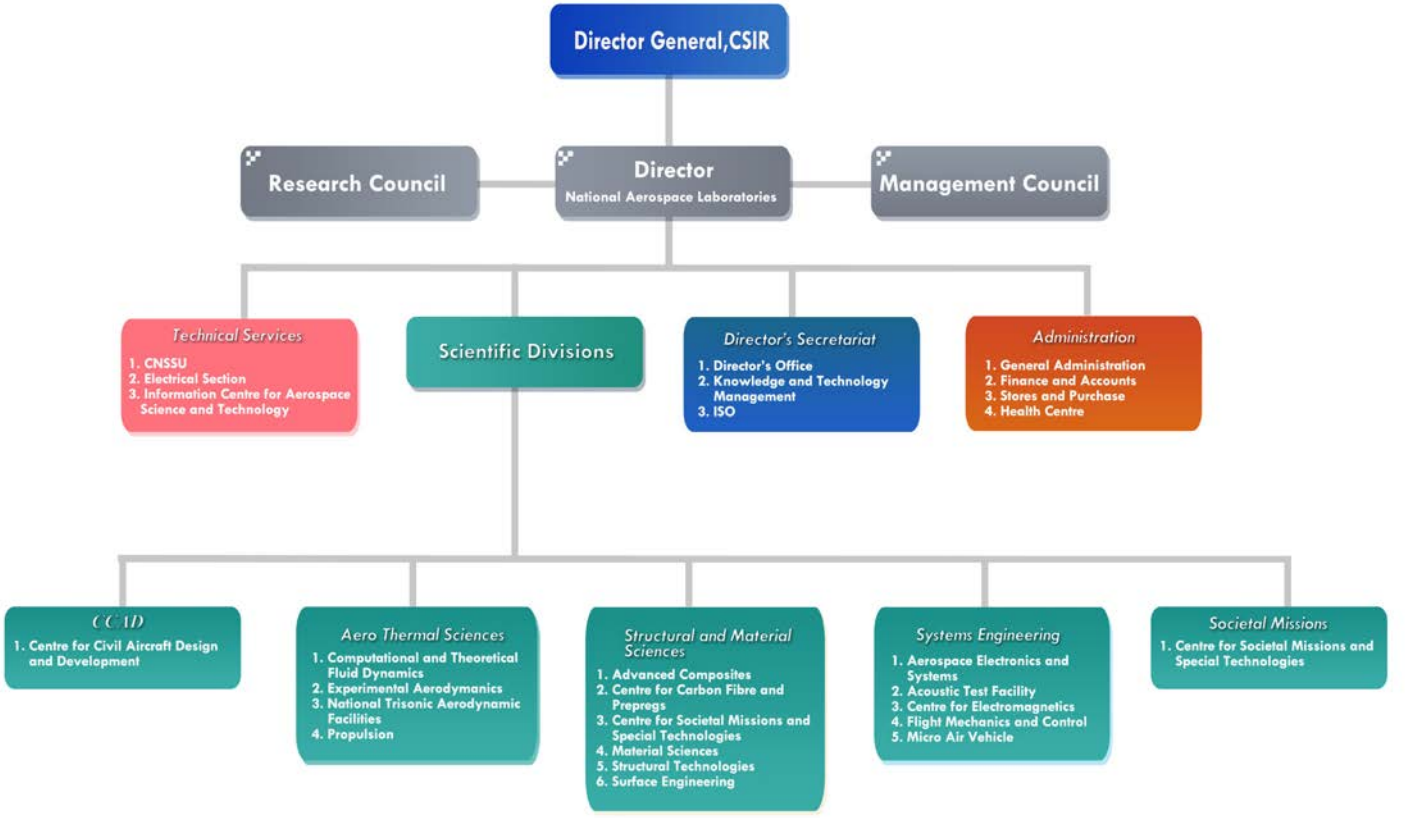
TEST FACILITIES

CSIR - NATIONAL AEROSPACE LABORATORIES



Contents

Organization Chart



Foreword

National Aerospace Laboratories (NAL), a constituent of the Council of Scientific and Industrial Research (CSIR), India is the only civilian aerospace R&D laboratory in the country. CSIR-NAL is a high-technology oriented institution focusing on advanced disciplines in aerospace and has a mandate to develop aerospace technologies with strong science content, design and build small and medium size civil aircraft and support all national aerospace programmes. Core competence of NAL spans practically the whole aerospace sector namely civil aircraft design and development, MAV design and development, computational fluid dynamics, experimental aerodynamics, flight mechanics and control, turbo machinery and combustion, composites, structural design, analysis & testing, structural dynamics & integrity, aerospace materials, surface modifications, avionics and instrumentation, electromagnetics, metrological modeling, wind energy etc. To carryout R&D in these multidisciplinary areas CSIR-NAL has many advanced test facilities recognized as National Facilities. These are not only best in the country but are also comparable to other similar facilities in the world. Along with these facilities and its globally recognized competence has enabled CSIR-NAL to achieve outstanding R&D successes, innovative technology developments and advanced national test capabilities. It is noteworthy to mention that every Indian aerospace vehicle has graduated out of NAL's 1.2m Trisonic Wind Tunnel. It has completed nearly 47000 blowdowns and performing reliably over 50 years. The Acoustic Test Facility commissioned at CSIR-NAL for ISRO in 1986 has carried out on all of ISRO's launch vehicle stages (ASLV, PSLV and GSLV) as well as satellites. These are the two major national aerospace test facilities to mention amongst the whole gamut of test facilities established at CSIR-NAL. This compendium of test facilities provides an insight on various test facilities at NAL and their significance with application. It also serves as a reference guide to our various stake holders.

JITENDRA J JADHAV
DIRECTOR

AERO THERMAL SCIENCES

Experimental Aerodynamics
National Trisonic Aerodynamic Facilities
Propulsion



EXPERIMENTAL AERODYNAMICS

At the Experimental Aerodynamics Division, research is carried out in three major disciplines: Aircraft & Spacecraft Aerodynamics, Flow Structure & Management, and Flow Diagnostics including Aeroacoustics. The prime objective of the division is to understand the physics of complex flows by use of novel flow diagnostic techniques and generation of aerodynamic data for the development of advanced design concepts and flow modelling.

Experimental Aerodynamics Test Facilities

Category of the Test :

1. 1.5m Low Speed Wind Tunnel
2. 0.3 m Trisonic Wind Tunnel
3. 0.5m Base Flow Wind Tunnel
4. Jet Aero acoustics Research Facility

Year of Establishment : 1990 onwards

1.5m Low Speed Wind Tunnel

0.3m Trisonic Wind Tunnel

0.5m Base flow Wind Tunnel

Jet Acoustics Research Facility

Test Application :

a. 1.5m Low Speed Wind Tunnel

- High Lift Aerodynamics/ Wing tip devices
- Landing gear studies
- Power effects
- Wing-flap optimization studies
- Three-component velocity field mapping

b. 0.3 m Trisonic Wind Tunnel

- Intake studies – buzz control
- Shock boundary layer interaction studies
- PSP Studies
- Density field studies

c. 0.5m Base Flow Wind Tunnel

- Twin jet interaction
- Aircraft afterbody flow studies

d. Jet Aero acoustics Research Facility

Carrier Aircraft launch noise studies

Test Features :

a. 1.5m Low Speed Wind Tunnel

Tunnel Details	
Test Section	1.5m X 1.5m square, 6.5m long
Entry	Square honey comb entry followed by three wire-mesh screens and a 12:1 contraction
Operation	Open circuit, continuous low speed suction tunnel
Power	112kW DC motor with thyristor control
Fan	12 blade low noise composite fan

Flow	
Velocity Range	8 to 50 m/sec
Reynolds number	0.5×10^6 to 3×10^6 per meter
Flow quality	Flow uniformity >99.7%, turbulence $\leq$ 0.11 %

b. 0.3 m Trisonic Wind Tunnel

Tunnel Details		
Test Section size	0.3 x 0.3 m 0.381 x 0.3 m	Supersonic Transonic
Mach number range	0.2 – 4.0	
Operation	Intermittent blow down type	
Reynolds number range	8 x 10^6 to 60 x 10^6 / meter	
Model support	Sting, Wall mounted	

c. 0.5 Base Flow Wind Tunnel

Tunnel Details	
Test Section size	524 mm dia
Nozzle	Variable geometry
Operation	Intermittent blow down type
Freestream Mach number range	0.5 to 4.0
Jet nozzle flow	upto 150psi

d. Jet Aero acoustics Research Facility

Anechoic Chamber	
Chamber dimensions	3.6m x 3.6m x 4.2m (12′ x 12′ x 14′)
Anechoic wedges (L,B,H)	203mm x 609mm x 304mm (8″ x 24″ x 12″)
Exhaust	Treated catcher and duct
Rating	Noise measurements from 500 Hz – 100kHz
Jet rig	
Mach Range	Subsonic to Mach 2.0
Temperature Range	800K at 2.5kg/s
Nozzle Diameter	Up to 50 mm (2″)

Other Test Information :

a. 1.5m Low Speed Wind Tunnel

Measurement capability	
Conventional	Digital manometer, 200 port ESP scanner, Hotwire and hot-film anemometer, 35 channel simultaneous unsteady pressure acquisition
Flow Visualization	Surface oil flow, tuft flow, smoke wire, laser sheet, chemical sublimation
Flow Diagnostics	Two-component LDV, Three component PIV

c. 0.5m Base Flow Wind Tunnel

Measurement capability	
Reynolds number range	10-50 million/m
Model support	Nozzle inner body, 127 mm dia
Test duration	30-40sec
Conventional	Digital manometer, 32 port ESP scanner, 35 channel simultaneous unsteady pressure DAQ
Flow Diagnostics	Particle Image Velocimetry (PIV), Schlieren, Background Oriented Schlieren (BOS)

b. 0.3 m Trisonic Wind Tunnel

Measurement capability	
Conventional	Digital manometer, 32 port ESP scanner, 35 channel simultaneous unsteady pressure DAQ
Flow Visualization	Surface oil flow, Dynamic Schlieren
Flow Diagnostics	Pressure Sensitive paint (PSP), Background Oriented Schlieren (BOS)

d. Jet Aeroacoustics Research Facility

Measurement capability
Far-field acoustic measurements • Arc measurements • Array measurements Flow field measurements • PIV – velocity field mapping • BOS –density field mapping

NATIONAL TRISONIC AERODYNAMIC FACILITIES

The National Trisonic Aerodynamic Facilities (NTAF) division of CSIR-NAL has been serving the country as a nucleus of research and development in high speed aerodynamic since the last four decades. The division is well known for its long and proven experience in providing high quality vital and strategic experimental aerodynamic data required for complex aerospace programmes of the country with the unique ability to develop novel and advanced test techniques. The NTAF is operated as national facility founded by three major users viz., ISRO, DRDO and CSIR and maintained by CSIR-NAL. The NTAF has contributed immensely to all the National programmes of CSIR-NAL, DRDO, ISRO and HAL with utmost security and confidentiality. The major test facilities in NTAF are the 1.2m and 0.6m Trisonic wind tunnels with the auxiliary facilities viz., electrical substation, compressed air facility, design and manufacturing section. NTAF is an active member of Supersonic Tunnel Association International (STAI).

1.2 m x 1.2 m and 0.6 m x 0.6 m Wind Tunnel

Category of the Test : Experimental Aerodynamic data for complex aerospace Programs with the unique ability to develop novel and advanced test techniques

Year of Establishment : 1964-1967

Test Application :

- Static & dynamic aerodynamic force & moment measurements
- Steady & Unsteady pressure measurements
- Carriage load measurements and store separation studies
- Dynamic damping derivatives
- High -speed flow visualization studies
- High speed Air-intake studies
- Hinge moment measurements
- Component load measurements
- Aeroelastic studies
- Supersonic air-intake studies
- Specialized tests for industrial aerodynamics

1.2m Trisonic Wind Tunnel

0.6m Trisonic Wind Tunnel

Test Features :

- Test Section : 1.2m X 1.2m and 0.6m X 0.6m
- Operation : Intermittent blowdown
- Test duration : 30 seconds for 1.2 tunnel; 60 seconds for 0.6m tunnel
- Mach number range : 0.2 to 4.0
  - Off-line flexible nozzle for supersonic
  - Mach number tests in 1.2m tunnel
  - On-line flexible nozzle for supersonic
  - Mach number tests in 0.6m tunnel
- Model incidence : -15° to +27° continuous and step modes
- Model roll : 0° to 360°
- Stagnation pressure : 1.5 to 8.0 bar
- Reynolds number : 8 x 10^6 to 60 x 10^6 per meter

Other Test Information :

a. 1.2m Trisonic wind tunnel

Over the years several augmentations have been incorporated to meet the wide range of needs of aerospace programmes in the country. The tunnel has logged more than 42000 blowdowns.

Tunnel Control System :

- The Integrated Tunnel Control system (ITCS) is based on a standard PC with real time hardware built into it.
- The control software is designed to be menu driven, operator independent, interactive and fully message oriented and is built with necessary safety and emergency routines.

Data Acquisition System :

- NI based 24 channel DAS
- 48 channel high-speed DAS for unsteady pressure data upto 40 kHz.
- 24 channel high-speed wireless system for simultaneously acquisition of unsteady pressure data for 10 kHz.
- DSP based automatic system for pitch and yaw damping derivatives using Forced Oscillation Rig.
- Multi port steady pressure measurements using 32/ 16 port scanners.

b. 0.6m Trisonic wind tunnel

- The special feature of the facility avoids start-stop loads on the model, wherein the tunnel can be started at low supersonic Mach number 1.4 and the nozzle contour changed online to achieve higher supersonic Mach numbers upto 10 sec using VMFN. The tunnel has logged more than 5000 blowdowns.
- The facility is backed by state of the art design tools
  - Solid and surface modeling capability (CATIA/ Solid Works/ Auto CAD).
  - C.A.E. solutions (COSMOS works/ HyperWorks).
  - NC programming (Solid CAM)

PROPULSION

The Propulsion Division is involved in carrying out basic and applied research concerning critical areas of gas turbine propulsion and aerothermodynamics. The division is known for its diverse research themes, exceptional experimental facilities and core expertise. The division's major areas of interest are turbo machinery, combustion and heat transfer, energy systems, rotor dynamics and mechanical aspects of turbo machinery. The Propulsion Division is also keen in research activities leading to development of products. The division has contributed immensely to the National programmes of DRDO and ISRO and has strong collaborations with several international agencies.

High Speed Combustor

Category of the Test : Tests for high speed gas dynamics flow characterization in gas turbine engine component

Test Application : The High Speed Combustor Test Facility is first of its kind in the country to design and evaluate combustors for flight technology demonstrators in the speed range of Mach 2-7

Test Features :

Mach Number	:	3.5
Flow Rate	:	25 kg/s
Pressure	:	20 bar
Temperature	:	1700 -1950 K

Other Test Information : This facility can be utilized for the development of scramjet combustor for flight Mach number 6 - 7. The facility consists of 200 bar air compressor and storage vessels of 30 m^3 capacity. The stored air at 200 bar is regulated to 20 - 25 bar by a control valve. The rig has two step kerosene combustion heaters to heat the air up to 1950 K with thermal protections and water cooling system. The uniform flow water cooled nozzle accelerates the flow to Mach 3.5 at entry to the test section. The diffuser system has been provided for diffusing the high supersonic flow to low subsonic Mach numbers. The 'self ejection principle' is used in this test section-diffuser system. A state of the art data acquisition and control system has been commissioned for this test rig. Application software has been developed exclusively for this facility for fully automated control / operation, data monitoring and logging.

High speed combustor

Semi free jet test

Compressor and Turbine Aerodynamics Studies

Category of the Test : Testing axial flow compressor and turbine stages

Test Application : The Large Scale Rotating Rig is a low speed suck down type of a rig capable of testing both axial flow compressor and turbine stages. It is equipped with instrumentation to make steady state and transient measurements in the stationary and rotating frames. Research work on unsteady rotor-stator interaction, hot streak migration, casing treatment, tip leakage flow characterization, cavity gas path ingestion, end wall leakage flows etc. can be carried out in this rig.

Test Features :

Test Component	:	Turbine/Compressor
Test Section	:	1.52 m dia.
Hub to Tip Ratio	:	0.3 to 0.8
Model	:	Two rows of aerofoils 1. First Vane 2. First Blade

Large Scale Rotating Rig

Rolling Element Bearings Test

Category of the Test : For various tests related to aerospace quality bearings and lubricants

Test Application :

- Testing bearings upto 300 mm outer diameter and speeds upto 25000 rpm. 10,000 class clean room housing all the necessary metrology equipment
- Approved test house by DGAQA
- Facility caters to various lubricant and bearing related tests. Major one's include
  - Fatigue test
  - Static load capacity test
  - Frictional coefficient measurement
  - SOAP Analysis
  - Metrological measurements
  - Inter-shaft bearing

Test Features :

- 10,000 class clean room & metrological equipment
- Fatigue test rig for testing bearings up to 300 mm OD and speeds 25,000 rpm under real life situations
- Rigs for testing static load capabilities, frictional coefficients, axial/radial wobble and sphericity

Other Test Information :

- Environmental chamber to test dimensional stabilities
- Atomic absorption spectrophotometer to evaluate contamination levels of lubricant oils
- Shear stability and four ball tester to evaluate extreme pressure capability of lubricant oils

Bearing Fatigue Test Rig

Small Gas Turbine Engine Test

Category of the Test : Testing of Engines up to 500kg force thrust capacity

Test Application : The facility can be used for testing aero engines less than 500 kg thrust category.

Test Features :

Facility has the following features

i. Test bay area
ii. Electrical room
iii. Control room
iv. Over head fuel tank
v. Compressor room
vi. Fuel room, 100 meters away from the test bay

Small Gas Turbine Test

Other Test Information :

The facility houses following subsystems.

i. Fuel line system
ii. Air line system with compressor
iii. Engine exhaust catch cone system
iv. Online smoke and emission analyzer system
v. Humidity meter
vi. Ground Power Unit (GPU)
vii. Data acquisition system
viii. Crane
ix. CCTV
x. Data acquisition &Instrumentation system

High Speed Axial Turbines

Category of the Test : Versatile Turbine Test

Year of Establishment : 1964-1967

Test Application : Versatile Turbine Test Rig (VTTR) is a hot flow rotating rig being set-up in the division to cater for the future R&D needs of high speed axial turbines.

Test Features :

Max air mass flow	:	9 kg/sec at a pressure of at the test facility 10 bar
Max turbine inlet Pressure	:	10 bar
Max turbine inlet temperature	:	1300 K
Max power absorbing	:	500 kW, (from 14000rpm)
Max speed	:	50000 rpm
Dynamometer	:	Eddy current type (bi - directional)
Stage	:	single stage and multistage

Compressed air supply, EOT crane & hot gas generator

Control room : Data acquisition system

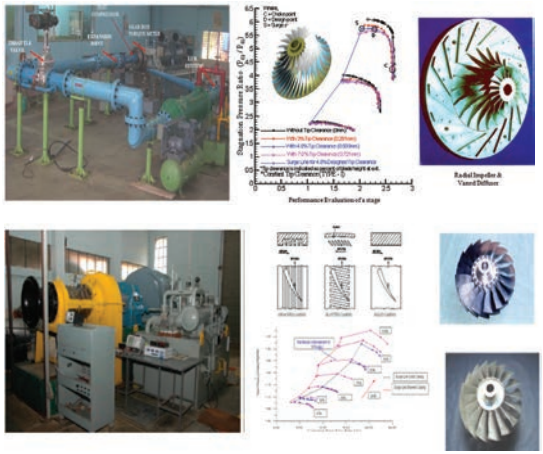
Hot gas generator

Centrifugal and Mixed Flow Compressor

Category of the Test : Closed Circuit Centrifugal Compressor Test

Test Application : The Closed Circuit Centrifugal Compressor Test Rig is a high speed rotating facility equipped to carry-out aerodynamic studies on centrifugal and mixed flow compressors.

Test Features : The rig incorporates a thyristor controlled 375 kW, 3000 rpm DC motor and a step up gear box that can cater for speeds up to 60,000rpm. The rig can handle impeller tip speed of 550m/s, mass flow rate of 10 kg/s and multiple flow mediums.



Closed Circuit Centrifugal Compressor Test Rig (CLOCTER)
and Axial Flow Compressor Test Rig (AFCR)

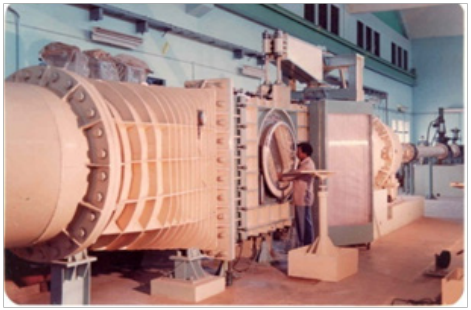
Gas Turbine and Compressor Aerofoils

Category of the Test : Transonic cascade high speed wind tunnel test

Test Application : The Transonic Cascade Tunnel is a high speed wind tunnel equipped to test linear cascade models of compressor and turbine airfoils for aerodynamic performance. The TCT can also cater for quasi 3D studies with coolant flows, end wall secondary flows, inlet boundary layers, inlet turbulence etc.

Test Features :

Type	: Intermittent blowdown
Blade chord	: 40 to 80 mm
Massflow	: 5 to 15 kg/s
Outlet Mach number	: Up to 1.5 (Turbine)
Inlet Mach number	: Up to 0.85 (Compressor)
Reynolds number	: 0.1 to 2.5 Millions



Transonic Cascade Tunnel

STRUCTURAL AND MATERIAL SCIENCES

Advanced Composites Division
Center for Carbon Fiber and Prepregs Centre for
Societal Missions and Special Technologies Materials
Science and Surface Engineering
Structural Technologies

ADVANCED COMPOSITES DIVISION

Advanced Composites Division (ACD) of CSIR-National Aerospace Laboratories (NAL) is regarded as a Centre of Excellence in Composite Structures by Aeronautics Research and Development Board (ARDB). ACD has significantly contributed to the design and development of composite structures for both military and civil aircraft. The division with a judicious mix of basic research and applied R&D has strived hard to identify future trends and stayed at the forefront of technology. It has a high level of expertise in the areas of design, fabrication, non-destructive evaluation, repair and structural testing capable of delivering "Concept to Certification" solution. The division is rigorously pursuing R&D activities in the forward looking areas of Structural Health Monitoring, Damage Tolerant Structures, Processing of Thermoplastics, 3D Composites and Nano Composites.

