

REPORT OF THE DIRECTOR

It gives me great pleasure to present the annual report for the year 2003-2004.

HIGHLIGHTS

The SARAS aircraft had its maiden flight on 29 May 2004 (*Figure 1*). SARAS became airborne at 8.20 a.m. and flew for about 25 minutes before making a safe landing (*Box 1*). It was a proud and momentous day for NAL, CSIR and the entire SARAS team. There were scenes of high emotion and jubilation when the two pilots, Sq Ldr K K Venugopal and Wg Cdr R S Makker of IAF's Aircraft and System Testing Establishment (ASTE), came out of the door smiling and waving. SARAS has subsequently flown again on 7 June 2004 and 19 July 2004. While the euphoria that followed this initial success was understandable, we are well aware that the SARAS programme has a long way to go before attaining the desired level of maturity.

↓ *Fig. 1 SARAS takes off on 29 May 2004.*



The HANSA programme continues to flourish. Seven HANSA aircraft are now flying in Indian skies and have together logged in well over 2000 hours of safe flying (*Box 2*). Our challenges in the HANSA development programme are now acquiring a different hue. We need to evolve procedures and systems to speed up the aircraft's production. We also need to work out strategies to market the HANSA more effectively, especially outside India.

NAL is deeply involved in the Tejas (LCA) development programme. We continue to fabricate and deliver critical Tejas parts (*Box 3*) such as the fin, rudder, centre fuselage components, wing spars etc. The Tejas flight test programme is going extremely well. Over 90 flight tests involving the Tejas TD1, TD2 and PV1 aircraft were completed last year and the reports from our control law team are very encouraging (*Box 4*).

The activity initiated some years ago, with ADRDE, Agra, to design and test lighter-than-air vehicles (LTAV), has now acquired considerable momentum. LTAV's offer several advantages: they are low cost, have long endurance, are viable for societal missions and provide a good platform for flight experiments. As a technology demonstrator, a radio-controlled blimp (*Box 5*) has been designed and is under fabrication.

Finally, I am delighted to report that the project to set up a pilot plant for producing aerospace-grade carbon

fibres and prepregs (*Box 6*) is progressing very well. This project will fill an important gap in our indigenous capability to develop high performance composite-bodied aircraft of the Tejas class.

IN THE DIVISIONS

The *Advanced Composites Division* continues to render outstanding support to both the SARAS and Tejas aircraft development programmes. For SARAS, the Division has developed all the control surfaces (elevators, rudder, ailerons, flaps), floor boards, wall assemblies and the fuselage-belly and flap-bottom fairings. A novel development is a versatile composites stitching machine to reinforce composite structures with weak 'out-of-plane properties' (*Box 7*). The project to continually monitor the structural health of composite structures using fibre optic sensors is also very promising (*Figure 2*).

1. SARAS is airborne

The SARAS aircraft took off on its maiden flight from the HAL airport just after 8.15 a.m. on 29 May 2004 with Sq Ldr K K Venugopal and Wg Cdr R S Makker, IAF test pilots, in command.

Soaring into the skies for the first time, SARAS climbed steadily. After a 25-minute triangular detour, when the aircraft flew over Anekal and Malur at an altitude of about 2100m and at a speed of up to 260 km/h, the SARAS landed safely to a thunderous ovation. Two 'chase' IAF Kiran aircraft and an IAF helicopter flew alongside SARAS during its maiden flight.

This first success constitutes a major step forward in NAL and CSIR's initiative to design and develop India's first civil transport aircraft.



SARAS in the course of its second flight on 7 June 2004

2. HANSA completes 2000 flying hours

The seven HANSA aircraft that are currently flying have together logged in more than 2000 flying hours. Another HANSA aircraft (VT-HNX) is now ready to fly away to the Haryana Institute of Civil Aviation, Karnal. The Ministry of Civil Aviation (MCA) has already positioned HANSA aircraft at Hyderabad, Trivandrum and Indore. A major effort has now been launched to develop detail and sub-assembly tooling for the HANSA so that the assembly and integration time can be significantly reduced.

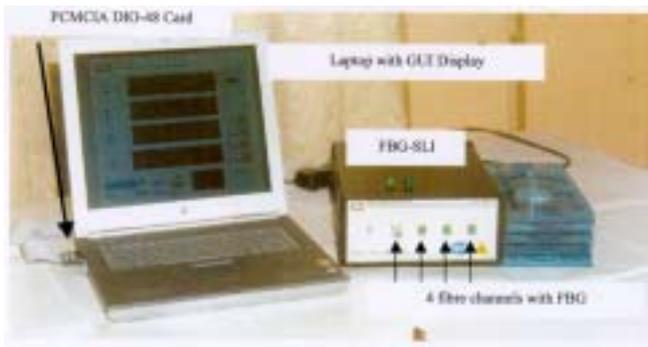
The table alongside contains the flying hours of the different HANSA aircraft as on 5 June 2004. The HANSA VT-HBL aircraft was earlier named VT-XBL

when it flew as an experimental aircraft. As VT-XBL, the aircraft has logged in at least an additional 200 flying hours.



HANSA flying over Jakkur airport

Hansa name	Flying club/Institution	Flying hours so far
VT-HBL	National Aerospace Laboratories, Bangalore	44.45 h
VT-HNS	Indian Institute of Technology, Kanpur	149.20 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	132.10 h
VT-HNW	Kerala Aviation Training Centre, Trivandrum	191.40 h



↑ Figure 2: The set-up for the health monitoring of composite structures using embedded fibre Bragg gratings (FBG) sensors.



↑ Figure 3: A view of the main instrument panel of the SARAS aircraft.

The *Aerospace Electronics and Systems Division* successfully installed and integrated the SARAS avionics and electrical system on the aircraft (Figure 3); it was also responsible for the design and development of the SARAS flight test instrumentation system and worked with ASTE teams to set up a telemetry ground station to acquire and monitor SARAS flight data in real time. The Division's FOQA software to monitor the flying perfor-

mance of aircraft evoked a good response at the Singapore air show. The Division also played an important role in the design and development of a wide variety of ground-based and airborne radomes.

