Sadhana

NAL showcase

National Aerospace Laboratories

There must be very few R&D establishments in the world capable of both designing and fabricating an aircraft under one roof. Or, indeed, of writing a weather prediction software and then building a customized parallel supercomputer to run it optimally.

That's what makes NAL a very special place. We are involved in R&D activity that encompasses practically every facet of aerospace. We design control laws for the highly unstable Tejas aircraft, we engineer radomes to protect airborne and ground-based electronic equipment, we investigate aircraft accidents, we pioneer the use of composites in aircraft structures ... we even redesign the shape of intercity buses to achieve very significant fuel savings.

I have therefore great pleasure in presenting this booklet, compiled from exhibits prepared for the CSIR Directors' Conference in August 2004, that lists 34 of NAL's most diverse and multi-faceted R&D programmes and achievements.

Dr B R Pai
Director

Editors: Srinivas Bhogle, K Anantha Rao, A S Rajasekar with C V Giri Raj.
Designer: P Sharath Chandra.

Contents

The NAL mission

Technology is our core vehicle

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.

SARAS in the course of its second flight; HANSA VT-XBL flying at Jakkur airport.

SARAS is a multi role transport aircraft; HANSA is an all-composite trainer.

Relaminarization on swept wings under high-lift conditions.

NAL successfully addressed this complex flow phenomena with carefully planned experiments at low speeds and data analysis.

NAL was a very active partner in the Tejas (LCA) programme.

CFD analysis for Tejas.

Quality solutions to problems of flight

SARAS is airborne

A milestone in Indian civil aviation

NAL's multirole light transport aircraft, SARAS, had its maiden flight on 29 May 2004. The aircraft took off at 8:15 am. and flew for over about 25 minutes. SARAS is the first civilian aircraft designed and developed in India.

The first flight was smooth and uneventful in moderately cloudy and windy conditions.

The test pilots, Sqn Ldr Venugopal and Wg Cdr Makker, after the first flight.

SARAS has a Pratt & Whitney power plant.

P&WC PT6A-66 engine.

SARAS has been designed for many roles: executive transport, light package carrier, remote sensing, air ambulance etc.

The many possible roles of SARAS.

Luxurious executive aircraft

14 seater commuter aircraft

Ambulance version

Combi version with 7 seats and place for light packages

Creating a vibrant and profitable Indian civil aviation industry

The HANSA success

The all-composite aircraft is flying at four Indian flying clubs

HANSA is India's first all-composite aircraft ideally situated for ab initio training. The aircraft was type certified in February 2000. Seven aircraft are currently flying in Indian skies.

HANSA has a neat cockpit with good visibility,dual controls with excellent control harmony and is rugged, operationally cost effective and easy to maintain.

HANSA flying near Jakkur airport.

The HANSA aircraft have together flown over 2000 hours without any unexpected event.

Details of HANSA's flying record as on 15.8.2004.

Hansa name	Flying club/Institution	Flying hours as on
VT-HNS	National Aerospace Laboratories, Bangalore	66.40 h
VT-HNT	Andhra Pradesh Aviation Academy, Hyderabad	782.55 h
VT-HNU	Kerala Aviation Training Centre, Trivandrum	621.00 h
VT-HNV	Madhya Pradesh Flying Club, Indore	132.00 h

HANSA is lightning protected and certified for day/night flying by DGCA under FAR-23.

The HANSA aircraft built by NAL over the years.

HANSA: an Indian aircraft in Indian skies

Development of powered hang glider

Inculcating air-mindedness among the general public

NAL has two powered hang gliders that are used to offer flying experience to aviation enthusiasts, and train the more serious enthusiast on how to control a flying vehicle. Both gliders operate on the 'weight shift control' principle and have flex type wings.

'Altair' is a single seater powered hang glider with a maximum air speed of 80 km/h and a maximum all up weight of 185 kg.

Altair is inexpensive to operate and has proved to be a useful vehicle for flight experiments.

Clipper is a heavy duty powered hang glider particularly suited for conducting training with two people on board. The glider has a maximum speed of 100 km/h and a maximum all up weight of 360 kg.

Clipper has been especially useful for aerial photography and cartography. Because it flies at lower speeds and at lower altitudes it is ideal for aerial spraying and other such applications.

Flying with the birds

Radio-controlled BLIMP

Innovative development of lighter-than-air vehicle systems

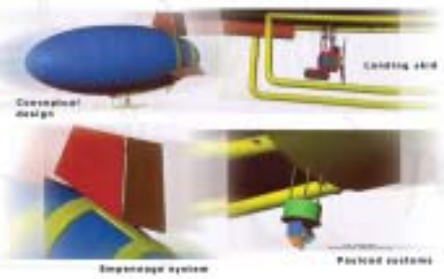
NAL has undertaken a wide variety of studies and experiments with aerostat systems in partnership with ADRDE, Agra. These lighter-than-air vehicle systems are low cost, have long endurance, viable societal applications and can be used as platforms for scientific experiments.

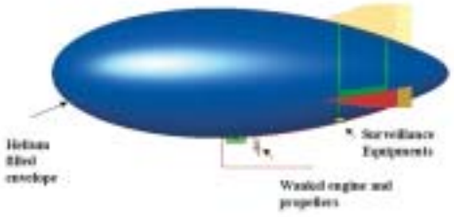
NAL has supported the development of aerostat systems through aerodynamic studies, tethered systems, equilibrium studies, development of flat pattern fabrication drawings and flight experiments.

250 m^3 aerostat flight trials at Agra in 2002.

NAL's contributions include: aerodynamic model, structural analysis, power plant integration, empennage installation, thrust vectoring mechanism, control law for RC prototype, simulation of dynamic model, payload and instrumentation.

Contributions to the design of the RC Blimp.





Blimps are especially useful for transporting food, for traffic surveillance, advertising and even joy rides!

Blimp assembly.

Doing wonderful things with a balloon

The avionics challenge

Ensuring a safe touchdown

AVRA is a fast-acting accurate instrument that automatically measures and reports the runway visual range and the meteorological optical range. The smart fatigue meter records 'g' levels that aircraft cross during flying manoeuvres.

