VISITOR RESEARCH REPORT

Visitor Name: Mr. Geoffrey Brian,
Defence Science and Technology Organisation, Australia

Area of Research: Aircraft Modelling

Period of Visit: 02/08/10 – 02/11/11

Goal:

A placement was undertaken with the NASA Langley Research Center (NASA LaRC) Dynamic Systems and Control Branch from February 2010 to February 2011. This was facilitated through the National Institute of Aerospace. The purpose of the placement was two fold: to investigate modern techniques for aircraft systems identification from flight; and to contribute to the development of a standard for the exchange of flight dynamics aerospace models, together with supporting the development of the Dynamic Aerospace Vehicle Exchange Markup Language (DAVE-ML).

Improving the timeliness of updating aircraft simulation models through automating the analysis of flight data and merging updated aerodynamic data with legacy data was a key goal of the aircraft systems identification activity. This built upon previous research conducted at NASA LaRC investigating real-time aerodynamic model identification from flight data. A proposed application for this capability was to apply it to post-stall flight regions, and flight conditions leading to departure from controlled flight. In doing so, it would provide an ability to monitor changes with the aircraft aerodynamic characteristics that may result in undesirable behaviour. Understanding the non-linear aerodynamics characteristic typical for these flight regions is of particular interest for studies investigating methods to improve airline operational flight safety.

Finalising the flight dynamics model exchange standard and its acceptance by the AIAA Modeling Simulation Technologies Technical Committee was an anticipated outcome of the standards development activity, in addition to proposing enhancements to the capability of DAVE-ML. Furthermore, modifying software used for aircraft systems identification to accept aircraft data files encoded using the DAVE-ML syntax was a desired outcome of the work program.

Strategy:

Accomplishments:

Aerodynamic System Identification

NASA LaRC is participating in a broad research initiative looking into aviation safety for civilian transport aircraft operations. A dynamically scaled model of a generic transport aircraft has been constructed to support research examining the aerodynamics of the vehicle at flight conditions near or at the extremes of the flight envelope. This vehicle is also being used to research different flight control law strategies designed to protect the vehicle against departure from controlled flight. Data collected during flight trials of this vehicle were provided

for the purpose of estimating the vehicle aerodynamics using system identification modelling techniques.

The System IDentification Programs for AirCraft (SIDPAC) software, developed by NASA Langley, was used to analyse the flight data and estimate the aerodynamic characteristics of the vehicle. These flight derived estimates were used to improve the aerodynamic representation contained within a simulation model of the vehicle. A software application was written to examine the effectiveness of automating the analysis of flight trial data and estimating the vehicle aerodynamics, and subsequently updating the aerodynamic representation used within the aircraft simulation model. The outputs from the data analysis software were data corrections to be applied to a baseline aerodynamic representation, together with simulated responses of the aircraft to control excitations using the improved aerodynamics.

A key component in developing this application was defining a technique to merge data from disparate sources (flight, wind tunnel, ...) while ensuring discontinuities in the aerodynamic data were avoided. Discontinuities cause the simulated vehicle behaviour to respond in an unnatural fashion to control excitations, and produce unrealistic motions and cues to pilots and/or auto-pilot systems. A technique was developed where by data from independent models of the aerodynamics derived from flight measurements could be blended to estimate improved aerodynamic characteristics at off-reference conditions.

Work on refining the automatic updating of aircraft simulation models is on-going, together with maturing the application performing this task. A paper summarising this work was submitted to the 14th Australian International Aerospace Congress, and a more comprehensive report is in preparation.

Modelling and Simulation Standards

The AIAA Modeling and Simulation Technical Committee, NASA, and the Defence Science and Technology Organisation (DSTO) Australia have been participating in a project defining a standard for exchange of aerospace vehicle flight dynamic simulation models. The purpose of the standard is to minimise the effort required to re-host models of aerospace vehicles when exchanged between simulation agencies who use different simulation architectures. Formalisation of the standard has been ongoing since 2004. A review of the report defining the standard was undertaken during this placement and advice provided for revisions. The report defining the standard has been submitted to AIAA Standards Committee for public review and subsequently recommended for formal adoption by the AIAA Modeling Simulation Technologies Technical Committee.

An adjunct to the standard is the Dynamic Aerospace Vehicle Exchange Markup Language (DAVE-ML). DAVE-ML is a syntactical language for exchanging flight vehicle dynamic data, and is the embodiment of the standard. It was designed to provide a programming-language-independent representation of aerospace vehicle characteristics, such as aerodynamics, mass, propulsion, navigation and control properties. Currently DAVE-ML includes the capability to manage scalar time-invariant data. Proposals were developed to extend the DAVE-ML syntax to manage data as vectors and n-dimensional matrices, and encode dynamics system models (both discrete and continuous). In addition, a syntax was defined for recording and managing dynamic data (such as time-sequenced data) that may be used for validating dynamics system models and the overall simulation package. These extensions should permit the capture of an entire flight dynamic model of a vehicle within the DAVE-ML syntax, leading to improvements with the exchange of aerospace vehicle model data.

A number of reports are in preparation detailing the proposals extending the DAVE-ML syntax. A paper summarising this work will be submitted to the 2011 AIAA Modeling Simulation Technologies Conference.

Future Work:

A strong working relationship has been established with members of the NASA LaRC Dynamic Systems and Control Branch during the visiting research period. Participation with the NASA civilian transport aviation safety programme will cease when the visit period ends. Even so, DSTO and NASA LaRC will continue to collaborate on applying aerodynamic systems identification techniques to the task of updating aircraft flight dynamic simulation models. The outcomes from the modelling and simulation work programme will direct the planning of future collaborations between DSTO and NASA LaRC in defining standards for the exchange of aerospace vehicle simulation models, and developing tools for implementation and promulgation the standard to different host simulation environments.

Pending Publications:

- Brian, G., Morelli E.A., *Rapid Automated Aircraft Simulation Model Updating from Flight Data*, Australian International Aerospace Congress 14, Melbourne, Australia, Feb 28 – Mar 3.
- Brian G., Jackson E.B., *Extensions to the Dynamic Aerospace Vehicle Exchange Markup Language*, AIAA Modeling Simulation Technology Conference, Portland, Oregon, 2011.
- Brian G., Vector and Matrix Variable Definition in DAVE-ML, Defence Science and Technology Organisation, Australia.
- Brian G., Time History for Aircraft Modelling Exchange Syntax, Defence Science and Technology Organisation, Australia.
- Brian G., Dynamics System Models in DAVE-ML, Defence Science and Technology Organisation, Australia.
- Brian G., Automated Aircraft Simulation Model Updating using Flight Data, Defence Science and Technology Organisation, Australia.

Seminars Presented:

- The Defence Science and Technology Organisation, Air Vehicles Division, Flight Systems Branch. Presentation given to NASA Langley Dynamics System and Control Branch and Flight Dynamics Branch, July 2010.
- DSTO usage of the Dynamic Aerospace Vehicle Exchange Markup Language (DAVE-ML), Presented at the NASA Flight Simulation Model Exchange Workshop, Johnson Space Center, October 2010.
- National Institute of Aerospace Visiting Researcher 2010/11, 27 January 2011.

Pending Presentations:

- Rapid Automated Aircraft Simulation Model updating from Flight Data. Australian International Aerospace Congress 14, Melbourne, Australia, Feb 28 – Mar 3.
- Dr. David Cox, Mr. Kevin Cunningham, Mr. Geoff Brian, *The AirSTAR Simulation and Reduced-Scale Flight Test Facility*, Flight Test Society of Australia Symposium 2011, Point Cook, Australia, Mar 5-6.