TEST FACILITIES

CSIR - NATIONAL AEROSPACE LABORATORIES

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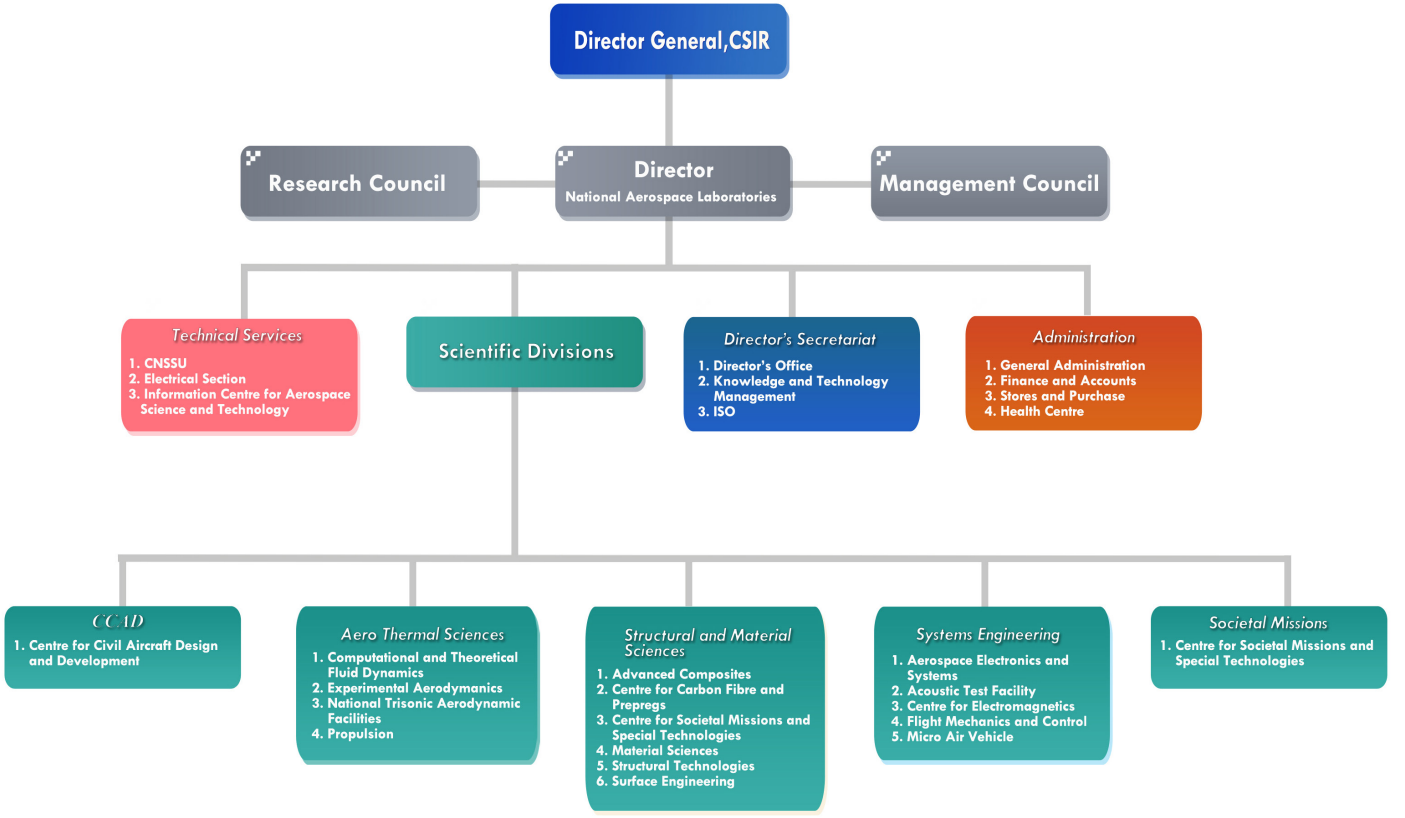
Organization Chart



