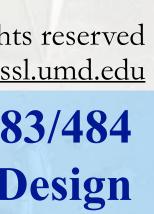
# **Term Project 1 and ENAE 484 Planning (continued)**

- 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



© 2023 University of Maryland - All rights reserved http://spacecraft.ssl.umd.edu





# **Teams for Team Project 1**

### Team 1 Peter Capozzoli Luca Petrescu Saimah Siddiqui Nikkole Merton

### Team 8

William Cook Nicholas Greco George Tang **Isaac Foote** 

**Team 15** William Sheesley **Brook Fikre** Nicholas Louloudes Nalina Attanayake

### Team 2

**Gustavo Lang** Ryan Rex Lucas Armyn Alexander Teacu **Cameron Patillo** 

Team 9 **Fletcher Smith** Antonio Gallardo **Olivia** Fiore Payten Flanigan

### **Team 10**

Team 3

Kuds Desta

Henri Roviera

Jeremy Snyder **Robert Fink** Amir Moon **Christian Foteping Wabo** 

Florian Grader-Beck

Chibueze Amos-Uhegbu

**Team 16** Jacob Frazee Elizabeth Quinn Hunter Shiblie **Daniel Corbett** 

**Team 17** Saim Rizvi **Justin Rhoads** Gursimar Singh Jack Getz Ali Hassannia

**Team 18** Justin Meyer William Rowe Lillian Spych



Team 4 Evan Ramm Karan Rai Nathaniel McIntyre Dmitri Kontchaev

Stephen McGowan

2

**Team 11** Ethan Tang Joseph Davis Sarah Pfau Sneha Sunilkumar



Team 5

Joshua Gehres Caleb Hoffman Adam Lahr Julia Joseph

**Team 12** Benjamin Loan Zachary Zarus Vincent Olindo Kaya Ozgun

Team 6

Aroni Gupta Henry Reimert Charley Diaz Matias Calderon Zachary Argo

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

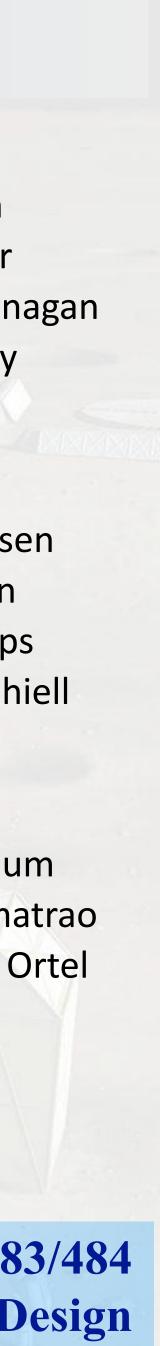
Team 7

Jordan Kreh **Brian Glover** Devin McLenagan Chelsea May

**Team 14** Lars Knudsen Samuel Lin Sean Philips Justin Dashiell

**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

3





# 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 ( $\Delta v$ =9300 m/sec)
- After a nominal wait of 1.25 orbits, the system shall perform the translunar insertion (TLI) burn (Δ*v*=3150 m/sec)
  The upper stage shall have a diameter at the payload interface of not less than 5 meters

4





**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 UNIVERSITY OF MARYLAND 5



# 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
- UNIVERSITY OF MARYLAND \*Corrected for gr

\*Corrected for gravity and drag losses Project Planning for ENAE 483/484 6 ENAE 483/788D – Principles of Space Systems Design



# **Final Expectations for Team Project 1 (1)**

• Performance trade studies fleet sizing - first baseline - Use of stage inert mass fraction heuristics for better estimates of inert System-level design each stage with 30% positive margins throughout - Re-examine staging optimizations as necessary - third baseline



– Number of stages, types of propellants, optimal staging, reusability,

mass, spot checking of results from initial trades - second baseline

- Use mass estimating relations to find estimates of mass breakdowns for

7



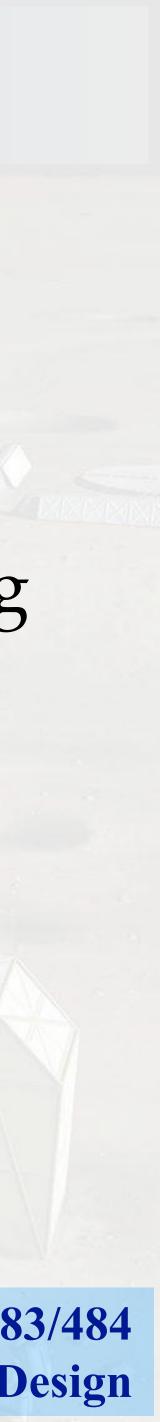
# **Final Expectations for Team Project 1 (2)**

