ASEN 2804 Aerospace Vehicle Design Lab

Course Kickoff

Spring 2025

Instructional Team Introductions

- Instructor: Prof John Mah
- Lab Coordinator: Prof Bobby Hodgkinson
- Lab Assistants
  - Bryce Pfuetze
- Teaching Fellow Mentors By Lab Section
  - Section 001: Nathan Varghese & Andrew Vo
  - Section 002: Sawyer Kuvin & Daniel Mascarenas
  - Section 003: Kelsey Mitchell & Alex Virga
  - Section 004: Rudolf Hansen & TBD

Specific Course Learning Objectives

Course Objectives: To introduce the mindset, theory and methods for the engineering design of aerospace vehicles. Specific learning objectives are:

1. **Gain experience as a member of an engineering team on an applied, multi-disciplinary aerospace engineering design problem**
2. **Demonstrate the ability to apply lower division engineering knowledge towards integrated aerospace vehicle design**
2. **Analyze performance of an aerospace system**
3. **Develop effective technical communication and team skills necessary for both intra-team coordination as well as formal technical reviews.**

DESIRED ATTRIBUTES OF AN ENGINEERING GRADUATE

- A good grasp of engineering science fundamentals.
  - Mathematics (including statistics)
  - Physical and life sciences
  - Information technology
- A good understanding of the design and manufacturing process (i.e., understand engineering).
- A basic understanding of the *context* in which engineering is practiced.
  - Economics and business practice
  - History
  - The environment
  - Customer and societal needs
- Possesses a multi-disciplinary, *system* perspective
- Good communication skills.
  - Written
  - Verbal
  - Graphic
  - Listening
- High ethical standards.
- An ability to think both critically and creatively - independently and cooperatively.
- Flexibility--An ability and the self-confidence to adapt to rapid/major change.
- Curiosity and a desire to learn - for life.
- A profound understanding of the importance of team work.

Note: This is a list of basic, durable *attributes* into which can be mapped specific *skills* reflecting the diversity of the overall engineering environment in which we in professional practice operate. In specifying desired attributes (i.e. desired outcomes of the *educational process*), we avoid specifying *how* a given university goes about meeting industry needs. Curriculum development is viewed as a university task to be done in cooperation with their "customers", and in recognition of their own local resources and constraints. Industry, as an important customer, must be an active partner in this process.

Source: John McMasters and Lee Matsch. "Desired attributes of an engineering graduate - An industry perspective," AIAA 1996-2241. Advanced Measurement and Ground Testing Conference. June 1996.

"Engineering is about *designing* and, in turn, manufacturing things people need and want, for sale. In industrial practice design and manufacturing are inextricably bound together. Thus any engineering education program that inadequately deals with either process, or artificially separates the two, is not responsive to industry needs."

-- McMasters & Matsch (Desired Attributes of an Engineering Graduate – An Industry Perspective)

Grading and Assessment

Individual Grades and Weights

Attendance in lab (Starting week 3)	10%
Wood / Composite Shop Training Completion (Online & Hands On)	2%
Milestone 1 Sub-Task A: Aerodynamic Modeling Quiz	10%
Milestone 1 Sub-task B: Thrust & Flight Dynamics Modeling Quiz	10%
Milestone 2 Sub-task A: Configuration Analysis of Alternatives (Individual design configuration portion)	10%
Macroethics Lesson	3%
Team Peer Evaluation	10%
INDIVIDUAL TOTAL	55%

Team Grades and Weights

Milestone 2 Sub-task A: Configuration Analysis of Alternatives (Team Portion)	10%
Milestone 2 Sub-Task B: Prototype Fabrication & Flight Test	
• Min 2x Prototypes + Flight Air Worthiness Check	10%
• Flight Test Completion (Min 1x Boost / 3x Glide)	10%
Milestone 2 Sub-Task C: Conceptual Design Presentation	15%
TEAM TOTAL	45%

Team Assignments

- Self-selected teams of 7-9 students depending on section enrollment
  - Must align with established team breakouts per section (see Canvas People tab for breakout by section)
  - Must be in the same section (no exceptions)
  - Teams will remain the same for entire semester
- Defined Team Roles
  - Team must select at Project Manager (PM) and Deputy Project Manger (DPM)
  - Authorities:
    - Establish & coordinate team schedule (within the context of the overall course project timeline)
    - Establish taskings for individual team members to support the completion of team assignments
  - Responsible for:
    - Coordinate/Lead the integration of work and unity of effort across the project
    - Ensure task load is distributed fairly across team
    - Facilitate leveling of knowledge across team members on all task concepts and identification of critical inter-dependencies
    - Communicate team issues with instructional team and relay guidance from instructional team to team members
  - Student who are PM and DPM may receive a bonus to their individual score based on performance during the semester. **PM Bonus will be additive only (i.e. you may not get the bonus, but it will not reduce your overall grade).**

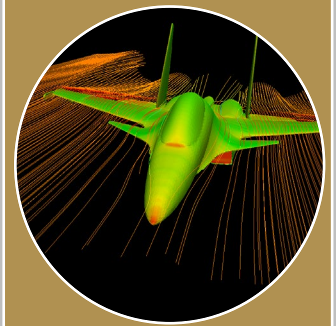
Overview of Aerospace Vehicle Design Methodology

