Lean (and Agile) System Simulation of Guided Projectiles in the Early Development Stage

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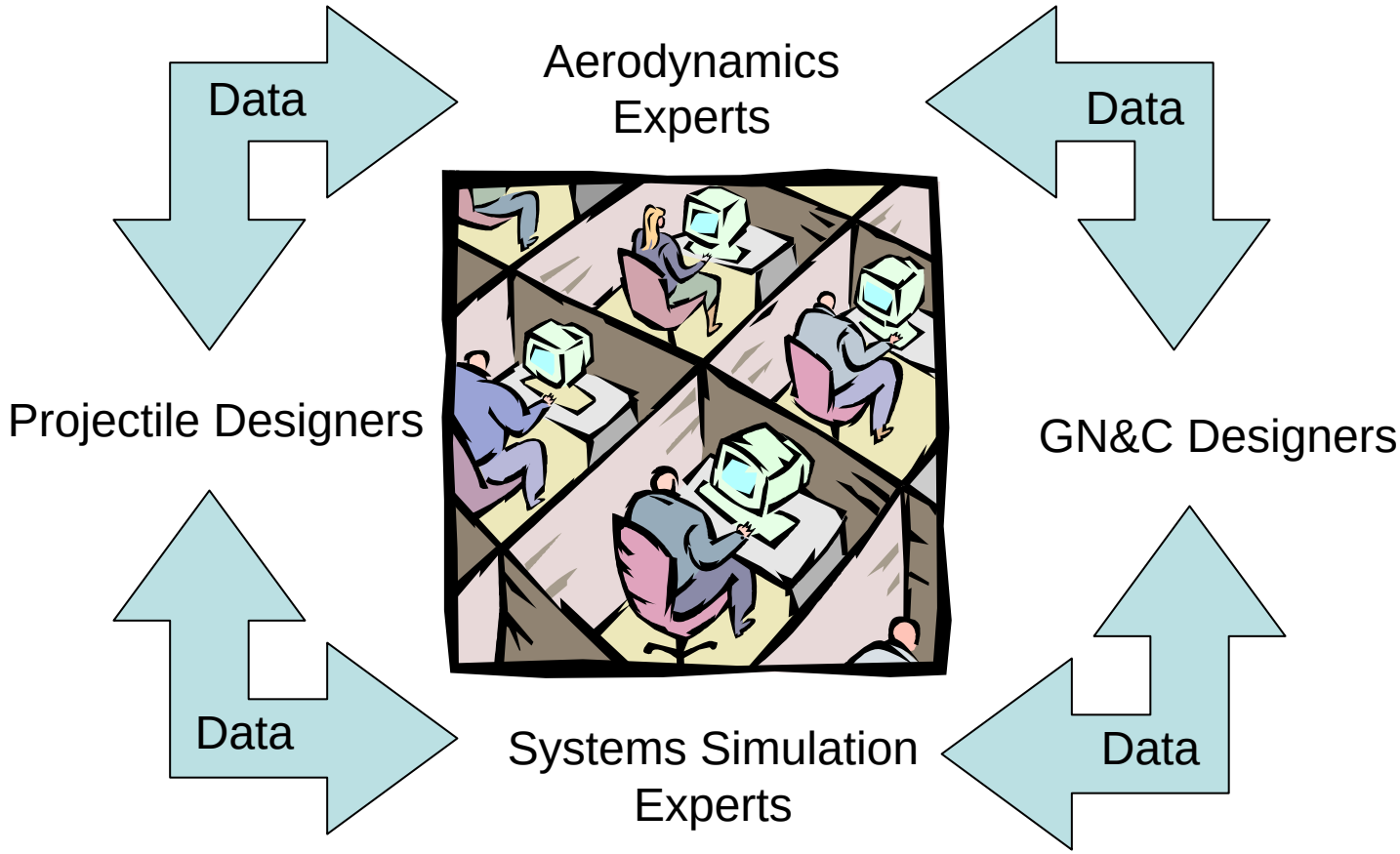
ARROW TECH
If you Can't Get a Bigger Target...

Typical Guided Projectile Development Team



Lean (and Agile) Concept

- Standardize on a validated toolset
- Eliminate waste and add value
- Streamline the process

Characteristics of the Toolset

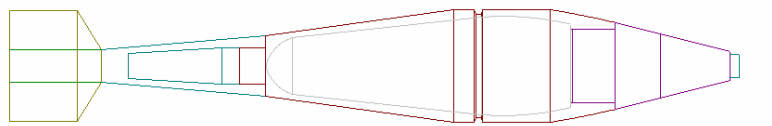
- Easy to use with common interface
- Seamless data flow between applications
- Industry standard algorithms to provide confidence in the results
- Easy to extract results for proposal support

