

REPORT OF THE DIRECTOR

It gives me great pleasure to present the annual report for the year 2005-2006.

HIGHLIGHTS

The SARAS flight testing programme is progressing well, and without any serious technical glitch, although bad weather and Bangalore's ever increasing air traffic are delaying matters. Sixty SARAS flights have now been successfully completed (*Box 1*). The flight test programme will gain momentum when the second SARAS prototype flies later in 2006.

NAL has successfully completed the first of its two programmes under the New Millennium Indian Technology Leadership Initiative (NMITLI) umbrella to develop a supercomputing platform for tropical weather predic-

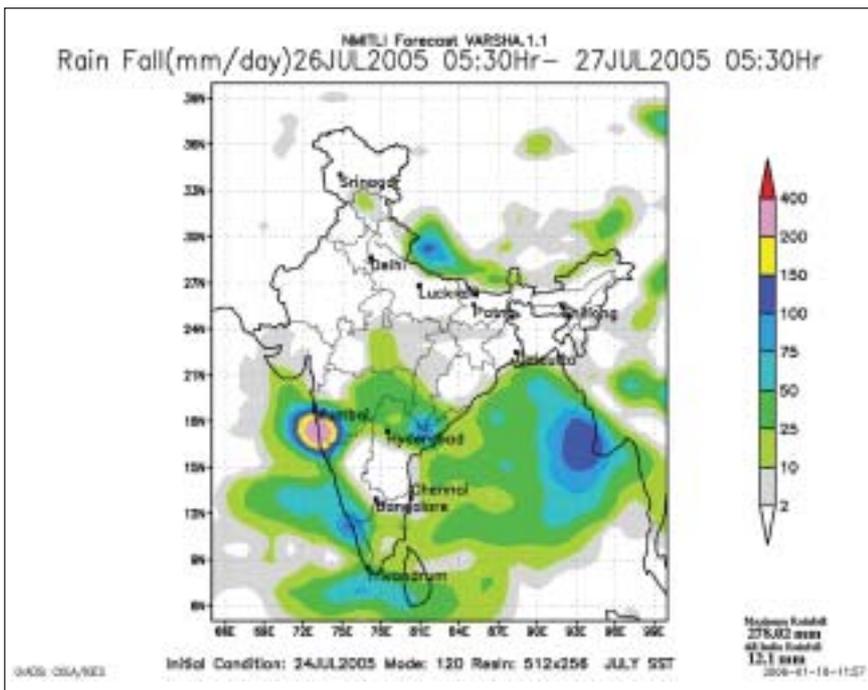
tion. The 128-processor parallel computer, with its innovative FloSwitch for rapid inter-processor communication, now runs the customized Varsha prediction software (*Box 2*) and can make sufficiently accurate meteorological forecasts; the very intense rainfall event over Mumbai on 26-27 July 2005, for example, was picked up sufficiently well (*Figure 1*).

The other NMITLI-funded programme, to develop a 500kW, low-cost, horizontal-axis wind turbine that is ideally suited for India's moderately windy and dusty conditions, is shaping up very well (*Box 3*). The experimental 300kW wind turbine, with nearly identical specifications, performed better than its imported equivalent when it was mounted in a wind farm in Tamil Nadu towards the end of the 2005 windy season.

NAL has now completed the total technical life evaluation of the MiG-21bis airframe using full scale fatigue testing. The test results are encouraging: a life enhancement of 1000 flying hours appears possible (*Box 4*).

NAL's Failure Analysis and Accident Investigation Group has been playing a leading role for more than three decades, having investigated every major aircraft or industrial accident or incident. Better still, NAL enjoys the confidence and faith of all investigating agencies and has built up a reputation of being scrupulously unbiased. It is therefore deeply satisfying to mention that the Group has now

↓ *Figure 1* The forecast for 26-27 July 2005 over Mumbai based on NCEP's initial conditions for 24 July. The massive build-up is clearly visible, although the observed rainfall was significantly greater than the prediction.





↑ **Figure 2** NAL is developing prototypes of smart shape memory alloy (SMA) based repair devices for difficult-to-access areas. The photographs show SMA strips before and after actuation.

completed its 1000th investigation (Box 5).

NAL also successfully undertook the task of replacing the 9m diameter inflatable radomes of the air combat simulator at Hindan Air Force Base, Ghaziabad with rigid composite domes made out of sandwich panels. The twin domes have now been successfully commissioned. NAL also developed 11 composite nose radomes for Jaguar Maritime aircraft. I am happy to report that these radomes passed all certification tests and have now been inducted by the end user.

IN THE DIVISIONS

The *Advanced Composites Division* remains deeply involved with both its SARAS and Tejas commitments. The Division is required to deliver CFC co-cured fins and rudders, centre fuselage components, wing spars, fairing skins, undercarriage doors etc. for Tejas. This is a daunting task often involving the complete lifecycle of design, development, fabrication, testing and certification, but our teams always seem to find the energy, resolve and quality required for these tasks. The Division is now discussing the development of a new fin and rudder for the production versions of naval Tejas, and the possibility of

1 | SARAS test flights | Dr K Y Narayan

The first SARAS prototype aircraft (VT-XSD) has now completed 60 flights successfully without any major hitch. The flight tests conducted so far have concentrated on basic handling qualities and performance, simulation of single engine climb and descent, take off and landing with 0° flap etc.

