AET//Argent Energetics Technology, LLC

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

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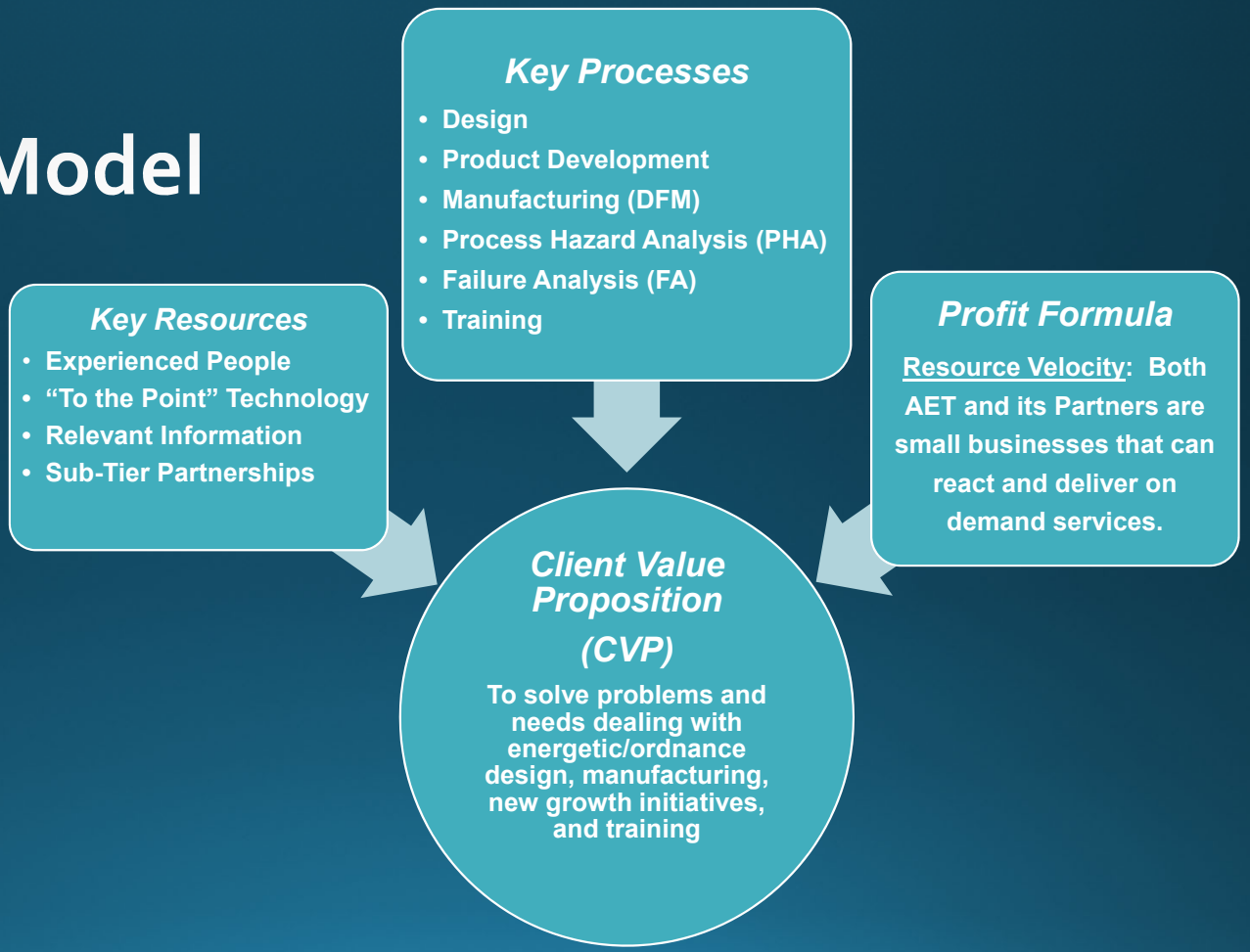
Argent Energetics Technology, LLC

AET// Business Model



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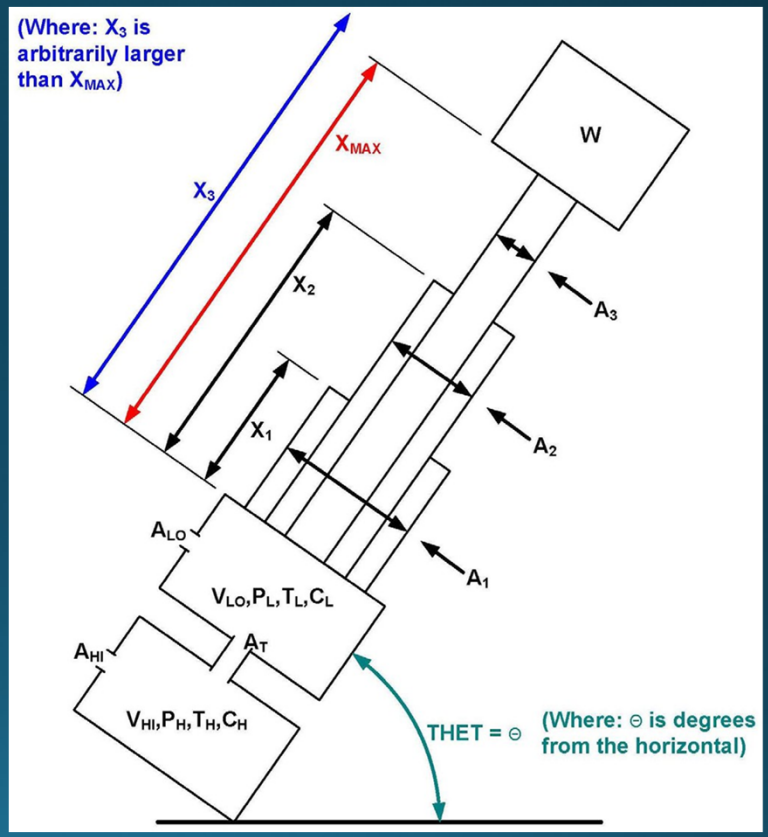
CADPROG, Basics