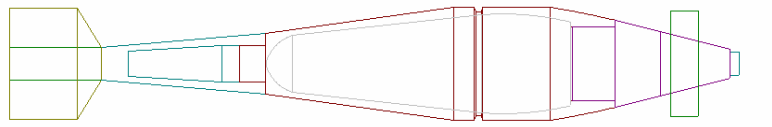
Example Walk Through

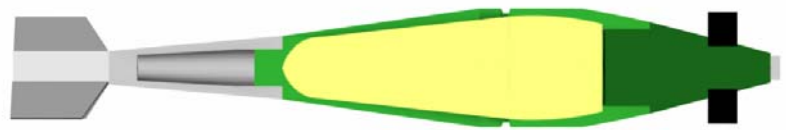
- Design a retrofit fuze to guide 81mm Mortar
  - Trade off control mechanisms
  - Trade off sensor options
- Evaluation
  - Range extension
  - CEP

Build the Model

- Multiple options
  - Build from scratch (1hr)
  - Modify existing (5 min)
  - Projectile Tracing Tool (15 min)
  - Import via DXF or IGES (30 min)

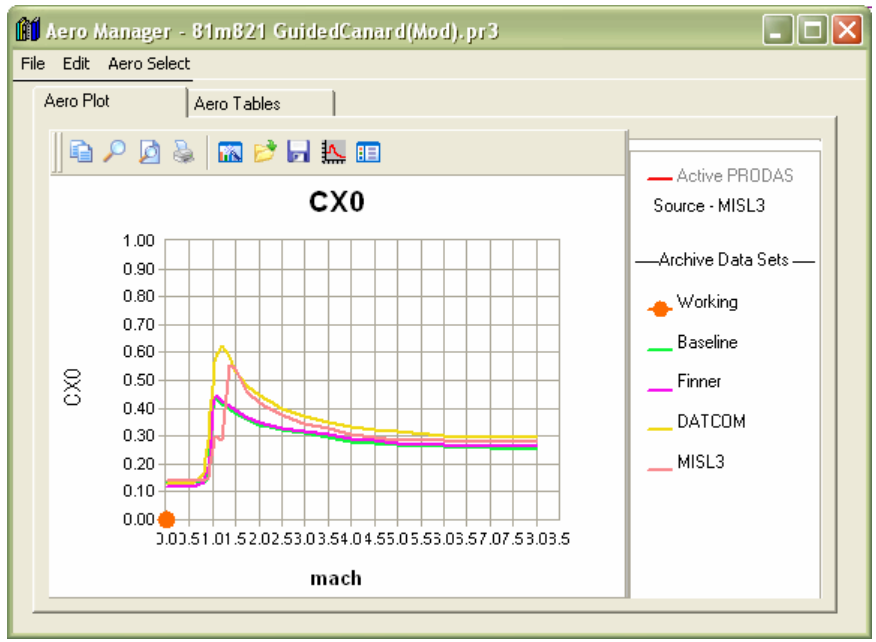






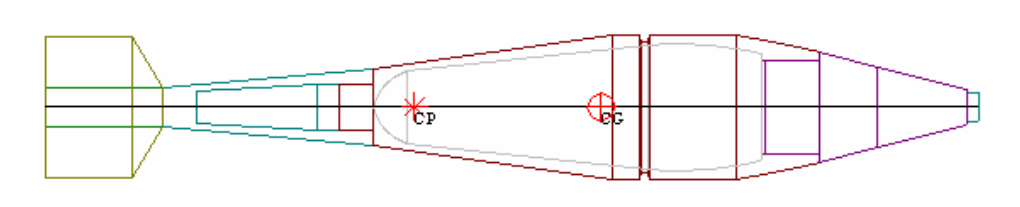
Estimate Aerodynamics

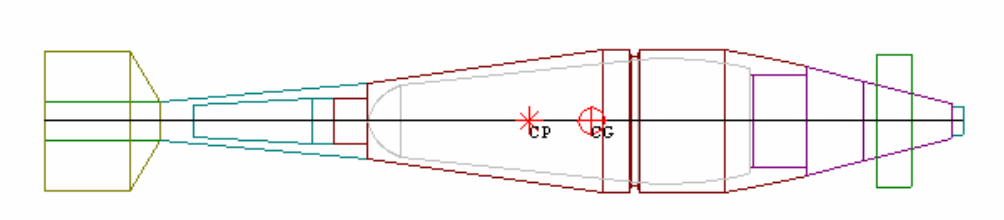
- Multiple Estimators
  - Spinner by Arrow Tech
  - Finner based on DeJonge
  - Missile DATCOM
  - MISL3 by Near
  - AP98 by NSWC



Evaluate Aero Stability

- Stability Evaluation
  - Baseline Static Margin 1.3 calibers
  - With canards 0.45 calibers





