# Using Low-Fidelity Digital Twins for High Speed Analysis

John Glatfelter,
Technical Fellow
Advanced Projects
Boeing

# Terms



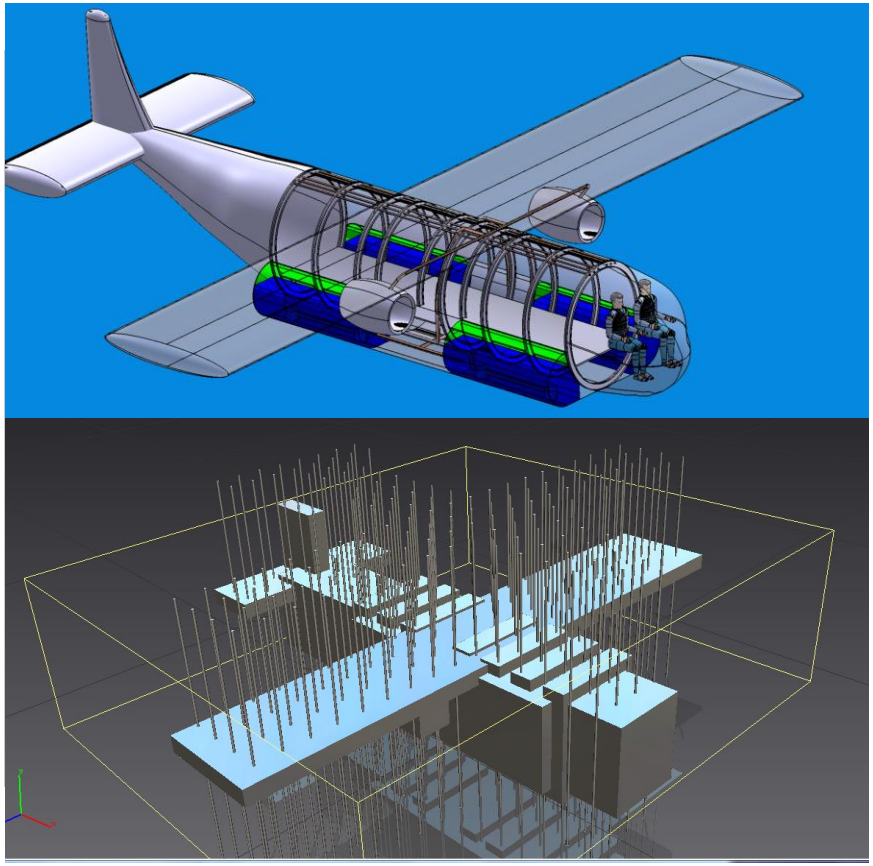
- **Susceptibility $P_H$ hit given a threat**
- **Vulnerability $P_{K|H}$ kill given a hit**

