

Using Low-Fidelity Digital Twins for High Speed Analysis

John Glatfelter,
Technical Fellow
Advanced Projects
Boeing

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2018



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Terms

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- **Susceptibility** P_H hit given a threat
- **Vulnerability** $P_{K|H}$ kill given a hit



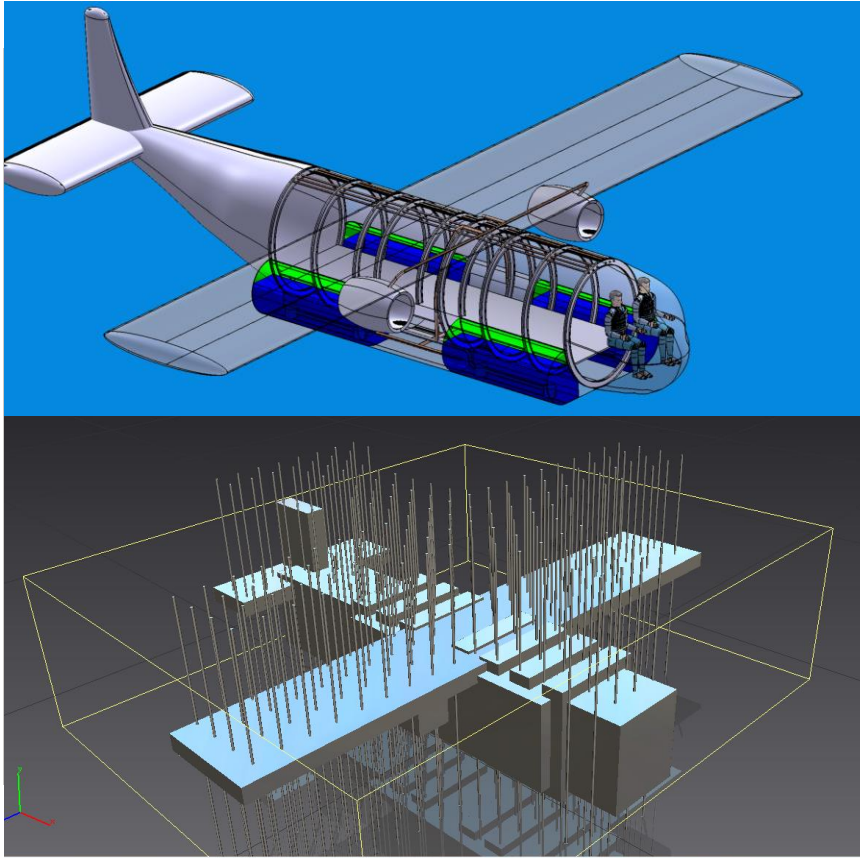
Reference: [wikipedia/commons/thumb/a/a1/F-117_Nighthawk_Front.jpg](https://commons.wikimedia.org/wiki/File:F-117_Nighthawk_Front.jpg)



