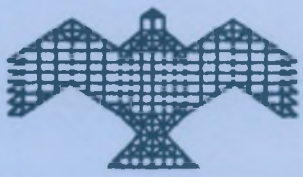

NIAS

w o r k i n g
p a p e r

Can it be Boom-Time for Indian Aerospace?

RODDAM NARASIMHA

NATIONAL INSTITUTE OF ADVANCED STUDIES

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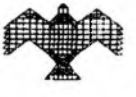
NIAS WORKING PAPER WP1 - 2003



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Not long ago, *Aerospace America*, a respected magazine published by the American Institute of Aeronautics and Astronautics, noted in a review of Asian aerospace that 'India is emerging as the region's most powerful aircraft manufacturing nation'. Surprised? So was the magazine, for it went on to say: 'This is curious, because South Korea, China, Taiwan and Japan would seem to have pursued the most practical course for developing their aerospace industries. . . India's policy of independence and non-alignment has meant that its aerospace companies have some of the fastest growing technology centres in Asia'. Another foreign review, this time of the Indian space programme, pointed out that 'India can reliably and inexpensively launch its own

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This is a summary of an invited lecture delivered on the occasion of Aero India 2003 at the International Seminar on *Aerospace Technologies: Developments and Strategies*, held on 6 February 2003 at Bangalore.

remote sensing satellites, among the world's most sophisticated'. The widely read US weekly, *Aviation Week and Space Technology*, lauded India for running its successful space programme 'on a shoe-string budget'. The former Chief Administrator of NASA, Dan Goldin, had often said (before the Pokhran II tests) that the US and India were natural partners in space. And many others have said similar things about other Indian aerospace programmes.

So, has India arrived on the global aerospace scene? Not quite yet, I am afraid, but few realize how close we are. Watching the fourth air show held so professionally earlier this month in Bangalore, and the visibly increasing presence of Indian aerospace products there and elsewhere, one cannot avoid the thought that Indian aerospace is now far more mature than many think.

But have not our aircraft programmes been victims of huge time and cost overruns? Didn't the LCA take nearly twenty years after approval before it could fly? Yes and yes; but the point is that we in fact have got *more* than the LCA out of those overruns – namely, a solid foundation on which to build a whole aeronautical enterprise in the country.

Consider these facts. Hindustan Aeronautics Limited (HAL) has produced a total of 23 types of aircraft, of which 11 are Indian designs, the most recent being the Advanced Light Helicopter *Dhruv*. Apart from the LCA, spear-headed by the Aeronautical Development Agency (ADA), two more aircraft are under development: the *Saras*

at the National Aerospace Laboratories (NAL), the country's first civil transport aircraft, which rolled out on 4 February, and the Intermediate Jet Trainer HJT-36 of HAL, due to fly shortly. Two more are under design (the Light Combat Helicopter (LCH) and a 100-seater transport). Limited series production of the all-composite trainer *Hansa* of NAL is on hand. Two unmanned air vehicles, *Nishant* and *Lakshya*, designed by the Aeronatuical Development Establishment (ADE), are also in limited series production. ISRO has tested four satellite launch vehicles, of which the PSLV has graduated to a reliable work horse. The GSLV, after its first successful flight test, is on its way to achieving operational status. A total of 35 Indian satellites have been launched, of which 16 are from Indian launch vehicles; four more satellites have been launched from India for foreign customers. The *Prithvi* missile is operational and six others are under various stages of development, including *Agni* and *Brahmos*. The *Kaveri* engine, with a unique flat rated performance, is in its final stages of development.

The *breadth* of this programme would be remarkable almost anywhere in the world. China has bigger missiles and launch vehicles, Brazil has a more vigorous civil aircraft industry, the Israelis have some fancy technologies, but none of these covers as broad a spectrum as India does.