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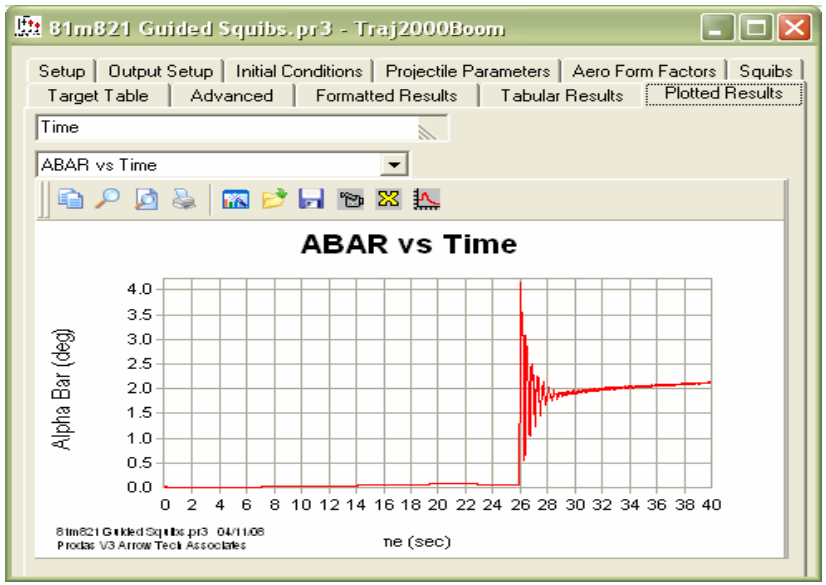
If you Can't Get a Bigger Target...

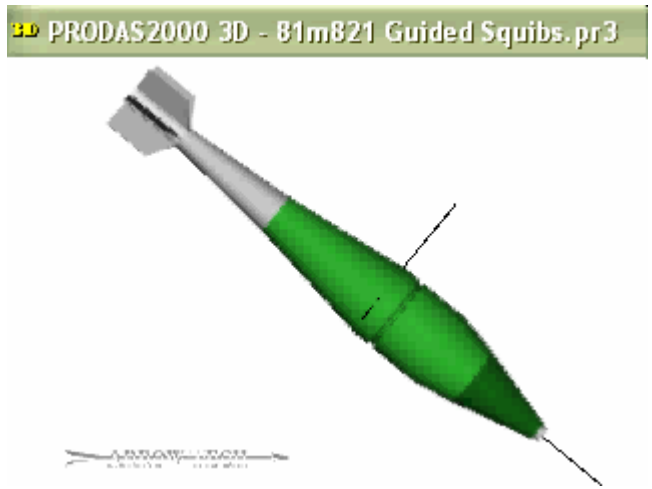
Evaluate Control Authority

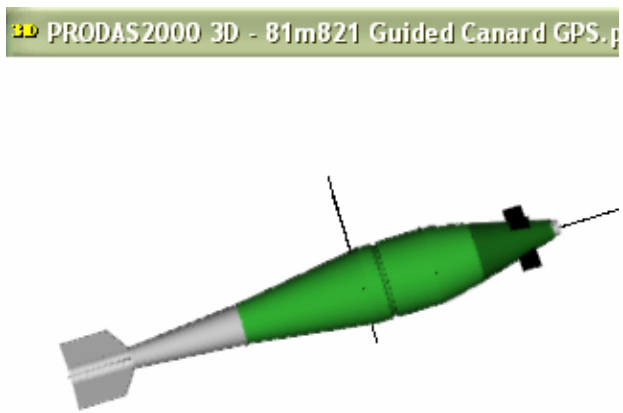
- Use CONTRAJ Module (Controlled Trajectory)
- Trade off Squibs versus Canards



Control Authority Results for this Example

- Squibs at this location
  - Lots of Motion
  - Small lateral movement
- Canards
  - 50% more range
  - Tremendous control authority