https://en.wikipedia.org/wiki/McDonnell_Douglas_F-15_Eagle

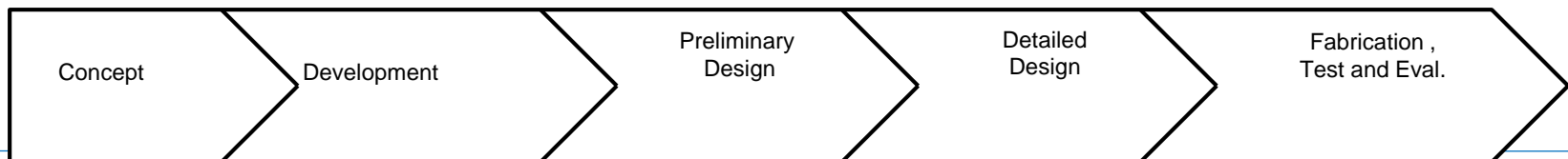
Goal

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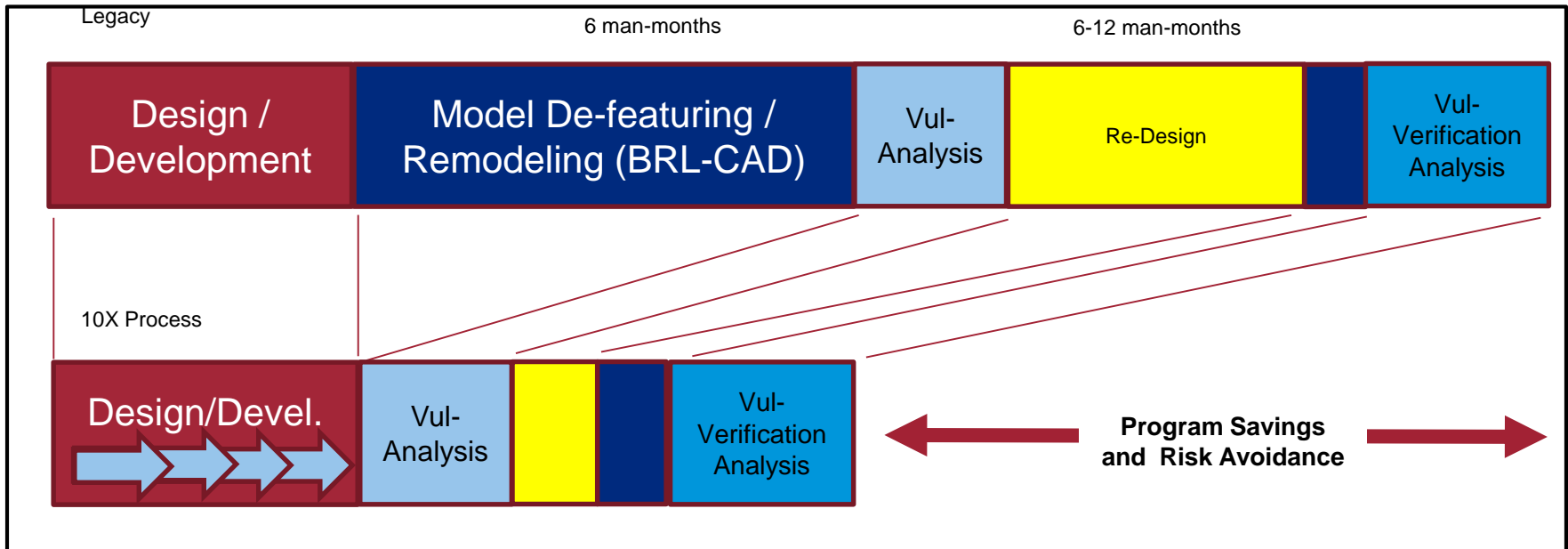
A design tool that can be used to measure the vulnerability of an air vehicle throughout the design process

- Ensures the vulnerability requirements are being met at each phase of the development cycle through continuous assessments
- Allows sufficient time to revise the design avoiding development delays and impacts to program costs/schedule.
- The tool enables predictive assessments vs. the current process of reactive assessments



Business Opportunity

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*Notional For Light Rotorcraft Program

10X Process Improvement – (From Months to Minutes)

Historical Perspective

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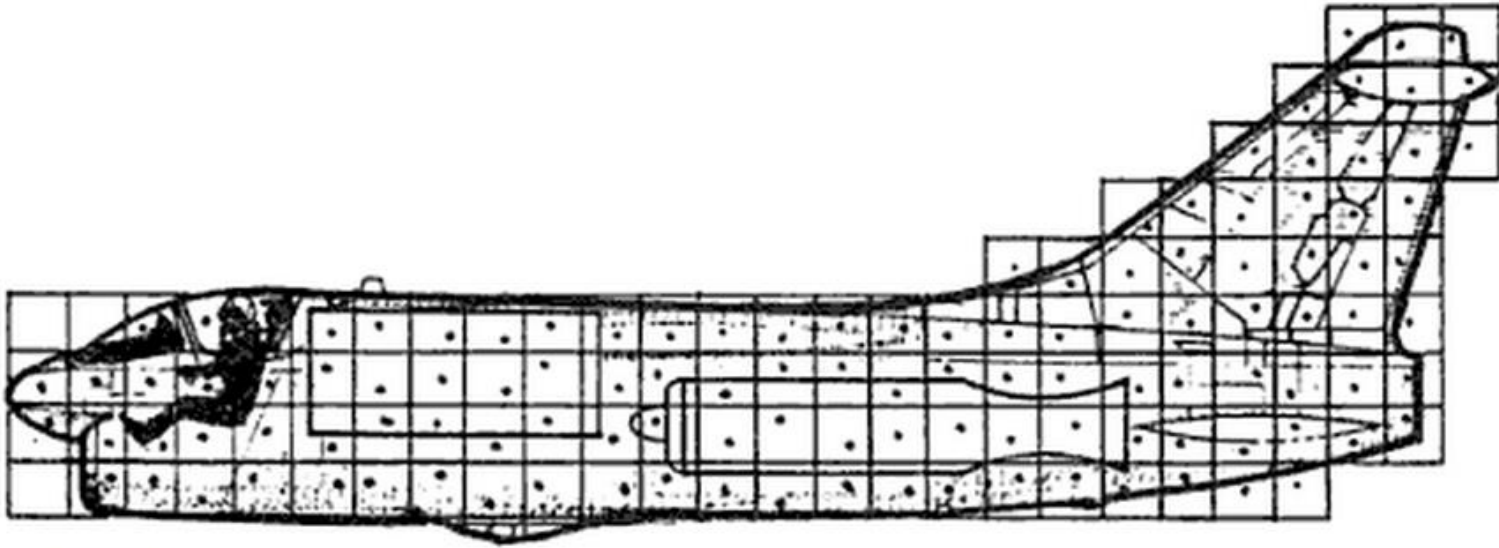


FIGURE 1-2 Example of a grid and random shotlines from FASTGEN for COVART (Ball, 1985). Copyright © AIAA 1985—Used with permission.