Reference: wikipedia/commons/thumb/a/a1/F-117_Nighthawk_Front.jpg

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

# Goal



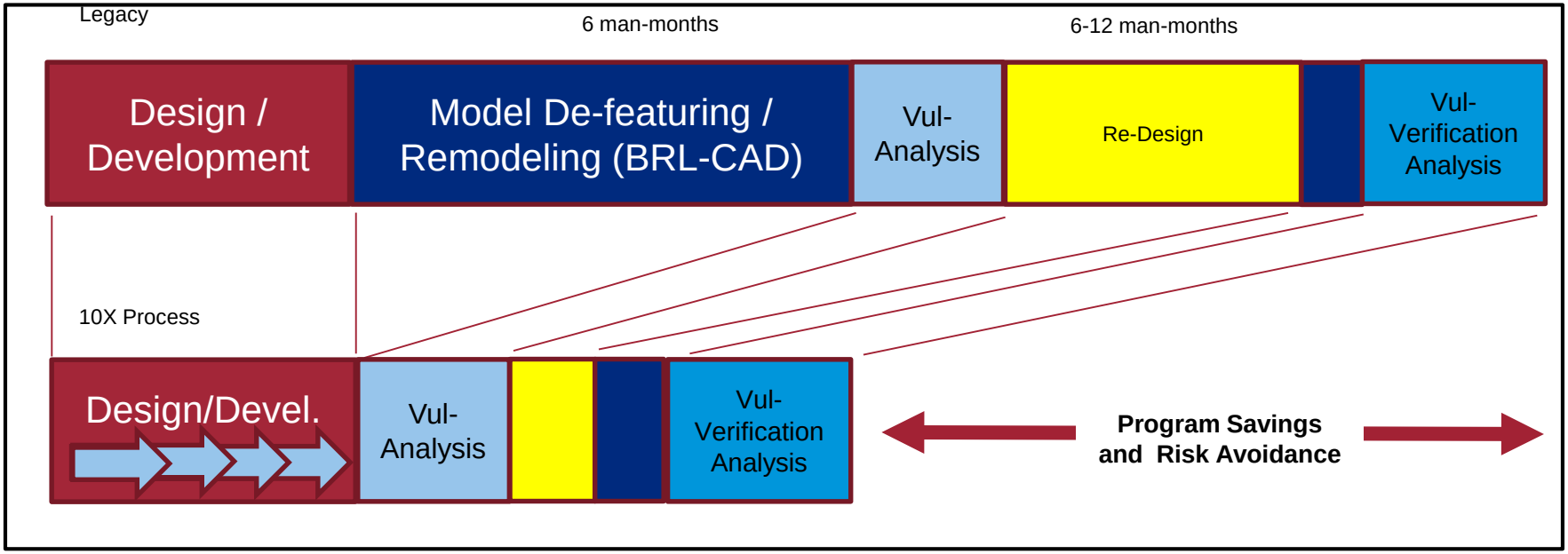


## A design tool that can be used to measure the vulnerability of an air vehicle throughout the design process

- **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






*Notional For Light Rotorcraft Program

*10X Process Improvement – (From Months to Minutes)*

# Historical Perspective



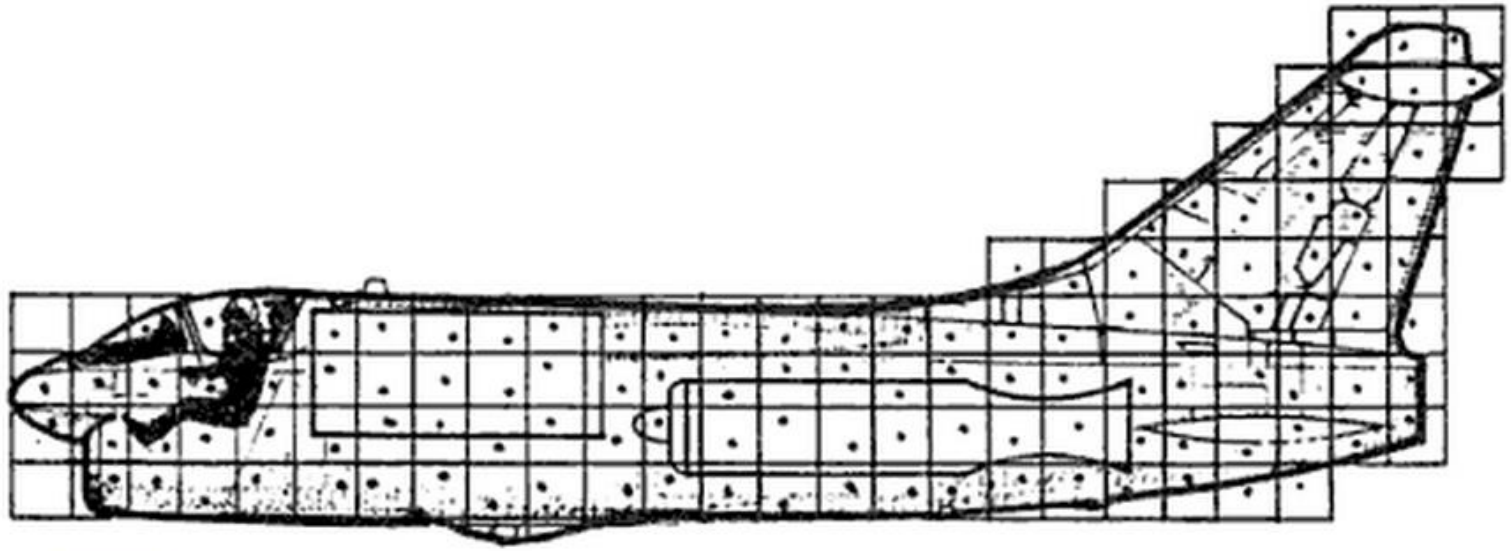


FIGURE 1-2 Example of a grid and random shotlines from FASTGEN for COVART (Ball, 1985). Copyright © AIAA 1985—Used with permission.

