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2.00AJ / 16.00AJ Exploring Sea, Space, & Earth: Fundamentals of Engineering Design
Spring 2009

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2.00AJ/16.00AJ Lab 1: Exploration on the Moon (well, Killian Court): Mission Planning for EVA and Geology

Prof. Dava Newman

Name: _____

Team Shackleton Position: _____

Team EARLE Position: _____

Background:

Several days ago, a rover sent through the Killian terrain identified various regions of distinct geological formations. Within each region, the rover mapped the locations of several sites where highly interesting geological samples may be collected. In response to this exciting discovery, a team of astronauts and rovers nearby on the surface has been re-directed to the Killian region in order to examine and bring back these samples. Nearing the end of their scheduled surface mission duration, the team has enough resources remaining for roughly 8 hours of work toward exploring Killian before they must return to the lunar module. In response to this change of plans, Mission Control must now develop a strategy to maximize the scientific return from Killian before returning the surface team home safely.

Mission Detail:

As shown in the map on the next page, Killian has been segmented into three distinct zones. Within each zone are the marked locations of sites of potential geological interest. Although various samples are expected to be encountered at each site, geological data will provide the identity of “samples of interest” that are to be collected by the astronauts. Different zones may have different “samples of interest”, and not every site is necessarily “interesting”.

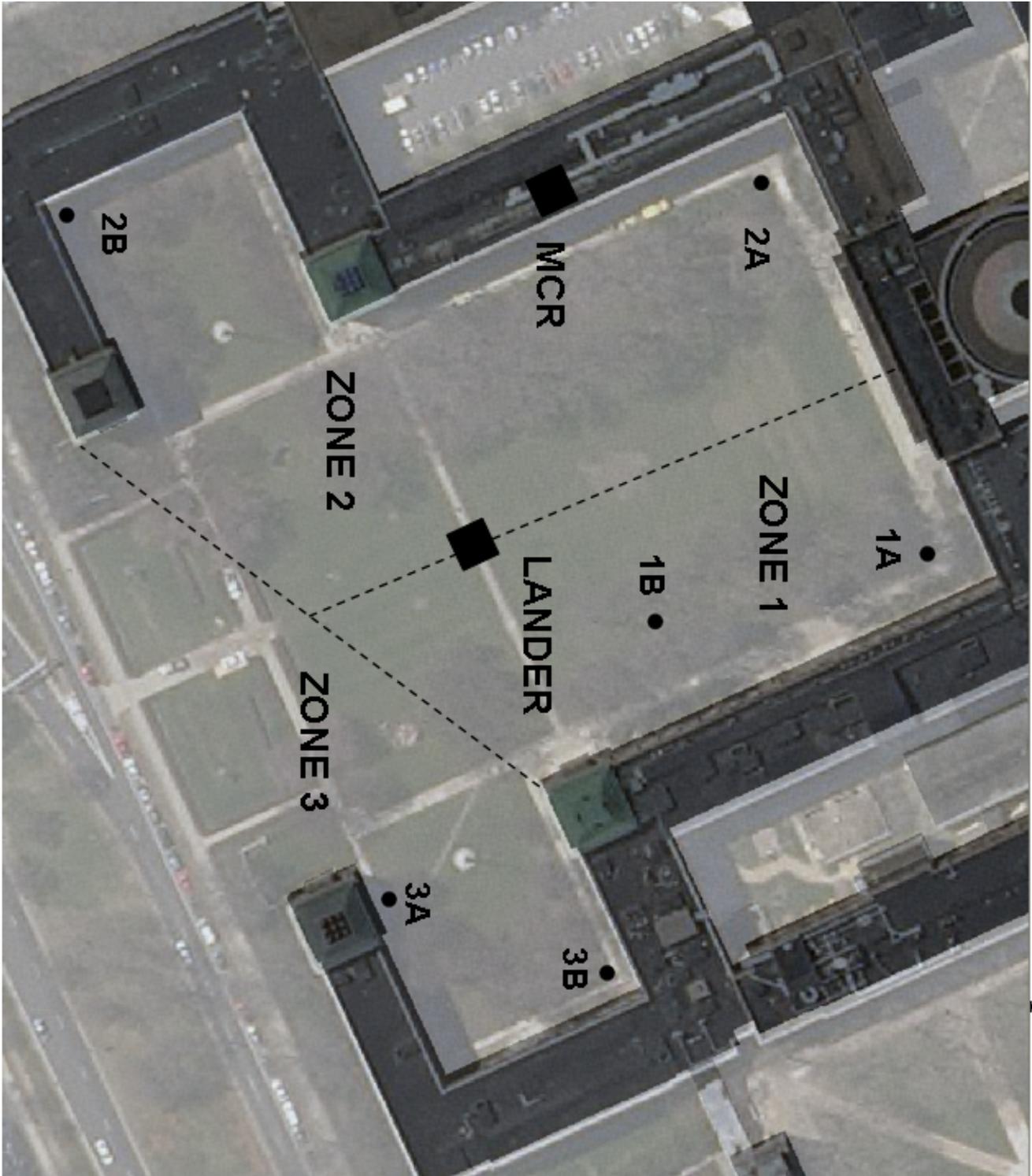
Objectives:

