ENAE 788X Term Project Overview

- Overview of Lunar Light Utility Vehicle (LLUV) concept and top-level requirements
- Rover design primer

Term Design Project Goals

- Provide opportunity to use principles of class to perform open-ended realistic design
- Reinforce experiences with engineering in teams, making technical presentations
- Address a problem of real relevance to NASA

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
- Controlled by autonomy or teleoperation from lunar surface, lunar orbit, or from Earth
- Focus on mobility chassis design aspects – parameters for payload elements will be provided


GITAI

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 mass in operational configuration of 500 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
- System shall be capable of self-connecting to recharger (provided)
- System shall be capable of driving over 30 cm high obstacles

Level 1 Requirements (2)

- System shall be capable of a top speed of 3 m/sec without external payload
- System shall be capable of transporting 1000 kg of payload, including 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

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
- Continue design work and analysis, incorporating feedback from status report and adding analysis areas as they are presented in class
- Final report due Monday, Dec. 9

How To Design a Rover? A Primer…

- Define the requirements – payload mass, volume, dimensions; surface velocity
- Terrain requirements – max slopes, max obstacles/gaps, surface characteristics
- Back of envelope (BOE) stability – height of CG $\Longrightarrow$ wheelbase/wheel span for static stability with margin
- Terramechanics – trade studies on number of wheels, wheel diameter(s) and width(s) $\Longrightarrow$ baseline design with number and placement of wheels, diameter and width of wheels, details of grousers

Rover Design (2)

- Suspension – based on mission requirements (speed, slopes, payload variations) perform trade studies on suspension approaches (e.g., fixed, independent, rocker variants, articulated body) $\Longrightarrow$ baseline on suspension design
- Steering – based on mission requirements (speed, energy, terrain) perform trade studies on steering approaches (e.g., skid-steer, differential drive, single/double Ackermann, independent steering) $\Longrightarrow$ baseline of steering approach
- Synthesis – bring everything so far into baseline design of mobility chassis $\Longrightarrow$ CAD model of baseline configuration concept

Rover Design 3

- Alternate concepts – if desired, consider alternative concepts (e.g., legs, tracks) and perform analyses to define them at similar level of detail to 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 suspension elements (springs and dampers), lateral forces on wheels for steering, details of weight transfer over obstacles and/or slopes
- Mechanisms – find required torque for actuators (e.g., wheel motors, steering, active articulation) and select candidate motors/gear systems for each category

Rover Design 4

- 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 section of the class for this term]
- Sensors – consider options and select sensors for vehicle operations
  - Interoceptive: sensors for measurements interior to the rover (e.g., suspension/body angles, actuator motions, power usage)
  - Exteroceptive: sensors for measurements exterior to the rover (e.g., cameras, lidar, radio/satellite navigation)
- Path planning algorithms – if and when…

Rover Design 5

- [These are “reach goals”/extra credit]
- Analyze required modifications to the design for use on Mars
- Analyze required modifications to the design for use as in analogue field simulations on Earth