Success Story

Altair

Explicit Dynamic Simulation of Tool Drop on the Outer Wing of the Swift020 Unmanned Aerial System using RADIOSS®

Swift Engineering Inc.

Key Highlights

Industry
Aerospace

Challenge
Define the specification for maximum weight of the maintenance tooling used on the Swift020 UAS

Altair Solution
RADIOSS Explicit Dynamic Impact Simulation

Benefits
- Elimination of costly trial and error testing
- Reduction in maintenance and component replacement time and cost
- Increased reliability

Background

Numerical analysis and simulation is one of the many techniques used to reduce cost and design time in aerospace structural engineering. To take these techniques into explicit analysis (i.e. impact modeling) allows precise visualization of many dynamic events that have often been facilitated by expensive high speed video testing, non-destructive evaluation and lengthy trial and error efforts. The net result of these evaluations typically leads to increase in weight in order to reduce the risk.

Swift Engineering, Inc., based in San Clemente, California is a product development company with over 30 years of experience designing, developing and building high performance advanced composite vehicles, unmanned systems, full-scale demonstrators, build-to-print, and automated robotics. Swift specializes in the design, development, and manufacturing of lightweight composite structures, components, and vehicles. Founded in 1983 as a leading developer of high-performance racecars, Swift has been applying its depth of composite talent to the aerospace and aviation industries since 1997. Swift has emerged as a premier air vehicle designer and manufacturer, as demonstrated through the successful KillerBee Unmanned Aerial Systems (UAS), (now the Northrop Grumman owned Bat™ UAS family), the Boeing Sikorsky Joint Multi-Role (JMR) Demonstrator (Full Airframe authority), the Eclipse Concept Jet program (completed in 200 days from contract to first flight), and many other similar aerospace and oceanic build-to-print composite manufacturing projects.

Keywords: RADIOSS, Impact Dynamic Analysis, Tool Drop, Limit Strain, Unmanned Aerial Systems (UAS)

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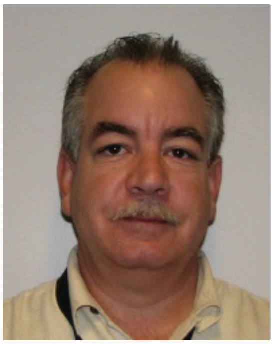

"RADIOSS solver coupled with HyperMesh were instrumental in the rapid design exploration and visualization of the effects of tool drop impact on a thin walled composite UAS wing structure".

William B Gianetti
Senior Research and Development Engineer
Swift Engineering, Inc.

An Accidental Tool Drop on Your Flight Structure

The successful launch of a new platform UAS (Figure 1) is a comprehensive design engineering and manufacturing endeavor. From initial sketches to a fully functional vertical launch; the horizontal high speed flight system requires hundreds of hours of engineering analysis. In addition to engineering the flight system, the full lifecycle must consider maintenance and replacement components. As these requirements often require the use of tools (i.e. screw drivers, wrenches, pliers), the concern became apparent that as the flight surfaces are minimum gage, heavy tools dropped on the structure could cause irreparable damage, down-time and expensive component replacement.

The objective of this project was to determine the specification for maximum maintenance tool weight such that, if dropped from a nominal height of 0.762 meters, would not cause permanent damage to any part of the Swift020 UAS. To accomplish this goal, an explicit model of the UAS was generated in HyperMesh® and impacted by a steel penetrator at defined drop energies. A parametric curve of maximum composite compression strain vs. impact energy and limit strain for the impacted composite material yielded the specification for the maximum tool weight.

RADIOSS Explicit Dynamics Impact Simulation

A full scale model of the Swift020 was generated in HyperMesh (Figure 2). The primary structural components comprised of graphite, fiberglass and Kevlar® epoxy advanced composite materials were modelled using MAT25 material property in RADIOSS. The majority of the structure was minimum gage to reduce weight as the aerodynamic surfaces are the most susceptible areas to tool drop damage due to their high impact cross-section.