The aircraft has behaved largely as expected with some shortfall in the climb performance. The results obtained are being analyzed and the next block of flights will concentrate on the pressure error corrections and measurement of control forces.

The second prototype aircraft PT-2 is now getting integrated and being equipped at a brisk pace. The new stub-wing and the nacelle are getting ready. The new engine-propeller combination is going through endurance qualification tests at NAL and is expected to be completed by the end of July 2006.

SARAS PT-2 is expected to fly by end-October 2006.



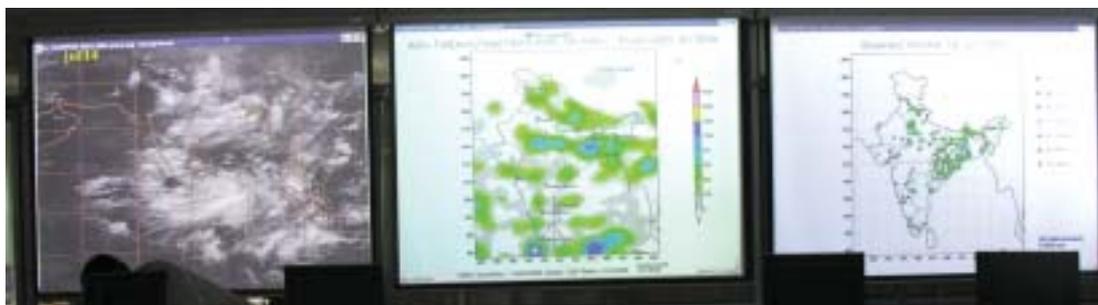
developing an experimental co-cured Tejas wing. The Division's commitments to SARAS are equally onerous: developing composite control surfaces and participating in the weight optimization programme, involving fabrication of a new composite empennage structure and, even more exciting and challenging, the development of a new composite wing itself using the innovative NAL-developed vacuum enhanced resin infusion technology (VERITY). I am also very impressed with the Division's new initiatives in structural health monitoring of composite structures,

and in structural repair technology using smart actuators (*Figure 2*).

Supporting the SARAS programme is still the dominant activity of the *Aerospace Electronics and Systems Division*. The Division has the total responsibility for the SARAS avionics and electrical system. The Division has now successfully completed the safety of flight tests for the SARAS stall warning system and obtained the DGCA certification for 25 hours of flight testing. Critical line replacement units for SARAS and HANSA aircraft are being certified by the

Division for aircraft applications. Code development, qualification testing and code testing for the smart fatigue meter have now been completed. The NALFOQA software, developed to monitor flight operations and quality assurance of civil aircraft, is now in active use both at Air India and Indian, and we believe that this product can be marketed even more widely. The active noise control technology developed in the Division is likely to find immediate practical application in designing the Tejas cockpit and in automobiles.

2 | Meteorological predictions using Varsha | Dr U N Sinha



The NMITLI platform for weather prediction, developed by a team led by NAL, is now ready. The 128-processor parallel computer, with its innovative FloSwitch, has been customized to run NAL's Varsha software. Varsha grew out of a global circulation model but the software is now completely re-engineered, completely rewritten in C, and incorporates, for the first time, new modules for the boundary layer and radiation.

Starting May 2005, NAL's Flosolver Unit started making five-day research predictions of rainfall, temperature, humidity, wind speeds etc. using initial conditions downloaded from the NCEP site. So using NCEP initial conditions, e.g. for 1 June, NAL used the NMITLI platform to "time march" ahead and make predictions for 1 June, 2 June ... 5 June.

This exercise was undertaken practically every day and the predictions were displayed at the Flosolver Unit foyer; indeed, these predictions often became a talking point on the NAL campus and both successes and failures evoked sharp reactions. Varsha did well with the very intense rainfall in Mumbai on 26-27 July 2005, as well the Gujarat rains earlier and the Tamil Nadu rains later.

In fact, it soon became very apparent – although this was hardly surprising – that Varsha captured the extreme events very well. So, before the onset of the 2006 monsoon, NAL decided to turn more ambitious and make long range predictions; e.g. using NCEP's initial conditions of 1 June, predictions were made for 1 June, 2 June ... right up to 30 June. This raised eyebrows (every new research initiative raises eyebrows), but the results were sufficiently satisfying. In particular, the extreme events were coming through well: using initial conditions of 1 July 2005, the big Mumbai build-up of end-July 2005 was clearly visible, however initial conditions of 1 July 2002 showed no build-up, because there indeed was no extreme end-July 2002 rainfall event.

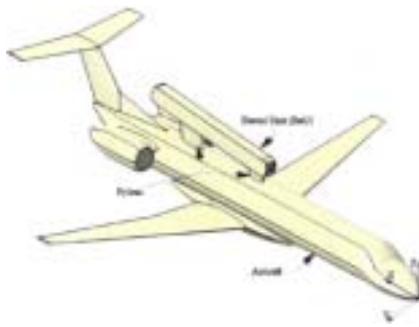
Varsha therefore is full of promise, although a great deal of work remains before the software can be truly "certified". When Varsha's success in spotting extreme events is better validated, it should be possible to indicate the likely monsoon onset date, identify long dry or wet spells and be better prepared to surmount the deadly fury of cyclones and floods.



↑ **Figure 3** Pilots from different Indian flying clubs attended a three-day HANSA familiarization programme at NAL recently.

Two major satellites, their subsystems and a launch vehicle subsystem were qualified in 2005-06 at the *Acoustic Test Facility (ATF)*. ATF is now engaged in a variety of other R&D services such as the design, fabrication and development of high intensity acoustic calibrators, air jet noise studies and the design of heat shield tilting fixtures for acoustic tests on launch vehicles such as the GSLV.

At the *Centre for Civil Aircraft Design*



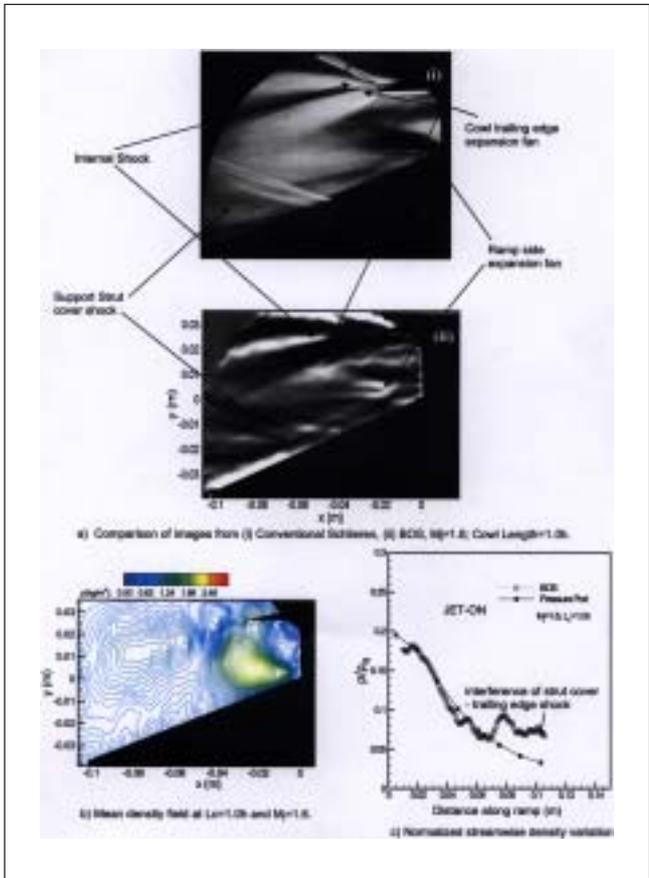
↑ **Figure 4** Preliminary design model and the unstructured mesh in the CFD study to measure external flow past an aircraft with dorsal unit.



and *Development (C-CADD)*, work on the second SARAS prototype is proceeding briskly, with plans for the first flight in October 2006. New engines (PT6A-67A) with higher power (1200 SHP) and bigger propellers for the PT-2 version have now been received and are undergoing tests on the engine test bed. All design modifications have been completed and the equipping of the aircraft is now in progress. The production of HANSA aircraft, and their delivery to Indian flying clubs via DGCA, is proceeding at a fair pace.

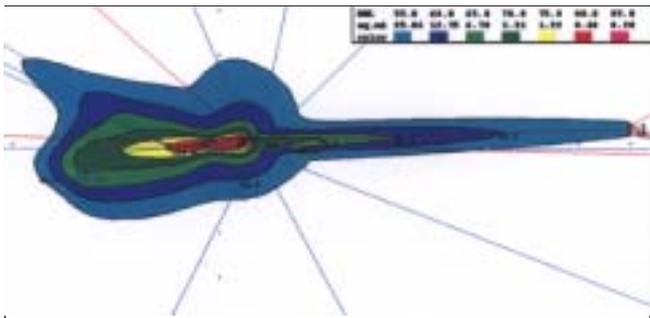
Three new HANSA aircraft (seventh, eighth and ninth of the series) are preparing to leave for flying clubs at Bangalore, Hyderabad and Trivandrum (*Figure 3*). It is also gratifying that we have commenced deliveries of HANSA aircraft manufactured by TAAL, our industrial partner.

The *Computational and Theoretical Fluid Dynamics Division* continues to extensively use its CFD codes, ranging from potential flow based panel methods to complex Reynolds-aver-



⇐ **Figure 5** Application of the background oriented Schlieren (BOS) technique to flow on a single expansion ramp nozzle

⇓ **Figure 6** As air traffic in India grows by leaps and bounds, it is becoming very important to consider issues related to air traffic management around busy airports. NAL has undertaken simulation studies to measure airport delays, controller workloads and noise environments. The figure shows noise contours measured around Bangalore's HAL Airport on 23 November 2005.



3 | NAL's wind energy programme | Dr J J Isaac

Wind turbines are increasingly playing a significant role in the generation of electrical power in the world. Although India has a huge wind power potential of 45,000 MW, hardly 10% has been harnessed for the generation of grid quality electricity and that too, by entirely employing imported wind turbines. Even though India ranks fourth in the world in wind power generation, after Germany, Spain and USA, high capital investment and suitability of the wind turbines to the Indian wind environment have been the main bottlenecks to the large-scale penetration of wind power.

A mission-oriented and technology-driven strategy has been evolved by NAL to develop indigenous, low cost, robust, technologically advanced wind turbines, specially suited for the Indian wind conditions of relatively low wind speeds and dusty environment. Studies elsewhere have revealed that the price per kW reduces with increasing capacity to a point beyond which it is rather insensitive to scale, for the latest medium to large designs. There is no cost advantage beyond a size of around 500kW where as there are definite advantages in adopting a modular approach and in the ease of maintenance and in the transport of relatively smaller size wind turbine blades on Indian roads.

The design and development of a 500kW, low-cost, horizontal-axis wind turbine has been taken up by NAL as a collaborative programme with the Structural Engineering Research Centre (SERC), Chennai and an industrial partner- Sangeeth Group of Companies, Coimbatore, with funding mainly under CSIR's New Millennium Indian Technology Leadership Initiative (NMITLI). The wind turbine, which will be 2-bladed, downwind, teetered and stall-regulated with a guyed-tilt tower, is expected to be installed by November 2006 at the Sangeeth Group's wind farm at Kethanur, Coimbatore District.

As a prelude, a pair of 300kW wind turbine blades has been made by NAL and installed on an available wind turbine platform at the same wind farm. The blades have operated successfully during the last two wind seasons and have given superior performance, as com-

pared to equivalent imported blades. Valuable outputs that have validated NAL's specially developed wind turbine design and performance prediction codes have been obtained and successful field trials to check out NAL's blade fabrication technology have also been carried out.

The special drivers of the programme are (a) application of NAL's aerospace technology to wind turbine development, (b) evolution of a comprehensive indigenous methodology and creation of a design database for the development of low cost small and medium-scale wind turbines suited for the Indian wind environment and (c) a target cost of an indigenous medium- scale NAL wind turbine, in view of its innovative features, to be around Rs. 3 cr/MW as against the current market rate of Rs.6.7 cr/MW for the imported machines.



aged Navier-Stokes solvers, for a wide variety of flow problems. For example, the implicit Reynolds-averaged Navier-Stokes solver (IMPRANS)

was used to estimate the average thrust and power of NAL's proposed wind turbine with reasonable accuracy. The NAL panel code did a fair

job in determining the force and moment coefficients for different configurations of ISRO's proposed reusable launch vehicle. The Division is

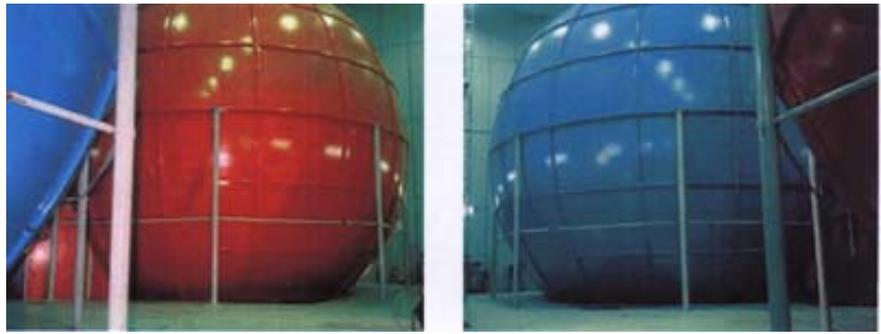


↑ **Figure 7** The history of the Flosolver programme, and its successes spanning two full decades, has now been compiled in a colourful pictorial publication.

also starting two interesting projects related to the development of an airborne early warning and control system (AEWCS): to measure internal flows in the AEWCS cooling system, and compute the external flow past the aircraft with the dorsal unit mounted on the fuselage (Figure 4).

The *Experimental Aerodynamics Division* works in the areas of flow structure and management, flow diagnostics, and aircraft and spacecraft aerodynamics. The Division made significant progress in its task to assess the characteristics of candidate binary pressure sensitive paints (PSP) formulations developed by the Surface Engineering Division; the winning formulation appears to have been found. Different non-planar wing tip devices for induced drag reduction of the SARAS model were

↓ **Figure 9** Acrylic precursor fibres and carbon fibres developed at NAL's IFCAP.



↑ **Figure 8** The composite domes fabricated for the HAL-IAF air combat simulator unit had to meet stringent requirements of sphericity.

evaluated at low speeds. Other successes include documenting the mean density field in the base flow region of a single expansion ramp nozzle using the BOS technique (Figure 5) and evaluating afterbody drag characteristics of a simulated complex launch vehicle geometry.

At the *Flight Mechanics and Control Division* work on validating and updating the Tejas control laws is progressing steadily. 107 Tejas flights were carried out by NFTC, ADA in 2005-06 and the fighter aircraft's flight envelope is being continuously expanded in Mach number, altitude, angle of attack and load factor. The project to develop the SARAS autopilot is now in an advanced stage of finalization. The Division's engineer-in-the-loop (ELS) simulator has migrated to a PC platform from the present SGI platform; cockpit displays too are being made more realistic. Work on the proposed SARAS

simulator is also progressing smoothly.

As Indian airports get increasingly crowded, air traffic management (ATM) will become a key concern. The Division has undertaken simulation studies to measure airport delays, controller workloads and noise contours in evolving air traffic scenarios (Figure 6). Other studies undertaken include advanced parameter estimation from high angle of attack flight data and data fusion strategies for situation assessment.

I have already commented on the successful completion of the NMITLI project to develop a customized hardware-software solution for tropical weather prediction at the *Flosolver Unit* and the remarkable achievement of the Flosolver team in com-

↓ **Figure 10** The large scale turbomachinery research rig, obtained from Pratt & Whitney, USA, will soon be ready for bench marking tests.



pleting 20 years of this path-breaking research and development (*Figure 7*). The Unit is now attempting long range simulations of monsoon rainfall, computing with greater precision and is getting ready to release of the C++ version of the Varsha software next year.

The *Fibre Reinforced Plastics Division* had another tremendously busy year. Some of the products fabricated by the Division in 2005-06 include: composite nose radomes for the Jaguar maritime aircraft, domes for the HAL-IAF air combat simulator (*Figure 8*), GFRP blades for wind turbines and metallised CFRP reflectors and feed components for satellite communication applications. I find it remarkable that the Division is also, at the same time, able to focus on basic research problems on matrix synthesis, heat transfer phenomena and sandwich optimization studies.

The Integrated Facility for Carbon Fibres and Prepregs (IFCAP), created at the *Materials Science Division*, has made remarkable progress with the development of process technology for the production of precursor fibres and standard modulus carbon fibres (*Figure 9*). The Division has now been approached by VSSC to develop high modulus carbon fibres suitable for space applications. In the area of smart materials, the task of fine tuning the functional and mechanical properties of SMA wires, so that they are suited for actuator applications, has achieved significant progress. The Division's isothermal chemical vapour infiltration reactor facility is now fully functional and work has already been initiated in the area of ceramic matrix composites. Finally Drishti, the Division's advanced version of the airport visibility range assessor based on an embedded FPGA system, is now undergoing field tests.

As I briefly reported last year, three

4 | TTLE programme of MiG-21bis completed | Dr P K Dash

The full scale fatigue testing (FSFT) on the MiG-21bis airframe C-2090 was successfully completed. With this, a major Indian Air Force (IAF) project on the total technical life enhancement (TTLE) of the MiG-21bis fleet came to an end. A life enhancement of 1000 flying hours for the fleet has been given based on NAL's FSFT results.

During the testing, the port wing suffered a structural fatigue failure of the main beam; the fatigue crack got initiated at the first bolt hole on the main beam bottom flange.



A close up of the crack initiation site



A fatigue crack also initiated from the same bolt hole on the starboard side.

new systems of *National Trisonic Aerodynamic Facilities (NTAF)*: twin roll model support system, additional air storage system and new compressor facility were successfully commissioned in 2005-06. The additional model cart too was successfully integrated with the 1.2m tunnel circuit. NTAF's augmentation programme is therefore practically over, except for the variable Mach number flexible nozzle for which the fabrication has now started. Although it proved to be a long, and occasionally painful, exercise, this augmentation was essential to improve the tunnel's productivity and its data quality, and because this is India's only wind tunnel facility servicing VSSC, DRDO and HAL as well. During 2005-06, the 1.2m trisonic tunnel was busy round the clock with 999 blowdowns.

I have already written about the very encouraging performance of the 300kW wind turbine, developed by an inter-divisional team under the leadership of the *Propulsion Division*, at the Sangeeth Wind Farm in

Kethanur, Tamil Nadu. The next step is to design and develop the 500kW NMITLI wind turbine; I feel confident that this R&D exercise will be equally successful, and extremely valuable to the country. In other developments at the Division, the installation of the large scale turbomachinery rig, transferred from Pratt & Whitney, USA, is almost complete (*Figure 10*); this rig will be very useful in our activities in turbomachinery aerodynamics. The large-scale, high-speed combustor test facility, and the national facility for testing rolling element bearings are both nearing completion. The 500m² Pondicherry solar pond power plant is undergoing final trials before formal commissioning and, following the completion of the detailed design of the 55 hp liquid-cooled Wankel engine, fabrication of the engine components is now under way.

The static test activities for SARAS continued at the *Structural Integrity Division*. Preparations are now on to carry out the pressurization test on

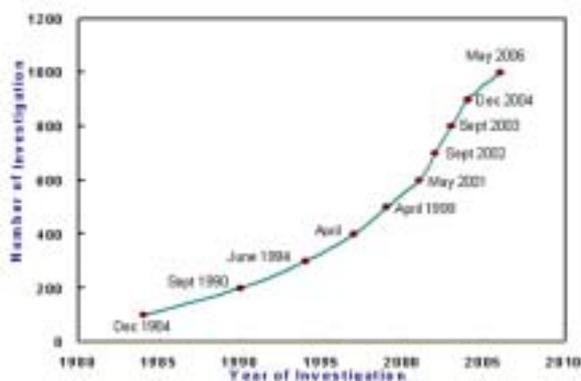
5 | 1000 investigations in failure analysis | Dr S K Bhaumik

Investigation of service failures and accidents is an area of utmost importance. Service failures and accidents lead to loss of machine time and production, and, above all, may cause loss of human life in extreme cases. Minimization of failures and prevention of accidents are challenges posed to the present day technologists. Unless a failure or an accident is investigated and the cause or causes made known, it is not possible to prevent its recurrence. Failure analysis and accident investigation therefore assumes great significance in modern society, particularly so in aviation and nuclear industries where high reliability and performance of the equipment is a matter of rule rather than exception.