**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





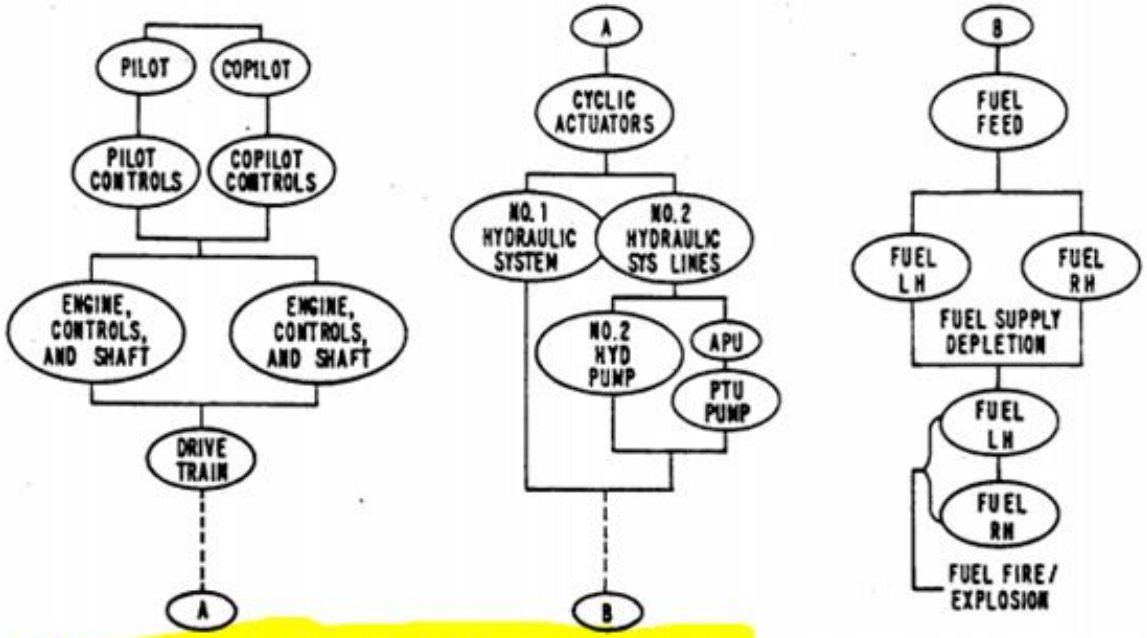
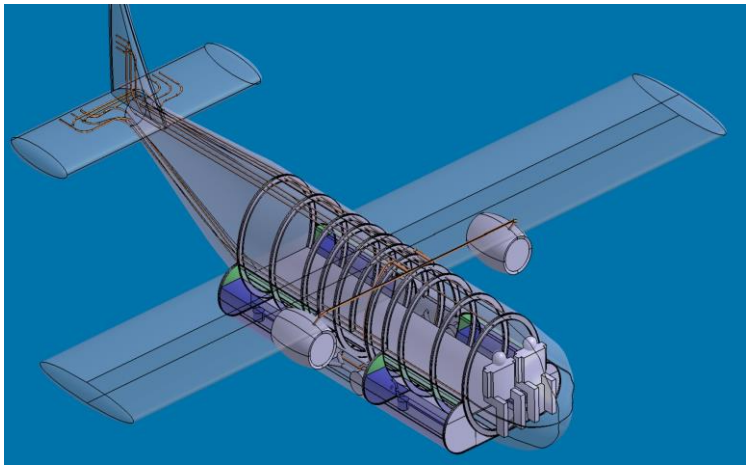


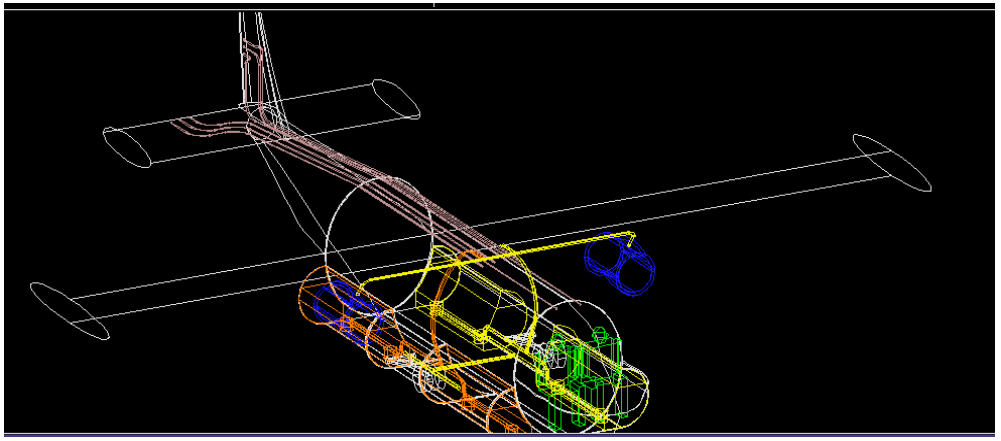

FIGURE 1-1 The attrition kill tree for a two-piloted, two-engined helicopter (Ball, 1985).

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

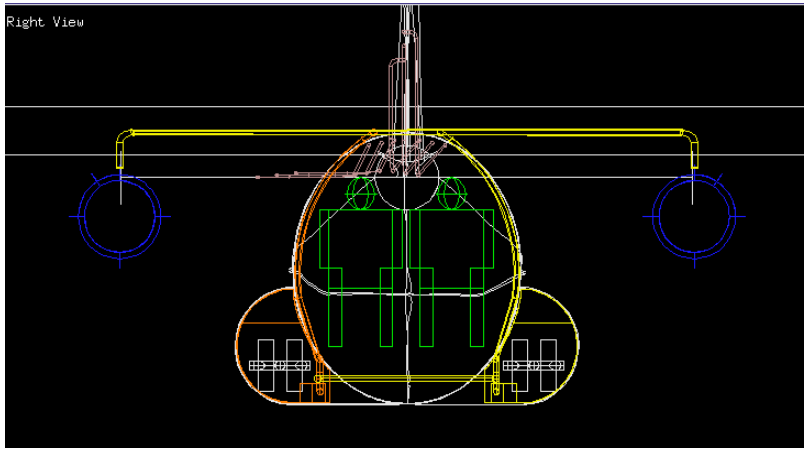
# Deliverable #1: Surrogate Aircraft Model