The penetrator was modelled as a 0.0254 meter diameter hemispherical tip rod. Initial velocity (INIVEL) of 3.867 m/s

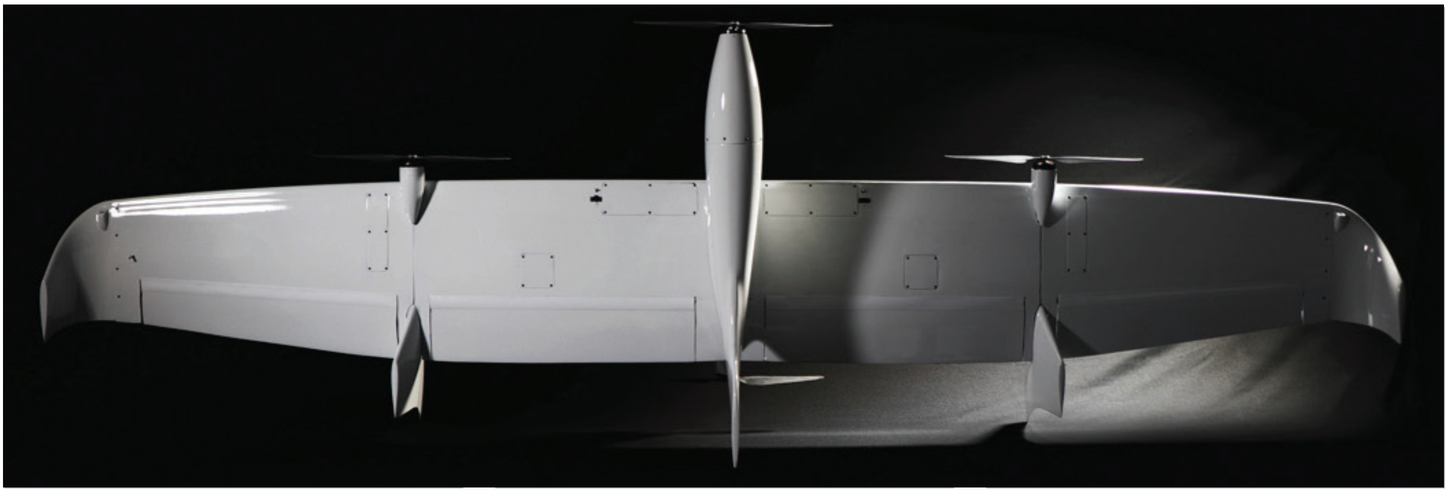

Figure 1. Swift020 Unmanned Aerial System

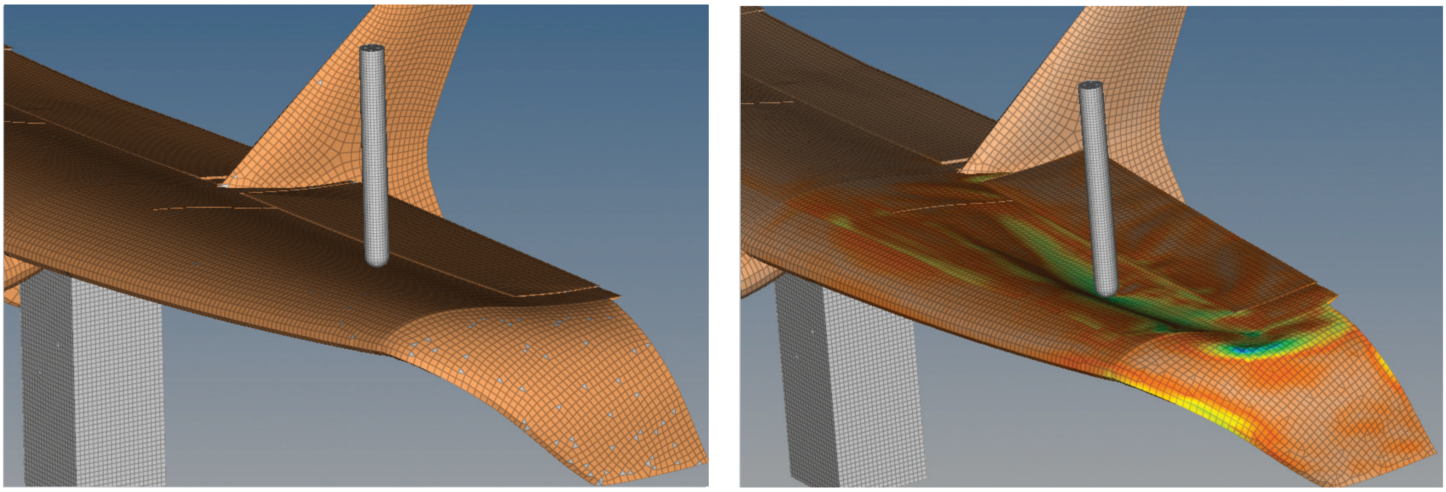

Figure 2. Swift 020 UAS impacted by a steel rod at center of outer wing adjacent to outboard spar

was imposed on the penetrator to simulate a 0.762 meter drop using Conservation of Energy. The impact energy was modulated using the density of the penetrator in the material card. RADIOSS TYPE7 contact was used between the penetrator and the composite wing surface. A Type7 self-contact was also modelled for all nodes and surfaces of the aircraft. The aircraft boundary conditions were modeled as two rubber mounts positioned under the wings. Type 7 contacts were used between the rubber mounts and the wing surface. The base of the rubber mounts were constrained by a Rigid Body(RBODY) entity.

"RADIOSS solver coupled with HyperMesh were instrumental in the rapid design exploration and visualization of the effects of tool drop impact on a thin walled composite UAS wing structure", said William B Giannetti, Senior Research and Development Engineer, Swift Engineering, Inc.

Defining the Maximum Tool Weight

A parametric analysis of the penetrator impact energy was performed in RADIOSS and the results were plotted as shown in Figure 3. The resulting maximum compression strain was compared to the allowable limit strain of the system, resulting in a limit on the tool energy and thus a limit on the tool mass given a constant initial velocity.