NAL's Automatic Visual Range Assesser (AVRA) forewarns incoming pilots about the runway visibility and helps them decide if they should land or divert the aircraft. More sophisticated AVRA systems are being developed for the Indian Navy.

AVRA installed at Bangalore airport. AVRA's have also been installed at Chennai and Kochi airports and will be positioned at Indian Navy bases

The micro-controller based smart fatigue meter is for use in military aircraft. It is powered by the aircraft power unit and has a built-in accelerometer to sense the change in 'g' levels.

The new smart fatigue meter

Attractive products for the civil aviation industry

The SARAS avionics adventure

Admirable success in electronics and instrumentation

NAL has integrated a contemporary avionics suite for the SARAS aircraft meeting all performance and safety certification requirements. NAL has also designed and developed software for a stall warning system.

Nearly 4500 tests were conducted to declare the SARAS avionics suite to be fully functional.

SARAS flight displays.

The SARAS avionics suite is fully digital and conforms to FAR 25 specifications.

SARAS controls on central pedestal.

Creating a happy conglomerate of the mind and the machine

Two initiatives in aerospace electronics

Towards safer and more comfortable flying

NAL has developed a software solution to monitor the flying performance of aircraft and alert airlines about the quality of their flight operations. NAL is also using active noise control technology to design quiet aircraft cabins.

A modern aircraft can fly safely and economically for a very long time if airlines set up efficient mechanisms to continually monitor the aircraft's flying performance.

Typical printouts from NAL's FOQA software for flight operations quality assurance.

The noise inside an aircraft cockpit or automobile is sought to be countered by a matching "anti-noise". Active noise control provides an efficient means of reducing low frequency noise (100-500 Hz).

DSP processor and electronics for active noise control.

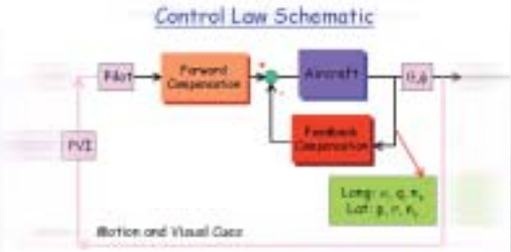
Products and solutions for the civil aviation industry

Controlling the Tejas aircraft

Studying the dynamics of unstable flight

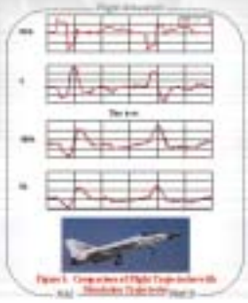
Like all modern fighter aircraft, India's Tejas (LCA) is highly unstable. NAL has led the national team that developed real-time flight control software for Tejas. NAL has also made significant contributions in Tejas modelling and simulation.

The Tejas control laws have so far performed extremely well.



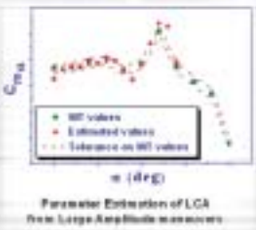
The basic concepts of aircraft control laws.

Estimation techniques have been developed to obtain Tejas stability and control derivatives and evaluate flight handling qualities.



The ELS simulator. The simulated and actual Tejas flight trajectories compare very well.

NAL developed an engineer-in-the-loop (ELS) flight simulator to facilitate Tejas design.



Parameter estimation of Tejas from large amplitude manoeuvres.

Notable contributions in helping the Tejas fly

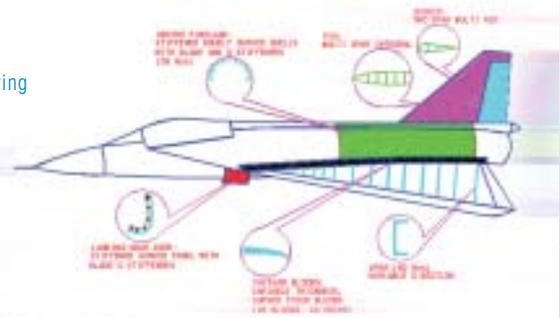
Composite structures for Tejas

Forty per cent of the Tejas airframe is fabricated at NAL

Composites are a very attractive option in aircraft development because they are lighter than metal and just as strong. NAL has pioneered the development and fabrication of composite structures for the Tejas (LCA) aircraft using very innovative, and cost-effective, fabrication technologies including the co-curing co-bonding technique.

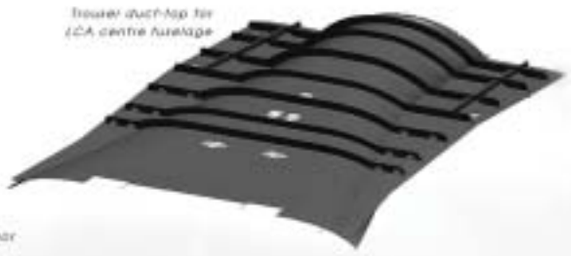
NAL fabricates wing spars, fairings and fairing blocks, fin, rudder, centre fuselage and the landing gear door of the Tejas.

The Tejas airframe is 90% composite; NAL contributes 40%.



The principal advantage of NAL's co-curing technology is the integration of a number of subcomponents into a single component. This ensures superior structural integrity, elimination of stress concentration due to drilling and a shorter assembly cycle.

Main landing door for LCA



Trouser duct-top for LCA centre fuselage

Closed structures of Tejas components realised by co-curing.

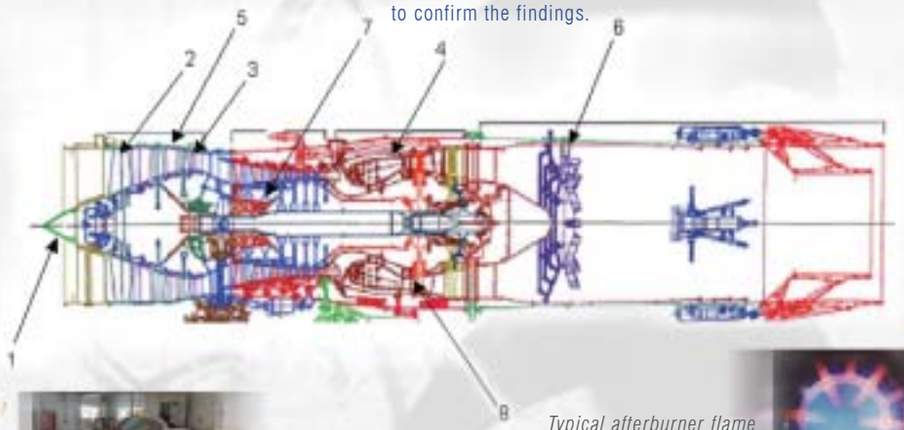
Remarkable strides in composite technology development for aircraft structures

Design studies on Kaveri engine for Tejas

Supporting the national effort to develop an aeroengine

NAL has studied every key component of the Kaveri engine to help evaluate the engine's suitability for the Tejas aircraft.

