AET//Argent Energetics Technology, LLC

Graphical User Interface (GUI)
Update to the
CADPROG Ballistic Computer Simulation Program

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Mr. Ted Witkamp, AET
**AET// Business Model**

**Key Resources**
- Experienced People
- “To the Point” Technology
- Relevant Information
- Sub-Tier Partnerships

**Key Processes**
- Design
- Product Development
- Manufacturing (DFM)
- Process Hazard Analysis (PHA)
- Failure Analysis (FA)
- Training

**Client Value Proposition (CVP)**
To solve problems and needs dealing with energetic/ordnance design, manufacturing, new growth initiatives, and training

**Profit Formula**
Resource Velocity: Both AET and its Partners are small businesses that can react and deliver on demand services.

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CADPROG, Basics

1. User supplied input parameters
2. “Hard-wired” parameters
3. Internally-computed parameters
4. Mass averaged thermodynamic properties of gas mixture
5. Model (time-dependent) variables

(Where: \( X_3 \) is arbitrarily larger than \( X_{MAX} \))

(Where: \( \Theta \) is degrees from the horizontal)
CADPROG VERSION HISTORY

- CADPROG v1-6, and v8-v9: UNIX (SGI) FORTRAN 77 Platform
- CADPROG v7: PC FORTRAN 77 Platform
- CADPROG v10: Windows, MATLAB® R2017A Platform
  - AET contract: N00174-16-P-0052
  - MATLAB® command and workspace structure, knowledge of MATLAB®
  - Presented at 2018 CAD/PAD Workshop
- CADPROG v11: Windows, MATLAB® R2018A Platform (application program interface, api)
  - AET contract: N00174-19-P-0123
  - MATLAB® GUI, little to almost no knowledge of MATLAB® required
CADPROG v11, Improvements

1. Improved “User” interface, which minimizes the knowledge required of the MATLAB® command language.

2. Option for the MATLAB® embedded Ordinary Differential Equations (ODE).
   a. The use of the MATLAB® embedded ODE will allow for the implementation of automated parametric studies for selected parameters (such as propellant charge weight(s) and dimensions and piston mass), and the detection of zero crossover for event determined termination criteria.
   b. An expanded burn rate table, allowing the user to enter more than the current six burn rate vs. pressure data points for defining a propellant’s burn rate vs. pressure curve.
APP’s Window for CADPROG v11
CADPROG GUI Opening Screen Shot
CADPROG GUI Default Simulation
CADPROG GUI Heat Loss Option
CADPROG GUI Dual Chamber Inputs

### Igniter
- Impetus (Ff): 99700 ft-lbf/lbm
- Mass (IM): 0.0006718 lbm
- Heat Loss option (FOPT): Gas
- Chamber Model: High / Low

### High / Low
- Throat Area (AT): 0.01 in²

### Low Chamber
- Volume (VLO): 0 in³
- Leakage Area (ALO): 0 in²
- Heat Loss (K3): 0

### High Chamber
- Volume (VH): 1 in³
- Leakage Area (AH): 0 in²
- Heat Loss (K2): 0

### Initial Temp (TLO): 294 K

### Ambient Press. (PA): 14.7 psia

### Pressure vs Time

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Pressure (psig)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>0.2</td>
<td>0.2</td>
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<tr>
<td>0.3</td>
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<tr>
<td>0.4</td>
<td>0.4</td>
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<tr>
<td>0.5</td>
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<tr>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Simulation
- Time Step (DT): 0.0001 sec
- Print Step (DTPR): 1
- Title: data1
- Solver: Runge-Kutta
Note that XMAX must be less than the final piston displacement. Error message will be created if XMAX is greater than the displacement.
GUI Propellant Tab

Once these buttons are activated, then the selected row can be edited or removed from the table. If the charge mass is greater than the allowed volume or if there is zero mass, an error message will be created to warn the ‘user’.
GUI Propellant Editor Thermo Tab
GUI Propellant Editor Geometry Tab (Model Default – Slab Pane)

Geometry pane options: slab, cylinder, sphere, and coefficient.

Note that for geometry selection of Coefficient, the ‘user’ may directly input the web or allow CADPROG to calculate the web by leaving the input window equal to zero (0).
GUI Propellant Editor Burning Rate Pane
GUI Formulation Drop Down Menu

File | View | Help
--- | --- | ---
Chamber | Piston | Propellant

<table>
<thead>
<tr>
<th>PROP</th>
<th>FORM</th>
<th>ST Time (T) sec</th>
<th>CH Mass (CE) lbm</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUSTOM</td>
<td>BP CL5</td>
<td>0</td>
<td>0.0100</td>
</tr>
</tbody>
</table>

Pressure vs Time

Pressure (psig)

Time (sec)

Time | Displacement | DRI
--- | --- | ---

Simulation

Time Step (DT) | 0.0001 sec
Print Step (DTPR) | 1
Solver | Runge-Kutta
Add Data | Open Fig | Overplot | Simulate
Opened Propellant.xlsx in Excel “Administer Access Only”

<table>
<thead>
<tr>
<th>Propellant</th>
<th>Formulation</th>
<th>N</th>
<th>M</th>
<th>R</th>
<th>C</th>
<th>V</th>
<th>NBRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Powder</td>
<td>British G12</td>
<td>22.5</td>
<td>63.33</td>
<td>0.0636</td>
<td>422.93</td>
<td>2155</td>
<td>burnrate_bp</td>
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<td>63.33</td>
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</tr>
<tr>
<td>Black Powder</td>
<td>COM_FFG</td>
<td>22.5</td>
<td>62.40</td>
<td>0.0772</td>
<td>375.00</td>
<td>2038</td>
<td>burnrate_bp</td>
</tr>
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<td>COM_FFG</td>
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<td>62.40</td>
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<td>0.0772</td>
<td>375.00</td>
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<td>63.33</td>
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<td>422.93</td>
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<td>63.33</td>
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<td>422.93</td>
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<td>63.33</td>
<td>0.0636</td>
<td>422.93</td>
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<td>63.33</td>
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<td>MIL Class 6</td>
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<td>63.33</td>
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<td>MIL Class 7</td>
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<td>Black Powder</td>
<td>MIL Class 8</td>
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<td>63.33</td>
<td>0.0636</td>
<td>422.93</td>
<td>2155</td>
<td>burnrate_bp</td>
</tr>
</tbody>
</table>
| DS | F1 COPE050 | 28.1 | 21.14 | 0.0570 | 499.80 | 2432 | burnrate_F1 | 0.325 0.000 0.670 0 0  
| DS | F1 COPE150 | 28.1 | 21.14 | 0.0570 | 499.80 | 2432 | burnrate_F1 | 0.325 0.000 0.670 0 0  

2:24 PM 6/6/2020
An ordinary differential equation problem is stiff if the solution being sought is varying slowly, but there are nearby solutions that vary rapidly.
Interior Ballistic Simulation
Edit Graph “Open Figure”
GUI View Drop Down Menu
All Figures

- Pressure vs Time
- Velocity vs Time
- Acceleration vs Time
- Thrust vs Time
- Pressure vs Displacement
- Velocity vs Displacement
- Acceleration vs Displacement
- Thrust vs Displacement
File Tab: Load and Save Workspace
Load Simulation through Explorer
You are correct these operations are MATLAB® command intensive! Even worse these operations are outside the GUI.
Import Data, continued

Argent Energetics Technology, LLC

Back to the GUI, YEAH!
Help Tab
Final Statement

The CADPROG v11 modeler is the property of the U.S. Navy.