GN&C System Simulation Development Options

Legacy Software Simulation

PRODAS GN&C Prototype Tool

MATLAB/ Simulink Simulation
Legacy Software Simulation

• **Pros**
  - Detail only limited by developer
  - Very fast simulation

• **Cons**
  - Tough to validate
  - Can get very complex

PRODAS GN&C Prototype Tool

• **Pros**
  - Trajectory Engine transparent to User
  - Very fast simulation
  - Simulation Data provided by PRODAS
  - Can be driven by a Macro
  - Validated Trajectory codes

• **Cons**
  - Limited detail

MATLAB/ Simulink Simulation

• **Pros**
  - Almost unlimited details can be included
  - Internal equations and variables visible
  - GN&C can transition easily into Hardware

• **Cons**
  - User must build and validate Trajectory Engine
  - User must provide inputs and build outputs
The New Combined Option

- **Pros**
  - Validated Trajectory Engine
  - Simulation inputs provided by PRODAS
  - Unlimited details can be included
  - GN&C can transition easily into Hardware
PRODAS – MATLAB/Simulink Simulation

**PRODAS Environment**

*Modeling*
- Projectile Modeler
- Aero Prediction
- Mass Properties
- Rocket Motor
- Initial Conditions
- Error Budgets
- MET

*Visualization*
- 3D Animations
- Extensive Plotting

**MATLAB/Simulink Environment**

*Development*
- Leverage All MATLAB/Simulink Toolboxes and Blocksets
- Focused Effort on GNC Design

*Simulation*
- Validated 6+DOF Trajectory Engine
- Seamless Data Interface and Execution Between PRODAS and MATLAB

**Product Tests**

*Hardware-In-the-Loop (HIL)*
- Use the same simulation to drive the HIL fixture

*Embedded Code Generation*
- Automatically generate flight code from the Simulink model

*Fire Control*
- Simulation software is the basis of fire control software
Industry standard projectile design and analysis environment

65+ integrated analysis modules
  - System simulation
  - Aerodynamic prediction and stability
  - Trajectory simulation and flight Dynamics
  - Guidance, navigation, and control
  - In-bore balloting and interior ballistics simulation
  - Aero-ballistic test data reduction
  - Software development kit

Over 500 Users at Government and prime contractors

In use in over 25 countries
Guided Projectile Development with PRODAS

**Build a Model**

*Simple Symmetric Model Editor*

*Projectile Tracing Tool*

**Estimate Aerodynamics**

*Arrow Tech Finner/Spinner*

*NSWC AP*

*Test Data*

*Nielsen Engr. MSL3*

*Missile DATCOM*

*PRODAS Aero Manager*

**Fly It**

*Standard 6DOF*

*GN&C Prototype Tool*

*GN&C MATLAB*

*3D visualization*
How Does It Work?

- Illustrate with a simple transformation
- Add nose and tail kit to a 60mm Mortar
Design the Air Vehicle

Model Editor

- Design the air vehicle:
  - Add control surfaces
  - Update mass properties
  - Estimate Aerodynamics
  - Evaluate Stability
  - Repeat as Necessary

Stability Evaluation

Mass Properties

Aero Prediction

PRODAS
Build a Simple Open Loop Controller

- Open Loop Controller to:
  - Deploy canards at apogee
  - Extend Range
    - Dither with roll angle

PRODAS MATLAB Interface

MATLAB/Simulink
Simple Open Loop Controller

- Validated trajectory engine
- Automatic interface to aeros and IC’s
- Design the GNC in Simulink
  - Use any Block Set
  - Inputs - Body states
  - Output - canard angle
- Model contained in PR3 file
Run Simulation Review Results

- Use MATLAB plot functions or
- Use built in PRODAS plots and visualizations
- Cross plot against other codes
Setup trade study scenarios varying:
- Body states
- Mass properties
- Aerodynamics
- Rocket Motor
- Environment (MET)
- 50 custom GNC parameters

Add system errors to any variable
- Mission-to-mission
- Weapon-to-weapon
- Round-to-round
System Error Budget

• Example entered errors for:
  • Muzzle Velocity
  • Mass
  • Winds
  • Temperature
  • Quadrant Elevation
• Monte Carlo Runs
  • Ballistic to validate errors
  • Open loop guidance to check control authority

PRODAS
Where To Go From Here

- Close Loop GNC
- Sensor Models
- Use 6DOF and GNC model for HIL
- Generate code for embedded processor

This then becomes the system simulation for the program
Conclusion

• The PRODAS tool set has been enhanced with the inclusion of the MATLAB/Simlink Trajectory Code

• Now PRODAS can be your tool from concept to final production.

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