Digital Image Correlation (DIC) facility for full-field measurements in quasi-static tests

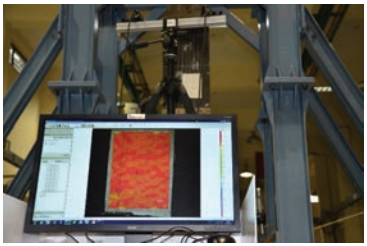
Category of the Test : Full Field Strain and Displacement Measurement

Year of Establishment : 2012

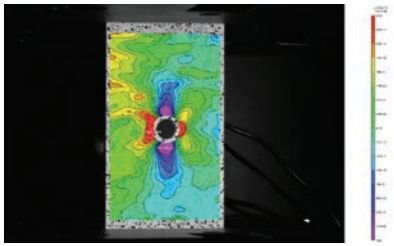
Test Application : Full-field deformation and strain measurements during quasi-static tests on structural components

Test Features : Full-field, non-contact measurements, Can handle test specimens of size ranging from 10 mm to 10 meters, Portable system which can be used for in-situ measurements, Can be synchronized to acquire data along with other data acquisition instruments at client location

Other Test Information : Vic-3D provides full-field, 3-Dimensional measurements of shape, displacement and strain, based on the principle of Digital Image Correlation. Using this method, actual object movement is measured and the Lagrangian strain tensor is available at every point on the specimen's surface.



Full-field strain measurements from DIC



DIC on a specimen with hole – stress concentration

The VIC-3D Digital Image Correlation Measurement System

Equipment for Composite Fabrication

Category of the Test : Facilities for composite fabrication till testing

Year of Establishment : 1990-2000

Test Application : Prepreg cutting, prepreg stitching, component curing, material cutting and composite coupon testing

Test Features : Test control parameters varies with part to part and instrumentation in semi automated mode

Other Test Information : Composite materials have been gaining important industrial and commercial applications world widely and they were developed because they can offer unique properties (lightweight, high strength and stiffness, chemical and corrosion resistance, tailorable electrical and thermal properties, etc.) Which no single homogeneous structural material could be found that had all the desired attributes for a given application. However, due to its composition complexity of a composite material, its final properties are not only depending on the properties of component materials (matrices, reinforcements, fillers and additives) used, but also significantly on the way it was fabricated as well as equipment, technologies and people skills.

Prepreg Cutting Machine

Autoclave

CNC water Jet Cutter

Universal Testing Machine for Coupon level testing

CNC Stitching machine

Composite Fabrication Shop

Category of the Test : Fabrication of laminates, feature level components and Airworthy aircraft structural

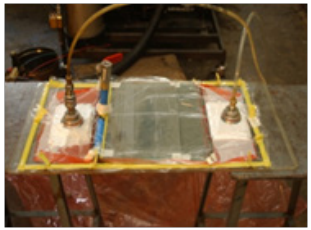
Year of Establishment : 1990-2000

Test Features : Different fabrication process for aircraft structures

Other Test Information : Test control parameters varies with part to part and instrumentation semi automated mode

Tooling Facility

10, 000 class clean room for prepreg layup



Resin Infusion facility

RTM equipment for injection

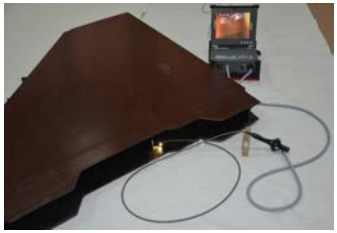
RTM equipment for injection of Epoxy Resins

Non Destructive Evaluation Lab

Category of the Test : Non Destructive testing and evaluation of composite aircraft structures

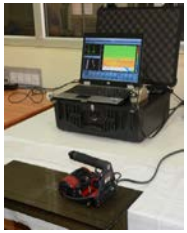
Year of Establishment : 2000

Test Features : Thin to Thick composites structures inspection, Computer controlled instrumentation



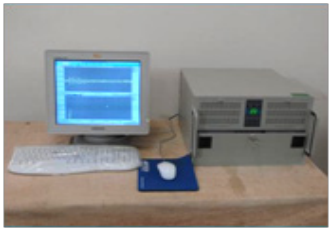
Videoscope

Air Coupled Ultrasonics



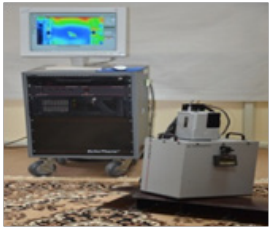
Ultrasonic rapid Scan

Ultrasonic computer controlled C-Scan III System



Acoustic Emission

Real time
X-ray Fluoroscopy



Infrared
Thermography

Structural Health Monitoring

Category of the Test : Structural health monitoring

Year of Establishment : 2000

Test Application : Online and offline strain measurement, Damage and load estimation using strain profile, Impact event monitoring and detection

Test Features : Test under different load conditions

Other Test Information : Structural health monitoring (SHM) is an emerging technology leading to systems capable of continuously monitoring structures for damage.

Power loss test set

FBGSLI

Visual Fault Locator

Spectral eye

sm130 with sm041

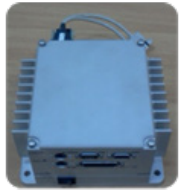
Integrated Optical test & Measurement

High Speed Optical Switches

Splicing Machine

1x4, 1x2 Couplers

Wx-M (Airworthy)



Flightworthy Computer

Optical Spectrum Analyzer

Structural Static Test Bay

Category of the Test : Structural testing

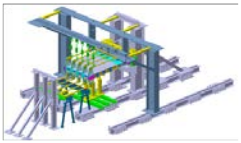
Year of Establishment : 1990-2013

Test Application : Structural testing of feature level components and flight worthy components

Test Features : MTS hydraulic power supply unit of up to 100 lpm at 3000 psi, 10 channel Servo Control system and extendable up to 32 channels (capacity of 53 ton servo controlled hydraulic jacks), Capacity of 50 ton manual control hydraulic loading cylinders, 24 channels Universal Data acquisition system for static and fatigue measurement of strain, displacement, pressure and temperature, 10 non contact,18 draw-wire sensors for displacement measurements High capacity (100 ton) dynamic axial test system

Other Test Information : Load control systems track the applied load and safely unload the test item should excessive deflections or load tracking errors occur. Data can be continuously recorded and data "snapshots" taken at prescribed loading increments.

Structural Testing Facility with MTS hydraulic jacks and control systems



Static Testing of Wing Box

Wing Box under Testing

MTS Hydraulic Jacks for loading with control system

High capacity (100 ton) dynamic axial test system

200 channel strain data acquisition system

Vacuum Membrane Press

Category of the Test : Prepeg forming

Year of Establishment : 2014

Test Application : Forming of flat laminated stack into typical C-sectional shapes (Eg.: Wing spars and ribs) made of Bi-directional carbon-epoxy prepregs for aerospace applications.

Test Features : Dimensions : Closed 3500 x 1800 x 1800 mm, Open 3500 x 1800 x 2160 mm, Working table useful area: 2800 x 1300 x 500mm

Vacuum unit : Oil lubricated, high performance rotary vane pump, Protected with oil and condensate filters, Air suction rate: 25 m^3/h, Vacuum pressure: up to max. – 997,0 mbar

Membrane unit : Membrane frame: reinforced steel construction, Quality silicone membrane, 700% elasticity, long-term flexibility, high temperature resistance up to 180 °C

Heating chamber : Insulated chamber with interior lighting, Circulating air system with overheating protection, Tubular heating elements, Window for monitoring of the process, Working temperature up to max. 120 °C

Other Test Information : This facility is very much useful for forming of flat laminated carbon-epoxy prepreg stack into a C-sectional shape. Shaping of complete flat stack in one go not only reduces the production time but also makes the fabrication process more economical (by 20-25%) for production setup compared to the conventional lamination technique of composite part fabrication.

Vacuum Membrane Press

Robotic Facility for 3D Composites Manufacturing

Category of the Test : Tufting and Z-pinning process

Year of Establishment : 2016

Test Application : Introduction of fibre in 'Z' direction using Tufting & Z-pinning technology in the dry preforms and prepregs

Test Features : Robot with 150Kg pay load, Robot arm reach: 3m, Accuracy: ±0.2mm, Tufting up to 40mm thick dry carbon stack possible, Z-pinning up to 25mm thick carbon prepreg stack possible, Introduction of 'Z' fibre for complex shape structure possible.

Other Test Information : This facility is useful for introducing of fibre in 'Z' direction which enhances the out of plane performance and also arrest the delamination growth. This could help in bringing down the margin of safety and thereby reduction in the weight of composite structures.

Robotic Machine with Tufting Head

CENTER FOR CARBON FIBER AND PREPREGS

The development of various grades of carbon fibers is the main objective of this division. The centre is equipped with pilot-scale processing equipment for the preparation and isolation of polyacrylonitrile (PAN) based copolymer, a fiber spinning line for Special Acrylic Fiber (SAF) and a Heat Treatment line for continuous conversion of SAF into carbon fiber. The centre is fully equipped with characterization instruments including gas chromatograph, spectrophotometer, rheometer, CHN analyzer, HPLC, for testing polymer, conducting rheological studies of polymer solutions, and universal testing machines for determining the mechanical properties of filaments and impregnated yarns, of synthetic polymeric fibers and carbon fibers.

Characterization of Polymeric and composites Materials

Category of the Test : Quantitative and Qualitative analysis of polymeric materials

Year of Establishment : 2012

Test Application : The facility can be used for characterisation and testing of polymeric and composites materials

Test Features : The facility is equipped with equipments like Optical microscope [Leica], High pressure liquid chromatograph [Perkin Elmer], Rheometer [Anton Paar], CHNO elemental analyser [Elementar], Gas chromatograph [Perkin Elmer], Universal testing machines [Instron and Hounsfield/Tinius Olsen] for single filaments, impregnated yarns and composites, Auto titrator, Karl Fisher titrator, capillary viscometer etc.

Other Test Information :

- This facility is used for characterisation and testing of polyacrylonitrile co polymer, special acrylic fiber (SAF), oxidised and precarbonised SAF and carbon fibers prepared in CCFP-NAL.
- This facility is also used for analysis of any polymeric materials, resins and composites in general for other labs in CSIR-NAL and other institutions in the country.

CHNO elemental analyser and Gas chromatograph

Rheometer and High pressure liquid chromatograph

Optical microscope and UV Visible spectrometer

Universal testing machine (UTM)

CENTRE FOR SOCIETAL MISSIONS AND SPECIAL TECHNOLOGIES

High end aerospace technologies have a great deal of potential for adaptation in the Societal Missions. It is in this background, that the "Centre for Societal Missions and Special Technologies" (CSMST) was created in June 2010. The prominent outcomes are in the areas of wind energy, ground and airborne radomes, autoclaves and micro air vehicle technologies. The Centre has been awarded several sponsored projects from ADA, AR&DB, DRDO, NPMASS in highly specialized and niche areas such as LCA wind tunnel models, smart materials (shape memory alloys and polymers) for morphing aircraft applications, 3D woven composites and advanced light weight airframe and nano technologies for micro air vehicles. The Centre has been engaged in providing value added spin-off technology solutions with strong aerospace content based on aerodynamics, composite materials technology and wind power forecasting to the Indian wind energy sector with an aim to make the industry globally competitive.

Environmental Test Facility

Category of the Test : To test a product's integrity, verify manufacturer's claims regarding operational limits, determine realistic warranty terms, and prepare procedures on proper and safe operation by Simulation of environmental aging by accelerated tests

Year of Establishment : 1994

Test Application : To generate design data as well as qualify the fibre reinforced polymeric composites for varied humidity, temperature, altitude & corrosive environments which may be encountered by the material during its service life.

Test Features : Test under different load conditions

Other Test Information : Load control systems track the applied load and safely unload the test item should excessive deflections or load tracking errors occur. Data can be continuously recorded and data "snapshots" taken at prescribed loading increments.

Type of Facilities:

a. Temperature/Humidity chamber (Walk-in type)

Inner Dim. : 2 m (L) x 4 m (D) x 2 m (H)
Temperature: Ambient to 100°C
Temperature Accuracy : ±3°C
Humidity: 20 to 95 % RH
Humidity Accuracy : ± 5 % RH
Rate of Heating : 3°C/ Minute

b. Temperature/Humidity chamber (Floor Model)

Inner Dim. : 1 m (L) x 1 m (D) x 1 m (H),
Temperature: -77 to +177°C,
Temperature Accuracy : ±3°C
Humidity : 20 to 95 % RH,
Humidity Accuracy : ±5 % RH,
Rate of Heating/ Cooling: 3°C/ min.

c. Temperature/Humidity chamber (Floor Model)

Inner Dim. : 1 m (L) x 1 m (D) x 1 m (H)
Temperature :Ambient to 100°C
Temperature Accuracy : ±3°C
Humidity : 20 to 98 % RH
Humidity Accuracy : ± 5 % RH
Rate of Heating : 3°C/ Minute

d. Constant Temperature Water Bath

Inner Dim.: 38cms (L) x 30cms (W) x 30cms (H)
Temperature: Ambient to 98°C,
Temperature Accuracy : ±1°C,
Total Power : 2 kW,
No. Of Water baths : 3 Nos

e. Combined Altitude, Temperature & Humidity Chamber

Inner Dim. : 750mm(L)x500mm(D)x750mm(H),
Temperature : -70 to 180°C,
Temperature Accuracy : ± 1°C
Humidity : Ambient to 95% RH,
Humidity Accuracy : ± 5% RH,
Altitude: Ambient to 1,00,000 Feet (10.9 mbar),
Altitude Accuracy : ± 300 Feet,
Altitude Rate: 2000 Feet/ Min Rate of Heating/
Cooling: 5°C/ Min. (Linear with load of 50 kgs MS),
Total Power: 165 kW

f. Temperature Oven -1

Inner Dim. : 0.5 m (L) x 0.5 m (D) x 0.5 m (H)
Temperature: Ambient to 300°C
Rate of Heating: 3°C/ Minute
Temperature Accuracy: ± 1°C
Total Power: 6 kW

g. Temperature Oven -2

Inner Dim. : 1 m (L) x 1 m (D) x 1 m (H)
Temperature : Ambient to 350°c
Rate of Heating : 3°C/ Minute
Temperature Accuracy : ± 1°C
Total Power : 9 kW

h. Temperature Oven -3

Inner Dim. : 350(L)x350(D)x 350 (H) mm
Temperature : Ambient to +300°C
Rate of Heating : 3°C/ Minute
Temperature Accuracy : ± 1°C
Total Power: 3 kW

j. Extended Temperature Oven (In House)

Inner Dim. : 12 (L)x2.5(D)x2(H) m
Temperature : Ambient to 100°C
Rate of Heating : 3°C/ Minute
Temperature Accuracy : ± 1°C
Total Power : 232 kW

k. High Temperature Muffle Furnace

Inner Dim. : 190(L)x190(D)x300(H) mm
Temperature : Ambient to 1200°C
Rate of Heating : 3°C/ Minute
Temperature Accuracy : ± 3°C
Total Power : 5 kW

Smart Material Testing Facility

Category of the Utility : Dynamic Testing of Materials

Year of Establishment : 2011

Test Application :

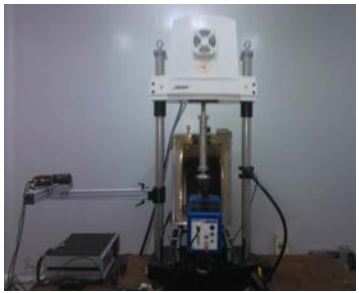
a. Computer Controlled Dynamic Testing
b. Infra Red Thermal Imaging Camera
c. Video Extensometer

Test Features:

Types of Tests Performed/Capabilities : (i) Displacement, Load and Time Control
(ii) Sine, Triangular, Ramp and User defined
(iii) Stress Analysis, Temperature distribution

Unique Characteristics/Special Features: (i) DC to 100Hz operating frequency
(ii) 5000N (Static) & 3000N (Dynamic) and
(iii) 412.5mm (Displacement)

Test Temperature Range : (i) -150°C to 300°C



Autoclaves for Curing Composites

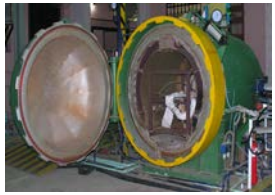
Category of Utility : Autoclaves are used to manufacture airworthy composite components under suitable settings of pressure, vacuum and temperature

Year of Establishment : 2006-2010

Test Application : Curing of laminates, feature level components and airworthy aircraft structural components.

Facility Features :

Specifications Mark IV	
Dia. of working space	4,400 mm
Length of working space	9,000 mm
Working pressure	7.14 kg/cm^2
Working temperature	250°C
Working capacity	2,14,000 litres
Operating weight	90,000 kg
Maximum charge	Equivalent to 12,000 kg of steel
Temperature uniformity	± 2°C
Rate of heating	0-5°C/min
Rate of cooling	0-3°C/min



Mark 0: Working Space:
0.9 m Dia x 0.9 m Len
Max. Temp. 250°C
Pressure: 7 bar(g)

Mark I: Working Space:
2.8 m Dia x 5.2 m Len
Max. Temp. 250°C
Pressure: 7 bar(g)

Mark II: Working Space:
1.8m Dia x 4m Len
Max. Temp. 200ºC
Pressure: 7 bar(g)

Mark III: Working Space:
2m Dia x 4m Len
Max. Temp. 350ºC
Pressure: 15 bar(g)

Mark IV: Working Space:
4.4m Dia x 9m Len
Max. Temp. 250ºC
Pressure: 7 bar(g)

Autoclaves are Dual computer, Recorder, PLC & PID controller based; In-house developed software, Fail-safe & fault-tolerant, Open communication system (non-proprietary) and Easy Maintainability

Material Testing and Characterisation Facility

Category of Utility : Chemical analysis of polymer matrices, coatings, paints, prepregs, composites, etc. for R & D, quality control of manufacturing process & also as acceptance tests for quality of procured raw materials.

Year of Establishment : 1993-2006

Test Application : Chemical analysis of polymer matrices, coatings, paints, prepregs, composites, etc. for determining cure kinetics, thermal stability, glass transition temp., Chemical structure, rheological behaviour etc.

Test Features :

a) MDSC (Modulated Differential Scanning Calorimeter)

Types of Tests Performed/capabilities	: Cure, melting, Tg, Heat Capacity Crystallinity of Polymers and composites
Unique characteristics/Special Features	: Thermal Conductivity Measurement, refrigerated Cooling system
Test temperature range	: -50°C to 400°C

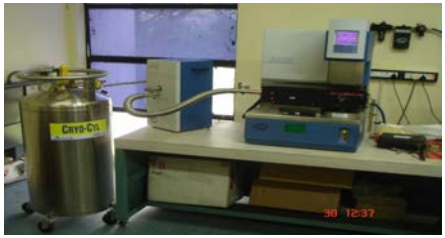
b) TGA (Thermogravimetric Analyser)

Types of Tests Performed/capabilities : Thermal degradation and thermal stability of materials
Test temperature range : RT to 1000°C

c) FTIR (Fourier Transform Infra Red Spectroscopy)

Types of Tests Performed/capabilities : Spectral characterization in Mid IR
Unique characteristics/ Special Features : Heat cell and ATR
Test temperature range : RT to 250°C

d) ARES (Advanced Rheometric Expansion System)



Types of Tests Performed/capabilities : Viscosity, Visco-elastic characteristics, cure and Tg of Polymers, prepregs and polymer composites
Unique characteristics/Special Features : Liquid Nitrogen cooling system
Test temperature range : -150°C to 600°C

MATERIALS SCIENCE AND SURFACE ENGINEERING

Materials Science Division (MSD) is primarily engaged in the research and development of materials for aerospace and industrial applications. Some of the important activities of the division cover development of high tensile strength and high tensile modulus grades carbon fibres, development of high temperature materials, development of smart materials such as shape memory alloys (SMAs), piezo sensors and actuators, piezo thin films and MEMs, development of airport instrumentations, failure analysis and accident investigation. The division has the expertise in characterization of ceramic, polymeric and metallic materials, and non-destructive testing of materials.

Surface Engineering Division (SED) of CSIR-NAL devotes itself to develop surface modification technologies for aerospace and engineering applications. SED works on import substitution in sensitive and critical areas to provide self-reliance. SED is involved in the development of innovative technologies driven by user industries. SED also undertakes research in niche areas such as nanoscale architecture and energy sector.

Chemical Vapor Infiltration Reactor

Category of the Test : Development of Continuous Fiber Reinforced Ceramic Matrix Composites(CFCCs) through Chemical Vapour Infiltration (CVI)

Test Application : Capable for silicon carbide (SiC), carbon (C), and Boron Nitride (BN)matrices.
Capable for C, BN, (C/SiC)m and (C/BN)m interphases.
Capable for CVD coatingsof SiC, BN, C
Capable for Cf/C, Cf/SiC, SiCf/SiC composites.

Test Features :

- Temperature Capability: up to 1400 C
- Pressure capability: 1- 70 mbar
- Reactor useful volume: 850mm dia x 900mm height

Other Test Information : The facility can be used for fabrication of Ceramic Matrix Composites panels and composites.

CVI Reactor Facility

Electron Probe Micro Analyzer (EPMA)

Category of the Test : Advanced test technique for material characterization

Year of Establishment : 2011

Test Application : The EPMA facility will enhance quality of research in better understanding of micro structural evolution during processing of materials in general and create opportunity to carry out research in new generation advanced materials.

Test Features :

Equipment details	
Model	SX 100
Manufacturer	CAMECA, France
Operating Parameters	0.2 to 30 kV accelerating voltage and 10^{-5} to 10^{-12} A beam current

Key Features	
Spectrometers	2 Wavelength Dispersive X-ray (WDX) spectrometers 1 Energy Dispersive X-ray (EDX) spectrometer
Sensitivity	Offers high sensitivity and stability with X-ray overlaps correction
Resolution	6 nm in secondary electron images
Detection	Elements except H, He and Li can be detected and quantified up to 0.1 wt% in solid samples

Other Test Information :

- Phase and compositional analysis in microscopic level helped in development of new shape memory alloys (SMAs) for high temperature applications.
- Oxygen analysis in the material was useful in solving problems encountered during processing of high temperature SMAs into wire forms.
- In many cases, the primary mechanism of failure in aero-engine components could be established unambiguously through micro structural study, phase analysis and compositional analysis.

Electron Probe Micro Analyzer

Field Emission Scanning Electron Microscope (FESEM)

Category of the Test : Characterization of Nano structured coatings and Nano materials

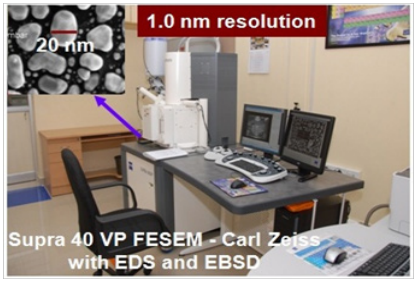
Year of Establishment : 2009

Test Application : The facility is an ideal tool to characterize nanomaterials. It has a resolution of 1.0 nm and hence most of the work carried out in the area of nanomaterials can be characterized using FESEM.