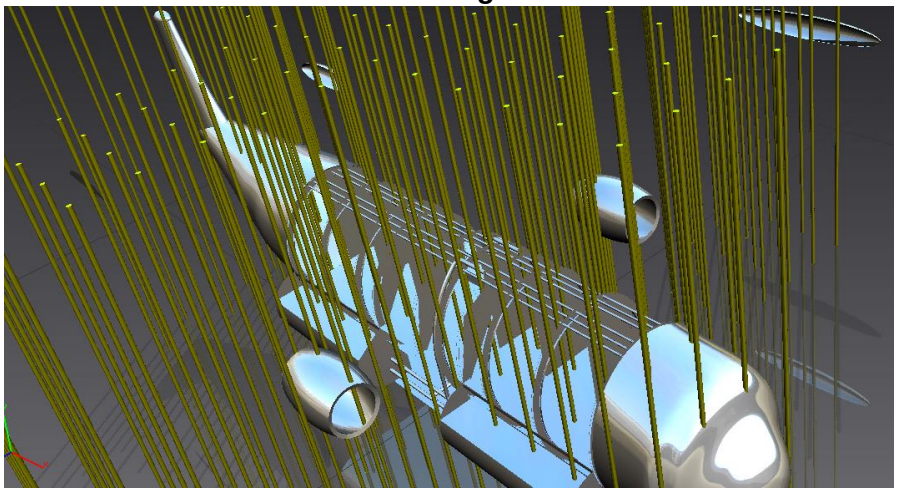






**Reference: 3D solid and wireframe images of a fictitious aircraft**

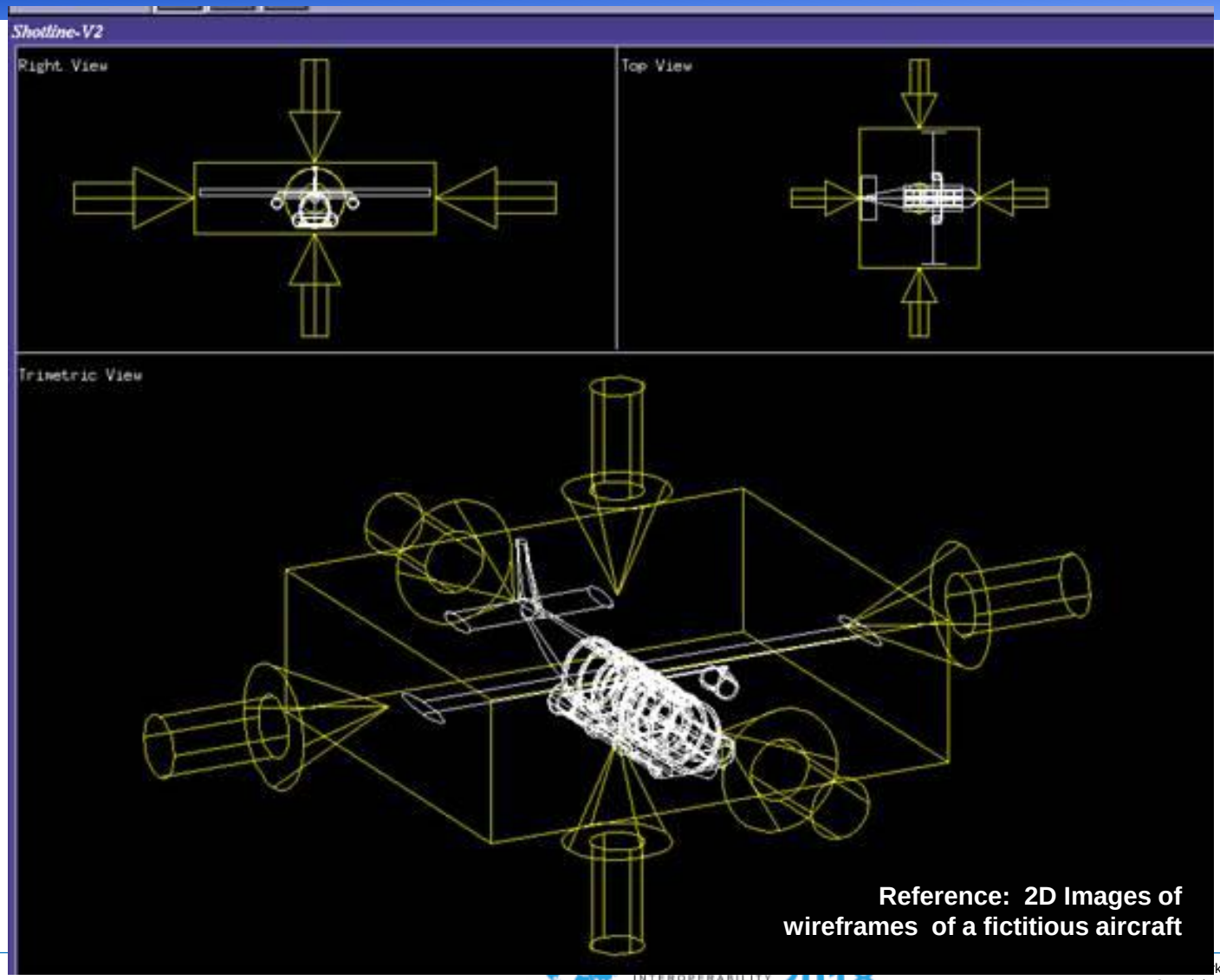


*Surrogate Aircraft Demonstrates Emerging Capability*

# Deliverable #2: Knowledge Model

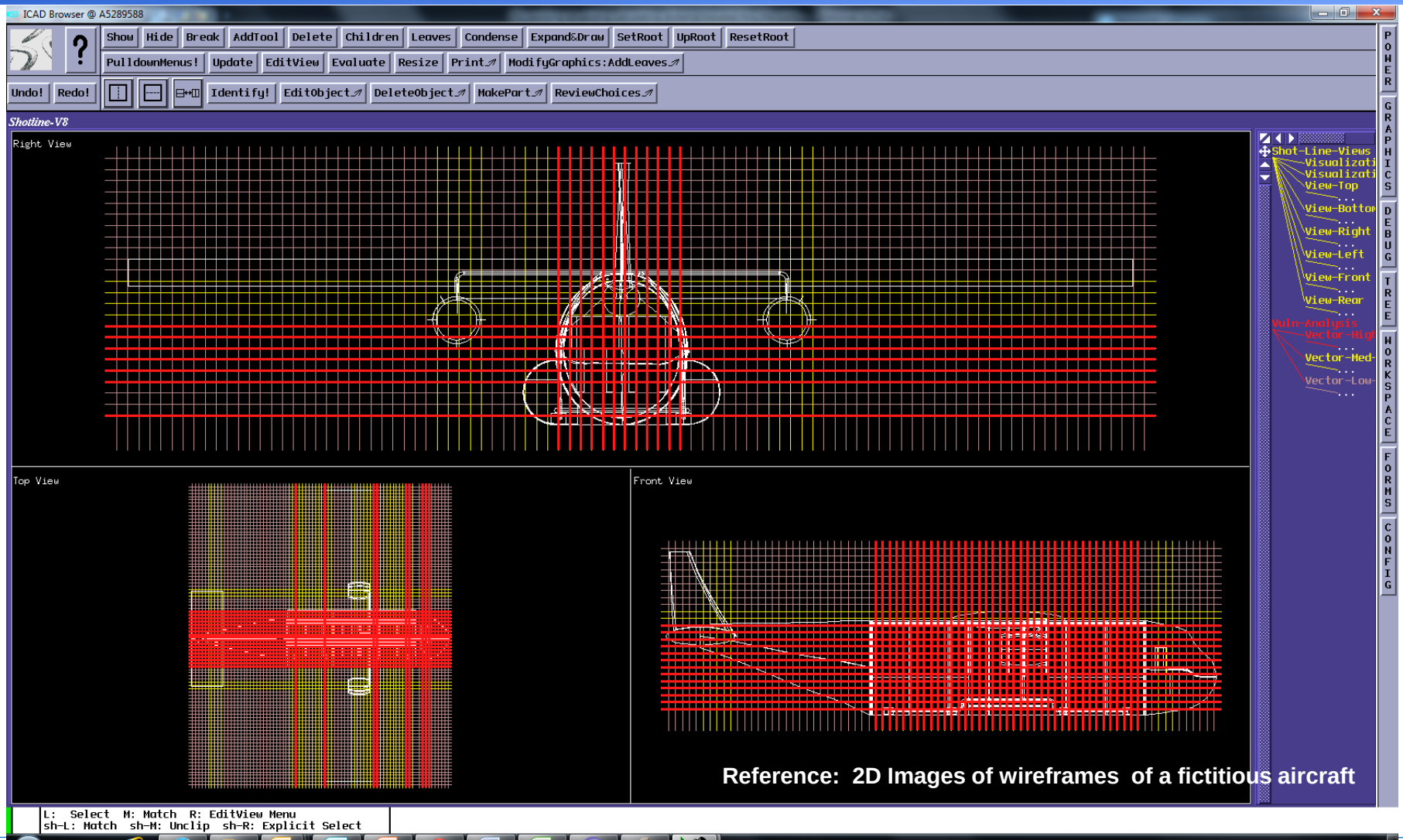