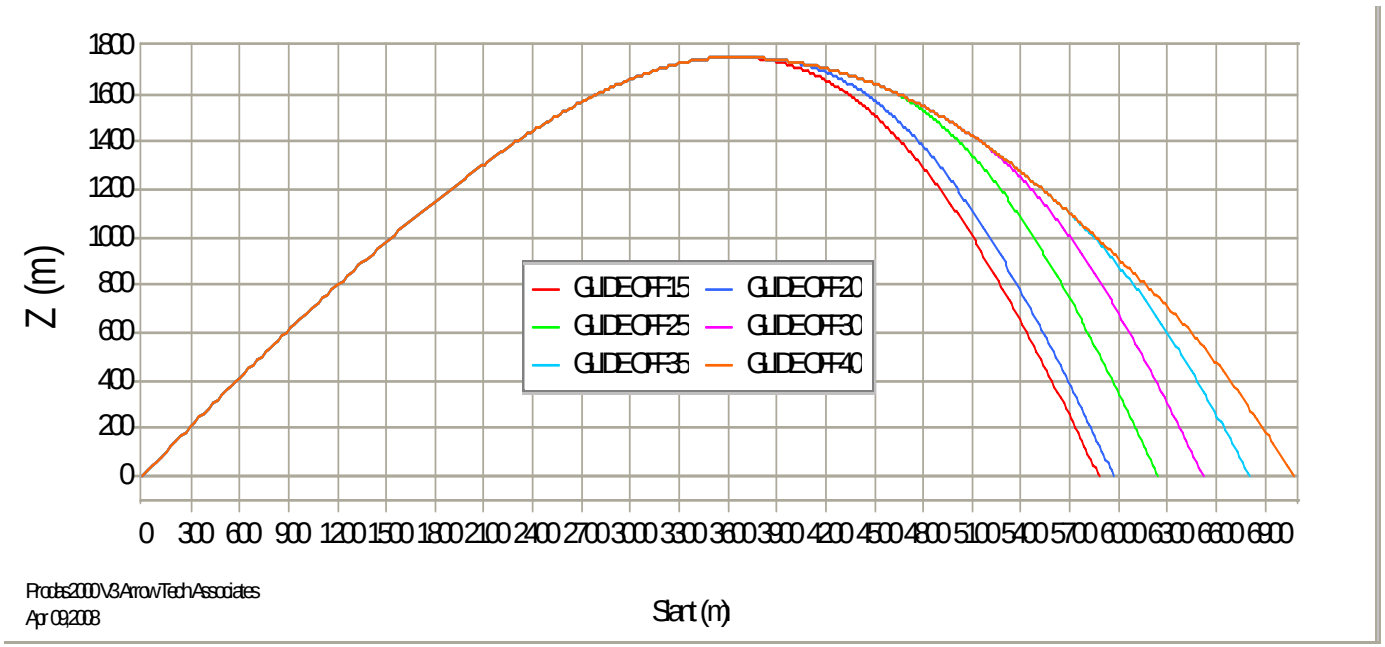
Recap

- Made two models based on an existing model
- Predicted the aerodynamics with three prediction codes
- Assessed aero stability of the modified shapes
- Evaluated control authority of squibs and canards
- Down selected the canard design

Total time invested up to this point ~ 2 hours

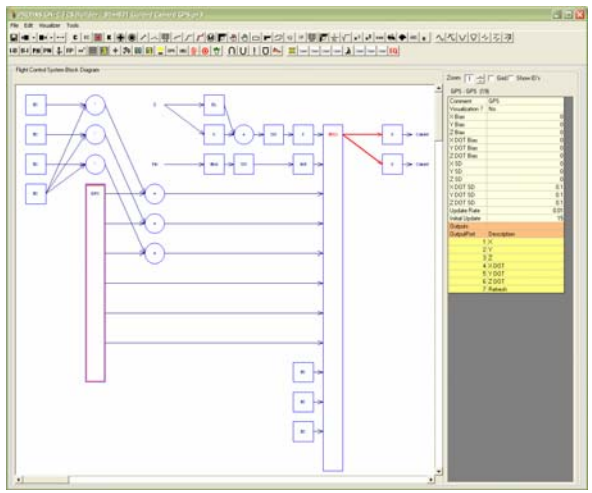
Next Step - Simulation

- Trajectory Codes
- System Effectiveness Simulation



The GN&C Prototype Module

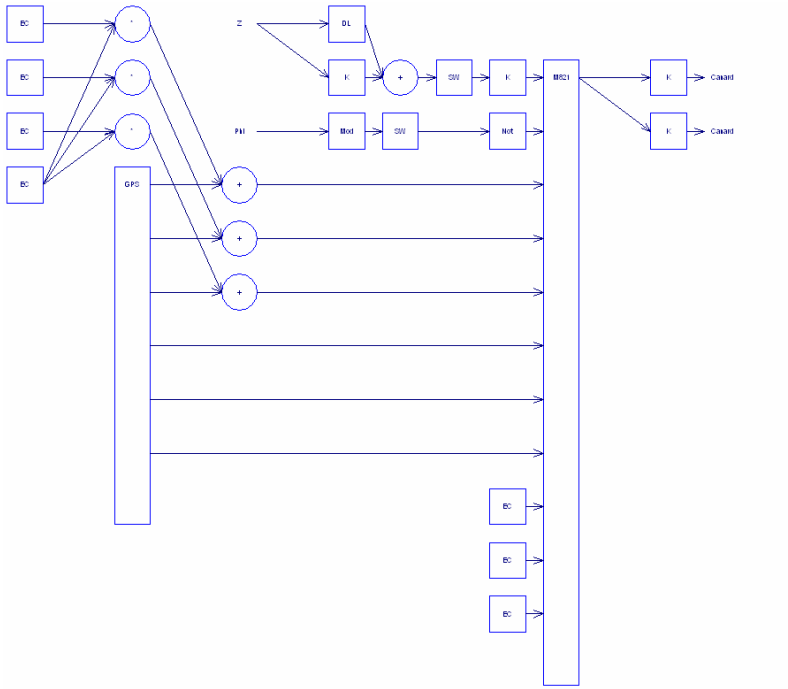
- Fully integrated 6DOF/GN&C Simulation
- Control with canards, squibs or generic forces
- Short learning curve w/ drag/drop FCS editor
- Control system can be coded in C or FORTRAN and linked at run time