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



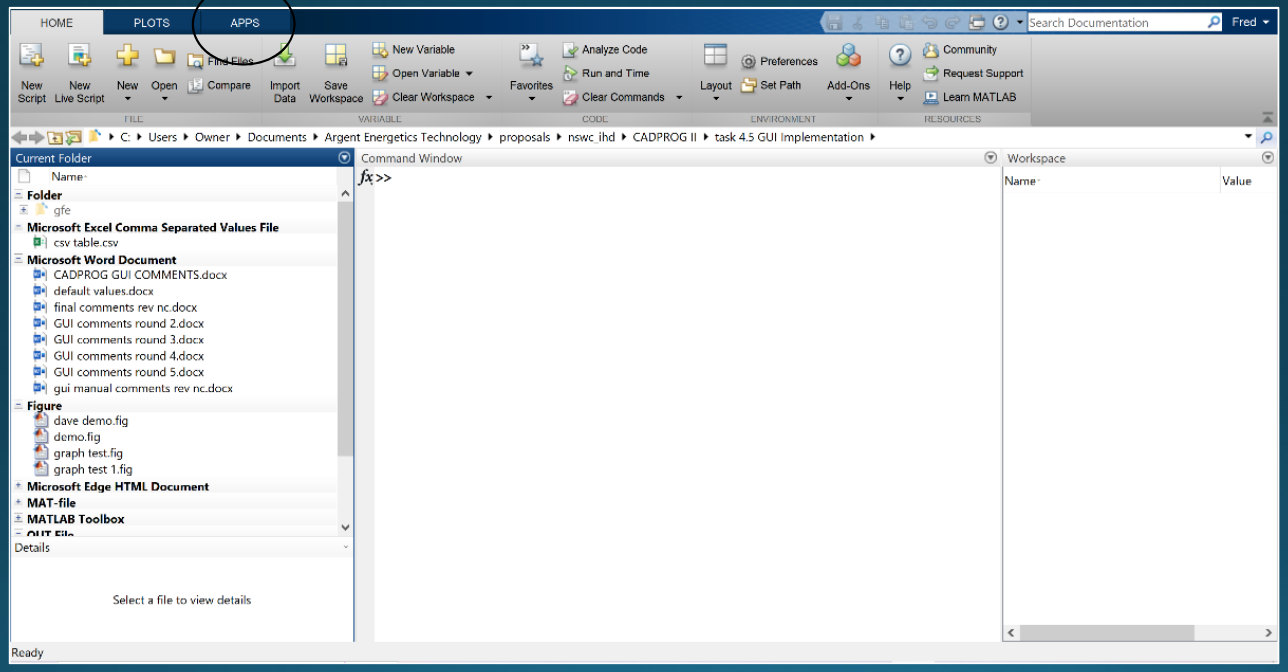
CADPROG VERSION HISTORY

- 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

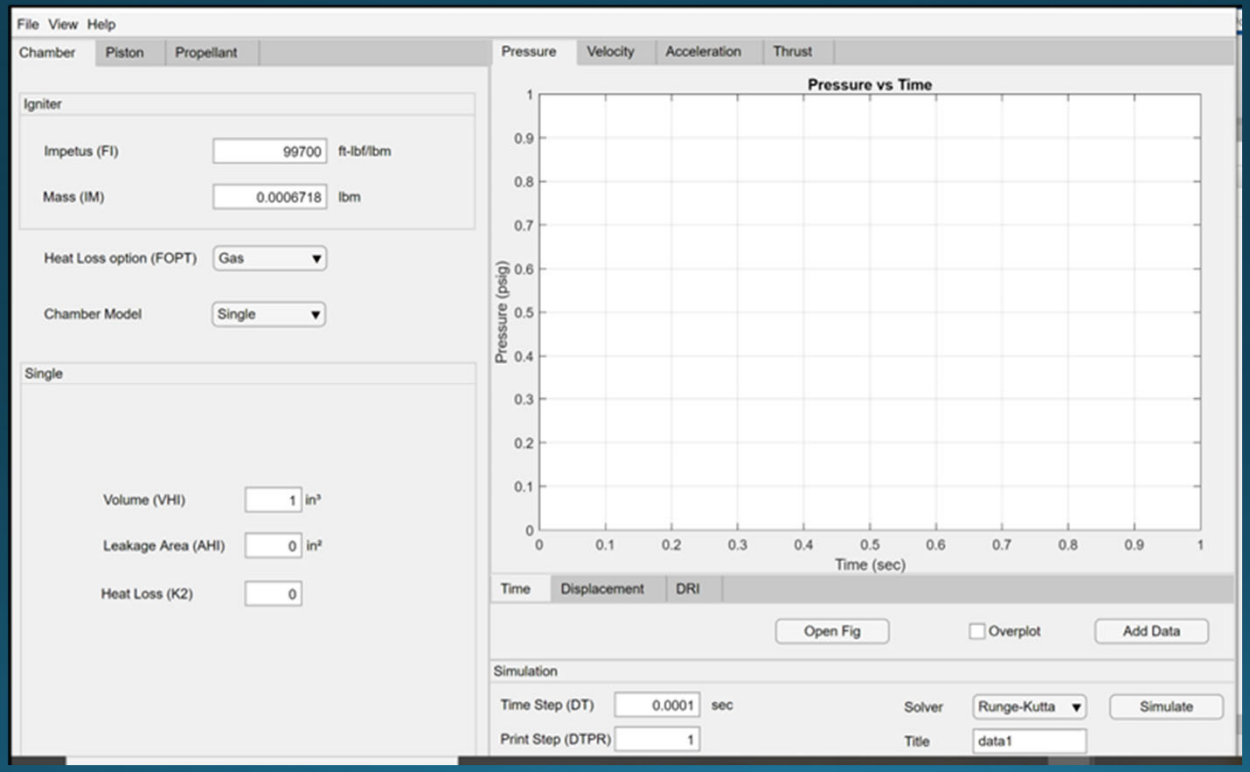
CADPROG v11, Improvements

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.