The aircraft is analyzed looking at 26 views typically. All flight critical components are modeled. A grid size is selected and a shot placed either at the center or randomly within the grid square.

Conceptual Kill Tree

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REVIEW OF CURRENT METHODOLOGIES AND IDENTIFICATION OF APPLICATIONS

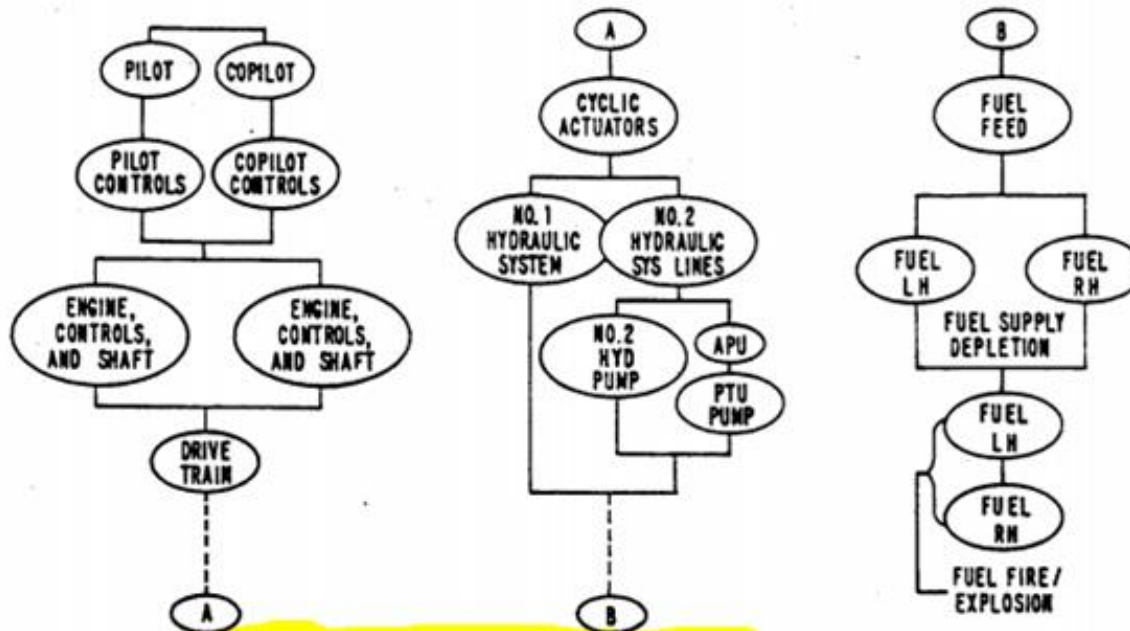
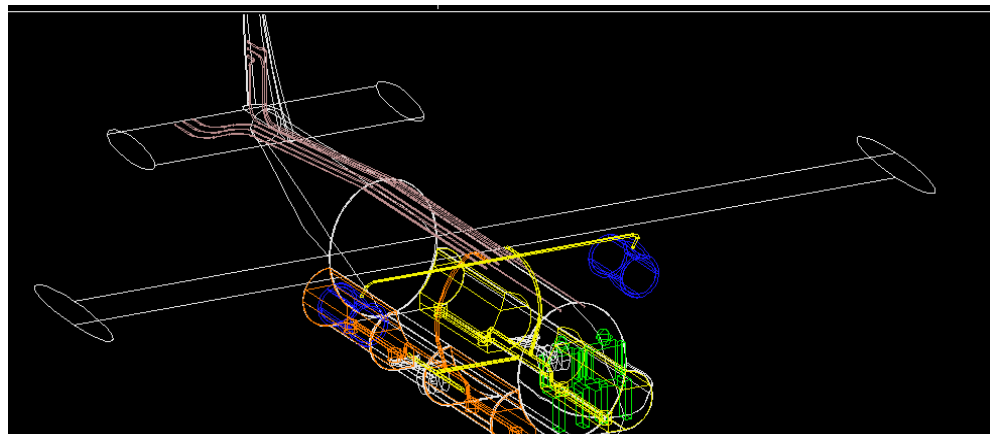
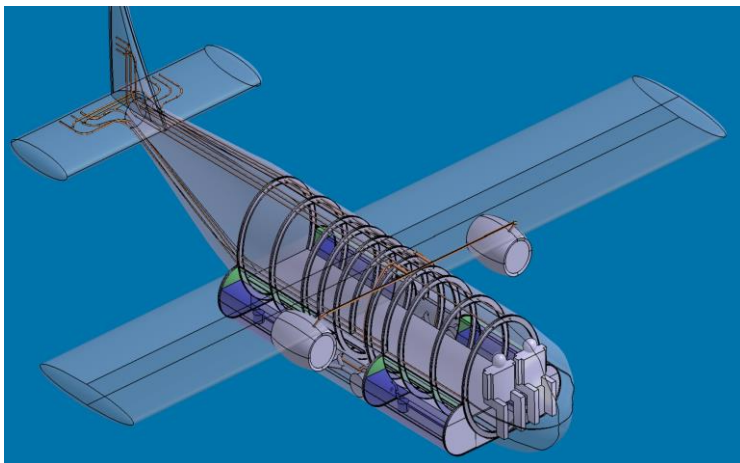


FIGURE 1-1 The attrition kill tree for a two-piloted, two-engined helicopter (Ball, 1985).