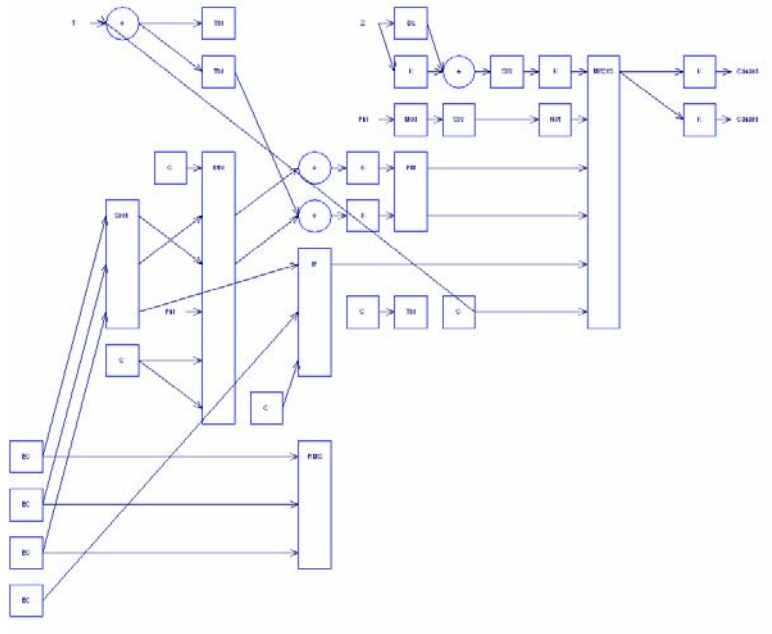
Why use the GN&C Prototype Tool

- Validated 6DOF that runs in real time or faster
- Intimately linked to the other tools
- Pre-built library of common projectile sensors and control surfaces
- Visualization modules can quickly produce reasonable marketing or training visuals

