NAL's Annual Report 1997-98

A quick round-up of last year's highlights and R&D events

It gives me great pleasure to present the annual report for the year 1997-98.

Highlights

Before the HANSA take-off

The success of HANSA-3II was a major milestone because NAL teams had succeeded in reducing the aircraft's all-up weight by about 100 kg; and thereby ensuring that it could be certified under the JAR-VLA umbrella.

On 11 May 1998, the second prototype of the HANSA-3 had its inaugural flight. The aircraft was flagged off by Dr Murli Manohar Joshi, Union Minister for Human Resource Development and Science and Technology. Mr Ananth Kumar, Union Minister of Civil Aviation was also present to witness the inaugural flight. It was a special moment for NAL and CSIR, and I was happy that our Director-General, Dr R A Mashelkar, and Directors of 40 other CSIR establishments,who had assembled at NAL for the CSIR Directors' Conference, were present to share our joy at this success. The flight of HANSA-3II marked a major milestone in the HANSA programme because NAL teams, after many months of assiduous work, had succeeded in reducing the aircraft's all-up weight by about 100 kg; and thereby ensured that HANSA could be certified under the JAR-VLA umbrella.

HANSA-3II ready for its inaugural flight

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With the 2-seater HANSA programme now in its last phase, the focus will start shifting to the HANSA stretched version, where preliminary studies have commenced, and the more ambitious SARAS multirole light transport aircraft programme. I am happy to report that the Technology Development Board (TDB) of the Government of India has agreed to support the SARAS development project. I am equally delighted to report that NAL has now formalised partnerships with Hindustan Aeronautics Limited (HAL), Taneja Aerospace & Aviation Limited (TAAL), Kumaran Industries Private Limited (KIPL), Central Mechanical Engineering Research Institute (CMERI), Structural Engineering Research Centre, Chennai (SERC-C) and Aircraft System Test Establishment (ASTE) for the joint development of SARAS. These synergistic partnerships should result in the development of a truly outstanding aircraft. The detail design of SARAS is now drawing to a close, and we are gearing up for 18 months of intense SARAS-related activity.

A few weeks ago, NAL began the process of transferring the technology for the development of carbon fibre prepregs to IPCL, Vadodara. Initial studies on the prepreg performance are most encouraging. I believe that this technology, developed with support from ADA and TIFAC, could prove to be very valuable for India's future composite aircraft programmes.

In the Divisions

In view of NAL's growing involvement in the area of advanced composites, an independent *Advanced Composites Unit* was created this year. While LCA-related projects will largely engage the Unit's attention, there is also a significant work component related to non-destructive evaluation and the use of repair technologies. The Unit is now involved in the development of LCA centre fuselage components and has successfully completed the static testing, including functional tests, on the LCA fin and rudder.

The *Aerospace Electronics and Systems Division* is increasing its involvement in the SARAS programme notably in the area of avionics. The system integrator for the proposed SARAS avionics system has been identified and the architecture for the electrical system has been finalised. Negotiations are now in progress for the fabrication of the master box and test rig. The work started last year in the area of active noise control is progressing well and the duct for conducting experiments will soon be ready. The Division has initiated new activity on global positioning system-based navigation techniques. The Division's Computational Electromagnetics Group concentrated primarily in the areas of radomes, aircraft antennas, and its effort to set up an experimental microwaves facility has progressed well.

I have already discussed the HANSA and SARAS programmes and the role of the *Centre for Civil Aircraft Design and Development (C-CADD)* in this activity. The Centre was involved in a concerted effort to reduce the structural weight of HANSA-3II, which was achieved by a judicious use of different thicknesses of foam and glass cloth and the lighter Rotax engine. The Centre is also leading the SARAS detail design effort and has made significant progress in the detail design of the wing, fuselage and empennage. The CATIA facility at the Raj Mahindra CAD facility is being extensively used in this exercise.