The *Acoustic Test Facility* conducted seven test campaigns for ISRO in 2003-04 including tests on the GSLV strap-on nose cone decks and the GSLV L40 engine bay (Figure 4); in

particular, the acoustic test to study the performance of the GSLV L40 engine bay required a specially designed 80Hz cut-off exponential horn with a circular cross-section. The horn performed exactly as expected in the final tests.

I have already talked of the SARAS maiden flight and the impressive forward strides in the HANSA programme. The *Centre for Civil*

3. Development of composite structures for Tejas (LCA)

NAL continues to fabricate composite structures for the Tejas (LCA) aircraft development programme. Deliveries of the fin, rudder, wing spars, wing-fuselage fairing skins and blocks, centre fuselage components and under carriage doors for the Tejas TD1, TD2, PV1 and PV2 aircraft have been completed.

The present commitment is to deliver five more sets of all these Tejas parts for the PV series. The first of these sets (for the PV3 aircraft) is nearly ready for delivery. The additional requirement of components for fuel test rigs, MAST, half wing for lightning test and modification of the air intake have also been met.

In addition to this, concurrent activity has begun at HAL for the Tejas limited series production (LSP). NAL's Advanced Composites Division (ACD) has a further commitment to supply eight aircraft sets (LSP1 to LSP8) of all the above composite components. The supply of

components for LSP1 and LSP2 is nearing completion and further supplies are in the offing. The requirement for production standards were different; this called for fine tuning of the process parameters and fabrication procedures – which in turn called for modification in tooling concepts, vacuum bagging techniques etc., and the need to develop new tools. This work, with the necessary documentation, is also now over.

A major achievement at ACD this year was the successful completion of the structural qualification test of the modified Tejas rudder with a composite torque shaft after subjecting it to hygrothermal conditioning. The modified rudder was exposed to the full moisture saturation level in a specially developed environmental chamber and tested up to ultimate load. This is the first time in the country that a full scale co-cured composite test article has been conditioned and tested.

4. Design and development of flight control laws and air data algorithms for Tejas

Significant progress was made in the Tejas flight test programme during the year. Over 90 test flights were flown on the TD1, TD2 and PV1 aircraft. The schedule gain version of the control laws were successfully integrated on all three airframes and the flight envelope was continuously expanded. TD1, TD2 and PV1 went supersonic and the behaviour of the flight control laws and air data system in the transonic regime was found to be satisfactory. Leading slats and air brakes were made operative and extensive flight tests were conducted to map the characteristics of the airframe with extended slats and air brakes. For carrying out flutter experiments and PID tests, a microprocessor based FCS test panel was introduced and this significantly improved the quality of excitation and productivity during flights.

Except for the reduced direction stability levels, no other major surprises were seen in the parameter identification (PID) results. The schedule gain control laws also includes an automatic pitching moment compensation scheme for air brake deployment, and the performance

of this loop was found to be satisfactory at low dynamic pressures. However, at higher speeds the pitching moment generated is obtrusive to the pilots and investigations are on find the cause to improve the performance.

Updated functional requirement documents were released for both the control laws and the air data system. This new updated version of the control laws and air data algorithms includes 1g auto trim, boundary limiting and fail op fail safe features to enable flight over an extended Mach number, altitude, angle of attack and Nz envelope. The control law gains, parameters and the air data correction tables have been updated in this new version based on the results of the flight test data analysis carried out so far.

The control and handling qualities group of the Flight Mechanics and Control Division as part of the National Control Law Team, continues to actively participate in all the Tejas design, test and certification tasks at NTFC, ADE, HAL and ADA.

Aircraft Design and Development (C-CADD) played the pivotal role in every facet of SARAS development: fabrication, assembly, integration, testing and readying the aircraft for the first flight (*Figure 5*). C-CADD was also required to man-

age the project efficiently; with the SARAS development spread across a dozen work centres all over the country and involving over 600 scientists, engineers and technicians, this by itself was a truly formidable task.

The capability in the *Computational and Theoretical Fluid Dynamics Division* now encompasses numerical algorithms, grid generation, advanced code development based on Euler and Navier-Stokes equations and post-processing the results for

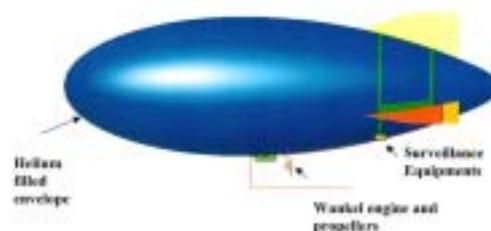
5. RC Blimp

NAL and Aerial Delivery Research and Development Establishment (ADRDE), Agra, are carrying out design studies on a technology demonstrator radio-controlled blimp, i.e. a lighter than air vehicle (LTAV) system. The objective behind this LTAV is to exploit inherent benefits in the use of such a vehicle for a variety of societal applications including sensing operations.

The present design of an envelope volume 320 cu.m with a payload capability of 30 kg was chosen because a large part of this vehicle's mission is to loiter for long hours. Powered by a Wankel engine, the proposed helium filled LTAV requires minimal fuel to stay aloft, and can maintain position efficiently. The proposed LTAV system is 18.3 m long, 7.53 m tall, and 6.0 m wide. The cruise altitude is 1500 m above sea level. It can

keep station in wind speeds up to 22 m/s.

LTAV systems present unique challenges in the form of difficulties in mooring, ground handling, and storage. These challenges have been addressed, and the benefits of the LTAV arguably outweigh all of these unique difficulties.



