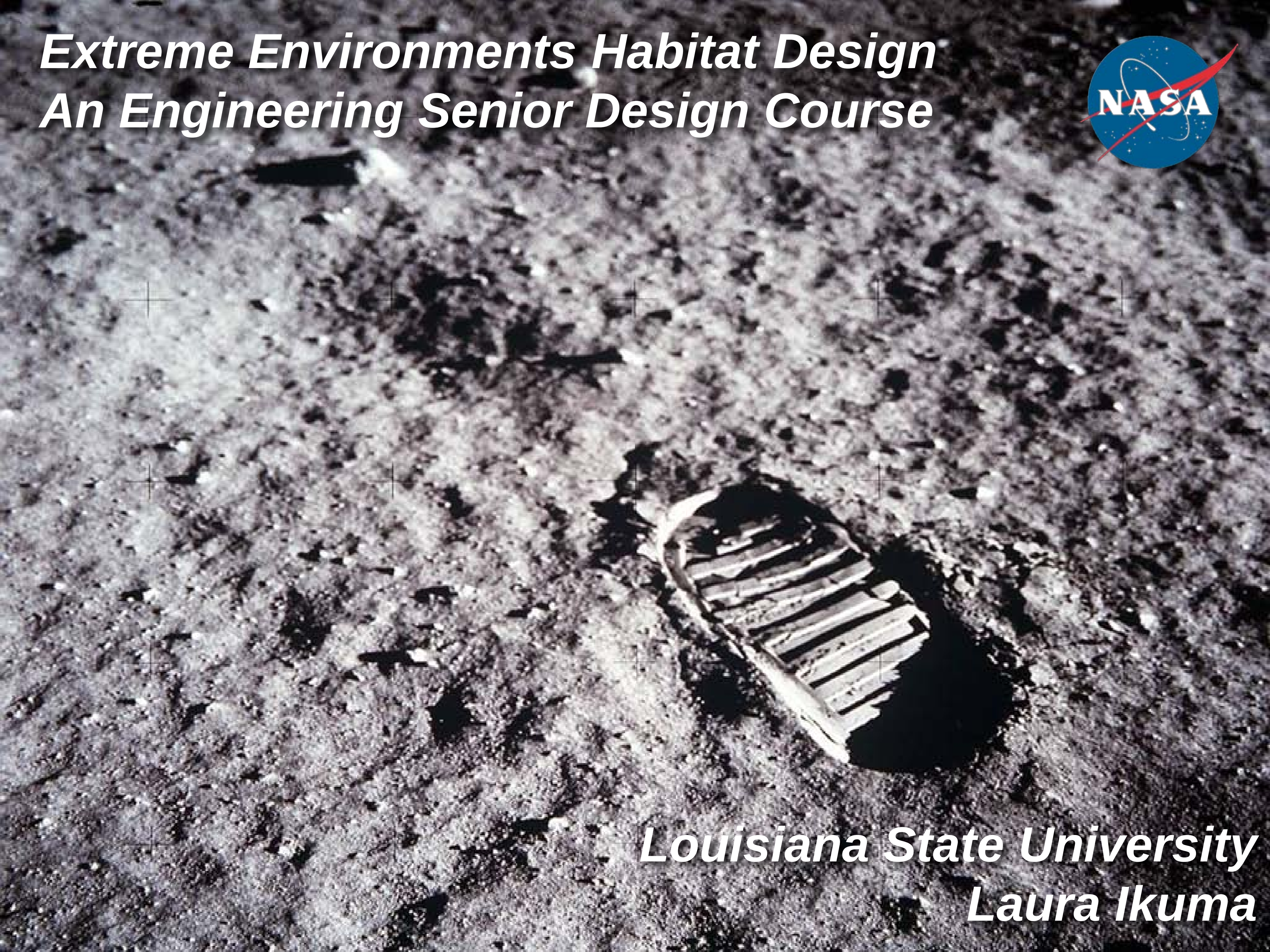

Extreme Environments Habitat Design
An Engineering Senior Design Course
NASA
Louisiana State University
Laura Ikuma

Course Description: Extreme Environments Habitats Design

- **Design of human habitats for extreme environments**
  - Lunar, Mars, space, and deep sea
  - Lecture materials on NASA's system engineering process and issues of concern in designing living and working quarters in extreme environments.
- **Team-taught by 3 faculty**
  - Dr. Harvey: human-computer interaction, worked at NASA
  - Dr. Ikuma: biomechanics, work physiology, information processing
  - Dr. Knapp: systems engineering, information technology
- **2-semester course meets senior design (capstone) course requirement for all students.**
  - Some students take fall semester only as an elective course