Consider these other facts as well. The Indian economy (– an 'oasis of stability', according to the same

AIAA report) has been growing at around 6% for nearly a decade; it is now something like the fourteenth largest in the world, and the fourth largest if we account for Purchase Power Parity (PPP). The Indian defence budget amounts to $13 B; our defence R&D budget is about the eighth largest in the world, sixth largest in PPP. The turnover of HAL is now approximately $555 M and growing rapidly. The budget for the Indian Space Research Organization (ISRO) during 2002-03 was approximately $450 M, up 18% over the previous year. During April-December 2002 domestic air traffic went up by 8.2% at a time when elsewhere in the world the traffic was going down. For the first time in almost a decade the national expenditure on R&D this year went up as a fraction of the GNP – albeit the increase was only 0.01%.

Of the aircraft made in India, *Dhruv* deserves special mention. This multi-role, multi-mission medium range helicopter, with a seating capacity of up to 14 passengers apart from the 2 crew, has no rival in its class from anywhere else in the world just now. It has been flying for a decade, and its users have sung loud praises of it. Curiously, however, the order book for the *Dhruv* stands right now at a doubtful 30. One is entitled to wonder whether a zero is not missing from this number: why is it not more like 300?

The LCA, state of the art in many ways and likely to be the most affordable high performance supersonic fighter in the world when it gets into production, has now

completed something like 50 test flights. Its projected fly-away cost is Rs.85 crores, less than $17 M (as against $ 30 M for the Swedish Gripen, the most nearly comparable aircraft in the world today). It has a limited series production order for 8. It has been criticised (with justification) for having taken a long, long time in development, but the fact is that even in 2003 it promises to be an aircraft to reckon with by any standards; indeed, I believe it has the potential to become a real winner.

The multi-mission UAV *Nishant* and the pilot-less target *Lakshya* are both flying and under limited series production. The trainer *Hansa* made by NAL has been fully certified by DGCA under FAR-23; four have been supplied and orders for 11 are in the pipeline. The Air Force has already expressed interest in acquiring six of the NAL *Saras* aircraft. HAL's intermediate jet trainer HJT 36 is projected to enter service as early as 2005; a production run of 225 aircraft is expected. It is to be hoped that it will turn out to be a worthy successor to that most successful Indian aircraft ever made, namely the HJT-16 *Kiran* (which saw a production run of nearly 300).

The big catch in all this, however, is that Indian aeronautical programmes have usually taken very much longer than projected; they have for that reason often been severely criticised by prospective users and the media. These delays have been occasioned by such diverse factors as US sanctions and slow decision-making, but primarily by the hard slog demanded by the harsh realities

of indigenous technology development. But the net result of this long drawn-out process has been that we find ourselves now with an unusually sound base of research, development, design and manufacture in the country. Indian capabilities, like Indian products, are now spread across the board. Such advanced technologies as the use of carbon fibre composites, modern control system analysis and design, computational fluid dynamics, CAD-CAM techniques, radar technologies, mission computers and many others have now been mastered by one or more laboratories in the country. India makes some of the largest solid boosters in the world, uses liquid propulsion systems extensively and is on the threshold of making its own cryo rockets.

All of this development has cost India a great deal less than it would have elsewhere in the world. Dr K Kasturirangan, Chairman of ISRO, estimated that advanced technology products that need high man-power inputs can be made in India at 60-70% of the global price. Experience with both aircraft and space systems bear out these figures. India therefore has a considerable economic advantage now in aerospace.

This is why the question to ask now is whether Indian aerospace is all set for a boom. Almost all the ingredients needed for it are now in place, but it will not happen unless it is pursued with determination. The temptation to draw a false analogy with the IT boom will have to be resisted. For the IT boom occurred without the benefit

(or, as many would say, the death-kiss) of Government planning. IT is highly diversified, is driven by civilian commerce and has prospered on software business start-ups that needed little initial investment. Aerospace on the other hand will not witness a boom without the will of the State. It requires huge resources, both hardware and software are crucial, civilian and military applications will benefit from synergy and there is little technology in the private, commercial sector. IT and aerospace therefore will need very different State policies. The main point therefore is that the aerospace boom will not occur if the right policies are not in place.

Ten – perhaps even five – years ago Indian aerospace was technology limited, now it will be policy limited.

