# Propellant Electric Feed System

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ME-491 Capstone Project Proposal
11/18/2016

## Team Members

1. **Jorden Roland, Team Facilitator:** jroland@pdx.edu
   PSAS member since 2013 including team lead on multiple projects, aerospace nerd, published AIAA member, Licensed HAM radio operator (Technician class), Working on this particular project since Sept. of 2016.

2. **Johnny Froehlich, Lead: Design/Analysis:** froeh@pdx.edu
   PSAS member, aerospace nerd. Propulsion engineering intern at NASA Goddard, 2015. Research assistant in Dryden Drop Tower lab at PSU, 2014-current. Statistics and R programming, scientific computing with Python, rapid prototyping, Arduino, design analysis and testing, CFD, strong believer in reproducible research.

3. **John Talik, Lead: Design/Modeling:** JTalik@pdx.edu
   Psas member and aerospace nerd. Relevant work experience includes Nike Design Engineering Intern, Undergraduate Research program in WET lab, Viking Motorsports Composite Team 2015/14. Heavy solid modelling/surfacing experience, preparing drawings for manufacturing, machine design and automation, 3D printing/rapid prototyping, Composite design and manufacturing.

4. **Rawand Rasheed, Lead: Turbomachinery:** Rawand@pdx.edu
   PSAS member and Aerospace nerd, President and Co-Founder of the Kurdish Youth Organization, Officer and Co-Founder of ASME: Engineers for Global Development at PSU, Undergraduate Researcher: WET Lab, Design Engineering Intern at Sulzer Pumps, Mechatronics Intern: Powertrain Systems at Daimler Trucks, Mechanical Engineering Intern at Intel: STTD R&D Pathfinding Lab, Tutor for MME Department at PSU. Proficient in Solidworks, NX, Autodesk: Inventor, R, Arduino, Swift, MATLAB, and LaTeX.

5. **Mimi Shang, Lead: Mechatronics/power:** mshang@pdx.edu
   Aerospace nerd, PSAS member since September 2016, president and member of Society of Women Engineers since 2015, Mechatronics Intern: Powertrain Systems at Daimler Trucks, Mechatronics Intern: HVAC at Daimler Trucks, Undergraduate Research: Ecoroof monitoring. Proficient in MATLAB, Simulink, Solidworks, and R.

6. **James Luce, Lead: Thermal/Structures:** jaluce@pdx.edu
   NASA internship at Marshall Space Flight Center, 2016: Finite element analysis for thermal and launch loads in rocket motors. Undergraduate research at PSU DDT lab, 2015: Microgravity capillary fluidics experiments and data analysis for ISS experiments. Product/Project management at Trulia et al, 2004-2013. Research, feature prioritization, logistics & project planning.

## Customer requirements: (As of 11/14/2016)

1. Design, build, and ground test an electric bi-propellant pump system that delivers a reasonable NPSH with a (~ 0.04 $ft^3/s$) delivery of isopropanol and a (~ 0.03 $ft^3/s$) delivery of LOX.
    a. Must be constructed from commercial-off-the-shelf parts (COTS) or manufactured in house.
2. Initial prototype is to be designed for the existing liquid fueled engine (LFE) with a targeted chamber pressure of (~375 psi)
3. Develop a design tool for choosing a candidate pump based on specific parameter inputs.
    a. Must be adaptable and well documented.
4. Perform a comparison study between a classic blowdown pressurization system and an electric feed system for the purpose of identifying possible advantages and disadvantages. Example output;
    a. Ratio between the feed system mass and the total propellant mass for the analyzed systems in function of the combustion chamber pressure, propellant mass, and burn time.
5. Determine required power delivery system.
    a. Evaluate current battery technologies (Li-Ion, Li-Po, Li-S, etc,.) for use in EFS
    b. Evaluate candidate DC-Brushless motors
        i. Must be COTS or manufactured in house
        ii. Must be reasonably priced
    c. Evaluate candidate inverters
6. Work in parallel with the CFPT team to optimize the pressure requirements for both groups. Pump successfully suppresses cavitation at whatever pressure the CFPT team is able to deliver.
7. LOX handling procedures and SOP documents.
8. Proposed materials for feed system manufacturing.
9. Reproducibility and technical documentation.

**Additional Requirements**

1. Design a test apparatus that is compatible with the existing Liquid engine test stand (LETS)
    a. Contains sensors and safety/emergency shutdown provisions.
2. Prototype testing to be performed if there is time
    a. Cold flow test w/ water -> Cold flow test w/ LN2.
    b. Possible Hot fire test.

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# Project Objective Statement

Design, build, and test an electric feed system using COTS parts and in-house manufacturing for Portland State Aerospace Society's liquid fueled rocket engine by June 6, 2017.

## Design Techniques:

- Information Gathering Methods:
    - Large cache of professional papers gathered on the subject.
    - Access to professional mentoring:
        - Army Air National Guard (for LOX handling procedures)
        - Industry expert contacts at SpaceX, Spaceflight Ind, NASA, Orbital ATK, Blue Origin.
- Currently Existing/Relevant Work and Studies:
    - Nadir Bagaveyev
    - Rutherford Engine (State of the art)
    - Analytical studies from University of Rio
- Analysis and Simulation:
    - Version control through Github.
    - iPython notebooks for design tool development.
    - Statistical analysis using R.
    - SolidWorks for CAD design.
    - Various software for simulation (Abaqus, Star-CCM, Matlab,.)

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## Resources:

- Access to most prototyping labs at PSU.
- Access to donated metal, professional machining labor, and DMLS 3D printing.
- Storage and workspace in PSAS Rocket Room
- Liquid Fuelled Engine Test Stand (LFETS) completed by 2014 capstone.
- Testing site outside The Dalles, OR

## Key Milestones and Deliverables:

- Analytical comparison between blowdown vs EFS
- Research COTS parts
    - Motor selection
    - Inverter selection
    - Bearings
- Feasibility study comparing COTS parts
- Prototyping and initial design.
- Fabrication of test pump unit
- Initial testing
- Post processing, comparison to alternative methods.
- Final prototype

## Organization:

**Team Meetings:** Mondays @ 4:30pm in Rocket room
**General PSAS meeting:** Tuesday @ 7:00pm in FAB 86-01
**Version control and shared file storage:** Github
**Document sharing/research bank**: Google Docs
**Task assignment:** Trello
**Team communication:** Slack