Test Features :

- Resolution – 1.0 nm at 20 KV
- Nano-powders, Nano-coatings, etc.
- Sample preparation not required
- VP mode for non-conducting samples
- EDAX - Down to B
- EBSD for crystallographic orientation
- Sample size 2 mm to 4 inches
- X-ray mapping
- UHV Compatible – Fast Recording

Other Test Information : The FESEM is commissioned in newly constructed building (area 5000 sq ft), which has been named as "Nanomaterials Research Laboratory". This building also houses other state-of-art instruments for the characterization of nanomaterials, including a 10,000 class clean room along with lithography



FESEM Facility

STRUCTURAL TECHNOLOGIES

Structural Technologies Division (STTD) with primary focus on Research & Technology for aerospace structures in India. The Division has expertise in aerospace structural design, analysis, testing, qualification, certification and Research and Technology development in aerospace structures and contributed to all aeronautics and space programs of India. The current R&D focus of the division include: Computational Mechanics and Simulation , Dynamics and Adaptive Structures , Fatigue and Structural Integrity , Impact and Structural Crashworthiness and Structural Health Monitoring . Also initiated a support on Integrated Vehicle Health Management (IVHM) activities. Approved under civil aircraft certification and military aircraft certification and follows ISO 9001:2008

Testing Facilities at Structural Technologies Division

Category of the Test :

a. Ground vibration test facility
b. Computer controlled vibration qualification test facility
c. Aeroelastic test facility
d. In-flight vibration measurement and flutter test facility
e. Vibro-acoustic test Facility
f. Static and dynamic full field non-contact strain measurement using 3D digital image correlation System
g. Full scale fatigue test facility
h. Material evaluation testing (MEL)
i. Sub component static / fatigue test rig
j. Static test facility for aircrafts
k. High velocity air gun impact test facility
l. Crashworthiness forward velocity sled facility
m. Drop test facility
n. SHM/NDE facility

Year of Establishment : 1980-2014

Test application, Test Instrument(s) Photograph & Test Features :

a) Ground vibration test facility
Year of Establishment : 2002
Test Application : Modal testing of aircraft, aerospace structures and automotive systems
Test Features : Estimation of natural frequencies, mode shapes, modal mass, modal damping and modal stiffness

b) Computer controlled vibration qualification test facility
(Low capacity-High frequency / High capacity- Low frequency)

Year of Establishment : 2000
Test Application : Aircraft subsystems, Automotive and rail systems
Test Features : Vibration qualification testing according to the standard specifications

c) Aeroelastic test facility

Year of Establishment : 1980
Test Application : Aircraft and launch vehicle
Test Features : Aerodynamic and buffet load estimation

d) In-flight vibration measurement and flutter test facility

Year of Establishment : 2007
Test Application : Aircraft
Test Features : In-flight vibration measurement and flight flutter testing

e) Vibro-acoustic test facility

Year of Establishment : 2014
Test Application : Aircraft and automotive panels,
Test Features : sound absorption and transmission loss studies, active, passive and active- passive hybrid vibro-acoustic control and noise mapping

f) Static and Dynamic full field non-contact strain measurement using 3D digital image correlation system

Year of Establishment : 2014
Test Application : Full-scale aerospace structures and scaled dynamic models
Test Features : Distributed 3D strains and frequencies, damping and mode shapes.

g) Full scale fatigue test facility

Year of establishment : 1981
Test application : Full scale fatigue testing and evaluation for fighter aircraft class and life extension studies for aging military aircraft
Test features : Computerised multi channel servo hydraulic control system for simulating in-service fatigue loads, 1000 channel Data acquisition system for monitoring the test response

Full-Scale Fatigue Test Set up

h) Material characterisation/evaluation facility

Year of establishment : 1987
Test application : Qualification / Certification tests on structural materials at room temperatures to elevated and subzero temperatures at hot-wet condition
Test features : Coupon level tests on metallic and composites specimens, feature level tests

i) Sub component static / fatigue test rig

Year of establishment : 1991
Test application : Fatigue testing under spectrum loads for certification requirement and Damage Tolerance tests.
Test features : Static and fatigue load cases simulation and pressurization test cases at RT and HTW conditions

j) Static test facility for aircraft

Year of establishment : 2001
Test application : Full scale static testing and evaluation for aircraft components
Test features : Static strength evaluation of aircraft components and pressurization load tests

k) High Velocity air gun impact test facility

Year of Establishment : 2010
Test Application : High velocity impact study for aerospace components
Test Features : Evaluation of structural damage due to bird impact, ice impact etc

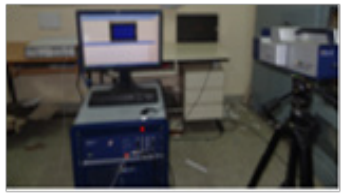
l) Forward velocity sled facility

Year of Establishment : 2013
Test Application : Aerospace and automotive industry
Test Features : Seat qualification and occupant safety

m) Drop test facility

Year of Establishment : 2008
Test Application : Aircraft crashworthiness
Test Features : Fuselage components and feature level components for energy absorption studies

n) SHM/NDE facility (Acoustic Emission Systems, Laser Vibrometer, Eddy Current Test, Advance Thermography system and Fibre Optics based Video image scope)

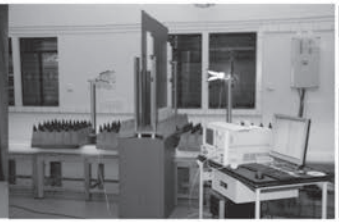


Year of Establishment : 2000
Test Application : Non-destructive evaluation of materials and structures, online health monitoring of structures, qualification of raw materials/components.
Test Features : Damage detection on metallic and composite materials / structures, large area coverage, material status (heat treatment, corrosion) evaluation, metal sorting, internal views on enclosed structures

SYSTEMS ENGINEERING

- Aerospace Electronics and Systems
- Acoustic Test Facility
- Centre for Electromagnetics
- Flight Mechanics & Control
- Micro Air Vehicle





AEROSPACE ELECTRONICS AND SYSTEMS

At the Aerospace Electronics and Systems Division of CSIR-NAL, research along with product D&D is carried out in four major disciplines: Civil Aircraft Avionics and Embedded systems, Systems Engineering, Software Engineering and Micro Air Vehicle and Signal Processing. The prime objective of the division is to address the civil aircraft activities for CSIR programs in particular and general aviation, regional class of civil aircraft in general.

Avionics Ground Integration Test Facility

Category of the Test : Ground based real –time test rig for simulated testing of Systems in Integrated mode

Year of Establishment : 2012-2013

Test Application : Integration and Testing of complete avionics suite in individual as well as integrated mode. Developmental and certification testing for applications and systems Integration and Testing of complete avionics suite in individual as well as integrated mode. Developmental and certification testing for applications and systems

Test Features :

- Can integrate and test communication system, navigation system, display system, recording system, radar systems and engine systems LRUs for integration functional, failure mode testing.
- Signal can be routed from real LRU or from the simulation source
- Every In and out signal can be monitored with respect to the LRU
- Availability of Simulation signals source such as ARINC 429, ARINC 708 , Ground/Open Discrete & DC Analogue signal.
- Error Injection on BIT level/Label Level/System Level can be obtain
- Near real testing using Standard test systems like IFR 4000 , IFR 6000 and ADTS 505 to simulate communication, Navigation, TACAS, Surveillance systems and Air data Systems

Other Test Information : Important interface simulation/monitoring capability, External A/C sensor interface capability, GPS and IRIG-B sync timing, Portable and movable industrial racks

Avionics real-time Ground Integration Test Facility

Integrated Global bus Avionics Processing System (IGAPS) and real-time integrated Test Station

ACOUSTIC TEST FACILITY

Acoustic Test Facility (ATF) is a national facility for acoustic environment qualification testing of satellites, launch vehicle stages and their subsystems for the ISRO. ATF carries out noise and vibration studies for automobile, white goods and electronic equipment manufacturers. Specialised acoustic studies for aircraft and helicopter development projects have also been undertaken. ATF has expertise in the design, development and commissioning of reverberation chamber based acoustic test facilities for spacecraft and launch vehicle ground testing.

Acoustic Test Facility

Category of the Test : Acoustic environment qualification testing of satellites, launch vehicle stages and their sub-systems

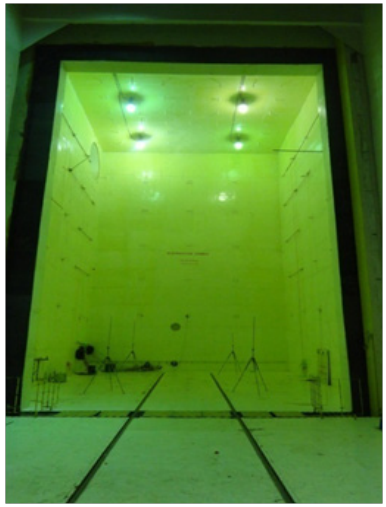
Year of Establishment : 1986

Test Application : Acoustic simulation of lift-off & atmospheric flight of launch vehicles / exposure of payloads carried by the launch vehicles

Test Features : 1100 cu.m Reverberation chamber in which a maximum sound pressure level of 157 dB (spectrum controlled) can be generated.

Other Test Information :

- Geometry : Volume (1100 cu.m), Dimensions (10.33 l X 8.2 b X 13 h – mtrs).
- Other Acoustic parameters : Sound pressure level (157 dB). Frequency range (25-10,000 Hz).Spatial Distribution OASPL (+/-1 dB in central 10% volume)
- Instrumentation and data recording : Real time acoustic measurements (11 channel), Vibration measurement (192 channel), Strain measurement (16 channel).



Acoustic Test Facility (ATF)

CENTRE FOR ELECTROMAGNETICS

The Computational Electromagnetics Laboratory (CEM Lab.) was founded in 1993 at the CSIR-National Aerospace Laboratories (CSIR-NAL) to initiate the activities in the area of computational electromagnetics for aerospace applications. The activities of the CEM Lab. include: Airborne and aerospace antenna analysis (for aircraft, satellite and SLVs), Radomes (for aircraft, missiles and on ground) , Surface modeling and Analytical ray tracing, Radar cross section (RCS) studies and RCS reduction (including active RCSR), Radar absorbing materials (RAM) and structures (RAS), Phased antenna arrays, Adaptive antenna arrays, Conformal antenna arrays, FSS structures for aerospace applications, Metamaterial applications and EM characterization of materials.

Adaptive Antenna Facility

Title of the Test : Test-bed for adaptive algorithms

Category of the Test : Active cancellation of probing sources

Year of Establishment : 2012

Test Application : Contemporary design of adaptive antenna systems and active RCS reduction

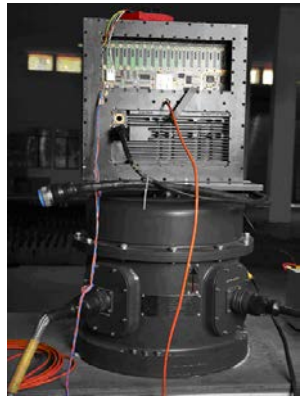
Test Features :

- A certified experimental facility
- Test-bed for adaptive algorithms
- Simulation Lab. complements the measurement facility
- Operational Frequency: 8.8-9.8 GHz
- Facilitates both indoor and outdoor measurements

Other Test Information : An integrated adaptive array system capable of (i) Controlled electronic beam scanning, (ii) Estimation of DoA, frequency, power of the emitters, (iii) Maintenance of sufficient gain towards desired directions, (iv) Suppression of interfering signals

Adaptive antenna control unit

Synthesized sweep oscillator



X-band receiving module with 16x16 adaptive array

Electromagnetic Materials Application Facility

Title of the Test : Electromagnetic Material Characterization

Category of the Test : Complex Permittivity and Complex Permeability Measurements

Year of Establishment : 2010

Test Application : Capable of catering EM material characterization in the following sectors :

Aerospace Sector- Radomes, RAS, Aircraft cabin components etc., RF/ MW Companies - Antennas, MW components etc., Medical Industry - Medical imaging/ Scans, Malignant tissues detection etc., Agro-Food Processing Industries - Denaturing of food, microwave heating applications etc. , Chemical Industry - Process flow control sensors

Test Features :

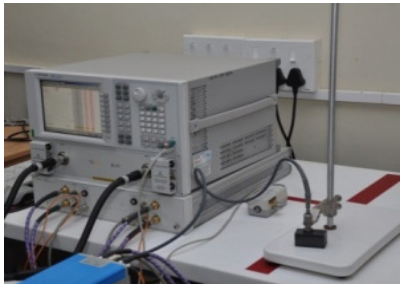
- A certified experimental facility
- State-of-the-art EM material characterization techniques based on: Free-space system, Dielectric probe, Waveguide system, Quasi-optic bench

Other Test Information : Capable of EM material characterization over the frequency range : 200 MHz -170 GHz

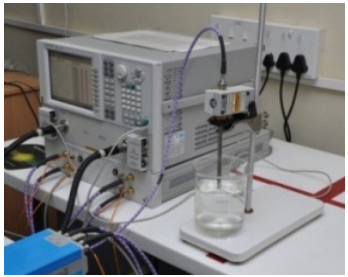
(i) Wave Guide System (26 GHz - 170 GHz) for thin slabs, (ii) Dielectric Probe (200 MHz - 50 GHz) for solids and liquids, (iii) Free Space method (2 GHz - 40 GHz) for large flat panels, (iv) Quasi-optic bench (75 GHz - 110 GHz) for thin substrates

Free-space System

Quasi-optic Bench



Dielectric Probe:
EM characterization of solid



Dielectric Probe:
EM characterization of liquid

Frequency Selective Surface-based Design and Development Facility

Title of the Test : Electromagnetic Performance Tests for FSS Structures

Category of the Test : Transmission (co-pol and cross-pol) and Reflection Measurements

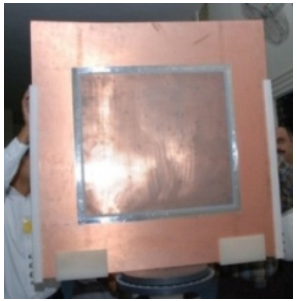
Year of Establishment : 2010

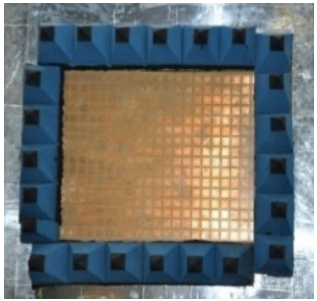
Test Application : Aerospace applications: Radomes and RAS

Test Features :

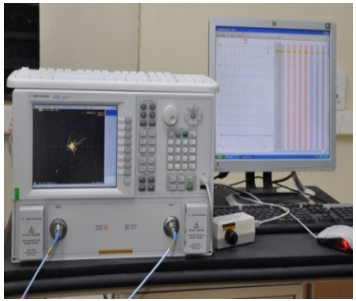
- A certified experimental facility
- EM performance tests for flat FSS panels:
  - Co-pol power transmission
  - Cross-pol power transmission
  - Power reflection

Other Test Information : Facility for full-scale EM characterization of flat FSS panels over the frequency range 2 - 40 GHz





Standard FSS Panels



FSS Measurement System

FLIGHT MECHANICS & CONTROL

The Flight Mechanics & Control Division (FMCD) is engaged in R&D activities in the areas of Modeling and Flight Simulation, Control and Handling Qualities, Multi Sensor Data Fusion Applications and System Identification. The division has a high level of expertise in these niche areas and is well equipped to address problems in the flight vehicle dynamics and control domain.

Flight Simulators

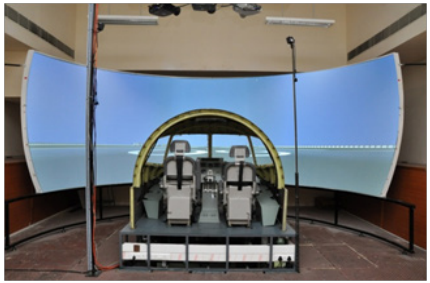
Category of the Test :

1. Desktop Simulator
2. Engineer-in-the loop simulator
3. Flight Training Device correspond to FAA level 3
4. Augmented Engineering Environment

Year of Establishment : 1990-2012

NALSim Desktop Simulator

Engineer-in-the loop simulator



Flight Training Device (FAA Level 3)

Augmented Engineering Environment

Test Application :

NALSim Desktop Simulator

- NALSim Desktop Simulator has being developed for aerospace engineering students to carrying out research in flight mechanics and control.
- This is achieved by closely coupling the simulation hardware to the code generation, simulation, and analysis capabilities of Simulink and Matlab.

Engineer-in-the loop simulator

- The ELS Simulator is in use extensively for LCA Tejas flight control law design, development and evaluation since 1993.

Flight Training Device (FAA Level 3)

- The SARAS Flight Training Device (FTD) configuration corresponds to FAA Level 3 for Flight Training Device (FTD) with visual system corresponding to FAA Level A for simulators.

Augmented Engineering Environment

- The Augmented Engineering Environment (AEE) for the RTA is a simulator established at NAL in joint partnership with CAE Inc., Canada and CAE India Pvt. Ltd.

Test Features :

NALSim Desktop Simulator

- The Simulator is designed for fixed wing, helicopter and a quad rotor
- Models of standard disturbances like gust, cross wind and turbulence is built into the simulator.
- Control of the simulation is exercised from the console. Simulated flight operations are effected using off the shelf USB joystick.
- The System is designed around a single workstation with a high-end graphics adapter.

Engineer-in-the loop simulator

- The simulator has single window visuals with 40° field of view horizontally and vertically.
- The basic aircraft dynamics equations are solved in real-time along with the flight control law and hydraulic system models.
- The system features a reprogrammable touch screen which can be used to rapidly reconfigure additional pilot control inputs.

Flight Training Device (FAA Level 3)

The FTD uses Commercial-of-the-shelf (COTS) high-end computers, interface cards and The major features of FTD are:

- Replica of cockpit shell, mounted on a fixed base
- Replica flight controls, switches, knobs, levers, etc.,
- Replica instruments and displays
- Digital Electronic Controls loading for simulation of force feel on three axes. COTS high-end PCs, Monitors and interface cards
- Computer generated image (CGI) for the Out-of -the-Window visual system with three-channel projection display system
- Field of view (FOV) of 140° in azimuth and 45° in elevation
- Aural cues system for aerodynamics, engine, avionics, and other aircraft systems related sounds
- Intercom system between trainee and instructor
- Instructor Station (IS) to control and monitor pilot training
- Flying in normal mode including handling emergencies / malfunctions
- Simulation of avionics
- Simulation of Auto-pilot and Stall Warning System (SWS)

Augmented Engineering Environment

- It consists of a DS and RES. The DS consists of desktop tools which allow the engineer to design prototype concepts for the displays. The RES is capable of providing support for design validation.
- The AEE developed by CAE is based on industry proven simulation scalable framework and system models. The RES is built on the Integrated Procedures Trainer (IPT) platform. The AEE also has a three window seamless edge matched visual system which is used to conduct piloted evaluations for the regional transport aircraft.
- The reuse of hardware and software during the development phase leads to cost savings. In particular, the following systems of the aircraft will benefit from the AEE:
  - Cockpit Ergonomics studies
  - Pilot Vehicle Interface studies
  - Flight Control System design and evaluation
  - Integrated Enhanced and Synthetic Vision System design evaluation
- The AEE is used for piloted evaluations of display symbology, control feel and FCS design aspects.
- It is also intended to be used for aircraft level Functional Hazard Analysis (FHA).
- The AEE will also provide the NAL research team a means to address any design level system integration issues with this facility.

MICRO AIR VEHICLE

The Micro Air Vehicle (MAV) Unit is a newly formed unit of CSIR-NAL with the mandate to carry out focused research and development of mini & micro air vehicles. A small group of scientists working in the unit are involved in airframe design, aero propulsion system selection and characterization using wind tunnel studies, prototype fabrication, integration of autopilot and payload and flight testing in semi and fully autonomous modes.

Micro Air Vehicle Aerodynamic Research Tunnel (MART)

Category of the Test : A Special purpose wind tunnel for the Aerodynamics ,Propulsion and Aero-elastic characterization of Fixed, Flapping and Rotatory wings

Year of Establishment : 2013

Test Application :

1. Closed and Open test section to facilitate flapping wing study
2. Betz chamber for tethered bird/insect studies.
3. Gust generation mechanism to simulate wind gust inside test section for the study of effectiveness of atmospheric gust on MAV.

Test Features :

1. Type - Open Circuit, Suction
2. Contraction Ratio - 9:1
3. Test Section –
   - Closed Jet : 0.8mx1.2mx2.5m
   - Open Jet : 0.8mx1.2mx1.0m
4. Betz chamber - 3m x 2.8m x 2.8m
5. Gust mechanism - Horizontal gust, louvers-based
6. Flow Characteristics:
   a. Velocity Range –
      - Closed Test Section : 1-45m/s;
      - Open Test Section :1-25m/s
   b. Mean Flow Velocity Variation - ±0.1%
   c. Flow Angularity - < 0.1°
   d. Freestream Turbulence Intensity - < 0.18 %
   e. Gust - Horizontal velocity 1-10 m/s

MAV Research Tunnel

Micro-Beacon fixed on Sting Mounted Balance

Control Room

Other Test Information :

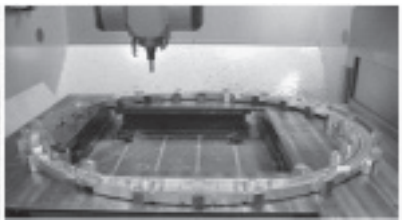
- Excellent flow quality, good flow stability, low free stream turbulence level
- The open test section has an advantage of having no boundary layer effects and reflections due to wall during flapping/rotary wind studies
- The tunnel also has a novel feature of generating gust that would simulate the atmospheric turbulence during MAV flights for understanding their dynamic response.

Acoustic Test Facility

CENTRE FOR CIVIL AIRCRAFT DESIGN AND DEVELOPMENT

Aircraft Prototype Manufacturing Facility

Flying Test Bed


AIRCRAFT PROTOTYPE MANUFACTURING FACILITY

The Aircraft Prototype Manufacturing Facility (APMF) of C-CADD plays a major role in realization of machined components for aerospace application. The facility equipped with 3/5 axes CNC machining centers, turning centers, grinding and jig boring machines carries out precision component manufacturing, sheet metal tool and part fabrication, welding and has a dedicated processing capability to undertake metal finishing and painting operations. The facility also has expertise to manufacture and assemble high precision wind tunnel models.