The aftermath of an accident is devastating. The secondary damages to the aircraft structure or engine are so huge that the investigating team faces a daunting task to analyze the wreckage and identify the components or structures that need to be examined in greater detail to determine the cause of failure. The scenario

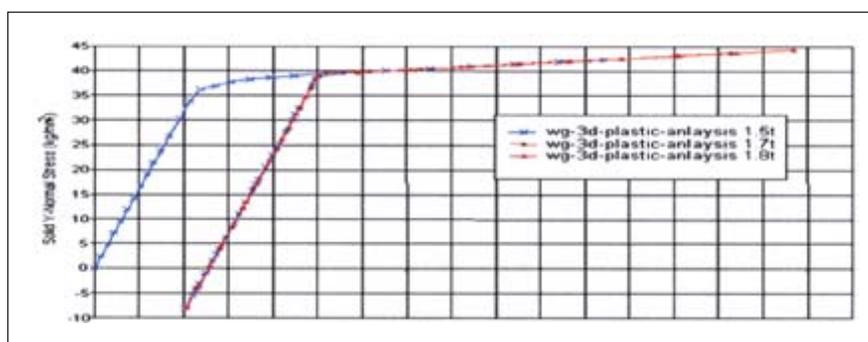
could become even more complex with pre or post accident fire. Such investigations require multidisciplinary teams and interactions with different organizations. NAL, with expertise from several related fields readily available below one roof, is therefore ideally suited for aircraft accident investigations.

NAL has been playing a leading role in failure analysis and accident investigation for more than three decades, and is now recognized as an independent centre of excellence in this area. NAL's Failure Analysis and Accident Investigation Group has rich experience in the field, having just completed 1000 investigations of service failures and accidents for a variety of industries in the public, private and defence sectors. A quarter of these have been major aircraft and industrial accidents. NAL's investigations have helped solve unique problems as well as recurring problems involving design modification, assessment of performance reliability or life estimation of critical components in various engineering systems or structures.



the SARAS fuselage. The total technical life evaluation (TTLE) of the MiG-21bis aircraft was completed in 2005-06. A life enhancement of 1000 flying hours is indicated based on the full scale fatigue test campaign. The Division has now started the TTLE programme of MiG-29, and is making good progress.

Structural analysis – static, dynamic and aeroelastic – for the SARAS aircraft is mostly undertaken at the Structures Division. The major SARAS-



↑ Figure 11 Elasto-plastic stress analysis of the high stress region in the SARAS aircraft wing.



↑ **Figure 12** NAL developed multi-purpose trolleys for HAL's Tejas Group.

related exercises in 2005-06 include design and rework for PT-1 and PT-2 versions, weight optimization of the SARAS fuselage, elasto-plastic analysis of the high stress region in the SARAS wing (*Figure 11*) and ground vibration tests of the SARAS empennage following certain structural modifications on the vertical tail of PT-1. Other R&D investigations included studies on the effective use of smart materials concepts and miniature systems in active vibration control and active flutter suppression in aircraft structures. The projects in mechanical design include the successful design of the 9m internal diameter air combat simulator dome and the design of equivalent CFRP parts to replace metallic SATCOM components.

The work on the development of sunshield mirrors for ISRO's INSAT-3D satellites has made considerable progress at the *Surface Engineering Division*. In other R&D projects involving surface modifications for the aerospace sector, the Division has developed a very promising pressure sensitive paint for wind tunnel applications and a process for internal taper chemical milling of the stabilizer spar tube for the Cheetah helicopter. For the energy sector, the Division is an active participant in the NMITLI project to develop solid oxide fuel cells. The Division's work on nano-layered multilayer coatings of transition metal nitrides is extremely

promising especially because such coatings offer better adhesion, higher toughness and higher chemical and thermal stability.

I have already talked of NAL's wind turbine development projects, led by the *Wind Energy Division*, and how NAL-designed 300kW blades are performing better than equivalent imported turbine blades. The crucial next step will be the development and installation of the proposed 500kW horizontal-axis NMITLI wind turbine. I am confident that NAL's inter-divisional teams will rise to this task and offer the country a technology that will prove to be extremely valuable in the years to come.

TECHNICAL SERVICES

The *Computer Support and Services Division* continued to offer useful technical and infrastructural support in the areas of networking, network security, PC maintenance, Internet and e-mail services. A "ready-reckoner" to calculate an employee's retirement benefits has been widely appreciated. The *Electrical Sections* on the Belur and Kodihalli campuses provided good technical support in the operation and maintenance of NAL's sub-stations, R&D facilities and air-conditioning services. The *Engineering Services Division* is still deeply involved in aircraft development programmes: for HAL, they successfully developed multipurpose trolleys for the Tejas wings (*Figure 12*). The Division has also recently fabricated an extruder of PVDF films for transducer applications.