Course Objectives

- To apply systems design, human factors, and other engineering skills and tools to address a specific design problem in extreme environment habitat design.
- To use project management skills to
    - Define a problem
    - Plan the necessary work activities
    - Develop a proposal of work to solve or alleviate the problem
- To complete project plans and present them through written and oral reports.
- To improve team building and oral and written communication skills in a real world environment

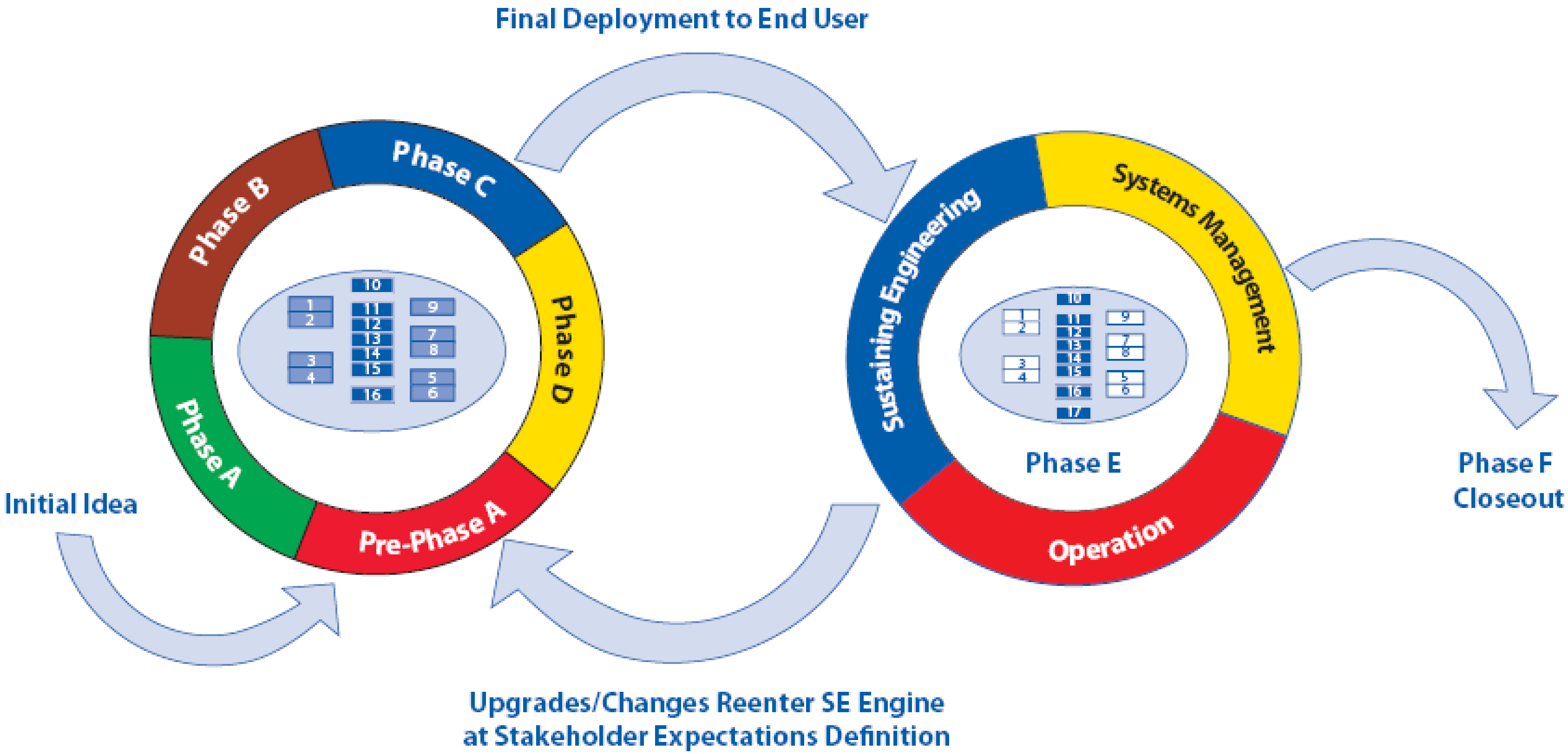
Multidisciplinary Senior Design Concept

- **Systems Engineering (SE): structured and methodical approach to the development of large, complex systems.**
  - Course uses SE as the framework for developing multidisciplinary engineering design projects

- **Students are from several engineering disciplines**
  - Industrial engineering (16)
  - Biological engineering (3)
  - Mechanical engineering (1)
  - Construction management (1)

- **Projects**
  - Are student-driven
  - Incorporate human factors, systems engineering concepts, and other engineering fields (e.g. biological engineering)