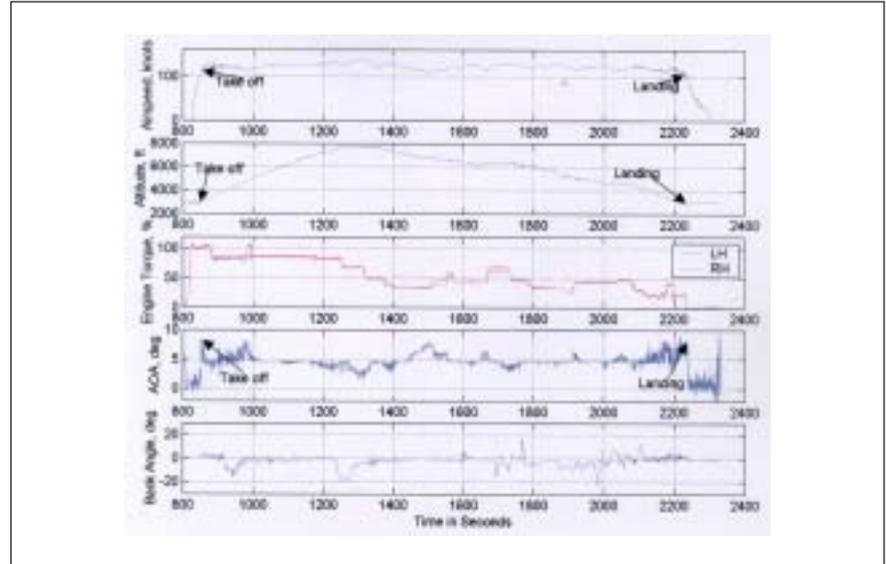
A schematic of the RC Blimp



↑ Figure 4: The acoustic test of the GSLV L40 engine bay in the 1100 m³ reverberation chamber. This test required the design and fabrication of a special 80 Hz horn.

effective flow visualization. The Division has also, over the years, veered sharply towards tackling realistic practical problems that arise in aerospace, including the rather special problems associated with hypersonic flows (*Box 8*). Figure 6 shows a typical result from computations on the full SARAS aircraft with side slip.

The *Experimental Aerodynamics Division* carried out successful experiments to assess the propeller performance of a 1:10 scale SARAS model in the 1.5m low speed wind tunnel. Such tests, involving power effects, have been attempted for the first time (*Figure 7*). The Division has also developed a Windows-based software in the MATLAB environment to meet



↑ Figure 5: Typical results from the SARAS first flight acquired by the onboard data acquisition system.

the future requirements of pressure sensitive paint (PSP) applications at NAL; the software includes options for PSP image registration and has been validated against existing PSP measurements on an aircraft model at transonic flow.

I am delighted to report that the *Flight Mechanics and Control Division* received the CSIR Technology Shield in 2003 in recognition of its R&D achievements in the areas of modelling and parameter estimation, flight simulation, flight control and multi-sensor data fusion. This year, the Division continued its support in ex-

panding the Tejas flight envelope, analyzed the Tejas flight test data using stabilized output error methods (*Figure 8*) and made good progress in developing the SARAS autopilot system. The Division has also developed the HELI-HQ PACK to study the handling qualities of helicopters in partnership with DLR, Germany.

The *FloSolver Unit* is now working full time on the New Millennium Indian Technology Leadership Initiative (NMITLI) project to design and build a customized parallel supercomputer for mesoscale modelling of the mon-

6. Establishment of carbon fibre facility

The task of setting up a pilot plant for producing carbon fibres and preregs for use in Tejas (LCA) and other defence programmes was taken up at NAL with funding from DRDO and ADA. This facility is envisaged as an integrated facility capable of producing special acrylic precursor fibres (SAF), carbon fibres and carbon/epoxy preregs. The pilot plant equipped with full process automation and control has been designed, fabricated and commissioned along with all the required utilities, safety and environment management systems. Development of various processes in the pilot plant is in progress. Polymer synthesis and fibre spinning pro-

cesses have been standardized. The process for conversion of SAF to carbon fibres is under investigation.