Example Systems

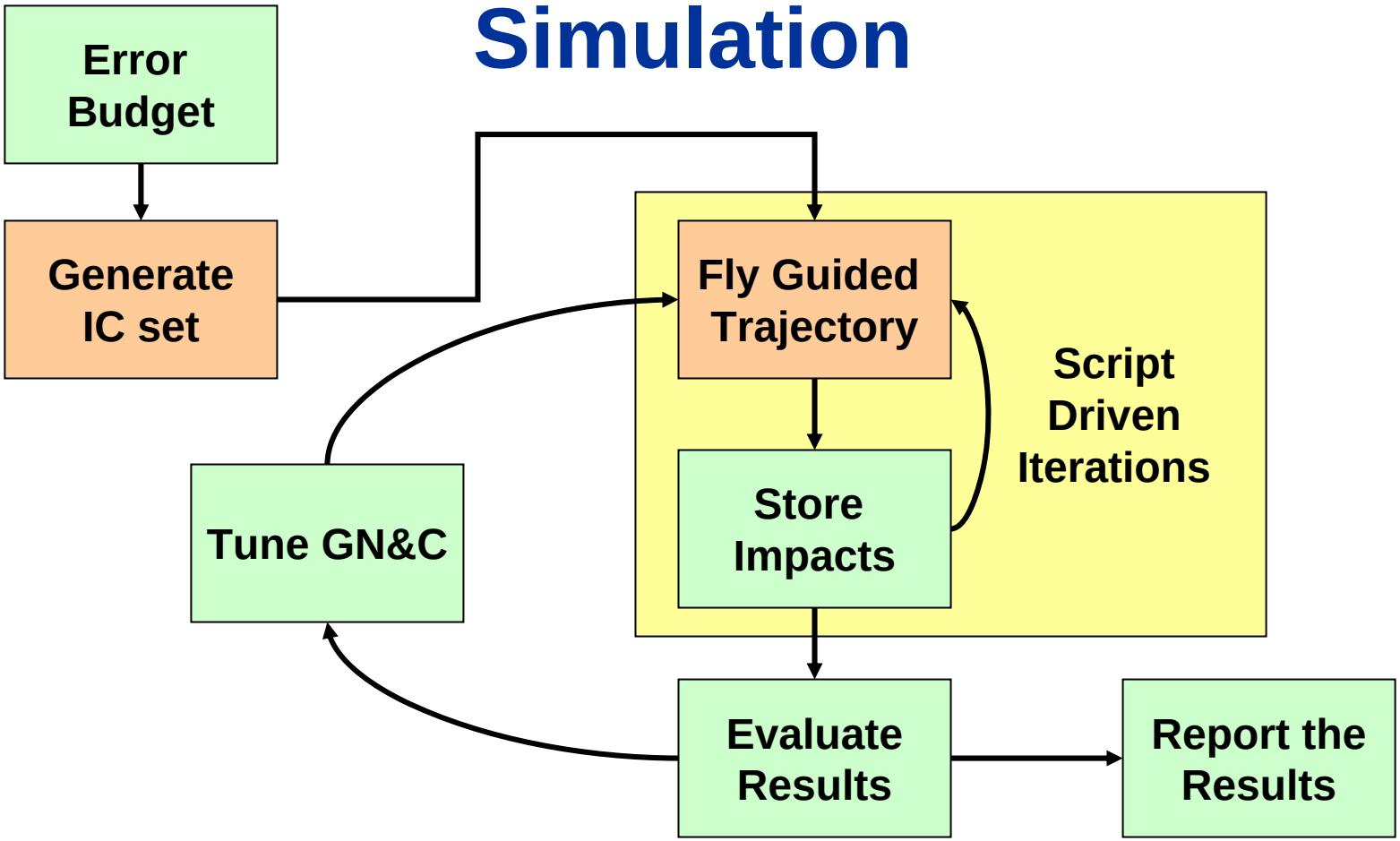


GPS guided



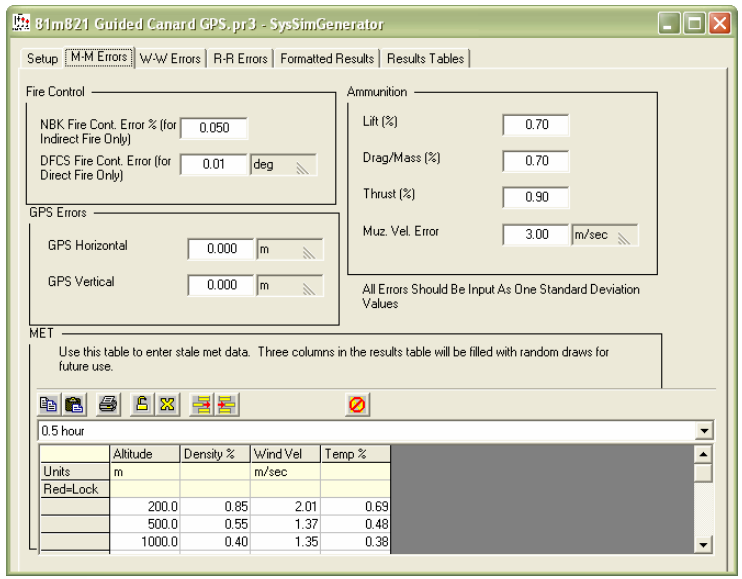
Seeker guided

Guided System Effectiveness Simulation



Initial Conditions Generator Module

- Generate error deltas from the error budget
- Delta plus nominal provide IC's for all of the subsequent runs
- Reality checked with ballistic projectile



Build an Automation Script

- Macro script language
  - Based on Visual Basic (EXCEL)
  - Projectile extensions added
- Build Options
  - Hand Code
  - Use Analysis Bot module
- Output text results file or cross plots

Recap

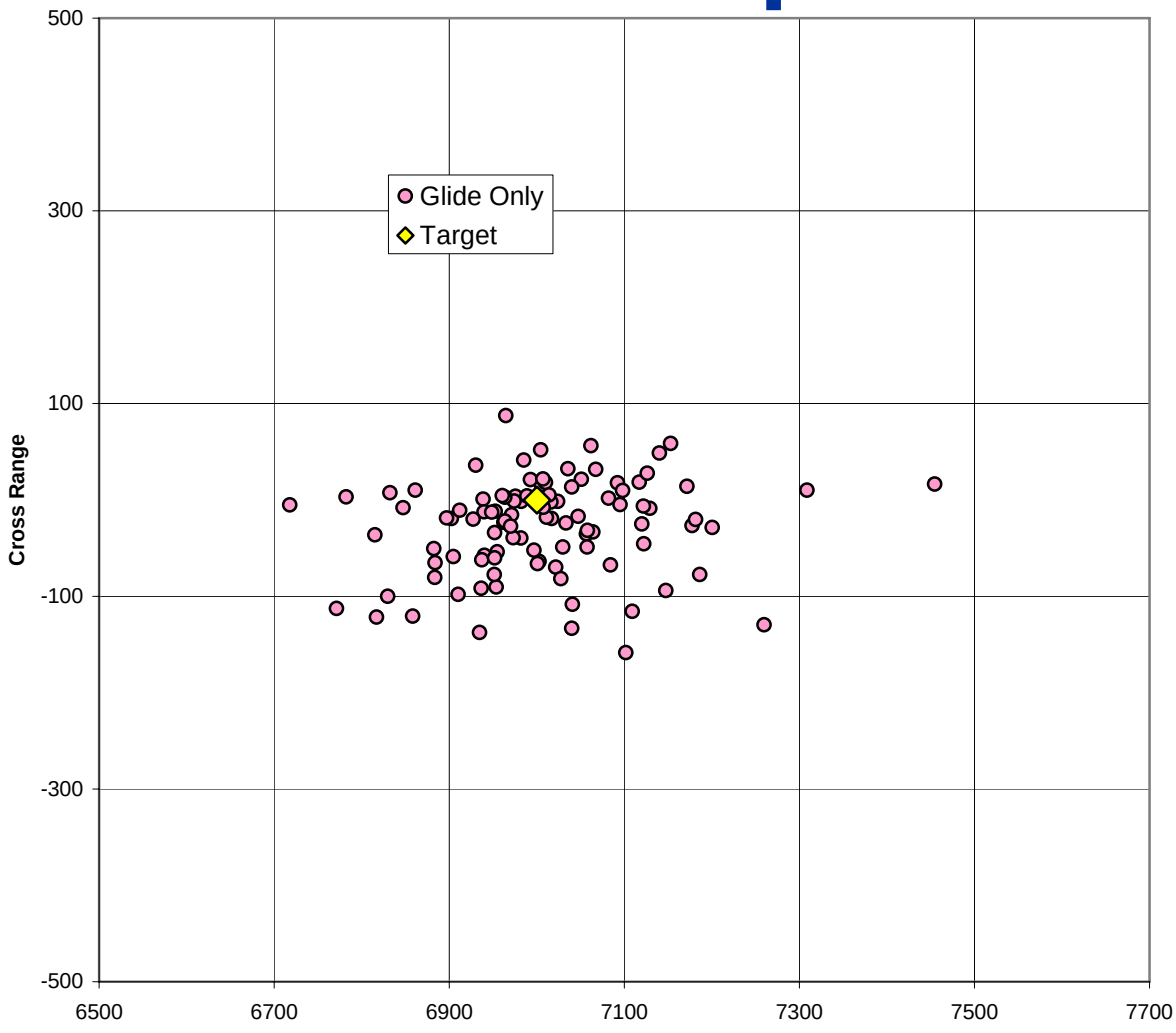
- Built Models & Estimated Aeros 2 hours
- Designed GN&C
  - GPS (modified existing) 2 hours
  - Seeker (new) 8 hours
- Developed Error budget and IC set 2 hours
- Modified existing scripts 1 hour
- Ran Systems simulations 1 hour