The major emphasis in the *Computational and Theoretical Fluid Dynamics Division* was in the development of advanced CFD codes for predictions in real-life applications. Some of the ongoing projects being handled by the Division include a new design information system for DRDL, work on torpedoes with stern appendages and highly skewed marine propellers for NSTL, code development for VSSC's satellite launch vehicles and the development of Doppler weather radomes for ISRO. The Division has also initiated computations on flow through a turbine cascade using a 3D RANS code, in association with Propulsion Division.

The *Experimental Aerodynamics Division* continued its involvement in the areas of drag reduction technology, turbulent and separated flows, development of test techniques and aircraft and other flight vehicle aerodynamics. In the context of the SARAS programme, a review was undertaken to study active and passive devices for induced drag reduction; the study revealed that while many devices do offer induced drag reduction of engineering value, their application to design must take into account other factors like device drag, weight penalty and other structural implications. Among other projects, the Division prepared a report for the Karnataka State Road Transport Corporation on aspects of drag reduction employing passive shaping techniques. Initial studies point to the possibility of significant fuel savings especially on inter-state transport. The contract research project on relaminarisation on swept wings for the Boeing Airplane Company was reviewed and plans for 1998 were finalised.

The activities of the *Flight Experiments Division* have been reoriented to focus on aircraft maintenance and operation, flight testing and flight research and prototype development and integration of HANSA. The Division played the pivotal role in the integration and testing of HANSA-2II, notably in the exercise to integrate the new Rotax engine with the HANSA aircraft.

The major effort of the *Flight Mechanics and Control Division* continued to be oriented towards the LCA project. The LCA TD-1 control law design phase has been successfully completed. The testing of the flight control laws for the initial flights of LCA TD-1, with a wide range of coverage for nominal and failure conditions, with and without tolerances, is now on. The Division also has the responsibility to undertake the flight data analysis of the LCA TD-1 and estimate the aircraft's stability and control characteristics. The Division's stabilised output error method (SOEM) parameter identification algorithm is expected to play a major role in this exercise. The engineer-in-the-loop realtime simulator continued to provide valuable support to the LCA control law development; the simulator has now been upgraded with a powerful graphics computer to improve the visual texture of the display.

The *Flosolver Unit* achieved good success in the development of a high-speed communication interface for SuperSolver; this interface is expected to significantly improve the scalability of the parallel computer. The Unit continued its studies on weather prediction codes with special reference to the T-80 GCM code. One interesting finding was that parallelising only the physical domain latitude loops results in poor efficiencies when the number of processors exceeds four. To get higher efficiencies it appears necessary to parallelise the linear calculations also in the spectral domain. The Unit completed its project to parallelise a molecular dynamics code for Hitachi, Japan and has now obtained a second parallelisation contract from Hitachi.

The *FRP Pilot Plant*, which will now function as an independent unit, was very busy with the fabrication activity related to the HANSA-3I1; the Unit's room temperature vacuum bag moulding technology was used to fabricate the fuselage, wing and control surfaces of the HANSA. The Pilot Plant is also involved in the development of the 12.8 diameter sandwich radome for ISRO.

I have already mentioned the successful development and transfer of the carbon fibre prepreg technology by the *Materials Science Division*. The Division carried out several improvements on its automatic visual range assessor (AVRA) unit and also introduced enhancements in its innovative optical approach slope detector system (OASIS). A PC-based data acquisition system has been developed for the Inter University Consortium, Indore, for the thermo-physical characterisation of materials up to 1000 deg C. The Division also developed a novel method for producing shaped castings from metals and alloys. One of the significant investigations of the *Surface Engineering Unit* relates to the development of pressure sensitive paint which could be used to measure surface pressure on airfoils in wind tunnel studies. A very promising compound for this exercise has been identified after studying the oxygen quenching efficiency of fluorescence of several candidate compounds.

PC-based data acquisition system for thermo-physical studies

High accuracy, control and stability are the characteristics of this system delivered to Inter-University Consortium, Indore.