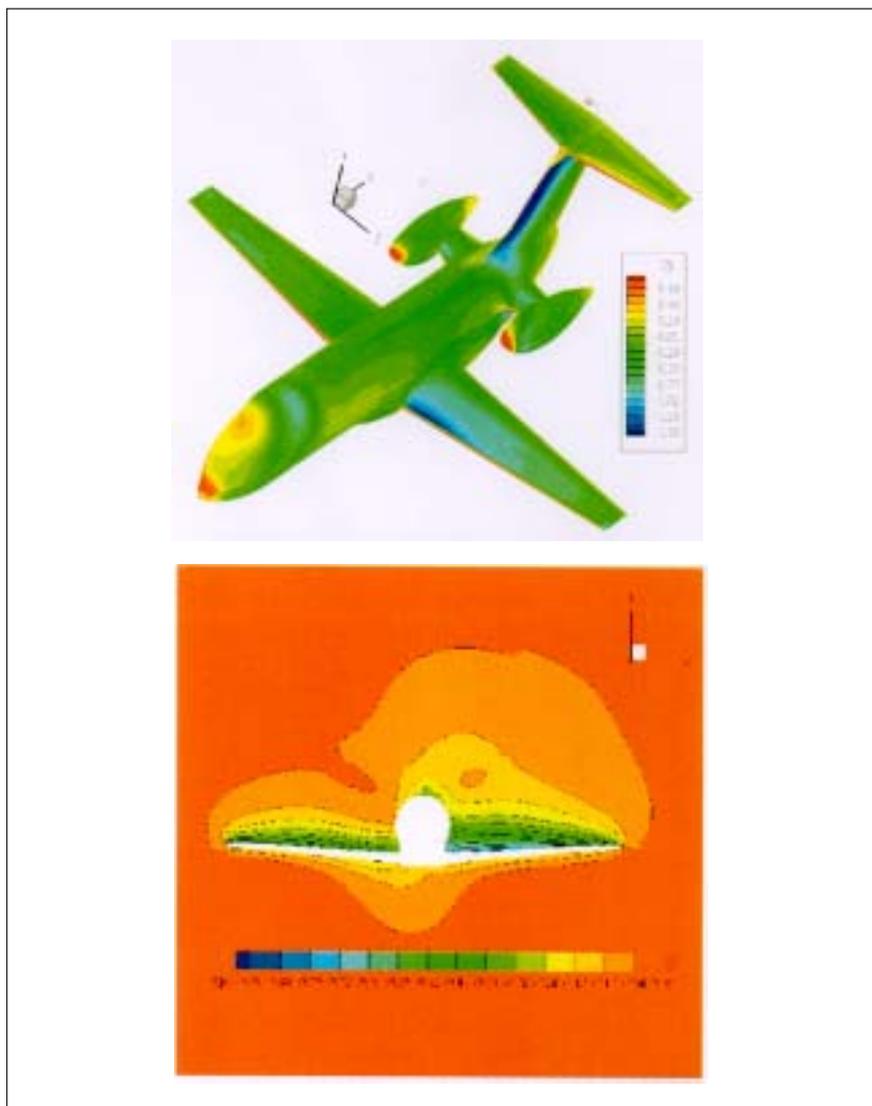


View of the pilot plant for establishing the carbon fibre facility

soon and tropical weather prediction. A 32-processor Flosolver Mk6 machine with the optical FloSwitch is now operational (*Figure 9*). The Unit is also ready to deliver an 8-processor Flosolver Mk6 to the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) to run its multi-grid Navier-Stokes solver. Test runs of the JNCASR code on the 8-processor Flosolver indicated an eleven-times speed-up. This is a wonderfully encouraging result; such super-linear speed-ups have seldom been achieved elsewhere.

The *Fibre Reinforced Plastics Division* had another typically busy year. The Division's major involvement this year was in fabricating airborne radomes: the nose radome for the Jaguar maritime aircraft, honeycomb core sandwich radome for the SARAS and the radome bulkhead, and radome fairings for the Tu-142M aircraft. Work on the Mark-2 version of the 12.88m diameter DWR radome for ISRO has started. The Division also fabricated composite Kaveri intake wind tunnel models (*Figure 10*) and started work to develop large composite blades for 300kW wind turbines.

As I mentioned earlier, the establishment of a carbon fibre facility at the *Materials Science Division* is progressing very well. The project team has successfully established the process for spinning polyacrylonitrile fibres, and efforts are now on to carbonize these fibres and make preregs. The Division's automatic visual range assessor (AVRA) is now performing satisfactorily at the Cochin international airport. AVRA deliveries to the Indian Navy will start in the next few months. The Division's failure analysis team carried out 99 investigations (77 aerospace-related) this year (*Figure 11*). Other promising initiatives include the synthesis of special piezo ceramic materials with attractive properties and the ongoing work related to the National



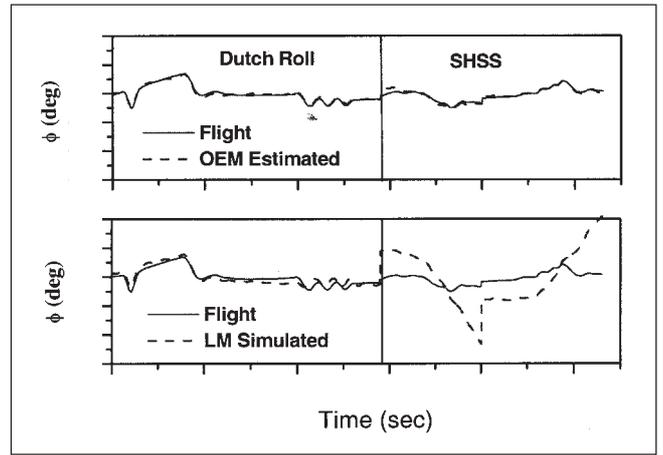
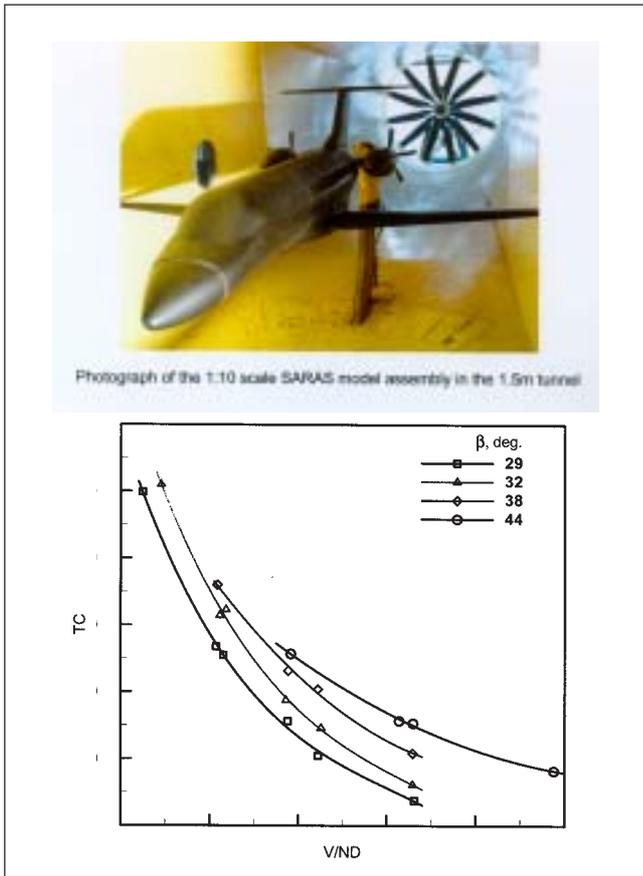
↑ **Figure 6:** A 66-block grid was used for Euler computations of flow past the complete SARAS aircraft with side slip.

Programme on Smart Materials.

months ago (*Figure 12*).

The *National Trisonic Aerodynamic Facilities (NTAF)* undertook wind tunnel tests both in the 1.2m x 1.2m trisonic wind tunnel (1095 blowdowns) and the 0.6m x 0.6m wind tunnel (171 blowdowns) for all its principal 'customers': ADA, HAL, VSSC and DRDL. About a third of these tests were for ADA — for different configurations of the Tejas aircraft. All the eight wind tunnel augmentation projects, initiated in October 2000, are progressing sufficiently well; the half model support system was commissioned a few

The *Propulsion Division's* applied research activities span turbomachinery, mechanical aspects of turbomachinery, combustion and heat transfer, and the design and development of entire propulsion and energy systems. In a major initiative, the Division is now setting up a large-scale high-speed combustor test facility, capable of combustor entry simulation corresponding to flight Mach numbers from 2 to 6. The 500m³ solar pond power plant is now about to be commissioned at Pondicherry.