A typical investigation involves analytical and computational analysis followed by experiments to confirm the findings.



Development of distortion screen for the Kaveri engine ground testing.

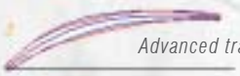
Typical afterburner flame viewed end on.

Improvement of stall margin (Widening of stable operating range).

Casing treatment.

Squeeze film damper optimization.

Flow visualization studies.



Advanced transonic blade design.

Effect of trailing edge ejection on profile losses.

Typical temperature field in the combustor predicted by CFD analysis.

Typical flow field (Mach number contours) in the 3-stage fan predicted by CFD analysis.

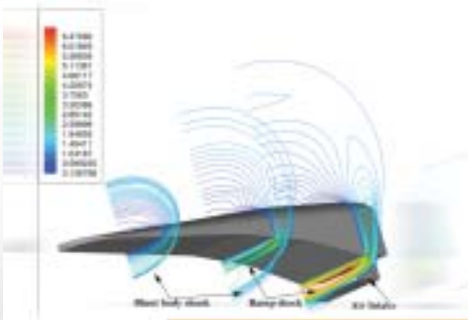
Nozzle guide vane and rotor film cooling studies.

Ensuring the right thrust

The CFD advantage

Examples of aerospace applications

NAL has used computational fluid dynamics (CFD) to model and optimize the performance of aerospace vehicles such as aircraft (in particular, the HANSA, SARAS and Tejas), launch vehicles and missiles.

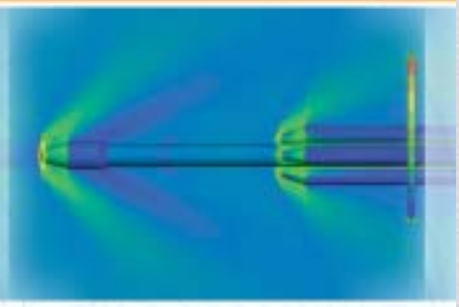


Reynolds-averaged computations (RANS) have been carried out on the inlet aerodynamics of a hypersonic research vehicle (HRV).

Density contours at the different inlet sections of the HRV.

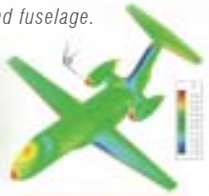
Euler computations were undertaken for the pressure contours of the geostationary satellite launch vehicle.

Pressure contours on GSLV.



Computations on the full SARAS aircraft with side slip.

Contours on the surface and the cross section across the wing and fuselage.



RANS computations of flow past Tejas.

Streamlines indicating flow on Tejas at transonic Mach number and high angle of attack.

Transcending the different flow regimes in aerospace

Flosolver and FloSwitch

Harnessing the power of parallel computing

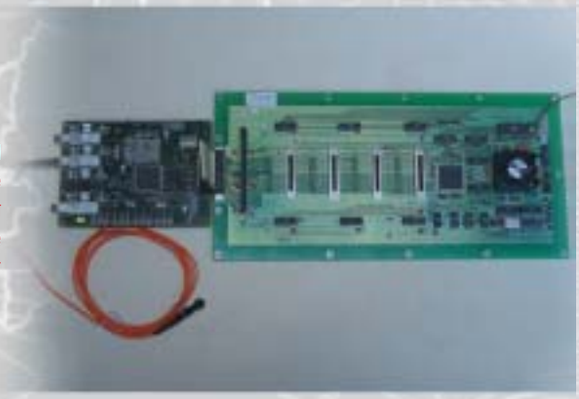
NAL built India's first parallel computer in 1986. Eighteen years later, the adventure continues! A customized parallel supercomputer for numerical weather prediction is now being built under the NMITLI programme.

Meteorological computing is so computationally challenging that only parallel supercomputers can do the job.

32 processor Flosolver Mk6.

When parallel computers are used for met computing no appreciable scale-up is seen beyond four processors. The FloSwitch holds the promise of linear scale-ups even for 32 or more processors.

FloSwitch with optical interconnect.



Pioneering the use of parallel supercomputers for tropical weather prediction

NAL and India's Space Programme

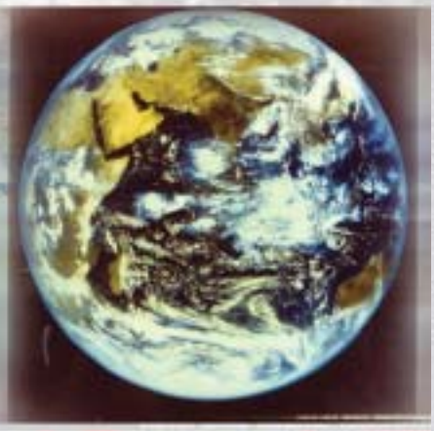
A very fruitful association

The Acoustic Test Facility is used to qualify all ISRO satellites and launch vehicles. NAL has been actively involved in wind tunnel and aeroelastic testing of all launch vehicles. Highly polished aluminium mirrors were built to help ISRO get good satellite pictures.

Satellites and launch vehicles are subjected to the high intensity acoustic environment experienced during launch and transonic flight.

Acoustic test facility

To get razor-sharp pictures from space, INSAT satellites use an infra-red detector. This detector functions best when its temperature is maintained at 105 deg K. NAL used surface modification techniques to make four highly polished aluminium mirrors to help maintain the optimum detector temperature.



A crystal clear satellite photograph.

Passive radiative cooler with the four polished mirrors.

The sky is the limit in ISRO-NAL cooperation

1.2m trisonic wind tunnel

Performing splendidly for 37 years

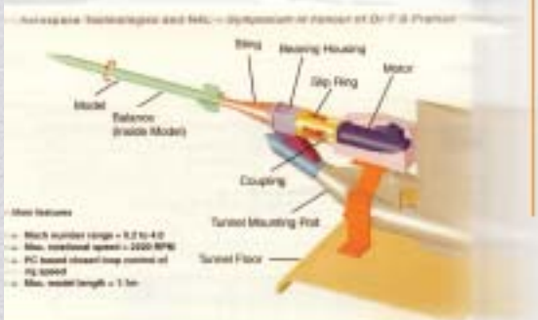
Every Indian aerospace vehicle has graduated out of NAL's 1.2m x 1.2m trisonic wind tunnel. Several novel testing techniques have been developed including the special test rig to measure roll damping on space vehicle models. The tunnel facilities are now being significantly upgraded.

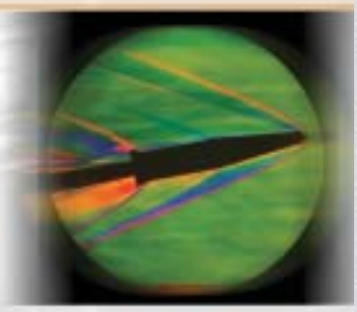
NAL's trisonic wind tunnel was planned around 1960 when the country didn't have a single aerospace programme!

Trisonic wind tunnel.

The roll damping rig employs the steady roll technique in which a model is rotated at a series of constant roll rates.

Roll damping rig.



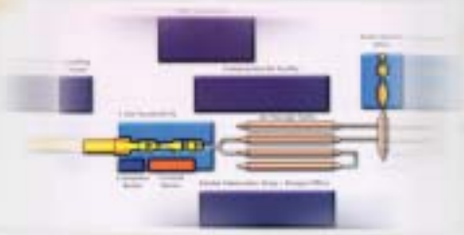


The wind tunnel has been extensively used for studies on the Tejas aircraft, launch vehicles and missiles.

Flow visualization.

The 1.2m tunnel has completed 30,000 blowdowns on 15.8.2004.

Tunnel schematic.



Creating an invaluable national facility for India's aerospace programmes

Fullscale airframe testing

Extending the service life of aircraft structures

Aircraft in service are constantly subjected to fluctuating loads of varying severity, leading to airframe fatigue. NAL's well-planned fullscale fatigue test facility provides inputs that can lead to a substantial increase in the structural life of airframes. Static testing of airframe components to the ultimate design load is also undertaken.

The fullscale fatigue test facility subjects airframes to a load environment history that closely simulates the actual service experience.

MiG-21 airframe testing.

Several innovative schemes were evolved for the structural testing of the SARAS aircraft.

Test set up of SARAS fuselage.

A test rig has been specially designed for static testing of airframe components at suitable locations till the ulitimate design load is reached.

Static test of HANSA wing.

A leading player in aircraft structural integrity

Testing aerospace structures

Mastering the art and science of dynamic qualification tests

The interaction between the aerodynamics and structural dynamics ("aeroelasticity") of moving aerospace vehicles, such as aircraft and launch vehicles, has to be studied very carefully to ensure the success of the mission. Ground vibration tests to measure the aeroelastic stability of aerospace vehicles also provide vitally important engineering inputs.

NAL has undertaken aeroelastic testing of the SARAS and Tejas aircraft, and of the launch vehicles in India's Space programme.

Aeroelastic testing of the PSLV, GSLV launch vehicles and the Tejas aircraft.

NAL carried out all the mandated ground vibration tests (GVT) for the SARAS aircraft.

SARAS aircraft undergoing GVT.

Wide experience in vibration and aeroelastic testing

The SARAS spin-off

Impressive capability in full aircraft testing

A very attractive spin-off of the SARAS development project is that NAL is now poised to emerge as India's leading nodal agency in developing civilian aircraft. The SARAS experience has provided NAL with the knowledgebase and infrastructure to successfully undertake a wide variety of tests on small and medium-sized aircraft.

SARAS engine running on test bed and engine test on the aircraft.

An engine test rig was designed and built to test the SARAS engine with its propeller. A hydraulic system test rig was also commissioned for system functionality and endurance tests.

Hydraulic system test rig.

The SARAS programme has helped NAL forge valuable partnerships with the aeronautical industry.

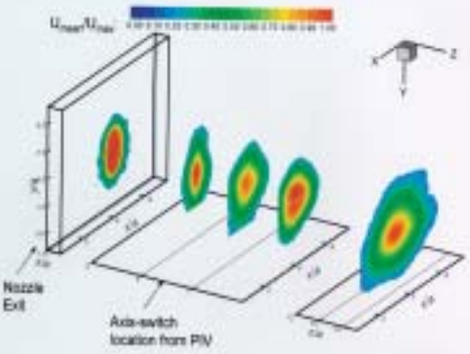
Fuel system testing at HAL.

The complete wherewithal for the design and development of small civil aircraft

Advanced flow diagnostics

Understanding complex flows

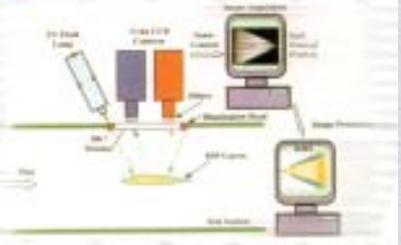
NAL has developed a novel pressure measurement system based on pressure sensitive paints (PSP). NAL has also used digital particle image velocimetry (DPIV) to measure the velocity field of an elliptic jet at low speeds.



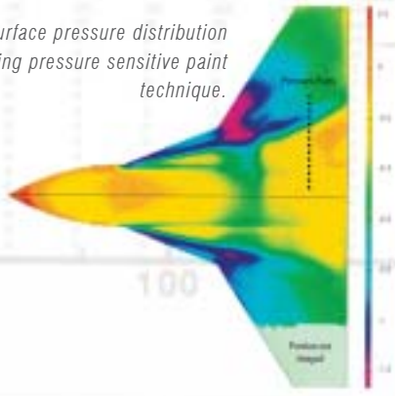
The PIV system uses a Nd-YaG 400mJ double pulsed laser, a cross-correlation CCD camera and image processing software.

Stereo particle image velocimetry measurements in an elliptic jet.

The PSP-based pressure measurement system consists of a specially designed UV illumination source, two slow scan CCD cameras, image processing software and a compact apparatus for accurate calibration of PSP samples.



Aircraft model surface pressure distribution obtained using pressure sensitive paint technique.

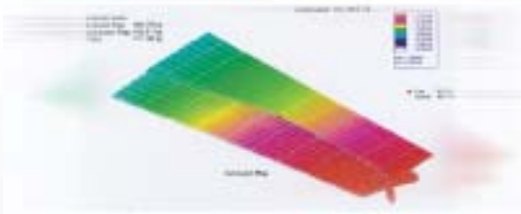


Innovative techniques to understand problems associated with complex flows

Finite element techniques

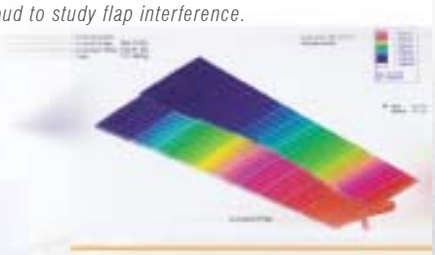
Studying loads and stresses

NAL has successfully used the finite element (FE) method, especially in the stress analysis of the HANSA and SARAS aircraft. FE techniques have also been employed in the analysis of aerostats and radomes.



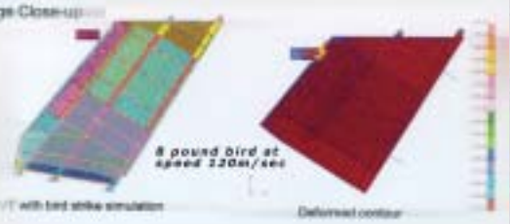
Integrated stress analysis of the SARAS wings with flaps and ailerons.

Displacement contours of the flaps with the wing shroud to study flap interference.



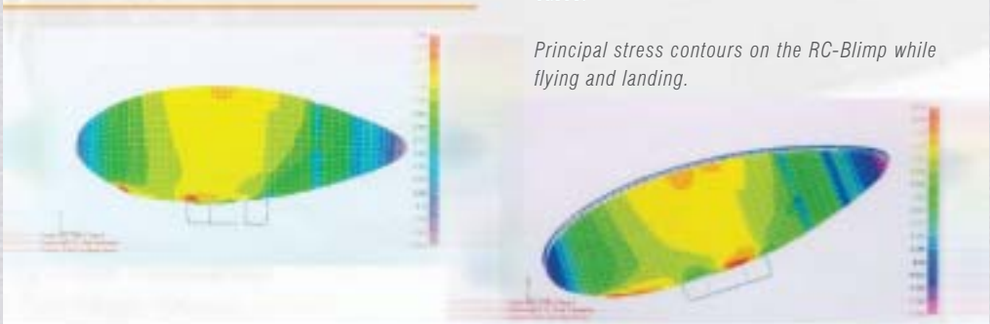
Impact analysis studies on the SARAS aircraft were undertaken, including bird strike simulation on the vertical tail, with a 8 pound bird at a speed of 120 m/s, and damage analysis on the SARAS propeller blade.

Impact analysis studies on SARAS.



A dedicated FEA of the RC-Blimp structure was carried out for both the flight and landing load cases.

Principal stress contours on the RC-Blimp while flying and landing.

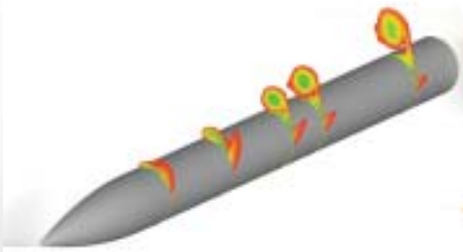


Exceptional ability in the analysis and design of aerospace structures

The CFD mirror

Tools to understand and explain flows in engineering applications

NAL has extensively used high performance computers to study the behaviour of complex engineering flows in applications spanning helicopters, aircraft, aerostats and underwater bodies.

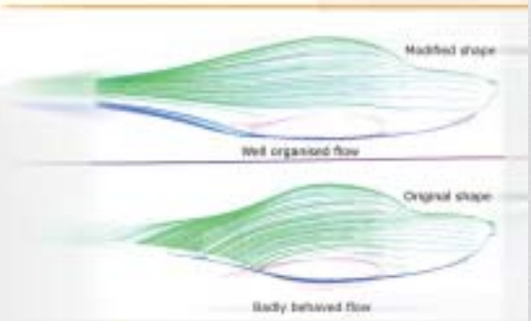


NAL has used computational fluid dynamics (CFD) to test turbulence models at high angles of attack.

Vertical supersonic flow over a slender body at high angle of attack.

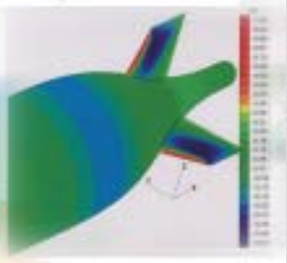
The panel code was used to design the HANSA's wing-body junction and ensure proper flow management on the real fuselage.

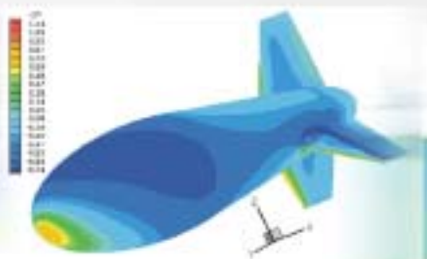
Panel coding to design the HANSA wing body junction.



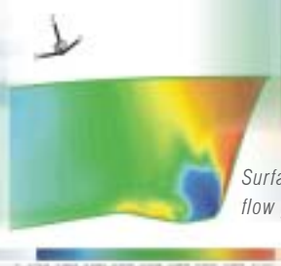
CFD codes were used to study turbulent flows past: aerostat balloon, ship hulls with bow mounted domes and axisymmetric underwater bodies with stern and appendages.

Surface pressure contours for turbulent flow around torpedo.





Turbulent flow around aerostat balloons.