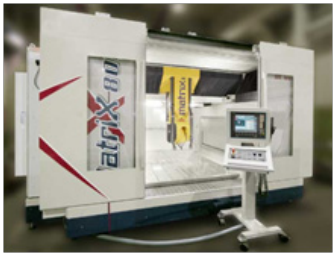
Aircraft Prototype Manufacturing Facility

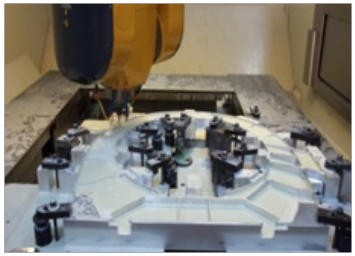
Category of the Utility : Manufacturing of critical machine and sheet metal Components for aircraft

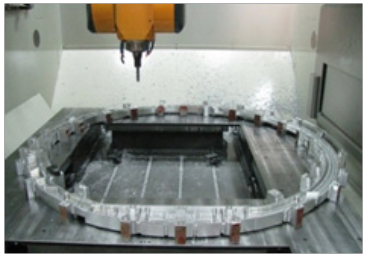
Year of Establishment : 1980-2010

Type of Facilities :

a. 5 Axes CNC Machining Facility







Features :

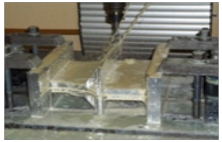
Description	Specification
Model	Breton Matrix 800
Table Size	2000 mm X 3000 mm
Traverse	X-2000 mm Y-2500 mm Z-800 mm A - ± 105 deg. C - 0 to 360 deg.
Spindle Taper	HSK63A
Spindle Speed	28000 rpm
Spindle Power	20Kw
ATC	Umbrella type with 30 tools
CNC Controller	Sinumerik 840D

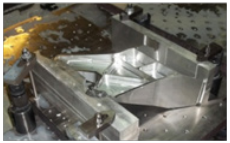
Potential Usage :

5 Axes CNC machining of aircraft components of size 2.5 m X 2.0 m X 0.7 m

b. 3 axes CNC Vertical Machining Centre Facility



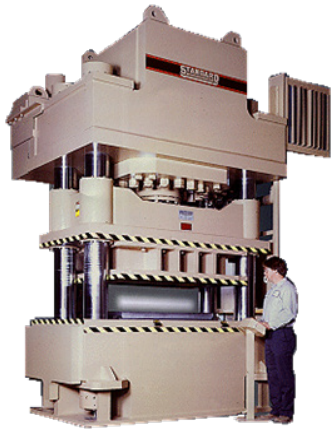




Description	Specification	Specification	Specification	Specification
Model	VICTOR VC -110 (1)	DAHLIH MCV 1020 BA (2)	DAHLIH MCV 720(3)	TAKUMI H13(1)
Table Size	1400 mm X 550mm	900 mm X 600mm	950 mm X 560mm	1400 mm X 900 mm
Traverse	X-1100 mm Y-600 mm Z-600 mm	X-1050 mm Y-550 mm Z-550 mm	X-760 mm Y-460 mm Z-510 mm	X-1300 mm Y-900 mm Z-700 mm
Spindle Taper	HSK63A	HSK63A	BT 40	HSK63A
Spindle Speed	12000 rpm	12000 rpm	10000 rpm	15000 rpm
Spindle Power	7.5 kw	10 kw	7.5 kw	12 kw
ATC	Umbrella type with 24 tools			
CNC Controller	Fanuc 21i MB		Fanuc 21i MB	Fanuc 18i MB

Potential Usage:
3 Axes CNC machining of aircraft components of max. size 1.3 m X 0.9 m X 0.7 m

c. Aircraft Sheet Metal Components Forming Facility



Description	Specification
Capacity	1000 ton
Press Type	Hydraulic Down stroking Rubber pad press
Mode of forming	Elasto forming using multi layered Rubber pad top down press
Drive System	Hydraulic
Stroke	600 mm from the container bottom
Daylight	800 mm
Bolster area (LR) X (FB)	1700 mm
Table area (LR) X (FB)	1300 mm

Potential Usage:
Sheet metal component fabrication for various aircraft parts like sheet metal bulkheads , stringers , longerons, frames etc.

d. Heat Treatment Facility

Description	Specification
Work Basket Size (effective)	1450mm Dia. x 2000mm Height
Furnace Inner Chamber Dimensions (baffle)	1700mm Dia.X 2200mm Height
Max. Temperature	700° C
Working Temperature	250° - 600° C (continuously variable with programmable control)
Temperature Accuracy	± 3° C at 600° C
Temperature Control System	Automatic through SCADA

Potential Usage:
Solution treatment of aluminium sheet metal component for various aircraft projects

e. Laser Tracker Inspection Facility

Features

- Set, inspect and certify large aircraft jigs, ICY gauges and transfer gauges.
- To inspect large aircraft and space vehicle assemblies.
- To carry-out reverse engineering activities.
- Range : 80m radius
- Software Used : METROLOG

Potential Usage

Jig setting, inspection and certification of aircraft assembly jigs and inspection of airframe structures

f. Laser Tracker Inspection Facility

Features:

- Inspect intricate CNC aircraft components, wind tunnel models, ICY gauges and transfer gauges.
- Capability to inspect components / assemblies of range X: 2500mm, Y: 1500mm Z: 1500mm
- Software: Sceptre, Power inspect, Camio studio & Quindos

Potential Usage:

- Inspection of aircraft components and sub assemblies.
- Inspection of aircraft ICY gauges and tools.

g. 3D Measuring Arm with Scanner Facility

Features

- Inspection of aircraft components and tooling elements and primary setting of ICY gauges and jigs.
- Carry out reverse engineering activities.
- Range : 3.6m diameter
- Software: Power Inspect and Copy CAD

Potential Usage

- Inspection of aircraft components and tooling elements.
- Primary setting of aircraft ICY gauges and tools.
- Reverse engineering requirements.

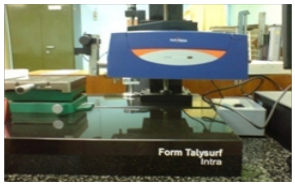
h. 3D Measuring Arm with Scanner Facility

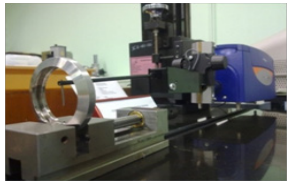
Features:

- Evaluate surface roughness parameters like Ra, Rt, Rp etc.,
- Measure angles, radius and distance.
- Range: 50 mm
- Software:Contour tester: Ultra contour, Surface tester: Ultra

Potential Usage:

- Inspection of bolts and aircraft components for root radii, angle and distances
- Surface finish of aircraft parts.





FLYING TEST BED - HANSA AIRCRAFT

Centre for Civil Aircraft Design and Development (C-CADD) has a mandate to play a lead role in the design and development of small and medium sized civil aircraft. C-CADD is currently involved in the development and certification of a 14-seater light transport aircraft (SARAS) and CNM5 a five seater general aviation aircraft designed and developed jointly by CSIR-NAL and Mahindra Aerospace Pvt. Ltd., (MAPL). C-CADD has also been actively providing product support to the DGCA (Director General of Civil Aviation) certified two-seat all-composite HANSA-3 aircraft being used by flying clubs for ab initio flight training.

Flying Test Bed - Two seat aircraft

Category of the Test : Two seat aircraft as flying test bed for conducting flight research activities

Year of Establishment : 2013

Test Application : Two HANSA aircraft at CSIR-NAL (VT-HBL & VT-HOA) have been re-registered for flying under experimental category as a flying test bed towards R&D purpose in the field of damage tolerance and structural health monitoring, active vibration control, avionics and flight controls, adaptive aero-elastic structures and vibro-acoustics.

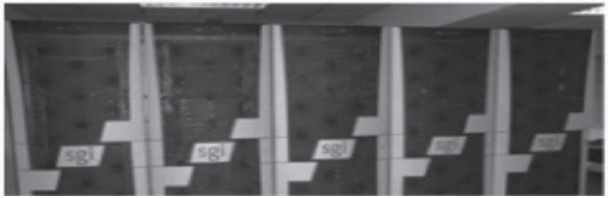
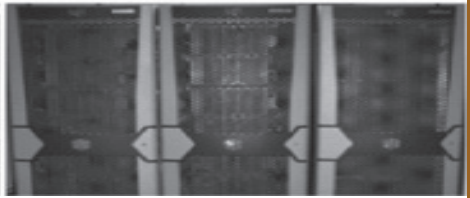
Aircarft Features :

- All composite aircraft Certified by DGCA under FAR 23 via JAR-VIA
- Suitable for ab-initio flying training, sport and hobby flying
- Provided with a lightning protection scheme
- Suitable for VFR and night flight operations
- Rotax 914F3 (Turbocharged engine with a 100 bhp max continuous power @ 5500 rpm and 115 bhp @ 5800 rpm)

Take-off distance: 413 m (1355 ft)	Max rate of climb: 198 m/min (650 ft/min)	Stall speed: 87 km/hr (47 KIAS) (with flaps 20°)
Landing distance : 540 m (1770 ft)	Max cruise speed: 178 km/hr (96 KIAS)	Endurance: 4 hr

Hansa Aircraft

CSIR - 4PI

HIGH PERFORMANCE COMPUTING FACILITY

Computation is the crux of modern scientific research. In contemporary research, capability of an organization is judged by its accessibility to computational facility. CSIR is committed to provide world class computational facility to all its scientists and researchers to address Grand Challenge problems in frontier areas of science and engineering. The computing facilities are one of the best in the country and provide multiple architectures suitable for domain specific applications.

High Performance Computing facility at CSIR-4PI (CMMACS)

Category of the Test : High Performance computing to provide multiple architectures suitable for domain specific applications

Year of Establishment : 2012

Utilization of the facility : Used as a common computing platform by various institutions

Test Application :

- HP Cluster Platform 3000

  Performance : 360 TFLOPS Peak & 304 TFLOPS sustained on LINPACK
  Hardware : HP blade system C7000 with BL460c Gen8 blades, 1088 nodes with 300 GB disk/node (319 TB), 2,176 Intel Xeon E5 2670 processors @ 2.6 GHz, 17,408 processor cores, 68 TB main memory, FDR Infiniband based fully non-blocking fat-tree topology, 2 PB high performance storage with lustre parallel file system

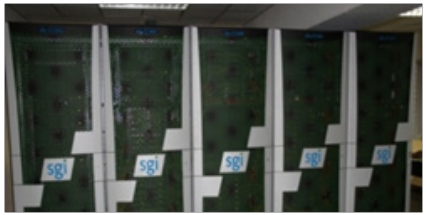
- SGI Altix ICE 8400

  Performance : 27 TFLOPS peak
  Hardware : 192 nodes , 2304 processor cores, 4.6 TB memory, Dual rail 4x QDR Infiniband, Enhanced hypercube

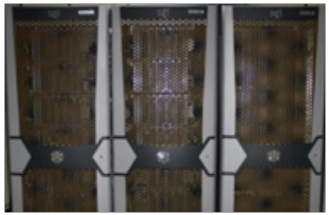
- SGI Altix 4700

  Performance : 1.9 TFLOPS peak
  Hardware : 288 cores of Intel Itanium2 Processor, 608 GB Global Shared Memory
  Operating System : SLES 10 OS (64-bit)

HP Cluster Platform 3000



SGI Altix ICE 8400

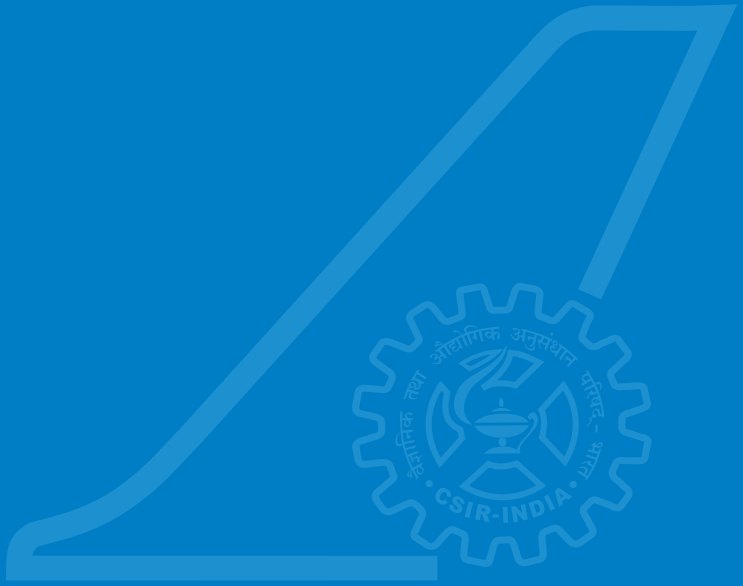


SGI Altix 4700

HP Cluster Platform 3000

SGI Altix ICE 8400

SGI Altix 4700



For more information please contact:
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Technologies & Products

DHVANI

ABHIAS

NTAF

Wankel Engine

Contributions to Light Combat Aircraft (Tejas)

Industrial Grade Autoclave Technology

Labscale Autoclave

Desktop Autoclave

Multi Zone Hot Bonder

Structural Integrity Expertise

Structural Technologies

Carbon Fibre

NiTi Shape Memory Alloys

Special Materials & Technologies

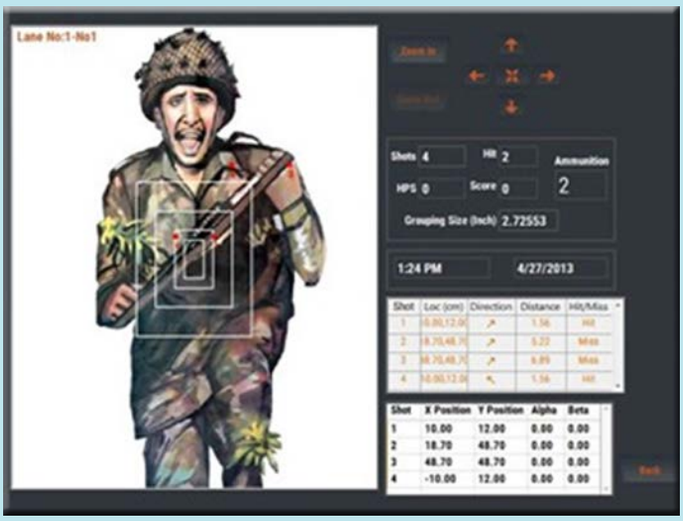
Integrated Avionics Display Computer (IADC)

DRISHTI & AWMS

DHVANI

Joint collaboration

CSIR- NAL and SDD, INDIAN ARMY



Precise and Perfect

Low cost and Ruggedized

DHVANI

Why DHVANI ?

Automated system to detect bullet using supersonic acoustic detection and localization of hits on target by acoustic time delay estimation methods.

Real time and precise system, catering for individual to tactical level of exercise settings.

Indigenous

Tailor made for Indian Armed Forces with high degree of ruggedisation to meet Mil Grade Standards. Configured out of COTS item to ensure low post sale maintenance cost.

Unique Features

- Automated Range Control with database management
- Variable firing positions without any re-calibration
- Exercises as per SAO 12/S/85 and facility for user defined exercise setting
- Seamless wireless network with Ethernet enabled network
- Roaming Firing Point Officer (RFI) and Firer End Display Interface (FEDS)
- Interactive and User Friendly GUI
- Power on self diagnostic and real time diagnostic during the exercise
- Pop Up Target System with Self Healing Targets and simulation units for illumination, smoke and flash
- Unit Level Package for firer management and performance evaluation outside the range
- All weather-proof carbon fiber composite sensor bar

System Capabilities

- Accuracy better than globally available systems
- Detection zone of 9 ft radius from centre of target
- Wide Azimuth and elevation angles
- Hit localization by position of X & Y and velocity of projectile
- Varied categorization of shot as per performance
  i.e. Hit, Miss, Improper, Ricochet and Cross Shot
- Real time Performance evaluation
- Real time HAT analysis
- Interactive Grouping and Zeroing
- Simplified alignment procedure

For more information contact
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Industry Partner
Director (Marketing)
Bharat Electronics Limited,
Outer Ring Road, Nagava, Bangalore 560 045,
India. Tel: 91-80-25039300;
www.bel-india.in

ABHIAS

ABHIAS is an automated system to detect bullets using acoustic detection and localization of hits on target by acoustic time delay estimation methods. Real time and precise system, catering for individual to tactical level of exercise settings. System caters to almost all weapons including rifles and CQC weapons.

Indigenous design tailor made for Indian Armed Forces and Paramilitary Forces with high degree of ruggedisation to meet Mil Grade Standards. Configured out of COTS item to ensure low post sale maintenance cost.

ABHIAS

Unique Features

- Automated Range Control with database management
- Variable firing positions without any recalibration
- Exercises as per SAO 12/S/85 and facility for user defined exercise setting
- Seamless wireless network with Ethernet enabled network
- Roaming Firing Point Officer (RFI) and Firer End Display Interface (FEDS)
- Interactive & User Friendly GUI
- Power on self diagnostic and real time diagnostic during the exercise
- Unit Level Package for firer management and performance evaluation outside the range
- All weather-proof carbon fibre composite sensor bar

System Capabilities

- Accuracy better than globally available systems
- Detection zone of 600mm diameter from centre of target
- Wide Azimuth and elevation angles
- Hit localization by position of X & Y
- Varied categorisation of shot as per performance i.e. Hit, Miss, Improper and Cross Shot
- Self Healing Targets capable of withstanding atleast 8000 shots
- Real time Performance evaluation
- Real time HAT analysis
- Interactive Grouping and Zeroing

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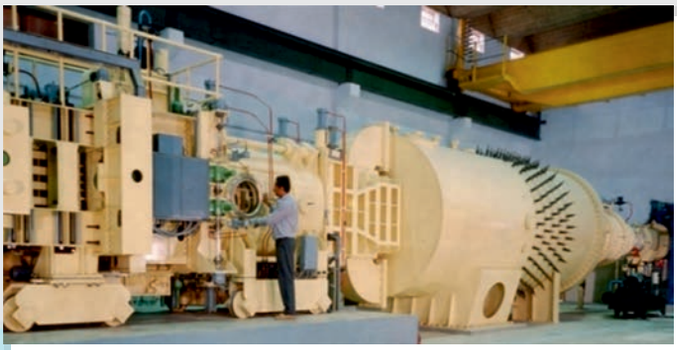
1.2m & 0.6m Trisonic Wind Tunnel



1.2m Trisonic Tunnel

Performing splendidly for over 50 years

- The National Trisonic Aerodynamic Facilities (NTAF) of CSIR-NAL has been serving the country as a nucleus of research and development in high speed aerodynamic over last five decades
- Contributed to all the National programmes of CSIR-NAL, DRDO, ISRO and HAL with utmost security and confidentiality
- Every Indian aerospace vehicle has graduated out of CSIR-NAL's 1.2m x 1.2m trisonic wind tunnel

Features

- Test section : 1.2 m x 1.2 m and 0.6 m x 0.6 m
- Operation : Intermittent blowdown
- Test duration : 30 seconds for 1.2 m tunnel; 60 seconds for 0.6 m tunnel
- Mach number range : 0.2 to 4.0
- Model incidence modes : -15° to +27° Continuous and step
- Model roll : 0° to 360°
- Stagnation pressure : 1.5 to 8.0 bar
- Reynolds number : 8×10^6 to 60×10^6 per meter

Wind Tunnel Measurements:

- Force & Moment measurements
- Steady & Unsteady pressure measurements
- Carriage load measurements and store separation studies
- Damping derivatives
- High speed flow visualization studies
- High speed Air-intake studies.
- Hinge moment measurements
- Component Load measurements
- Aero-elastic studies

Contribution of NTAF to National Programmes

Organization	ISRO	DRDO	ADA	HAL/IAF	CSIR-NAL
Programmes	RH series SLV3 ASLV PSLV GSLV SRE ABLV RLV	TRISHUL AGNI AKASH PRITHVI NAG ASTRA PJOB PTA HSTDV	LCA LCA-Navy Air Intake Weapon Integration	GAF HF-24 HSS-73 AJEET MIG-21 HJT-36	SARAS In-house R&D

CSIR-NAL

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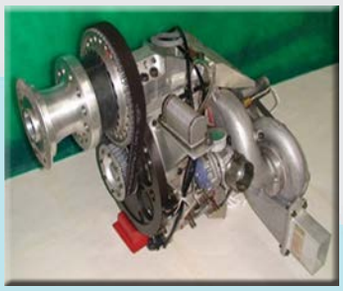
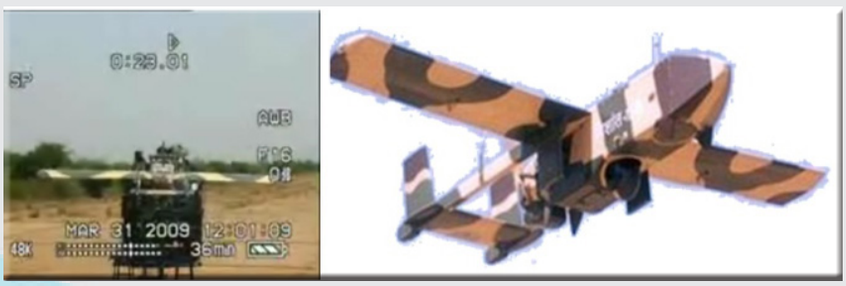
Wankel Engine

Indigenous Wankel Engine for a UAV
A CSIR & DRDO Partnership



55 Hp Wankel engine



UAV-Nishant maiden successful flight with Wankel engine

The indigenous Wankel engine development program was originated from DRDO through Vehicles Research & Development Establishment (VRDE), Ahmednagar, and was jointly designed, developed and successfully flight tested by CSIR-NAL, VRDE, and ADE. Under this program the 55 hp Wankel engine was developed for ADE's NISHANT UAV. NAL designed and developed the core engine; VRDE and ADE were in-charge of peripheral systems and flight testing respectively.

The Wankel engine is the first of its kind to be totally designed and developed in the country. Very few countries in the world have the capability to develop and master this technology. CEMILAC accorded the Certificate for 'Limited Series Production' on 7th February 2013. Twenty Wankel engines are being manufactured by VRDE, DRDO.

Features

Type	:	Single rotor Wankel engine
Cycle	:	Otto cycle
Power	:	55 hp (41 kW) @ 8000 rpm at ISA-sea level
Thrust	:	90 kgf with 1 m diameter propeller
Compression ratio	:	9.2
Housing Cooling	:	Water-Glycol mixture
Rotor cooling	:	Air
Lubrication	:	Total loss forced lubrication system
Ignition	:	CDI system
Carburettor	:	Diaphragm type
Specific fuel consumption	:	335 to 365 g/ kWh (0.55 to 0.60 lb/ hp/ h)
Engine weight (dry)	:	25 kg

Other Applications

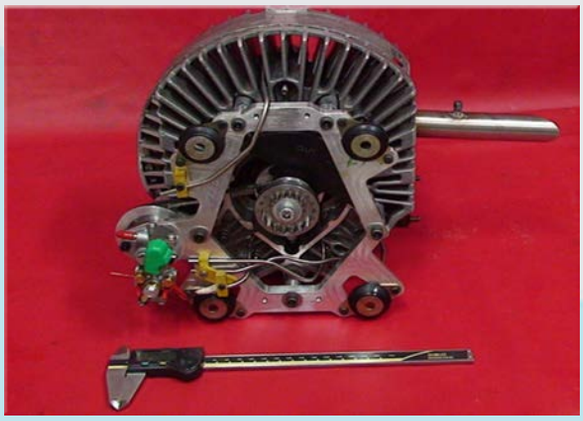
This type of engines are used for powering smaller air vehicles and also in automotive (Mazda, and Racing Cars), hybrid vehicles as range extenders, out-board motor for boats and other industrial applications in particular for compact power generators.

Cost Economics

Presently this technology is direct substitute for an imported 51 hp engine for DRDO's NISHANT UAV. The cost of the indigenous engine is around 40 percent less than the imported one during the limited series production stage. The cost will further come down during the mass production.

