PROJECT: **Aries**

VALID THROUGH: **Preliminary Design Review (see *Project Cycle Schedule & Guide 2020-2021*)**

PREPARED BY: **Rob Davis, Technical Planning Committee**

Revision	List of Changes	Date
0	N/A	3-16-2020
1	1. Changed "VALID THROUGH" milestone from the CDR to the PDR; this document will be reviewed and reissued in January 2. Revised Section 3 and 4 to reflect the three-Group organization of the Project into Propulsion Engineering, Test & Launch Infrastructure and Electrical & Computer Engineering 3. Moved Instrumentation & Control Systems (I&C) from Test & Launch Infrastructure to Electrical/Computer Engineering Group 4. Changed to the deliverable schedule for I&C to have a Preliminary *Research* Review in December instead of a PDR 5. Revised Section 5 to better articulate why certain documentation is being used to serve as a Design Basis and provided links 6. Added the scheduled dates for the PRR/PDR/CDR 7. Updated Section 2 Resources & References	10-1-2020

1 - PROJECT DESCRIPTION

Design and manufacture paraffin wax – nitrous oxide hybrid rocket engine capable of lifting 8.8 lbs of usable payload to 10,000 feet above ground level.

2 - RESOURCES & REFERENCES

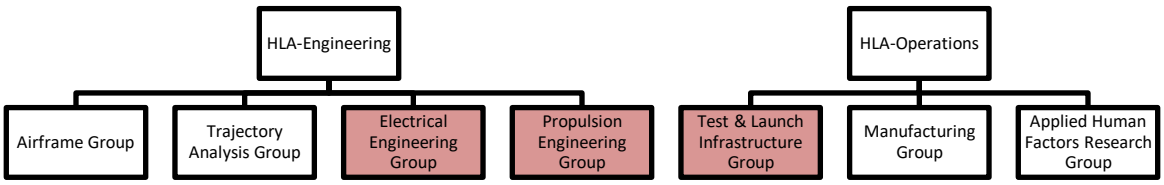
Engineering & Operations Shared Drive Library

Elements of Rocket Propulsion & *Rocket Propulsion* are the two main rocket engineering textbooks (see above)

Aspire Space Technical Papers

Collegiate Rocketry Slack Channel

3 - PROJECT RESOLUTION



The three principle Groups involved in Project Aries are Propulsion Engineering Group (PEG), Test & Launch Infrastructure Group (T&LI), and Electrical & Computer Engineering Group (ECE) though the project may require others. The breakdown of each Group into Sections and sub Sections is as follows:

- Propulsion Engineering Group
  - Systems Engineering Section
    - Mechanical Design Engineering
    - Propulsion Design Engineering
  - Chemical Engineering Section
    - Analysis
    - Fuel Systems
    - Propellant Chemistry
- Test & Launch Infrastructure Group
  - ME 471 Senior Design Section 1 *Test Stand for a Hybrid Rocket Engine Ground Firing*
  - ME 471 Senior Design Section 2 *Propellant Transfer System for a Hybrid Rocket Engine*
- Electrical & Computer Engineering Group
  - Instrumentation & Control Systems

4 - MAJOR SYSTEMS, STRUCTURES AND COMPONENTS BY GROUP/SECTION

PEG – Systems Engineering

1) Thrust Chamber Systems
   a) Nozzle
   b) Nozzle Housing
   c) Combustion Chamber
   d) Pre-Combustion Chamber
   e) Post-Combustion Chamber
   f) Ignition System
   g) Combustion Chamber Joint Sealing System
   h) Tubing and Fittings
   i) Thrust Chamber Instrumentation System (see ECE - I&C Section)
   j) Thrust Chamber Mounting System (see T&LI ME 471 Section 1)
   k) Heat Dissipation System

2) Oxidizer Feed Systems
   a) N20 Run Tank
   b) N2 Run Tank (if applicable)
   c) Injector
   d) Injector Manifold
   e) Ignition System
   f) Tubing and Fittings
   g) Valves and Regulators
   h) Oxidizer Feed System Instrumentation System (see ECE - I&C Section)
   i) Oxidizer Feed System Mounting System (see ME 471 Section 1)