↑ Figure 8: A comparison of the responses from a linear model and an estimated output error model for the Tejas steady heading side slip manoeuvre.

↩ Figure 7: Thrust measurements on a SARAS model to study the variation of the thrust coefficient with the propeller advance ratio.

The development of a novel, light-weight, single seater helicopter (*Figure 13*) based on the 'weight shift' principle is making good progress; the prototype is expected to fly within the next six months.

The major activity at the *Structural Integrity Division* this year was the structural testing of the SARAS aircraft. The SARAS fuselage (*Figure 14*), wing, fin and horizontal tail were all tested to their respective limit loads

in a variety of load cases. A number of coupon levels tests were also carried out in the Division's Material Evaluation Laboratory to qualify SARAS materials and validate designs. The IAF programme on the total technical life extension of the

MiG-29 aircraft also gathered a significant momentum this year.

The *Structures Division* too spent the best part of the year supporting the SARAS programme. Equivalent test loads, corresponding to critical flight

↓ Figure 9: The 32-processor Flosolver computer built as a part of the NMITLI project on mesoscale modelling of the monsoon.



↓ Figure 10: The 1/4 scale Kaveri intake model being packed for delivery to ADA.



⇔ ↓ Figure 11: The fractured wheel hub of an aircraft and the fatigue crack origin.



7. CNC based advanced composites stitching machine

Conventional laminated composites structures often have weak out-of-plane properties. One of the ways to overcome this limitation is to provide reinforcements in the third direction — realized through stitching. The stitching of composites aerospace components and structures has special requirements; e.g., access for stitching only from one side, and — because the job can be heavy and unwieldy — the necessity that the stitching head, instead of the job, moves.

Keeping these requirements in mind, the Advanced Composites Division has designed, developed and commissioned a versatile composites stitching machine (see figure) for stitching both orthotropic and quasi-isotropic composite laminates of thicknesses up to 2.4 mm using a carbon fibre thread of 0.5 mm diameter. This stitching machine has a workspace volume of 6000 mm x 3600 mm x 1150 mm — large enough to accommodate the Tejas wing. The machine has a stitch rate and stitch pitch control capable of being programmed for a specific stitching job. The machine uses a new chain stitch method employing a specially designed hook and thread needle mechanism. The movable stitch head is interfaced with a 7-axis numerically controlled bed.

The stitched and cured composites laminates have

exhibited improved mechanical properties, inter laminar shear strength and compression properties in comparison to the unstitched conventional composites laminates.

Commission trials have been satisfactorily made using this machine in the stitching of carbon/glass preforms, tufting of carbon/glass preforms and PU foam covered with carbon/glass fabrics.

A comprehensive plan has been drawn to utilize the stitching technology for the manufacture of advanced composite structural elements for aerospace applications. This plan includes an intensive training programme for operating this stitching machine to realize the desired component parts.



CNC stitching machine for composite structures

cases, were simulated for all the major SARAS components such as the fuselage, main wing, control surfaces and the stub wing; the test results were then correlated with the results

obtained from finite element analysis to establish the adequacy of every component's static strength and stiffness. Ground vibration tests were conducted on the full fuel and zero

fuel conditions on SARAS. The Division also intensified its R&D initiatives in the area of smart structures for active vibration and flutter control.

↓ *Figure 12: The half model support system for the 1.2m trisonic wind tunnel was commissioned in March 2004.*



Half Model Support System

↓ *Figure 13: The light weight helicopter prototype structure.*



8. CFD technology for hypersonic real gas flows

A very high level of energy primarily characterizes hypersonic flows. Across the shock wave, the kinetic energy is transformed into enthalpy. The temperature of the flow between the shock wave and the body is very high. Under these conditions, the properties of air are considerably modified. Phenomena like vibrational excitation and dissociation of molecules of oxygen and nitrogen occur. The energy is stored under a thermochemical form and the temperature of the flow is strongly reduced compared to the value that will be obtained if the gas were perfect. The thermodynamic and transport coefficients are no longer constant. In short, the ideal gas assumption breaks down and such a flow is called hypersonic real gas flow.

During reentry and hypersonic flight of the space vehicles through the atmosphere, real gas effects come into play. The analysis of such hypersonic flows is critical for proper aero-thermal design of such vehicles. The numerical simulation of hypersonic real gas flows is a very challenging task. Due to strategic reasons, CFD

technology for analyzing such flows is not commercially available and international cooperation in this area is usually not forthcoming.

An initiative for the development of CFD technology for hypersonic real gas flows was therefore taken at NAL a few years back. As a result of this effort, a Reynolds averaged Navier-Stokes equations (RANS) based CFD technology has been developed for numerical simulation of hypersonic flows in chemical non-equilibrium past complex aerospace configurations. The code is called MB-EURANIUM-R. It is an implicit, multi-block code that employs a novel formulation of Roe's Riemann solver as a basic discretization scheme. It solves the fluid dynamic and species equations in a coupled manner. The parallel version of the code, which employs MPI libraries, can be ported on any parallel platform. This is a unique national capability and likely to be in demand by organizations involved in the design and development of aerospace vehicles, like VSSC and DRDL.

The work on the development of sunshield mirrors for the INSAT 3D satellite has made considerable progress at the *Surface Engineering Division*; a nano-crystalline nickel plating facility was set up for this purpose. Technologically important nano size oxides like alumina, zirconia etc. were prepared using a solution combustion process and the nano size structure was confirmed by studies. Nano-layered multiplayer

coatings of TiN/NbN with very high hardness were also prepared and characterized at the Division. Special mention must be made of the novel concept used to deposit superhard nano-composite coatings of TiN/a-C (*Box 9*).

Wind turbine development continues to be the major concern of the *Wind Energy Programme*. Field performance studies and detailed blade

analyses (*Figure 15*) have been carried out on a medium-scale wind turbine to make a critical assessment, and derive inputs, for an improved machine design specially suited for Indian wind conditions of relatively low wind speeds and a dusty environment.