For the case of the impact on the outer Kevlar® epoxy wing, the maximum allowable tool drop energy of 1.3 Joules was defined. From the kinetic energy relationship, the maximum tool mass of 0.174 Kg was determined.

Using this value as a requirement for the upper limit on tool mass, can mitigate tool drop impact damage and thus increase reliability and reduce the risk of structural damage.

Tool Drop Impact - Outboard Kevlar Wing
1.0"Impact Rod
Dropped from 2.5 feet

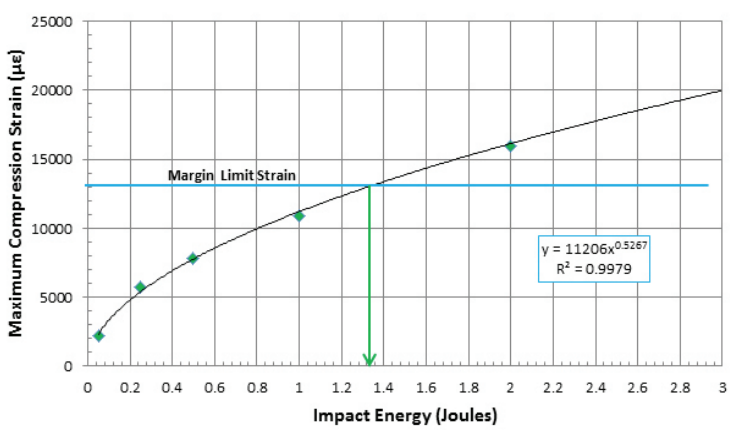

Figure 3. Maximum Laminate Compression Strain (P3min) as a function of Impact Energy and Margin Limit Strain

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About Altair

Altair is focused on the development and broad application of simulation technology to synthesize and optimize designs, processes and decisions for improved business performance. Privately held and headquartered in Troy, Michigan, USA the company operates globally to serve customers in a diverse range of industries including automotive, aerospace, defense, meteorology, architecture and construction, energy, electronics, and consumer goods.

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About HyperWorks

HyperWorks is the most comprehensive open-architecture simulation platform, offering technologies to design and optimize high performance, efficient and innovative products. HyperWorks includes modeling, analysis and optimization for structures, fluids, multi-body dynamics, electromagnetics and antenna placement, model-based development, and multiphysics. Users have full access to a wide suite of design, engineering, visualization, and data management solutions from Altair and its technology partners.

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