Linking multiple engineering disciplines through systems design



- **Pre-Phase A: Concept Studies**
- **Phase A: Concept Development.**
- **Phase B: Preliminary Design.**
- **Phase C: Design & Fabricate.**
- **Phase D: System Assembly, Integration, Test, and Launch (SAITL)**
- **Phase E: Operations**
- **Phase F: Closeout**

Main topics (course coverage)

- **Space operations overview**
  - History of space programs, current and future programs
- **Systems engineering design**
  - Design process
  - Major subsystem types
- **Habitat requirements**
  - Crew (& Payload) Accommodations
  - Supporting Human Habitat
  - Environmental Control & Life Support Systems (ECLSS)
  - Closed vs. Open Loop and Regenerative vs. non-Regenerative Technologies
  - Extravehicular Activity
- **Habitat design (Human factors considerations)**
  - Biomechanics, Work-related injuries and illnesses, Anthropometry
  - Environment: thermal, radiation
  - Cardiovascular demands
  - Safety
  - Information Processing, Situation Awareness
  - Augmented Reality, Assistive Technology

Engineering Design Process (EDP)

- **The iterative process of designing a subsystem, component or process to meet desired deeds.**

- **Design Phases:**
  - **Phase 1. Project Definition and Planning Phase**
  - **Phase 2. Requirements Definition and Engineering Specifications**
  - **Phase 3. Concept Generation and Evaluation Phase (also known as the Conceptual Design Phase)**
  - **Phase 4. Product Design Phase**

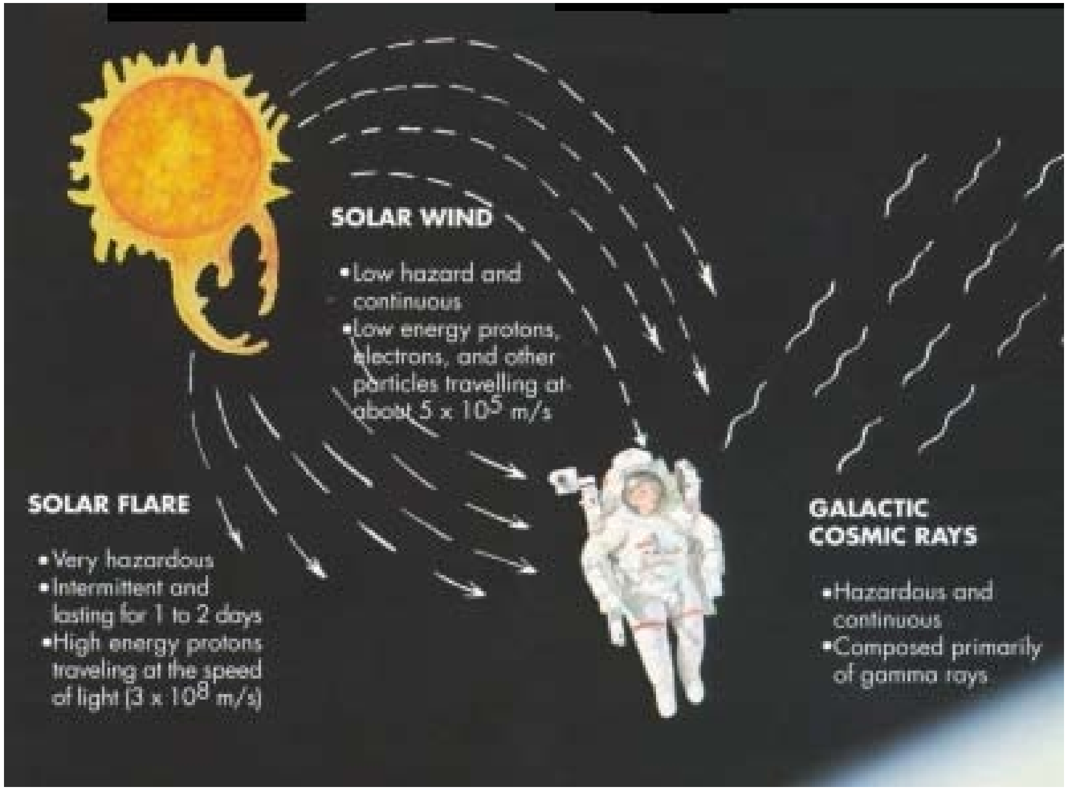
Project Requirements Report

- **Objective and background**
- **Quantitative design constraints**
  - Money, mass, energy, and volume budgets
  - Environment and associated conditions (temperature ranges, gravity, atmosphere, light, radiation, etc.)
  - Length of mission
  - # crew members and activities
- **Weighted user requirements**
  - Functional and performance requirements
  - Interfaces
  - Environmental
  - Safety and reliability
- **Design evaluation plan**
- **Team organization and project plan**

Concept Generation and Evaluation Plan

- **Provides complete design specifications**
- **Provides statement of work for prototype generation and testing**
  - This work will be carried out in the spring semester
- **Presented to class, instructors, and NASA contacts via video conference**

Objective: To reduce human exposure to cosmic and solar radiation in a lunar base to an acceptable level for a six-month period.