- Cost Analysis other costs elements using SVLCM algorithms as appropriate costs
  - average \$/kg for payload delivered to TLI - Repeat analysis of \$/kg using net present value in the year 2023



- Calculate nonrecurring, recurring, refurbishment, operations, and – Allocate all costs year-by-year, using beta functions for nonrecurring

- Calculate total program costs in constant \$2023 dollars and find



# **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)

9





# **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



10

# – 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 $\Delta v$ – Lunar fly-by mission ( $\Delta v$ =300 m/sec) – Lunar orbit mission ( $\Delta v$ =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 UNIVERSITY OF ARYLAND 11



# Large-Scale Lunar Prospector (RASC-AL)

### AFSS Saim Rizvi Justin Rhoads Sneha Sunilkumar

**Crew Systems Kuds Desta** Nazifa Mahmud **Justin Dashiell** 

MPA Elizabeth Quinn Nicholas Greco Saimah Siddiqui PPT Peter Capozzoli Nikkole Merton **Daniel Corbett** 



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

Jordan Kreh Gavin Bramble Kaya Ozgun



# Sustained Lunar Infrastructure (RASC-AL)

AFSS Stephen McGowan Evan Ramm Jeremy Snyder

Crew Systems Olivia Fiore Hunter Shiblie Vincent Olindo

### **MPA**

Karan Rai Charley Jackson Diaz William Sheesley Chelsea May

UNIVERSITY OF MARYLAND **PPT** Luke Brauch Brook Fikre Henry Reimert

13

### <u>LSM</u>

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

MPA **Benjamin Loan** Alexander Hernandez Yimang Tang (George)

UNIVERSITY OF MARYLAND

**Crew Systems Lillian Spych** Justin Meyer

> PPT Jack Getz

**Payten Flanigan Athenais Culleron-Sun** 

## LSM Joseph Davis Henri Roviera Nalina Attanayake

# **Ethan Goldberg** Nicholas Louloudes

14

### SASE

**Gustavo Lang Jr Dmitri Kontchaev Brian Glover** 



# Mars Simulation at the Moon (RASC-AL)

### AFSS William Cook Caleb Hoffman Ryan Rex

**MPA** Ali Hassannia Adam Lahr Hailu Daniel **Christian Foteping Wabo** 

UNIVERSITY OF MARYLAND

PPT

### **Crew Systems**

Josh Gehres Julia Joseph Justin Rahr Sarah Pfau

### LSM Lars Knudsen Jacob Frazee Sean Philips

### Antonio Gallardo

Amir Moon Isaac Foote

### SASE

Kruti Bhingradiya William Rowe **Devin McLenagan Gursimar Singh** 



# ENAE 484 Activities – Fall 2023

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

UNIVERSITY OF MARYLAND

# Work in your ENAE 484 teams to do the planning and initial

16



# **Requirements** Development

- RASC-AL, faculty)
- "Flow-down" to successively finer levels of detail, and branching into discipline areas • Requirement Verification Matrix (RVM) should track connecting it to one or more Level 1 requirements



• Level 1 requirements: externally imposed by sponsor (e.g.,

connection between lower and higher level requirements • Every requirement at every level should have a clear path

17



# Work Breakdown Structure

• Basically an outline of everything that has to be done to complete the systems design for ENAE 484 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



• Hierarchical breakdown into systems, subsystems, assemblies,



# **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

19





# **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.)

20





# **List of Trade Studies**

- 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

21



# • Every design decision should be based on an analytical trade



# **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 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



February, Critical Design Review (CDR) last week of April,



# Deliverables

- term



## • Each project should document all of their development plans in the form of a Powerpoint presentation due at the end of this

• On October 31, each project will submit their list of Level 1 requirements and drafts of any other progress at that date

> **Project Planning for ENAE 483/484 ENAE 483/788D – Principles of Space Systems Design**

24



# **Operational Notes**

- Each project will have a Microsoft Teams site USE IT! This is remote meetings
- everything in Teams is the easiest solution You WILL need to meet as teams (both project teams and good practice for next term



the most effective way to have archival access to everything submitted by each team member, and also is convenient for

• Remember, you don't get credit for work I can't see - storing

within specialty groups) to do this planning work - and it's

25