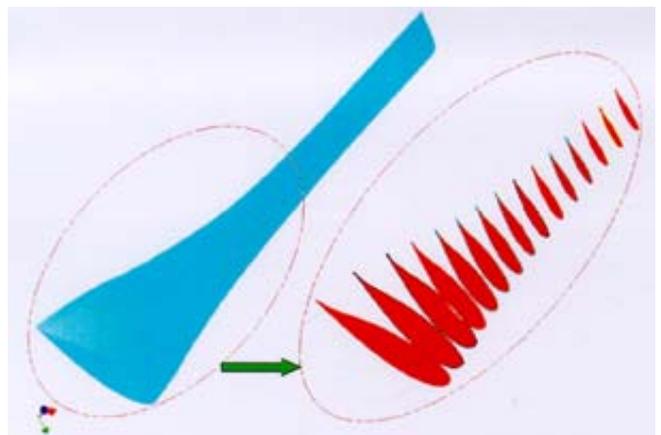
TECHNICAL SERVICES

The *Computer Support and Services*

↓ *Figure 14: The test rig for the SARAS fuselage.*



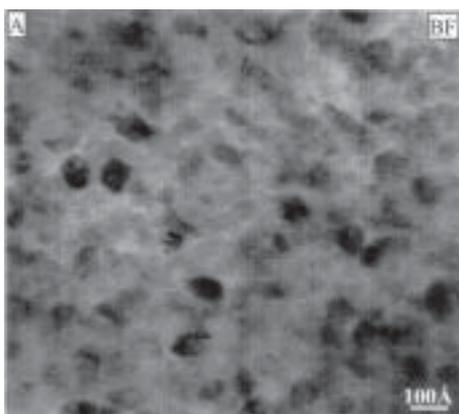
↓ *Figure 15: A typical blade solid model. The effort is to design a medium-scale wind turbine best suited for Indian wind conditions.*



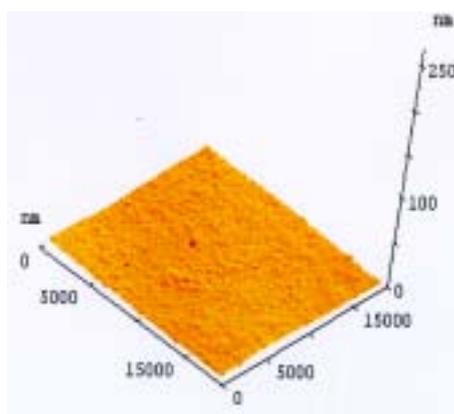
9. Novel superhard nanocomposite coatings of TiN/a-C

Superhard nanocomposite coatings of TiN/a-C were deposited using a reactive DC magnetron sputtering process. These coatings were developed using a novel concept, wherein the average crystallite size of the coatings was controlled by judicious control of process parameters such as – ion bombardment during deposition and inclusion of the amorphous phase (a-C) in the matrix of the hard material (TiN). Examination of coatings under a transmission electron microscope (see figure) indicated that the average crystallite size of the

coatings was ~8 nm. The atomic force microscopy image (see figure) showed that the average surface roughness of the coatings was ~4 nm. Nanoindentation measurements performed on the coatings showed a hardness of ~50 Gpa, which is very high in comparison to conventional hard coatings such as TiN (20 Gpa). This concept can be used to develop superhard coatings of other materials, such as TiAlN/a-Si₃N₄, which show thermal stability at very high temperatures (~1000°C).



Bright field transmission electron microscope image of a typical TiN/a-C superhard nanocomposite coating



Atomic force microscopy image of the coating

Division continued to manage NAL's extraordinarily busy campus network; in particular, the network security system functioned admirably thwarting all external threats. The *Electrical Sections* at the Belur and Kodihalli campuses rendered useful support especially for activities related to the SARAS programme. A new 1000kVA 11/0.433 kV electrical sub-station for the combustor test facility at Propulsion Division was also commissioned this year. The *Engineering Services Division* continues to be deeply involved with SARAS; among other things, they worked on the SARAS air data boom and developed a crate to transport the SARAS wing.

The *Information Centre for Aerospace Science and Technology (ICAST)* did very good work both in providing conventional library services and in developing web-based utilities for information search and retrieval. The

online newspaper clipping service has been well-conceived and contains practically every media reaction to the SARAS programme. The *Information Management Division* had another typically busy year: they designed attractive posters and multimedia presentations for the Singapore air show in February 2004 and prepared half a dozen VCD-based films, including two films that vividly capture the drama of SARAS design and development and the SARAS maiden flight. The WebISTAD software for CSIR has now been considerably improved and the 'Arogya' software for managing NAL's health care services is settling down nicely.

The *Project Management and Evaluation Division* continues with its many activities such as managing NAL's sponsored projects and external cash flow, supporting the massive planning exercise related to the Tenth Five

Year Plan and CSIR's network projects and managing a wide variety of other R&D management activities. The *Technical Secretariat* helped in the filing of three patents and two copyrights and played the leading role in launching the CSIR Research Intern programme at NAL.

OTHER EVENTS

The seventeenth NAL Foundation Day lecture was delivered by Mr N Vedachalam, Director, Liquid Propulsion System Centre on 29 July 2003 (*Figure 16*). The hour-long lecture on "Challenges in rocket propulsion" proved to be a remarkable tribute to ISRO's GSLV programme. Ms Padma Madhuranath delivered the accompanying NAL Technology lecture on "Air traffic management and simulation". The CSIR Foundation lecture on 26 September 2003 was delivered by Mr S C Kaushal,



↑ *Figure 16: Mr N Vedachalam delivering the seventeenth NAL Foundation Day lecture on "Challenges in rocket propulsion" on 29 July 2003 at the S R Valluri Auditorium.*



↑ *Figure 17: Mr S C Kaushal's CSIR Foundation Day lecture on "Kaveri engine design and development", delivered on 26 September 2003.*

Director, GTRE (*Figure 17*). Mr Kaushal's lecture on "Kaveri engine design and development" was a compelling account of the many challenges involved in designing a high performance aeroengine. Mr M K Sridhar delivered the accompanying NAL Business lecture on "Fibre technologies at NAL".