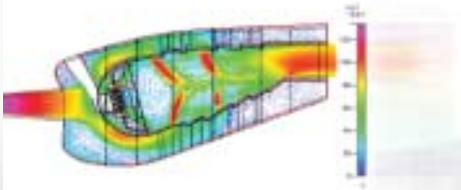
Surface pressure contours for flow past slip hull.

Understanding complex flow behaviour

Simulation of aeroengine components

CFD speeds up things

Computational fluid dynamics (CFD) is now the preferred route to design complex aeroengine components. NAL has successfully used CFD to evaluate the performance of gas turbine combustors and turbomachinery.



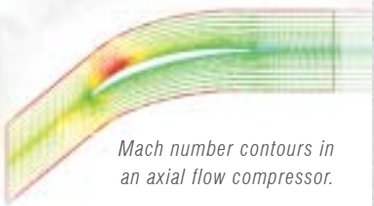
The flow field in the gas turbine combustor.

NAL has carried out hot flow analysis in a typical gas turbine combustor using a general purpose CFD code.

CAD model of a combustor sector.

Flow patterns in a cascade, an axial flow compressor and a centrifugal compressor have also been studied using CFD.

Flow over a cascade blade.



Mach number contours in an axial flow compressor.

Flow fields in a centrifugal compressor blade passage.

Understanding what happens inside an aeroengine without costly experiments

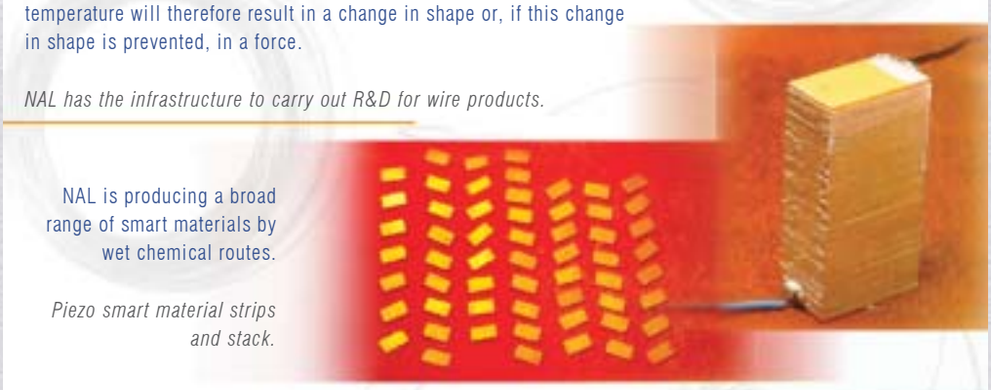
Smart materials for smart structural applications

Exploiting the shape memory effect

Smart materials are extremely attractive candidates to develop sensor and actuator applications in the aerospace sector. NAL is developing a wide variety of smart materials under the National Programme on Smart Materials (NPSM).

Smart shape memory alloy (SMA) exist in two different shapes above and below a critical transformation temperature. A switch in temperature will therefore result in a change in shape or, if this change in shape is prevented, in a force.

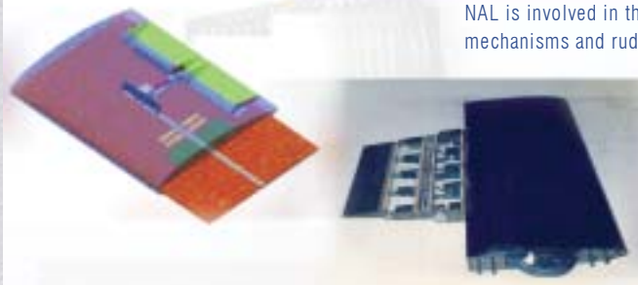
NAL has the infrastructure to carry out R&D for wire products.



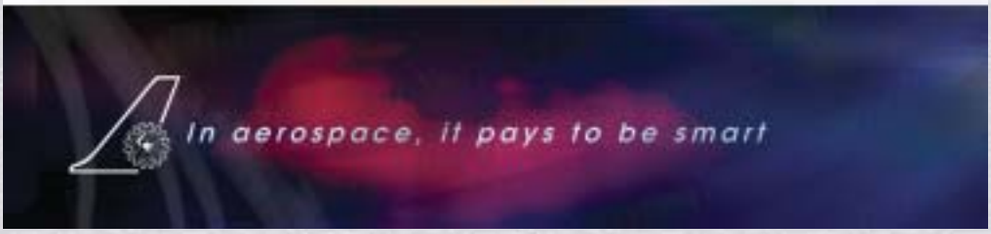
NAL is producing a broad range of smart materials by wet chemical routes.

Piezo smart material strips and stack.

NAL is involved in the development of active flutter control mechanisms and rudder models with SMA actuators.



Smart aeroelastic wing model with active control surface; and a SMA-actuated rudder model.



Two new composite technologies

Adding more value to our capabilities

NAL is currently working on two exciting ideas involving composite structures. The first is to embed sensors in carbon-epoxy composites that will continuously monitor the health of the structure. The second is a novel stitching technique to re-inforce structures with weak out-of-plane properties.

PC to decode bonding data.

Test box undergoing static testing.

A test box was designed and fabricated to test the health monitoring system. To simulate debonding, a certain numbers of bolts were removed from a 'healthy' box. The decoded data from the 'healthy' and 'unhealthy' boxes agrees well with finite element prediction.

Conventional laminated composite structures often have weak out-of-plane properties. NAL's new stitching technology provides reinforcement in the third direction.

NAL's new stitching machine with a workspace volume of 6000 mm x 3600 mm x 1150 mm - large enough to accommodate the Tejas wing.

A leading national player in airworthy composite structures

Supersonic combustion

Propelling aerospace vehicles

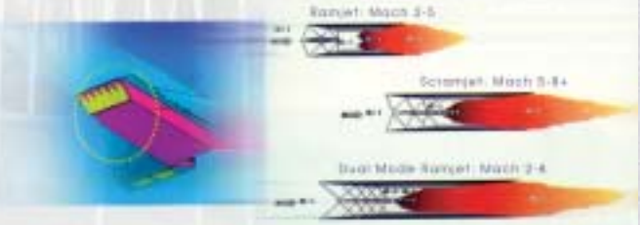
Advanced flight vehicles will in future fly at hypersonic speeds using special engines called scramjets. NAL has successfully developed the vitally critical technology needed to burn fuels at supersonic speeds (around 1 km/sec) in such engines.

