ESI

AIR ACCIDENT CASE HISTORY

Cirrus SR22 Crash, Boynton, FL

USING THE UNIQUE J2 UNIVERSAL TOOLKIT PROCESS TO RECREATE THE EVENTS OF A FLIGHT FROM FDR DATA, DETERMINE THE PILOT INPUTS, AND ASSESS HOW THEY AFFECTED THE CONTROL SURFACES AND RESULTED IN A LOSS OF CONTROL OF THE AIRCRAFT

DISCOVERY

- The j2 Universal Tool-Kit is used to build a full non-linear predictive solution.
- The full physics-based model of aircraft kinematics produced a much smoother and physically feasible aircraft flight path
- The reconstruction process removed any noise and bias from the sensors.
- Steady state behaviour indicated by the predictive model is compared with data obtained from Flight Data Recorder (FDR) information.
- 3-D visualisation enables views of the dynamic behaviour of the aircraft from all angles.

CONCLUSIONS

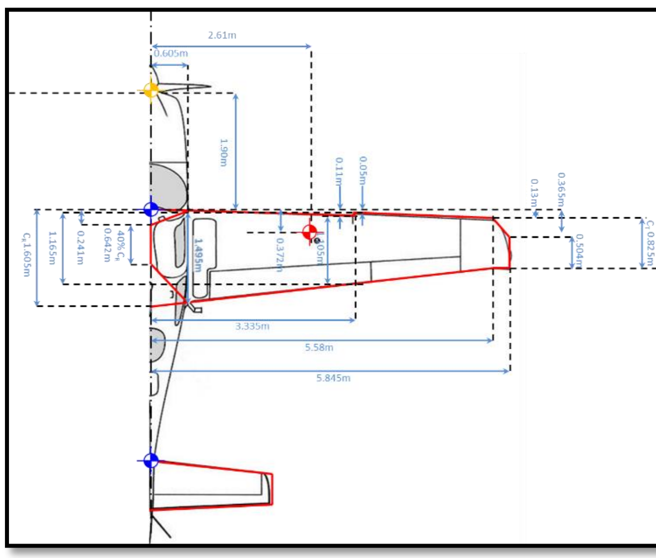
- The flight path reconstruction process unlocked important information from the GPS data.
- It is possible to assess the pilot inputs for each control surface by evaluating the capabilities of the control surfaces.
- The bank-to-bank inputs and the increased bank angle caused a progressive loss of energy until the nose up attitude resulted in a lack of sufficient speed, and stalled the aircraft.
- The final results from the model are validated by the original flight data.
- The model can be input directly into a desktop simulator, allowing the manoeuvre and possible recovery scenarios to be performed and evaluated in a safe environment.

High Fidelity Model Build

A high fidelity model of the Cirrus SR 22 was constructed using a variety of non-OEM data sources, including widely available dimensional and performance data, airfoil section, the software tools Digital DatCom, JavaFoil, and AAA. This model is used to generate data about a range of angles of attack. Well-recognised, published literature served as the source for undercarriage and engine/propeller data.

Model Sanity Check

Once constructed, the model was "sanity checked," using a unique property of the **j2 Universal Tool-Kit,** known as the virtual wind tunnel. To identify the characteristics of the aircraft, a series of angle of attack and sideslip sweeps were run, along with angular velocities. These numbers were compared to values from an aircraft of a similar type and class to ensure that there were no significant differences.



Steady state behaviour from the predictive model is compared with points from the Flight Data Recorder (FDR).   These checks compared whether the aircraft was at the same incidence as the FDR for a given speed and altitude. Thus confirming the chore aerodynamics for the model

Flight Path Reconstruction and Control Surface Identification

The GPS data did not include any surface deflections or accelerations - to get control surface information, we had to look at secondary effects. Initially, the **j2 Universal Tool-Kit** was used to reconstruct the aircraft states. This reconstruction comprised of a detailed physics-based model of aircraft kinematics and removed the noise and bias from the sensor data. Once reconstructed, we were able to produce an aircraft flight path that was physically feasible and considerably smoother.

By running the data from the reconstruction through the re-prediction built into the **j2 Universal Tool-Kit**, we were able to establish the necessary coefficient data. The aircraft model and motion equations were then put through a Single Value Decomposition (SVD) analysis for each point in time.