So what must be done to make that boom happen, assuming the country wants it? The first and most important decision will have to be about the ALH and the LCA. If India is to track a rising trajectory in aerospace, we will have to make these two products in large numbers – at least 200, preferably 300. Here, I believe, are the first test-cases for national will, imagination and ambition in aerospace technology. If we don't seize the opportunity provided by the present cusp, the energy and enthusiasm of the various 'national teams' built during the last two decades will cool down, the experts will seek greener pastures elsewhere, and we will slide back to the pessimism of the seventies (triggered at that time by a loss of nerve following the tragic crash of the reheat

version of the HF 24). On the other hand, if today the Government were to announce that it intends to acquire a total of 300 *Dhruvs* (say for all the three Services combined and for other public sector units), the effect on the Indian aerospace industry will be electrifying, the boom will be safely on its way. (If we can announce large orders for foreign products, why not for Indian ones?) A similar decision on the LCA would be needed soon after its performance parameters are clearly known and its flight envelope is more extensively explored. This will have to be followed immediately by a policy that ensures that derivatives are built out of these products: *that* will be the real pay-off. In fact, in a small way, we have already started reaping the benefits of that twenty-year investment in aerospace RD&D that I mentioned earlier, for look how rapidly the *Saras* and the IJT projects are now progressing. They are being rolled out in the order of two years after funding – precisely because of that solid foundation laid over the last twenty years.

Finances do not seem to be a major problem, as HAL can raise money on the market, and Defence keeps returning part of its allocations to the exchequer. Procurement decisions *are* a major problem, and some drastic revamp would seem necessary here. A smart decision-making system will go a long way towards pushing that boom.

But R&D and industry also have to learn to tackle their problems. As the national learning phase concludes,

they have to be able to define projects with development times of the order of five to eight years, instead of the 20-year durations that have become the norm. Such time-frames require a totally different kind of decision-making process, and in particular would have to involve private enterprise within India and, in some cases, abroad. International collaboration may now well be the way to go in some projects for two reasons. First, because of the Indian strengths mentioned above we need not always be junior partners any longer in such ventures. But the other important reason is that Indian aerospace products now have no global brand equity, and the best way to acquire it quickly, especially in the highly sensitive aerospace market, is to team with companies which already have it and so can reassure a naturally skeptical global customer. Furthermore, selling abroad is a complex business: better technology is necessary but not sufficient, and financial arrangements, product support mechanisms, market presence are all factors that can have a decisive influence on eventual success: the private sector should be able to do that better.

All of this argues for more 'Indo-X' products, where X can be a suitable brand owner from elsewhere in the world, especially where export is a serious possibility. From this point of view the *Brahmos* cruise missile, and the agreement that has been signed between HAL and Israel Aircraft Industries regarding new avionics for the ALH and marketing help abroad, seem to be the right direction to pursue.

The other major thing that is required before the aerospace boom can occur is a total transformation of the civil aviation system in the country. The major national airlines and airports will have to be privatized. Suitable changes in the regulatory regime should make entry conditions simpler for new operators. An independent safety board will have to be set up, special regimes for remote areas like the North East and Jammu & Kashmir will have to be made. Air travel tax may have to be abolished. The establishment of low-fare airlines will have to be encouraged: Ryanair, buzz and others in Western Europe and USA have shown how, by marrying aviation with IT, air transport can be transformed – with benefits to both airline and passenger; for while passengers can now fly for a fare that is sometimes less than what a cup of tea costs on board (remember, there are no frills on those services), the low-fare airlines are making money as the big ones totter.

To summarise, therefore, if the boom has to occur, Government, industry and R&D have to pursue new policies soon on issues like design, development and delivery to time, collaboration with suitable companies here and abroad, entry into export markets and a new civil aviation regime. Connectivity by both aviation and IT, especially with the more poorly connected parts of the country, should be enhanced. A National Task Force may have to be set up to look into the future of Indian aerospace as a whole, involving representatives from R&D,

public and private industry, airline operators and military users, management schools, academia and government.

I believe India is all set for an aerospace boom as everything needed is present, except a wider appreciation of the broad-spectrum capability the country has built up and of the special window of opportunity we now have, and the will of the State and the technological community.

