THE DESIGN AND IMPLEMENTATION OF THE *ARIADNE* ROCKET ENGINE COMPUTER ANALYSIS UTILITY

by

Elijah Creed Fedele

An Investigatory Project Supplementing the Studies
of the Bachelor of Science Degree in Engineering

EMBRY-RIDDLE AERONAUTICAL UNIVERSITY

January 2023

ABSTRACT

Among all propulsive technologies, the design of modern, liquid-fueled rocket engines stands on its own as possibly the most arduous. Under simultaneous and competing pressures of maximum performance and minimum mass and cost, the design of even small rocket engines is an undertaking previously available to well-equipped nation-states and highly-capitalized government contractors. Even with a newfound democratization in space industry, the process of designing aerospace engines remains an extremely intensive workload. It is for this purpose that the *Ariadne* application was conceived — by building much of the rocket engine preliminary design functionality within the application logic, the designer is now free to consider many other aspects of the problem space. Using sophisticated deep learning models for combustion thermodynamics prediction, *Ariadne* is capable of assisting the designer in initial design planning, thrust chamber geometry layout, heat transfer and power cycle design, and overall performance estimation across the entire rocket engine operating envelope.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

NOMENCLATURE

ASI Augmented spark igniter

CEA NASA *Chemical Equilibrium with Applications* combustion code

IFV Inlet fuel valve

IOV Inlet oxidizer valve

JANNAF Joint Army-Navy-NASA-Air Force working group

LOX Liquid oxygen

MCC Main combustion chamber

MFV Main fuel valve

MOV Main oxidizer valve

TCA Thrust chamber assembly

TCV Thrust control valve (in some contexts, *turbine bypass valve* or *TBV*)

TDK JANNAF *Two-Dimensional Kinetics* combustion code

TVC Thrust vector control

Γ Vandenkerckhove function

γ Adiabatic index (ratio of specific heats; $\gamma = c_p/c_v$)

$\mathfrak{T}$ Thrust

ε Expansion area ratio (at nozzle)

ε_c	Contraction area ratio (for combustion chamber)
φ	Propellant oxidizer-to-fuel mixture ratio
c^*	Characteristic velocity
c_p	Specific heat capacity (constant-pressure)
c_v	Specific heat capacity (constant-volume
L^*	Characteristic length for combustion chambers
p	Pressure
T	Temperature
c	Combustion chamber (injector entry plane) (standard station)
e	Nozzle exit plane (standard station)
SL	Sea-level conditions
t	Throat plane (standard station)
vac	Vacuum conditions

Introduction