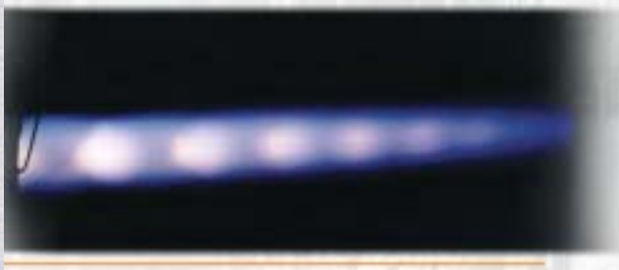
NAL is undertaking an R&D programme related to high Mach number air breathing propulsion. A large database for the design and development of advanced high speed combustors has been built up.

Cavity based strut combustor.

Although a scramjet is mechanically simple, the supersonic air flows inside are extraordinarily complex.

Scramjet and other ramjet derivatives.





A kerosene-fuelled dual mode ramjet/ scramjet combustor has been designed, developed and successfully tested at a combustor inlet Mach number of 2 in the direct-connect supersonic combustor test facility.

Kerosene/hydrogen flame (subsonic/supersonic combustion).

Keeping the flame alight in a hurricane

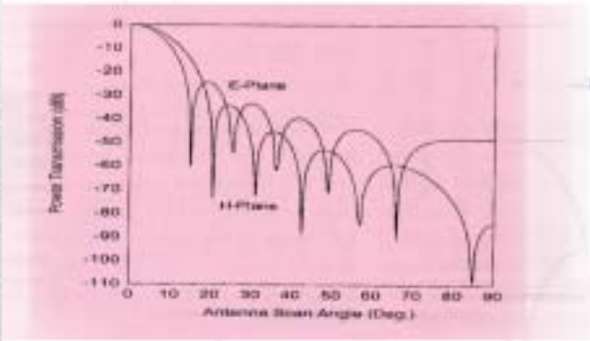
Understanding radomes

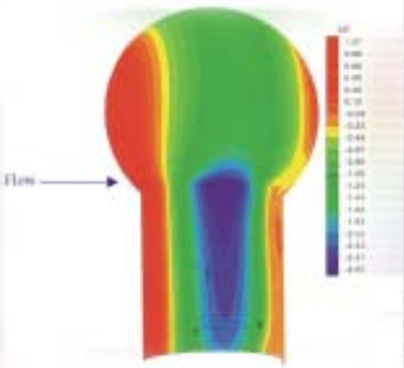
A formidable technological challenge

Radomes, that protect the antennae or reflectors of valuable radar installations, are critical in aerospace, defence, meteorological and communications applications. NAL is now an established national player in the indigenous development of radomes.

Radome development is highly inter-disciplinary: The R&D challenges are in the areas of electromagnetic design, structural and CFD analysis, material characterization, mechanical design and in devising innovative composite fabrication techniques.

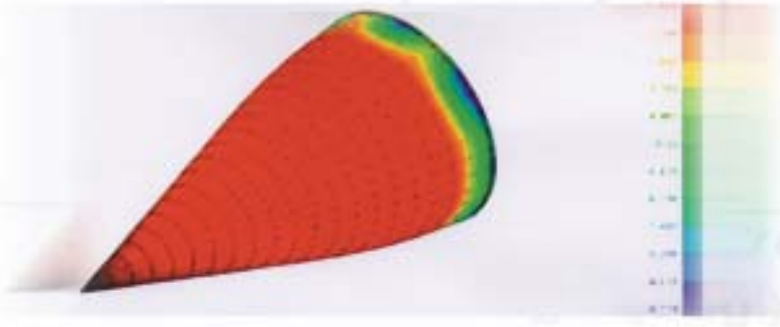
Electromagnetic design and analysis of radomes.





Surface pressure contours for turbulent flow past a DWR radome.

Stress analysis on a radome shell.



Engineering radomes

Protecting sophisticated electronic equipment

NAL has developed and installed a large number of radomes of varying size for a variety of applications. Both airborne and ground-based radomes have been fabricated in an activity spanning almost three decades.

Schematic of the Mark-2 version of the DWR radome with fewer (and larger) panels.

A very large (12.88 m) Doppler weather radar radome has been installed for ISRO at Shar, Sriharikota.

12.88 DWR radome to protect cyclone warning radar.

NAL has built nose radomes to protect the SARAS weather radar and the Jaguar's fire control system.

Nose radomes for the SARAS and Jaguar aircraft.

Development of a variable thickness radome for a strategic application.

Ceramic radome for a DRDL missile project.

Ensuring that there is no chink in the armour

Design and development of autoclaves

Engineering a marvel

Autoclaves are used to manufacture airworthy composite components under suitable settings of pressure, vacuum and temperature. NAL now has acknowledged capability in building large computer controlled autoclaves with the associated subsystems.

NAL has built one of the largest autoclaves in the world with innovative features such as a Davit arm suspended quick-lock safe door mechanism and an advanced control strategy.

The 4m x 8m autoclave handed over to HAL in 2002.

Promoting the Indian composites industry

Repairing aircraft structures

The technology of curing

NAL uses innovative bonding techniques to repair metallic and composite aircraft structures. A portable adaptive cure controller has been developed to repair aircraft structures on the airfield itself.

A damaged part is examined visually and by NDT techniques to determine if repair is feasible. If yes, a repair scheme — involving the design of a patch and joint — is finalized and repair implementation, by adhesive bonding or mechanical fastening, is completed. The repair is then validated by NDT before final acceptance and certification.

Damaged radome and fin repaired.

The portable PC based system for in situ bonded repair of aircraft structures is rugged, has MIMO adaptive PID control to maintain job temperature uniformity and appropriate accompanying software. The entire system, except the heaters, works on a single PC adapter.

Cure controller for bonded repair.

Wide experience in repairing aircraft structures

Aircraft accidents

Asking why

Accidents do not happen. They are caused. NAL has investigated dozens of air crashes for 30 years and is now India's prime organisation for carrying out failure analysis and accident investigations.

