User Manual

PROpulsion Modeling and Performance Tool (PROMPT)

Ayush Srinivasan

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1 Acknowledgments

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2 Introduction

PROpulsion Modeling and Performance Tool (PROMPT) is a Python tool to allow for the fast prototyping of liquid rocket engine contours. Currently, the program has support for conical and bell nozzles, with injector characterization, stress analysis, and heat transfer being added at a later date. The purpose of this document is to explain how to use PROMPT and the features that are enabled. To use this program, a computer with Python 3.13 is required. Additionally, if forking the program from GitHub, it is recommended to have a code editor such as Microsoft VS Code. Documentation for the equations used can be found in the PROMPT Engine Documentation file.

3 Getting Started

PROMPT is designed in Python 3.13 and relies on several third-party libraries for numerical analysis, visualization, chemical-equilibrium analysis, and its user interface. Specifically, PROMPT uses NumPy, SciPy, MatPlotLib, Pandas, RocketCEA, and PySide6.

To install all required dependencies, run the following command in a Windows PowerShell Terminal with python 3.13 already installed and available on the system PATH:

python -m pip install -r requirements.txt

PROMPT is meant to be run from a code editor with an integrated terminal, such as VS Code or PyCharm. To run PROMPT, open the project folder in your code editor and ensure the terminal's working directory is set to the PROMPT project root. Ensure the editor is configured to use Python 3.13 with all required dependencies installed. The program can be run on the terminal using the command **python main.py**.

4 User Interface

PROMPT uses PySide6 to build the graphical user interface. The user interface includes a top menu, menu bar for results, plots, and visualization, and sidebars for inputs.

4.1 Top Menu

The top menu has dropdown menus called File, View, Help, and Settings.

When File is pressed, it gives the options to open, save, and exit. Open and save are inoperable with the eventual goal of adding in options to open and save runfiles. When exit is pressed, the program will shut itself down and exit.

The View menu allows for toggling or un-toggling the feature tree, properties, or console. This can allow for more space to view the main section with plots and visualization if needed.

The Help menu includes an About section which gives details for further information. Future tasks include adding in a direct link to the user manual and design documentation.

The Settings menu allows for customization of the color scheme. The menu includes light and dark modes with special magenta and green themes as well. Additionally, PROMPT can be set to Windows theme settings as well.

4.2 Menu Bar

The menu bar has two options, inputs and export. Inputs will have the option to run or reset the inputs provided to the PropertyManager tool. If Run is pressed, the program will run and give results. If Rest is pressed, all inputs are removed allowing for the user to re-input the parameters to run.

The export option has three options: Export CEA, Export Engine Data, Export CAD Datapoints. Export CEA creates a csv file for the chemical equilibrium analysis data. Export Engine Data creates a csv file with all the major parameters for the engine that are calculated from the program. Export CAD Datapoints creates a csv file which can be inputted to computer aided design programs such as Fusion 360 or SolidWorks as an engine contour. It is important to note that Export CAD Datapoints will only export one contour selected by the OF Ratio in the Visualization Tab (more details below).

One quirk of PySide6 is that when switching between Inputs and Export, the options for each are removed. To fix this, right click on the button you want and retoggle Inputs or Export on the dropdown.

4.3 PropertyManager

The PropertyManager is the toolbar that contains all the inputs that are required for the program to function. The manager is split into 2 sections: Chamber/Propellants and Nozzle.

Chamber/Propellants is used to give inputs for CEA analysis. A major property to note are that the oxidizer-fuel ratio can be either a single value or swept. If sweeping, choose the option to Sweep O/F. Another property to note is the ability to choose for frozen flow. Frozen flow assumes that the gases in a engine chamber do not change during combustion. If this is selected, PROMPT will assume that this is true. Real rocket engines operate between frozen and unfrozen (or equilibrium) states. It is recommended for you to do your own research as to what works for your design.

Nozzle is used to give inputs for the contour and performance characteristics for a engine. The primary properties to note are type, the external pressure checkbox, and Contraction Ratio, Throat Ratio, and L*. PROMPT can generate a conical or bell nozzle , and type allows you to select either option. If Bell is selected, another dropdown menu will be created which allows the user to select their bell percentage. More information on this is provided in the PROMPT Design Documentation. The external pressure checkbox allows the user to use ambient pressure for sea level or input their own external pressure. Finally, the contraction ratio, throat ratio, and L* can be chosen with the tables provided in the PROMPT Design Documentation. Be sure to research the ratios that are chosen.

4.4 Main Menu

The main menu has three sections: Results, Plots, and Visualization.

The results section exports a table with O/F ratio, Isp, characteristic and exit velocities, mass flow rates, and temperatures at the chamber, throat, and exit sections of the nozzle.

The Plots section has a dropdown menu for plots of Isp vs O/F, Velocity vs O/F, and Temperature vs O/F. All three of these plots can be used to select an O/F ratio to design.

The Visualization Section has a dropdown of O/F ratios and generates the engine contour and 3D views of the engine for the selected O/F. It is important to know that the dropdown for selecting O/F visualization also selects the contour that will be exported (see section 4.2).

5 Code Pipeline

When an analysis is executed, PROMPT follows a fixed computational pipeline that transforms user inputs into performance data and nozzle geometry. This pipeline ensures consistent assumptions and repeatable results across runs. The pipeline is shown below:

1. Define input parameters and nozzle geometry
2. Run CEA analysis
3. Run Isentropic and Performance characterization
4. Output Results, Visualizations, and Exports

6 Roadmap

The next steps for PROMPT include fixes and additions to the User Interface, including load/save options and renamable export files. Additionally, injector modeling and exports directly to CAD API tools are major features that will be added. In the long run, PROMPT hopes to add stress and heat transfer modeling for liquid rocket engines, along with possible time-step analysis of engine performance.