PROPULSIM
A Model Based Design Software for Propulsion System Design

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1 Stage of the project

We have developed a rapid prototype for the core layer, one that handles computations, under MATLAB environment. This core at the time being is able to solve the steady-state behavior of simple pipe networks and some turbo-machinery components. We also developed a user friendly graphical user interface (GUI) and started porting our MATLAB code into C#. Now, we can show a stand-alone proof-of-concept desktop application demo that can solve pipe networks that are defined by the user via drag and drop interactions. We also began implementing databases for some standard components. As a next step we will start implementing Git integration which lets teams of all sizes to collaborate easily in a shared project.

2 Short description of the project

Development of power and propulsion systems is an iterative and costly task with typical design times spanning to about seven years and an exponential cost . Our aim is to reduce iteration cycle times at least 15%, by cutting 5% in the overall project cost. Our software product "Propulsim" is an object oriented software for the model based design, simulation and optimization of power and propulsion systems, offering a concurrent and collaborative team design environment.

Figure 1: Propulsim and Simenergy Logos

We are also developing another product "Simenergy" which shall be the energy sector counterpart of Propulsim. It will be capable of solving power plant cycles (Rankine, ORC, combined cycles etc.) and targets energy customers. Both software are essentially thermodynamic cycle solvers, they have a lot in common. This will enable us develop both software concurrently.

2.1 Conventional vs Model Based Design

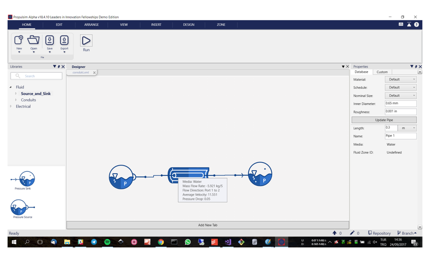

Figure 2: Propulsim GUI

As engineering systems become more complicated, software dependent and complex, model based design provides enabling technologies for robust and cost-effective product development. Model based development also helps to ensure design quality, functional safety verification and re-use of design assets.Conventional silo design approach wherein each component is optimized individually and put together in a system only results in a sub-optimal design at the system scale. Model based design offers a holistic perfective that remedies this drawback.

Successful companies apply modeling and analysis of systems at start of the process using model based design as early as possible and throughout component design, then integrating this information to address the full system.

2.2 Collaborative Working Environment

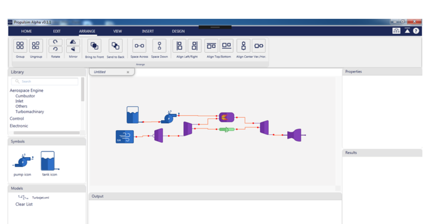

Figure 3: A Turbojet Model in Propulsim GUI

Propulsim offers a collaborative working environment. A team of engineers can work on the same design simultaneously. Within this framework, they can either focus on different parts of the project or they may simultaneously evaluate different alternatives without hindering one another's work. Distributed version control offers new possibilities about how project are shared and documented. This feature is expected to reduce overhead and paperwork associated with documentation.

2.3 Physics Based Modeling

In order the simulation to be accurate fidelity of mathematical modeling must match the reality closely. We aim to gain a competitive advantage by providing high fidelity turbo-machinery and engine component models within our libraries.

2.4 Design of Experiments, Optimization and Statistics

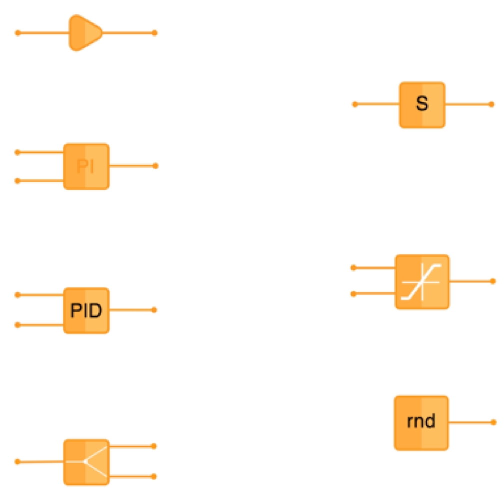

Figure 4: Control Library Icons

Software will include an automatic design of experiments (DoE) tool in order to explore a vast number of design alternatives which is impossible to do manually. Based on the results of DoE analysis a response surface will be generated which will be used for optimization. This tool provides insight into design alternatives and trade-offs. We will also incorporate a statistical uncertainty quantification tool into our software.

2.5 Co-Simulation and Data Exchange

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                                                      |Web: www.melina-aero.com
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Number of nodes = 3
Number of connections = 2

Number of pressure sources = 1
Number of pressure sinks = 1
Number of pressure pipes = 1

Number of state-variables = 12
Number of steady-state equations = 12

Validating model
Model validation complete
Compiling steady-state equations and state variables
Compilation finished
Solving steady state equations
Starting Newton-Raphson iteration
Steady-state solution found succesfully
```

Figure 5: Sample Log File from a Simple Pipe Network Simulation

Software will have two-way data exchange capabilities with third-party proprietary applications such as Excel, Matlab, Tecplot etc. On top of that, SaaS version will provide data exchange with other SaaS tools such as Google Sheets, Google plots etc. Another goal is to provide co-simulation capabilities with common third party software such as SIMULINK.

3 The technology and the intellectual property

At the very heart of the software there is a robust differential-algebraic equation (DAE) solver which is capable of handling stiff systems of equations. What the program does actually is to convert the model defined by the user via drag and drop interactions into a DAE system of the following semi-explicit form.

$$
\begin{aligned}
\dot{x} &= f(t, x, z) \\
0 &= g(t, x, z)
\end{aligned}
$$

Propulsim and Simenergy both are being built upon the MVVM (Model-View-ViewModel) architecture, and both will have two variants one a desktop application built using WPF technology, another one will be a web application using Silverlight. This not only minimizes redundancy, but also makes software maintenance easier. The web application will be licensed with a Software-as-a-Service (SaaS) model. We believe that having a SaaS version will democratize the market, empower individual and SME scale customers and reach a much wider user base generating constant revenue.

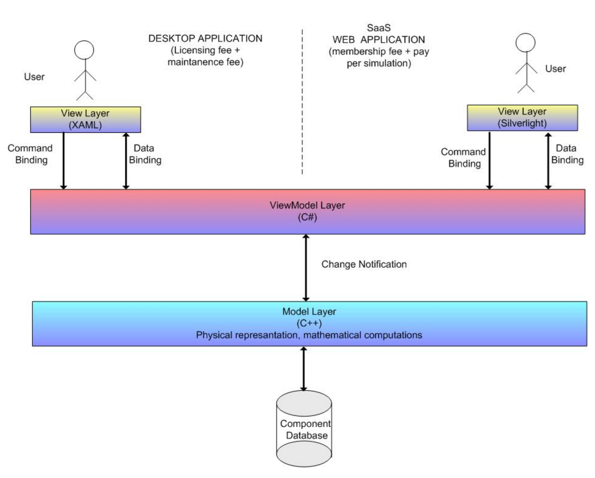

Figure 6: Model-View-View Model Design Pattern for Both Desktop and SaaS Delivery

Software with its modular loosely-coupled yet coherent architecture will incorporate lots of design modules as well. These add-on modules will enable the conceptual design of engine components. This feature will be aimed at providing a seamless preliminary-integrated-design (PID) approach for the customer.

Figure 7: Aerospace and Energy Market Size

4 The market size and opportunity

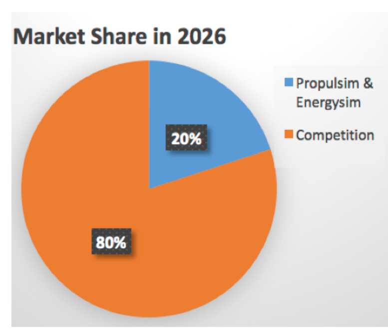

Figure 8: Projected Market Share by 2026

Aerospace and energy markets globally represent a market size of nearly a trillion dollars per year. In today's software driven world software has a large share in this market, because software plays a crucial role throughout the life-cycle. Model based design plays an ever increasing role in this lifecycle, from preliminary design to plant control. We are estimating a modest 1% estimate for the market share of model based design software in this market.

5 Route to market

We outline a eight year projection from the start of the project.

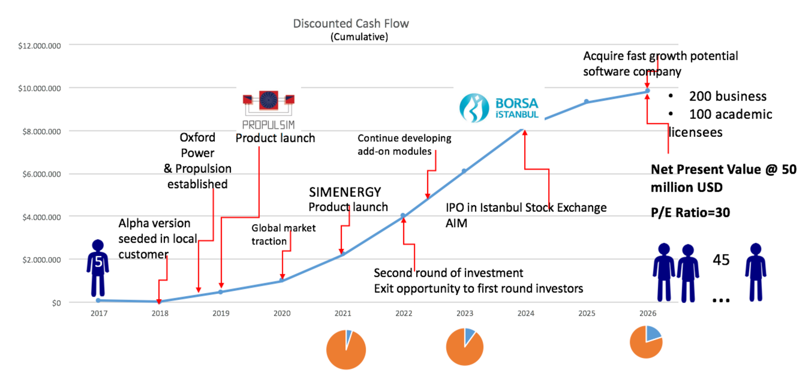

Figure 9: Discounted Cash Flow Analysis

- 2017 proof-of-concept complete
- 2018 beta testing for Propulsim
- 2019 Propulsim sold in local market
- 2020 First global customer for Propulsim
- 2021 Simenergy in the market
- 2022 IPO in the AIM market of Borsa Istanbul
- 2023-2026 Add-on software module development
- 2026 50 million USD net present value

6 The Team

- Onur Tunçer, Founding Partner, Mechanical Engineer
- Ferit Tunçer, Computer Scientist
- Yekta Mirkan, Software Developer
- Stanislav Grate, Aerospace Engineer
- Nagihan Aydınlık, Graphical Designer
- Murat Özfırat, Business Development Consultant
- Mark Vellacott, Mentor

7 Investment

A discounted cash flow analysis puts Melina Aero's net present value at 50 million USD in 2026.While performing the analysis only revenues from desktop versions of Propulsim and Simenergy are taken into account. Revenue projections from SaaS version were not considered. Therefore Melina Aero's value for today is 5 million USD. We are therefore offering 20% equity in the company in exchange of 1 million USD investment.

Acknowledgements

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