Council of Scientific and Industrial Research
NATIONAL AEROSPACE LABORATORIES

National Aerospace Laboratories (NAL), a constituent of the Council of Scientific and Industrial Research (CSIR), India, established in the year 1959 is the only government aerospace R&D laboratory in the country's civilian sector. CSIR-NAL is a high-technology oriented institution focusing on advanced disciplines in aerospace. CSIR-NAL has several advanced test facilities, and many of them are recognized as National Facilities. These are not only the best in the country, but are also comparable to other similar facilities in the world. CSIR-NAL has also provided significant value added inputs to all the Indian national aerospace programmes. Its contributions over the last five decades have enabled it to create a niche for itself in advanced aerospace research and technology development.

Major Focus / R&D Disciplines

Core competence of NAL spans practically the whole aerospace sector

- Civil aircraft design & development
- Micro Aerial Vehicle design and development
- Computational fluid dynamics
- Experimental aerodynamics
- Flight mechanics and control
- Turbo machinery and combustion
- Composites
- Structural design, analysis & testing
- Structural dynamics and integrity
- Surface modification
- Aerospace materials
- Aerospace electronics and systems
- Electromagnetics
- Meteorological modeling
- Wind energy

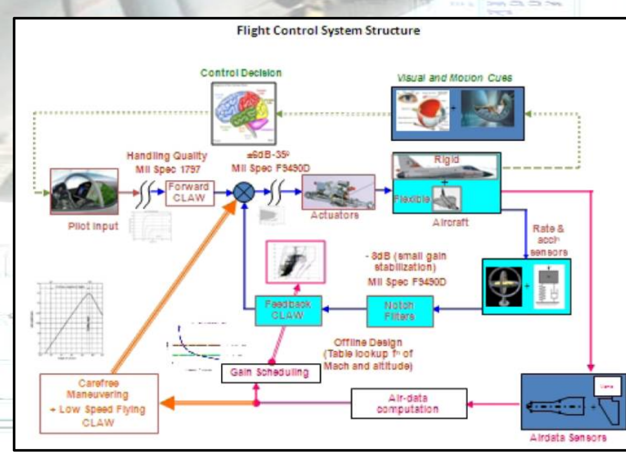
A Glimpse of the Significant Contributions to Light Combat Aircraft (Tejas) – Airforce variant

The Aeronautical Development Agency (ADA), Department of Defence R&D is the nodal agency for the design and development of the Light Combat Aircraft, Tejas. HAL is the principal partner in the LCA programme with the participation of DRDO and CSIR laboratories, public and private sector industries and academic institutions. Over the years CSIR-NAL has developed many critical technologies for Tejas and continues to support the programme.

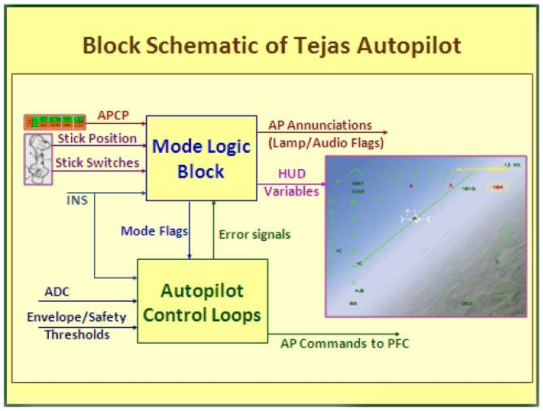
Fly-by-wire (FBW) control systems

- CSIR-NAL has led the national team effort to design, develop and certify the fly-by-wire flight control laws and airdata algorithms for Tejas. It has been the work centre for the National Control Law team which has spearheaded the activities leading to the Initial Operational Clearance (IOC) Standard Control Law and Airdata algorithms for TEJAS Airforce variant.

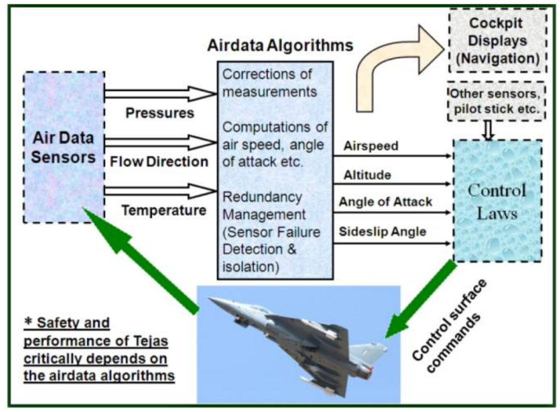
- It is to the credit of this team that the flight test programme for TEJAS has today successfully completed a total of over 2400 flights, carried out on 14 different prototypes by 17 test pilots over a continuously expanding flight envelope meeting the IOC 2 requirements in full.