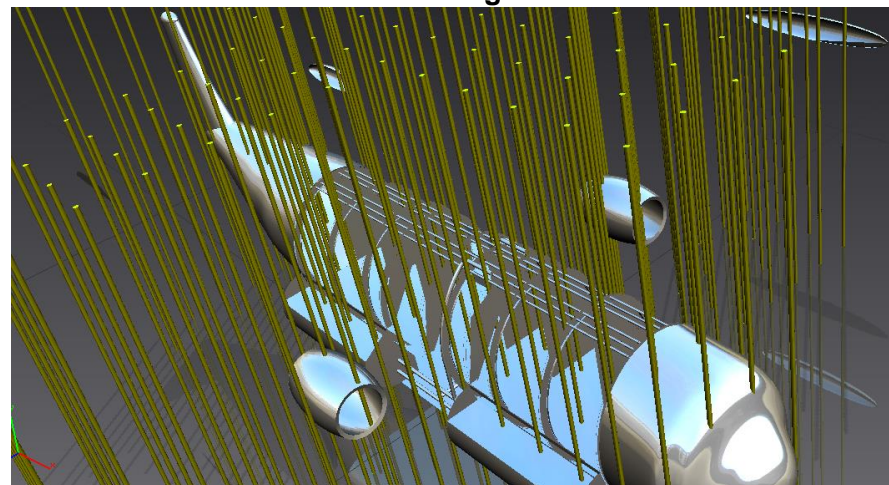
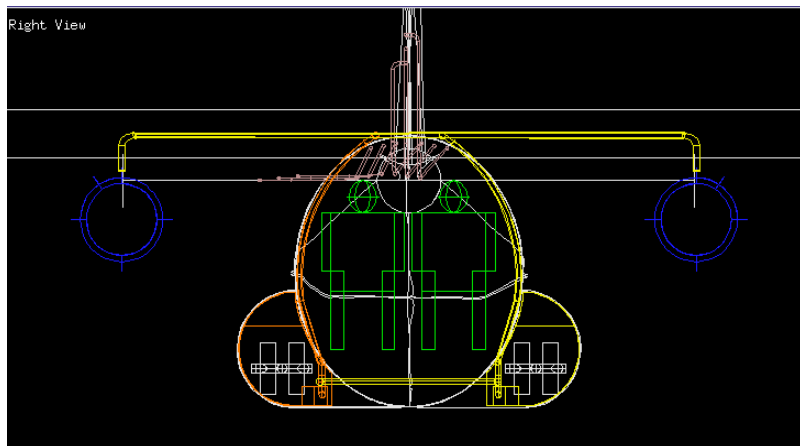
Reference: The Fundamentals of Aircraft Combat Survivability Analysis and Design, Robert E. Ball