**Reference: 2D Images of wireframes of a fictitious aircraft**

# Automated Shot-line Calculations

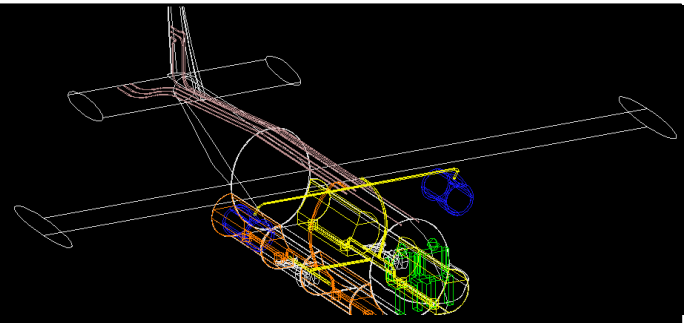


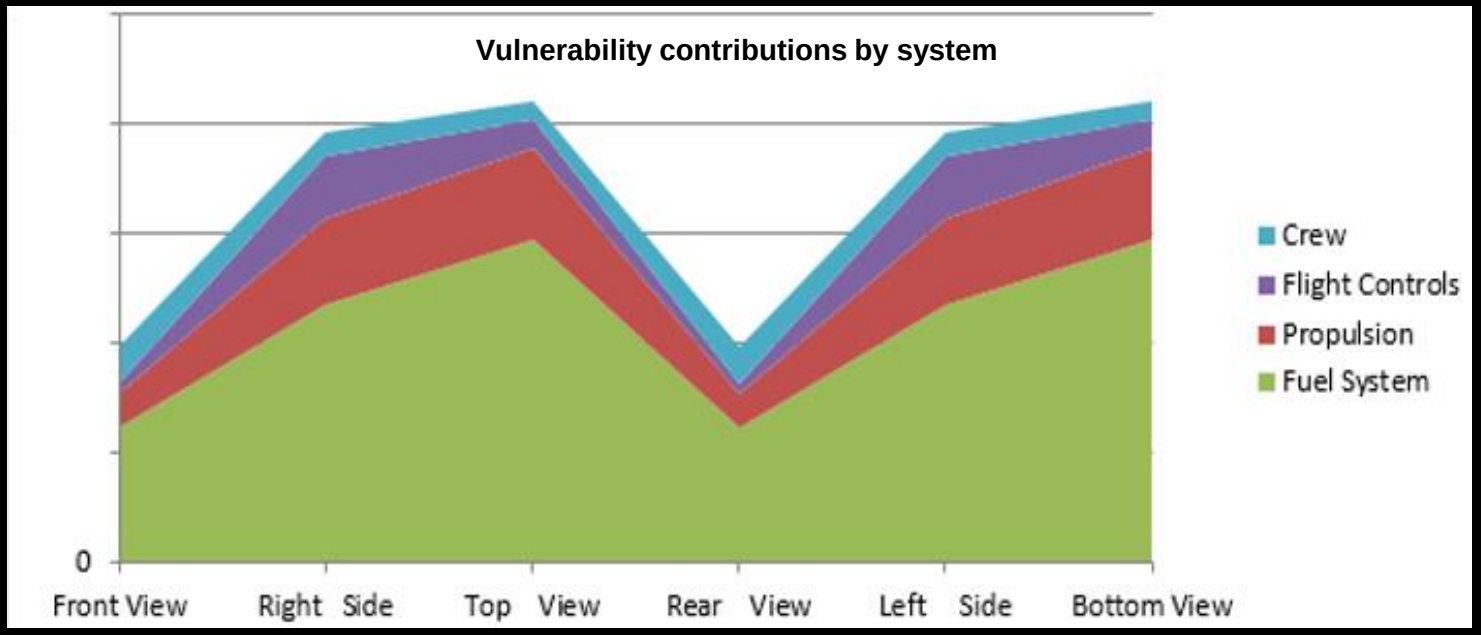



**Reference: 2D Images of wireframes of a fictitious aircraft**

# Vulnerability Assessment of the