The CLAW team has also provided decisive leadership in implementing the autopilot modes, simulation and modeling including wake encounter simulation and advanced parameter identification techniques for flight validation/update of the aerodynamic database leading to safe flight envelope expansion for LCA air force variants.



Basic and advanced autopilot mode design



Complete design of data processing and redundancy management algorithms for LCA airdata sensors

Modeling

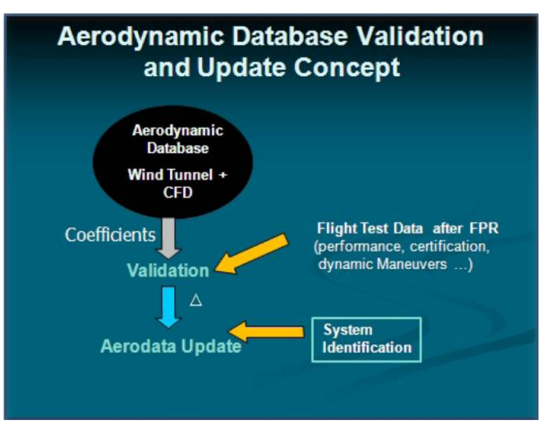
➢ Aircraft 6-Degree-of-Freedom simulation technology is a key requirement for Control law development and piloted real-time assessments in simulator.

➢ CLAW team has developed and fine tuned the simulation models for LCA-Tejas.

Simulation

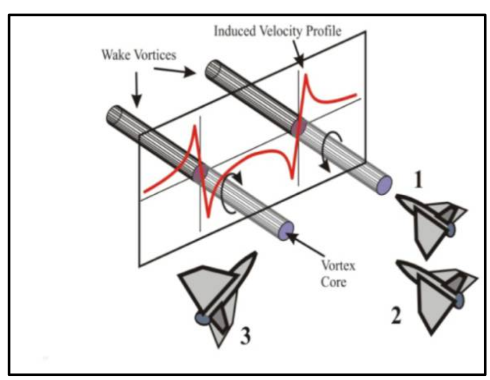
➢ Engineer-in-Loop Simulator (ELS) is a friendly real time simulator and a single window projection based facility for preliminary evaluation of CLAW design developed at CSIR-NAL.

Parameter Identification



Advanced PID techniques applied to update aerodynamic database generated from wind tunnel tests

Wake Encounter Simulation

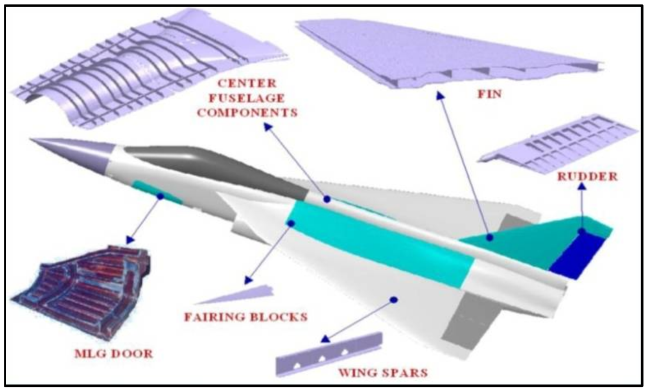


Wake encounter simulation is a very complicated and a challenging modeling and control problem. To ensure there is no hazard to Tejas on entering the wake extensive modelling and simulation studies were carried at CSIR-NAL.

Composite Structures for LCA - Tejas

Composites offer a very attractive option in modern aircraft development because they are lighter than metal and just as strong. Tejas airframe is 45% composites (mostly carbon-epoxy) by weight contributing to its reputation as the world's smallest light weight fighter aircraft.

- CSIR-NAL successfully led the National Team for the composite wing development for Tejas.
- CSIR-NAL has pioneered the development and fabrication of composite structures for the Tejas aircraft using innovative and cost-effective fabrication technologies including co-curing / co-bonding construction.
- This innovative technology developed at CSIR-NAL not only reduces the cost but also improves the structural efficiency by minimizing the number of mechanical joints. With this innovation, composite aircraft structures have become cost effective and structurally far superior to conventional aircraft structures.
- Tie-up with Tata Advanced Materials Ltd., for supply of critical CFC components for the series production of LCA.