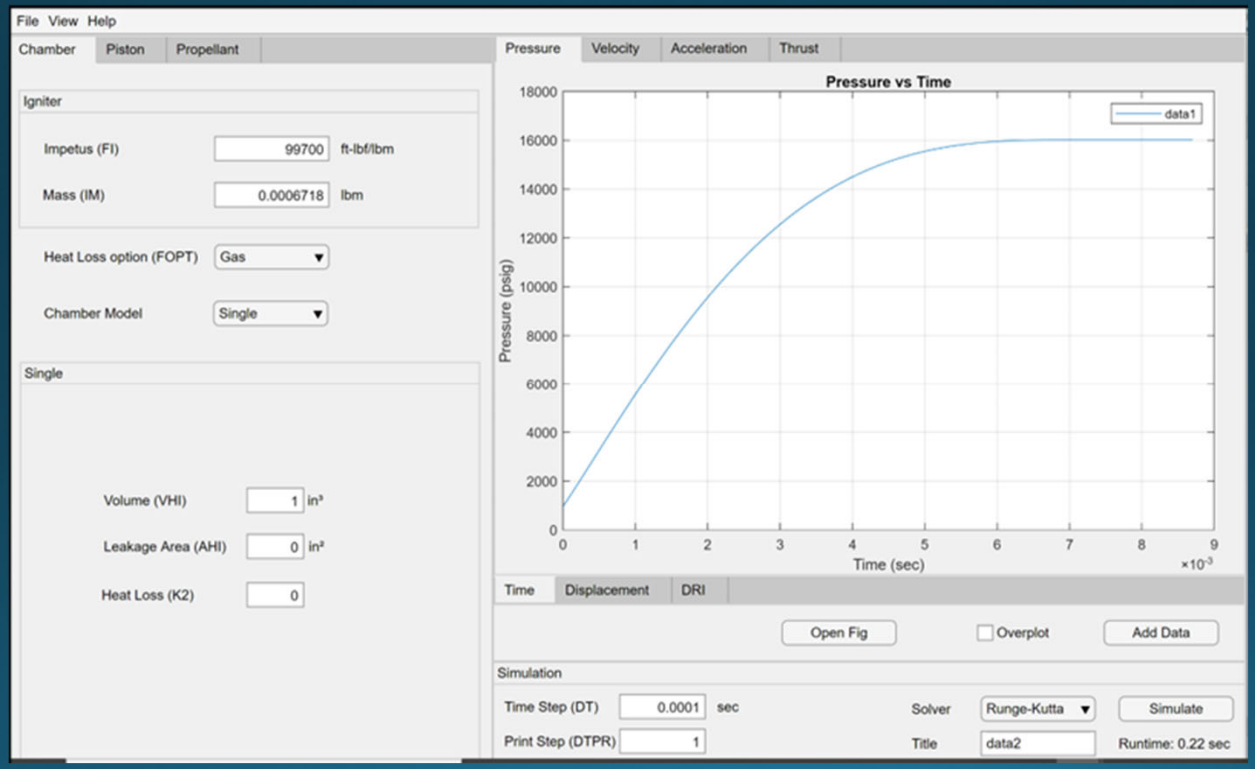
APP's Window for CADPROG v11



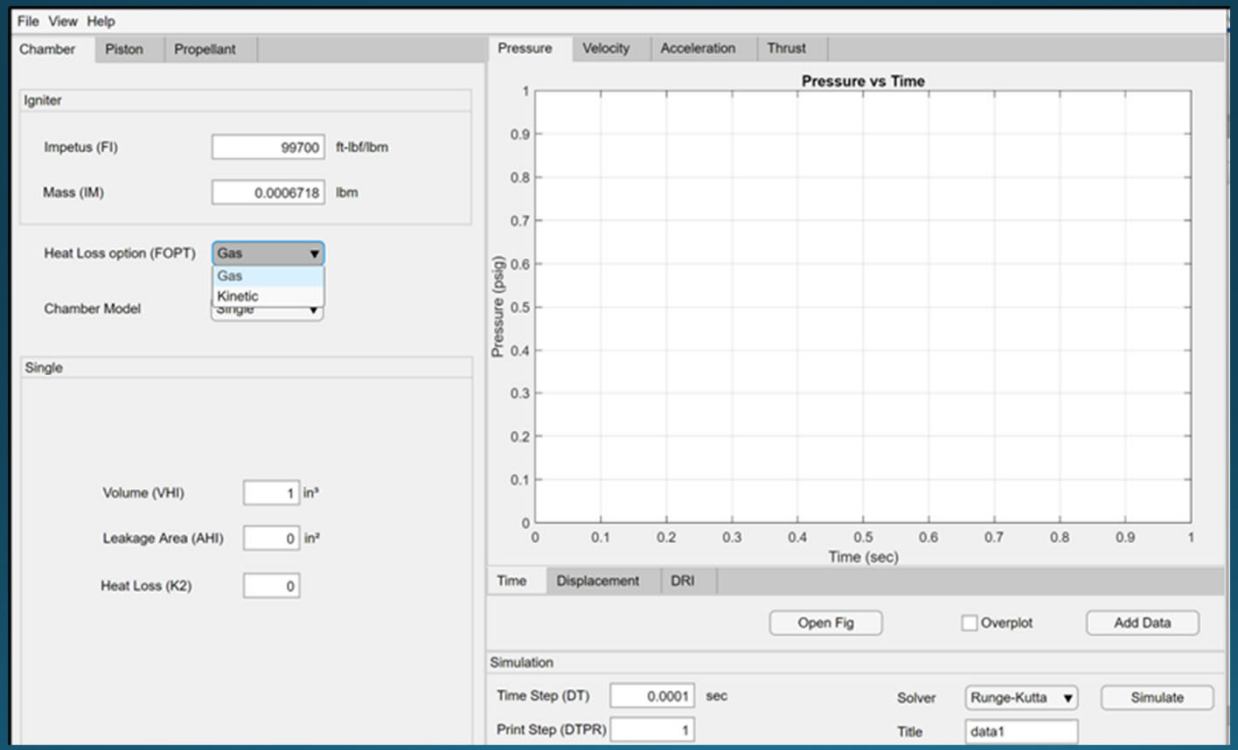
CADPROG GUI Opening Screen Shot



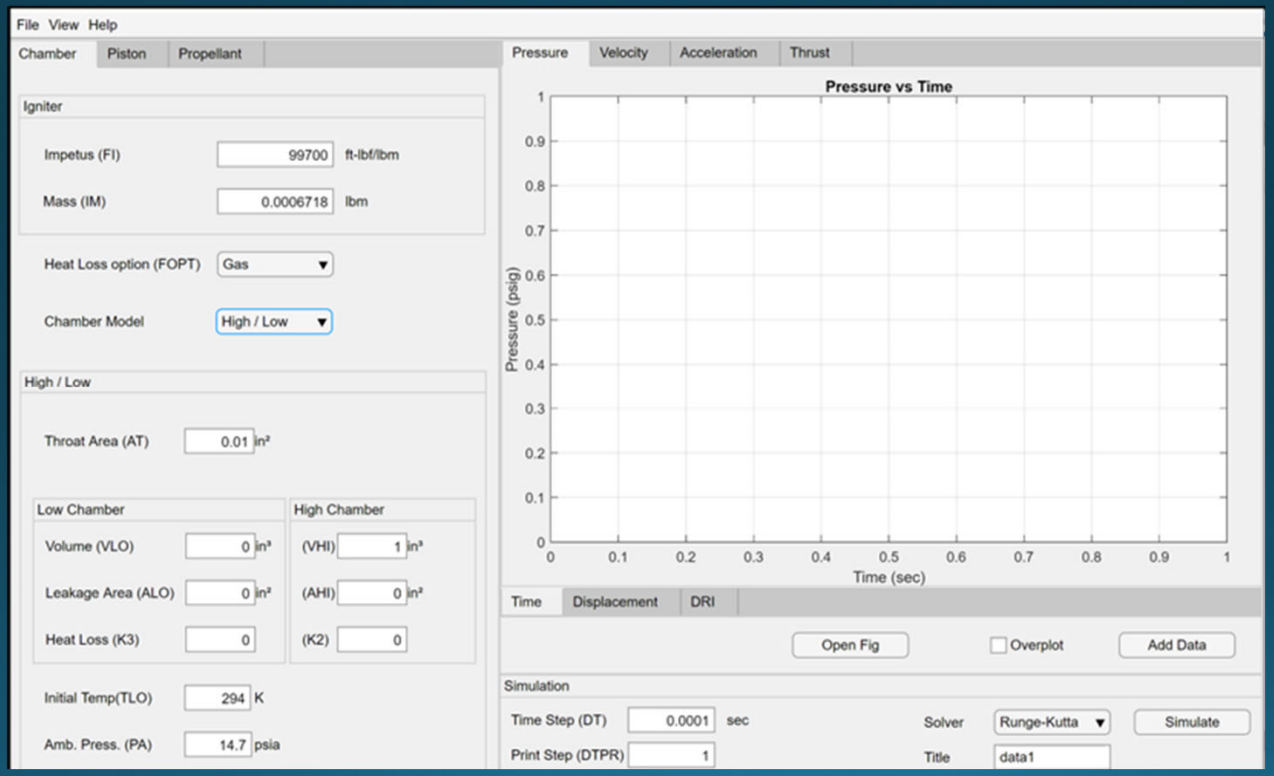
CADPROG GUI Default Simulation



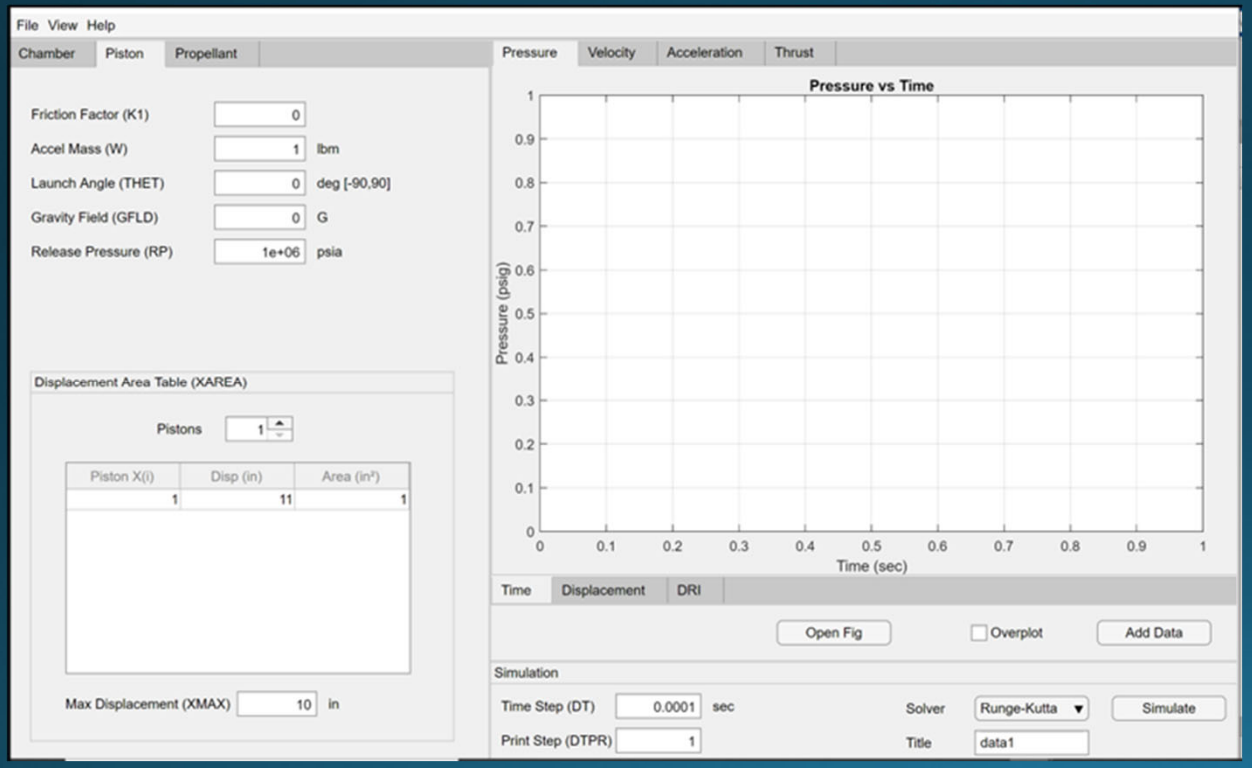
CADPROG GUI Heat Loss Option



CADPROG GUI Dual Chamber Inputs

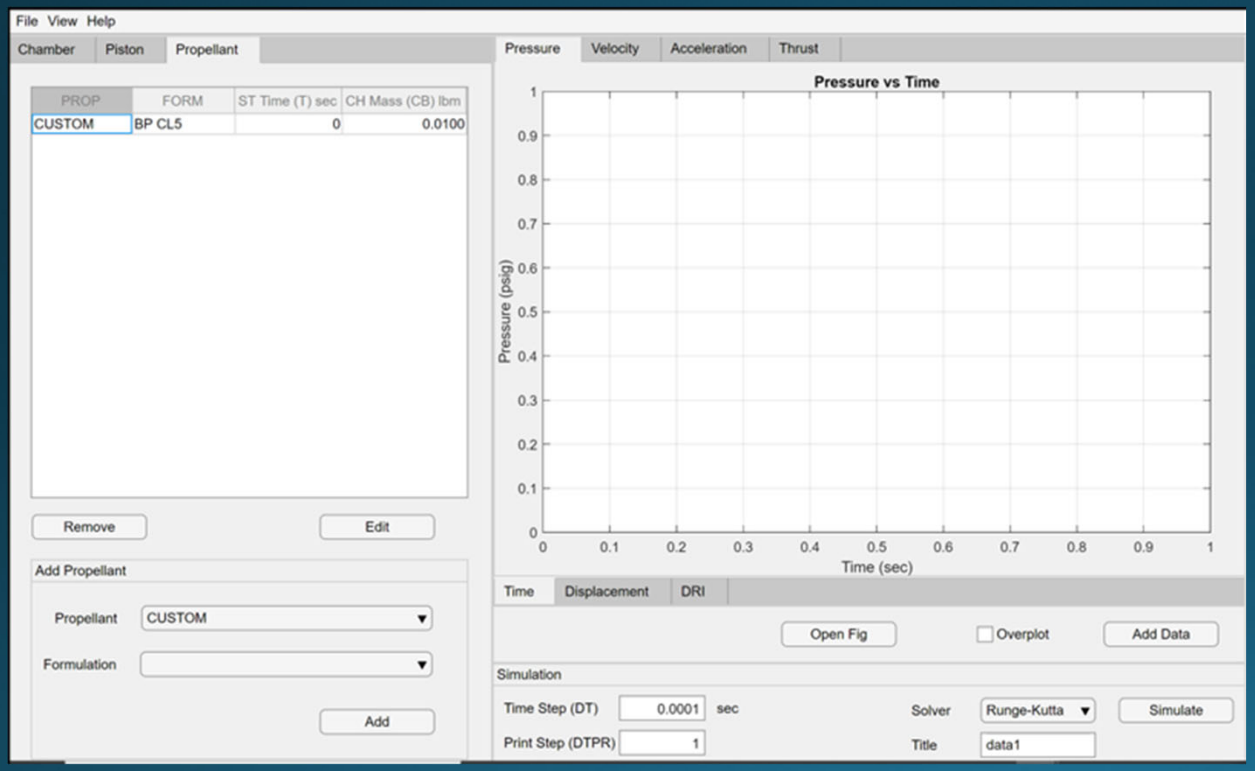


CADPROG GUI Piston Tab



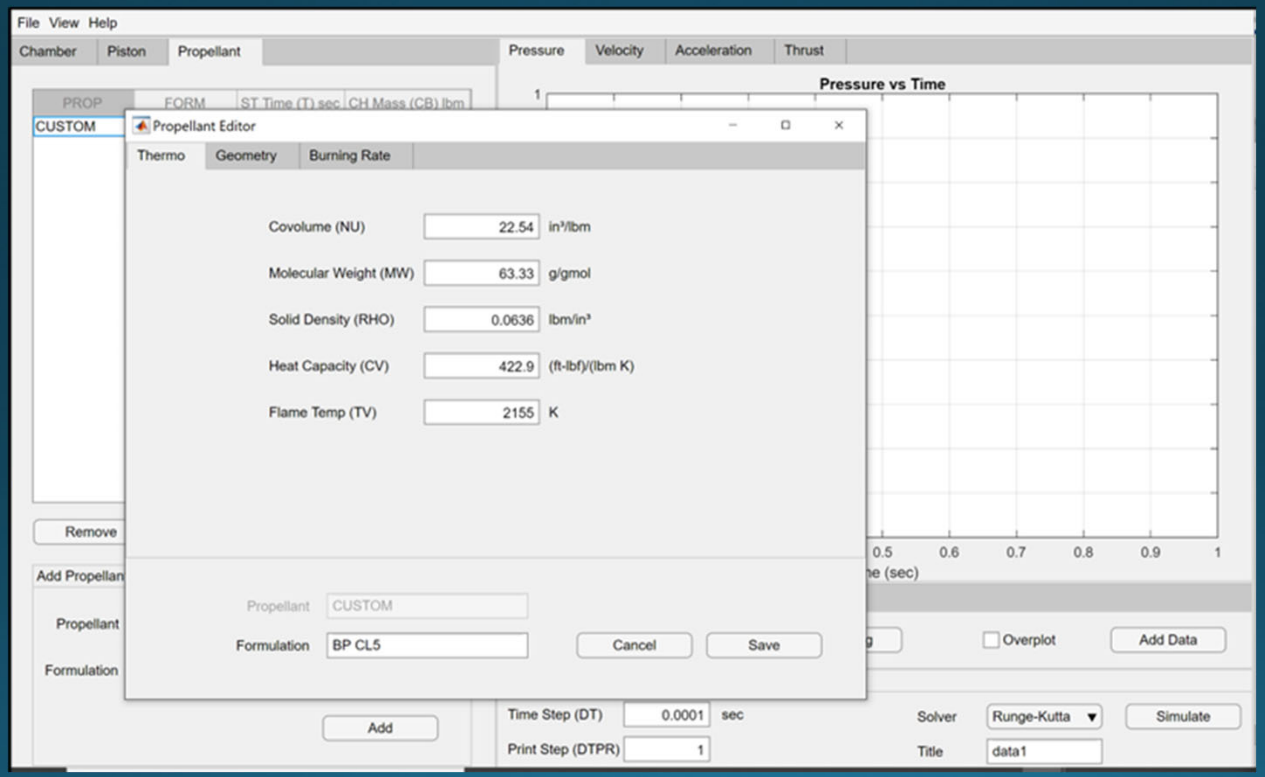
Note that XMAX must be less than the final piston displacement. Error message will be created if XMAX is greater than the displacement.