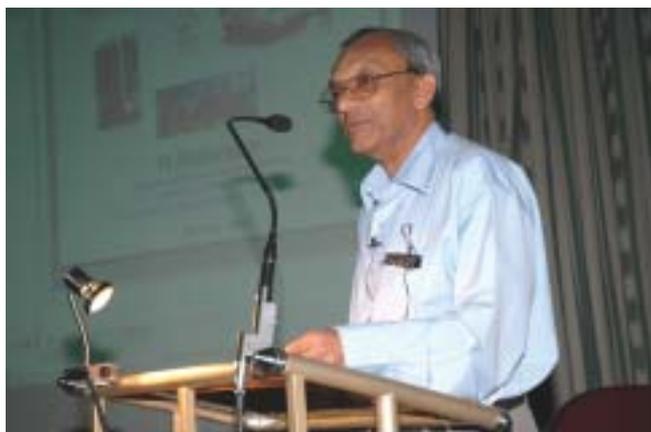
The *Information Centre for Aerospace Science and Technology (ICAST)* now offers a wider variety of web-based services: better access to e-journals and more single window links to find aerospace information. ICAST's digital library initiative is beginning to acquire greater momentum and the NAL institutional repository now has

more than a thousand records. The Arogya healthcare system developed by the *Information Management Division (IMD)* is now extensively used to keep track of the health of NAL employees and make online prescriptions. The Khoj software was successfully used in the recent recruitment and screening campaigns for Group III and Group IV positions. IMD is also helping CFRI, Dhanbad to set up their campus intranet. I am a little concerned, however, with the progress achieved so far with the new ERP implementation.

The *Project Management and Evaluation Division (PMED)* had another typically busy year: in particular, PMED is managing the CSIR-funded networked programmes exceedingly well. Once again PMED ensured that NAL had a truly impressive external cash flow in 2005-06. The *Technical Secretariat (TS)* continued to be in the thick of things: two license agreements and six MoU's were signed in 2005-06, one patent and three copyrights were granted. TS also facilitated NAL's participation in seven exhibitions and successfully achieved the difficult task of receiving over 75 batches of project students.

OTHER EVENTS

The nineteenth NAL Foundation Day lecture was delivered by Mr M Natarajan, SA to RM (*Figure 13*). Mr Natarajan's spoke on *Opportunities and challenges in defence programmes and projects* and identified future niche technologies in aerospace. Dr S Viswanath delivered the accompanying NAL Technology Lecture on *Trends in modelling and simulation of aerospace structures*. Prof P Balaram, Director, Indian Institute of Science, delivered the CSIR Foundation Day Lecture (*Figure 14*) on *Measuring and assessing science*, in which he voiced concern at the insidious stranglehold of the impact factor. In the accompanying NAL Business Lec-



↑ **Figure 13** Mr M Natarajan, SA to RM, delivering the nineteenth NAL Foundation Lecture at the SRValluri Auditorium on 23 July 2005. Mr Natarajan spoke on Opportunities and challenges in defence programmes and projects.



↑ **Figure 14** Prof P Balaram, Director, Indian Institute of Science and Editor, Current Science, delivered this year's CSIR Foundation Day Lecture on 26 September 2005 on Measuring and assessing science.

ture Mr M S Ramachandra spoke on *Current business strategies of NAL*.

NAL resumed its celebrations to mark the International Women's Day (IWD); this year's IWD Lecture was delivered by Dr Malini Subramanyam of Bangalore's Forensic Science Laboratory on *Scientific methods of criminal investigation*.

Prof Raghavendra Gadagkar's National Science Day lecture on *Units of Darwinian natural selection – when*

should players sacrifice themselves for the sake of the team? enthralled NAL colleagues, especially his account of the social behaviour of wasps (*Figure 15*). The National Technology Day Lecture by Dr B G Prakash of General Motors indicated that the automobile industry is now mostly about electronics.

It was disappointing that Dr Subhash Bharani IPS and ADGP, Karnataka, could not make it to deliver this year's Dr B R Ambedkar Birthday Lecture on

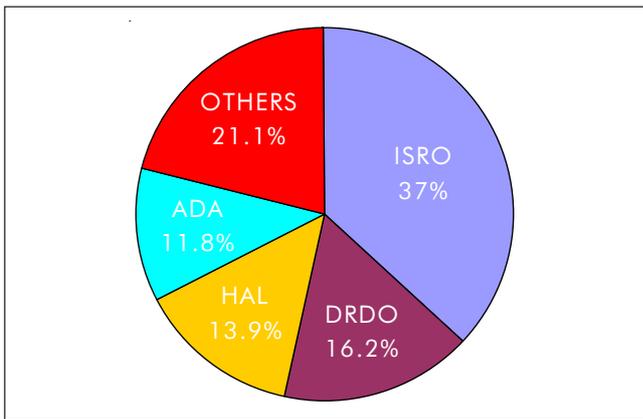
27 April 2006, but the gaiety and festivity that marks Dr Ambedkar's birthday celebrations at NAL remained undiminished (*Figure 16*).

As always, NAL hosted a number of very significant conferences and symposia: the Fourth ISSS International Conference on Smart Materials, Structures and Systems on 28-30 July 2005, the Indo-US Workshop on Micro Air Vehicles on 1-2 August 2005, the Eighth Annual CFD Symposium of AeSI on 11-13 August

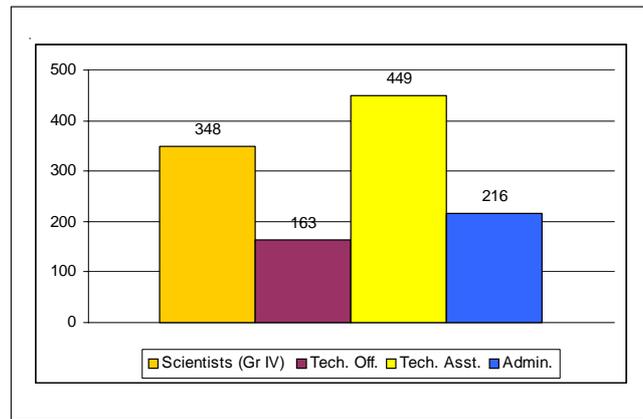
↓ **Figure 15** Prof R Gadagkar in the course of his National Science Day Lecture on Units of Darwinian natural selection – when should players sacrifice themselves for the sake of the team? on 28 February 2006.