Surrogate Aircraft





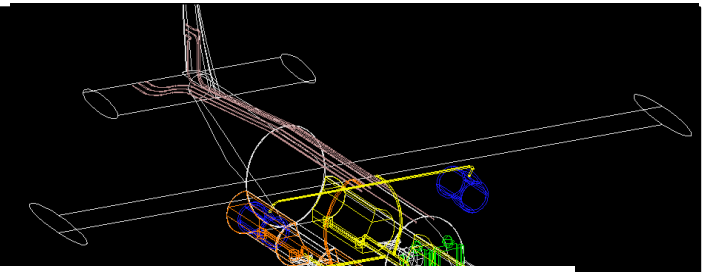


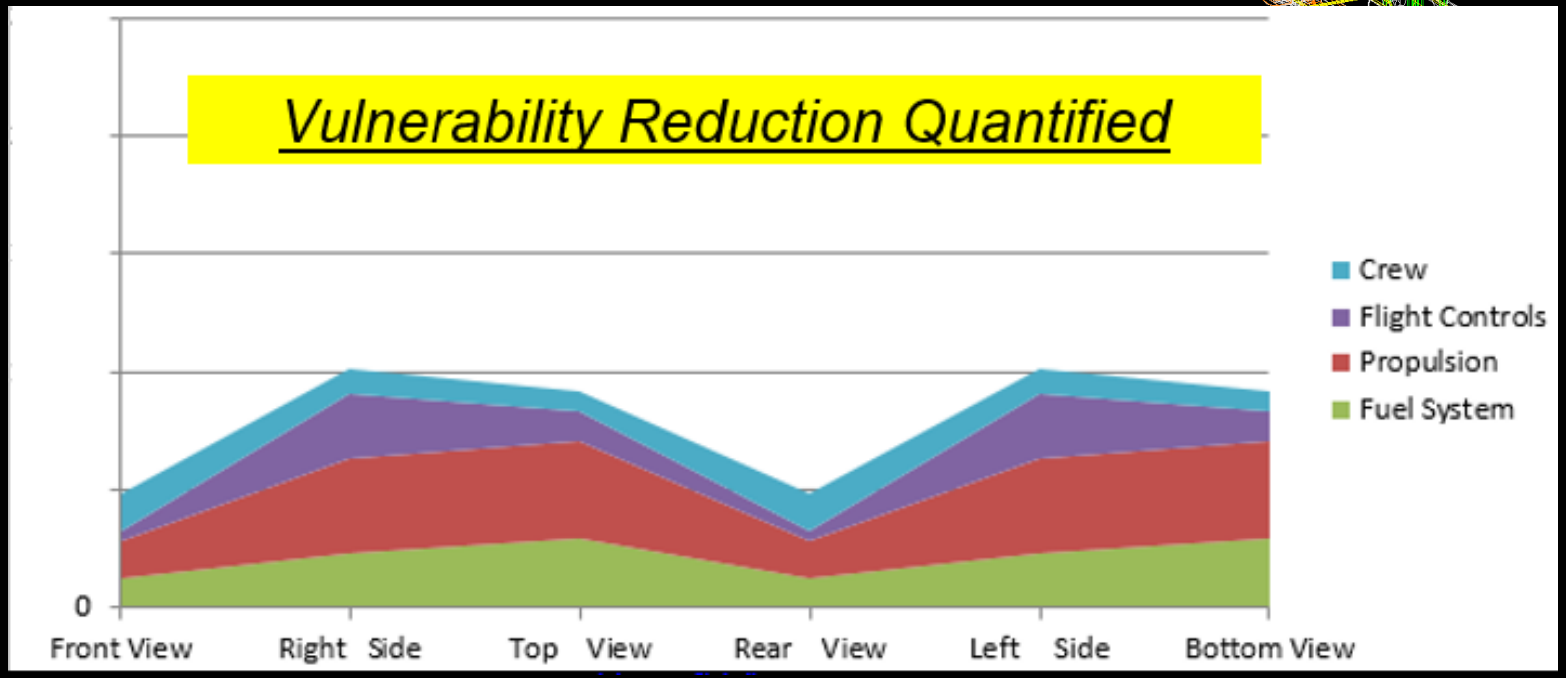

Aircraft View

# Vulnerability Assessment of the Surrogate Aircraft



Vulnerability contributions by system
Self-sealing fuel lines incorporated

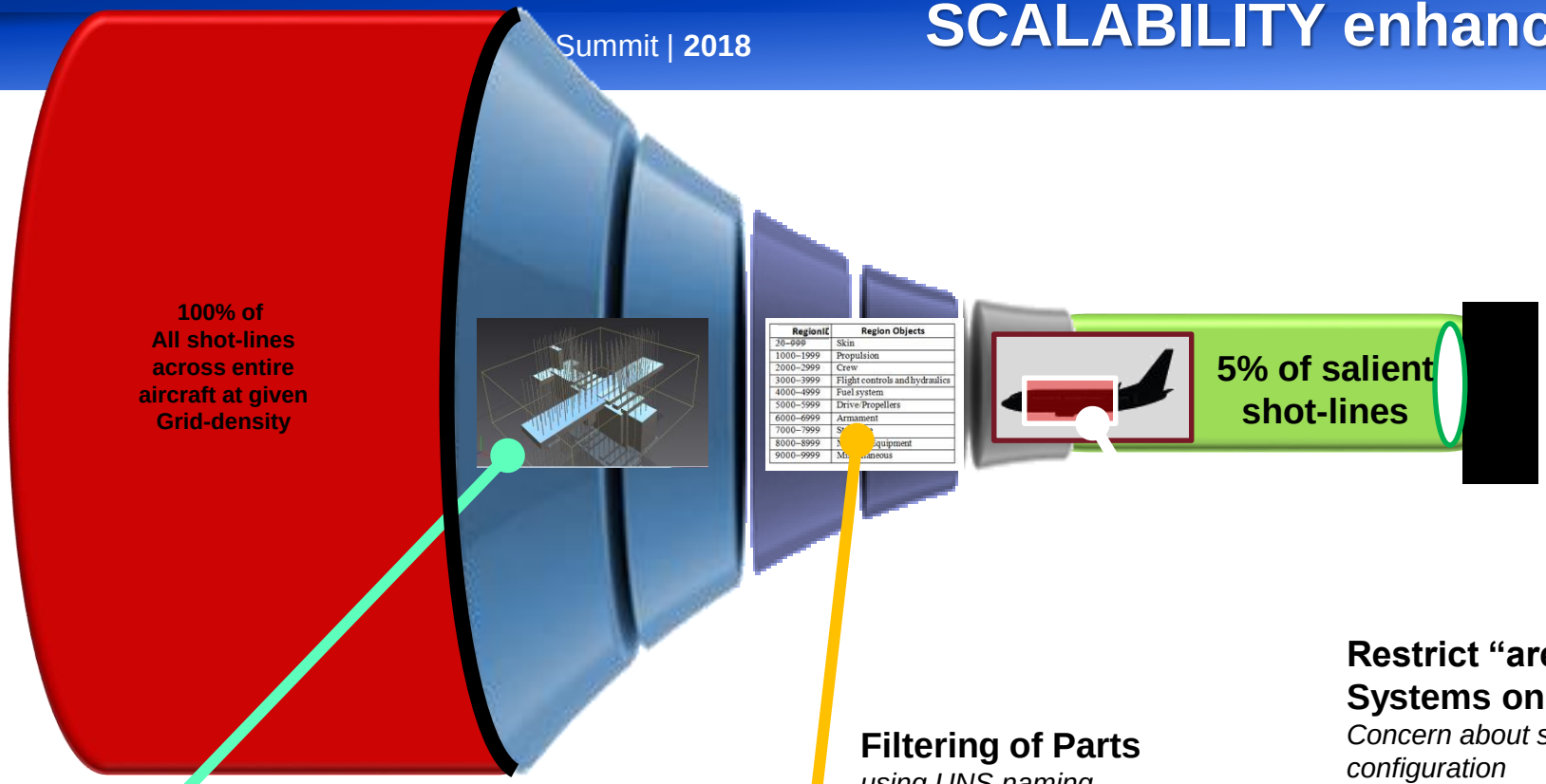