GUI Propellant Tab

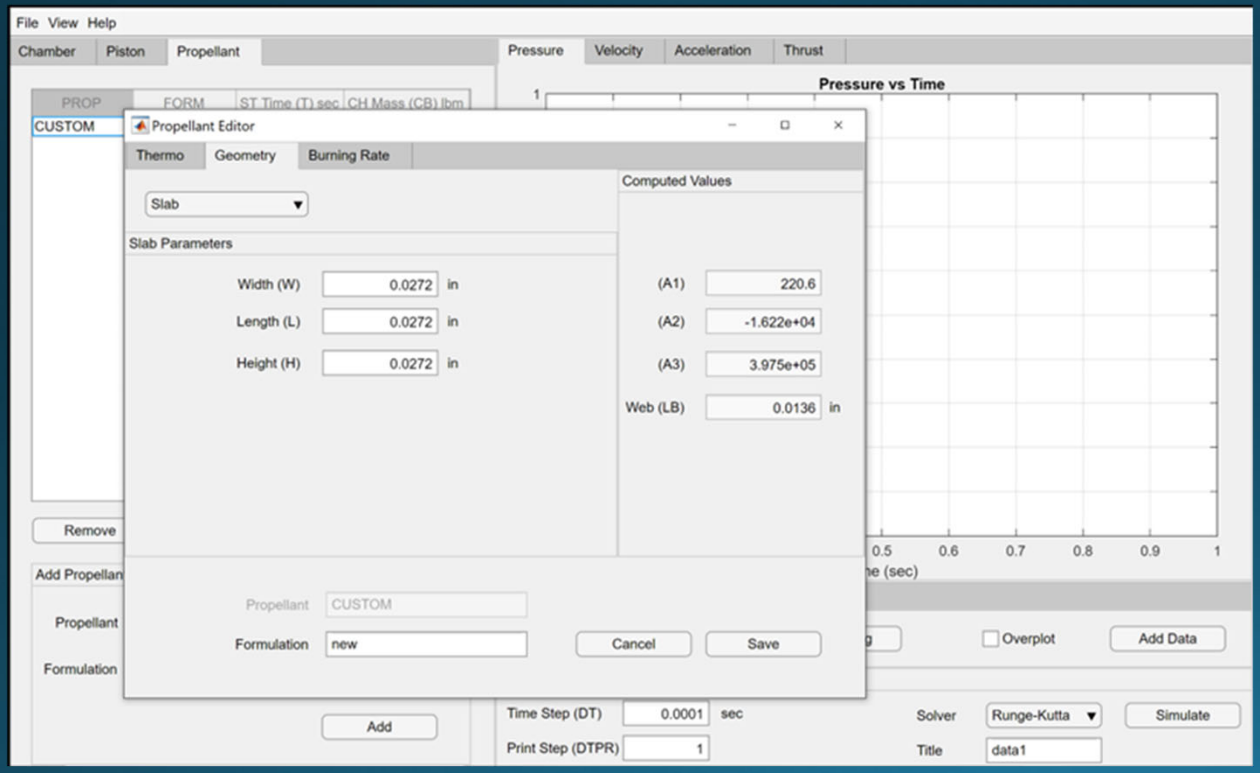


Once these buttons are activated, then the selected row can be edited or removed from the table. If the charge mass is greater than the allowed volume or if there is zero mass, an error message will be created to warn the 'user'.

GUI Propellant Editor Thermo Tab



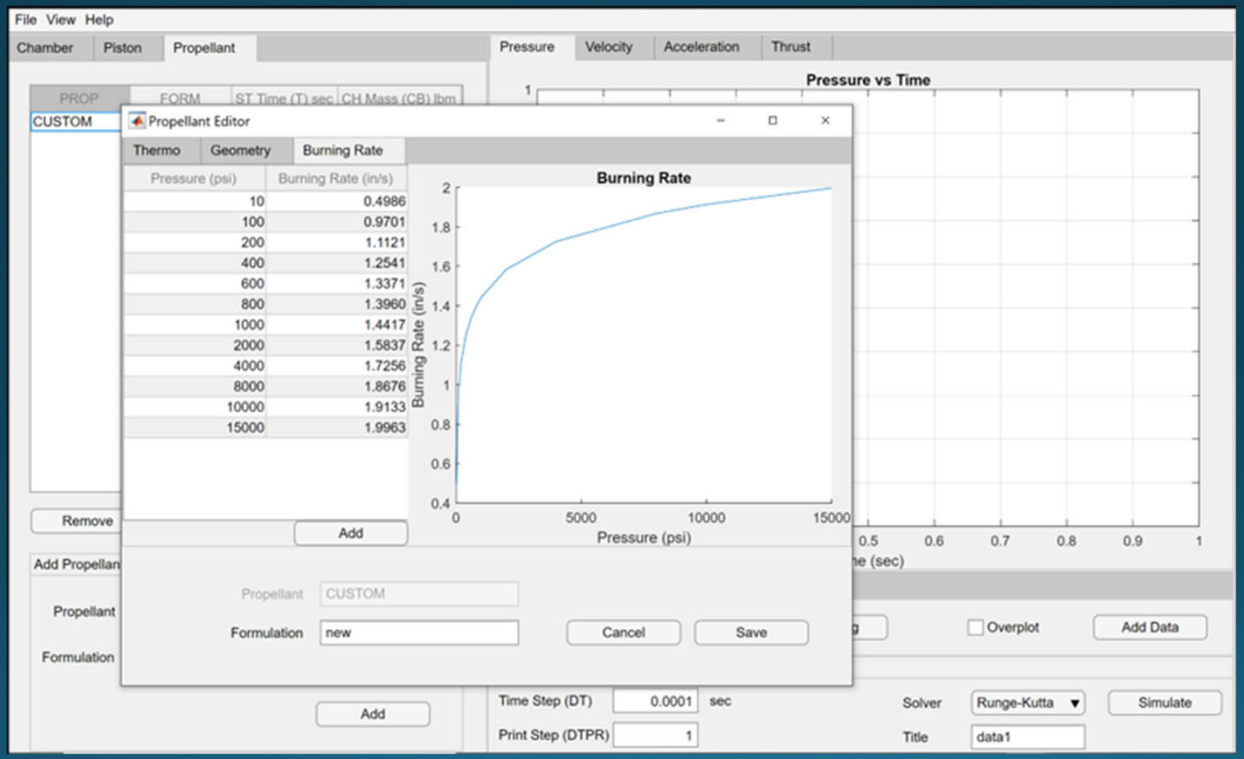
GUI Propellant Editor Geometry Tab (Model Default – Slab Pane)



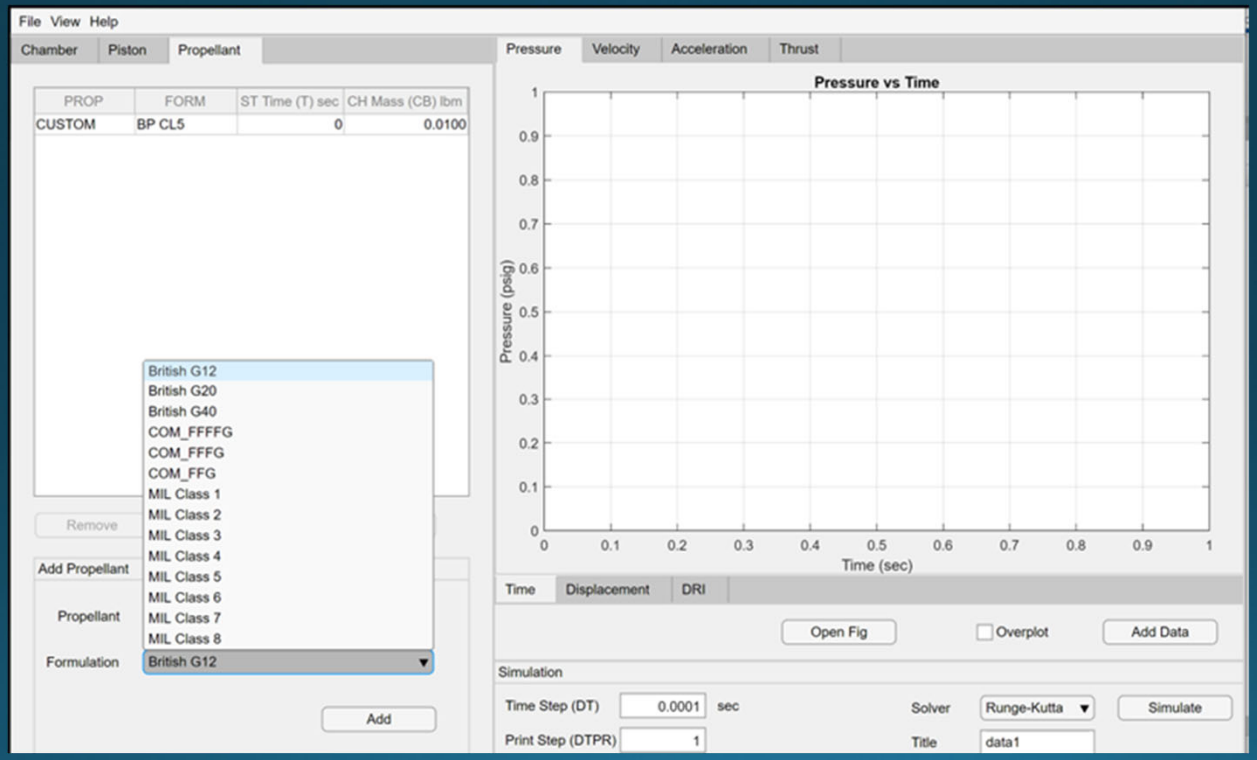
Geometry pane options: slab, cylinder, sphere, and coefficient.