The suited astronauts and rovers will explore the Killian terrain beginning at the starting base. The mission objectives, listed in order of priority, are as follows:

- 1) Safely return all astronauts and rovers to the base
- 2) Collect a sample of interest from as many zones as possible
- 3) Collect as many samples of interest as possible

Schedule:

02:30 Introduction & choosing team positions
03:00 Mission planning
03:20 Team Shackleton EVA1
03:50 Debrief, demos, cleanup



Killian Terrain: Marked Aerial Map

Resources and Limitations:

General

- The EVA mission will be run on a 1/30 time scale, so every minute in real-time is weighted as a half-hour.
- The Exploration Surface Team will have a continuous audio link with Mission Control via the Communicators; however, the Surface Team will have no access to maps or data and must rely on Mission Control to guide them. Likewise, Mission Control will not be able to see the Surface Team and must rely upon the communications link.

Astronauts

- The astronauts have enough oxygen for about 9 hours of *light* activity. To conserve oxygen, astronauts should attempt to remain relatively still and should lope¹ or walk and may not run while exploring. Carrying a load also increases oxygen consumption.

Monitored by the Medical Officers

- The astronauts are limited to a cumulative traverse distance of 1,500 meters.

Monitored by the Positioning Officers

- The astronauts must stick together in groups of 2 and travel as a group.
- Each astronaut may carry one sample (or rover) at a time.

Rovers

- The rovers have battery power for an expected 5-10 hours of use. This is highly dependent upon the rover and the level of activity.

Monitored by the Rover Technician and rover operators

- The rovers may travel independently
- Rovers cannot carry samples

¹ Loping (a form of run with increased arial phase) is more energy efficient than walking, per unit distance and mass, in environments with gravity reduced more than 50% relative to Earth (<0.5G). Newman, D.J., Alexander, H.L. and B.W. Webbon, "Energetics and Mechanics for Partial Gravity Locomotion," *Aviat Space and Environ Med*, 65: 815-823, 1994; C.E. Carr and D.J. Newman. "When is running in a space suit more efficient than walking in a space suit?", Society of Automotive Engineers, Inc., Warrendale, Pennsylvania, USA. SAE paper 2005-01-2970, 2005; Carr, C. E., Newman, D. J., "Space Suit Bioenergetics: Cost of Transport During Walking and Running", *Journal of Aviation, Space Environmental Medicine*, 78:1093-1102, 2007.

Team Format:

Lunar Exploration Surface Team

Astronauts (4) The astronauts will be physically moving (“loping” is the preferred means of locomotion by lunar astronauts) about Killian, wearing Apollo “space suits”. Astronauts must stick together. The lunar astronauts will communicate with Mission Control via walkie-talkie. Each astronaut will be able to carry one “sample” at a time.

Rovers (6) The lunar rovers will be three RC robots, and are part of the exploration team in Killian. Unlike astronauts, rovers do not need to stick together and can move wherever commanded. The rovers will be equipped with wireless cameras fed back to Mission Control. RC rover motion will be controlled by human operators out in the field who will receive commands from Mission Control. Operators (considered part of Mission Control) should not physically assist the rovers; however, an astronaut can move or carry a rover should it get stuck or run out of battery power. Rovers cannot carry “samples.” *See rover detail, page 5*

Lunar Exploration Mission Control Team

Director The Director oversees the mission and makes final decisions regarding how to proceed. All other Mission Control positions report to the Director.

Communicators(2)The first Communicator is an astronaut, and the only person who may communicate with the exploration astronauts via walkie-talkie. The other Communicator is responsible for sending rover commands.

Positioning (2) The Positioning Officers will update and display current astronaut and rover positioning on a real-time map display. The Positioning Officer will also need to keep track of distance traveled, inform the Director of astronaut constraints (i.e. distance to return ‘home’, etc.), and report if/when the exploration activity needs to end. *See Positioning Officer detail, page 6*

Medical (2) The Medical Officers will update and monitor the astronauts’ heart rate and oxygen levels and detect any problems. They will inform the Director of the astronaut status (heart rate & oxygen remaining) and if/when the exploration activity must end based upon data. *See Medical Officer detail, page 7*

Rover Tech. (2) The Rover Technicians will monitor the rover video feed and track battery life. Rover positioning commands will need to be given to the Communicator, and visual data provided to the Geologists. They will inform the Director of rover battery status and if/when the activities must end based upon data. *See Rover Technician detail, page 8*

Geologist(3) The Geologists in Mission Control will be provided with data regarding samples of interest to be collected by the field astronauts. Based upon this data, the Geologists will advise the Director as to which sites are most valuable for scientific return.

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Rover Detail

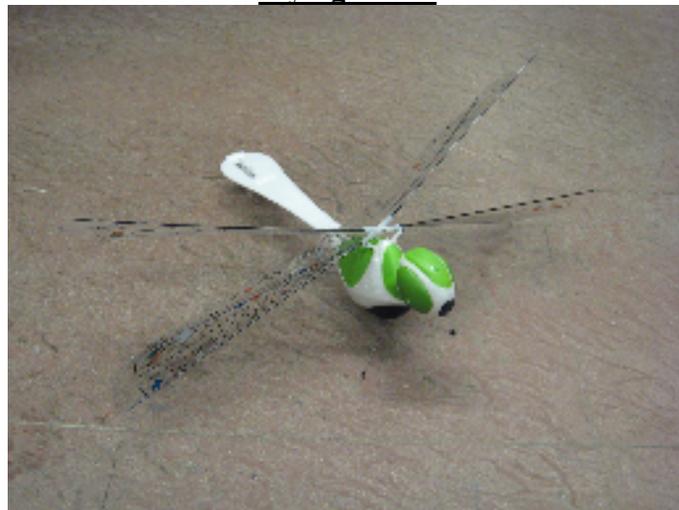
Rolling Rover



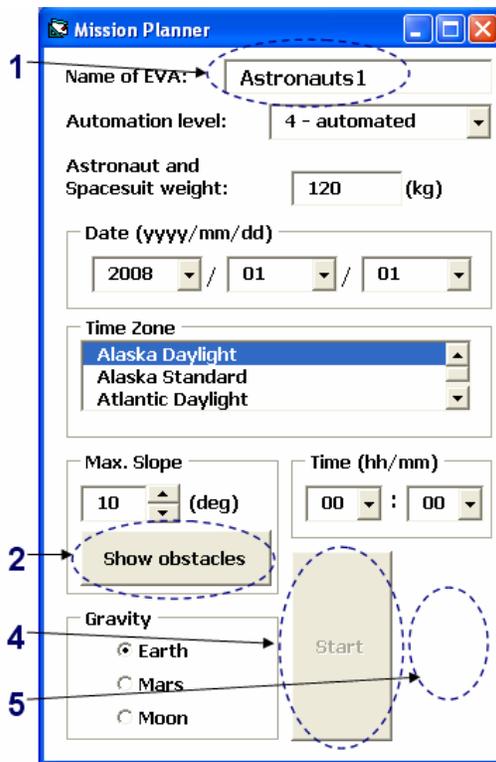
Crawling Rover



Flying Rover



Positioning Officer Detail



1) Identify the traverse path segment

2) Click “Show obstacles”

