## ENAE 788X Term Project Overview

- requirements
- Rover design primer



## • Overview of Lunar Light Utility Vehicle (LLUV) concept and top-level

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# **Term Design Project Goals**

- realistic design
- Reinforce experiences with engineering in teams, making technical presentations
- Address a problem of real relevance to NASA



## • Provide opportunity to use principles of class to perform open-ended



# Lunar Light Utility Vehicle (LLUV)

- Smaller in size than the lunar terrain vehicle (LTV)
- Not designed for direct human support (e.g., no crew transport)
- Carries manipulator(s) for performing tasks around lunar base
  - Site preparation
  - Light assembly
  - Connection of umbilicals (e.g., electrical, fluids)
- Launchable on Commercial Lunar Payload Services (CLPS) landers
- or from Earth
- Focus on mobility chassis design aspects parameters for payload elements will be provided



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• Controlled by autonomy or teleoperation from lunar surface, lunar orbit,





# Design Project Statement

- Perform a detailed design of an LLUV rover, emphasizing mobility systems
  - Chassis systems (e.g., wheels, steering, suspension...)
  - Support systems (e.g., energy storage)
  - Navigation and guidance system (e.g., sensors, algorithms...)
- Design for lunar operations, then assess applicability to Mars





# Level 1 Requirements (1)

- LLUV shall have a maximum ma kg with 30% mass margin
- LLUV shall be designed to be delivered to the lunar south pole on CLPS lander (specific vehicle to be selected by design team)
- System shall be capable of driving off of lander
- System shall incorporate batteries for eight hours of operation with 20% margin

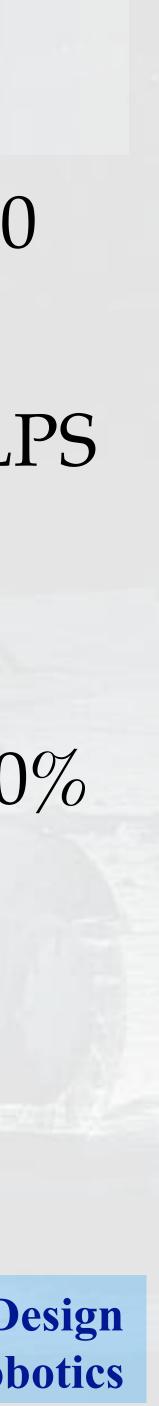
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- System shall be capable of self-connecting to recharger (provided)
- System shall be capable of driving over 30 cm high obstacles



## • LLUV shall have a maximum mass in operational configuration of 500

onnecting to recharger (provided) g over 30 cm high obstacles



# Level 1 Requirements (2)

- System shall be capable of a top speed of 3 m/sec without external payload
- lifting it off of the lunar surface and returning it to the surface
- System shall carry sufficient robotic manipulation systems to accomplish
  - Mechanical connections
  - Electrical connections
  - Fluid connections
  - Surface contour modifications

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• System shall be capable of transporting 1000 kg of payload, including



# Term Project Overview

- Teams of 2 students
- Review requirements as published
- Consider design approaches and options
- Perform trade studies to refine and verify design(s)
- Use CAD to create vehicle design drawings
- Prepare a "work in progress" status report due Monday, Oct. 28
- report and adding analysis areas as they are presented in class
- Final report due Monday, Dec. 9



Continue design work and analysis, incorporating feedback from status



# How To Design a Rover? A Primer...

- velocity
- Terrain requirements max slopes, max obstacles / gaps, surface characteristics
- span for static stability with margin
- and width(s)  $\implies$  baseline design with number and placement of wheels, diameter and width of wheels, details of grousers



• Define the requirements – payload mass, volume, dimensions; surface

• Back of envelope (BOE) stability – height of  $CG \implies$  wheelbase / wheel

• Terramechanics – trade studies on number of wheels, wheel diameter(s)



# **Rover Design (2)**

- independent, rocker variants, articulated body)  $\implies$  baseline on suspension design
- Steering based on mission requirements (speed, energy, terrain) perform trade studies on steering approaches (e.g., skid-steer, baseline of steering approach
- Synthesis bring everything so far into baseline design of mobility chassis  $\implies$  CAD model of baseline configuration concept



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• Suspension – based on mission requirements (speed, slopes, payload variations) perform trade studies on suspension approaches (e.g., fixed,

differential drive, single/double Ackermann, independent steering)  $\implies$ 



# **Rover Design 3**

- wheels baseline, compare to decide whether to pursue alternate design(s) or stick with baseline
- Advanced analyses perform analyses at finer levels of detail than required for initial configuration studies, e.g. dynamic analysis of steering, details of weight transfer over obstacles and / or slopes
- for each category UNIVERSITY OF MARYLAND

• Alternate concepts – if desired, consider alternative concepts (e.g., legs, tracks) and perform analyses to define them at similar level of detail to

suspension elements (springs and dampers), lateral forces on wheels for

• Mechanisms – find required torque for actuators (e.g., wheel motors, steering, active articulation) and select candidate motors / gear systems



# **Rover Design 4**

- section of the class for this term]
- Sensors consider options and select sensors for vehicle operations
  - body angles, actuator motions, power usage)
  - radio/satellite navigation)
- Path planning algorithms if and when...



• Power – Considering motors and mission parameters, calculate energy storage requirements for vehicle and specify battery capacity required • [Caveat – the details of this section will depend on how I revise the last

– Interoceptive: sensors for measurements interior to the rover (e.g., suspension/

- Exteroceptive: sensors for measurements exterior to the rover (e.g., cameras, lidar,



# **Rover Design 5**

- [These are "reach goals" / extra credit]
- Analyze required modifications to the design for use on Mars
- field simulations on Earth



# • Analyze required modifications to the design for use as in analogue

