The Flight Mechanics & Control Division (FMCD) of the CSIR-National Aerospace Laboratories (NAL) is engaged in R&D activities in the areas of Modeling and Flight Simulation, Control and Handling Qualities, Multi Sensor Data Fusion Applications and System Identification. The division has a high level of expertise in these niche areas and is well equipped to address problems in the flight vehicle dynamics and control domain.

**Expertise**

- Parameter Identification for Fixed and Rotary Wing Aircraft
- Rigid Body and Flexible Aircraft Simulation
- Nonlinear Flight Dynamics
- Control Synthesis using Conventional and Modern Approaches
- Target Tracking, Data and Information Fusion and Situation Assessment
- Air Traffic Management and Air Transportation

FMCD is the work centre for the National Control Law team responsible for the design and development of Fly-by-wire Digital Flight Control System for the Indian Light Combat Aircraft LCA-TEJAS. The team includes members from other sister organizations like ADA, ADE and HAL, and has spearheaded the activities on design and clearance of Control Law and Airdata algorithms for TEJAS Airforce, Trainer and Naval variants.

System Identification techniques have been successfully applied to the TEJAS flight-test data for validation/update of the aerodynamic database leading to safe flight envelope expansion. These techniques have also been used for the aerodynamic characterization of a variety of fixed wing and rotary wing aircraft like Mig 21, Jaguar, Ajeet, HS-748, HJT36, Chetak and ALH.
Flight Mechanics & Control

FMCD has designed algorithms for Autopilot & Stall Warning Systems for the SARAS aircraft. The autopilot test rig (mini bench) has been integrated with the SARAS FTD for conducting pilot-in-loop tests. Algorithms have been developed for characterization of nonlinear elements in the Primary Flight Control System.

The division is actively involved in the development of an indigenous autopilot system for the National Program on Micro Aerial Vehicles (MAVs).

Advanced algorithms and strategies for state estimation, multi-sensor multi-target tracking, maneuvering target tracking, artificial intelligence techniques for higher levels of fusion and Bayesian networks for situational awareness have been developed for missile flight test range safety and air defense applications. FMCD is actively pursuing research work towards the development of Integrated Enhanced and Synthetic vision system (IESVS) for increased pilot/operator situational awareness.

The division has developed fixed base simulators for major national aircraft programs – Engineer-in-loop Simulator (ELS) for LCA-TEJAS Airforce and Naval Variants and Flight Training Device (FTD) for the CSIR-NAL light transport aircraft (SARAS). These facilities are used for engineer / pilot-in-loop evaluation tests.

A novel inertial navigation scheme was developed & tested in a software-in-the-loop platform. This architecture combines the benefits of a nonlinear complementary filtering (NCF) scheme and an extended Kalman filter (EKF) based estimation scheme.
Software Packages developed in house
- FAST – Flight Analysis and Simulation Tool
- HQPACK – for handling qualities evaluation for fixed and rotary wing aircraft
- DTMSDF – software package for Dynamic Tracking filter and Multi Sensor Data Fusion
- MSMTDAT – Multi Sensor Multi Target tracking
- FIETBX – Fuzzy Implication Functions Evaluation Tool box
- PESTIM & FIDA – Parameter Estimation Software Tools

Facilities
- Engineer-in-loop Simulator (ELS) for LCA TEJAS
- Flight Training Device (FTD) for the SARAS
- Augmented Engineering Environment (AEE) for Regional Transport Aircraft Design
- MAV Hardware-in-the-Loop (HILS) Simulator
- Air port/Air Traffic Simulator

A Desktop Flight Simulator (DFS) for real time simulation of aircraft and sub system models for flight control design has been developed. It uses a low cost visualization platform for pilot visual cues and display. This rapid prototyping environment enables autopilot performance evaluation, airport runway profile and terrain data integrity monitoring studies.

Airport/ Air Traffic Simulator
This unique facility can be used for airport capacity studies, generating noise contours around airports, investigating fuel burn and operator workloads.
A variety of commercial software analysis tools like SIMMOD, KRIT, ESTIMA, HUGIN, VEGA PRIME etc., are available to address a wide range of problems in data analysis, state and parameter estimation, control synthesis, bifurcation analysis, multi-sensor data fusion, modeling and simulation of aircraft dynamics.

Nonlinear Flight Dynamic modeling and analysis is critical for design and development of advanced high performance aircraft as well as for high-risk high-angle-of-attack flight testing. FMCD has taken up this cutting-edge research to support aircraft programs in the country and to advance the basic understanding of high angle-of-attack aerodynamic modeling and flight dynamics analysis for safety and recovery design.

**Industrial Partners**
- CAE, Montreal, Canada
- CAE India Pvt. Ltd.
- Honeywell Technology Solutions, Bangalore
- Serial Innovations Pvt. Ltd, Bangalore

**International Collaborations**
- **DLR Institute of Flight Systems & Flight Guidance, Germany**: The division has had a long and fruitful collaboration with DLR Braunschweig, Germany, on various aspects of flight mechanics and air transportation.
- **UKIERI (UK India Education Research Initiative)**: Joint research work was carried out with the University of Leicester on Reliable Smart Adaptable Flight Vehicles under a major grant awarded by the British Council UK.
- **De Montfort University, UK**: Collaborative research in the area of High Angle of Attack unsteady nonlinear aerodynamic modeling and simulation is being pursued.

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