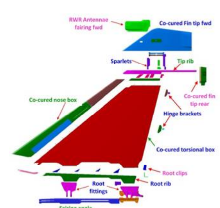


Parts	Reduction of part count due to co-curing (compared to conventional technology)
LCA Fin	200 parts to 15 parts
LCA Rudder	50 parts to 6 parts
LCA Centre Fuselage	500 parts to 44 parts
LCA undercarriage Doors (Aft and Fwd)	40 parts to 5 parts

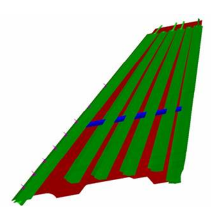
Co-curing technology has resulted in more than 20% savings in cost and about 15% reduction in weight.

Composite Fin

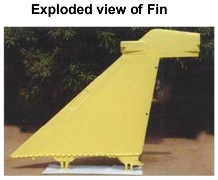
- The entire box is made as a single piece in one operation using Innovative and complex tooling concepts.



Exploded view of Fin



Torsional box



Fin component

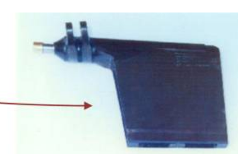
Comparison of CFC torsional tox over metal		
	Metal	CFC
Weight	45.5 kgs	38.5 kgs
No of parts	27	1
No of fasteners	2500	Nil
Assembly time	4 weeks	Nil

Benefits derived

Composite Rudder

- Integral rib-skin co-cured construction has resulted in 20% weight reduction, eliminated expensive and complex machining of titanium torque shaft and resulted in weight savings of 35 %.

LCA rudder



Composite torque shaft

Under Carriage Doors

Under carriage door aft

Under carriage door forward

Central Fuselage parts

Circular duct top

Trouser duct top

Top skin centre

Wind Tunnel Tests for LCA

The National Trisonic Aerodynamic Facility of CSIR-NAL houses a 1.2m trisonic wind tunnel. Every Indian aerospace vehicle has graduated out of this wind tunnel. The tunnel has completed more than 40000 blowdowns and has been performing reliably for over 50 years.

Characterization of overall aerodynamics

- Extensive 6-component aerodynamic force & moment data required for Control-Law development of LCA were generated in the 1.2m trisonic wind tunnel, has led to freezing of the aerodynamic design of the LCA, including sizing of wing & control surfaces.

LCA model mounted in the NAL 1.2m wind tunnel

Dynamic tests

- A dynamically scaled model of LCA was designed, manufactured and tested in the 1.2m wind tunnel at angles of attack up to 16° and Mach number of 1.8 to obtain pitch and yaw-damping derivatives using Forced Oscillation Technique.

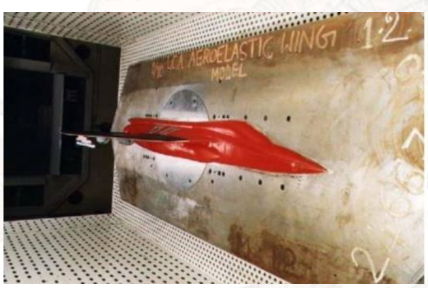
Air-Intake tests

- Isolated air-intake duct tests with bell mouth entry and ejector induced flow were carried out on a 1:7.645 scale model to validate the duct design through extensive static pressure measurements. Subsequently, extensive design, manufacture, development of measurement systems have been realized to arrive at the acceptable configuration.

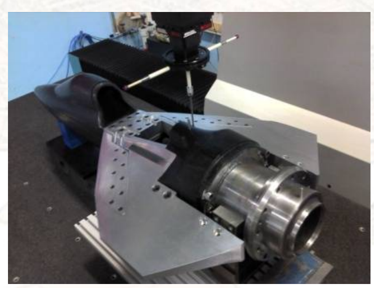
- Complex instrumentation involving dynamic & semi-dynamic total & static pressure rakes (comprising 225 static, 25 total and 40 unsteady pressure sensors), data acquisition & processing systems were developed to enable measurement of steady & unsteady pressures along with mass flow control and thereby characterize pressure pulsations at the aerodynamic interference plane of the GE 404 engine used on LCA and establish buzz boundaries of the basic configuration.

Aeroelastic Model Studies

The transonic flutter of LCA wing with R-73 missile has been cleared through wind tunnel testing in 1.2 m NAL trisonic wind tunnel for initial flight clearance. A scaled flexible model of the wing is designed, fabricated and instrumented simulating both structural dynamics and aerodynamics of the wing for the aeroelastic testing. The other studies include design and analysis of the fin (stress), development of various scaled models of LCA air intake models (for Wind Tunnel testing), wing box component testing, and all material evaluation and characterisation (composite and metal).



LCA aeroelastic wing model with R-73 missile in the NAL 1.2m wind tunnel



Air force air intake wind tunnel model at Coordinate Measuring Machine

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