The Big Picture: Life-Cycle Phases of an Aerospace Vehicle

Conceptual Design

- "Paper" Design (Drawing)
- Requirements Analysis
- Design Space Analysis
- Analysis of Alternatives
- Design is "squishy"
- **Is it feasible?**

ASEN 2804 Lab



Preliminary Design

- "Refined" Design
- Risk Reduction
- Rapid Prototyping
- Sensitivity Analysis
- Optimization
- Cost Estimate
- Major Changes Over
- **Configuration Frozen**
- **Can it be done on time and on budget?**

Detailed Design

- Full-Scale Production
- Detailed Component-level Design
- Design tooling & fabrication process
- Test major items
- Finalize weight & performance

Manufacturing, Test, Certification

- Full-scale Prototype Manufacturing
- Full Scale Testing
- Certification of Function

Production

- Full scale manufacturing
- Quality Control & Modifications

Operations

- Performance "in the wild"
- Sustainment & Upgrades

Disposal

- Removal from service
- Hazards and cost

Weeks to Years   Months to Years

Micro-Design Framework: Aerospace Vehicle Conceptual Design Process

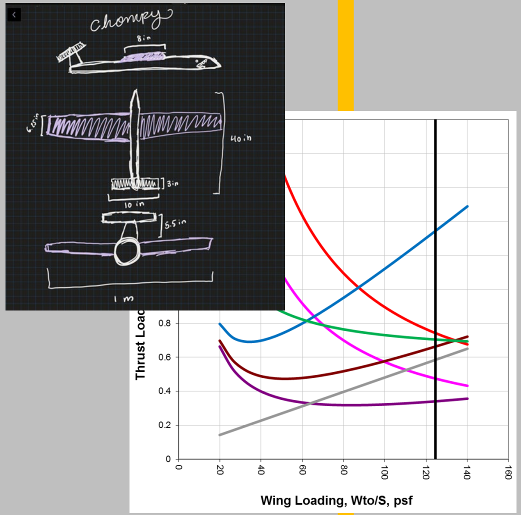
Define Feasible Design Space
- Requirements
- Available Technology
- Develop & Assess Models

Initial Trade Studies

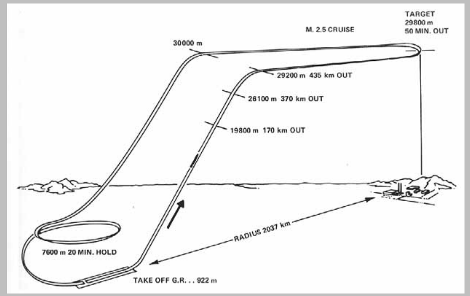
Initial Configuration

Initial Size (T/W, W/S, Weight Estimate)

Determine Design Point



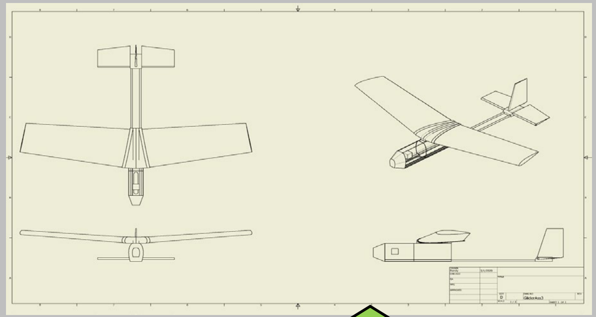
Sizing & Mission Performance Analysis
- Aerodynamic Analysis
- Propulsion Analysis
- Stability & Control Analysis
- Structure & Weight Analysis



Updated Configuration

Updated Size (Wing Loading & Weight)