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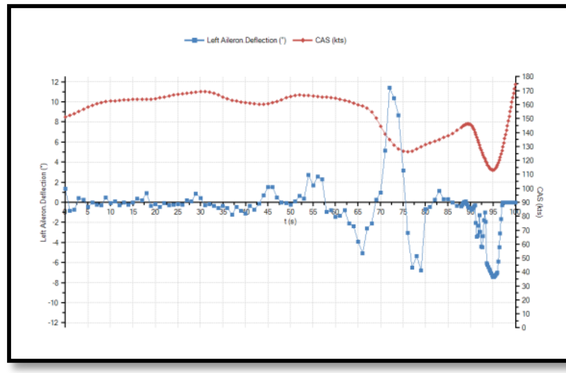
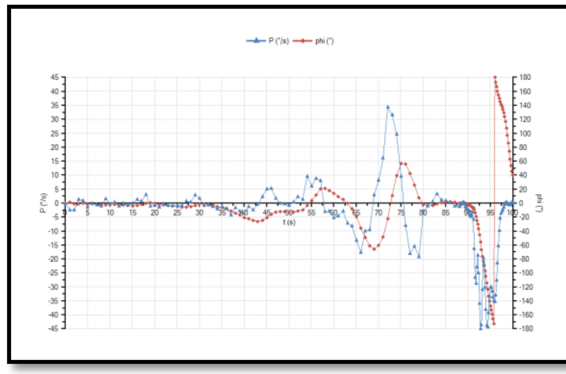
The j2 software "solved" for the major contributions of the control surfaces, and factored in any coupling of states and control surfaces. Additional corrections were then applied to the control surface data to match resultant states and behaviour. This provided the complete set of control surfaces and throttle settings for the flight.



Control Surface Validation

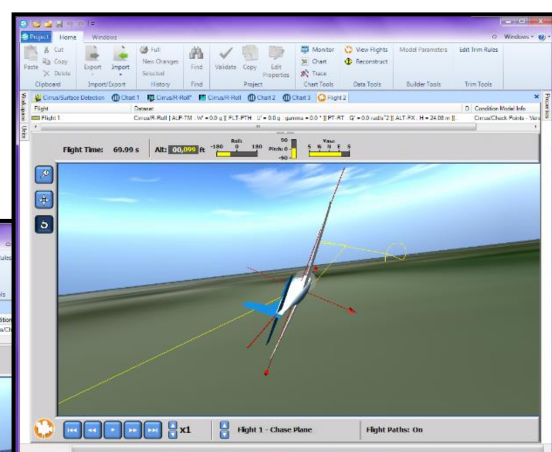
Once the control surfaces were identified, they were further validated to qualify the magnitude and direction of deflection. In order to accomplish this, the limits of the control surfaces were identified. The control surface deflection through various manoeuvres was then compared, as a % of the identified limits. During the bank-to-bank of the aircraft, the aileron deflections ranged from -6° to +11.5°. This is consistent with the limits (12.5°) and the type of manoeuvre.

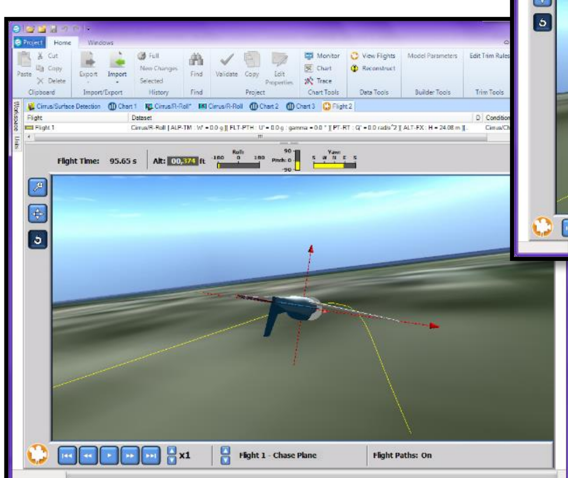


Conclusions

With the j2 Universal Tool-Kit, it is not only possible to generate a "video" of the flight from very basic flight data information, but also to take the data and use it to qualify a predictive model and then use the model to identify control surface deflections.

In this scenario, the bank angles got progressively larger, and the airspeed decreased. The resulting loss of control was a combination of a ¾ roll stick, a pullback which led to an elevation of the nose, and the resultant reduction in airspeed, which produced a stall. There was insufficient altitude for the pilot to recover.





More Information

For further information contact Engineering Systems Inc (ESI)_

Robert Winn, Ph.D.

T: (719) 535-0400

E: rcwinn@esi-co.com

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