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).

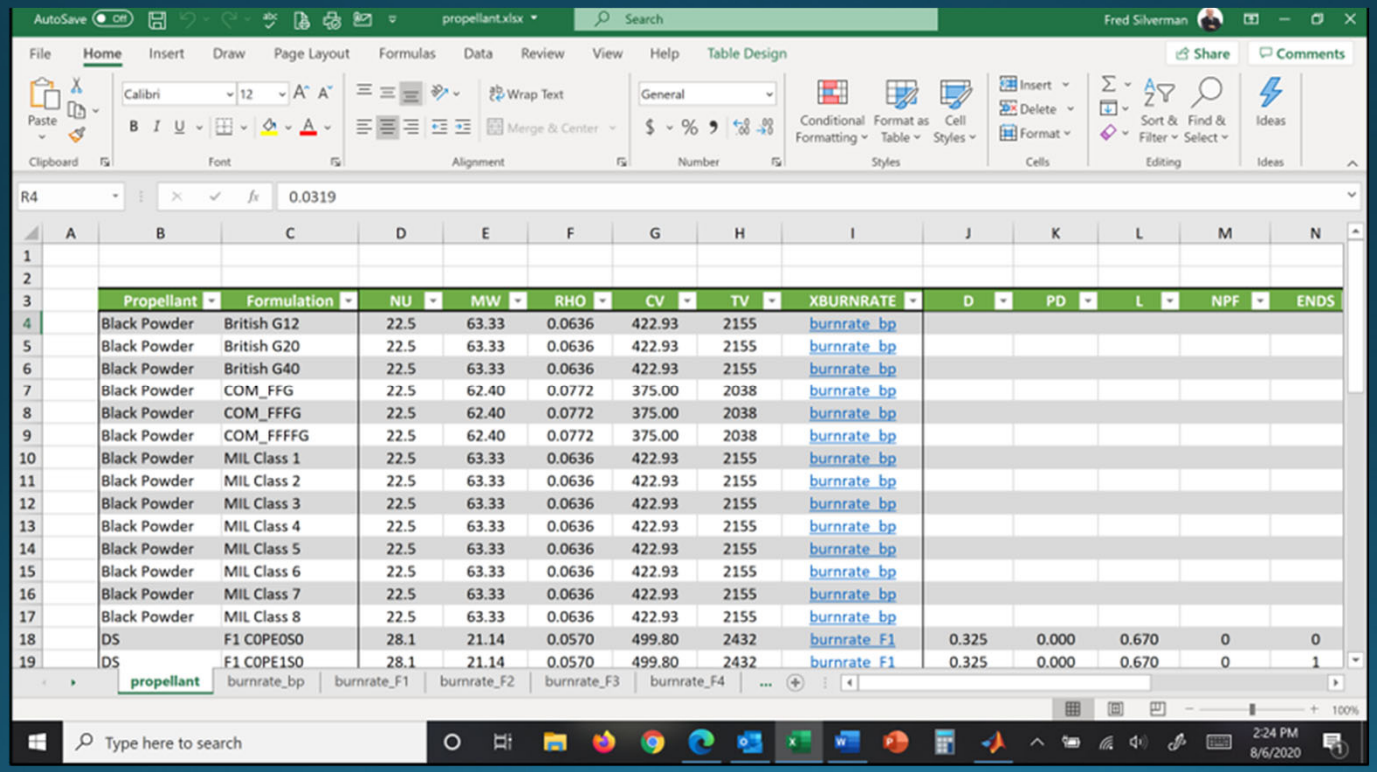
GUI Propellant Editor Burning Rate Pane



GUI Formulation Drop Down Menu



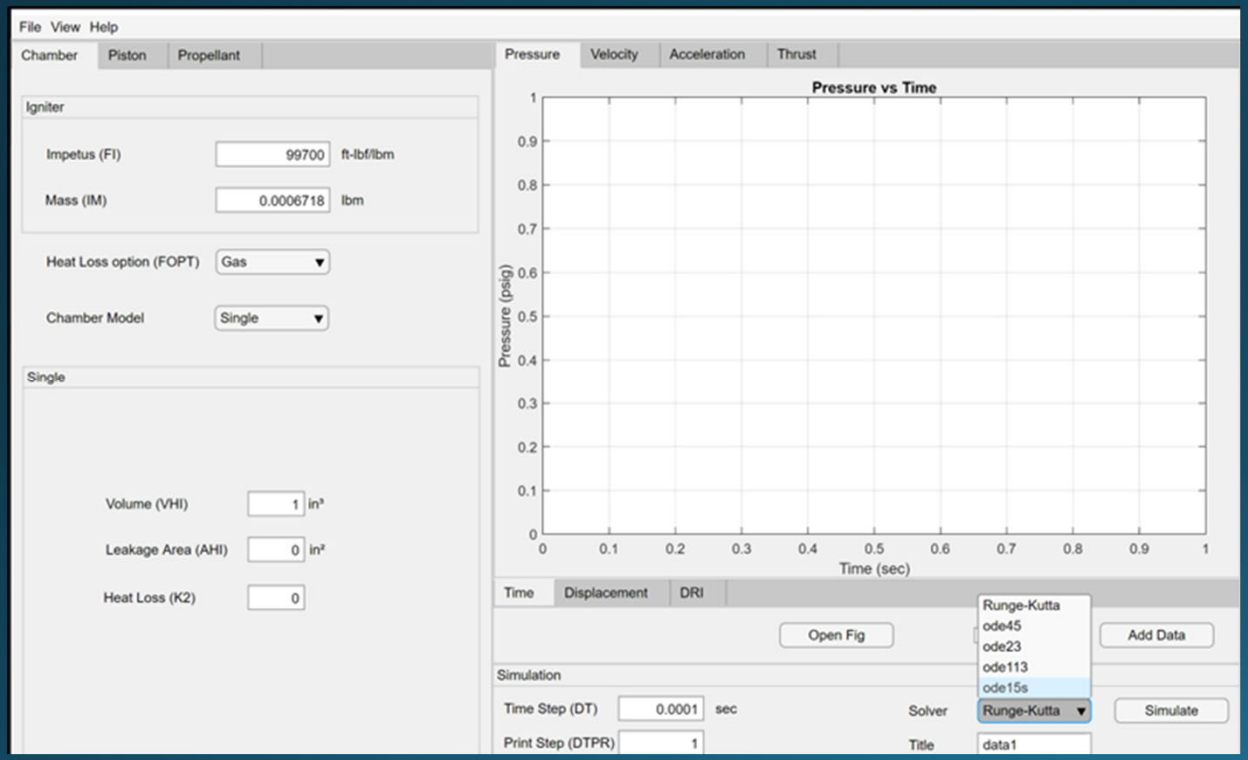
Opened Propellant.xlsx in Excel "Administer Access Only"



propellant.xlsx

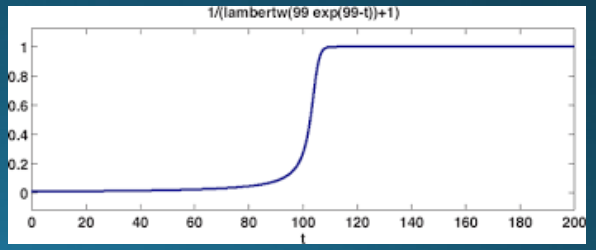
Propellant	Formulation	NU	MW	RHO	CV	TV	XBURNRATE	D	PD	L	NPF	ENDS
Black Powder	British G12	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	British G20	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	British G40	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	COM_FFG	22.5	62.40	0.0772	375.00	2038	burnrate_bp					
Black Powder	COM_FFFG	22.5	62.40	0.0772	375.00	2038	burnrate_bp					
Black Powder	COM_FFFFG	22.5	62.40	0.0772	375.00	2038	burnrate_bp					
Black Powder	MIL Class 1	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	MIL Class 2	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	MIL Class 3	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	MIL Class 4	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	MIL Class 5	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	MIL Class 6	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	MIL Class 7	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
Black Powder	MIL Class 8	22.5	63.33	0.0636	422.93	2155	burnrate_bp					
DS	F1 C0PE0S0	28.1	21.14	0.0570	499.80	2432	burnrate_F1	0.325	0.000	0.670	0	0
DS	F1 C0PE1S0	28.1	21.14	0.0570	499.80	2432	burnrate_F1	0.325	0.000	0.670	0	1

GUI Solver Drop Down Menu



MATLAB® Solver	Problem Type	Accuracy
ode23	Non-Stiff	Low to Moderate
ode45	Non-Stiff	Medium
ode113	Stiff	Low to High
ode15s	Stiff	Low to Medium

An ordinary differential equation problem is stiff if the solution being sought is varying slowly, but there are nearby solutions that vary rapidly.