I am grateful to several of my friends and colleagues who have provided me with much valuable information, in particular to Mr N R Mohanty, Chairman, HAL,Dr C G Krishnadas Nair, President, SIATI, Dr S C Kaushal, Director and Dr S Kishore Kumar, Scientist, GTRE, Dr M D Aravamudan, Director, ADE, Dr K Y Narayan and Dr Satish Chandra, Scientists, NAL, Mr S K Chari, my colleague at NIAS, and Dr V Siddhartha, DRDO. The opinions expressed here are, however, my own.

International Seminar, Aero India-2003

Aerospace Technologies: Developments and Strategies

Is Indian Aerospace all set for a Boom?

RODDAM NARASIMHA
National Institute of Advanced Studies
6 February 2003

OUTLINE

- A Survey (Why a Boom seems possible)
- A Summing up (Why it wont occur by itself)
- The Way Forward (How it may be made to happen)

ARE WE SET FOR A BOOM?

Consider these facts:

- Economy growing at a steady ~ 6% for nearly a decade
  about 12th largest in world
  (4th largest in PPP)
- Defence budget 2002-03: Rs.65,000 cr, approx. $13 B
- Indian Defence R&D budget
  8th largest in $
  6th largest in PPP
- ISRO budget 2002-03: Rs.2300 cr, approx. $450 M up 18% over previous year

ARE WE SET FOR A BOOM? (Contd.)

- HAL turnover Rs 2775 cr. approx. $ 555 M. in 2001-02, up 12% over previous year
- Domestic air traffic up 8.2% April - Dec. 2002
- For the first time in almost a decade, the national expenditure on R&D as % GNP went up (although only by 0.01%)
- Effective synergies built up between industry, R&D, academia

WHY AEROSPACE IS *NOT* LIKE IT

- The IT boom occurred without the benefit of Government planning (or ***because*** of no State planning?)
- An aerospace (AS) boom will not occur without the State's will, carefully directed
- IT is highly diversified, software start-ups need little money, civilian commerce has been driver
- AS requires huge resources, both hardware and software are crucial, civilian and military applications benefit from synergy
- **IT and AS need different State polices**

INDIAN AEROSPACE

Products now cover a broad spectrum

Aircraft: 23 types produced (of which 11 Indian designs) at HAL
+ 1 at NAL
+ 2 under development (Saras at NAL, IJT at HAL)
+ 2 under design (LCH, 100-seater transport) at HAL

UAVs: 2 in limited series production (ADE)

Space 4 launchers designed, tested, of which
1 operational (PSLV),
1 flight tested, on way towards operational status (GSLV)

INDIAN AEROSPACE (Contd.)

Space: 35 satellites launched, of which
- 16 are Indian launches
- 23 are in orbit
- 14 are geostationary

+ 4 satellites launched in India for foreign customers

Missiles: 1 operational
6 under various stages of development

DHRUV (Advanced Light Helicopter)



- Multirole, multi-mission, medium-weight class
- Max Take-off Weight : ~ 550 kg
- Cruise speed : 245 km/h
- Range (20 min. reserve) 800 km
- Endurance (20 min. reserve) : 4h
- Cabin volume : 7.33 m^3
- Seating capacity : 14 (max) + 2 crew

Features:
- Hingeless main rotor
- Advanced cockpit
- Turn engines (with FADEC)
- Bearing-less tail rotor
- Extensive use of composites
- **Order for 30?**

LCA (Light Combat Aircraft)



- Light weight, multi-role, affordable supersonic fighter
- Extensive use (45%) of composites (including wings and sections of the fuselage)
- Unstable configuration, with digital fly-by-wire control system
- Glass cockpit
- Advanced avionics, multi-mode radar
- Powered by GE404, to be replaced by Kaveri
- ~50 test flights completed
- **Projected fly-away cost**
  Rs. 85 cr. (< $20 M)
- **LSP order for 8**
- **Initial Operational Clearance in 2007?**
- **Induction into service by 2010?**