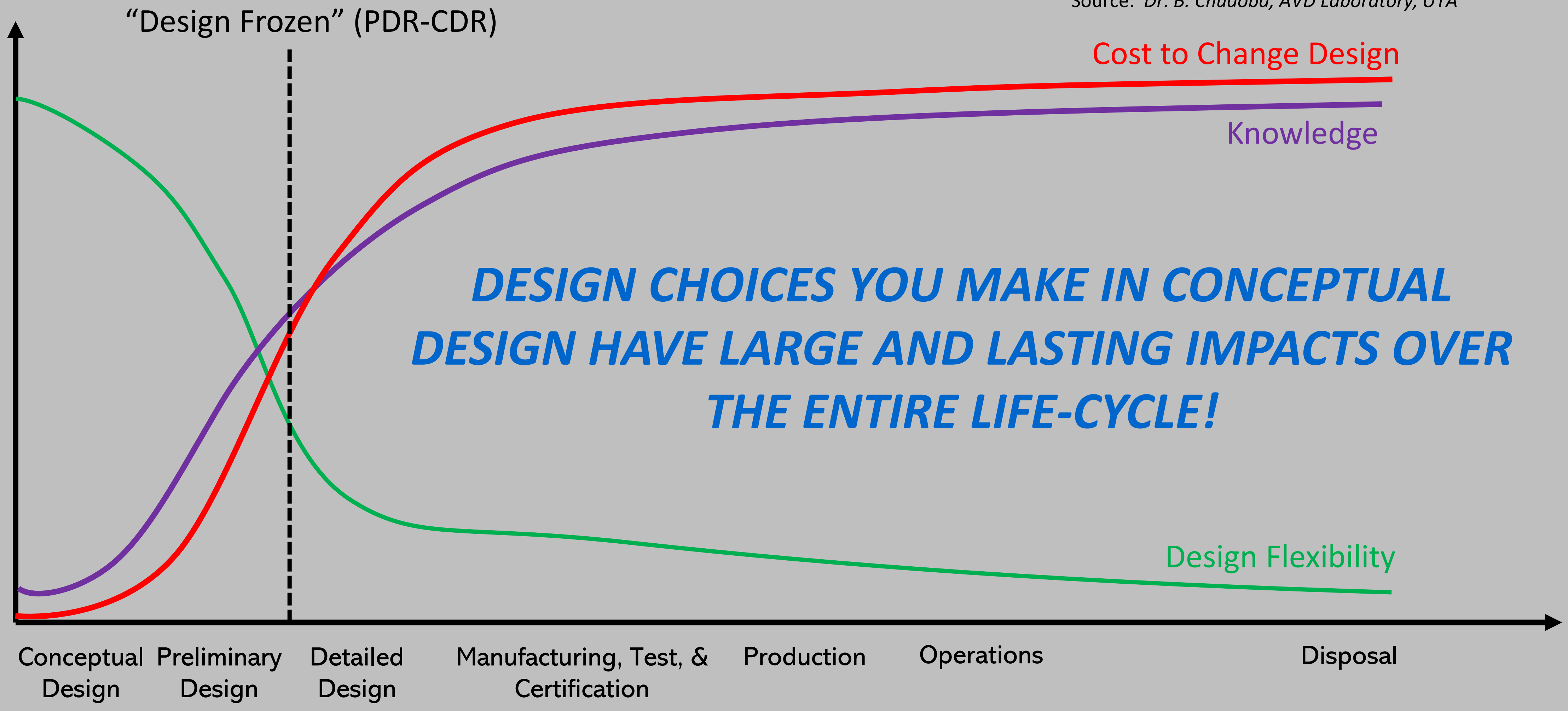
Iterative Loop



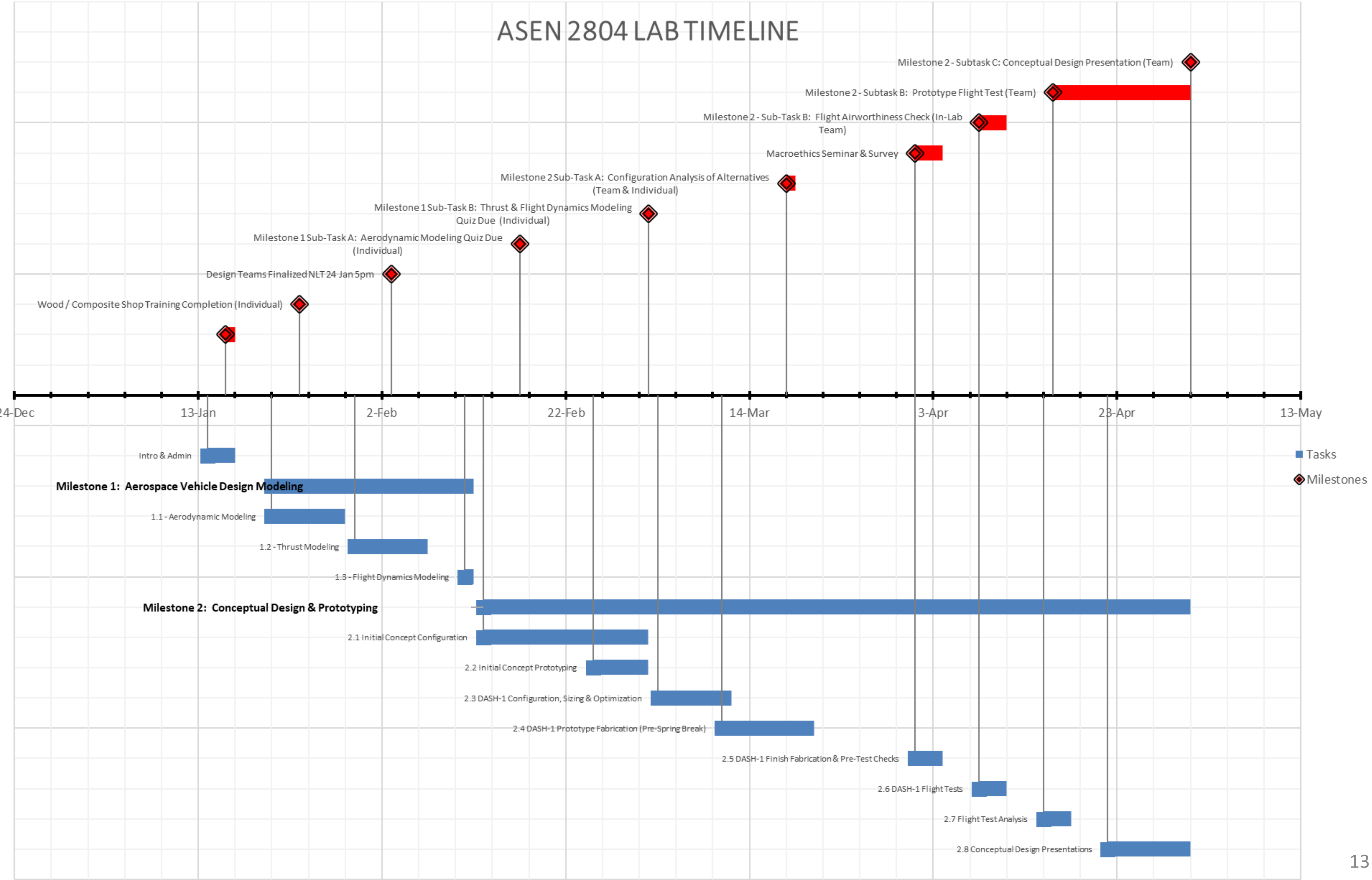
Proceed to Preliminary Design

The Design Paradox: Here's the Problem…

Source: *Dr. B. Chudoba, AVD Laboratory, UTA*



DESIGN CHOICES YOU MAKE IN CONCEPTUAL DESIGN HAVE LARGE AND LASTING IMPACTS OVER THE ENTIRE LIFE-CYCLE!



ASEN 2804 LAB TIMELINE
Milestone 2 - Subtask C: Conceptual Design Presentation (Team)
Milestone 2 - Subtask B: Prototype Flight Test (Team)
Milestone 2 - Sub-Task B: Flight Airworthiness Check (In-Lab Team)
Macroethics Seminar & Survey
Milestone 2 Sub-Task A: Configuration Analysis of Alternatives (Team & Individual)
Milestone 1 Sub-Task B: Thrust & Flight Dynamics Modeling Quiz Due (Individual)
Milestone 1 Sub-Task A: Aerodynamic Modeling Quiz Due (Individual)
Design Teams Finalized NLT 24 Jan 5pm
Wood / Composite Shop Training Completion (Individual)
24-Dec
13-Jan
2-Feb
22-Feb
14-Mar
3-Apr
23-Apr
13-May
Tasks
Milestones
Intro & Admin
Milestone 1: Aerospace Vehicle Design Modeling
1.1 - Aerodynamic Modeling
1.2 - Thrust Modeling
1.3 - Flight Dynamics Modeling
Milestone 2: Conceptual Design & Prototyping
2.1 Initial Concept Configuration
2.2 Initial Concept Prototyping
2.3 DASH-1 Configuration, Sizing & Optimization
2.4 DASH-1 Prototype Fabrication (Pre-Spring Break)
2.5 DASH-1 Finish Fabrication & Pre-Test Checks
2.6 DASH-1 Flight Tests
2.7 Flight Test Analysis
2.8 Conceptual Design Presentations

Major Schedule Items

Work Breakdown (Phases and Tasks)

Start	End	Duration	Label
1/14/2025	1/17/2025	3	Intro & Admin
1/21/2025	2/12/2025	22	Milestone 1: Aerospace Vehicle Design Modeling
1/21/2025	1/29/2025	8	1.1 - Aerodynamic Modeling
1/30/2025	2/7/2025	8	1.2 - Thrust Modeling
2/11/2025	2/12/2025	1	1.3 - Flight Dynamics Modeling
2/13/2025	5/1/2025	77	Milestone 2: Conceptual Design & Prototyping
2/13/2025	3/3/2025	18	2.1 Initial Concept Configuration
2/25/2025	3/3/2025	6	2.2 Initial Concept Prototyping
3/4/2025	3/12/2025	8	2.3 DASH-1 Configuration, Sizing & Optimization
3/11/2025	3/21/2025	10	2.4 DASH-1 Prototype Fabrication (Pre-Spring Break)
4/1/2025	4/4/2025	3	2.5 DASH-1 Finish Fabrication & Pre-Test Checks
4/8/2025	4/11/2025	3	2.6 DASH-1 Flight Tests
4/15/2025	4/18/2025	3	2.7 Flight Test Analysis
4/22/2025	5/1/2025	9	2.8 Conceptual Design Presentations

Major Milestone Assignments

Milestones (Major Graded Events)

Date			Label
Start	End	Duration	
1/16/2025	1/17/2025	1	Wood / Composite Shop Training Completion (Individual)
1/24/2025	1/24/2025	0	Design Teams Finalized NLT 24 Jan 5pm
2/3/2025	2/3/2025	0	Milestone 1 Sub-Task A: Aerodynamic Modeling Quiz Due (Individual)
2/17/2025	2/17/2025	0	Milestone 1 Sub-Task B: Thrust & Flight Dynamics Modeling Quiz Due (Individual)
3/3/2025	3/3/2025	0	Milestone 2 Sub-Task A: Configuration Analysis of Alternatives (Team & Individual)
3/18/2025	3/19/2025	1	Macroethics Seminar & Survey
4/1/2025	4/4/2025	3	Milestone 2 - Sub-Task B: Flight Airworthiness Check (In-Lab Team)
4/8/2025	4/11/2025	3	Milestone 2 - Subtask B: Prototype Flight Test (Team)
4/16/2025	5/1/2025	15	Milestone 2 - Subtask C: Conceptual Design Presentation (Team)
5/1/2025	5/1/2025	0	Team Peer Eval

Weekly Schedule Breakdown & Lab Guide

ASEN 2804 Aerospace Vehicle Design Lab

SPRING 2025

Last Update: 13-Jan-25

	Lab Day A (Tue - Sect 001/002 and Wed - Sect 003/004)		Lab Day B (Thur- Sect 001/002 and Fri - Sect 003/004)	
Week:	**1**			
Dates:	14-Jan-25	15-Jan-25	16-Jan-25	17-Jan-25
Phase:	**Aerospace Vehicle Design Introduction & Administration**		**Aerospace Vehicle Design Introduction & Administration**	
Workshop Topics:	Course Overview Aerospace Vehichle Design Methodology Design Project Requirements		Hands on Woodshop/Composite Shop Training (In-lab completion)	
Task Assigned:	Wood/Composite Shop Online Training (Individual Task) Design Team Formation Assignment			
Assignments Due:			**Wood / Composite Shop Online Training Completion (PRIOR TO LAB START)**	
Week:	**2**			
Dates:	21-Jan-25	22-Jan-25	23-Jan-25	24-Jan-25
Phase:	**Aerospace Vehicle Design Modeling: Aerodynamic Modeling Workshop Pt 1**		**Aerospace Vehicle Design Modeling: Aerodynamic Modeling Workshop Pt 2**	
Workshop Topic:	Milestone 1 Overview Design Code Overview Modeling Aircraft Geometry, Lift & Weight		Modeling Aircraft Parasite Drag Modeling Aircraft Induced Drag	
Task Assigned:	Aerodynamic Model Benchmarking In-Class Activity: Design Geometry, Airfoil, & Weight Input (Individual)		Aerodynamic Model Benchmarking In-Class Activity: Oswalds Model Research & Input (Individual)	
Assignments Due:			**Design Teams Finalized NLT 24 Jan 5pm**	
Week:	**3**			
Dates:	28-Jan-25	29-Jan-25	30-Jan-25	31-Jan-25
Phase:	**Aerospace Vehicle Design Modeling: Aerodynamic Model Validation**		**Aerospace Vehicle Design Modeling: Thrust Modeling Workshop**	
Workshop Topics:	Engineering Model Validation Overview		Modeling Water Rocket Thrust Profile Static Test Stand Method & Demo	
Task Assigned:	Aerodynamic Model Benchmarking In-Class Activity: Benchmarking Results Analysis (Individual) **Milestone 1 - Sub-Task A: Aerodynamic Modeling Take-Home Quiz (Individual Task)**			
Assignments Due:				

Design Evolution Context: Space Shuttle High-Level Conceptual Design

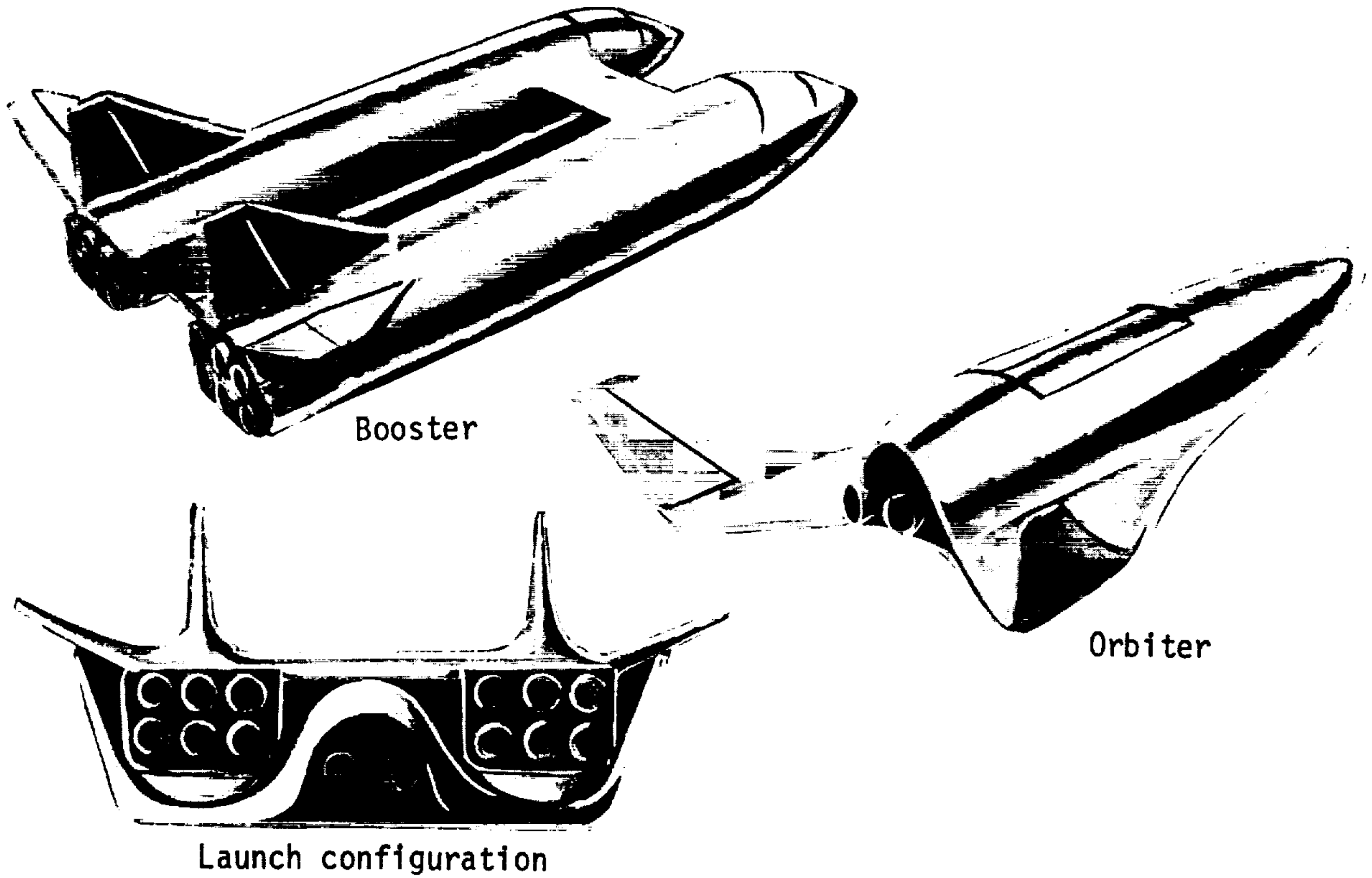


FIGURE 1.- TYPICAL PHASE A CONFIGURATION CONCEPT.

Design Evolution Context: Space Shuttle High-Level Preliminary Design

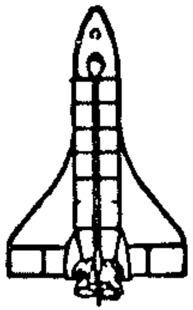
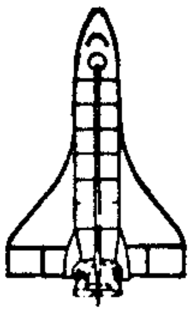
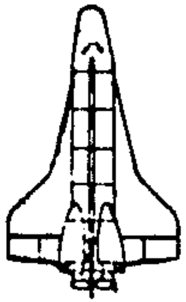
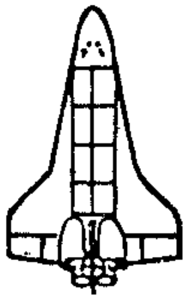
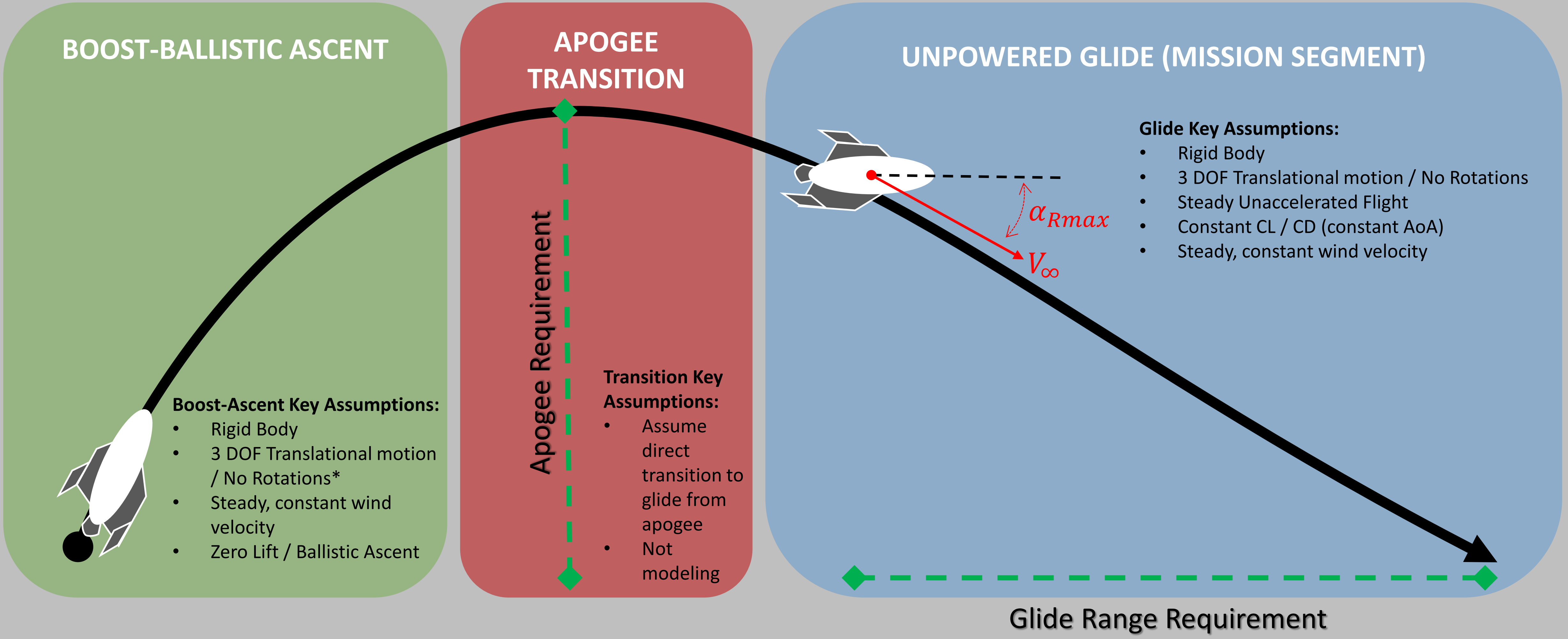
CONFIGURATION NUMBER	ATP	PRR	PDR	CDR
WING PLANFORM	50^{o} BLENDED DELTA	50^{o} BLENDED DELTA	$45^{o}/79^{o}$ DBL DELTA	$45^{o}/81^{o}$ DBL DELTA
PROFILE				
DRY WEIGHT (Kg)	77,110	77,110	68,039	68,039
PAYLOAD (Kg)	18,144	18,144	11,340	14,515
CG RANGE % L_B	65-68	65-68	65-67.5	65-67.5
WING AREA (m^2)	299.15	299.15	249.91	249.91
WING SPAN (m)	25.60	25.60	23.80	23.80
OVERALL LENGTH (m)	37.79	38.10	38.10	37.28

Fig. 15 ORBITER EVOLUTION SUMMARY

Design Project Introduction

Project Introduction: Boost-Glide Vehicle Design

Project Introduction: Boost-Glide Vehicle Concept of Operations (CONOPS)



Requirements: Performance

Req. #	Requirement	Threshold	Objective	Notes
1	Performance Requirements			
1.1	Glide Range **(Ground range measured post-apogee)**	Minimum of 100 m	MAX	Ground range measured post-transition from apogee (established on glide path). Range determined form ground track path (if IMU/GPS tracking); if no tracking, direct (straight line) laser range finder range is used and extrapolated base on apogee height obtained during boost-ascent phase.
1.2	Trimmed Glide Velocity (steady state)	Between 7 to 15 m/s	-	Glide velocity determined by team's desired glide coefficient of lift for L/D max and aircraft weight estimates.

Requirements: Stability

Req. #	Requirement	Threshold	Objective	Notes
2	Static Stability & Control Requirements	Natural Static Stability		Must be longitudinally and lateral-directionally statically stable (with no stability augmentation).
2.1	Static Margin	Between 10 – 30% SM	15%	Based on aerodynamic analysis of neutral point and direct measurement of CG location.
2.1.1	Horizontal Tail Volume Coefficient (VH)	VH = 0.4	VH = 0.7	Does not apply for delta wings. Elevons on deltas must be a minimum of 1/4 chord in length and run the full span of trailing edge of the wing.
2.1.2	Trimmable at different useable CLs	-	-	Must have movable and securable pitch control surfaces capable of +/- 20 deg travel.
2.2	Directional / Weathervane Stability	-	-	Requirement not quantified directly, but assessed via Vv, Vh requirements and test. Vehicle must initially move to zero sideslip ("turn into the wind").
2.2.1	Vertical Tail Volume Coefficient (Vv)	Vv = 0.04	Vv = 0.07	
2.3	Roll Stability	Natural Static Stability	-	Requirement not quantified. Vehicle must be designed to roll "wings level" after roll disturbance from equilibrium.

Requirements: Physical Geometry and Payload

Req. #	Requirement	Threshold	Objective	Notes
3	Geometric / Payload Requirements	-	-	
3.1	Total Wingspan	Maximum of 1 m	MIN	Tip to Tip Span. Wing may be variable geometry or change configuration between boost-ascent and glide phases, but at max extension cannot be greater than 1 meter. Additionally, any variability or configuration change must be shown to be mechanically feasible, and all parts of the wing must be physically on both boost-ascent and glide prototypes.
3.3	Payload (Altimeter / Data Acq Instrumentation)	Meet volume & security requirements	TBD	Payload must be secured for flight and impact to avoid shifting of cg in flight and survival at impact. Validated at pre-flight inspection. More details on data acquisition instrumentation provided later.
3.4	Launch pad integration	Pass Fit Test, Non-pressurized / pressurized	Pass/Fail	Vehicle must securely mate with existing launch pad without modifications to launch pad (upper guide rails can be removed with approval of instructor).