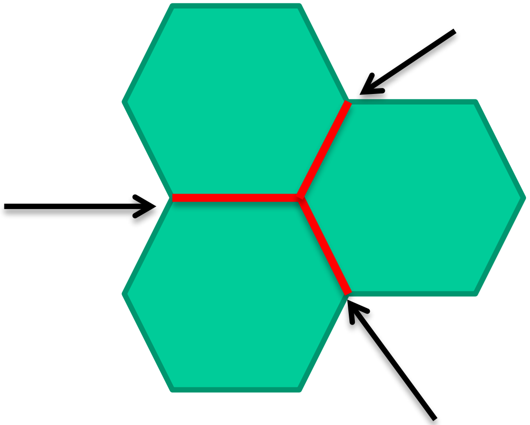


http://www.nsbri.org/HumanPhysSpace/introduction/intro-environment-radiation.html

Objective: This project will focus on the design of an efficient and effective sleeping environment that will allow astronauts to obtain a sufficient and quality amount of sleep while residing on the moon and in space.

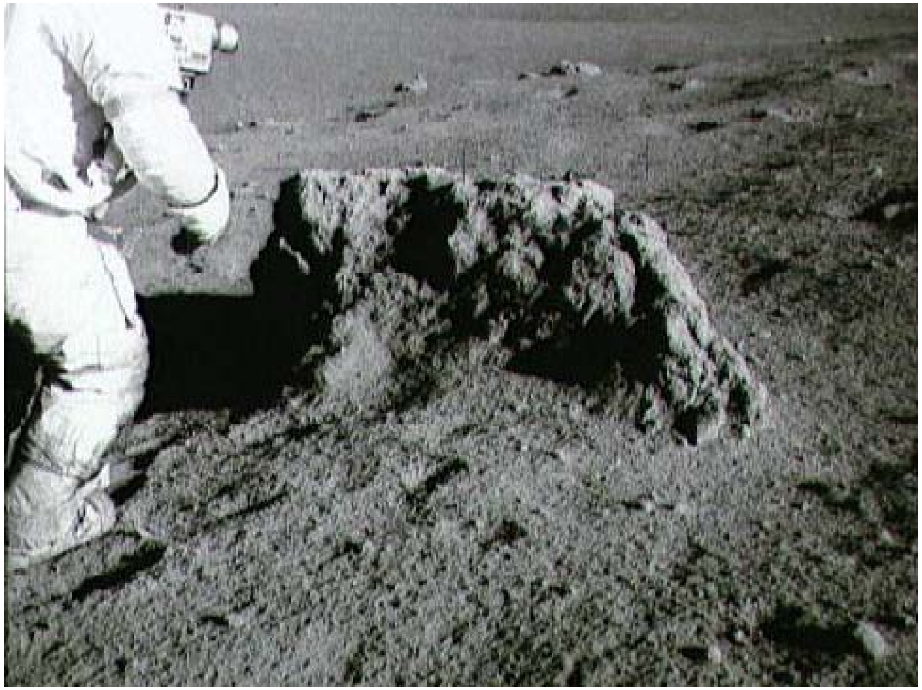
Objective: To find the shape, materials, and shipment and assembly processes which maximize compatibility and flexibility in a modular Martian habitat while staying within Design Reference Mission specifications

http://www.jpl.nasa.gov/news/news.cfm?release=2008-214



Objective: The main goal of this design project is to minimize the amount of lunar dust that is tracked into the habitation module on the moon.

Currently, an estimated 227g/suit of dust reenters the module after an EVA, approximately 7% of which becomes airborne. Our objective is to decrease the amount of airborne dust to 2%.



Bioregenerative Life-Support System (BLSS)

Source: www.nasa.gov

Objective: To design and optimize a hydroponic nutrient delivery system for phototrophic organisms, which sustain oxygen levels required for human life, utilizing available sources present on Mars.

Course Timeline

Fall 2010

- Project Proposals
- Project Requirements
- Concept Generation & Evaluation Plan

Spring 2011

- Testing and evaluation
- Outreach to local elementary school

Summer 2011

- Course workshop
- Finalize course materials

Fall 2011

- Ready for implementation in other schools!

Learn more, come to the workshop (FREE!)

- **Workshop on this senior design course held July 2011**
- **NASA will cover expenses**
- **Course content will also be available on NASA website**
  - Presentation slides
  - Course materials