Deliverable #1: Surrogate Aircraft Model

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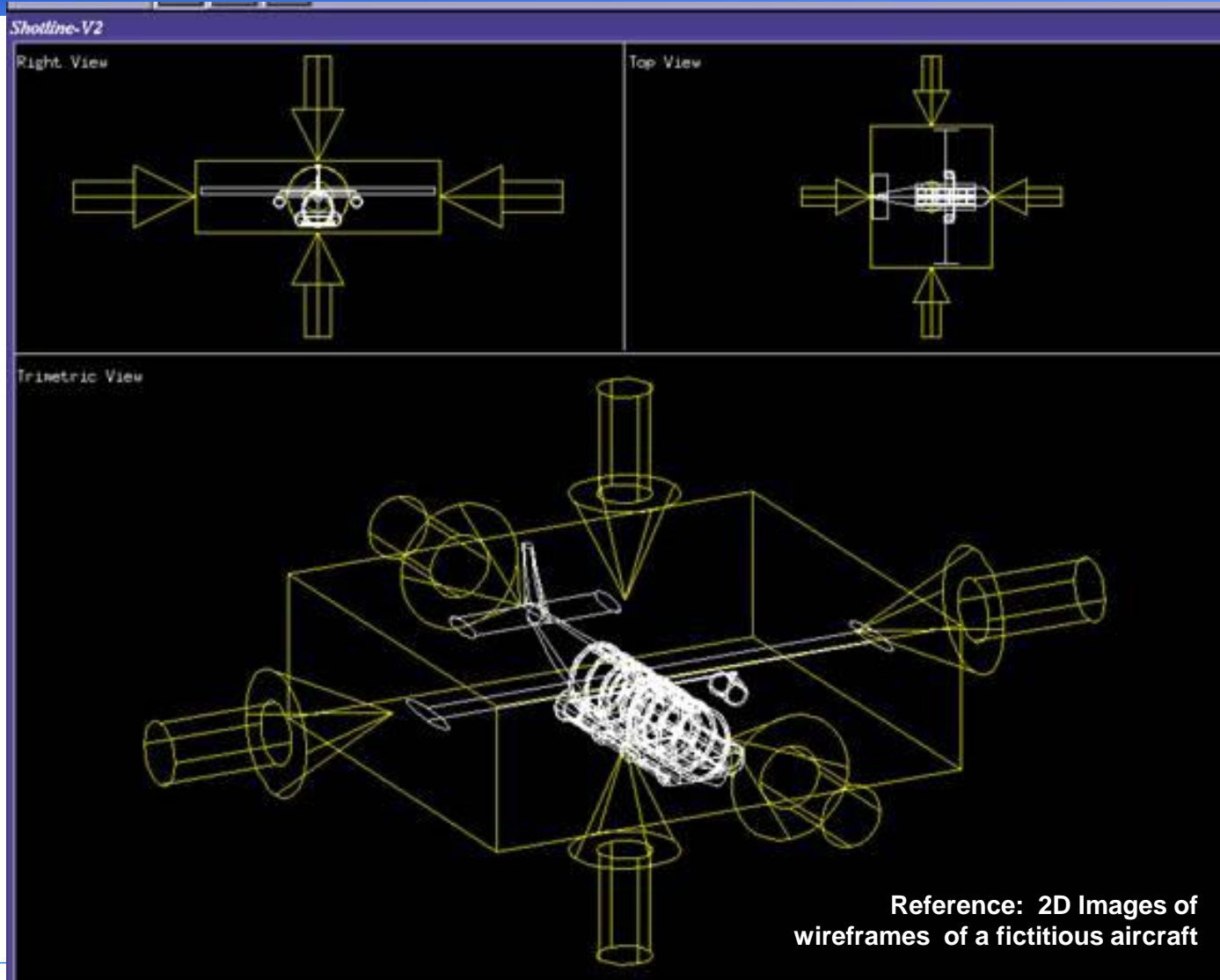
Reference: 3D solid and wireframe images of a fictitious aircraft



Surrogate Aircraft Demonstrates Emerging Capability

Deliverable #2: Knowledge Model

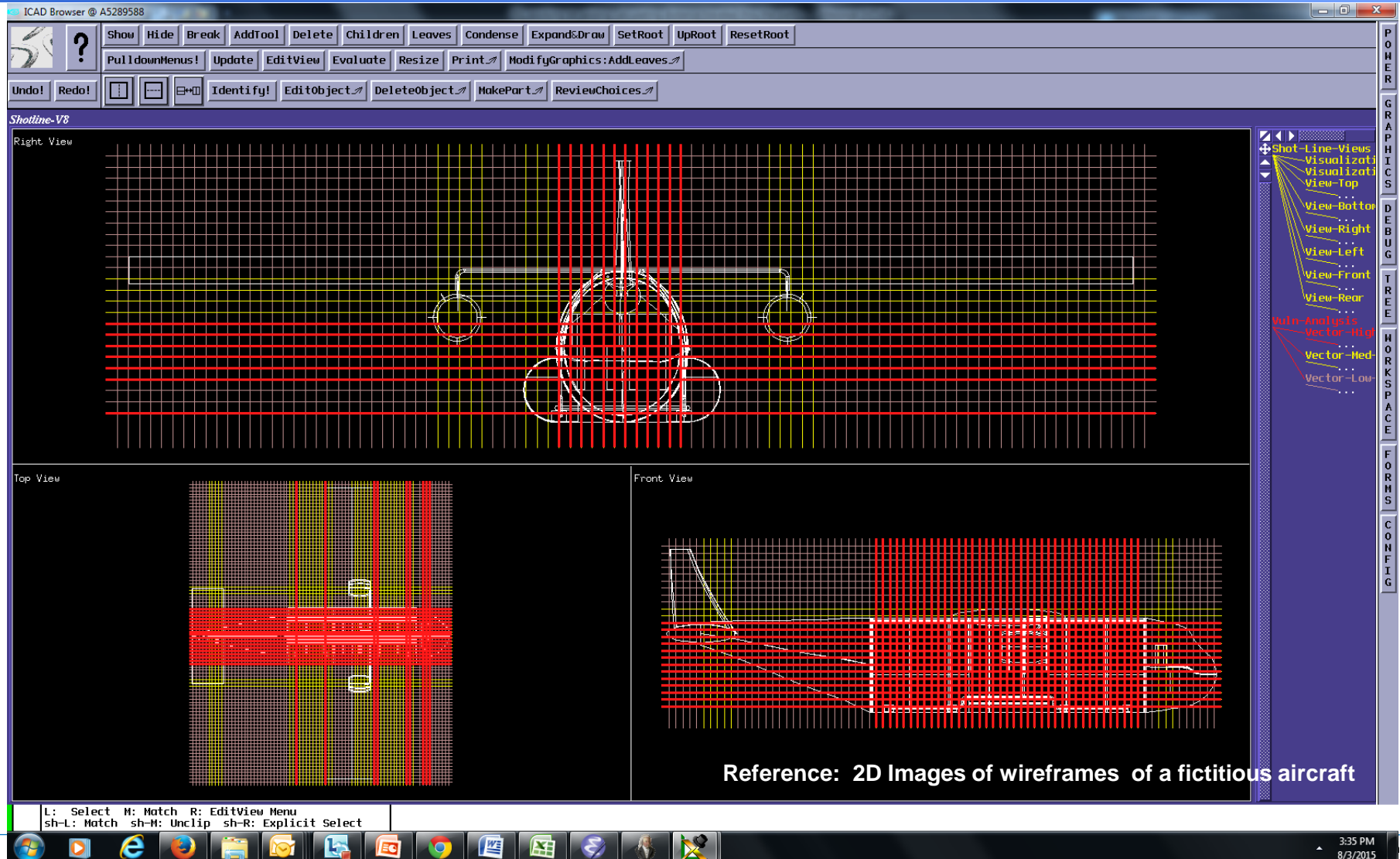
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Automated Shot-line Calculations

