Extreme Environments Habitat Design
An Engineering Senior Design Course

Louisiana State University
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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
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
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
Radiation Reduction

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

Sleep Environment

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.
Modular Habitat Design

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

The Lunar Dust Dilemma

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%. 
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.

Source: www.nasa.gov
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