Rocketry Projects Conducted at the University of Cincinnati 2009-2010

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Spacecraft Design Course Objectives

• Students gain experience with:
  – Project management
  – Space systems engineering
  – Design, analysis, construction, test, operations
  – Fund raising
  – Real world problem solving
Project Management

- Project Definition
- Project Planning
- Project Implementation
- Project Communication
Systems Engineering

- Requirements
- Validation
- Verification
- “V” Model

Design, Analysis, Construction, Test

• Application of methods and principles previously learned in a realistic environment with technical, budget, and schedule constraints
Fund Raising

- Students took the primary role in finding funding sources and writing proposals
Real World Problem Solving

• Risk Assessment
• Anticipating problems and opportunities
  – Planning responses ahead of time and setting triggers
Project & Competition
Competition Overview

Deploy Rover

Coast to Apogee

Rover/Rocket Fall to Earth

Rover Traverse

Thrust
Competition Requirements

• Rocket must
  – Reach a minimum altitude of 1000 ft
  – Completely house rover
  – House at least a single Perfectflite A15K Rev 2 recording altimeter

• Rover must
  – Deploy and descend safely without freefall
  – Place a marker at point of touchdown
  – Traverse a minimum displacement of 3 meters from touchdown marker
Integrated Rocket/Rover Design

Rocket Dimensions
- 4’8” tall
- 6 inches diameter
- 13 lbs with rover
Rocket Body Separation

Lower Body

Upper Body

Custom Coupler
Propulsion System

• Aerotoch I-600R Motor

• Simulation Results
  – Calm conditions: 0-2 mph winds
  – Max Altitude of 1712 ft.
  – Max Velocity of 382 ft/sec
  – Range of 205 ft.

• Competition flights, altitude reached:
  – 1346 ft., 1348 ft., and 1372 ft.
  – Discrepancy in simulation and actual flights due to increase in weight during fabrication and winds higher than 0-2 mph at competition
Rocket Fabrication
Rocket Fabrication
Completed Rocket
Rover Concept

- Based on a World War I tank concept
- Treaded vehicle with a single drive wheel
- Tensioned guide wheel
- Lightweight frame to allow for robust electronics system
- Original design used GP03 fiber glass with aluminum supports for the frame
- 4 in. x 10.5 in. (with wheels) x 2 in.
Locomotion

Tread Drive Wheel
- Translates motion from the gear box to the drive wheel via miter gears
- Drive wheel axle is potted in the drive wheel using epoxy.

Tensioned Guide Wheel
- Springs provide about 12 lbs. tension force on the tread
- Tensioned system relies on friction to move the tread
Rover Control Components

System Components
- Accelerometer
- Programmable Logic/Micro Controller
- Motion Controller
- DC Motor
- Gear Box
- Drive Train

Electrical Power Source
- Main Power supply

Computational Components
- Key
  - Mechanical Motion
  - Electrical Power
  - Information Route

Motion Generators and Converters
- 1. Sensors
- 2. Intelligent Decision making
- 3. Mechanical and motion

System Functions
Electronics Layout

- Gearbox
- Motor
- Encoder
- PLC & Battery (stacked)
- Microcontroller
Release Mechanism

• Nichrome wire was used to release the parachute and beacon
• Nichrome was coiled around the chords
• Op-amp restricted current from battery to wire
Rover Electronics System

- Microcontroller
- Op-Amp
- Motor
- Gearbox
- PLC
- Accelerometer
- Battery
Completed Rover
Rover Test
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<th>Date</th>
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<th>Rocket Name</th>
<th>Payload</th>
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<td>Icarus</td>
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Competition Flight (Artemis)
Results

- Rocket with rover crashed at a test launch 1 week before competition
- Had a backup rocket ready to use
- Used same electronic system on an off-the-shelf rover for competition
- At competition, no teams met the requirements. UC Prime had a successful launch and deployment and the beacon was released upon landing, but the rover didn’t move
Lessons Learned

• A design is rarely left unchanged throughout fabrication
• Expect problems with your design and plan accordingly
• Redundancy, redundancy, redundancy
  – High probability of catastrophic failure
• Testing is crucial to expose flaws or weaknesses in design
Acknowledgements

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