↓ **Figure 16** The Dr B R Ambedkar birthday celebrations were marked with traditional gaiety and festivity.





↑ Figure 17 A chart showing the break-up of NAL's 2005-06 external cash flow of Rs 30.36 cr. ISRO (37%) and DRDO (16.2%) were the two biggest contributors. NAL also earned about Rs 0.5 cr from its foreign sponsors.



↑ Figure 18 The break-up of NAL's staff strength of 1176. R&D scientists make up 30% of this total. NAL's staff strength has depleted by about 50 in the last year, but over 80 new positions will soon be filled up to restore the balance.

2005, the National Symposium on Acoustics on 15-16 December 2005 and the first ever Karnataka Science Congress on 15-17 September 2005 (Box 6).

In 2005-06, NAL received an unusually large number of visitors and visiting delegations from foreign aerospace companies, R&D institutions, universities and academies wishing to collaborate with us on R&D projects and contracts. I believe that this is a pointer of the shape of things to come: aerospace is getting increasingly global; so there will be more international competition, there will be more public-private partnerships. We must quickly adapt to this changing scenario and evolve strategies to win in these new technological playing fields.

STATISTICAL SUMMARY

57 new sponsored projects (total value: Rs 14.34 cr) and 17 new grant-in-aid projects (Rs 7.17 cr) were taken up during 2005-06.

Our external cash flow this year was Rs 30.36 cr; as always, NAL continues to be among the largest ECF earners in CSIR establishments.

6 | Karnataka Science Congress | Dr M R Nayak

The first ever Karnataka Science Congress, organized in association with Swadeshi Vijnana Andolana (Karnataka), opened at NAL on 15 September 2005, the birthday of Sir M Visvesvaraya, and attracted over 250 delegates.

The three-day meeting featured over 100 research papers on themes like aerospace science, computer and mathematical sciences, biological science, energy, medical and pharmaceutical sciences, agricultural science, technology and general science, spread over 21 sessions.

Mr Basavaraja Horatti, Karnataka's Minister for S&T, was the chief guest. Dr V K Aatre, the former SA to RM, delivered the keynote address and Dr M S Thimmappa, Vice Chancellor, Bangalore University, made the presidential remarks.

The Science Congress honoured the following eminent scientists from Karnataka with the Sir M Visvesvaraya Vijnana Puraskara: Dr V K Aatre, Prof U R Rao, Prof S K Ramachandra Rao, Prof R Narasimha, Prof C N R Rao and Mr N R Narayana Murthy.



The major ECF contributors were ADA (Rs 3.57 cr; 11.8%), ISRO (Rs 11.24 cr; 37.0%), DRDO (Rs 4.91 cr; 16.2%) and HAL (Rs 4.22 cr; 13.9%). About 1-2% of the cash flow in 2005-06 came from international sources such as Pratt & Whitney and Boeing (*Figure 17*).

The CSIR annual grant for 2005-06 was 50.36 cr. From this, Rs 29.10 cr (58%) was spent on salaries and allowances. NAL received a further grant of Rs 70.48 cr for CSIR's "networked projects".

The NAL staff strength is currently 1176. This includes 348 scientists, 163 technical officers, 449 technical assistants and supporting personnel and 216 officers and staff from the administrative cadre (*Figure 18*). 123 scientists and staff members were promoted to higher

grades during the year and 59 NAL colleagues retired from service in 2005-06.

HONOURS

It is finally a pleasure to mention the many awards and laurels won by my colleagues in 2005-2006. The Advanced Composites Division received the 2005 CSIR Prize for Engineering Technology for their development of innovative techniques in composite aircraft development. Dr K Yegna Narayan and Dr R M V G K Rao were both elected Fellows of the Indian National Academy of Engineering. Dr R M V G K Rao was also invited to join the editorial board of the Journal of Reinforced Plastics and Composites. Dr Sekhar Majumdar was invited to be a member of the Asian Fluid Mechanics Committee. Dr P R Viswanath was elected Fellow of

the Society for Shock Wave Research. Mr Kotresh M Gaddikeri received the "Swarna Jayanthi" award 2005 of the Aeronautical Society of India, while Dr R Mukund was awarded the 2006 Raman Research Fellowship to work in DLR, Germany. Mr J Dhayanidhi too was in Germany on a DAAD Fellowship. Dr G K Suryanarayana was invited to be an Honorary DAAD Advisor (2006-09) and Dr Lalitha Chattopadhyay figures in the 2006-07 edition of Marquis Who's Who in Science and Engineering. I congratulate all of them. I was personally happy to receive the 2006 IIT Kharagpur Distinguished Alumnus Award and be invited to be a Member of the Board of Governors of the Engineering Council of India.

Dr A R Upadhya
Director