Total time invested up to this point ~ 16 hours

Conclusions

- It is possible to streamline the early stage development of a guided projectile
- Tools need to be integrated and inclusive
- System effectiveness comparisons of configuration changes as well as guided projectile performance can be evaluated in a timely manner, using readily available tools.
- Design the projectiles – NOT THE TOOLS

Ballistic Impacts



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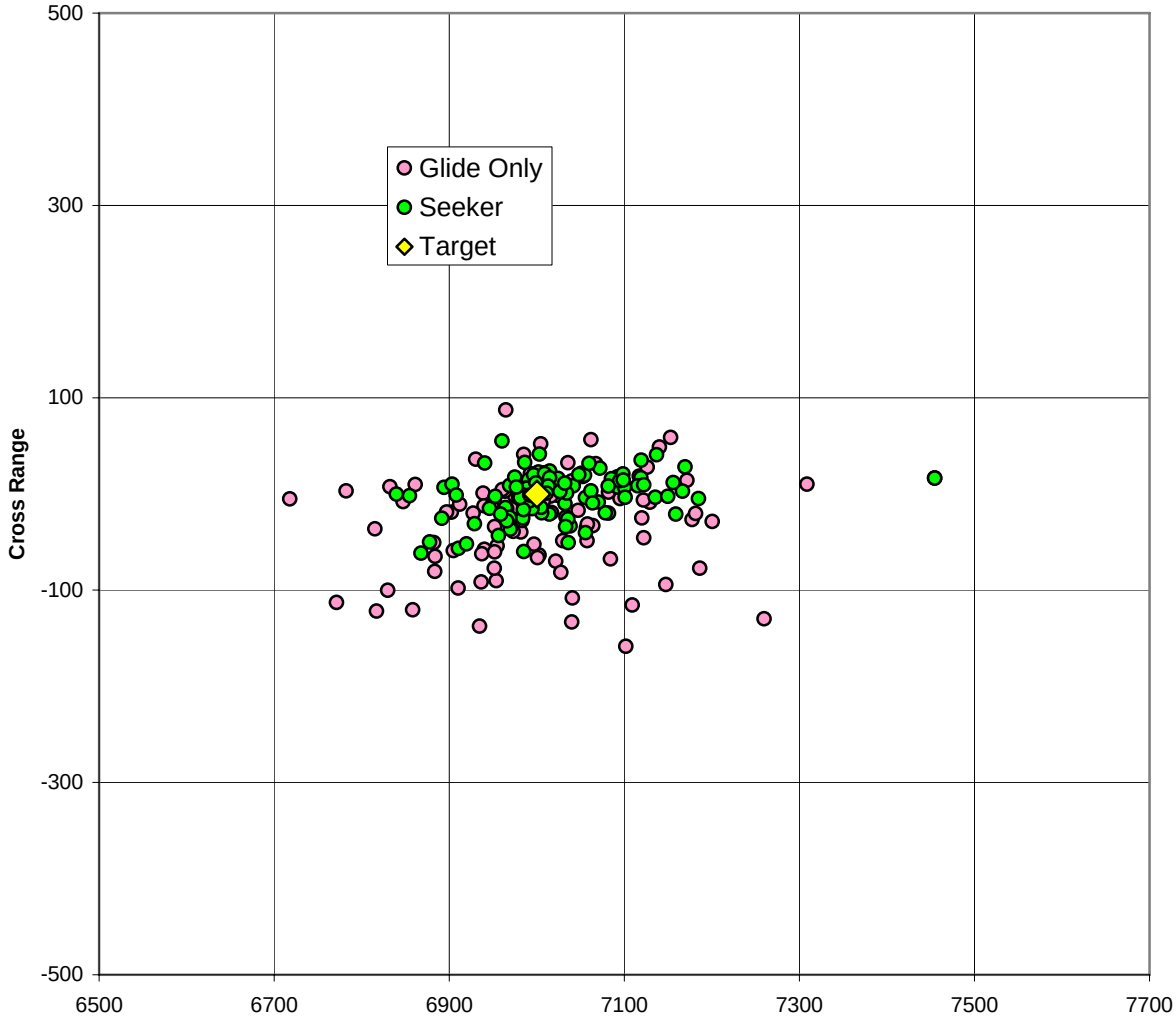
Ballistic and Seeker Guided Impacts