Wankel Engine

Indigenous Wankel Engine for a UAV
A CSIR & DRDO Partnership



First Prototype 30 hp Wankel Rotary Engine

Indigenous 65 hp Wankel Rotary Prototype Engine

COMPARISON OF CSIR-NAL'S INDIGENOUS WANKEL ROTARY COMBUSTION ENGINES

Comparison of CSIR-NAL's Indigenous Wankel Rotary Combustion Engines

	55 hp	65 hp	30 hp
Type	Single rotor Wankel engine		
Thermodynamic cycle	Otto cycle		
Power (ISA-sea level)	55 hp (41 kW) @ 8000 rpm	65 hp (48 kW) @ 8000 rpm	30 hp (22.4 kW) @ 7000 rpm
Max propeller speed	4000 rpm (Reduction drive)	4000 rpm (Reduction drive)	7000 rpm (Direct drive)
Cylinder capacity	324 cc	397 cc	216 cc
Compression ratio	9.2	9.2	9.2
Housing Cooling	Water-Glycol mixture	Water-Glycol mixture	Ram air
Rotor cooling	Air cooled	Air cooled	Ram Air
Lubrication	Total loss forced lubrication system	Total loss forced lubrication system	Total loss forced lubrication system
Ignition	CDI system	CDI system	CDI system
Fuel used	AV GAS- 100LL/ Gasoline	AV GAS- 100LL/ Gasoline	AV GAS- 100LL/ Gasoline
Fuel supply	Carburetor- Diaphragm type	Carburetor- Diaphragm type	Carburetor- Diaphragm type
Specific fuel consumption	335 to 365 g/ kWh (0.55 to 0.60 lb/ hp/ h)	335 to 365 g/ kWh (0.55 to 0.60 lb/ hp/ h)	335 to 365 g/ kWh (0.55 to 0.60 lb/ hp/ h)
Engine installed weight	35.6 kg	41 kg	< 15 kg
Status	Development Completed	2 Nos. Prototype Engine delivered to DRDO for flight testing	Under development

For more information contact
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Significant Contributions to Light Combat Aircraft (Tejas)

National Aerospace Laboratories (NAL), a constituent of the Council of Scientific and Industrial Research (CSIR), India, established in the year 1959 is the only government aerospace R&D laboratory in the country's civilian sector. CSIR-NAL is a high-technology oriented institution focusing on advanced disciplines in aerospace. CSIR-NAL has several advanced test facilities, and many of them are recognized as National Facilities. These are not only the best in the country, but are also comparable to other similar facilities in the world. CSIR-NAL has also provided significant value added inputs to all the Indian national aerospace programmes. Its contributions over the last five decades have enabled it to create a niche for itself in advanced aerospace research and technology development.

Major Focus / R&D Disciplines

Core competence of NAL spans practically the whole aerospace sector

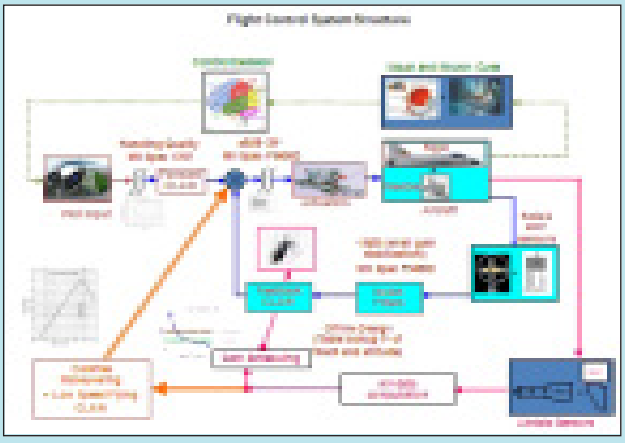
- Civil aircraft design & development
- Micro Aerial Vehicle design and development
- Computational fluid dynamic
- Experimental aerodynamics
- Flight mechanics and control
- Turbo machinery and combustion
- Composites
- Structural design, analysis & testing
- Structural dynamics and integrity
- Surface modificatio
- Aerospace materials
- Aerospace electronics and systems
- Electromagnetics
- Meteorological modeling
- Wind energy

A Glimpse of the Significant Contributions to Light Combat Aircraft (Tejas) – Airforce variant

The Aeronautical Development Agency (ADA), Department of Defence R&D is the nodal agency for the design and development of the Light Combat Aircraft, Tejas. HAL is the principal partner in the LCA programme with the participation of DRDO and CSIR laboratories, public and private sector industries and academic institutions. Over the years CSIR-NAL has developed many critical technologies for Tejas and continues to support the programme.

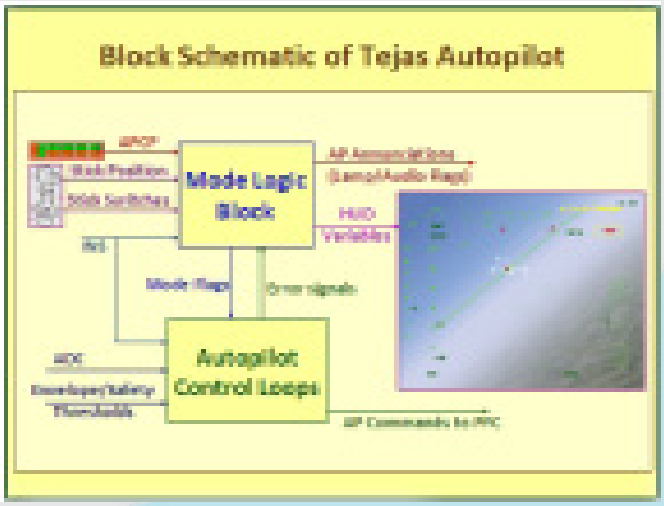
Fly-by-wire (FBW) control systems

➢ CSIR-NAL has led the national team effort to design, develop and certify the fly-by-wire flight control laws and airdata algorithms for Tejas. It has been the work centre for the National Control Law team which has spearheaded the activities leading to the Initial Operational Clearance (IOC) Standard Control Law and Airdata algorithms for TEJAS Airforce variant.

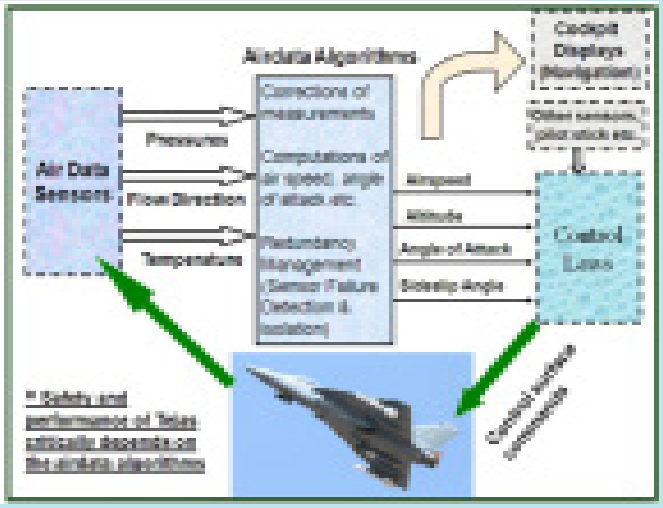


➢ It is to the credit of this team that the flight test programme for TEJAS has today successfully completed a total of over 4957 flights, carried out on 16 different prototypes by 32 test pilots over a continuously expanding ight envelope meeting the FOC requirements in full. LCA has also been inducted to IAF and flying in the squadron.

The CLAW team has also provided decisive leadership in implementing the autopilot modes, simulation and modeling including wake encounter simulation and advanced parameter identification techniques for flight validation/update of the aerodynamic database leading to safe flight envelope expansion for LCA air force variants.



Basic and advanced autopilot mode design



Complete design of data processing and redundancy management algorithms for LCA airdata sensors

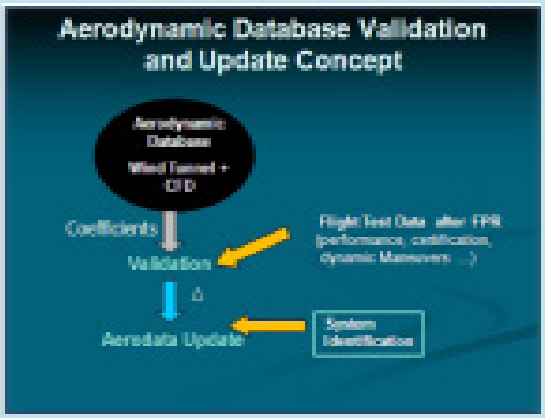
Modeling

- Aircraft 6-Degree-of-Freedom simulation technology is a key requirement for Control law development and piloted real-time assessments in simulator.
- CLAW team has developed and fine tuned the simulation models for LCA-Tejas.

Simulation

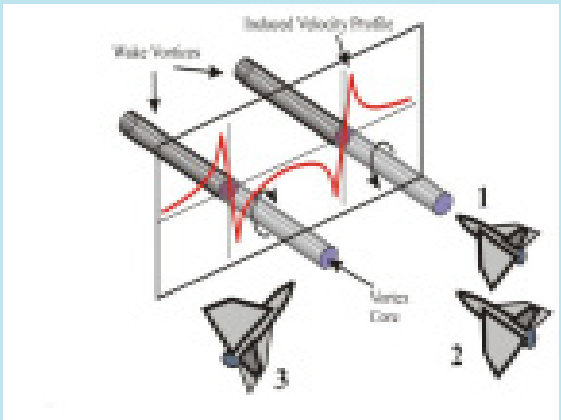
- Engineer-in-Loop Simulator (ELS) is a friendly real time simulator and a single window projection based facility developed at CSIR-NAL for preliminary evaluation of CLAW design.

Parameter Identification



Advanced PID techniques applied to update aerodynamic database generated from wind tunnel tests

Wake Encounter Simulation

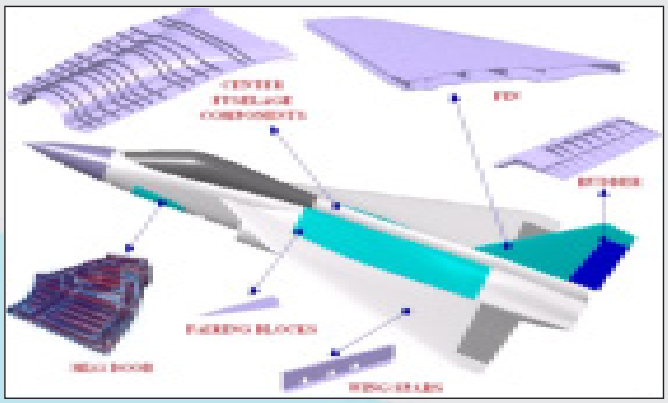


Wake encounter simulation is a very complicated and a challenging modeling and control problem. Extensive modelling and simulation studies were carried at CSIR-NAL to ensure there is no hazard to Tejas on entering the wake.

Composite Structures for LCA - Tejas

Composites offer a very attractive option in modern aircraft development because they are lighter than metal and just as strong. Tejas airframe is 45% composites (mostly carbon-epoxy) by weight contributing to its reputation as the world's smallest light weight fighter aircraft.

- CSIR-NAL successfully led the National Team for the composite wing development for Tejas.
- CSIR-NAL has pioneered the development and fabrication of composite structures for the Tejas aircraft using innovative and cost-effective fabrication technologies including co-curing / co-bonding construction.
- This innovative technology developed at CSIR-NAL not only reduces the cost but also improves the structural efficiency by minimizing the number of mechanical joints. With this innovation, composite aircraft structures have become cost effective and structurally far superior to conventional aircraft structures.
- Tie-up with Tata Advanced Materials Ltd., for supply of critical CFC components for the series production of LCA.

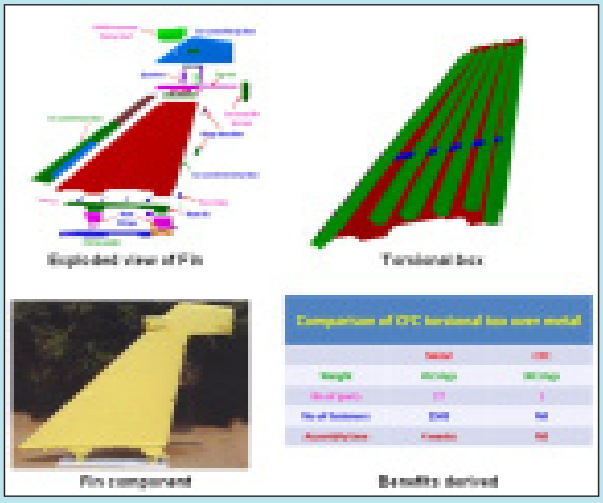


Parts	Reduction of part count due to co-curing (compared to conventional technology)
LCA Fin	200 parts to 15 parts
LCA Rudder	50 parts to 6 parts
LCA Centre Fuselage	500 parts to 44 parts
LCA undercarriage Doors (Aft and Fwd)	40 parts to 5 parts

Co-curing technology has resulted in more than 20% savings in cost and about 15% reduction in weight.

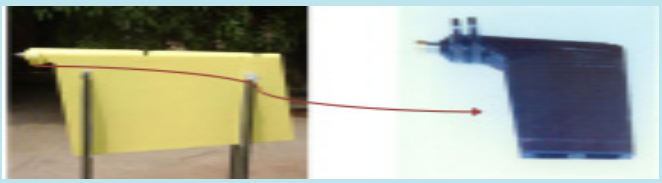
Composite Fin

- The entire box is made as a single piece in one operation using innovative and complex tooling concepts.



Composite Rudder

- Integral rib-skin co-cured construction has resulted in 20% weight reduction, eliminated expensive and complex machining of titanium torque shaft and resulted in weight savings of 35 %.



LCA rudder *Composite torque shaft*

Composite Fuselage parts

Circular duct top

Trouser duct top

Under Carriage Doors

Under carriage door forward

Under carriage door aft

Top skin centre

Wind Tunnel Tests for LCA

The National Trisonic Aerodynamic Facility of CSIR-NAL houses a 1.2m trisonic wind tunnel. Every Indian aerospace vehicle has graduated out of this wind tunnel. The tunnel has completed more than 40000 blowdowns and has been performing reliably for over 50 years.

Characterization of overall aerodynamics

➢ Extensive 6-component aerodynamic force & moment data required for Control-Law development of LCA were generated in the 1.2m trisonic wind tunnel, has led to freezing of the aerodynamic design of the LCA, including sizing of wing & control surfaces.

LCA model mounted in the NAL 1.2m wind tunnel

Dynamic tests

➢ A dynamically scaled model of LCA was designed, manufactured and tested in the 1.2m wind tunnel at angles of attack up to 16° and Mach number of 1.8 to obtain pitch and yaw-damping derivatives using Forced Oscillation Technique.

Air-Intake tests

➢ Isolated air-intake duct tests with bell mouth entry and ejector induced flow were carried out on a 1:7.645 scale model to validate the duct design through extensive static pressure measurements. Subsequently, extensive design, manufacture, development of measurement systems have been realized to arrive at the acceptable configuration.

➢ Complex instrumentation involving dynamic & semi-dynamic total & static pressure rakes (comprising 225 static, 25 total and 40 unsteady pressure sensors), data acquisition & processing systems were developed to enable measurement of steady & unsteady pressures along with mass flow control and thereby characterize pressure pulsations at the aerodynamic interference plane of the GE 404 engine used on LCA and establish buzz boundaries of the basic configuration.

Aeroelastic Model Studies

The transonic flutter of LCA wing with R-73 missile has been cleared through wind tunnel testing in 1.2 m NAL trisonic wind tunnel for initial flight clearance. A scaled flexible model of the wing is designed, fabricated and instrumented simulating both structural dynamics and aerodynamics of the wing for the aeroelastic testing. The other studies include design and analysis of the fin (stress), development of various scaled models of LCA air intake models (for Wind Tunnel testing), wing box component testing, and all material evaluation and characterisation (composite and metal).

LCA aeroelastic wing model with R-73 missile in the NAL 1.2m wind tunnel

Air force air intake wind tunnel model at Coordinate Measuring Machine

CSIR-NAL

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AUTOCLAVE

Industrial Grade Autoclave Technology

World-class Autoclave Technology Indigenously Developed by CSIR-NAL

- Industrial Duty, High temperature (425°C) and High Pressure (15 barg) Autoclaves for Demanding Applications

National Aerospace Laboratories (NAL), Bangalore, India has an acknowledged capability in building large, computer controlled, state-of-the-art autoclaves along with the associated subsystems.

NAL's expertise in designing and building autoclaves is evident from the number of autoclaves that are operational in NAL itself, namely Mark I, Mark II, Mark III and Mark IV, catering to various requirements. While Mark III is a high temperature (350°C) and high pressure (15 barg) autoclave, Mark IV is built to be an industrial workhorse with operating space as much as 4.4m in diameter and 9m in length.

Earlier, NAL has supplied an autoclave with a working space of 4m dia x 8m length, to Hindustan Aeronautics Ltd., Bangalore, India, which has been functioning satisfactorily over the years. NAL has also revamped a few autoclaves for Vikram Sarabhai Space Centre, Trivandrum, India.

M/s. KRR Heavy Engineering, Chennai and M/s. Unique Chemoplant Equipments (UCE), Mumbai, India, have taken License from NAL for marketing and manufacturing of Industrial and lab scale grade Autoclaves

Industry Partners

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Mumbai - 400 604, Maharashtra.
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AUTOCLAVE

Labscale Autoclave

- Aerospace Autoclave with state of the art features at an affordable cost
- Developed to cater the needs of R&D and Educational Institutions
- An ideal equipment for Research Labs with interest in Polymer Composites

Salient Features

- Auto, semi-auto and manual modes of operation
- PC, PLC, Front-end controllers and Recorder based C&I architecture
- User friendly Mimic & Touch screen based data acquisition
- Fail-safe and simple to operate
- Quick-lock door without lock-ring
- Compact and skid mounted
- High efficiency pressurized fan motor with health monitoring
- Peripheral duct for efficient air circulation
- Creep and oxidation resistant high temperature heating elements
- SS tubular Heat exchanger with fins for better heat transfer
- Exhaust silencer for noise reduction
- Closed loop water cooling system to minimize consumption
- Water softener for long life of heat exchanger and fan motor
- Pressurization with built-in compressor and storage tank
- Automatic vacuum level control with bag burst protection
- Advanced part temperature control

Specifications

Working space	900 mm dia and 1000 mm length
Maximum Temperature	200°C
Maximum Pressure	7 bar(g)
Heating Rate	0 to 3°C per min
Cooling Rate	3°C / min (Avg)
Temperature Control Accuracy	±1°C (Air Temperature)
Temperature Uniformity	±2°C (under steady state conditions)
Pressure Control Accuracy	±0.1 bar
Vacuum Control Accuracy	±5% of FSR
Maximum Vacuum at source	3 mbar
Total Power Rating	23 kW

Safeties

- Door lock safety device to prevent opening under pressure
- Emergency pressure dump
- Pressure & Temperature overshoot prevention
- Auto-hold to prevent higher temperature gradient
- Manual override (if the computer, PLC and control system fails)
- Earth leakage trip for the electrical system
- High current and overload protection for all the motors

Industry Partners

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AUTOCLAVE

Desktop Autoclave

- Compact, affordable Aerospace Autoclave with state of the art features
- Ideal for Academic and Research institutions for composites processing

Salient Features

- Fail-safe and easy to operate
- Quick lock hinged door with integrated lock ring
- Compact table mounted
- Works on 32A, 230V Single phase power supply
- Forced air circulation with compact pressurized fan
- Fits in a space of 1.5m cube
- Optional closed water circulation system
- Optional compressed air system
- Automatic vacuum bag failure protection
- Air less, solenoid operated control valves

Safeties

- Burst Disc
- Double Safety Relief Valve
- Wedge Lock Type Door Safety
- High Pressure switch
- Thermostat
- Emergency Dump Valve
- Earth fault protection at Incomer
- Protection for blower and Vacuum pump
- Emergency stop Push button
- Key switch for cure start

Specifications

Working space	450mm dia. and 500mm length
Maximum Temperature	200°C
Maximum Pressure	7 bar(g)
Heating Rate	0 to 3°C /min on air
Cooling Rate	1°C per min (Avg) up to 70°C on air
Temperature Control Accuracy	±1°C (Air Temperature)
Temperature Uniformity	±2°C (under steady state conditions)
Pressure Control Accuracy	±0.1 bar
Vacuum Control Accuracy	±0.5% of FSR (digital)
Maximum Vacuum at source	3 m bar
Total Power Rating	7 kW single phase

Industry Partners

datasol
Inspiration, Innovation & Inculcation

The Managing Director, DATASOL (B) Pvt. Ltd.
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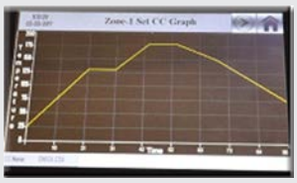
COMPOSITE REPAIR

Multi Zone Hot Bonder for Airframe and Composite Repair

Multi Zone Hot Bonder



Touch Screen Controller

Military Standard Carry Case

CSIR-NAL's Multi Zone Hot Bonder (MZHB) enables bonded repair of aircraft structures with controlled temperature, highly minimized temperature gradient and vacuum control, while meeting the stringent quality assurance and safety requirements.