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

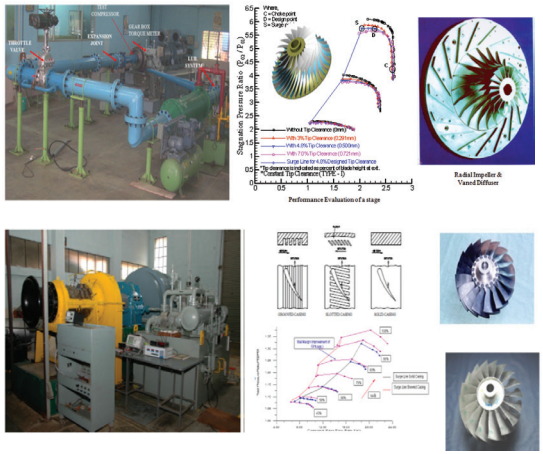
Hot gas generator

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)

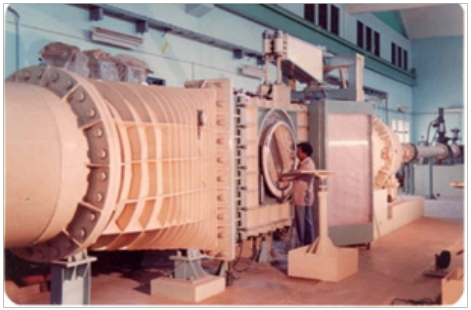
Gas Turbine and Compressor Aerofoils

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

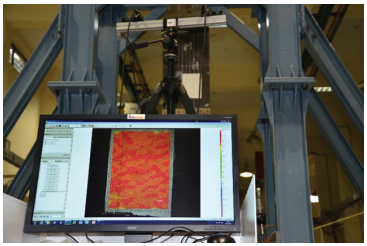
Category of the Test : Full Field Strain and Displacement Measurement

Year of Establishment : 2012

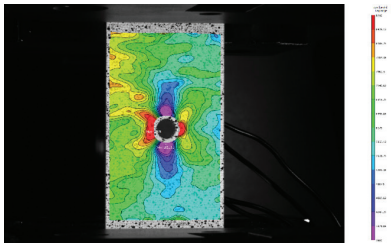
Test Application : Full-field deformation and strain measurements during quasi-static tests on structural components

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

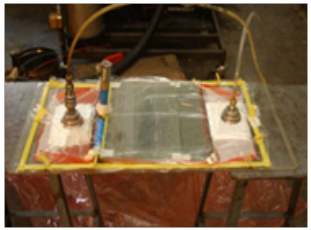
Year of Establishment : 1990-2000

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

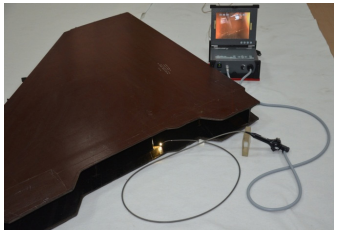
RTM equipment for injection of Epoxy Resins

Non Destructive Evaluation Lab

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

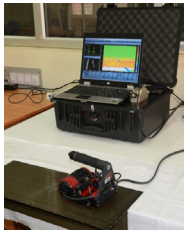
Year of Establishment : 2000

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



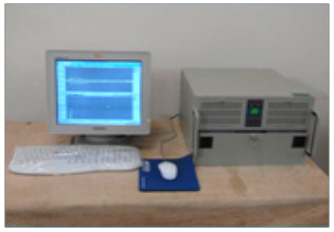
Videoscope

Air Coupled Ultrasonics



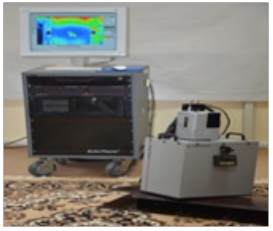
Ultrasonic rapid Scan

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

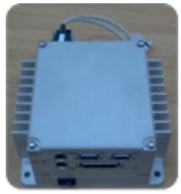
Integrated Optical test & Measurement

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

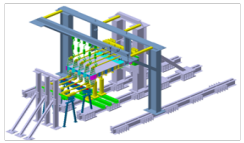
Year of Establishment : 1990-2013

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

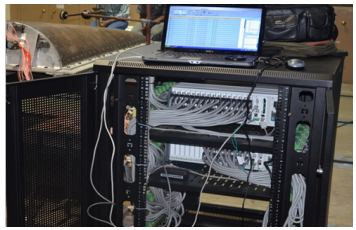


Static Testing of Wing Box

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 :