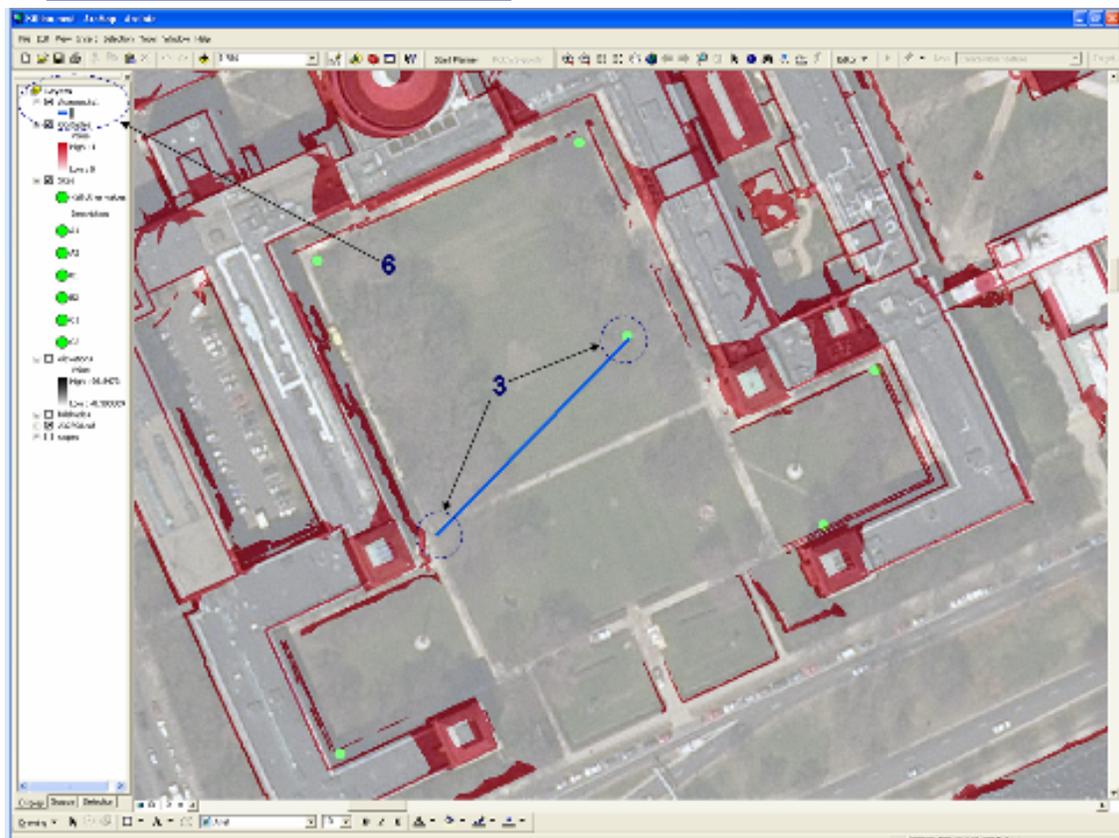
3) Click on start then end point on map

4) Click “Start”

5) Record traverse distance data

6) Edit path segment appearance on map

7) Repeat from (1)



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Medical Officer Detail

- Point and click to record current astronaut activity
- Monitor astronaut heart rate and Oxygen supply
- Notify team of astronaut status and/or problems

Rover Technician Detail

- Monitor rover video feed
- Inform Geologist of data from sites
- Point and click to record current rover activities
- Monitor rovers' battery power
- Notify team of rover status and/or problems

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Notes: