Term Project 1 and ENAE 484 Planning (continued)

- Lecture #14 – October 12, 2022
- Team assignments for Team Project 1 (up to date)
- Expectations and assumptions for Team Project 1
- Project and specialty assignments for ENAE 484
- Expectations and milestones for ENAE 483

Teams for Team Project 1

Team 1
Peter Capozzoli
Luca Petrescu
Saimah Siddiqui
Nikkole Merton

Team 2
Gustavo Lang
Ryan Rex
Lucas Armyn
Alexander Teacu
Cameron Patillo

Team 3
Florian Grader-Beck
Kuds Desta
Henri Roviera
Chibueze Amos-Uhegbu

Team 4
Evan Ramm
Karan Rai
Nathaniel McIntyre
Dmitri Kontchaev
Stephen McGowan

Team 5
Joshua Gehres
Caleb Hoffman
Adam Lahr
Julia Joseph

Team 6
Aroni Gupta
Henry Reimert
Charley Diaz
Matias Calderon
Zachary Argo

Team 7
Jordan Kreh
Brian Glover
Devin McLenagan
Chelsea May

Team 8
William Cook
Nicholas Greco
George Tang
Isaac Foote

Team 9
Fletcher Smith
Antonio Gallardo
Olivia Fiore
Payten Flanigan

Team 10
Jeremy Snyder
Robert Fink
Amir Moon
Christian Foteping Wabo

Team 11
Ethan Tang
Joseph Davis
Sarah Pfau
Sneha Sunilkumar

Team 12
Benjamin Loan
Zachary Zarus
Vincent Olindo
Kaya Ozgun

Team 13
Ethan Goldberg
Kruti Bhingradiya
Athenais Culleron-Sun
Justin Rahr

Team 14
Lars Knudsen
Samuel Lin
Sean Philips
Justin Dashiell

Team 15
William Sheesley
Brook Fikre
Nicholas Louloudes
Nalina Attanayake

Team 16
Jacob Frazee
Elizabeth Quinn
Hunter Shiblie
Daniel Corbett

Team 17
Saim Rizvi
Justin Rhoads
Gursimar Singh
Ali Hassannia

Team 18
Justin Meyer
William Rowe
Jack Getz
Lillian Spych

Team 19
Luke Brauch
Gavin Bramble
Alex Huang
Gursajan Singh

Team 20
Andrew Stevens
Alexander Hernandez
Elias Daniel
Nazifa Mahmud

Team 21
Eric Kim
Adin Goldberg
Joynob Kaoshar

Team 22
Rachel Blum
Raj Khismatrao
Kathleen Ortel

Team Project 1

- Work in 3-5 person teams to design an Earth launch vehicle
- Focus on systems engineering, systems analysis, trade studies, solid modeling, and presentation design
- Progress report (in the form of an informal PowerPoint presentation) due October 24 – expectations are
  – Show that you have met together as a team and started work
  – Any preliminary results that you have
- Final report (also PowerPoint presentation) due November 16

Team Project 1 Level 1 Requirements

- Each team shall design an Earth launch vehicle capable of injecting 25,000 kg of payload into a lunar transfer orbit
- The system shall initially enter a circular parking orbit with an altitude of 300 km (Δv=9300 m/sec)
- After a nominal wait of 1.25 orbits, the system shall perform the translunar insertion (TLI) burn (Δv=3150 m/sec)
- The upper stage shall have a diameter at the payload interface of not less than 5 meters

Team Project 1 Level 1 Requirements

- The system shall be capable of launching six missions per year for a minimum of 10 years
- The system shall be operational by 2030
- The design objective is to minimize the cost/kg of payload delivered over the life of the program
- Any reusable elements shall be costed assuming a 4% refurbishment fraction
- Cost discounting shall use a discount rate of 10%
- Learning curve analyses will use 80% learning rate

Notes on First Stage Reuse (a la Falcon 9)

- Assume that first stage inert mass is increased by 10% to account for entry and landing systems
- For a return to launch site landing, velocity at first stage burnout is ≤3000* m/sec, and 15% of the initial propellant load must remain at separation for entry and landing
- For a landing on a downrange drone ship, velocity at first stage burnout is ≤3500* m/sec and 5% of the initial propellant load must remain at separation
- Use of a ship for downrange landing adds $1M in ops costs

*Corrected for gravity and drag losses

Final Expectations for Team Project 1 (1)

- Performance trade studies
  - Number of stages, types of propellants, optimal staging, reusability, fleet sizing - first baseline
  - Use of stage inert mass fraction heuristics for better estimates of inert mass, spot checking of results from initial trades - second baseline
- System-level design
  - Use mass estimating relations to find estimates of mass breakdowns for each stage with 30% positive margins throughout
  - Re-examine staging optimizations as necessary - third baseline

Final Expectations for Team Project 1 (2)

- Cost Analysis
  - Calculate nonrecurring, recurring, refurbishment, operations, and other costs elements using SVLCM algorithms as appropriate
  - Allocate all costs year-by-year, using beta functions for nonrecurring costs
  - Calculate total program costs in constant $2023 dollars and find average $/kg for payload delivered to TLI
  - Repeat analysis of $/kg using net present value in the year 2023

Final Expectations for Team Project 1 (3)

- Mission Design
  - Design reference mission showing mission elements
  - Masses and center of gravity locations for each mission phase (i.e., stages) at beginning and end of burn
  - Reliability estimation and analysis of resiliency requirements
  - Identification of critical risks (5x5 chart)

Final Expectations for Team Project 1 (4)

- CAD
  - Solid models of each stage and (notional) payload
  - Dimensioned three-views
  - Interior section showing tanks, engines, etc.
  - High-quality image render(s)
- Final report
  - PowerPoint presentation of all listed elements
  - Anything else you are motivated to add (e.g., program name, logo, etc.)

For Teams 21 and 22 (not taking 484)

- For the second half of the term, you will also design a crewed spacecraft to be launched to the moon via your launch vehicle
- Your choice of missions, affecting spacecraft Δv
  - Lunar fly-by mission (Δv=300 m/sec)
  - Lunar orbit mission (Δv=2000 m/sec)
- 20% of S/C mass at entry interface is reserved for EDL systems
- The purpose of this task is to use the tools and techniques in the second half of the course (CS/AFSS/LSM/PPT) with particular attention paid to Crew Systems

Large-Scale Lunar Prospector (RASC-AL)

AFSS
Saim Rizvi
Justin Rhoads
Sneha Sunilkumar

Crew Systems
Kuds Desta
Nazifa Mahmud
Justin Dashiell

LSM
Robert Fink
Florian Grader-Beck
Cameron patillo
Samuel Lin
Matias Calderon

MPA
Elizabeth Quinn
Nicholas Greco
Saimah Siddiqui

PPT
Peter Capozzoli
Nikkole Merton
Daniel Corbett

SASE
Jordan Kreh
Gavin Bramble
Kaya Ozgun

Sustained Lunar Infrastructure (RASC-AL)

AFSS
Stephen McGowan
Evan Ramm
Jeremy Snyder

MPA
Karan Rai
Charley Jackson Diaz
William Sheesley
Chelsea May

Crew Systems
Olivia Fiore
Hunter Shiblie
Vincent Olindo

PPT
Luke Brauch
Brook Fikre
Henry Reimert

LSM
Lucas Armyn
Chibueze Amos-Uhegbu
Alexander Teacu
Zachary Argo

SASE
Andrew Stevens
Alex Huang
Gursajan Singh
Ethan Tang

Collaborative Exploration Rovers (GSFC)

AFSS
Aroni Gupta
Luca Petrescu
Nathaniel McIntyre
Fletcher Smith
Zach Zarus

Crew Systems
Lillian Spych
Payten Flanigan
Justin Meyer
Athenais Culleron-Sun

LSM
Joseph Davis
Henri Roviera
Nalina Attanayake

MPA
Benjamin Loan
Alexander Hernandez
Yimang Tang (George)

PPT
Ethan Goldberg
Nicholas Louloudes
Jack Getz

SASE
Gustavo Lang Jr
Dmitri Kontchaev
Brian Glover

Mars Simulation at the Moon (RASC-AL)

AFSS

William Cook

Caleb Hoffman

Ryan Rex

Crew Systems

Josh Gehres

Julia Joseph

Justin Rahr

Sarah Pfau

LSM

Lars Knudsen

Jacob Frazee

Sean Philips

MPA

Ali Hassannia

Adam Lahr

Hailu Daniel

Christian Foteping Wabo

PPT

Antonio Gallardo

Amir Moon

Isaac Foote

SASE

Kruti Bhingradiya

William Rowe

Devin McLenagan

Gursimar Singh

ENAE 484 Activities – Fall 2023

- Work in your ENAE 484 teams to do the planning and initial stages of design activities for ENAE 484
  - Level 1 requirements
  - Requirements flow-down
  - Work breakdown structure
  - Design reference mission
  - Baseline systems architecture
  - List of trade studies
  - Plans for experiments/hardware development
  - Schedule for Spring term

Requirements Development

- Level 1 requirements: externally imposed by sponsor (e.g., RASC-AL, faculty)
- "Flow-down" to successively finer levels of detail, and branching into discipline areas
- Requirement Verification Matrix (RVM) should track connection between lower and higher level requirements
- Every requirement at every level should have a clear path connecting it to one or more Level 1 requirements

Work Breakdown Structure

- Basically an outline of everything that has to be done to complete the systems design for ENAE 484
- Hierarchical breakdown into systems, subsystems, assemblies, components, etc.
- Frequently tied into scheduling process to ensure everything gets done in a timely manner
- Write it down now so it gets done later

Design Reference Mission (DRM)/CONOPS

- Detailed description of how a standard mission should proceed from beginning to end
- Could be graphical, numerical list, prose – just needs to provide information for designing the systems that accomplish the mission, e.g.
  - Moon to Mars: where the crew is housed for the “transit” phase, how they get to/from the lunar surface, requirements for the surface base
  - Lunar Evolution: additional capabilities needed and when, plans for expansion in terms of specific surface locations or regions

Systems Architecture Baseline

- Closely related to DRM/CONOPS, but outlining how things happen (as opposed to what things happen)
- Conceptual representation of each component of transportation/construction/operations of each phase of program development
- Usually graphically presented with icons for each major system (e.g., transport, lander, habitat, etc.)

List of Trade Studies

- Every design decision should be based on an analytical trade study (Akin's Law #1!)
- Brainstorm the issues that affect design decisions, how you would quantify the parameters, and how you will perform the analysis to identify the best design decision
- Responsibility for each trade study should be assigned to specific group within the project
- Should also have schedule for when each trade study (design decision) should be completed

Plans for Experiments/Hardware Testing

- Each project may (should?) have a plan for incorporating hardware testing into the Spring activities
- Develop and document list of hardware development activities, with justification, challenges, and benefits
- Prioritize hardware testing objectives
- For top priorities, develop initial designs and list of items which need to be ordered prior to the end of the term

Schedule for Spring Term

- Develop a Gantt chart for 484 design activities next term
- Include Preliminary Design Review (PDR) last week of February, Critical Design Review (CDR) last week of April, comprehensive final report at the end of the term
- Include deadlines such as RASC-AL deliverables
- Set your own internal milestones/deadlines to avoid crunches around PDR/CDR

Deliverables

- Each project should document all of their development plans in the form of a Powerpoint presentation due at the end of this term
- On October 31, each project will submit their list of Level 1 requirements and drafts of any other progress at that date

Operational Notes

- Each project will have a Microsoft Teams site - USE IT! This is the most effective way to have archival access to everything submitted by each team member, and also is convenient for remote meetings
- Remember, you don't get credit for work I can't see - storing everything in Teams is the easiest solution
- You WILL need to meet as teams (both project teams and within specialty groups) to do this planning work - and it's good practice for next term