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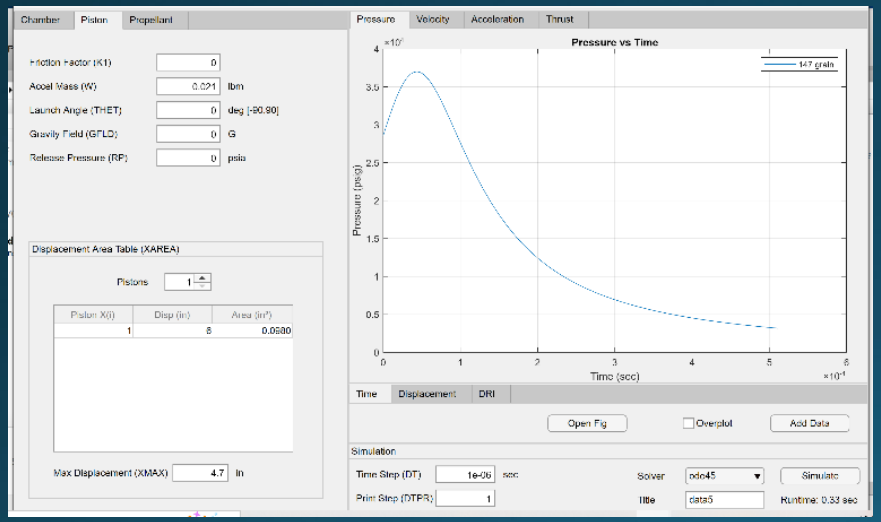
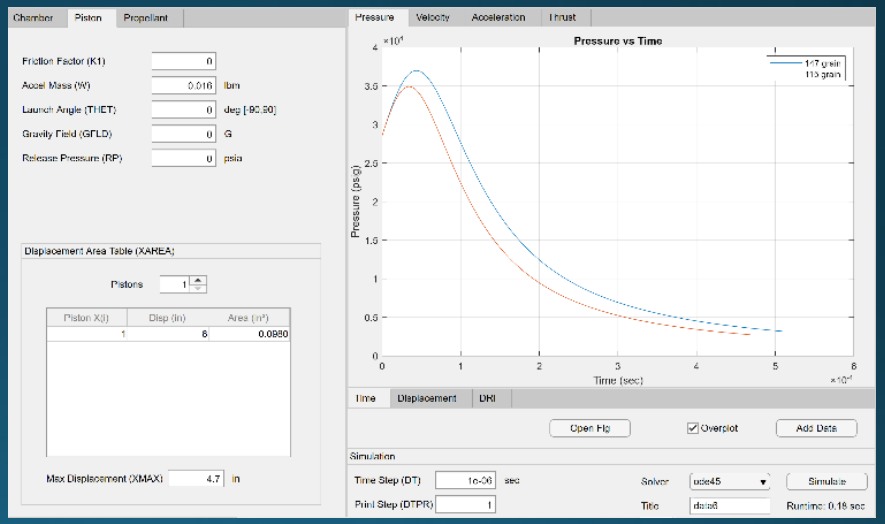
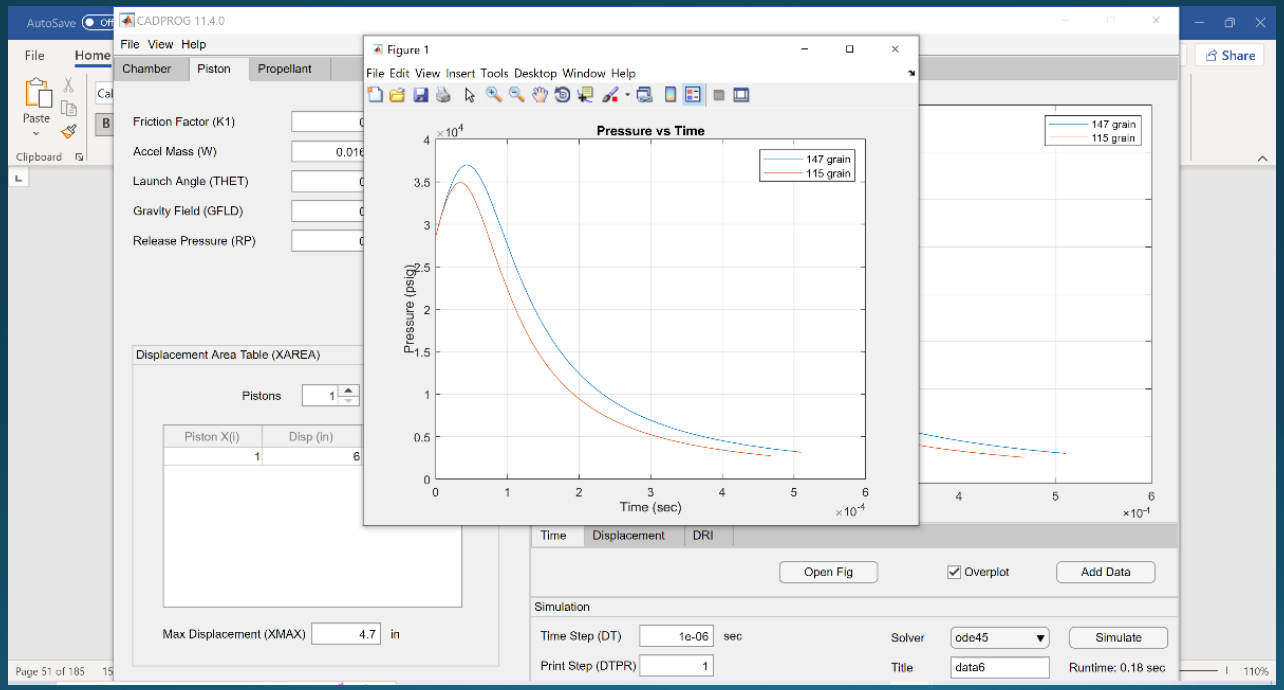
Interior Ballistic Simulation