The focus of activity at the National *Trisonic Aerodynamic Facilities* continued to be aerodynamic data generation in the 1.2m trisonic wind tunnel for various national aerospace programmes; 1148 blowdowns were conducted in 1997-98. The emphasis of tests for ADA was on aerodynamic performance enhancement of combat aircraft configurations using leading edge manipulators such as LEVCON and vortex plates. Among the tests for VSSC was the time-march test done on a multi-booster launch vehicle configuration to determine the trajectories of boosters separating from a core vehicle using the semi-captive trajectory technique concept developed at NAL Tests were also undertaken for DRDL and, in a limited test for ADRDE, the performance of a special type of parachute, used for stabilisation of the pilot's ejection seat in a military aircraft, was studied.

Supersonic combustor development

If truly low cost space launch operations are to be achieved, launch vehicles which are fully reusable must eventually be developed.

The *Propulsion Division* achieved good progress in all its ongoing projects, especially those related to the Kaveri engine and the LCA. The collaborative project, with CAE, China, to design and develop an advanced fan stage with a 2:1 pressure ratio is progressing smoothly. The Division has also begun a series of projects on high Mach number cooled turbine cascade testing for Pratt & Whitney, USA. Other projects are in the area of supersonic combustor development, and the testing of the compressor and combustor for the low cost gas turbine; the compressor performance was mapped up to 87% of the design speed. And, in what was probably a world first, the Division successfully test flew a single seater powered hang glider fitted with a specially modified and air cooled Wankel rotary engine.

The *Structural Integrity Division* executed several sponsored projects during 1997-98 including the analysis and testing for lug damage tolerance studies for Boeing Airplane Company. The chief objective of the Boeing study was to establish correlations between analytically predicted stress intensity factors and fatigue crack growth rates with increasing crack length in a pin loaded lug specimen. For ADA, the Division continued its activity relating to the testing and certification of composite features and components. The Division was also involved in the mechanical property characterisation of the carbon and glass fibre composites employed in the HANSA development.

The activities of the *Structures Division* have now been re-oriented with the creation of groups for structural analysis and design, structural dynamics, mechanical design and advanced research. The Division played an active role in the HANSA and SARAS development programmes, notably stress analysis and structural analysis of the SARAS wing, rear fuselage and control surfaces and weight reduction and other structural changes in HANSA-3II. In a major initiative, the Division improved the frequency resolution of the shake test system, handed over to HAL a few years ago for ALH testing, by an order of magnitude across all the frequency ranges. This was achieved by developing new hardware involving a PC, a digital signal processor and other associated hardware and software. The Division also continued to support mechanical design activity related to the 4m x 8m autoclave and wind tunnel models and continued its basic research in field-consistent and higher order elements.

The *Wind Energy Group* continued its work in the area of wind resource assessment and wind energy studies at Antarctica. Two innovative ideas for future wind machine installations have now been successfully tested at India's Maitri Station in Antarctica.

Technical Services

The first phase of NAL's proposed campus-wide network became operational. Good network connectivity has now been established within the Belur and Kodihalli campuses. The *Computer Support and Services Division* played a major role in this project. In the years to come, I see this Division playing a major role in managing our computer networks. The *Engineering Services Division* was almost entirely occupied with the fabrication, quality control and assembly of non-FRP structural components of the HANSA-3II, and the mechanical, electrical and civil works related to the development of the 4m x 8m autoclave for HAL. The newly reorganised *Estates and Buildings Unit* was busy managing NAL's civil construction activity. The Unit has played a central role in civil work related to the LCA wing/fuselage development programme and the construction of a new aircraft hangar at the Nilakantan Wind Tunnel Centre. The *Information Centre for Aerospace Science and Technology (ICAST)* is currently in the middle of a major programme involving library automation and bar coding. Information about most of the library books has now been automated. The *Information Services & Systems Section* has successfully set up the campus intranet and created NAL's Web site on the Internet. The *Project Monitoring and Evaluation Section* continued its good work and played the pivotal role in ensuring that the Laboratories' external cash flow stayed above the Rs 30 crore mark. The *Technical Secretariat* successfully negotiated 15 business develop agreements and continued to manage our training and student programmes very effectively.