NISHANT (Multi-Mission UAV)

- Autonomous flight capability
- Multi-mission steerable payload
- Recovery by parachute, landing bags
- Max speed 185 km/h
- Service ceiling 3600 m
- Endurance : 4h 30 m
- Command range : 160 km, Payload data link 100 km
- **LSP has started, orders for 15?**

Features

- Day / night battle-field reconnaissance
- Mobile launcher, Ground Control Station

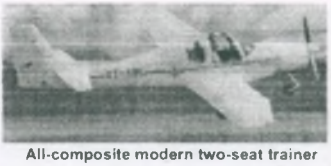
LAKSHYA (Aerial Target System)

- Carries 2 two-bodies with augmented IR, RF signatures, scoring, miss-distance indication systems
- Max AUW 705 kg, Booster thrust 3750 kg
- Endurance 50 min
- Max speed 0.65 M
- Max altitude clean 9 km
- Max manoeuvrability 3.0 g
- **8 supplied**

Features

- Land / ship launch
- Zero length launcher, rocket - assisted take-off

HANSA-3
All-Composite Light Aircraft



All-composite modern two-seat trainer

- Fully certified by DGCA under FAR-23 via JAR-VLA for day/night operation
- Aerodynamic design optimized with extensive use of CFD and wind tunnel testing
- Maximum cruise speed: 115 ktas
- Stall speed with 20° flaps: 48 ktas
- Endurance: 4 hours
- Take-off distance: 450 m
- All-up weight: 750 kg

4 supplied, orders for 11 in pipline

- Turbo-charged engine (ROTAX 914 F-3) with constant speed propeller
- Extensively tested including for lightning protection
- Day-night flying capability

SARAS (Light Transport Aircraft)

- Multi-role Turbo-prop Light Transport -
  - Commuter services (14 pax)
  - Light Package Carrier
  - Executive aircraft (9 seats)
  - Aerial research
  - Coast Guard, Border Patrol, Air Ambulance
- 2 P&WC PT6A-66 engines, 850 SHP
- Max range: 400 km with 14 pax
  - 1900 km ferry
- Block time: 88 min for 600 km stage
- **Rolled out 4 February 2003**
- **Two prototypes being completed**
- **IAF interest in acquiring 6 aircraft**

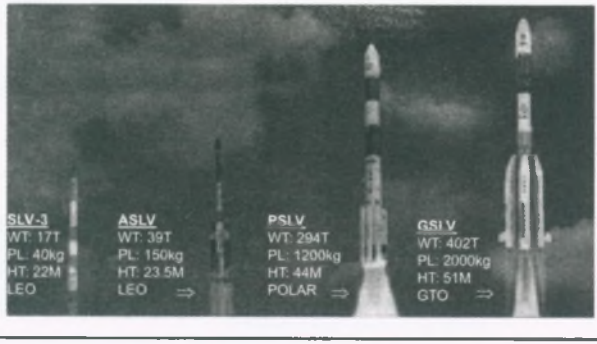
HJT 36 - INTERMEDIATE JET TRAINER

- Tandem seating
- AUW ~ 3500 kg
- Powered by single 3170 lb
  - Snecma /Turbomeca Larzac

- **2 prototypes being made**
- **Anticipated production : 225 aircraft**
- **Projected entry into service : 2005**

Ind. Av. 17-23 Jan 2003

ISRO LAUNCH VEHICLES



SPACE CENTRES AND UNITS IN INDIA

INDIAN SATELLITES

- 35 launched to-date
- 14 geostationary
- 23 in orbit
- 16 Indian launches

METSAT
(now renamed KALPANA)

CAPABILITIES IN SPACE TECHNOLOGY

- Some of the largest solid boosters in world
- Liquid propulsion units used extensively
- Cryo rockets in very advanced stage of development
- High resolution (1 m or better) satellite imagery
- Extensive capabilities in remote sensing

THE MISSILE PROGRAMME

Prithvi

- All-weather, tactical battlefield surface-to-surface missile
- 150-250 km range
- Single-stage twin-engined liquid propulsion
- Closed-loop. Strap down inertial navigation system
- **Operational**

