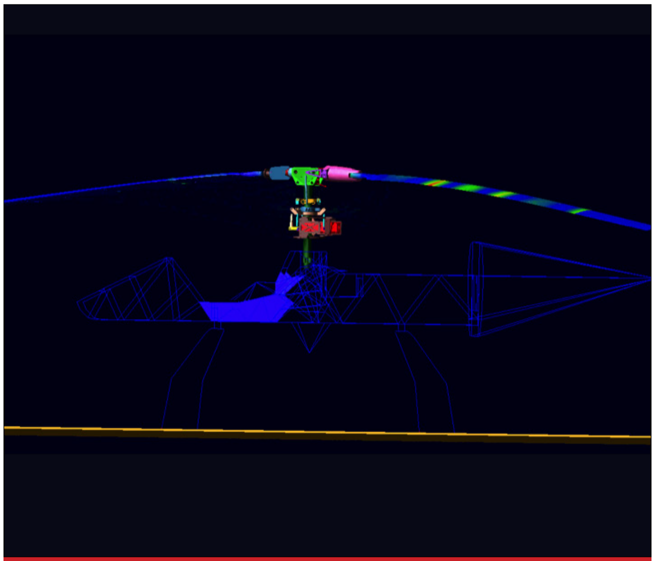
MSC Software

Case Study: **Saab**

Adams Simulation Solves Stability Problem in Rotary Wing Unmanned Aerial Vehicle, Saving At Least 6 Months by Reducing Physical Testing

Overview

The Saab Skeldar V200 is a unique entrant in the unmanned aerial vehicle (UAV) market which is dominated by fixed wing aircraft. As a rotary wing aircraft, the Skeldar does not require runways to take-off or land from and can hover in one position. Skeldar is designed for land- and sea-based patrol, light transport, electronic warfare and surveillance applications. With dimensions of 4 meters long by 1.3 meters high by 1.2 meters wide, the UAV flies at speeds up to 130 km/h with a range of 150 km.



Multiple-flexible-parts method for blade simulation

“The Adams simulation saved us at least 6 months that would have otherwise been required to solve the problem by modifying and testing the prototype”

Dr Per Persson, Technical Fellow, Structural Dynamics for Saab

Challenge

Early in the process of developing the Skeldar, problems were seen in the stability of a prototype. The prototype had been developed with the aid of analytical models based on derivations of equations. The behavior of the prototype demonstrated that these models did not fully capture the UAV's flight behavior. Accurate simulation of the flight behavior of a rotary-wing aircraft requires the ability to accurately capture the interactions between the lifting forces on the rotor blades and downwash, the change in direction of air deflected by the blade as part of the process of producing lift. To the best of MSC's and Saab's knowledge, no simulation up to this point had ever managed to address this issue.

Solution/Validation

Dr Per Persson, Technical Fellow, Structural Dynamics for Saab decided to use MSC Software's Adams to model Skeldar's flight behavior. Dr Per Weinerfelt, also a Technical Fellow at Saab, provided support regarding aerodynamics and inflow modelling. Persson imported a structural model of the helicopter into Adams. The two rotor blades were each modeled as eight flexible bodies in MSC Nastran and their modal representations were incorporated into the Adams model. Dividing the rotor blades into smaller segments makes it possible for the rigid body motion of the outer part of the rotor blade to apply forces to the inner part of the blade in order to more accurately model the deformation of the blade during flight. Each segment contains about 25 beam elements with varying characteristics. The flight study was focused on the rotor system so the main helicopter frame is represented simply as a rigid body.

The aerodynamic forces and moments acting on the UAV are calculated by a model that is implemented as a user-defined function (UDF) in Adams. The actuator motion of the rotor blades and helicopter frame provide input to the aerodynamic model. From the blade motion, aerodynamic forces are computed and applied at different positions on the blade. Drag force on the helicopter frame is computed using a square plate analogy. Deformation and motion of the blades contribute to the calculation of the angle of attack. The lifting line approach was used to calculate lift and drag forces and the Peters-He inflow model was used to capture the highly nonlinear effects of downwash. The force required to create the downwash is equal in magnitude and opposite in direction to the lift force on the airfoil. The lifting force is used as input in the downwash model and the downwash reduces lifting force which is fed back into the downwash model.

Key Highlights:

Product: Adams

Industry: Aerospace

Benefits:

- Leverage Adams simulation to accurately capture the interactions between the lifting forces on the rotor blades and downwash
- Use multiple-flexible part method to capture the large deformation of the rotor blades during the flight
- The aerodynamic forces and moments acting on the UAV are incorporated into the Adams model as a user-defined function
- Adams analysis results correlates well with physical tests regarding flight behavior
- Adams simulation saved the team at least 6 months compared to the traditional approach

A state space representation of the actual flying control system equations was implemented to control the simulated aircraft. The state space system includes position