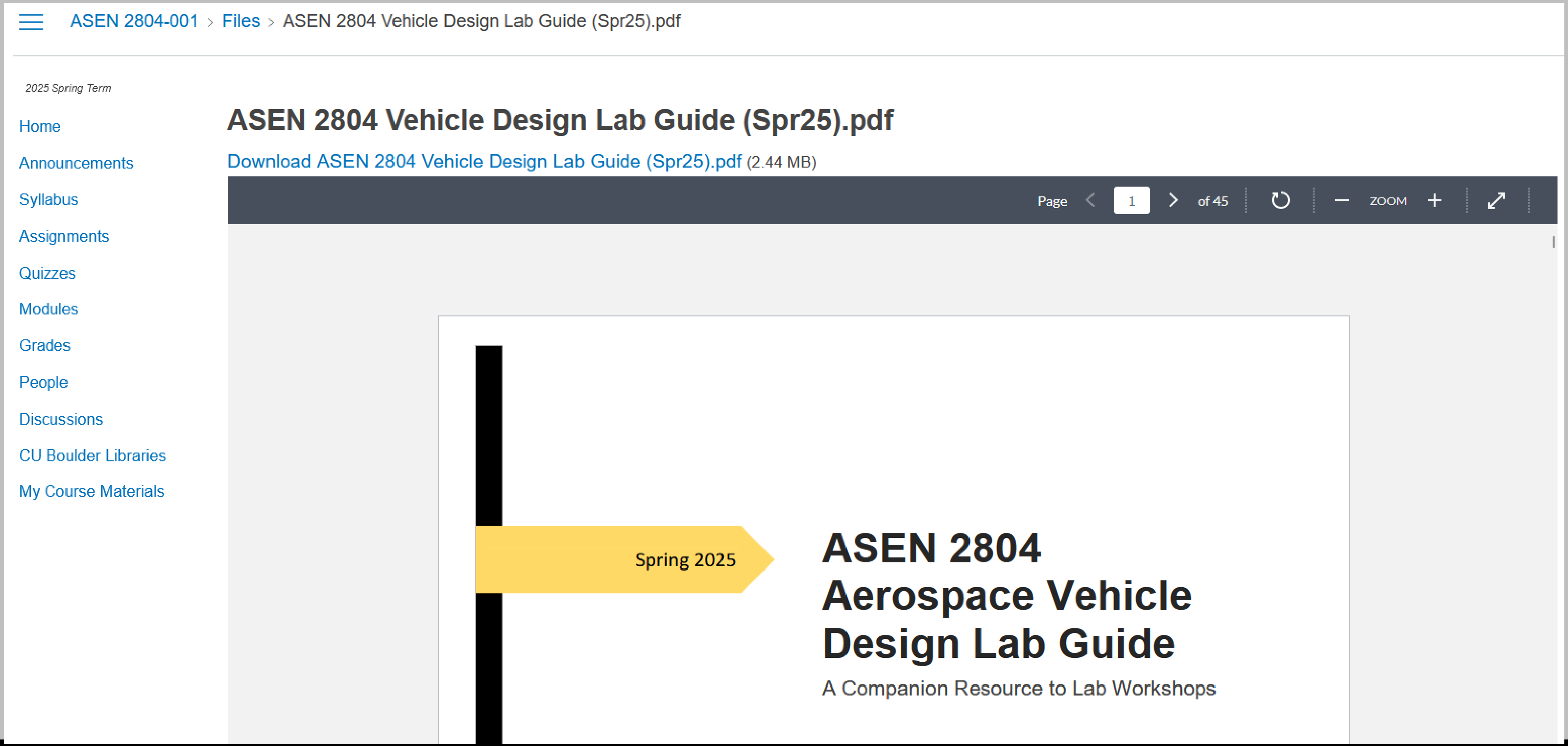
Requirements: Structure

Req. #	Requirement	Threshold	Objective	Notes
4	Structural Requirements	Survive multiple launch iterations / glide iterations	-	Not quantified. Teams should account for survivability in concept design and fabrication methods.
4.1	Wing Stiffness / Strength	Pass Wingtip Lift / Deflection Test (Elastic behavior, no fractures or damage (30 sec).	Pass/Fail	Wingtip lift must be conducted with payload weight and any ballast required for flight. No water weight (propellant).
4.2	Control Surface Stiffness / Strength (Including any tail / empennage structure)	Pass Wind Flutter Test (30 sec)	Pass/Fail	Observe behaviors under load in front of test fan. Control surface must maintain set orientation at full deflection of +/- 20 deg with no shifting and minimal flexure.
4.3	Pressure Vessel Integrity (No Leaks / Damage)	Pass Pressurization Test (On Flight Test Day)	Pass/Fail	Conducted with team's design volume of water. No leaks or structural deformation observed after pressurized on launch pad at pressure of 60 psi.

Customer Defined Constraints

Con. #	Constraint	Max	Min	Notes
A	Max chamber pressure (Launch)	60 psi (gage)	-	For safety reasons, no greater pressure is allowed.
B	Pressure vessel volume	2.0 liter	1.25 liter	Must be a Coca-Cola brand bottle; ensure threaded cap mates with launcher stopper/restraining device before using in your vehicle.
C	Propellant	-	-	Water; additives must be approved by lab coordinator.
D	Fabrication materials / Budget	$40	-	You must purchase the pressure vessel (Coke bottle) of your choice based on your design. Any additional materials you want to use must be purchased by your team with a total limit of $40 per team (team provided).
E	Symmetric Airfoils Only			No cambered airfoils may be used for any lifting surface to eliminate need for trim during boost-ascent phase.
F	Max Launch Elevation Angle	60 deg		Maximum elevation is meant to minimize transition issues from boost-ascent to glide phase and limit damage for prototype test flights.

Weekly Schedule Breakdown & Lab Guide



Your Task for Rest of Today and this Week

- Do Wood / Composite Shop Online Training
- Team Formation (NLT Next Friday – 2 Weeks)
  - Canvas Groups will be established later this week
  - Get to know each other!
- Review project requirements and schedule
- Review Lab Assignment Guide (Modeling Portions)
- Ask Questions!