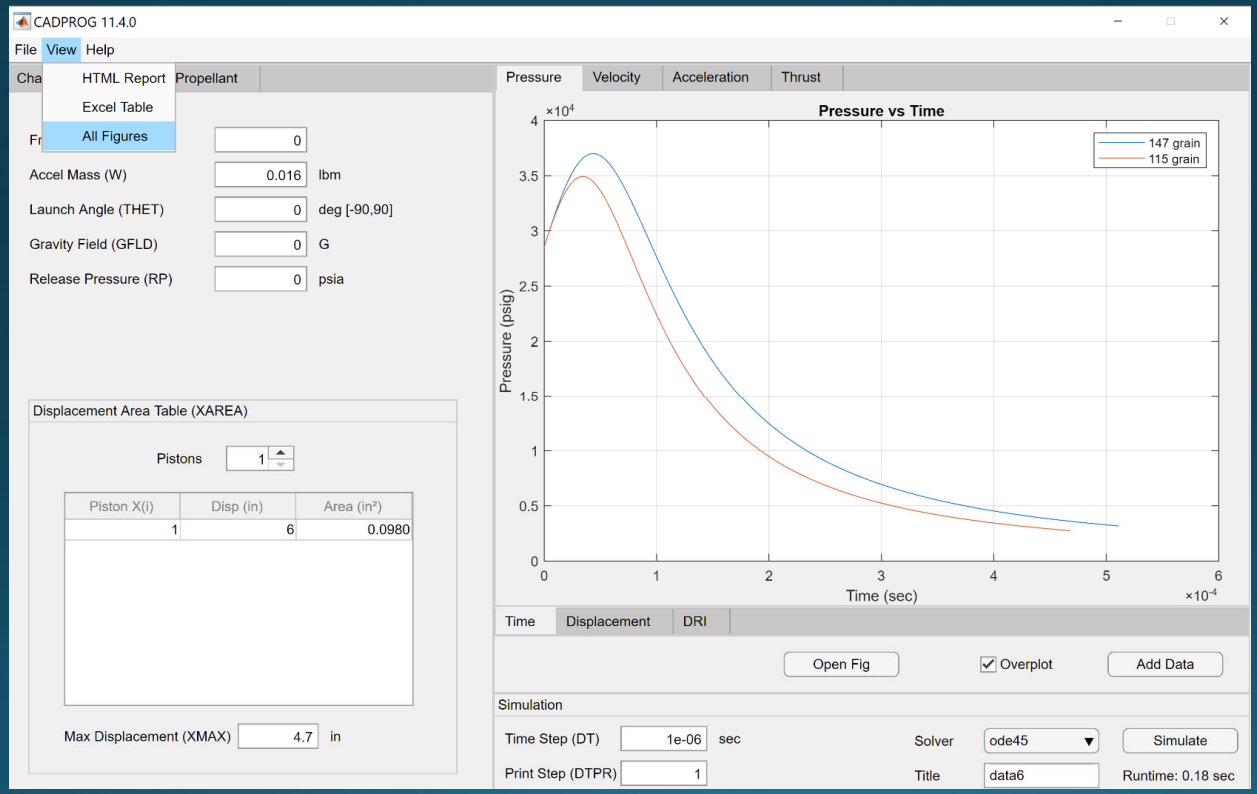




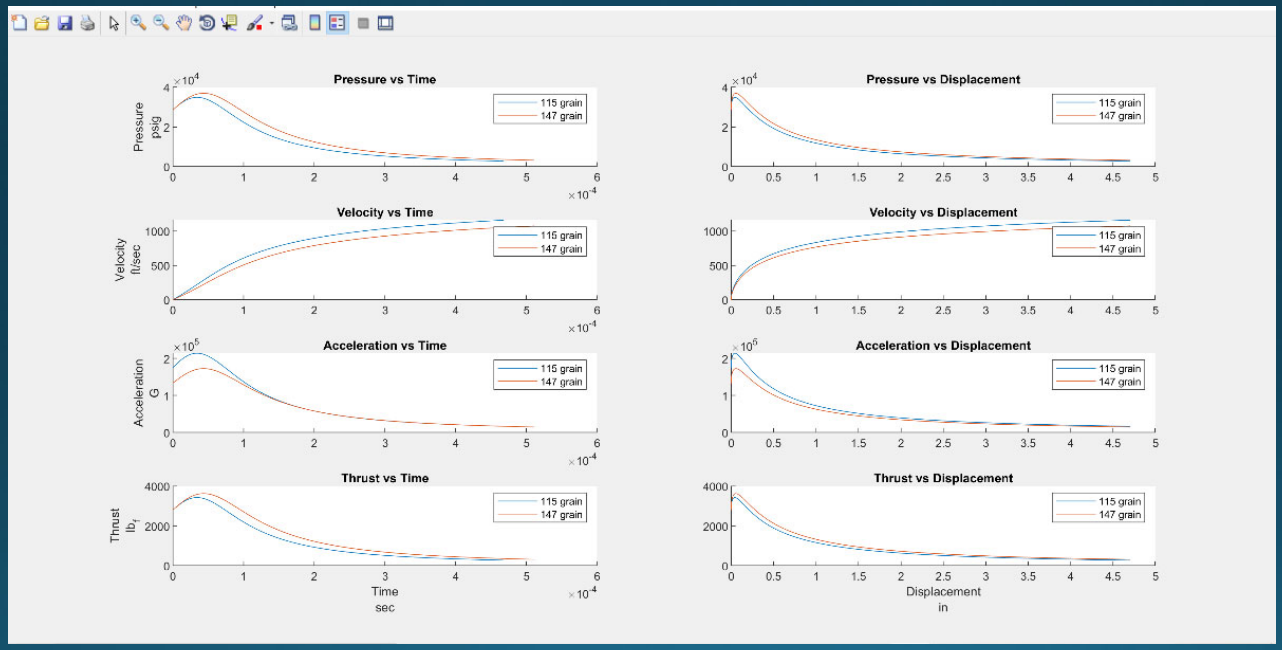
Edit Graph "Open Figure"



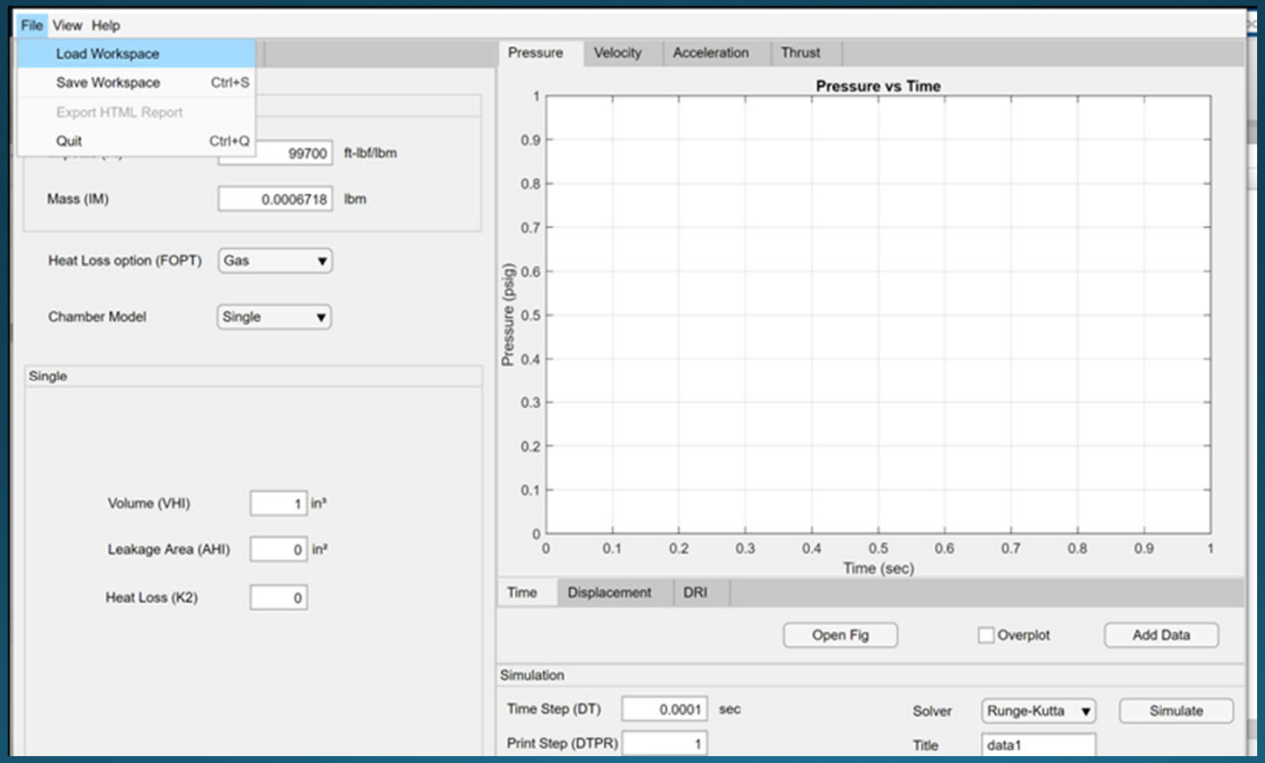
GUI View Drop Down Menu



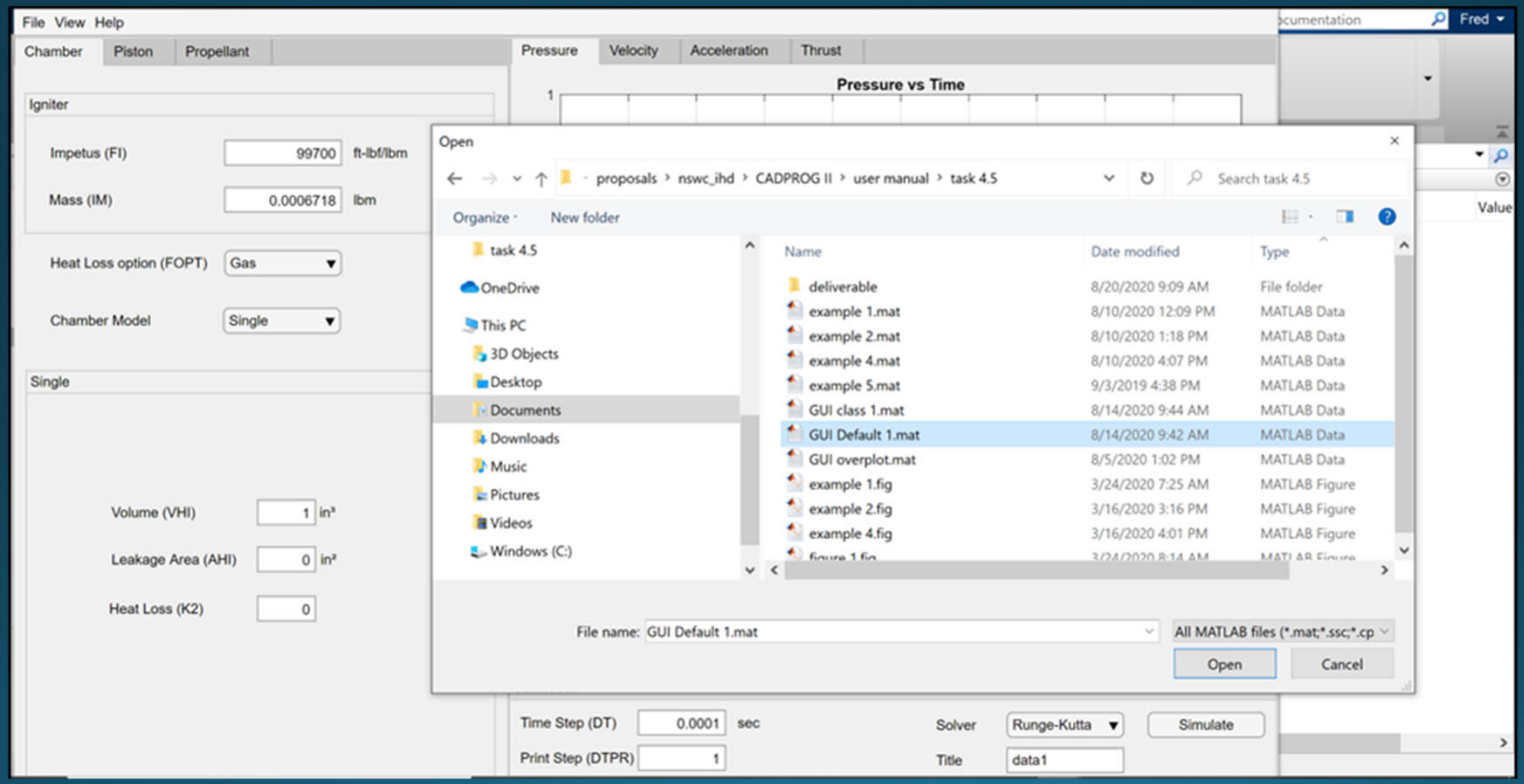
All Figures


Pressure vs Time
Pressure
psig
Pressure vs Displacement
Velocity vs Time
Velocity
ft/sec
Velocity vs Displacement
Acceleration vs Time
Acceleration
G
Acceleration vs Displacement
Thrust vs Time
Thrust
lbf
Thrust vs Displacement
Time
sec
Displacement
in
115 grain
147 grain