PEG – Chemical Engineering

1) Fuel Systems
   a) Fuel Elements
   b) Fuel Grain
   c) Heat Dissipation System
   d) Casting Equipment

2) Propellant Chemistry
   a) N2 Storage Tanks
   b) N20 Storage Tanks
   c) N2 Run Tank

d) N20 Run Tank

T&LI – Test Stand (ME 471 Section 1)

1) Test Stand
   a) Test Stand Base
   b) Test Stand Tower
   c) Engine Mounting System
   d) External Instrumentation (see ECE – I&C)
   e) Test Stand Transport / Mobility System (if any)

T&LI – Propellant Transfer System (ME 471 Section 2)

1) Propellant Transfer System
   a) N20 Storage Tanks (and regulators)
   b) N2 Storage Tanks (and regulators)
   c) Tubing and Fittings
   d) Remotely Detachable Nitrogen Fill Valve
   e) Remotely Detachable Nitrous Oxide Fill Valve

ECE – Instrumentation & Control Systems

1) Internal Instrumentation
   a) N2 Run Tank Pressure
   b) N2 Run Tank Temperature
   c) N20 Run Tank Pressure
   d) N20 Run Tank Temperature
   e) N20 Run Tank Liquid Level (if possible)
   f) Valve Positions (OPEN, CLOSED, TRAVEL)
   g) Injector Mass Flow Rate
   h) Combustion Chamber Pressure
   i) Combustion Chamber Temperature
   j) Real-time data logging and display for all parameters

2) External Instrumentation
   a) Thrust Load Cell (if applicable)
   b) Strain Gauges (on Engine Mounting System)
   c) Real-time data logging and display for all parameters

3) Control Systems
    a) Concept of Operations Development
    b) Control Board
    c) Manual (operator-initiated) Abort Algorithm
    d) Automatic Abort Algorithm (if applicable)

5 - DESIGN BASIS

As the hybrid engine will be flown at the 2022 Spaceport America Cup (SAC) hosted by the Experimental Sounding Rocket Association (ESRA), the design must comply with the last revisions and relevant sections of:

ESRA Design, Test and Evaluation Guide
SAC Range Standard Operating Procedures
IREC Rules and Regulations

All of which can be found here: http://www.soundingrocket.org/sa-cup-documents--forms.html

Further, the design and planned operations processes must also comply with the Base 11 Space Challenge safety guidelines and best practices for engine design and testing available here:

Guidelines: https://www.herox.com/spacechallenge/guidelines
Safety: https://www.herox.com/spacechallenge/61-safety

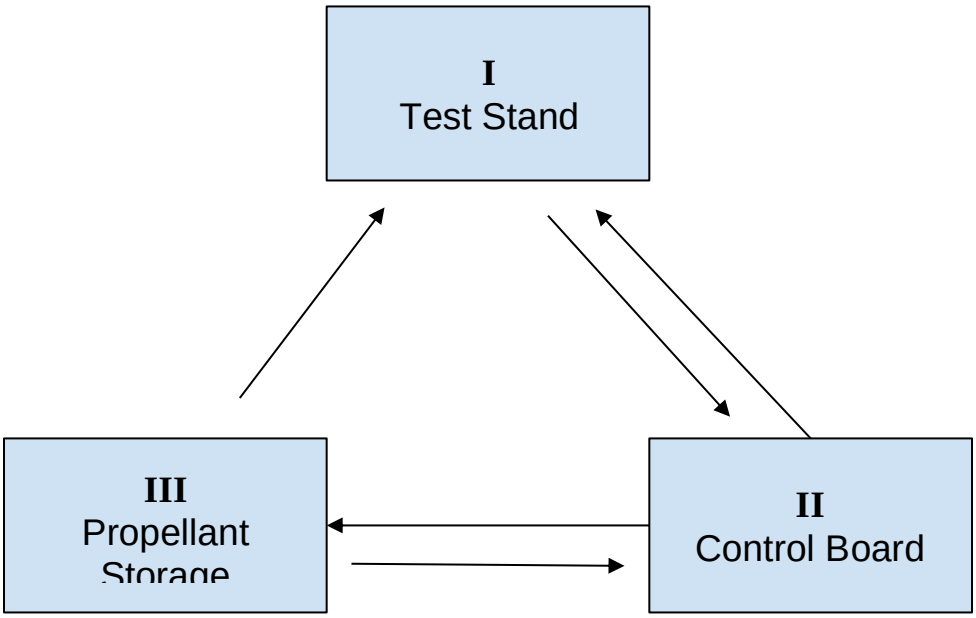
Technical Planning Committee may also establish further guidelines based on the National Fire Prevention Association (NFPA) consensus codes, particularly:

55 - Compressed Gases and Cryogenic Fluids Code
1122 - Model Rocketry Code
1125 - Manufacture of High-Power Rocket Motors Code
1127 - Code for High Power Rocketry

Though it is not the responsibility of the design teams to be familiar with them, NFPA Codes are available for free electronic viewing here: https://www.nfpa.org/Codes-and-Standards/All-Codes-and-Standards/Free-access

In addition to these requirements all design teams are expected to obey all safety rules and best practices observed at CCNY, the chosen test location and those currently being observed in the collegiate rocket engineering community.

6 – TEST FIRING LAYOUT



Arrows represent the flow of information among people and equipment. The arrow from III to I represents the flow of propellant to the test stand.

7 - ENVIRONMENTAL, HEALTH AND SAFETY CONCERNS

As per the *Project Cycle & Deliverables* the design teams will be responsible for presenting a Risk Analysis in the Preliminary Design Review (PDR) that identifies all hazards specific to their system(s). A non-exhaustive list of potential/likely hazards across the entire project are listed here for reference:

1. Graphite machining (inhalation hazard)
2. Aluminum machining (mill and lathing)
3. High voltage electric hazard (Igniter System)
4. Pinch points (assembly work)
5. Rupture of combustion chamber while firing
6. Cryogenic liquids
7. Compressed gases
8. Release of oxidizer into the environment
9. Environmental hazards specific to the test/launch location
    - 9.1. Heat Exhaustion
    - 9.2. Dehydration
    - 9.3. Exposure
    - 9.4. Animal life (desert locations)
    - 9.5. Hypothermia (winter test locations)

10. Hazards associated with travel
    10.1. Fatigue
    10.2. Car accidents
11. Inhalation of combustion products during firing

8 - RECORD KEEPING

Observe good record keeping practices by:

1. Keeping dated design notebooks
2. Commenting Excel workbooks / Matlab code or any computer analysis
3. Ensuring drawings are maintained according to *HLA-Engineering Schematics Labeling Guidelines (2020)* (Contact Mohammad Chowdhury for the latest copy)
4. Maintaining minutes of every design meeting OR filling out a weekly design team summary

9 - SOURCE OF FUNDING

Project Aries will be funded through Harlem Launch Alliance Inc. grant and donation solicitation and the budget granted to the HLA Undergraduate Student Organization by the Undergraduate Student Government.

10 - COST ESTIMATE

First estimate to be made during the Preliminary Design Review.

11 - SCHEDULE & DELIVERABLES

~~March 16 - April 20, 2020: Self- and peer- study / brain storming~~
~~April 20, 2020: Preliminary Design Strategy Meeting~~
~~Summer 2020: Preliminary research continues~~
~~August 22, 2020: Engine Technical Specifications~~
See *Project Cycle Schedule & Guide 2020-2021*

12 - REFERENCE DRAWINGS

To be updated after the Preliminary Design Review

13 - REVIEWS AND APPROVALS

Preliminary Design Strategy Meeting
Date: April 25, 2020
Minutes and/or Comments:

Technical Specifications & Supporting Commentary
Date: August 22, 2020
Minutes and/or Comments: