Short Course:

Flight Vehicle System Identification in Time Domain

Synopsis:

The scope of application of system identification methods has increased dramatically during the last decade. The advances in modeling and parameter estimation techniques have paved way to address highly complex, large scale and high fidelity modeling problems. The objective of this one-day course is to review the recent advances in the time-domain methods of system identification from flight data, both from the theoretical and practical view points. Starting from the fundamentals, a systematic approach will be presented to arrive at the solution. Benefits derived from flight validated models applying system identification will be highlighted. The course will provide an overview of key methods of parameter estimation in time domain, will cover many examples covering both fixed-wing and helicopter applications, and address model validation in both time and frequency domain. The course will be supplemented with an overview of software tools available.

Key Topics:

- Insight and familiarity with modern techniques and intricacies
- Large scale systems and high fidelity modeling
- Real world problems and possible solutions
- Establish contact with leading organization
- Demonstration of some highly flexible and powerful integrated software tools

Course Outline

- **Background**
  - What is system identification, parameter estimation and simulation
  - Systematic Quad-M approach

- **Parameter estimation methods in time-domain**
- Output error method
- Nonlinear systems and large scale problems

- **Applications**
- Trim point identification
- Global model (ATTAS, C-160, DO-328, X-31A)
  - Aircraft mass properties
  - Nonlinearities in control surface effectiveness
  - Functional dependencies on flow variables
- Unstable aircraft
- High bandwidth model for Helicopter applications
- Identification of nonlinear phenomenon (ex. Stall hysteresis)

- **Model validation**
- Time histories and cross plots (plot programs THplot and CRSplot)
- Residual analysis (PSD plots of residual)

- Convergence of parameter estimates (CONVER)
- System analysis through eigenvalues and vectors (EIGENPLOT)
- Frequency response of identified model (BODEPLOT)

• **Demonstration of software tools**
- A modular and integrated software tool ESTIMA (Fortran-77 based) (encompasses file-management software, parameter estimation software, and several post-processing software for visualization of results).
- Brief overview of other software tools.

• **Wrap-up**
- Summary
- Open discussion and possibilities of addressing actual problems raised by attendee

Instructor:

Dr. Ravindra Jategaonkar is a senior scientist and the leader of the system identification group at the German Aerospace Center, DLR-Institute of Flight Systems, in Braunschweig, Germany. He has been extensively involved in the application of system identification methods to flight vehicle modeling, covering nonlinear models, generation of Level-D aerodynamic databases for flight simulators and estimation in the presence of atmospheric turbulence. He is primarily responsible for the commercially available integrated software tool ESTIMA for parameter estimation from large-scale nonlinear systems and post-processing visualization. He is the author and co-author of more than 40 scientific papers and 45 technical reports, and co-author of the invited AIAA survey paper on *Evolution of Flight Vehicle System Identification* (Journal of Aircraft Vol. 33, Number 1, 1996). He is recipient of DLR Title "Senior Scientist" for scientific excellence. He is a member of DGLR and Associate Fellow of AIAA.

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