File Tab: Load and Save Workspace

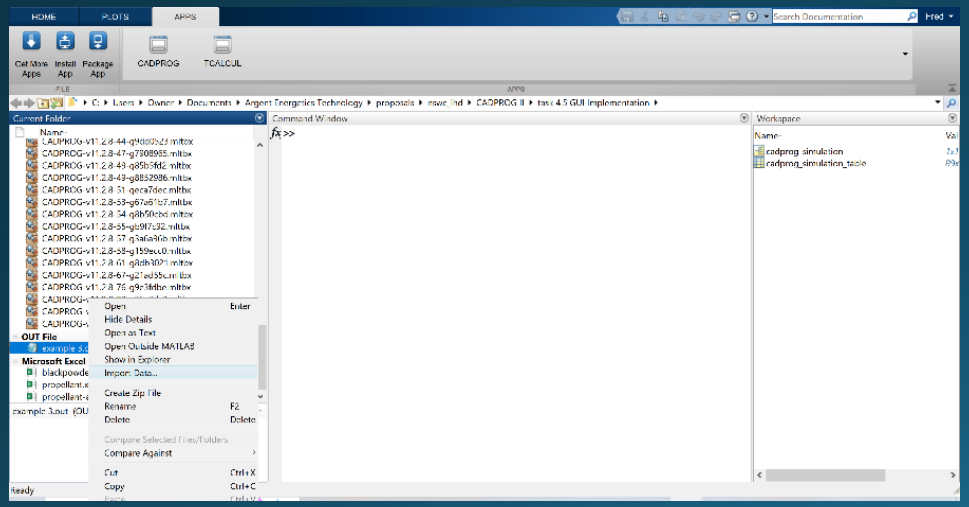


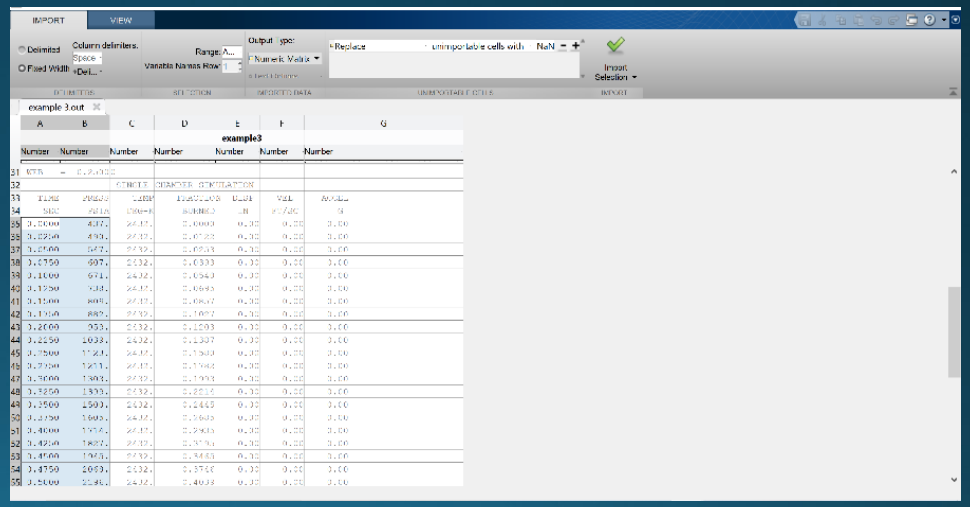
Load Simulation through Explorer



Import Data

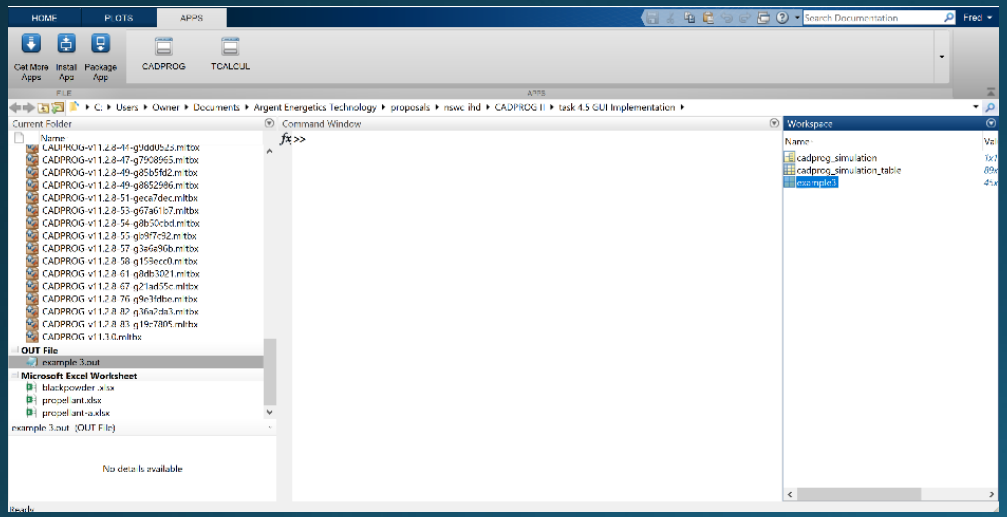
You are correct these operations are MATLAB® command intensive!
Even worse these operations are outside the GUI.

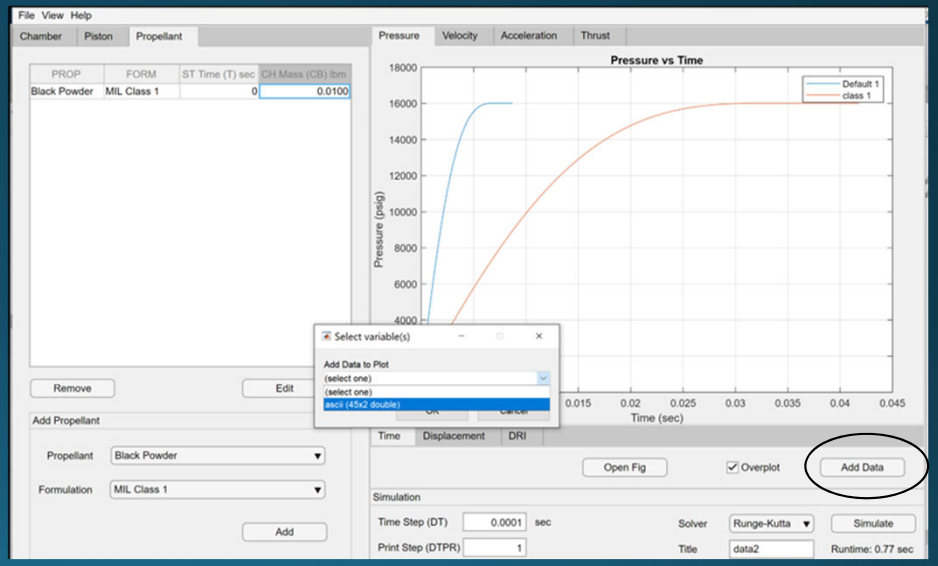




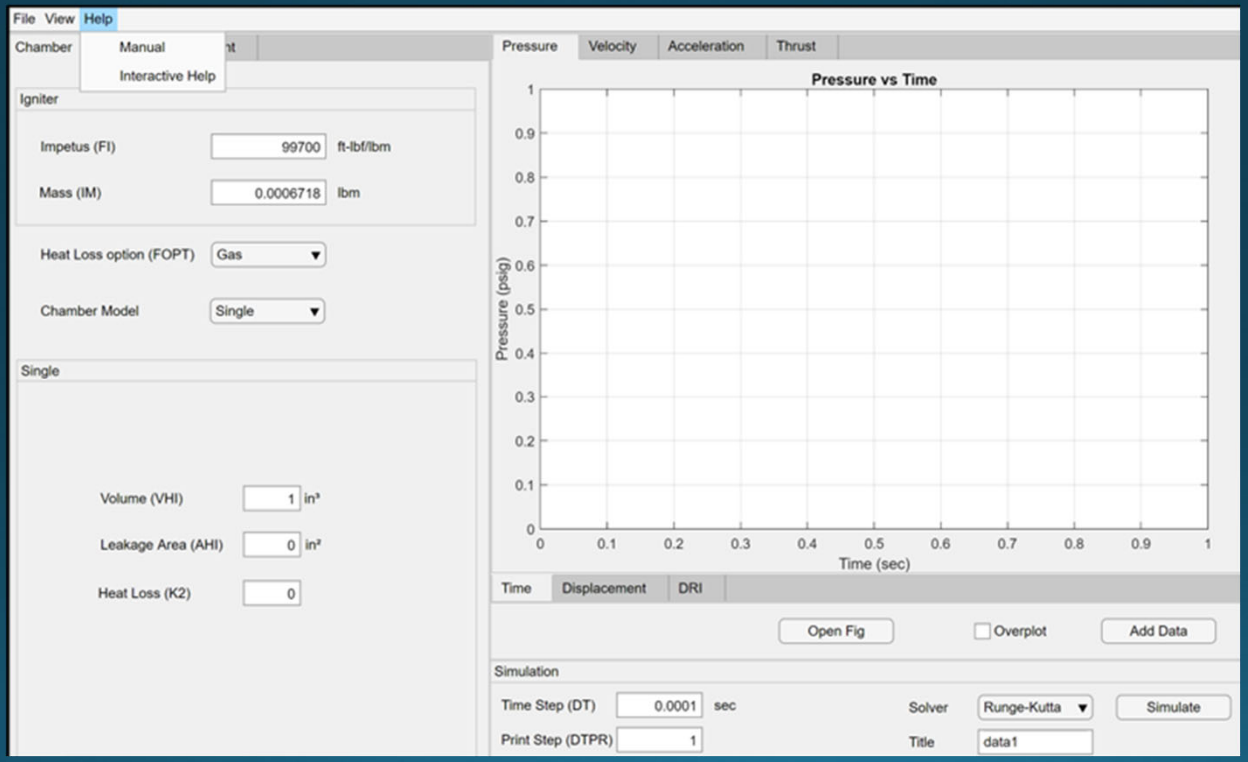
Import Data, continued

Back to the GUI, YEAH!





Help Tab


File View Help
Chamber
Manual
Interactive Help
Igniter
Impetus (FI)
99700
ft-lbf/lbm
Mass (IM)
0.0006718
lbm
Heat Loss option (FOPT)
Gas
Chamber Model
Single
Single
Volume (VHI)
1
in³
Leakage Area (AHI)
0
in²
Heat Loss (K2)
0
Pressure
Velocity
Acceleration
Thrust
Pressure vs Time
Pressure (psig)
Time (sec)
Time
Displacement
DRI
Open Fig
Overplot
Add Data
Simulation
Time Step (DT)
0.0001
sec
Print Step (DTPR)
1
Solver
Runge-Kutta
Title
data1
Simulate

Final Statement

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