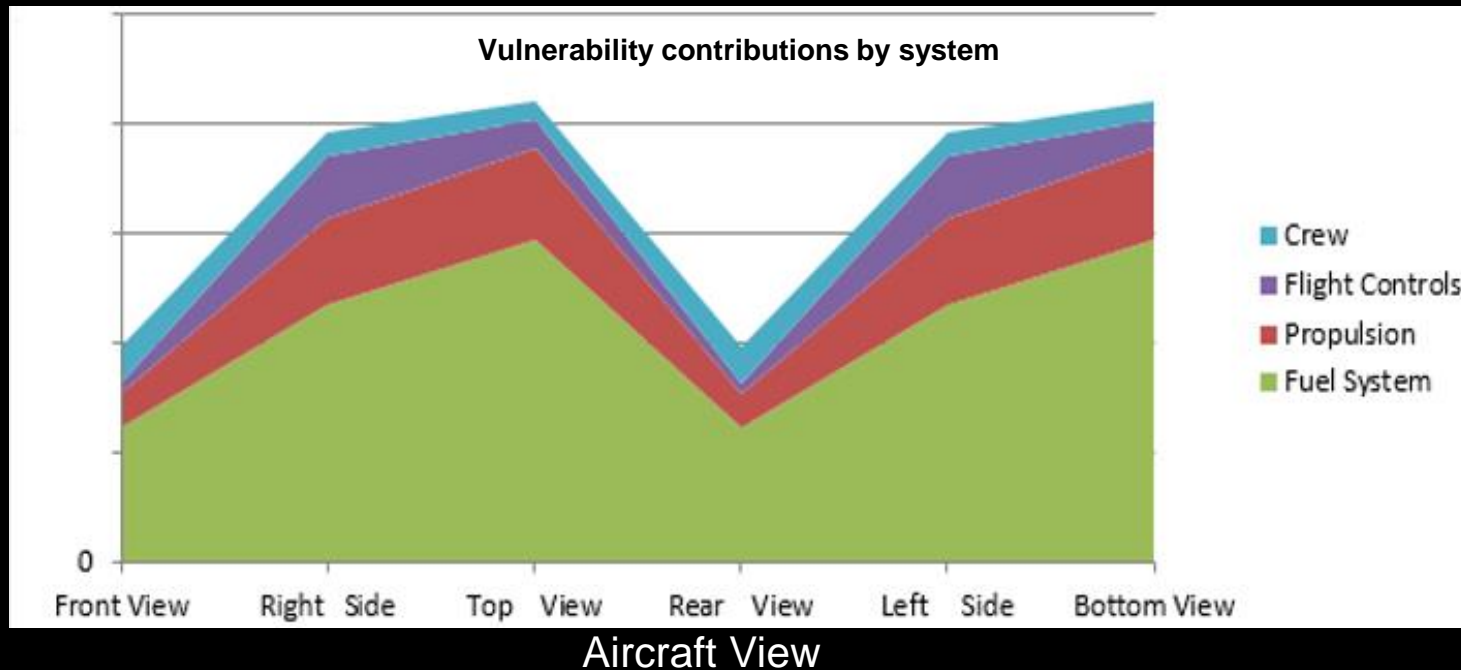
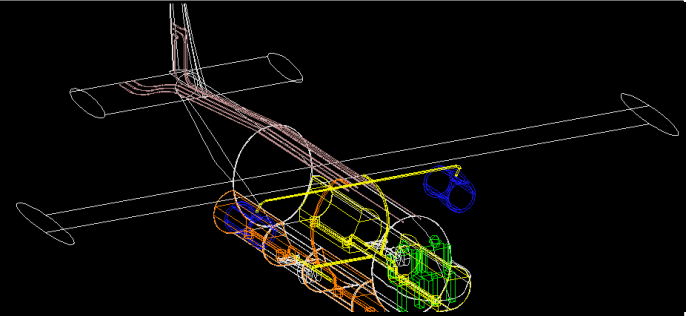
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Reference: 2D Images of wireframes of a fictitious aircraft