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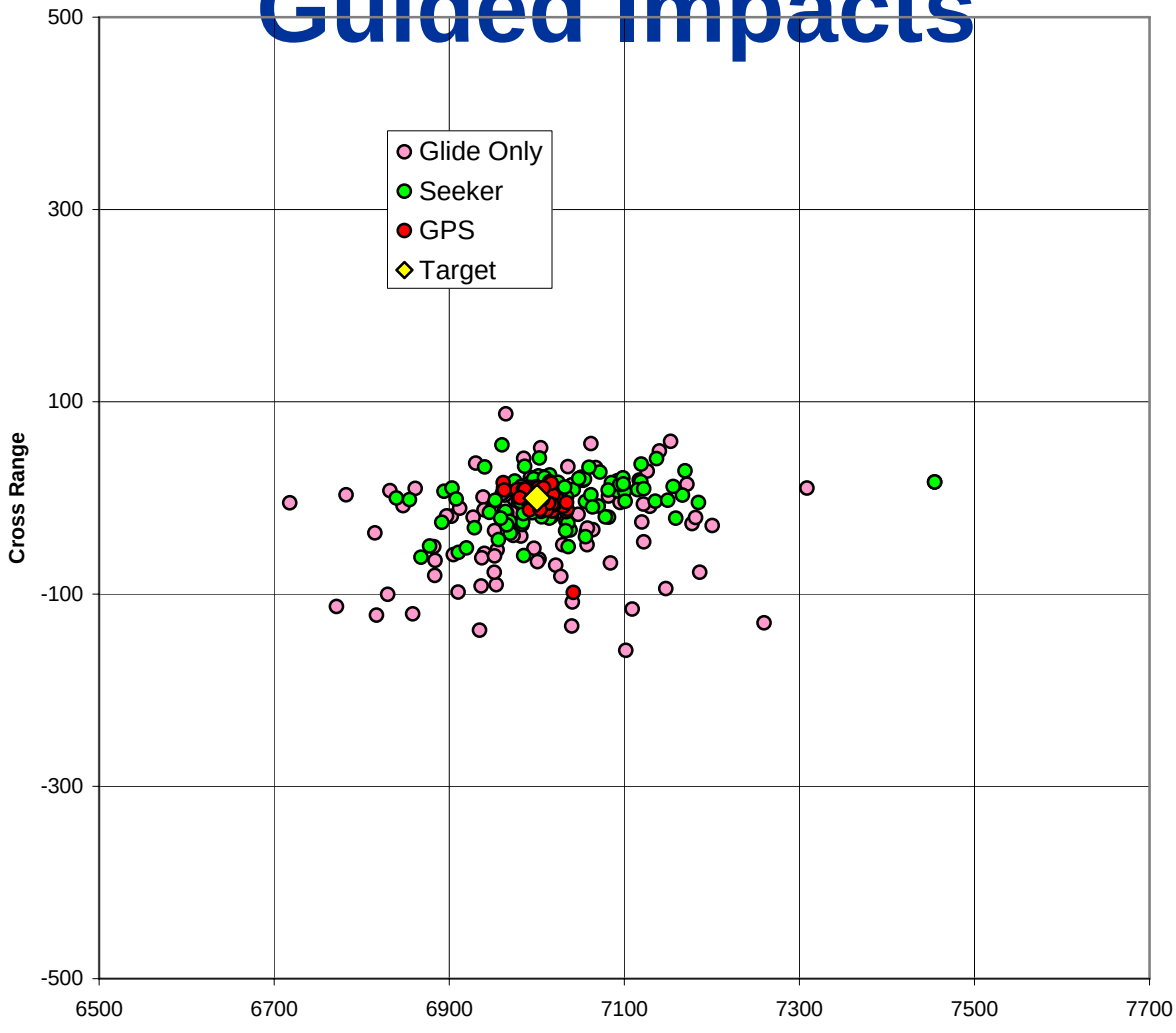
Ballistic, Seeker and GPS Guided Impacts



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Results from our Example

	Range km	CEP m
Ballistic	5.1	96
Ballistic with Glide	7	106
Seeker Guided	7	68
GPS Guided	7	16

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Questions ?