Specifications

- Two parallel repair cure cycles with 12 zones of independent temperature profile control
- Two vacuum control and 24 thermocouple inputs
- Maximum heater area 0.9 Square Meter per zone
- 30A power output per zone
- Maximum temperature of 230 °C (for silicon heater blankets)
- Temperature control accuracy ± 1°C
- Temperature uniformity ± 2°C among the 12 zone controlled value
- Heater – thermocouple mapping of any heater to any one or more thermocouple
- Control based on minimum, maximum or average of the selected thermocouples
- Military Standard Carry Case

Salient Features

- High performance & cost effective
- Innovative solutions for the complex and multiple repair
- 7 inch colour touch screen PLC-HMI controller
- User friendly and feature-rich menus for hot bonding
- Online and offline reporting / printing
- USB Interface for data export to USB storage device
- Multiple ramp / soak capabilities

Safeties

- Automatic detection of heater-thermocouple mismatch
- Thermocouple failure management
- Over temperature cut off
- Dynamic alarm / control integration
- Software security lock with password access
- Auto recovery option on power interruptions

Industry Partners

SAN
ULTIMATE SOLUTIONS

The Managing Director, San Process Automation
48/3,11th Main ,3rd Cross , Channappa Building,
A.K.Colony, M.S.Ramaiah Industrial Estate
Mathikere, Bangalore - 560054
Tel: 08040926026 www.sanprocessautomation.com

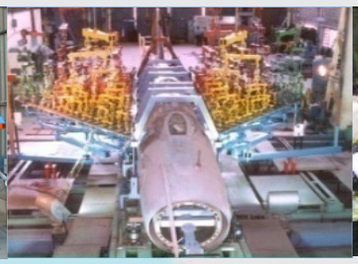
Applications

- To perform in-situ repair / hot bonding of aircraft, automobile and wind turbine blade composite structures
- Thermo-forming of foams for aircraft structures

The Managing Director, Ajay Sensors & Instruments
 # 45/17, 12th "A" Cross, Gubbanna Indl. Garden, VI Block, Rajajinagar, Bangalore 560010
Tel: 080 2330 4997, www.ajaysensors.in

For more information contact
Director, CSIR-National Aerospace Laboratories
PB 1779, HAL Airport Road, Bangalore 560 017, India.
Tel: 91-080-25086000. 25270584;
e-mail: director@nal.res.in; www.nal.res.in

STRUCTURAL INTEGRITYDIVISION

Structural Integrity Division (SID) is one of the prime divisions of NAL, which has expertise to serve commercial and military clients with their proof-of-concept demonstration and certification needs. Major activities of the Division includes static, fatigue, durability and damage tolerance testing and evaluation ranging from entire airframes down to the subsystem, component and material level, supported by advanced NDT/NDE techniques. SID has contributed immensely to all aeronautics and space programs of India by undertaking various structural and material testing and life extension studies. The division has expertise in the following fields

- Full Scale Structural and component level Test
- Life Extension studies
- Damage tolerance Evaluation
- Material Characterisation of structural materials
- R & D in Fatigue and Fracture
- NDT /NDE

Equipment

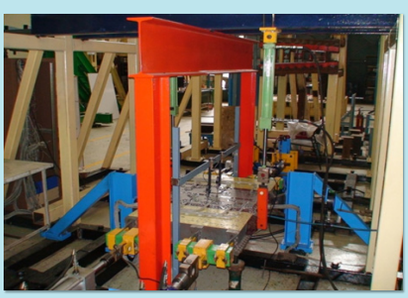
- Over 100 channel test controllers
- Over 1000 channel Data Acquisition Systems
- Servo hydraulic actuators with capacity ranging from 1-30 Tons
- Hydraulic power packs capacity range 80-260 lpm with 3000 psi operating pressure
- Advanced Displacement & Measuring sensors CDS, LDVT
- NDT equipment's with advanced damage detecting techniques

Facilities

- Static and Fatigue test bay/hangar
- Component testing area (test rig)
- Machine shop/Work shop
- FSFT control room
- Sub-component test control room
- Material Evaluation laboratory
- Non destructive testing

Structural Integrity Evaluation

- Test definition and management
- Test Rig design
- Loads spectrum development
- Test article instrumentation
- Rig assembly and commissioning
- Static testing
- Fatigue testing

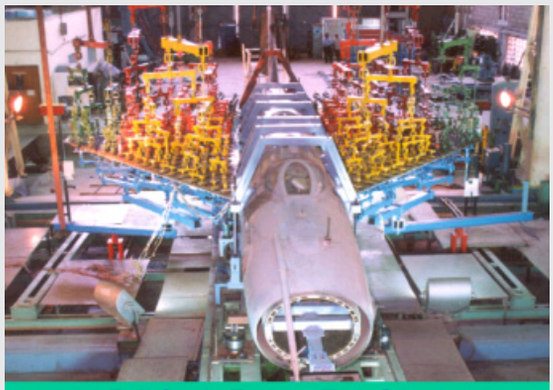



Significant contributions to major projects: HANSA, SARAS, LCA (ADA), Mig-21, Mig-29, Mi-8/16

STRUCTURAL INTEGRITY DIVISION

Full Scale Fatigue Test

- MOOG multichannel (37 Channel) Control System
- 30 Nos. of Servo hydraulic Actuators for load simulation with varying load and displacement capacities
- Hydraulic power packs of various capacities (from 4 lpm to 260 lpm @ 3000 psi).
- High speed data acquisition system (upto 1000 channels)
- Full scale fatigue testing and Life extension studies for fighter aircrafts.



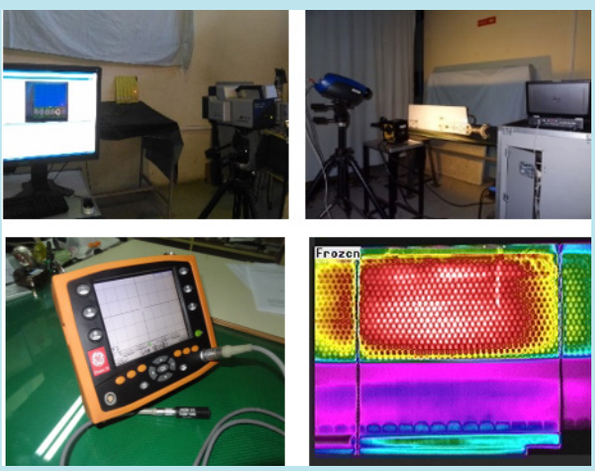
Full-Scale Fatigue Test Set up

Life extension of Mig-21 BiS

- Life extended from 2400 to 3200 flight hours through laboratory testing and analysis

Material Evaluation Laboratory

- Series of servo-hydraulic INSTRON test machines
- Capacity: 500 kN, 100 kN, 50 kN, 25 kN
- Standard test fixtures, Advanced software
- Environmental chamber : -150 C to + 600 C
- Tests carried out as per respective ASTM standards
- Coupon and feature level tests can be carried out at RT and Hot-wet conditions



Component level and full-scale structural testing

- The facility has competence to provide the solutions to Structural Testing and Evaluation for Static and Fatigue Tests at Component Level and Full Scale level. The test bed is capable of handling 50 ton reaction load.
- Additional reaction floor area of 11 m X 8 m width with 1m X 1m grid anchoring points is available for component level testing .
- The facility also caters for pressurization tests and component level hot-wet tests at controlled temperature and humidity

Materials Evaluation Laboratory

NDT/NDE Facilities

- Infra red thermal camera with integrated active thermography systems.
- Laser doppler vibrometer with spatial scanning facilities
- 16 Channel acoustic emission system for on line damage detection
- Versatile eddy current system with wide range of probes to inspect surface, subsurface damage detection
- Optical fibre Video images scope integrated with lighting and imaging facilities to inspect internal structures

Contact us

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www.nal.res.in

Certification

DGAQA

Customers

EMBRAER

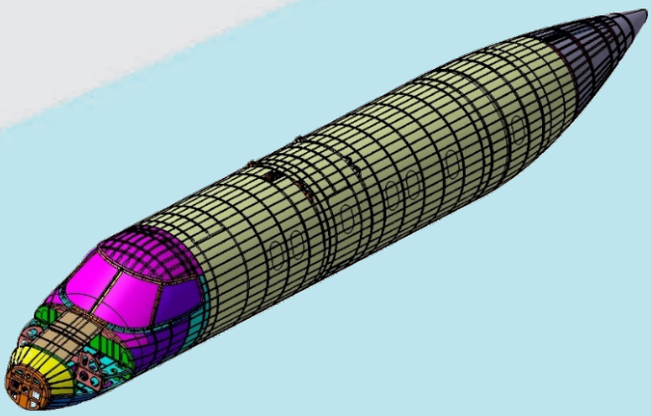
STRUCTURAL TECHNOLOGIES

Structural Technological Division (STTD) is one of the largest divisions of NAL, with primary Research & Technology lead for aerospace structures in India. The Division has expertise in aerospace structural design, analysis, testing, qualification, certification and Research and Technology development in aerospace structures and contributed to all aeronautics and space programs of India. Approved under civil aircraft certification and military aircraft certification and follows ISO 9001:2008. The division is organised as follows:

- Airframe Design Group (ADG)
- Mechanical Systems & Design Group (MDG)
- Dynamics & Aeroelasticity Group (DAG)
- Impact & Crashworthiness Group (ICG)

Airframe Design

- ADG has expertize in carrying out the following:
- Stress, Buckling, Thermo-elastic, Nonlinear Analysis and Optimization of both Metallic and Composite Aircraft Structures
- Structural Inertial Load Computation of various Aircraft Components
- Computational Fatigue & Fracture



SARAS-Mk2 Fuselage - CAD Model

Core Activity

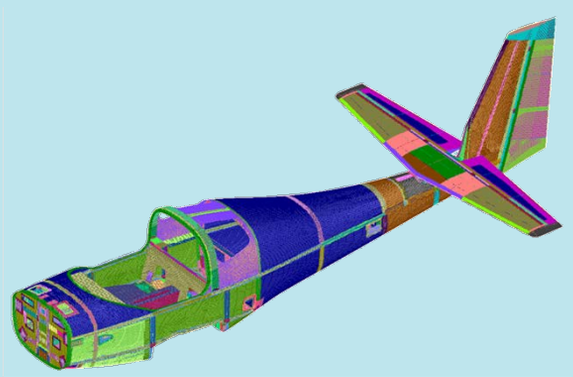
- Airframe Design, Analysis and Detail Engineering

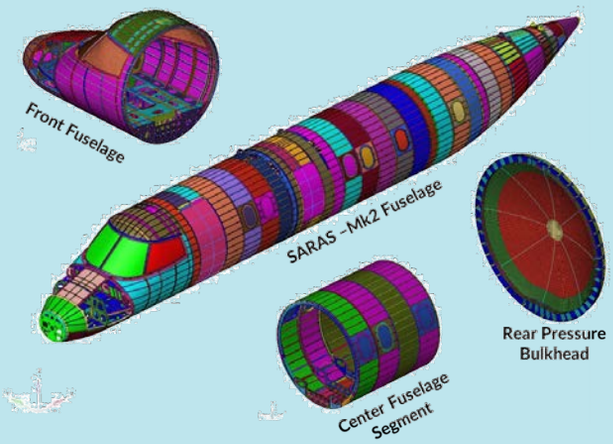
Software Tools:

- Altair HyperWorks (HyperMesh, OptiStuct, Radioss), FEMAP, MSC Software (Nastran, Patran, Nastran Embedded Fatigue), AFGROW; positioned in two state-of-the-art computational work centres.

Major Contribution to Aerospace and Strategic Sectors

- Structural Design of HANSA-NG (Fuselage, VT and HT))
- Structural Design of SARAS–Mk2 (Fuselage)
- AMCA structural design and analysis





SARAS-Mk2 Fuselage – Finite Element Model

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Industry Partner
Director (Marketing)
Bharat Electronics Limited,
Outer Ring Road, Nagava, Bangalore 560 045,
India. Tel: 91-80-25039300;
www.bel-india.in

Mechanical Systems & Design

The Group has expertise in the following

- Landing gear design and multibody dynamics
- Mechanical actuation & 6 DOF simulation
- Iron bird facility design and development
- Design of flight control actuation mechanisms
- Design and development of composite Airborne and ground based radome

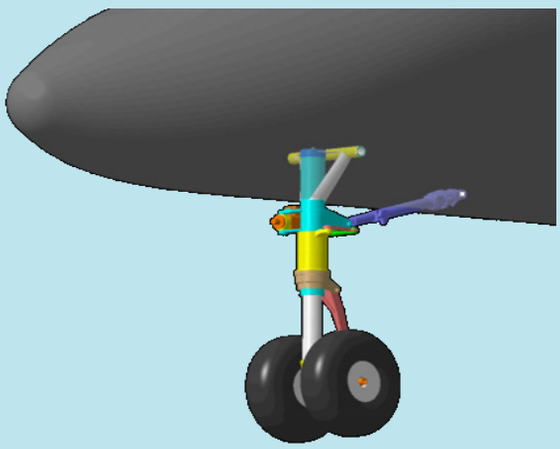
The group is equipped with state of the art simulation packages such as

- Matlab/Simulink with Sim-Hydraulics and Sim-Mechanics modules
- Flowmaster with Aircraft ECS, Hydraulic and Fuel system modules with compressible flow and transient solvers
- MSC ADAMS for Multi-Body Dynamics Simulation
- MSC EASY5 for General System simulation

Landing gear design & Multibody dynamics

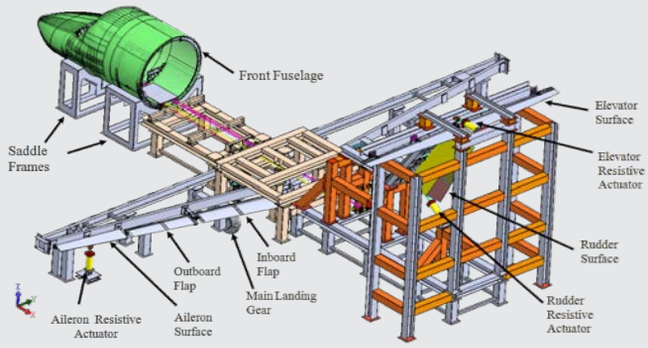
Design, Development, Analysis and Simulation of Landing Gears for civil and military aircrafts. Experience in designing the landing gears conforming to airworthiness standards like FAR, Military standards, JAR-VLA etc.

Expertise in Landing Gear mechanism synthesis and Multibody dynamics



Design and development of iron bird test facility for civil aircraft

Conceptual Model, 3D CAD Modeling of the structural framework of the Iron Bird Test Facility with primary control surfaces, flaps and landing gears of the aircraft with corresponding resistive actuators. Kinematic and Dynamic Force Analysis of primary FCS, Flaps & Landing Gear Mechanical Systems using MSC ADAMS, Design and detailed FE analysis of the structural framework.



Mechanical actuation & 6 DOF simulation

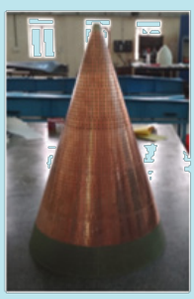
Electrically actuated 6 degrees of freedom (6 DOF) motion platform, capable of carrying a Pay Load of 1962 Newton (200 kgf). The platform produces motion in any combination of the six spatial axes consisting of three linear (Surge, Sway & Heave) and three angular (Pitch, Yaw & Roll) by individually controlling the six leg extensions.

Design of flight control actuation mechanisms

Kinematic Synthesis, 3D CAD Model (CATIA), preliminary Inboard Studies, force analysis and design of control linkages of primary and secondary flight control surface actuation mechanisms including aileron, elevator, rudder and flap actuation mechanism for mechanically actuated civil aircraft.

Design and development of composite Airborne and ground based radome

Geometric Modeling, Design, detailed FE Analysis, detailed Engineering and preparation of Production Drawings of Composite airborne and ground based radomes. Design, simulation and development of FSS (Frequency Selective Surfaces) based airborne radomes.



Dynamics and Aeroelasticity

The group has core competence in providing analysis and testing solutions in the following niche areas:

- Ground vibration testing of full-scale aircraft
- Qualification of LRUs for vibration and shock
- Inflight measurement & flight flutter testing
- Dynamic and flutter analysis
- Weapon integration and upgradation of aircraft
- Aeroelastic model testing
- Store release simulation
- VTOL based Unmanned Aerial Vehicles
- Structural health monitoring
- Vibro-acoustic simulation and testing
- FE based LRU qualification
- DIC based noncontact measurement and material characterization
- Active vibration control and adaptive structures

Weapon integration through GVT, Flutter analysis and Flight flutter testing

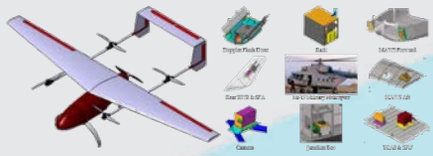
Carriage and handling clearance is provided for captive trials of IAF Jaguar, Mirage 2000 and Su-30 MKI aircrafts' integrated with next generation close combat missiles and other stores. The facility consists of aerospace industry standard ground vibration test system with 400+ channels, inflight data acquisition system and sensors, 3T shaker for adaptor & LRU qualification and approved procedures for certification.

Aeroelastic qualification of space vehicles

The group has qualified most of the launch vehicles of ISRO/fixed wing aircraft for flutter and buffet through wind tunnel testing. It has design/analysis tools, sophisticated aeroelastic model making facility, and testing infrastructure.

VTOL Based Unmanned aerial vehicles

Successfully designed, developed and tested a Separate Lift and Thrust concept vehicle for multi-mission application, and it's a hybrid VTOL (Vertical Take Off Landing) winged UAV.

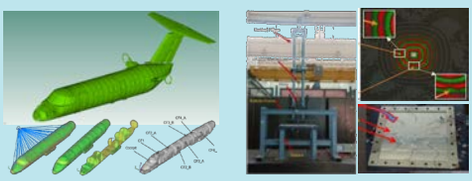


LRU qualification through FE simulation

Structural analysis of LRU installations and load substantiation for the upgradation of MI-17 1V military helicopter of Indian Air Force. Capability to certify any LRU in operational helicopter through analysis (stress, thermal, fatigue & vibration response)

Vibro-acoustic simulation and testing

Cabin noise prediction, active-passive noise control solutions, source identification using 3D acoustic camera, ground/inflight noise measurement of aircraft and automotive/aerospace subsystems.



Lamb wave based damage detection

Lamb wave based damage identification on isotropic and composite plates including stiffened aerospace structures. Off-line SHM techniques for operational and developmental aircrafts'.

DIC based noncontact measurement

Digital image correlation based noncontact full field 3D static and dynamic strain measurement on structural coupons/components, aerostat and other aerospace products.

Smart multifunctional adaptive structures

Development of biocompatible shape memory polymer composites and the process. Constitutive model for nanocomposites. Studies on CNT impregnated composites and self-healing structures. AVC techniques for real-time applications.

Impact & Crashworthiness

- Bird Strike and other FOD testing / analysis / qualification
- Landing Gear testing/analysis /qualification
- Analysis / Testing for emergency landing
- Aircraft Ditching analysis
- Abnormal / Belly Landing analysis
- High Strain Rate Testing / Modelling of metals, composites
- CVID / BVID testing and assessment

Landing Gear drop testing / analysis / qualification.

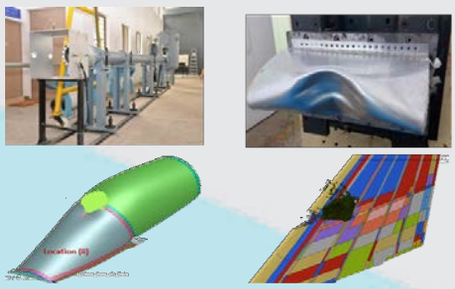
The Limit energy drop tests of existing Hansa-3 airplane main landing gear structure as per JAR-VLA/CS-VLA regulations have been conducted using the full scale drop test facility. The facility consists of all aerospace industry standard LVI test system, sensors and optical sensors for the measurement of impact response parameters from the test. Aircraft components weighing up to 4 tonnes can be Tested/Qualified in the facility.

Analysis / Testing for emergency dynamic landing for occupant safety.

Deceleration crash pulse as per FAR 23/25/27.562 requirements is generated using the Forward Velocity Sled Facility for seat qualification / design of energy absorption system / occupant safety and passive safety. The sled has a maximum payload of 1000Kg and maximum velocity of 60Km/Hr. The facility is equipped with SAE compatible sensors, DAS and Hybrid III 50th Percentile fully instrumented FAA Dummy.

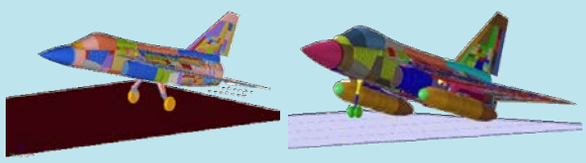
Bird Strike and other FOD testing/analysis / qualification

The airgun at NAL is the only facility in the country which caters for an impact of an 8-lb bird at over 200m/s on civil / military aircraft components that are vulnerable to bird strike (In civil transport aircraft empennage (FAR 25.631) is subjected to 8-lb bird impact. The team has strong computational expertise on HVI studies due to FOD using commercial explicit FE software's like PAMCRASH / RADIOSS / ABAQUS etc.



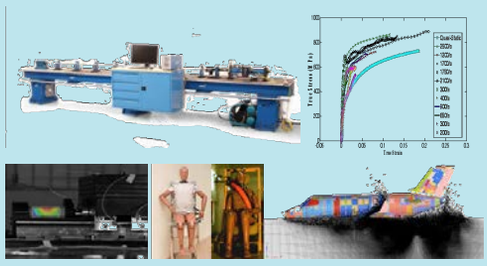
Assessment of feasibility of belly / Abnormal Landing

Assessment of feasibility of Belly Landing and Abnormal Landing (with only MLG down and with only NLG down) through simulation for military aircraft with and without the drop tanks have been performed.



High Strain Rate Testing / Modeling

The facility consists of compressive/tensile SHPB which can test metals/polymers/composites. Besides that facility exists for Taylor impact tests at higher strain rates and for validation. Materials like Nitinol, VT9, Al2024-T3 and St-37-2 are tested in the Compression SHPB using the facility up to 10,000/s strain rates.



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CARBON FIBRE

Development of Indigenous Carbon Fibre Technology - Self Sufficiency

Carbon Fibre plant at CSIR-NAL

Carbon fiber is a high strength, high-stiffness but low weight material, used extensively in manufacture of aircraft, missiles, launch vehicles and satellites. It is also an important raw material in many vital industrial applications such as wind energy, infrastructure, sports and transportation, to name a few.

CSIR-NAL established carbon fibre Facility in 2003. This facility is an integrated facility and is capable of producing special acrylic precursor fibres (SAF), carbon fibres and carbon/epoxy prepregs. The carbon fibre R&D activity was started in CSIR-NAL at a time when carbon fibres were not easily available due to sanctions and denial regimes. CSIR-NAL pioneered the development of carbon fiber technology and demonstrated the same on a pilot plant of 10 TPA capacity. Subsequently, CSIR-NAL successfully transferred the technical know-how to Kemrock Industries and Exports Limited, Vadodara, for the production of carbon fiber on commercial scale up to 300 TPA; Kemrock commissioned India's first commercial scale carbon fiber manufacturing facility on May 9, 2010. Type certified by Centre for Military Airworthiness and Certification (CEMILAC), Bangalore on September 21, 2011.

Products developed at CSIR-NAL

CSIR-NAL offers complete process 'Know-How' for standard modulus grade carbon fibres, which includes

- Synthesis of Polyacrylonitrile copolymer
- Wet spinning of Special Acrylic Fibre (SAF)
- Heat treatment of special acrylic fibre to 'Carbon Fibre'.

Components developed from indigenous Carbon Fibre

Technical details:

Base material : Carbon Fibre **Grade:** 3K, 6K and 12K

End Use: Manufacturing of prepregs commonly employed in the construction of aeronautical structures.

Storage life: 12 months (from date of application of sizing/finish) when stored at room temperature with adequate protection from dust.