This year's NAL Science Day lecture on 27 February 2004 featured butterflies. In his utterly delightful lecture, titled "Life on wings", Prof Madhav Gadgil of Indian Institute of Science (*Figure 18*) talked of the butterfly's flight, its extraordinary vision and its many enemies and

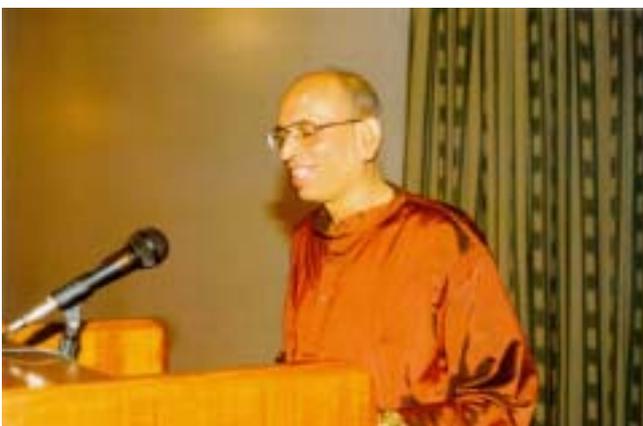
friends. It was disappointing that the chief guest at this year's Dr B R Ambedkar birthday function on 28 April 2004 could not be present because of a sudden indisposition, but the charm and enthusiasm that characterizes this event every year was very much on view (*Figure 19*).

As always, the Hindi Day function, held on 15 September 2003 -- and the Hindi Fortnight preceding the function -- was celebrated with customary enthusiasm; there were a large number of participants in the various contests held during the Hindi Fortnight. I find this very encouraging. The Kannada Samskrithika Sangha

celebrated the Karnataka Rajyothsava on 21 November 2003. Prof Narahalli Balasubramanya, the noted critic and litterateur, was the chief guest. The 29th issue of *Kanaada*, NAL's popular science magazine, was also released that day. I feel very proud of what *Kanaada* has done for science education in Karnataka and elsewhere.

The other major events in 2003-04 included the celebrations to mark the first flight of the Wright Brothers (*Box 10*), Air Race 2003 organised by the Aeronautical Society of India in which NAL's HANSA VT-HBL participated, the NAL-NALTech industry meet on

↓ *Figure 18: Prof Madhav Gadgil delivering the National Science Day lecture on "Life on wings" at NAL on 27 February 2004.*



↓ *Figure 19: The Dr B R Ambedkar birthday celebration function at NAL on 28 April 2004.*

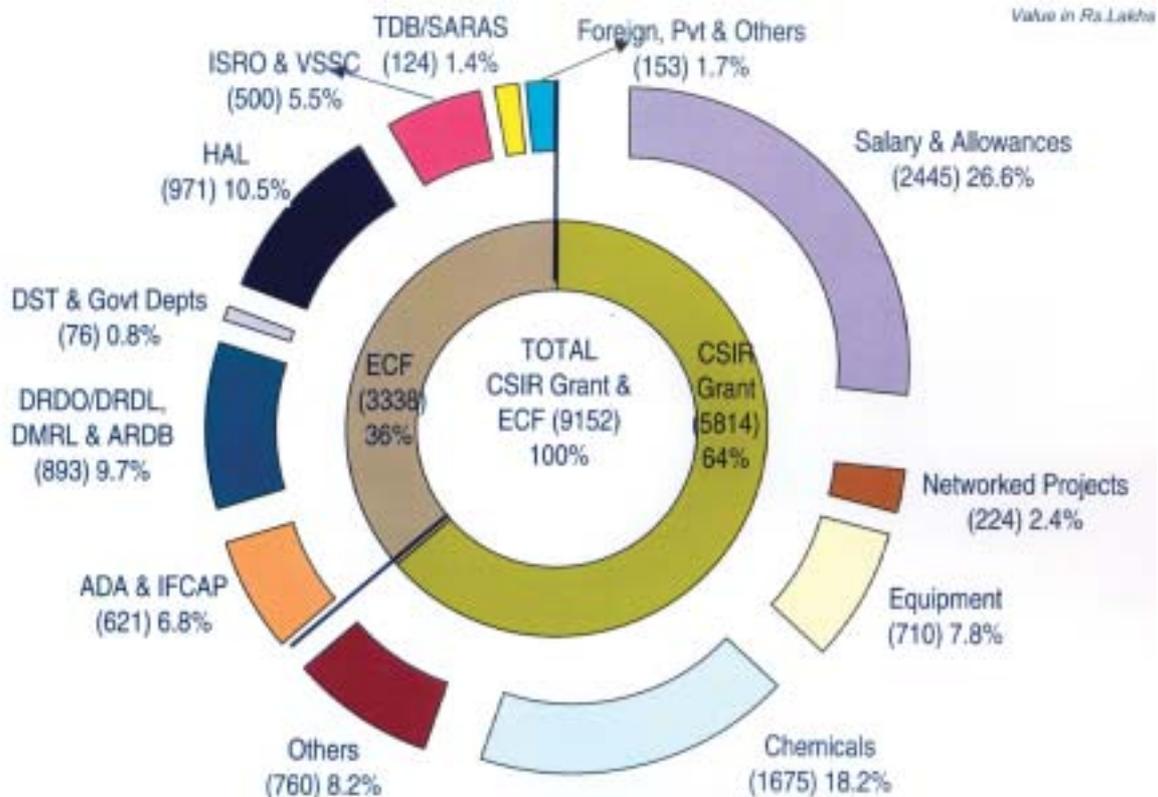


10. The centenary of powered manned flight

NAL organized a large number of programmes and events to commemorate the centenary of the first powered manned flight by the Wright Brothers. The primary focus was towards children and youth. There were aero quizzes, paper plane contests and a variety of other events organized in different schools around Bangalore. The winners of these contests were taken for recreation flights: 20 children had a flying experience on the HANSA (with Capt Yogendra Urs) and 30 children flew on the powered hang glider (with Dr B R Pai). The celebrations ended with an impressive function on the NAL campus featuring 60 school children and two wonderful lectures by Prof R Narasimha (on how the Wright Brothers built and flew their Flyer) and Wg Cdr P Ashoka (on his experiences as a fighter pilot).