Other Events

This year's NAL Foundation Day function, held on 18 July 1997, was special. At a simple ceremony graced by Prof Y K Alagh, who was then also the Union Minister of State for Science and Technology, the Wind Tunnel Centre was renamed the Nilakantan Wind Tunnel Centre in honour of NAL's first Director. Prof Alagh later delivered the 11th NAL Foundation Day Lecture. In a thoughtful lecture Prof Alagh discussed different models for sustainable R&D development. To commemorate 50 years of Indian Independence, NAL also honoured Prof S Dhawan, Prof U R Rao and its four former Directors: Dr P Nilakantan, Dr S R Valluri, Prof R Narasimha and Dr K N Raju.

The CSIR Foundation Day Lecture was delivered by Dr M Rammohan Rao, Director, Indian Institute of Management, Bangalore. Dr Rao delivered an illuminating lecture on *R&D Management in the Indian Context: Prospects and Challenges*. The 1998 National Science Day Lecture was delivered by Prof N Mukunda of the Indian Institute of Science on *Development of Modern Physics*. Prof Mukunda's superlative lecture summarised a decade of developments in modern physics. The Fifth Dr B R Ambedkar Lecture was delivered by Mr I R Perumal, Managing Director, Karnataka State SC/ST Development Corporation on *Fifty Years of Independence - Where We Stand*. The lecture was powerful, occasionally anguished and replete with the poet's sentiment.

As usual, NAL also hosted several national and international meetings; in particular the 7th NASAS with the theme "recent advances in structural dynamics and aeroelasticity". The meeting also provided the platform to pay a well-deserved tribute to Dr B R Somashekar on the eve of his retirement. Other major events were the the 4th NAL-CAE Workshop on Advanced Gas Turbine Technologies, the 11th AGM of ISAMPE, a National Seminar on Free Flight, the WIPO-CSIR Roving Workshop on Patents, The Indo-German Round Table meeting to discuss new collaborations in materials and composites, and the

International Workshop on Surface Engineering and Coatings held only a few weeks ago.

Statistical Summary

NAL's staff strength as on 30 June 1998 was 1266. This includes 501 scientists (Group IV: 330; Group III: 171), 522 technical support staff and 243 administrative staff. 68 new sponsored projects were taken up during 1997-98. Our external cash flow this year was Rs 3041 lakhs; about 64.4% came from ADA (34.4% for the CFC Wing project, and 30% for other LCA-related projects). The ADA component is now beginning to taper off, but it is heartening to note that the Laboratories' earnings have not suffered significantly; indeed, NAL once again recorded the largest external earnings among all CSIR establishments.

NAL actually spent Rs 3309 lakhs during 1997-98 on inhouse programmes (up 10.3% from the previous year), of which salaries accounted for nearly 51%, following the implementation of the Fifth Pay Commission. Barely 8% of the CSIR grant was available for capital expenditure, although a matching amount was available under CSIR's modernisation programme. However, the long-term scenario is a cause for concern; we must evolve new mechanisms to supplement our R&D income. I am discussing certain proposals in this regard with CSIR and our Research Council.

Honours

It is finally a pleasure to mention the distinctions won by my colleagues in the Laboratories. *Dr Indira Rajagopal* received the FICCI Award for her contributions to surface engineering and physical sciences, *Dr B K Parida*, *Dr M Krishna Murthy and Dr M V A Murthy* were elected Fellows of the Aeronautical Society of India, Dr Girija G and Dr J R Raol's paper on parameter identification of unstable systems won a certificate of merit from the Institution of Engineers (India), Mr M S Rameshaiah received the "Vijay Shree" award from the Government of India and Mr H N Ranganatha was the joint recipient of ISAMPE's 1997 Vijay Zaveri Award for Best Technician. I congratulate all my colleagues for their excellent contributions to aerospace science and technology.

NAL received the third prize from the Town Official Language Implementation Committee (TOLIC) for its efforts to promote the use of Hindi as the national language. I was also delighted to learn that NAL had again won the Bangalore Urban Art Commission Trophy for the "best maintained gardens" in the city.

Dr T S Prahlad, *Director*