Agni 1

- Nuclear-capable, range : 700-800 km
- **Induction into Strategic Forces Command : end 2003 or early 2004.**

Under development / flight testing

- **Agni 2**
  Range: 2000 km+
- **Agni 3**
  Range: 3000 km+
- **Astra**
- **Brahmos**
  Supersonic cruise missile

MAJOR TECHNOLOGICAL CAPABILITIES

- CFD (many centres)
- CAD-CAM (ADA, NAL,HAL, . . .)
- Composites (NAL, HAL, . . .)
- Flight control: analysis, design (ADE, NAL, CAIR, . . .)
- Radar technologies (LRDE, BEL, HAL)
- Avionics (HAL, DARE, ADE)
- Manufacturing (HAL, TAAL)

MAJOR FACILITIES

- Wind tunnels
  (Major 1.2m x 1.2m trisonic. NAL
  14 ft x 9 ft low-speed, IISc
  ~ 10 in. dia hypersonic (IISc. VSSC)
  + numerous other low and high speed tunnels at NAL. IISc. IITK. etc.
- Structural test facilities
  NAL, HAL
- Simulators (ADE, NAL)
- Engine test rigs (GTRE. NAL)
- Parallel computers (ADA, NAL. IISc. IITM, many others)
- Large autoclaves (HAL. NAL)

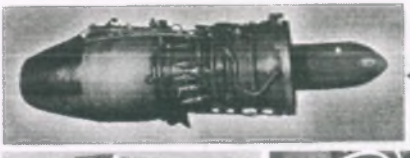
Many others

GAS TURBINE PROGRAMMES

KAVERI (FLAT -RATED)
DRY THRUST : 5201 KG
REHEAT THRUST : 8264 KG
WEIGHT : 1070 KG
⇐ DRY SFC : 0.78 H^{-1}
REHEAT SFC : 2.03 H^{-1}

CORE ENGINE – KABINI ⇒

GAS TURBINE PROGRAMMES IN INDIA (Contd.)

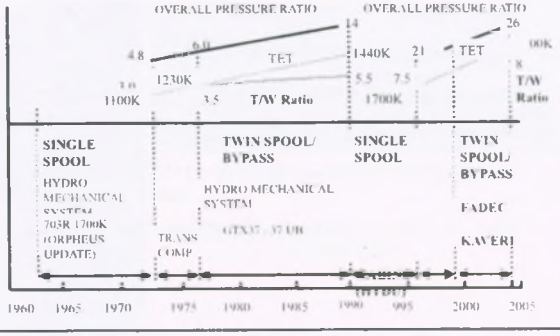


⇐ PILOTLESS TARGET AIRCRAFT ENGINE

JET FUEL STARTER

AIR TURBINE STARTER

KAVERI ENGINE TECHNOLOGY UPDATE
AERO ENGINE TECHNOLOGY PROGRESS



TECHNOLOGICAL CAPABILITIES : AIRCRAFT ENGINES

- CFD
- CAD CAM
- Structural Analysis
- Materials & Manufacturing
- Full Authority Digital Control Systems
- Test Rigs for

  Blades, Stages, Fan, Compressor, Combustors, After-burner, Heat Transfer, Structural Integrity

INSTITUTIONAL BASE

DRDO : *13 laboratories / Establishments*

CSIR : *National Aerospace Laboratories + 4 others involved in some aerospace work*

ISRO : *ANTRIX + 13 Centres*

PSUs : *HAL (13 Divisions, 9 Research & Design Centres), BEL, BDL, MDN*

Educational + Training : *9 institutes / colleges*

SIATI (Society of Indian Aerospace Technologies & Industries) : *300+ members*

INSTITUTIONAL BASE (Contd.)