Vulnerability Assessment of the Surrogate Aircraft

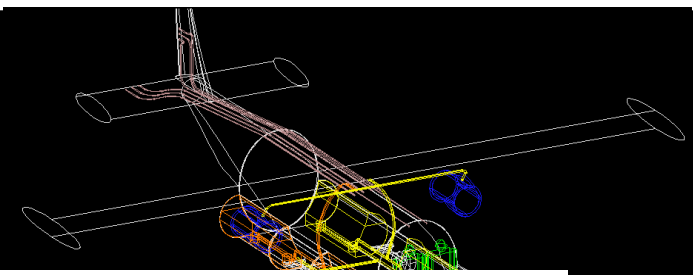
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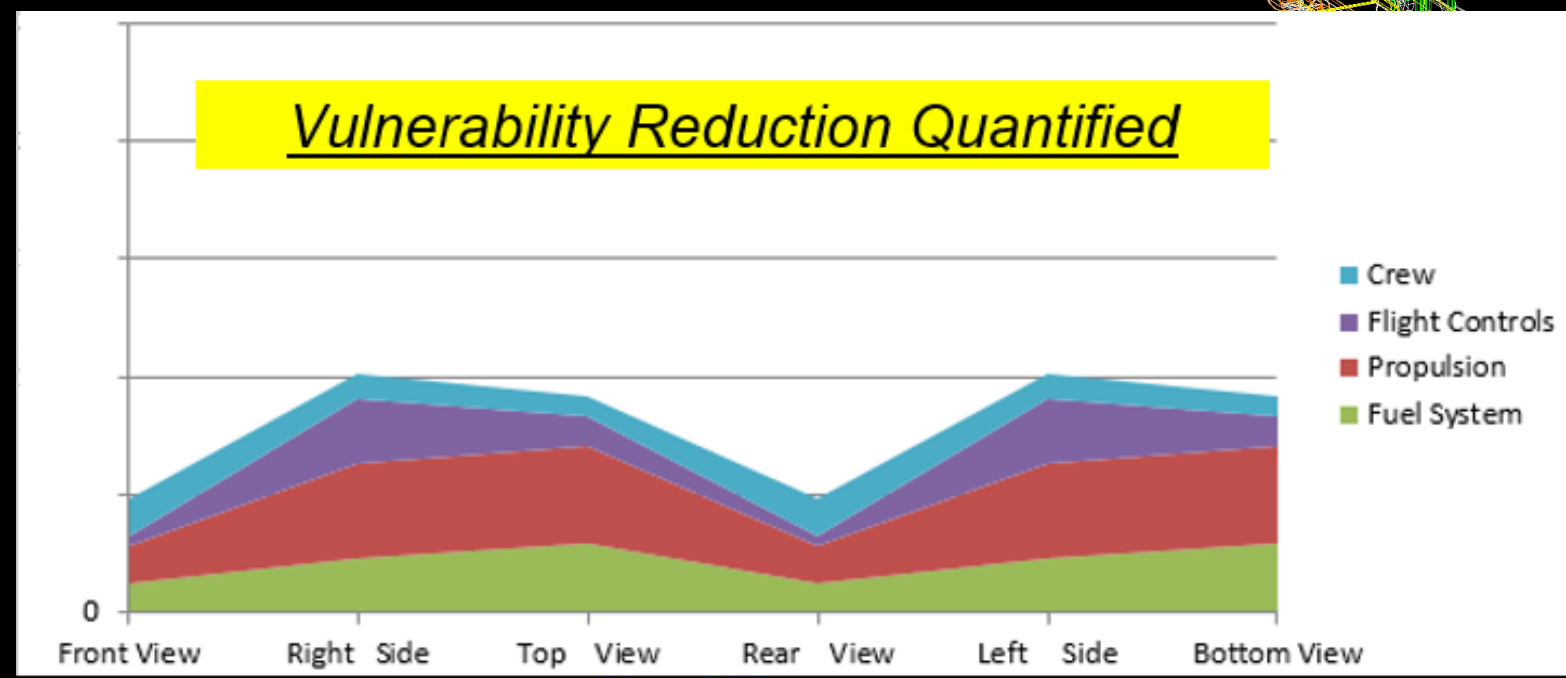
Vulnerability Assessment of the Surrogate Aircraft

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Vulnerability contributions by system
Self-sealing fuel lines incorporated



Vulnerability Reduction Quantified

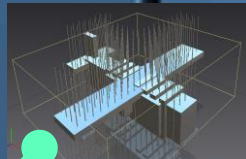


Aircraft Views

PERFORMANCE and SCALABILITY enhancements

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100% of
All shot-lines
across entire
aircraft at given
Grid-density



RegionID	Region Objects
25-999	Skin
1000-1999	Propulsion
2000-2999	Crew
3000-3999	Flight controls and hydraulics
4000-4999	Fuel system
5000-5999	Drive/Propellers
6000-6999	Armament
7000-7999	Structural equipment
8000-8999	Yoke equipment
9000-9999	Miscellaneous

5% of salient
shot-lines



Filtering of Shot-lines
using Advanced De-featuring
and uni-directional vector
symmetry.