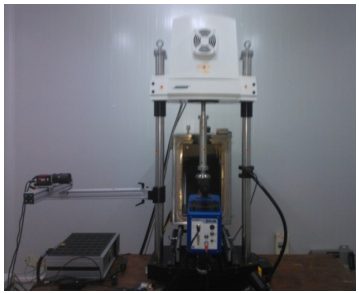
a. Computer Controlled Dynamic Testing
b. Infra Red Thermal Imaging Camera
c. Video Extensometer

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

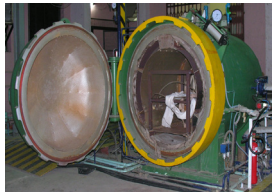
Category of Utility : Autoclaves are used to manufacture airworthy composite components under suitable settings of pressure, vacuum and temperature

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

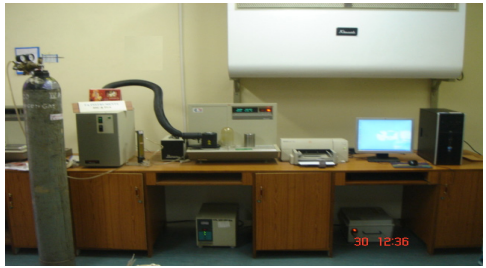
Category of Utility : Chemical analysis of polymer matrices, coatings, paints, prepregs, composites, etc. for R & D, quality control of manufacturing process & also as acceptance tests for quality of procured raw materials.

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

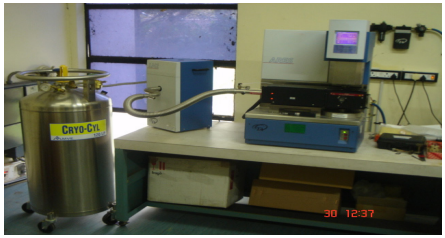
b) TGA (Thermogravimetric Analyser)

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

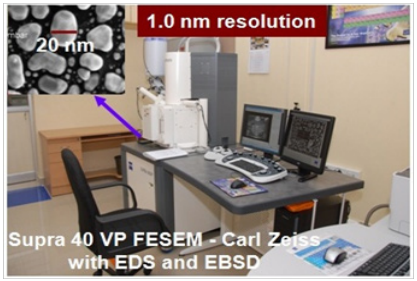
Year of Establishment : 2009

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

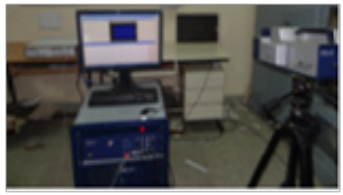
l) Forward velocity sled facility

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

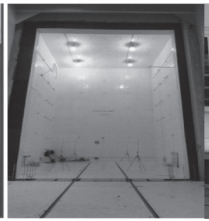
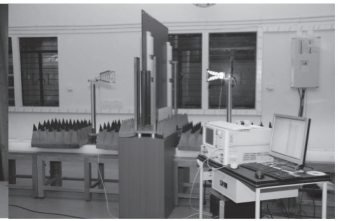
n) SHM/NDE facility (Acoustic Emission Systems, Laser Vibrometer, Eddy Current Test, Advance Thermography system and Fibre Optics based Video image scope)

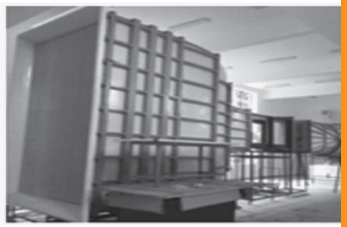


Year of Establishment : 2000
Test Application : Non-destructive evaluation of materials and structures, online health monitoring of structures, qualification of raw materials/components.
Test Features : Damage detection on metallic and composite materials / structures, large area coverage, material status (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