Major airlines : *5*

Corporate Flying Operators : *~30*

Flying + Gliding Clubs : *32 + 15*

Private industries : *77*

Professional Societies, Bodies : *IAS, IRS, ISAMPE, SIATI*

Also : *Institute of Aerospace Medicine, DGCA, IAA, and many others*

WHAT OTHERS SAY ABOUT INDIAN AEROSPACE

- India is emerging as the **region's [Asia's] most powerful aircraft manufacturing nation**. This is curious, because South Korea, China, Taiwan, and Japan would seem to have pursued the most practical course for developing their aerospace industries . . .
- India is an **oasis of economic stability** . . .
- India has always been a **prolific user of helicopters**, particularly for military purposes.

Aerospace America, 1999

WHAT OTHERS SAY ABOUT INDIAN AEROSPACE (Contd.)

- India's policy of independence and nonalignment has meant its **aerospace companies have some of the fastest growing technology centers in Asia**.

WHAT OTHERS SAY ABOUT INDIAN AEROSPACE (Contd.)

TWO TYPICAL VIEWS

WHAT OTHERS SAY ABOUT INDIAN AEROSPACE (Contd.)

- **India can reliably and inexpensively launch its own remote sensing satellites, among the world's most sophisticated** . . . India also has considerable expertise in receiving, processing and analysing remotely sensed data; international and domestic users value its high quality data products.

CSIRO Review

WHAT OTHERS SAY ABOUT INDIAN AEROSPACE (Contd.)

- The Indian Resources [sic : Remote Sensing] Satellites **(IRS) series is a "jewel in the crown"**, says Tina Cary, director of applications and training for Eosat, the U.S. - based satellite imagery marketing firm.
- In the long term, IRS may have 30 percent of the global market

THE INDIAN ADVANTAGE

- 'If an advanced-technology product needs high man-power input, then we can produce it at 60 to 70 percent of the global price'

  - K. Kasturirangan, Chairman, ISRO

- India and the US are natural partners in space technology.

  - Dan Goldin
  (former) Chief Administrator, NASA

These statements are true across the board in Aerospace - not just for the US, not just in space.

SUMMARY

- Thanks to investment in material and human resources over two decades India now possesses a **broad-spectrum capability** in aerospace technology:

  combat aircraft, UAVs, Light Transport, helicopters, aircraft gas turbines, solid, liquid and cryo rockets, space launch vehicles, satellites, missiles

SUMMARY (Contd.)

- Discipline-wise strengths cover:

  Aerodynamic + structural testing, CFD, composites, control systems, simulation

  CAD-CAM, manufacture

- Sound, solid, broad **knowledge infra-structure** in aerospace now exists - in R&D, industry, academia

SUMMARY (Contd.)

- The number of Indian systems in the air today is growing, but is still **not commensurate with the current technological capabilities of the country**.

- India has competitive advantages in industry that demands science-intensive human skills, including aerospace research, design, development and testing

SO WILL THE BOOM HAPPEN?

YES, but ONLY IF :

- ALH, LCA can be made in large numbers (≥ 200) (Why does the widely admired Dhruv have order for only 30, not 300?)
- Derivatives are built based on the products now developed (helicopters, combat aircraft, trainers, light transport), and see service
- Procurement decisions (orders) are quick (Decisions on ALH, LAH, LOH, LCA, UAVs and their variants will be test-cases for Government's will to promote boom)
- Global brand equity is established for Indian aerospace products

WILL THE BOOM HAPPEN? (Contd.)

- Projects are defined for development times of 5-8 years.
- Global marketing, financing infrastructure and skills are developed
- Private enterprise is involved in a significant way: need to move Indian industry from vendor to partner status (perhaps eventually to that of independent player)

WILL THE BOOM HAPPEN? (Contd.)

- World wide product support can be assured
- Regulatory system in civil aviation is reformed
- Government is determined to make boom happen

CIVIL AVIATION : NEW POLICY?

- Privatise the 4 Metro Airports, 2003?
- Independent Airports Economics Regulatory Authority Proposed
  - simpler entry conditions for new operators
  - independent safety board
  - special regime for remote areas like NE, J&K
  - enabling policies for establishing low-fare airlines
- Abolish Inland Air Travel Tax?
  (could reduce air fare by 16.7%)

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FUTURE DIRECTIONS

- Design, Develop and Deliver to time - by appropriate arrangements (international when necessary)
  Brahmos and HAL / IAI agreements show the way for co-design, co-development, co-manufacturing agreements
- Build brand equity for Indian - or for Indo-X - products (X = suitable brand owner from elsewhere)
- Make bold procurement decisions on Indian / Indo-X systems, help Indian industry move rapidly along learning curves

FUTURE DIRECTIONS (Contd.)