For more information contact
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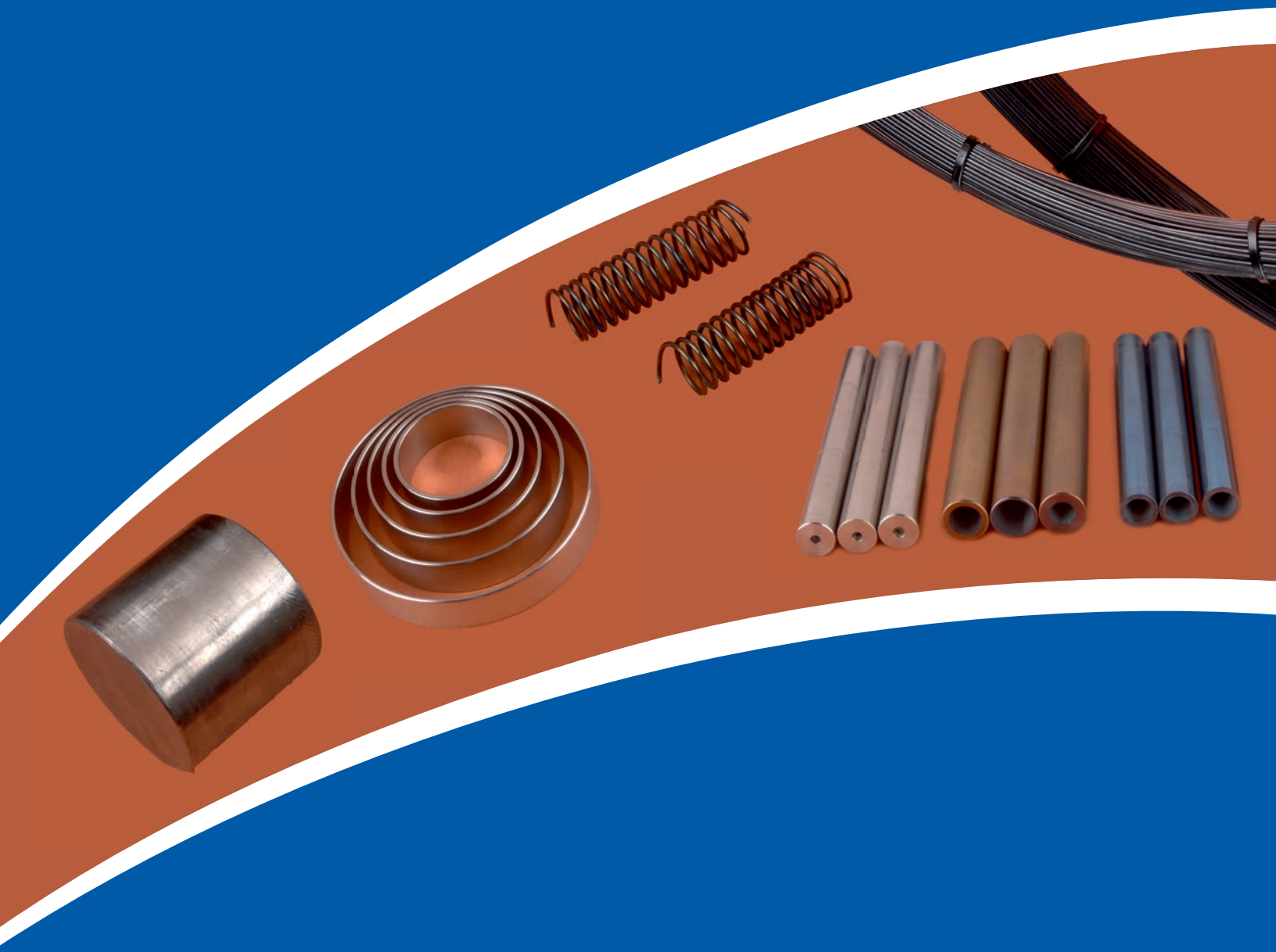
NiTi Shape Memory Alloys

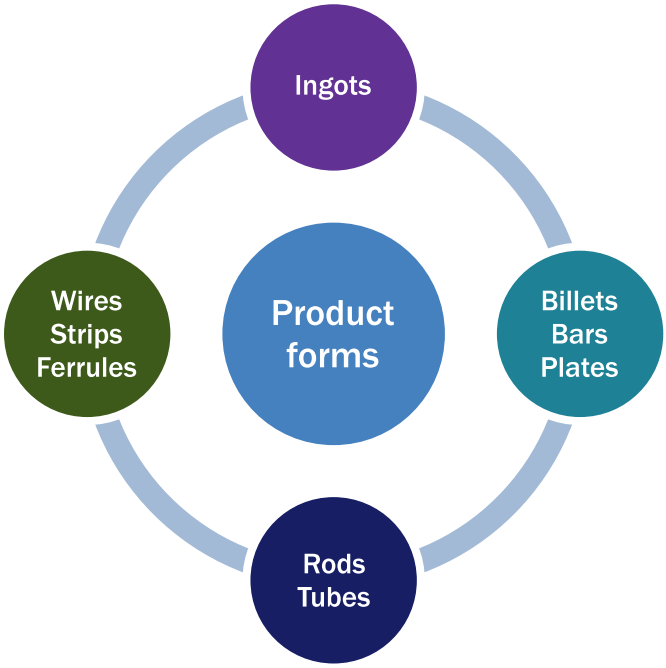


Technical know-how of CSIR-NAL

In Collaboration with
HAL, Bengaluru and MIDHANI, Hyderabad

Preamble

The Materials Science Division of CSIR - National Aerospace Laboratories has been carrying out R & D on NiTi Shape Memory alloys (SMAs) for the past 10 years. The Division has successfully developed the know-how for the processing of NiTi SMAs in various semi-finished and finished product forms. The SMAs developed are suitable for both engineering and biomedical applications. The technology is being transferred to MIDHANI, Hyderabad, a defence public sector undertaking (DPSU) for commercial production and marketing.



Customers

- Aerospace
- Defense
- Robotics
- Power sector
- Automobile
- Healthcare

Manufacturing

Alloy melting	Vacuum Induction Melting (VIM) Vacuum Arc Remelting (VAR)	Clean melts with desired Transformation Temperatures	Melt capacity in the range 10 - 40 kg
Thermo-mechanical Processing	Hot forging, Hot rolling, Hot swaging, Hot wire drawing, Cold wire drawing	Process control with controlled atmosphere	Rods – 5 to 10 mm ϕ Wire – 0.15 to 2.0 mm ϕ Plate – 10 to 15 mm thick Strip – 0.3 to 1.5 mm thick
Finishing	Shape setting, Shape memory annealing	Oxide or oxide-free surface	Straight or customized shapes

Technical Support

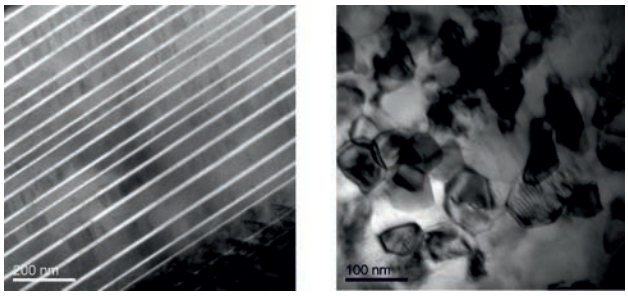
- Post know-how transfer technical support by a team of knowledgeable scientist and engineers
- Training of industry personnel
- Access to CSIR-NAL SMA test facilities for evaluation of products till self sufficiency
- R & D support for future product development

Technical Information

Shape memory and Superelasticity

Nickel-titanium (NiTi) SMAs have received considerable scientific attention because of their two unique functional properties: shape memory effect (SME) and superelasticity (SE). SME is the ability of the material to be deformed at low temperature and then revert to its original shape upon heating above a critical temperature. SE is the ability of the material to experience large recoverable strains when deformed within a temperature range. These, combined with the superior mechanical properties and corrosion resistance enable SMAs as promising class of material for a variety of engineering applications.

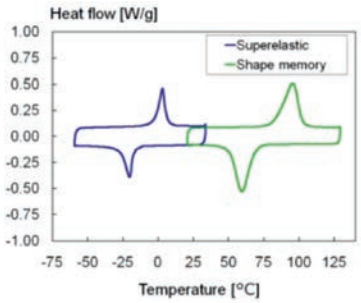
Microstructure – Phase Transformation



Martensite (low temperature) Austenite (high temperature)

Transformation Properties

Differential scanning calorimetry as per ASTM F2004.

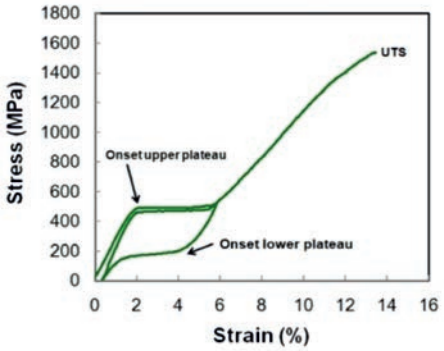


Alloy grade	Shape memory (SME)	Superelastic (SE)
Austenite finish (A_f), °C	65-105	10-25
Martensite start (M_s), °C	25-45	- 70 to -40
Hysteresis (A_f-M_s), °C	30-40	35-50

Mechanical Properties

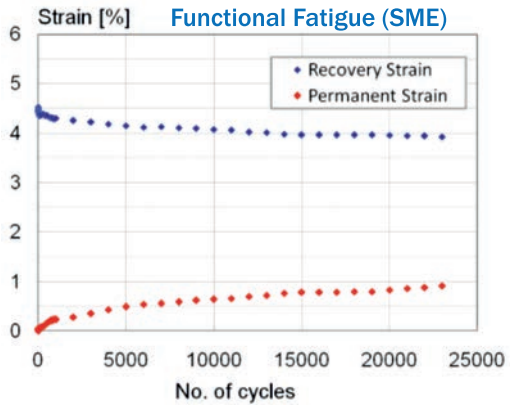
Tensile testing (ASTM E8, ASTM F2516) of the products are routinely done to evaluate the mechanical properties viz., plateau stress, recovery strain, ultimate tensile strength and elongation to failure to ensure quality products

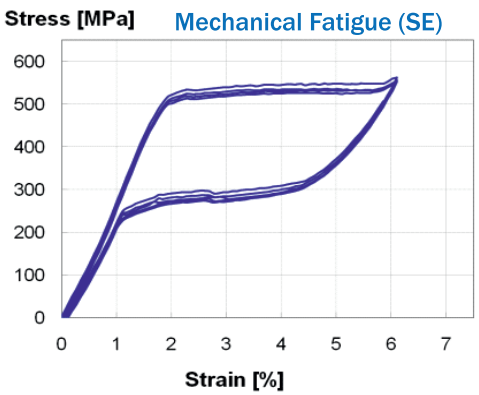
Alloy grade	Shape memory (SME)	Superelastic (SE)
Modulus (GPa)		
Austenite	65-70	65-70
Martensite	25-30	25-30
Ultimate tensile strength (MPa)		
Austenite	1300-1400	1500-1600
Martensite	1400-1500	-
Elongation to failure (%)		
Austenite	12-14	14-16
Martensite	16-18	-



Fatigue properties

Functional fatigue testing of NiTi (SME) alloy under thermo-mechanical loading conditions are performed using custom-built apparatus for determination of recovery strain, permanent strain and number of cycle to failure. Functional fatigue life of SMAs are highly dependent on stress-strain-temperature of applications and varies from 20,000 to >1,00,000 cycles. Mechanical fatigue testing of NiTi (SE) in strain controlled mode are performed to evaluate the variations in plateau stress, transformation hysteresis and number of cycle to failure.





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Web: www.nal.res.in

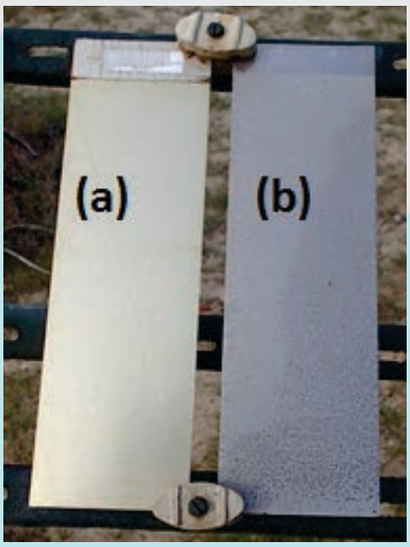
Special Materials & Technologies

Moving from Chromate to Non Chromate Process

- Eco-friendly replacement for chromic acid anodizing (CAA) by modified tartaric sulphuric acid (MTSA) process
- Indigenously developed for long term corrosion resistance (MIL-8625 F), self-healing, adhesion with retained mechanical properties
- Suitable for Al alloys of 2XXX, 6XXX, 7XXX etc.
- Process clearance obtained from RCMA, CEMILAC, Bangalore (RCMA(F&F-FOL)/NAL/223-06/443/C-01/2018/01, dt. 07/05/2018)

Outdoor Exposure Study

Qualified > 18 months outdoor exposure carried out at Corrosion Testing Centre, Mandapam Camp, Rameshwaram.



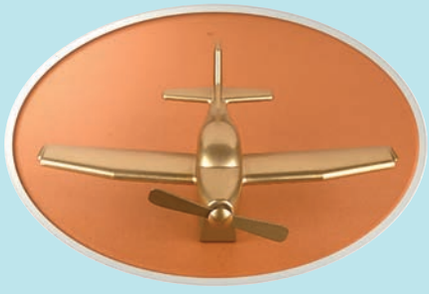
Visual appearance of MTSA (a) and bare Al alloy (b) exposed to real time corrosion

Specifications

- Visual Appearance : Smooth, pore/crack free
- Thickness : 4±2 µm (Max. 20 µm)
- Corrosion resistance : > 2000 h of salt spray (ASTM B117)
- Adhesion with primer : Excellent (ASTM D3359; BS 3900; DEF 1053)
- Electrical breakdown : >80 V
- Sealing temperature : <80° C

Anodized Components (AA 2024)

Complex shape



Aircraft Step Down Model

2' X 2' Sheet

Industry tie-ups

- HAL, ADA, VSSC, DMRL, Ordinance Factory

CSIR-NAL

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Special Materials & Technologies

NAL MRA SENSOR FOR NON CONTACT MEASUREMENTS

The NAL MRA 1426 is a giant magnetoresistive (GMR) technology based magnetic sensor, which allows to quantify various physical parameters in a perturb magnetic field environment. It consists of highly sensitive unshielded GMR elements (250 x 300 µm2) configured in a form of single Wheatstone bridge. The Wheatstone bridge generates a differential output voltage in presence of magnetic field gradient along the sensitivity direction. Each resistor has 6.3 kΩ nominal resistance and output of the bridge is purely ratiometric with the input voltage. NAL's unique GMR technology and design make it highly sensitive and enable to detect motion of the object at larger air gap. The excellent thermal and voltage stability make it suitable for challenging environments.

Gear Tooth Sensors based on Giant Magnetoresistance (GMR)

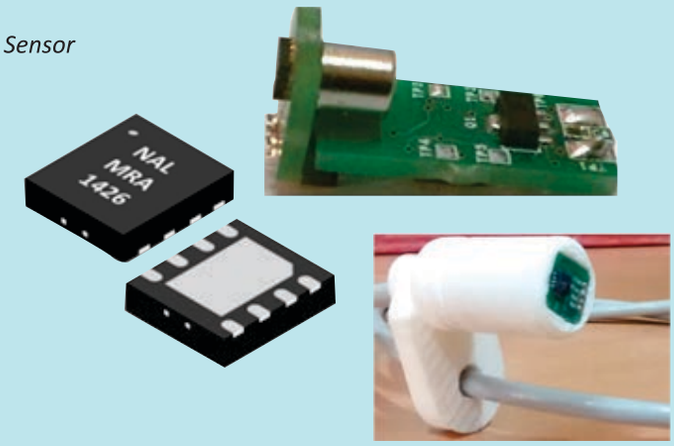
CSIR-NAL

- The sensors have wide band width and low power operation (2mA@12V), and miniature size (3mm x3mm) with low cost
- Patented technology will benefit Two Wheeler & Four Wheeler Automotive Companies in India

Application

Speed sensing, Current sensing, Pressure sensing, Implantable medical devices, Power electronics modules and Vibration detection

GMR Sensor



Features

- Giant magnetoresistance based technology
- High sensitivity (0.08 %/G)
- 0 to ± 150 G operation range
- Omni-polar operation (either N or S pole)
- Wide gap tolerance (> 5 mm)
- DC (0 Hz) to > 1 MHZ operation
- Low power consumption (2 mA @12 V)
- Excellent voltage and thermal stability
- Low hysteresis (< 9% FS) and nonlinearity (< 2% FS)
- Miniature size (3 mm x 3 mm)
- Low cost

Advantages

- Non-contact measurement allows maintenance-free, wear less operation
- Large permissible air gap between sensor and target, thus reducing the manufacturing cost
- Large bandwidth allows to monitor highly dynamic processes
- Reliable and safe to use in challenging environment

CSIR-NAL

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Integrated Avionics Display Computer (IADC)

Software Applications

Functions Hosted

- Autopilot (AP) and Flight Director(FD)
- Yaw Damper (YD)
- Stall Warning System (SWS)
- Brake Management System (BMS)
- Central Maintenance System (CMS)
- Utility Services and Management (USM)
- Flight Data Acquisition System

Computer Applications

- Avionics Display Computer
- Flight Control Computer(AP,FD,SWS)
- Central Maintenance Computer
- IESVS Computer
- Utilities Computer
- IVHM Computer

Interfaces Standards

- ARINC 429, ARINC 664, ARINC 818, ARINC 708, ARIN 825, ARINC 615
- RS-422, RS-232
- Ethernet, JTAG
- Analog and Discretes

Certification Standards

- ARINC 653, ARINC 615A
- DO 178 C, DO 254 , DO 160 G
- VPX VITA 46

Salient Features

- Drives Five high bandwidth (3.172 Gbps)1400 x 1050 pixel displays using NAL's ARINC 818 IP-Core – Fibre Channel communication
- ARINC 653 compliant multi partition
- Modular Design and expandable IO
- Dual redundant processor, IO , Power and Communication channels
- 42 ARINC 429 and 124 Discrete with 20 % growth potential
- Designed to operate from -40 Deg C to +65 deg C
- Model based D&D for complete application software
- **Performance Results**
  - Processor time utilisation of 3.8 mSec out of 25 mSec (15.2 % utilisation)
  - Complete Input Acquisition in 1.4 mSec
  - Processor MIPS of 5150(after de-rating), Requirement is 1620 MIPS (31.4%)
  - 95 to 98 % BIT Coverage
- Memory utilisation – 18 % of 250 MB
- Supports high speed Intra modules (VPX) connectivity
- Dual redundant Power Source (+28 V)

CSIR-NAL

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DRISHTI & AWMS

DRISHTI and Aviation Weather Monitoring System (AWMS)

Drishti Transmissometer, a visibility measuring system is an innovative, indigenous product first of its kind,designed and developed by CSIR-NAL.

DRISHTI uses novel signal processing techniques with high accuracy and resolution. The data acquisition at fieldsite is in FPGA embedded platform with computation of Visibility using “Drishti RVR software” in industry standard Lab View environment. Web enabled health monitoring, remote control of the system from any location in the country for accessing the data and for maintenance are the other important features of this state of the art system.

The system is extremely robust with high mean time between failures. DRISHTI has been issued International Class-I Certification. Servicing is made user-friendly and cost-effective by modular electronics and virtual instrumentation concepts in the design.

DRISHTI gives Runway Visibility to Pilots

IGI Airport, New Delhi

DRISHTI and AWMS together gives all the weather parameters required for

SAFE Airport operations

AWMS gives

- Wind speed
- Wind direction
- Pressure
- Temperature
- Dew Point
- Humidity

AWMS

At Kannur Airport

- Indigenous and Cost Effective
- Base line : 30 meters
- Measurement Range of Visibility : 10-10000 meters
- Meets International Civil Aviation Organisation (ICAO) and World Meteorological Organsation (WMO) requirements

KIA, Bangalore

Mandatory systems for safe landing and take off operations at Airports

Industry Partners

The Managing Director, Central Electronics Limited
Site IV, Industrial Area
Sahibabad - 201 010 (U.P.), India

Tata Advanced Systems Limited
42 - 43 Electronics City, Phase-1, Hosur Road,
Bengaluru 560 100, India

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SARAS Mk II

19 - Seat Light Transport Aircraft

CSIR-NAL

SARAS Mk II

Indigenous Next - Gen Commuter Transport Aircraft

SARAS Mk II Features

- Multi-role using Quick Conversion Kits and max utility
- Operation from HOT/High Altitude Airfields (high PLF)
- Operation from Semi-prepared Runways
- Cockpit ergonomics comfort from 3P to 97P pilots
- Single pilot operation cockpit
- Auto pilot & Avionics with CAT II landing
- Pressurized Cabin
- Cabin comfort at 55 deg OAT on Ground
- Low block fuel consumption
- Provision for Special equipment & NVG Military roles
- IRNSS & GAGAN compatibility
- Low acquisition cost

Technologies of SARAS Mk II

- Digital controlled Advanced Turbo Prop
- Auto pilot & Hydraulic boosted actuators
- Open distributed modular Avionics
- Smart AMLCD's display system
- Low Drag & high aerodynamic performance
- TCAS
- Air Data Computer
- Composite airframe
- Structural Health Monitoring
- Advanced Materials
- Self clean coatings
- Anti-icing coatings
- Abrasion resistant coatings
- Advanced General Systems
- Lean Ground Infrastructure
- Maintenance Concepts that reduce maintenance (Hardware/Software)

SARAS Mk II specifications

Avionics system

Full glass cockpit: EFIS - Four PFD / ND / MFDs
Comm/Nav suite: VHF - VOR and radio, ADF, DME, ILS
TAWS - Terrain Avoidance Warning System
FMS: Flight Management System
TCAS: Traffic Collision Avoidance System
Auto pilot and Weather Radar

Power plant

SARAS is powered by two Pratt and Whitney Canada PT6A-67A turbo-prop engines (flat rated to 1200shp) driving 2.6m diameter 5 bladed constant speed propllers at 1700 rpm in a tractor configuration.

Main dimensions

Span	:	18.0 m (59.0 ft)
Length	:	16.7 m (54.8 ft)
Height	:	5.5 m (18.0 ft)

Weights

Max. take-off	:	7500 kg (16530 lb)
Operating empty wt.	:	5000 kg (11020 lb)
Max. fuel weight	:	1832 kg (4038 lb)
Max. pay load	:	1710 kg (3769 lb)

Performance (ISA)

Take-off distance	:	840 m (2755 ft)
Landing distance	:	670 m (2198 ft)
Max. rate of climb	:	7.64 m/s (1504 ft/min)
Max. range* (19 pax)	:	728 km (393 nm)
Max. range* (7 pax)	:	2330 km (1258 nm)
Ferry range*	:	2400 km (1296 nm)
Max. cruise speed	:	465 km/hr (251 kt)
Stall Speed	:	156 km/hr
Endurance	:	6.1 hours
Service Ceiling	:	30,270ft (9.23 km)
High Altitude Operation	:	3300 m

*With 45 min reserve

Saras - Mk II Cabin Layout

Seating Pitch - 28 inch Aisle width - 20 inches Luggage volume - 2 cu.m

Lavatory - 32" Wide, located behind cockpit wall

Doors and Emergency exits as per FAR 23, Wider Cargo Door - 1.2m x 1.45m on LH Side

Lavatory

Seat Plan

Seat Geometry

SARAS Mk-II - Cabin - Troop Transport - 18 seat with lavatory

For More Information Contact

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www.nal.res.in

Hansa-NG

Comfort, Performance & Economy

CSIR-NAL

India's First All Composite Ab-initio Trainer

Mesco Aerospace

Coming Soon

Hansa - Next Generation : The Next Level of Performance

Just in time Prepeg
less weight & higher production rate

Provision for Baggage

Bubble Canopy
opening towards front

New MIP with Glass Cockpit
Aspen EFD 1000 pro PFD

MTV-21-A / 175-05
Propeller

Rotax 912 iSc 3 sport engine
option to use both MOGAS and AVGAS

Increased Range & Endurance
500 nm, 6 hrs

Steerable Nose Landing Gear
for better control

More Range : 500 nm (926 km)

Longer Endurance : 6 hrs

Advanced Engine : Rotax 912 iSc 3 sport 100 hp

Lower Acquisition & Operating cost

JAR - VLA / CS -VLA Certification

Hansa-NG : *Better choice for flying clubs*

Hansa - is India's first all-composite light aircraft designed & developed by CSIR-NAL in the CS-VLA category, ideally suited for ab-initio flying training, sport and hobby flying.