In two related events, NAL's HANSA participated in Air

Race 2003, organized by the Aeronautical Society of India between 20-22 November 2003, and the project, organized by the Visweswaraiiah Industrial and Technological Museum, to build a full-scale replica of the Wright Flyer.



↑ Figure 20: NAL received Rs 9152 lakhs in 2003-04 from various sources. Rs 5814 lakhs (64%) of the money came from CSIR and the remaining Rs 3338 lakhs came from external sponsors (the external cash flow in 2003-04 was Rs 33.38 crores). HAL (Rs 9.71 crores) was the largest single contributor.

11. Padma Shri for Dr T S Prahlad

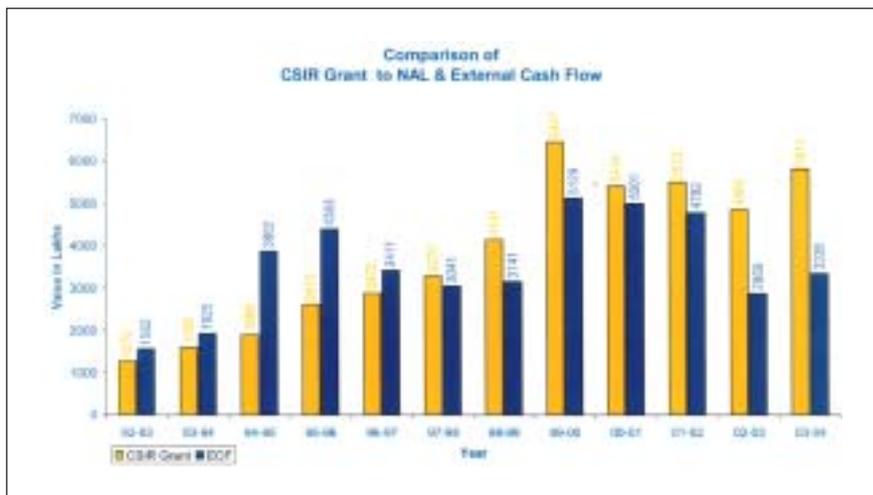
It is a pleasure to congratulate my predecessor, Dr T S Prahlad, upon being conferred the Padma Shri by the President of India. To us, Dr Prahlad is much more than a distinguished scientist and leader. He is, above all, a close friend. It would not be wrong to say that most members of the "Team NAL" know him personally and have benefited by interactions with him. Dr Prahlad is truly an "aerospace man" given his close association with the space programme, the Tejas (LCA) programme and NAL's own aeronautical R&D programmes. I find it remarkable how Dr Prahlad blended his own rich knowledge and experience with NAL's inherent capabilities to give concrete shape to our many R&D activities and deliver both tangible and intangible outputs. He also championed inter-disciplinary projects and strong networking.

Dr Prahlad's greatest achievement was to steer NAL's nascent civil aviation programme through some very difficult phases and bring it to a mature level. His contributions in making the HANSA aircraft opera-

tional, getting it certified and enabling its flight in different parts of the Indian sky is a great achievement indeed. The SARAS programme, that he led so capably, is a landmark achievement for both NAL and CSIR. More than anyone else, he is responsible for making our SARAS dream a reality. / B R Pai



Dr T S Prahlad receives the Padma Shri from President Kalam



↑ Figure 21: A comparative assessment of NAL's external cash flow (ECF) during the past decade. The average annual ECF during the decade was about Rs 39 crores.

26 June 2003 to introduce NAL's ECAAM technology and two remarkable lectures related to trends in civil aviation: Prof R T Krishnan of IIM, Bangalore's lecture on why Brazil's Embraer is now doing so well and by Capt G R Gopinath on the successful emergence of Air Deccan.

STATISTICAL SUMMARY

65 new sponsored projects (value: Rs 33.63 crores) and 15 new grant-in-aid projects (value: Rs 4.41 crores) were taken up during 2003-04. Our external cash flow (ECF) this year was Rs 33.38 crores with the largest

contribution (Rs 9.71 crores; 29%) coming from HAL (see Figure 20). The ECF rose moderately (from Rs 28.69 crores to Rs 33.38 crores) this year. It is noteworthy that NAL's ECF has never fallen below Rs 20 crores for a full decade; in fact the average ECF during the last ten years has been Rs 38.96 crores (see Figure 21).

The NAL staff strength is currently 1239. This includes 348 scientists and 168 technical officers.

HONOURS

It is finally a pleasure to mention the many laurels won by my colleagues in 2003-04. Dr T S Prahlad, my illustrious predecessor, received the Padma Shri from the President of India (Box 11). The Flight Mechanics and Control received the 2003 CSIR Shield for its work in flight modelling, control and simulation. Dr Abhay Pashilkar received the Young Engineer Award 2003 from INAE and the Mrs Sabita Chaudhuri Memorial

Medal from IISc. Mr M Subba Rao received the National Aeronautics prize for the year 2003 from AeSI and was also elected Fellow of INAE. Dr P R Viswanath and Dr K Y Narayan received the Distinguished Alumnus award from IISc's Department of Aerospace Engineering. Dr S Sridhara Murthy was elected Fellow of AeSI. Dr R M V G K Rao received the MRSI Medal for 2004 and Dr P K Panda received the Raman Research Fel-

lowship for 2004-05. Dr Mukund was invited to be an AIAA Member, Dr Manoj Nair was selected as a new Foreign Country Member of AIAA's Applied Aerodynamics Technical Committee and Mr Laxmikant Merchant received the Air India prize for his performance as an aerospace engineering student at IIT, Madras. Mr R Narayana, Dr S Viswanath, Mr V M Pratape, Mr H V Narasimha and Mrs R S Rajagopal, my colleagues of

the Structures Division, contributed an award-winning poster at the 5th International Food Convention (IFCON 2003). Dr M N Sathyanarayana received a coveted award from the Rotary Club of Bangalore South Parade. I congratulate all of them.

Dr B R Pai
Director