



# HIGH VELOCITY IMPACT ANALYSIS

## FOR AERONAUTICS



- ### KEY BENEFITS
- Use predictive simulation to get certification by simulation
  - Implement industry validated design methodologies for high accuracy of results
  - Shorten development process: save time and lower costs
  - Benefit from multi-disciplinary compatibility

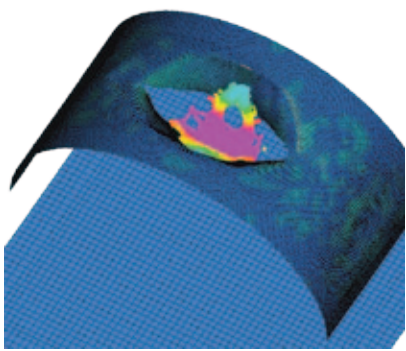
Aeronautics and Aerospace industries take into account very seriously the risks of impact on aircraft and spacecraft structures. High Velocity Impact (HVI) simulation is used to analyze the dynamic behavior of material under very high speed impacts. This typically finds applications in aerospace where understanding the damage suffered by spacecraft encountering space debris such as micrometeoroid is very important. This is also urgently required by the aircraft industry as impacts from birdstrikes or foreign objects can be a serious jeopardy.

Virtual Performance Solution includes PAM-SHOCK, a dedicated application for the analysis of HVI scenarios. It enables also the simultaneous use of explicit and implicit modules for advanced structural dynamics and impact simulations.

### AIRCRAFT

#### Foreign Object Damage upon metallic and non-metallic components

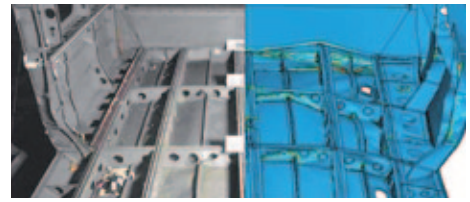
One strong request from the aircraft industry is to be able to simulate the high velocity impact response of primarily composite aircraft structures. PAM-SHOCK enables the predictive simulation of impacts from birds, hail and stones, which eventually can lead to certification by simulation. A dedicated models library containing ESI proprietary bird models for birdstrike simulation is also included.



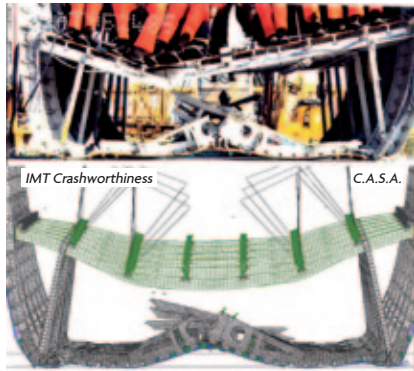
Birdstrike and failure analysis

#### Crashlanding and Splashdown of Fixed and Rotary Wing Aircraft

With the support of several European Research projects, ESI developed design methodologies for aircraft impact survivability through simulation techniques for both metallic and composite structures. As a result, PAM-SHOCK successfully simulates aircraft crashlanding on hard or soft soil and helicopter splashdown for instance.



Helicopter splashdown: simulation vs experimentation  
Courtesy of project CAST, Westland and DLR



A320 crash survivability: experiment vs simulation.  
Courtesy of project IMD & EADS-CASA

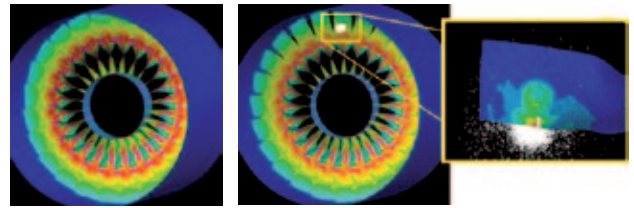
#### Onboard Passive Safety

PAM-SHOCK can interface with ESI's Fluid Dynamics solutions. Producing a fluid-structure interaction capability of unparalleled magnitude, it provides analysts with realistic simulation of complex deformations. For instance, a thin-walled aerospace structure can suffer under extreme loads like internal explosions.

## Engine Blade Containment

PAM-SHOCK allows the simulation of turbine engine blade containment thanks to predictive material models (like elastoplastic shells and solids with EWK\* damage and failure). Besides, it uses the Implicit module for the centrifugal blade pre-stressing initialization.

\* ESI-Wilkins-Kamoulakos model



First step: Implicit run: pre-stress of a centrifugal load for an aircraft turbine

Second step: Explicit run: bird (SPH modeling) striking a prestressed turbine blade

## AEROSPACE

Validated with the European Space Agency against experimental data for hypervelocity impacts, Virtual Performance Solution supports several simulation needs in the aerospace industry.

### Space Debris Shielding

One of the most advanced capabilities of PAM-SHOCK concerns the response of matter under extreme strain rates and pressures. Under these conditions powerful shock waves appear in the condensed associated media which lead to incipient melting and vaporization phenomena.

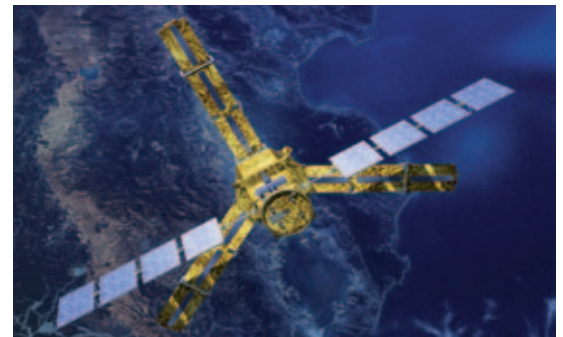
Corresponding material models and equations of state describe the full range of these thermodynamic processes. Additionally, to strengthen an effective protection of satellites and space modules against arbitrary impacts with orbiting Space Debris, the advanced Smoothed Particle Hydrodynamics (SPH) option allows simulation of oblique impacts upon Whipple and Double Bumper metallic and non-metallic spacecraft shields.

### Spacecraft Pyrotechnic Separation

To describe the full Pyrotechnic Separation process, including the detonation process, rocket fairing rupture and associated shock propagation to the upper-stage payload section, PAM-SHOCK offers a range of suitable material models and equations of state.

### Satellite Payload Shock Response and Safety

PAM-SHOCK can simulate the High-Frequency Vibration Response due to a short duration pulse, which typically affects Satellite Payload or Vehicle Equipment Bay after the pyrotechnic cutting used to separate modules in spacecraft or rockets.



SMOS Satellite  
Courtesy of ECA – P. Carril

For more information, visit: [www.esi-group.com/virtual-performance-solution/hvi-analysis](http://www.esi-group.com/virtual-performance-solution/hvi-analysis)

## ABOUT ESI GROUP

ESI is a world-leading supplier and pioneer of digital simulation software for prototyping and manufacturing processes that take into account the physics of materials. ESI has developed an extensive suite of coherent, industry-oriented applications to realistically simulate a product's behavior during testing, to fine-tune manufacturing processes in accordance with desired product performance, and to evaluate the environment's impact on product performance. ESI's products represent a unique collaborative and open environment for Simulation-Based Design, enabling virtual prototypes to be improved in a continuous and collaborative manner while eliminating the need for physical prototypes during product development. The company employs over 750 high-level specialists worldwide covering more than 30 countries. ESI Group is listed in compartment C of NYSE Euronext Paris. For further information, visit [www.esi-group.com](http://www.esi-group.com).



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