Hansa - NG is a two seater, low wing aircraft, low noise emission and option to use both MOGAS and AVGAS allows for more flexible and economical operations meeting IFR certification.

All glass cockpit with cabin comfort and good ergonomics Easy to fly with good handling qualities & low operation and maintenance cost.

Hansa-NG would be affordable and appreciable single engine aircraft.

Hansa - NG Key Data

Geometry		
Overall length	:	7.658 m (25.12 ft)
Overall height	:	2.614 m (8.576 ft)
Wing span	:	10.47 m (34.35 ft)
Wing area	:	12.47 sq m (134.22 sq ft)
Cabin width	:	1.07 m (3.5 ft)

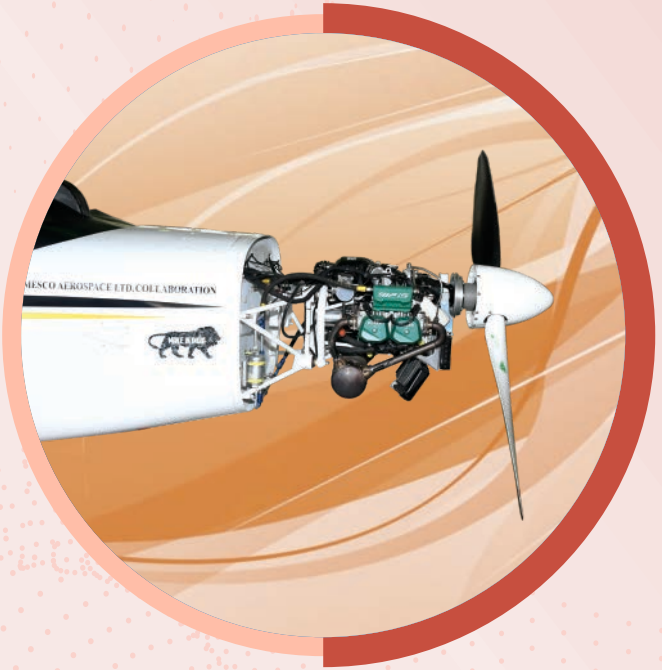
Weight		
Empty weight	:	540 kg (1190.50 lb)
All-up-weight	:	750 kg (1653.46 lb)
Useful load	:	210 kg (463 lb)
Usable fuel	:	95 ltr capacity

Aircraft Data (Performance)		
Take-off distance	:	450 m (1476 ft)
Landing distance	:	600 m (1968 ft)
Max rate of climb	:	198 m/min (650 ft/min)
Max cruise speed	:	200 km/hr (108 KTAS)
Stall speed (flaps 20°)	:	80 km/hr (43 KCAS)
Range (with 45 min reserves)	:	500 nm (926 km)
Endurance	:	6 hrs
Engine	:	100 hp Rotax 912 iSc 3 sport

Thrust U Can Trust

Hansa-NG is powered with Rotax 912 iSc 3 sport engine. The 4-cylinder, 4-stroke liquid/air cooled engine runs on AVGAS 100 LL (ASTM D910) / MOGAS EN 228 Super/ Super Plus or equivalent fuel (INDIAN standard IS 2796:2008). Provides maximum power of 100 hp @ 5800 rpm for 5 min duration and maximum continuous power of 98 hp @ 5500 rpm.

Advanced Rotax Engine



Advance Features

It has got advanced electronic fuel injection system, which controls the fuel and air mixtures electronically and provides optimum fuel air mixture at every altitude. The engine management system transfers the engine information electronically to the digital display unit "Engine Management Unit (EMU)" in the cockpit.

Why Hansa - NG

Improved Airframe

Better alternate composite materials with cost effective just in-time prepreg manufacturing process

Improved Ingress / Egress

Bubble canopy opening towards front to improve the ingress / egress

Crew Baggage

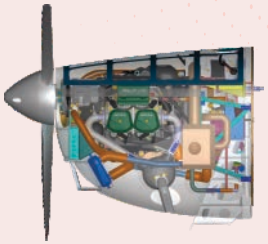
A separate baggage compartments behind the seats for long range operations

Modern Avionics

Full glass cockpit, Aspen EFD 1000 pro PFD, EMU, Avidyne NAV/COM/GPS, AMU, Transponder, secondary COM. Better cockpit aesthetics & ergonomics

Improvements in Configuration

Redesigned engine cowl for minimum drag, landing gear wheel fairing and optimized MLG-fuselage interface fairing



Advanced Propulsion

Advanced 100 hp Rotax 912 iSc sport engine with better SFC and runs on both MOGAS / AVGAS

Steerable Nose Wheel

Oleo-pneumatic type steerable nose landing gear for better control

Low aquisition & operating cost

Low acquisition & operating cost is the moto of Hansa -NG. It is one of the best in class in terms of acquisition cost , operating cost, fuel efficiency.

All up weight : 750 kg

Max. Speed : 200 km/hr

Endurance : 6 hrs

Take off distance : 450 m

Max. Altitude : 10000 ft

Hansa-NG : Performance with Economy

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Kailash Colony, New Delhi 110048
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www.mescoaerospace.com

Mesco Aerospace

Multi-Mission General Aviation Aircraft : C-NM5

Joint Development by

CSIR - National Aerospace Laboratories and

Mahindra Aerospace Pvt. Ltd.

FEATURES

Multi-Mission : Air Taxi, Training, Tourism, Cargo, Executive Transport

Certification basis : FAR Part 23
Normal Category
Day / Night VFR / IFR

Equipping options :

Standard : Conventional instruments
Stand alone avionics
Limited cabin environment control
Basic audio for pilot and passengers

Deluxe : Glass cockpit with Electronic Flight Instruments System (EFIS)
Autopilot integrated with GPS-enabled Nav / Com
Air-conditioning
Improved sound-proofing
Improved cabin audio system

First Flight on 1 September 2011 in Australia
Prototype Manufactured by Mahindra GippsAero.

C-NM5 SPECIFICATIONS

Mahindra Aerospace

Dimensions

Overall length	: 8.8 m (28 ft 9 in)
Overall height	: 3.0 m (9 ft 10 in)
Wing span	: 10.9 m (35 ft 8 in)
Wing area	: 16.0 m^2 (172 ft^2)

Weights

Max. take-off weight	: 1525 kg (3362 lb)
Empty weight	: 945 kg (2083 lb)
Useful load	: 580 kg (1280 lb)

Airframe

All metal construction with composite cowling and fairings

Power plant

Lycoming IO-540 engine, 300 bhp @ 2700 rpm, 3-bladed constant-speed propeller

Avionics system

AMS, NAV / COM / GPS, CDI, Transponder, and ELT

Electrical system

24 V DC electrical system

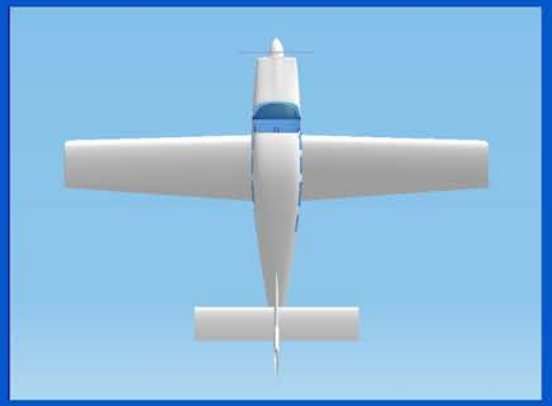
- 28 V, 70 A external generator
- 24 V, 19 Ah maintenance free battery

Performance (ISA)

Take off distance	=	500 m (1640 ft)
Landing distance	=	450 m (1476 ft)
Max. Level speed	=	296 km/hr (160 KIAS)
Max. Rate of climb	=	335 m/min (1100 fpm)
Flaps-up stall speed	=	120 km/hr (65 KIAS)
Flaps-down stall speed	=	102 km/hr (55 KIAS)
Range (with 320 kg payload)	=	1300 km (700 nm)
Cruise altitude	=	3050 m (10000 ft)

Optional systems

Air-conditioning and 2-Axis Autopilot



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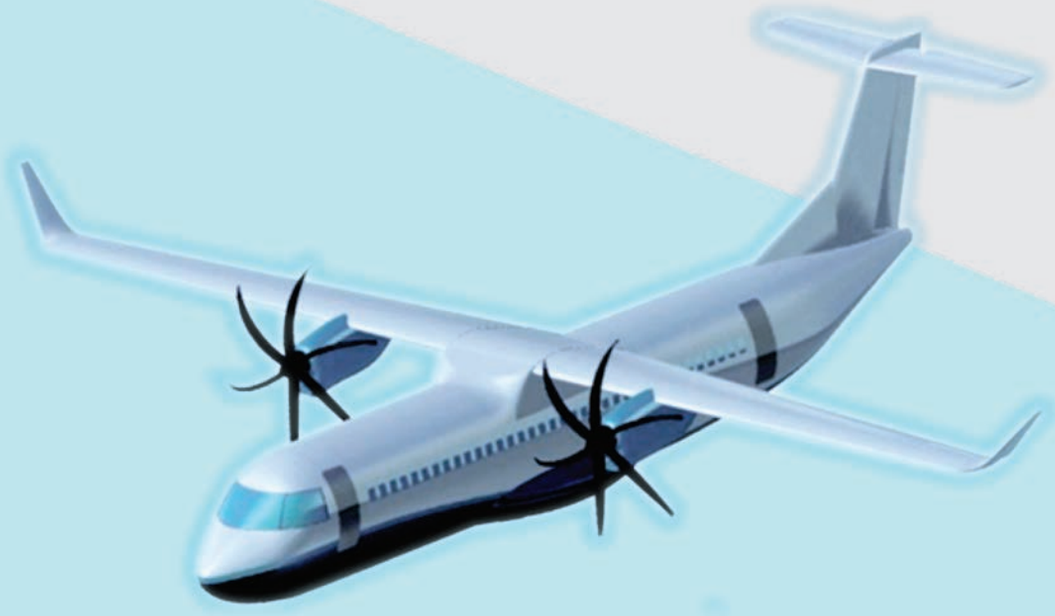
Mahindra Aero Structures Pvt. Ltd.,
Plot #251 to 265, Narasapura Industrial Area, Kolar Taluk
Karnataka 563 133, India
Tel: 91-8152 280510

New Gen Regional Transport Aircraft

For Regional Connectivity



RTA-90

Salient Features

Lower acquisition / operating & maintenance cost

Landing and take-off from unequipped airfields

Lower emissions

All weather operation

Low noise level

Cargo hold for additional payload

Range with 90 pax - 1500 km

Wide cabin 4 abreast arrangement

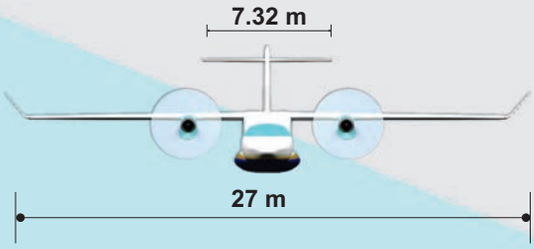
Avionics & FCS - Open architecture

COTS, FBW, GPS, ADS, Low cost HUD, etc.

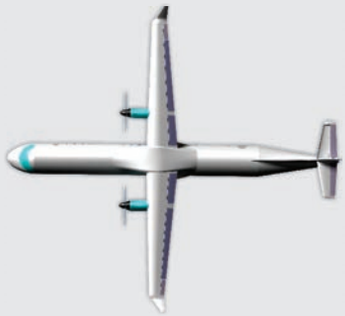
New Gen Regional Transport Aircraft - *For Regional Connectivity*

Three-View

Front-View



Top-View

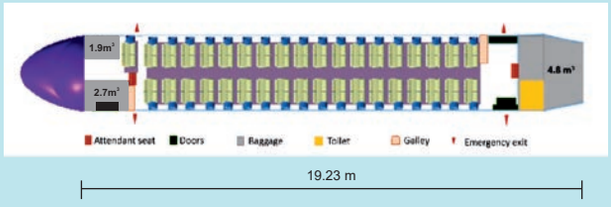


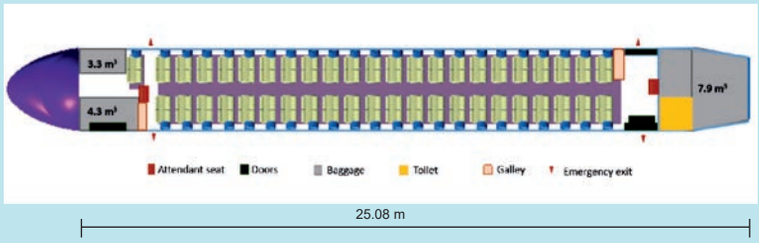
Side-View

Specifications - RTA 90

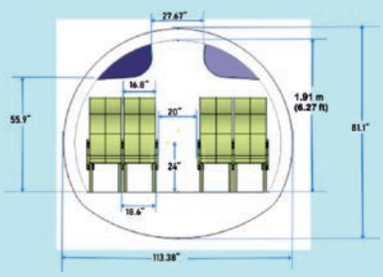
- Cruise speed 550 kmph
- Ceiling 30,000 ft
- Net single engine ceiling - 20,000 ft
- Wide cabin 4 abreast arrangement
- Cargo hold volume 20 cu.m
- Balanced take-off field length (ISA,SL,MTOW)-1200 m
- Landing field length (ISA,SL,MLW)-900 m
- Avionics and FCS-Open architecture, COTS, FBW, GPS, ADS, Low cost HUD, etc.

Cabin Layout





Baggage Volumes $(m)^3$	70 seat RTA	90 seat RTA
Baggage compartment	9.5	11.75
Baggage per pax	0.136	0.131
Total Overhead bin volume	3.25	3.94
Total baggage (incl. overhead bins)	12.75	15.69
Total baggage per pax	0.180	0.175



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Octocopter

Dimensions	:	**Ready to Fly - Ø2267 mm x 730 mm**
Weight	:	**Empty Weight - 20 kg-f** **Battery Weight - 16 kg-f** **Payload Capacity - 20 kg-f** **Max. Take-off Weight - 60 kg-f**
Hovering Endurance	:	**No Payload - 38 min** **20 kg-f Payload - 20 min**
Operation	:	**Fully Autonomous**
Flying Speed	:	**Operational Speed - 2.5 m/s** **Max. Speed - 10 m/s**
Max. Range of Operation	:	**5 km**
Max. Rate of Climb	:	**2 m/s**
Max. Rate of Decent	:	**1.5 m/s**
Altitude	:	**Operational Altitude - 100 m AGL** **Max. Altitude - 3000 m AMSL**
Operating Temperature	:	**0 – 40 C**
Structure	:	**Carbon Fiber Frame with high-grade Aluminum Chassis**
Propulsion	:	**2.7 kW Motor + 30' Foldable Propeller**
Battery	:	**Lithium Polymer – 60Ah**
Payload	:	**1. Hyperspectral Camera** **2. Chemical Tank** **a. Volume - 18 L** **b. No. of Nozzles - 3** **c. Max Flow Rate - 1.5 lt/min**

CSIR-NAL

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UAV

SUCHAN - MINI UAV

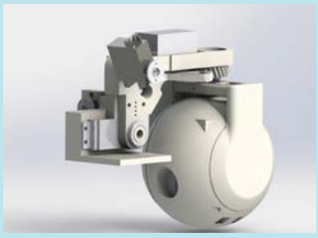
Suchan is an all composite, light weight, modular mini UAV designed and developed by CSIR-NAL. Its designed to meet high altitude operation requirements and has a ceiling altitudes of 5000 m ASL. This Indigenously designed and developed mini-UAV is a far more cost efficient solution than other UAVs.

Specifications

Payload	:	Interchangeable nose assembly (Pan-tilt Gimbal) - Option 1 : EO camera (1080p) - Option 2 : Infra-red camera (640x480 pix)
Range	:	10 km (Communication Link)
Endurance	:	90 min
Speed	:	10- 25 ms^{-1}
Wing span	:	1.85 m
Length	:	1.40 m
Weight	:	5.0 kg (Max. take-off wt.)
Launch	:	Hand Launch
Recovery	:	Belly Landing
Propulsion	:	Pusher type BLDC Motor
Operating Altitude	:	100 - 300 m AGL, with 5000 m max Altitude

Key Features

- Rugged system for harsh environments
- Easy and quick assembly
- Fully autonomous operation(Take-off to Landing)
- GPS aided waypoint navigation and loiter
- User friendly GCS with real time video and recording
- RPV and Safety Pilot
- Return to home at loss of link and/or low battery
- Two man portable (Backpack or Trolley)



In-House Sub-systems Development

- Inhouse UAV Design
- Inhouse Airframe Manufacturing
- NALAutopilot Hardware
- NAL Control Algorithm
- NAL Ground Control Software
- Inhouse Gimbal- Interchangable Camera
- NAL Vision Algorithms

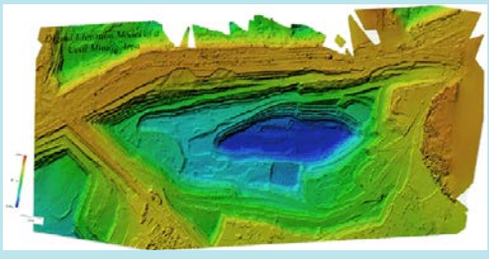
Mission Applications

- ISTAR Missions
- Border and Coastal Patrol
- Battle damage assessment
- Situational Awareness
- Observing the enemy lines
- Search and rescue mission
- Traffic monitoring
- Forest fire detection
- Commercial aerial surveillance
- Mapping Applications

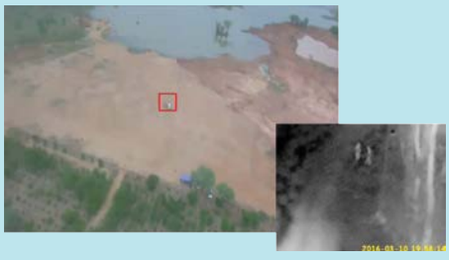
Advance features

- Software Image Stabilization and Mosaicking
- GEO Tagging
- Target Tracking

Orthomosaic of the Coal Mines at West Bengal



Digital evaluation model of a coal mining area at West Bengal



In flight video tracking & Night Surveillance

For more information contact
Director, CSIR-National Aerospace Laboratories
PB 1779, HAL Airport Road, Bangalore 560 017, India.
Tel: 91-080-25086000. 25270584;
e-mail: director@nal.res.in; www.nal.res.in

MAGNETO - HEXACOPTER

20 min *
with 4kg payload

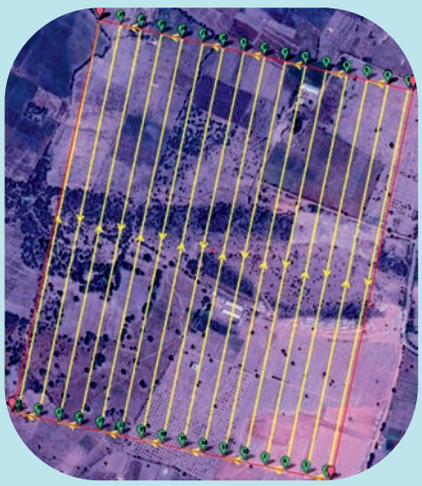
Autonomous Flight Operations from take-off to landing

5 kg
max. takeoff payload

Low Battery Indications and safe landing at critically low battery

5 km
Communication Range

Safe landing even if the communication with the base is lost



Mission profile for a survey

PAYLOAD

GEM System's Airbird

Dimensions & Weights:

Sensor:

161mm x 64mm (external dia) with 2m cabling; 0.43kg

Electronics Box:

236mm x 56mm x 39mm; 0.46kg

With all components added, including power, the Airbird weighs just under 3.6kg

CSIR-NAL

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NAL QUAD

30 min *
with 0.5kg payload

Autonomous Flight Operations from take-off to landing

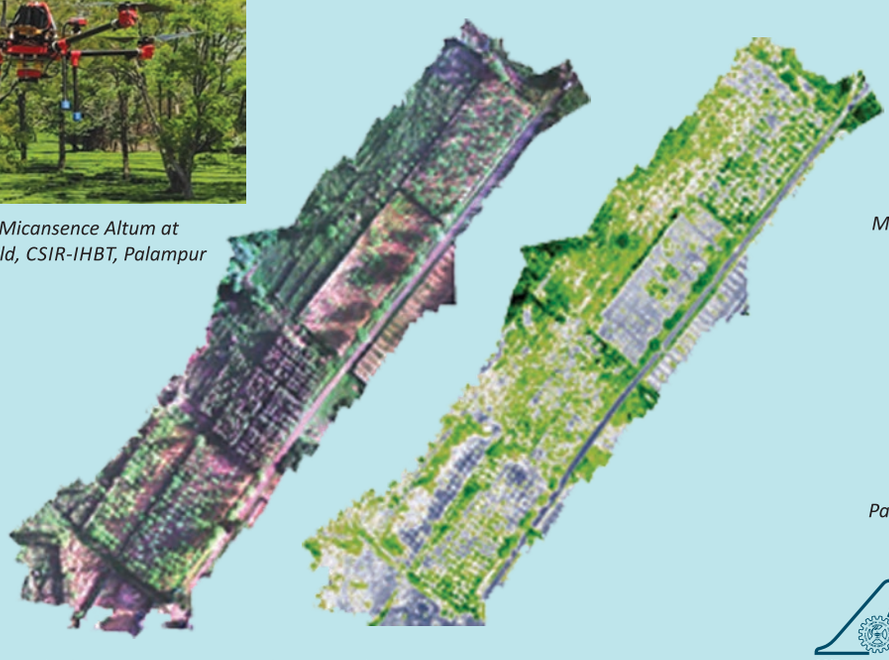
0.7 kg
max. takeoff payload

Low Battery Indications and safe landing at critically low battery

5 km
Communication Range

Safe landing even if the communication with the base is lost

Flight with Micansence Altum at Agriculture Field, CSIR-IHBT, Palampur



Constructed RGB Image *Constructed NDVI Image*

Payload

Micansence Altum Multispectral Sensor

Parrot SEQUOIA+ Multispectral Sensor

CSIR-NAL

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