The Boeing 747 Kanishka crash in 1985 was due to a chemical explosion.

Kanishka wreckage retrieved from the Atlantic Ocean.

NAL studied the Airbus A320 crash at Bangalore in 1990 to identify the pilot's voice and a metallic click sound.

A320 wreckage.

NAL has investigated problems involving fighter aircraft.

Parts of the wreckage of a fighter aircraft following a mid-air explosion.

Boeing 737 aircraft VT-ECR which force landed at the Madras Airport, following a mid-air explosion.

The belly landing at Madras.

Ensuring that many benefit from the misfortune of a few

The NALSUN technology

Solar energy for water heating

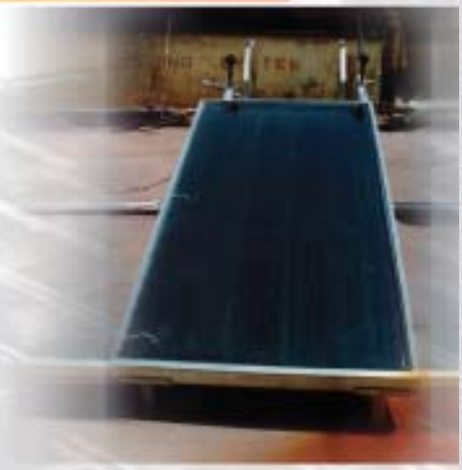
NALSUN is a room temperature black chromium bath for coating flat plate collectors of solar water heaters. This technology has so far been transferred to 23 industries.

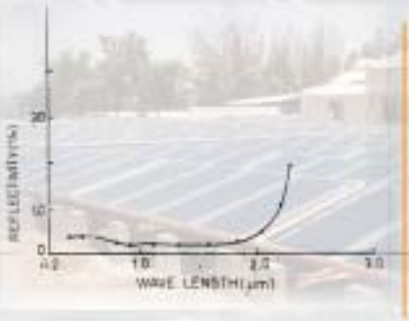
The NALSUN coating ensures that very little of the absorbed heat is emitted. Water temperatures can reach 80°C after six hours of sunshine.

Solar collectors lined up at one of the NALSUN-coated installations.

NALSUN gives excellent coating efficiently and at low current densities.

A flat plate collector.





NALSUN has an absorptance of 0.98 and an emittance of 0.12.

Very low reflectivity in the visible spectrum.

Saving almost 80,000 units of electricity every day

Streamlining and modifying buses

Finding unexpected spin-offs from aerospace experiences

The shape of buses belonging to the KSRTC fleet were streamlined using wind tunnel simulation to reduce drag and so effect fuel savings. A low noise composite bus was designed to function as a mobile clinic for speech and hearing evaluation.

The streamlined bus body designed for inter-city bus routes in Karnataka has helped achieve a fuel saving of about 10%.

The KSRTC bus before and after modification.

NAL has designed a mobile speech and hearing clinic using a composite bus body. The bus has three chambers for examining patients and a sound level of about 25 dB inside (it's about 90dB outside).

Mobile unit for hearing impaired.

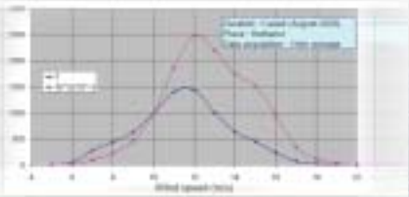
Medium scale wind turbines

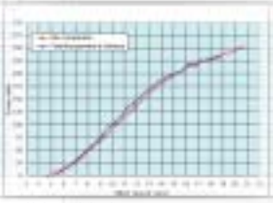
Why is India's installed capacity less than 5% of estimated wind potential?

Wind energy is not taking off in India because of high capital investment and the absence of a wind turbine designed to perform in a dusty and moderately windy environment. NAL is collaborating with an industrial partner to develop a low cost, technologically advanced wind turbine for India.

Extensive field trials and analysis were undertaken to map India's typical wind environment.

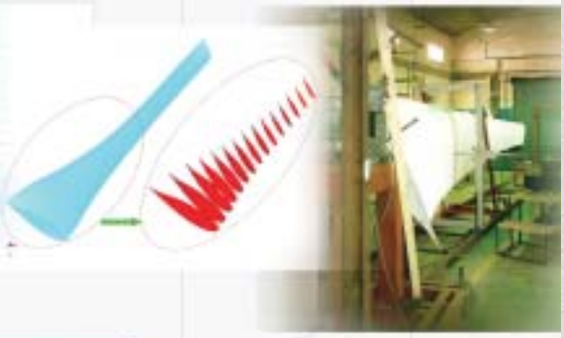
Field trials and wind data analysis.





A candidate blade geometry was studied and modelled to fit the observed field measurements.

Studies on the blade geometry, the computed predictions match the observed field measurement.



The task of building a prototype blade of 300 kw size has started with funding from one of CSIR's NMITLI-type programmes.

Blade master and FRP mould to build blade prototype.

Building windmills that are suitable for India

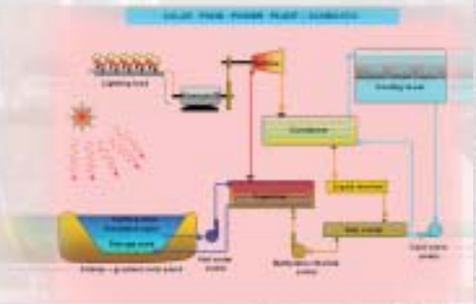
The Pondicherry experiment

Power generation from a solar pond

In solar ponds the water is saline. The salinity inhibits the normal convective process. Hot brine (75-80° C) is therefore 'trapped' at the bottom of solar ponds. NAL's Pondicherry experiment involved the extraction of the trapped thermal energy to generate electric power.

The 500m² experimental salt gradient solar pond.

The key idea was to use NAL's organic Rankine cycle technology.



Schematic of the solar pond power plant.

The procedure involves passing the hot brine from the solar pond through a heat exchanger where it imparts its heat to the Rankine fluid. The fluid is then heated, vaporized and expanded through a turbine that is directly coupled to an electric generator.

The plant has been successfully operated at the full design level of 6kWe net.

Harnessing energy from unlikely sources