Aircraft Views

# PERFORMANCE and SCALABILITY enhancements






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

1

**Filtering of Parts**
*using UNS naming conventions*
*Removing skins and structure*

2

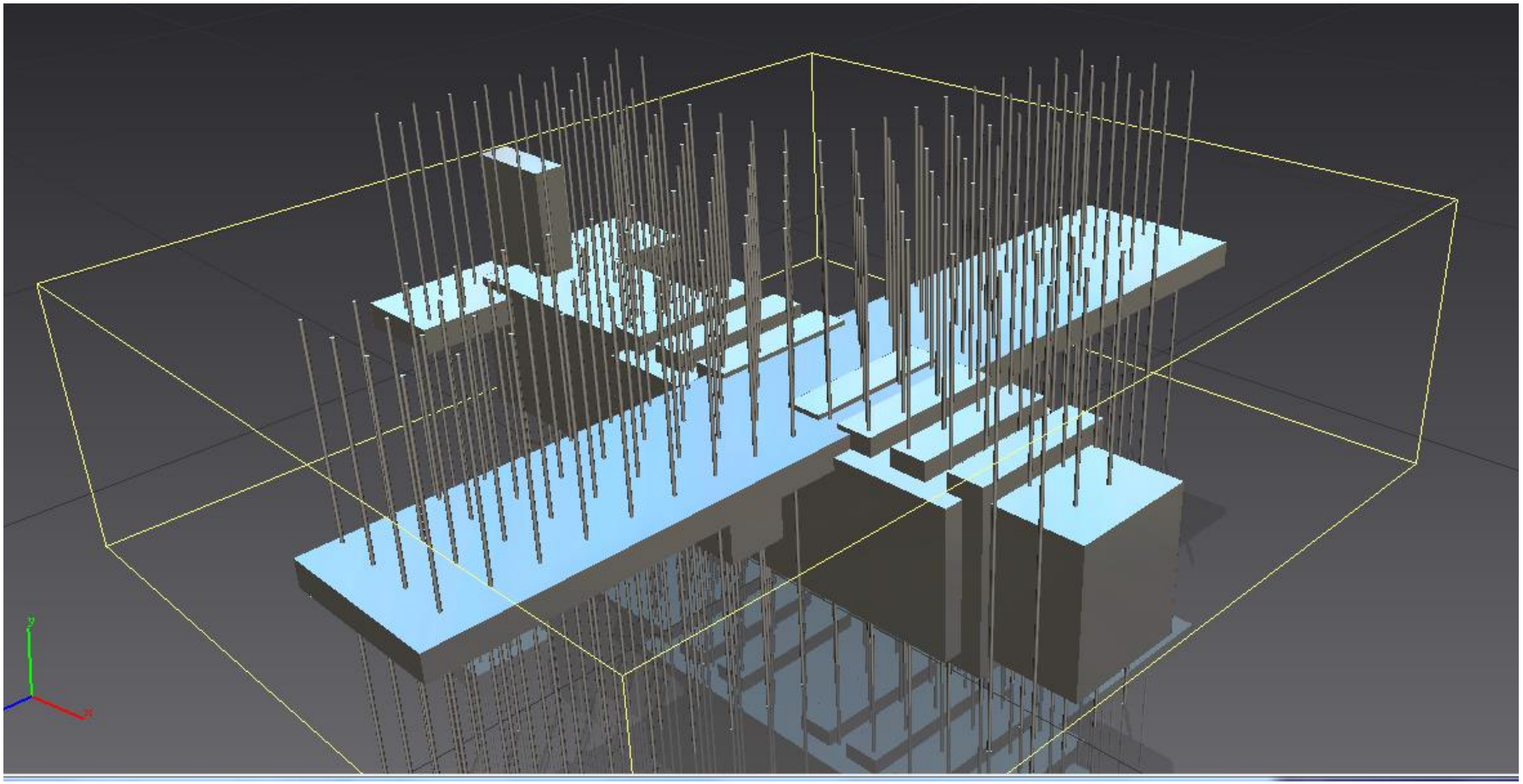
**Restrict "arena" to Systems only**
*Concern about systems configuration*

3

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

# Course Shot-line vector reduction Using Lo-Fidelity Model





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

# Summary



- **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**