- Aggressively seek export markets
- Work towards India being seen as a willing and able partner in joint (international) ventures
- Set up a National Task Force on the Future of Indian Aerospace involving R&D, industry, operators/users, management experts, academics
- Enhance connectivity by IT + aviation, especially in weakly connected parts of country (NE, J&K, Island Territories)

FUTURE DIRECTIONS (Contd.)

- Change regulatory regime in Civil Aviation to promote low-fare airlines (like Ryanair, buzz, go etc.)
- Promote India as RD&D platform for world (cf. IT, BT; GE now does more than half its total R&D in Bangalore)
- Institute Small Business Initiatives across the board

CONCLUSION

- So: **Is India all set for an Aerospace boom?**
- Answer: Everything needed is there, except possibly
  - an appreciation of how vast the opportunities are, and
  - the will of the State to pursue them aggressively

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Appendix

A listing is provided below of aerospace vehicles designed and manufactured in India.

HAL

Aircraft produced under license at HAL (12)

1. Percival P.40 Prentice T-3
2. Vampire
3. Gnat
4. Mig 21
5. Mig 21 Bis
6. Chetak
7. Cheeta
8. Dornier 288
9. Jaguar
10. Mig 27M
11. Mig 29
12. SU 30 MKI

Aircraft designed and produced by HAL (11 + 2)

1. HT 2
2. Kiran I
3. Kiran II
4. HPT 32
5. HTT 32
6. Pushpak
7. Krishak
8. Basant
9. HF 24
10. ALH
11. LCA

To this list may be added 12. Ajeet (development of Gnat) 13. Light Attack Helicopter Lancer (development of Cheetah).

Aircraft assembled (with manufacture of some spare parts) during WWII

1. Harlow PC-5A trainer
2. Curtiss 75A-5P Hawk fighters
3. Vultee V-12-D attack bombers

Under development now (1)

IJT

Under design (2)

1. Light Combat Helicopter
2. 100-seater aircraft

Under preliminary study

1. Light Observation Helicopter

Agreement for license production

1. ATR 42

UAV designed by ADE

1. Nishant (under LSP)
2. Lakshya (under LSP)

Aircraft designed by NAL

1. Hansa (under LSP)
2. Saras (under development)

HAL Engines:

Engines produced under license in India

1. DART
2. ORPHEUS
3. ARTOUSTE III B
4. R 11
5. R 25
6. GARRETT
7. R 29B
8. ADOUR
9. RD 33

Under an advanced stage of development:
Kaveri (GTRE)

Missiles under production
Prithvi (operational)

Missiles under development
1. Trishul
2. Nag
3. Akash
4. Agni
5. Astra
6. Brahmos

Satellites:

Satellites launched from India

1. RTP
2. RS-1
3. RS-D-1
4. RS-D2
5. SROSS-1
6. SROSS-2
7. SROSS-C
8. IRS-1E
9. SROSS C2
10. IRS-P2
11. IRS-P3
12. IRS-1D
13. IRS-P4
14. GSAT-1
15. TES
16. MetSat

Satellites launched from foreign platforms

1. Aryabhata
2. Bhaskara 1
3. APPLE
4. Bhaskara 2
5. INSAT 1A
6. INSAT 1B
7. IRS 1A
8. INSAT 1C
9. INSAT 1D
10. IRS 1B
11. INSAT 2A
12. INSAT 2B
13. INSAT 2C
14. IRS 1C
15. INSAT 2D
16. INSAT 2DT
17. INSAT 2E
18. INSAT 3B
19. INSAT 3C

Satellites launched for foreign customers

1. KITSAT 3, Germany
2. TUBSAT, Germany
3. BIRD, S. Korea
4. PROBA, Belgium

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