Fig. 1: Saab Skeldar V200 unmanned aerial vehicle

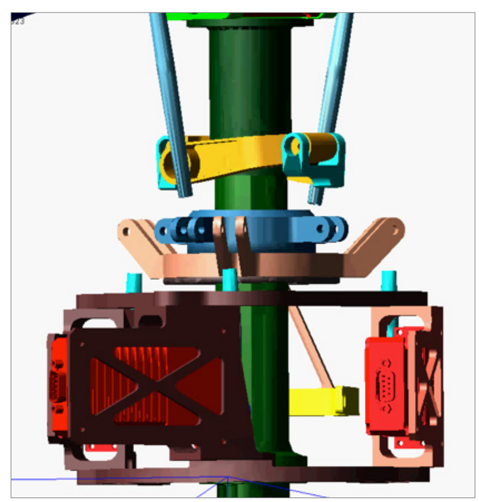


Fig. 2: Adams model of rotor mechanism

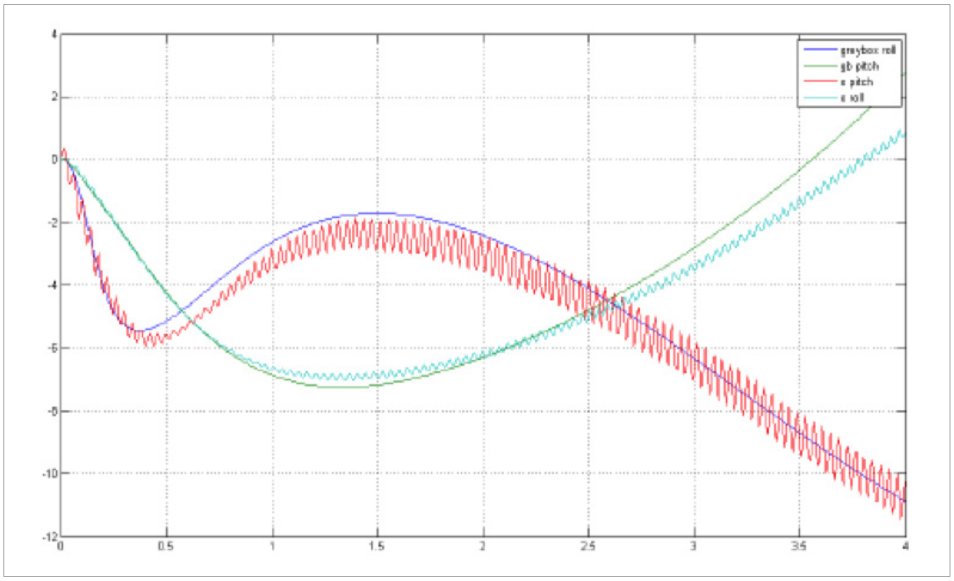


Fig. 3: Comparison of simulated flight response for pitch step data with measured response

error feedback, time integrated position error and time derivative position feedback. Since the UAV's motion is also dependent on its attitude, the control loop is also fed by attitude and attitude rates. The model is driven by applying rotation to the main rotor shaft. Tail rotor control is also applied to prevent the UAV from spinning in reaction to the forces applied to the rotor. The motion of the rotor blades results in applied external aerodynamic loads. The loads cause the helicopter to move and this motion is used as input by the control system which controls the rotation of the main and tail rotors.

An extensive process was used to validate the model. Static modal measurements on the blade matched up well with the numerical model. Flap moments were measured in rotor rig tests and compared to the model. The overall shape of the flapping motion was well captured by the model. The flight behavior of the model was correlated to flight tests by feeding the actual flight control input for a test case to the simulation model. The model did a good job of duplicating the pitch and roll response of the prototype, even though the wind during the actual flight was not known. For more controlled tests in no wind using smaller control inputs, the response of the model compared even better to measured data.

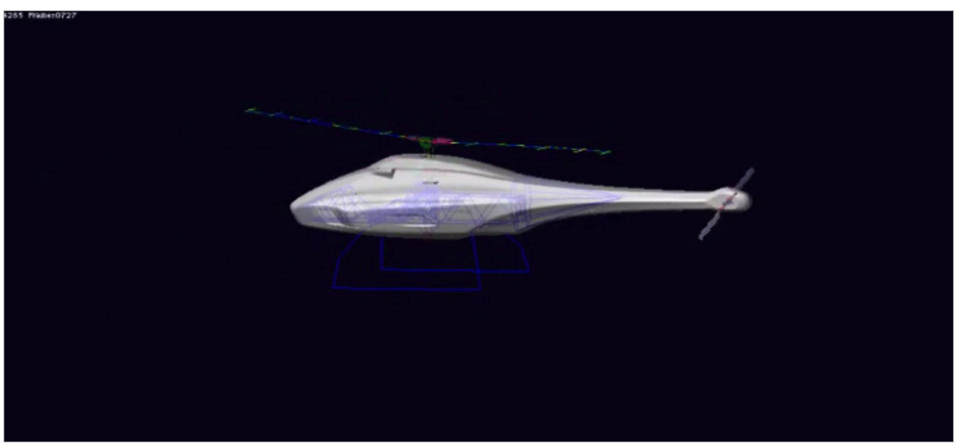


Fig. 4: Simulation of actual flights helped solve design problem

Results

After validating the model, Persson applied it to the issue that had been experienced with the prototype and discovered that the simulation model accurately duplicated the behavior seen in the prototype. The simulation model provided far more detailed information than could be obtained by instrumenting the prototype, such as the aerodynamic forces acting on each section of the blades. The model also made it possible to evaluate the performance of the UAV under a much wider range of conditions than could ever be evaluated with the prototype due to the time, cost and risks involved in actual test flights. The simulation results helped Persson and other Saab engineers diagnose the cause of the stability problem and develop a potential solution. After the model was updated to evaluate this proposed fix, the problem disappeared in the simulation. At this point, the same change was made to the prototype and test flights showed that the problem had indeed been solved. "The Adams simulation saved us at least 6 months that would have otherwise been required to solve the problem by modifying and testing the prototype," Persson concluded.

About Saab

Saab provides military defense and homeland security products to the global market. The company has about 14,700 employees and sales of $2.8 billion.

For more information on Adams and for additional Case Studies, please visit **www.mscsoftware.com/product/adams**

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