J2 Aircraft Dynamics Case History Embraer–Conceptual/Preliminary Design and Analysis

AIRCRAFT MODELLING AND PERFORMANCE PREDICTION SOFTWARE

KEY BENEFITS

- Easy integration of existing legacy code and knowledge base

- Large time saving due to no requirement to write code/scripts in order to run multiple analyses.

- Increase in design process speed due to the powerful analytical toolset being able can run many test cases instantly.

- The Design team could look at detailed certification manoeuvres and failure analyses across the complete flight envelope.

- j2 software was able to use existing trusted FORTRAN models with ease, exposing tables, derivatives and formulae within the **j2 Builder** environment

- j2 was able to fly models to Sim allowing for real time Pilot evaluation of updates and proposed variations**.**

- j2 software has a mature installation process and is easily networked onto any company system without access or permission issues arising.

THE GOAL

Embraer's goal was to evaluate how their internal design process could be enhanced through the use of 'new technology'. The evaluation focused on speed, accuracy and the ability to integrate directly with the knowledge in its legacy modelling system. Embraer selected the **j2 Universal Tool-Kit** because the software was able to integrate seamlessly with their existing aerodynamic modelling code base which was running in FORTRAN preserving and using the valuable knowledge that resided in the legacy modelling system. The new **j2/Embraer** modelling environment also enabled Embraer to fly the Aircraft model directly into their engineering simulation platform, providing actual flight evaluation of design updates.

EMBRAER VALIDATION

Stage 1 – Training and Orientation

A 1 week training programme focused on the use of the j2 software, navigation around the product and familiarisation. The trimming rules were mastered and the project aircraft was trimmed over all configurations and Mach numbers

Stage 2 – Integration with Legacy Code

- J2 created 9 x interface DLL's for different variants of the legacy toolset, including a working version for experimentation. The variants were tested over a range of Alpha's and Mach numbers and the results cross checked and compared with existing Embraer spread-sheet output. This was deemed a success.

- Ran straight and level trims, looking at flight envelope, introduced filters to eliminate unrealistic characteristics. Completed 390 test cases covering all the data tables in 1 day.

- Set up, and visualised, on j2 Virtual (3-D Visualisation,) a range of operational scenarios and sensitivity analyses e.g. load drops and a range of control surface rate limiting factors.

- Created delta models with internal pallets (payload) and ran test cases. All CG, Mass and Inertia calculations were handled by j2 software without any need for scripting.

- Generated 140 test points for a given configuration in an afternoon looking at flight path angles and flap settings for approach studies and evaluated further test manoeuvres on j2 looking at trim rules associated with a complete engine out, crab into the wind scenario over a range of altitudes and flap deflections. A total of 8 cases where run as examples in a period of minutes. J2 visualisation was used.

- j2 handled all analysis internally and automatically. This normally requires separate "blocks" of code for aerodynamics, mass (complex scripted mathematics for mass, inertias, and cg), and propulsion. If no Automatic Flight Control System (AFCS, FCS or Fly-by-Wire) is required, then you don't even need Matlab as the complete solution can (and was) modelled in j2 directly.

- Intelligent Pilots were introduced looking at constant G pull-up resulting in a loss of airspeed. This was updated into a wind up turn, banking the aircraft in the same manoeuvre and then fixing the air speed. j2 could plot and view the onset and maintenance of G and the corresponding elevator deflection so that the impact of the change was automatically charted, logged and visualised.

- j2 Pilot was used to configure the aircraft and fly real time using j2's stick. Embraer were able to configure the head down displays to monitor various parameters and configure the joystick to enable them to re-trim the aircraft, select flap settings and turn engines on/off as required. This also resulted in them flying the 'engine out crab into the wind' manoeuvre.

- Created a large number of cases on the project aircraft running in excess of 1000 cases in a couple of hours. These cases were presented to the Embraer engineers and management using the functionality embedded in **j2 Visualize** (charting) and **j2 Virtual** (3-D playback facilities) to provide a real understanding of aircraft behaviour.

CLIENT VALUE RETURN

Such was the success of the integration and the trusted nature of the j2 output, Embraer have been able to greatly accelerate the speed with which they can go and crucially have been able fly the model directly to Simulation at any stage in its development.

> *"Once we knew that we could use our existing modelling code within the j2 Universal Tool-Kit software environment we began to see the significant benefit of using this very powerful analytical and evaluation modelling tool. The idea is to use only j2 Dynamics for the entire Flight Mechanics analysis. We intend also to install j2 in our Engineering Simulator as the main simulation software for this project."*
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> **Decio Pullin**
> **Preliminary Design Team Manager, Embraer**

j2 AIRCRAFT DYNAMICS' AEROSPACE ENGINEERING AND AIRCRAFT DESIGN SPECIALISTS HAVE DELIVERED A 'FULLY CODED' AND INTEGRATED SOLUTION THAT ENABLES THE j2 UNIVERSAL TOOL–KIT TO INVESTIGATE ALL ASPECTS OF AIRCRAFT HANDLING AND PERFORMANCE.

…………..NO MORE CODING FOR ANALYSES.

This state-of-the-art, but easy-to-use software suite gives you unprecedented power to design and 'fly' multiple configurations of the complete flight envelope in a 3-D virtual environment – all at the click of a mouse! When using the J2 Universal Tool Kit, you can save thousands of man hours by streamlining your process, maximizing your analysis capability and reducing the risk of serious project flaws.

At the heart of j2's software is the j**2 Universal Framework**, a cutting-edge configuration control and data management platform that hosts all steps of the design process. Everything j2 offer begins and interacts with this key framework.

Investigate our range of plug-ins. 'Mix and match' their additional design and analysis capabilities using floating licenses. Take control of a bespoke package that perfectly fits your requirements. This way, you get the right functionality and maximise the return on your investment.

IMAGINE IF YOU COULD PREDICT THE FUTURE? NOW YOU CAN………..

To find out more about j**2 Aircraft Dynamics**, our software and associate consultancy programme, visit **www.j2aircraft.com**

PLUG-INS

J2 Builder
An easy-to-use graphical interface that rapidly develops aircraft models and builds multiple variants for comparison

J2 Elements
Enables automatic calculation of total aerodynamic coefficients and derivatives through integrated strip theory.

J2 Developer
A Software Development Kit (SDK) for all users to write their own components and libraries with an interface into J2 Aircraft Models.

J2 Freedom
Provides flight dynamics simulation of aircraft data models, allowing you to evaluate the complete flight envelope.

J2 Active
A .COM interface that instantly integrates your existing design packages with the power of the J2 Universal Tool-kit.

J2 Matlab Toolbox
Get the full capability of J2 with Simulink Model files. Manoeuvres within J2 can be flown on Simulink Models. Run all analyses from within J2 Universal ToolKit.

J2 Visualize
Instant understanding and evaluation of aircraft behaviour through data visualization and graphic displays.

J2 Virtual
View any results in a virtual 3-D real-world, to understand what exactly happens during unexplained/complex manoeuvres

J2 Pilot
Using the J2 Pilot plug-in's automatic interfaces/models you can fly aircraft on your. You can also use J2 Pilot interfaces to merge the finished design into pilot training simulators.

J2 Classical, a fully integrated component of the **J2 Universal Tool-Kit,** takes the results of previous steady state analyses and linearises the aircraft about that point. At the same time it will calculate a state space set of matrices and all derivatives about the chosen point. In minutes the eigenvalues/eigenvectors are established from the state space system on the full set of trim results, as well as the subsequent modes of motion that these relate to. From these results we can then look at the stability characteristics.