Development of a Cost-Effective 1.5kN Liquid-Fueled Rocket Propulsion System

Jason Y. Chen *[1]

[1] *Founder, Project Caelus 501(c)(3)*

(Initial revision 06 August, 2019; received 02 February, 2020)

This is an example of the abstract. Mit der CNN.com Europe Edition verfügt der TV-Sender CNN über eine umfassende Webseite, die im Minutentakt rund um die Uhr aktualisierte Weltnachrichten aus einer europäischen Perspektive auf den Bildschirm bringt. Wichtige, globale Ereignisse, geordnet in den Rubriken breaking news, current news headlines oder in depth, werden mit Hilfe von Video- und Audioclips, Bildern, Karten, Profilen, Zeitachsen und Tatsachenberichten fundiert dargestellt. Die Nachrichten stützen sich auf die Expertenanalysen der CNN Korrespondenten. Die Berichte verweisen auf andere relevante CNN Reportagen und zu Meldungen anderer Websites. Zusätzlich besteht die Möglichkeit, Videos anzufordern und mittels einer Suchfunktion Zugriff auf bereits gesendete Berichte und gesonderte Themenbereiche, die seit 1995 bearbeitet wurden, zu erhalten.

1 Nomenclature

Symbols				**Acronyms**		
C_v	=	Valve flow coefficient		CEA	=	Chemical equilibrium w/ applications
f_d	=	Friction factor		$COTS$	=	Commercial off-the-shelf
I_{sp}	=	Specific impulse	s	$GLOW$	=	Gross lift-off weight
Q	=	Volumetric flow rate	L/s	SF	=	Safety factor

2 Initial System Characterization

The following section outlines the characterization process used given certain mission constraints and objectives.

2.1 Objectives

The Callisto 1 system is set to the following objectives:

1. Reach an altitude of $1500m$ ($\approx 5000ft$).
2. A $GLOW$ of no more than $30kg$ ($\approx 70lbsm$).
3. A nominal main engine thrust of $1.5kN$ ($\approx 350lbsf$).
4. A chamber pressure in the range of around $1.5MPa$to$2.0MPa$ ($\approx 218psi$to$300psi$)
5. Consume a budget of no more than $10,000 USD.
6. Utililize 95% ethyl alcohol and nitrous oxide as the propellant combination.

*contact@projectcaelus.org, jay.chen135@gmail.com

2.2 Aphlex 1B

The first step is to realize the theoretical maximum performance to be expected from our propellant combination. 95% ethyl alcohol (ethanol) was chosen for its availability, low pricing, and a modest specific impulse. A 95% dilution (by mass) with water was chosen as to lower the expected combustion chamber temperature while not sacrificing too much I_{sp}. Industrial nitrous oxide was chosen for its self-pressurizing characteristics, non-cryogenic nature as opposed to liquid oxygen, relative ease to obtain, and a modest I_{sp} with ethanol. Using CEA, an open-source thermodynamics library provided by NASA's Glenn Research Center, critical data relating propellant combustion characteristics could be obtained. The MATLAB plots below show the results for out analysis:

2.3 Callisto 1

2.4 Plumbing System

The following section describes the theoretical process used to dimensionalize the prelimiary plumbing framework in preparation for the first static cold flow test. By definition, these calculations are purely speculatory and are only used for the initial design process. The purpose of the cold flow test is to verify these parameters, and consequently adjust these parameters to better fit the system requirements.

2.4.1 Assumptions

To simplify the rigorous analysis and optimization processes often associated with viscous pipe flow, a couple of assumptions are applied in the following section to both shorten the development timeline and to avoid unecessarily complex or expensive methods outside of the scope of a high school amateur rocketry program. They are as follows:

1. Flow is driven by both pressure and gravity.
2. Pipe is circular and is of constant cross-sectional area.
3. No swirl, circumferential variation, or entrance effects.
4. No shaft-work or heat-transfer effects.
5. Flow is fully developed (minimal boundary-layer effects).