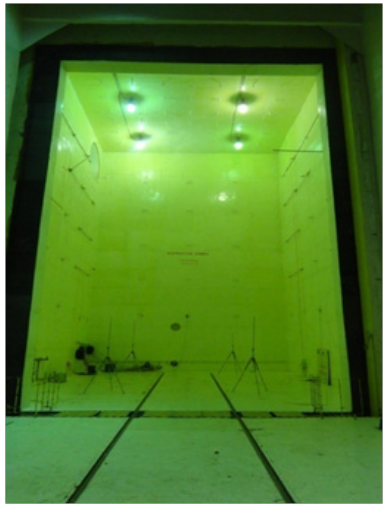
Year of Establishment : 1986

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

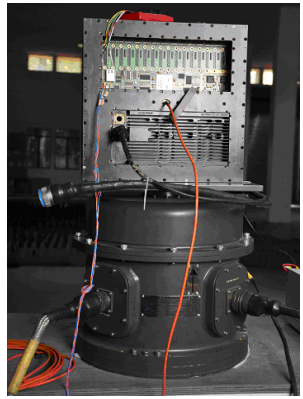
Test Features :

- 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 :

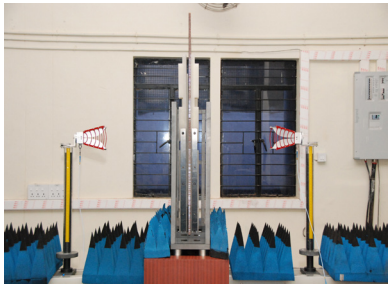
Aerospace Sector- Radomes, RAS, Aircraft cabin components etc., RF/ MW Companies - Antennas, MW components etc., Medical Industry - Medical imaging/ Scans, Malignant tissues detection etc., Agro-Food Processing Industries - Denaturing of food, microwave heating applications etc. , Chemical Industry -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

Test Features :

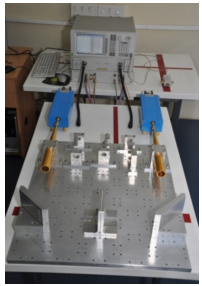
- A certified experimental facility
- State-of-the-art EM material characterization techniques based on: Free-space system, Dielectric probe, Waveguide system, Quasi-optic bench

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

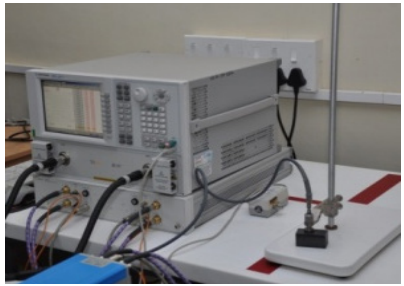
(i) Wave Guide System (26 GHz - 170 GHz) for thin slabs, (ii) Dielectric Probe (200 MHz - 50 GHz) for solids and liquids, (iii) Free Space method (2 GHz - 40 GHz) for large flat panels, (iv) Quasi-optic bench (75 GHz - 110 GHz) for thin substrates



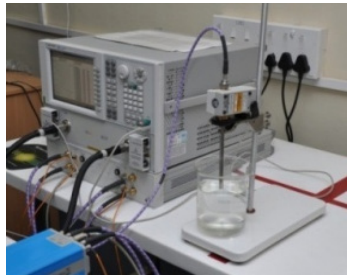
Free-space System



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

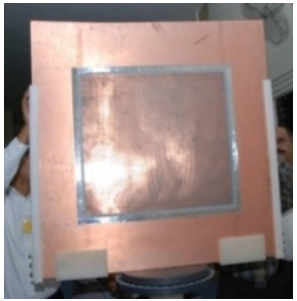
Year of Establishment : 2010

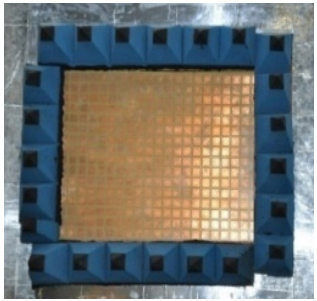
Test Application : Aerospace applications: Radomes and RAS

Test Features :

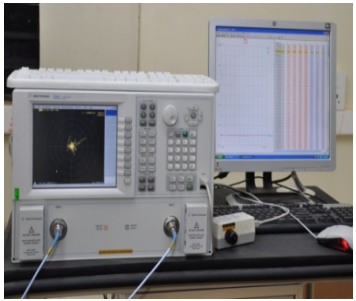
- A certified experimental facility
- EM performance tests for flat FSS panels:
  - Co-pol power transmission
  - Cross-pol power transmission
  - Power reflection

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

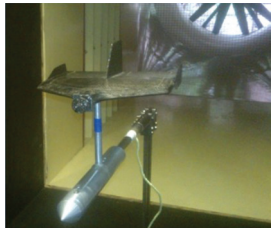
Test Application :

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 :

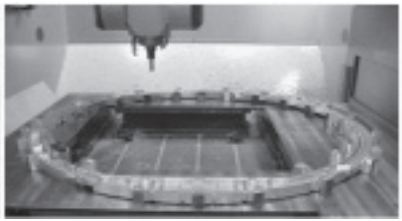
- Excellent flow quality, good flow stability, low free stream turbulence level
- The open test section has an advantage of having no boundary layer effects and reflections due to wall during flapping/rotary wind studies
- The tunnel also has a novel feature of generating gust that would simulate the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

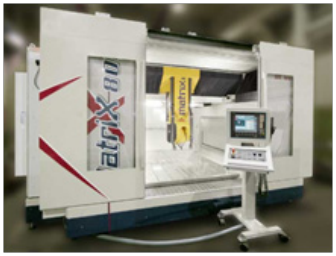
Aircraft Prototype Manufacturing Facility

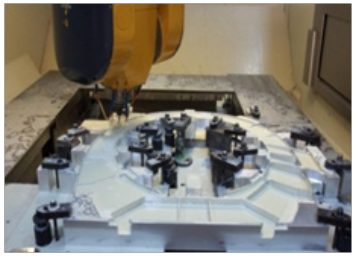
Category of the Utility : Manufacturing of critical machine and sheet metal Components for aircraft

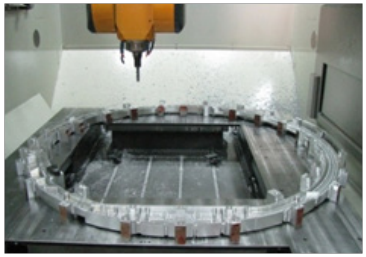
Year of Establishment : 1980-2010

Type of Facilities :

a. 5 Axes CNC Machining Facility







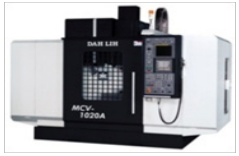
Features :

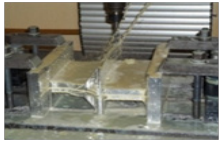
Description	Specification
Model	Breton Matrix 800
Table Size	2000 mm X 3000 mm
Traverse	X-2000 mm Y-2500 mm Z-800 mm A - ± 105 deg. C - 0 to 360 deg.
Spindle Taper	HSK63A
Spindle Speed	28000 rpm
Spindle Power	20Kw
ATC	Umbrella type with 30 tools
CNC Controller	Sinumerik 840D

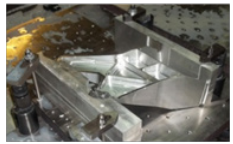
Potential Usage :

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

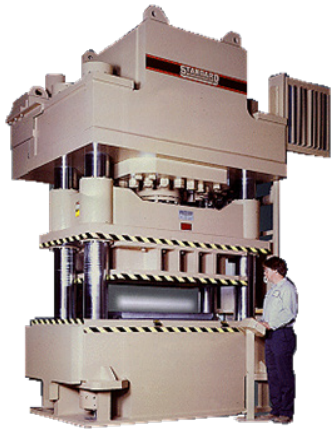





Description	Specification	Specification	Specification	Specification
Model	VICTOR VC -110 (1)	DAHLIH MCV 1020 BA (2)	DAHLIH MCV 720(3)	TAKUMI H13(1)
Table Size	1400 mm X 550mm	900 mm X 600mm	950 mm X 560mm	1400 mm X 900 mm
Traverse	X-1100 mm Y-600 mm Z-600 mm	X-1050 mm Y-550 mm Z-550 mm	X-760 mm Y-460 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.

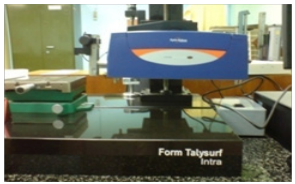
h. 3D Measuring Arm with Scanner Facility

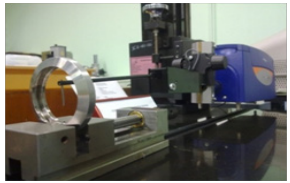
Features:

- 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

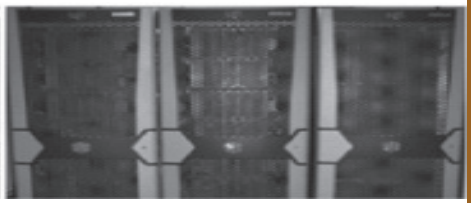
Test Application : Two HANSA aircraft at CSIR-NAL (VT-HBL & VT-HOA) have been re-registered for flying under experimental category as a flying test bed towards R&D purpose in the field of damage tolerance and structural health monitoring, active vibration control, avionics and flight controls, adaptive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



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

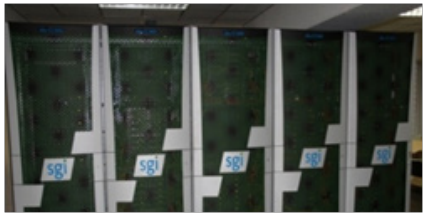
- SGI Altix ICE 8400

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

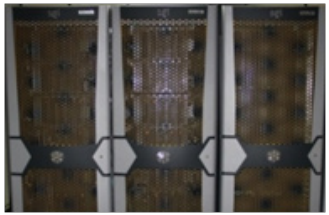
- SGI Altix 4700

  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



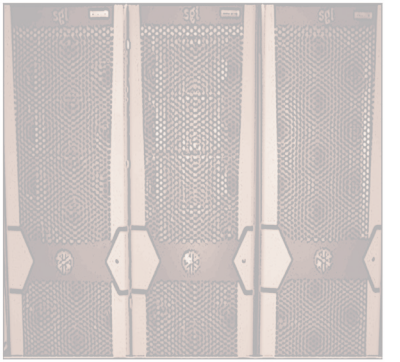
SGI Altix ICE 8400



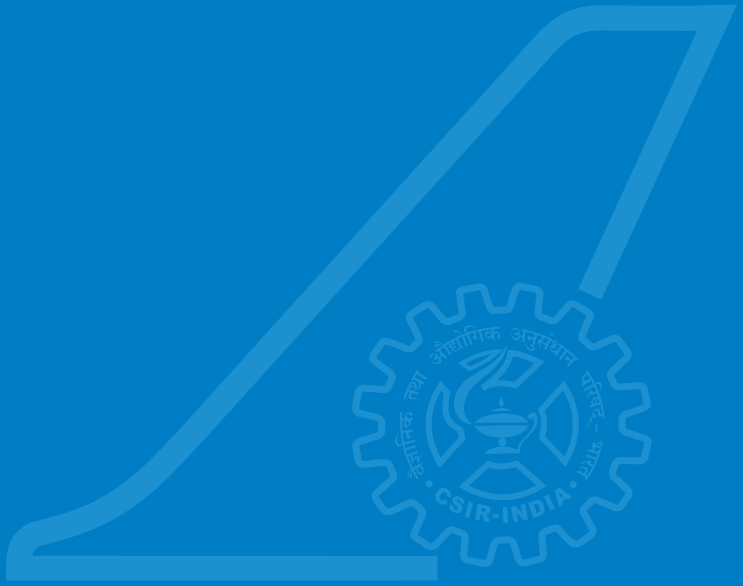
SGI Altix 4700

HP Cluster Platform 3000

SGI Altix ICE 8400



SGI Altix 4700



For more information please contact:
Director, CSIR-National Aerospace Laboratories, PB 1779, HAL Airport Road, Bengaluru - 560 017, India
Tel: + 91-80-25086000, 25270584; Fax: +91-80-25260862; E-mail: director@nal.res.in; www.nal.res.in