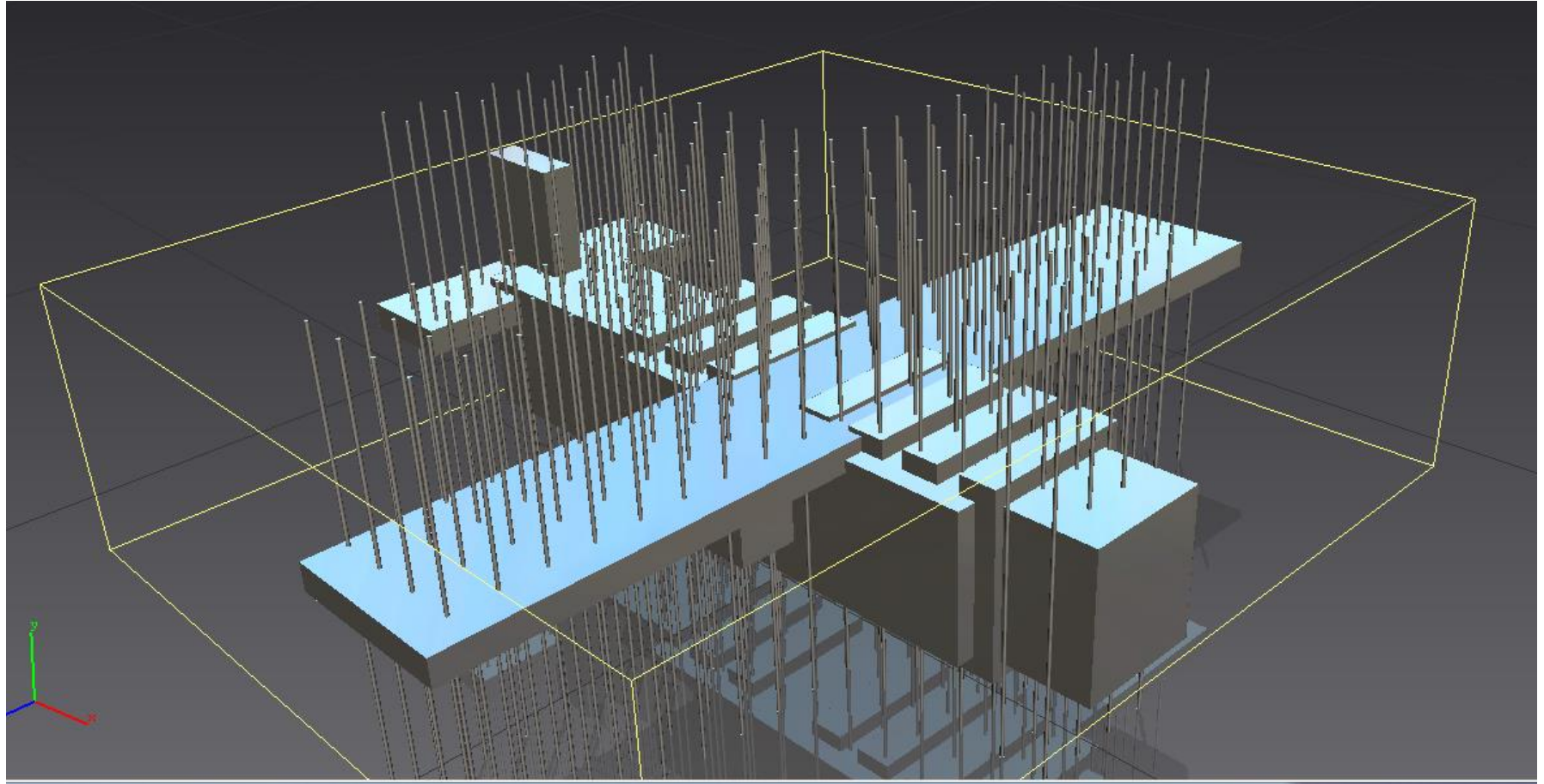
Filtering of Parts
using UNS naming
conventions
Removing skins and structure

**Restrict "arena" to
Systems only**
*Concern about systems
configuration*

**95% Reduction in Boolean Permutation Computations necessary to
perform Vulnerability Analysis**

Course Shot-line vector reduction Using Lo-Fidelity Model

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Reference: 3D Image of Boolean solids of a fictitious aircraft

Summary

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- **Exceeded the objectives, we can create the presented area calculations of a 50' aircraft in under 2 minutes**
- **Developed a working prototype**
- **Demonstrates its use on a notional aircraft**
- **3 Patent disclosures – 2 filings.**
- **Months- to-minutes improvements**