Gateway To Space

ASEN 1400 / ASTR 2500

Class #11

Colorado Space Grant Consortium
Today:

- Announcements

- Next classes

- Guest Lecture – Students from HELIOS

- Requirements and Foam Core

- One Minute Report Questions/Answers
Announcements:

- All Teams are rolling (**ATPs complete**)

- All hardware has been **ordered**

- Please **pick up orders** when notified – don’t let it sit

- Arduino **Training** is complete

- Where to get **help**…(me, TAs, **Dan, and Tim**)
Announcements:

TA’s Team Assignments
- Amber - Teams 1, 3, 4, 10
- Leina - Teams 5, 8, 9
- Gabe - Teams 2, 6, 7

Office hours in either ITLL 150 or 160:
- Amber - Tuesday and Thursday 5-6pm
- Leina - Tuesday 5-6pm and Thursday 6-7pm
- Gabe - Thursday 5-7pm
Announcements:

- First round of grades should be next Thursday 2/25

- **Passwords** will be handed out on Tuesday 2/23

- Use class website and your password to see your grades
Thursday...

Guest Lecture – Systems Engineering
Jessica Brown Young
Lockheed Martin

HW 08 Due
Next Tuesday...

Guest Lecture – Thermal Design

Emily Brisnehan

Lockheed Martin
Next Thursday...

Guest Lecture – Structural Design
Bruce Davis
ROCCOR Engineering
Questions?
HELIOS

Colorado Space Grant Consortium
Requirements:

- What is a Requirement?

- Requirements define the design space and thus the project. They DO NOT DEFINE the MISSION.
Why spend all the time on requirements?
- They let you know when you are done. (With implementation and finally verification)

What is the difference between Verification & Validation?
- Verification = build the thing right
  You captured the performance

- Validation = build the right thing
  You captured the spirit
Requirements make sure that the end product comes out as the customer desired it to (validation) with the performance to accomplish the job (verification).
1. Clear
   - Make sure you, your customer, AND your team understand the goals.
   - Every requirement should capture one idea, not multiple at a time.

Requirements:

- How the customer explained it
- How the Project Leader understood it
- How the Analyst designed it
- How the Programmer wrote it
- How the Business Consultant described it
- How the project was documented
- What operations installed
- How the customer was billed
- How it was supported
- What the customer really needed
Requirements:

- Five aspects of a good requirement

1. CLEAR

2. NECESSARY

3. TRACEABLE

4. ATTAINABLE

5. HAVE A METHOD OF VERIFICATION
Requirements:

1. Clear

- Make sure you, your customer, AND your team understand the goals

- Every requirement should capture one idea, not multiple at a time

No person shall spit in, or in any other way contaminate the pool, its floors, or dressing rooms.
Requirements:

2. Necessary

- A statement of need for a problem/challenge

- Without requirements, the design will not end up the same way

If the requirement appears to be stand alone then is it truly necessary
1. Clear
- Make sure you, your customer, AND your team understand the goals.
- Every requirement should capture one idea, not multiple at a time.

THE IDEAL MISSILE DESIGN FROM THE VIEWPOINT OF VARIOUS SPECIALISTS

AERODYNAMICS

PROPULSION

STRUCTURES

PRODUCTION

GUIDANCE

CONTROLS

ANALYSIS
Requirements:

3. Traceable

A requirement should be able to traced all the way back to the mission statement

- Exists in a hierarchy of breaking down the problem

- Lower level requirements answer this fundamental question “What do I have to do to do X or Y?”
**Requirements:**

- Requirements flow from your mission statement and mission objectives

- They are always traceable back to the mission statement

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**Anatomy of Requirements**

1. **Mission Statement (aka Mission Goal)**
   A very general description of the problem being addressed by the system.

2. **Mission Objectives**
   3 to 5 general statements elaborating the Mission Statement.

3. **Objective Requirements**
   Quantify each objective: when, what, where, for how long

4. **System Requirements**
   The system as a whole must perform to this set of specifications in order to meet the objective requirements, mission objectives, and mission statements.

5. **Subsystem Requirements**
   Each subsystem must perform to these specifications in order to meet the criteria defined above. This part is done separately for each subsystem i.e. power, mechanical, computer, science, thermal.

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*Step 1: General definition.* Subjective description and a few numbers

*Step 2: Numbers and ranges.* Focus in on defining the problem.

*Step 3: Subsystems.* Repeat step 2 for every subsystem, tracing from system requirements.

*Koehler & Pilinski 2007*
Requirements:

4. Attainable

- A design challenge should be **physically possible** and requirements help bound the problem

- A requirement must be met (at some point)
- Lack of resources, design methods, and human smarts must be taken into account
- Don’t find yourself saying, “Well it was too hard”
5. Have a Method of Verification

- If you have a need then you must verify your end product meets that need (performance)

To truly answer the question, “Are you done and ready to fly?” you must have verified each of your requirements
Requirements:

Examples

A black sports car shall reach 60 mph in 3 seconds
Requirements:

Examples

A **black** sports car shall reach 60 mph in 3 seconds

*Lacks Traceability & Necessity*
Requirements:

Examples

EPS may consume 70W at 5V and 12V
Requirements:

Examples

EPS may consume 70W at 5V and 12V
Lacks Clarity (how long?)
Requirements:

Examples

A space imager will be cooled to 0K to monitor Thermal IR
Requirements:

Examples

A space imager will be cooled to 0K to monitor Thermal IR

Lacks Attainability & Verifiable
Examples

The purple spacecraft, brought to you by Carls Jr, shall carry 10 cats and should be in a 30 mile orbit above the Earth and has to stay over Boulder 24 hours a day.
Requirements:

Examples

The purple spacecraft, brought to you by Carls Jr, shall carry 10 cats and should be in a 30 mile orbit above the Earth and has to stay over Boulder 24 hours a day.
Requirements:

Do Not Tell HOW

- A requirement should **bound the solution but not be the solution**

*BobSat shall measure the rotation rate of the BalloonSat through the duration of your flight.*

*BobSat shall measure the rotation rate of the BalloonSat in three axes to a resolution of 0.1 degree/sec using a magnetometer and gyroscope from SparkFun for 15 minutes of the flight.*
The Right Words:

Standardized Wording
**SHALL**: Something that must be verified in the final design
**SHOULD**: A stretch goal of the project (i.e. pie in the sky)
**WILL**: Statements that are facts or explanations

Star Wars/Yoda was right! “**There is no try, only do or do not**”
The Wrong Words:

Don’t use words that are vague like: Minimum, Maximum, Average, Better, Worse, Maximize, Minimize, Simultaneous, Rapid, Real-Time, Satisfactory, Adequate, Sufficient, Always, Sometimes, May, Most, Ideal(ly), Significant(ly)

Your requirements should be strong and self-supporting; these words aren’t.

Avoid being wordy in your requirements, generally that leads to capturing multiple goals at the same time, each requirement should convey one point.
Requirements:
The V
Requirements:

Even now as you write your requirements consider:
- How are you going to make sure you meet them in the end?
- What kind of testing are you going to need?
- How will you turn the testing data into something meaningful?
- Converting voltages from a sensor into units (C, psi, G, etc)?
- Characterization of your experiment so that you know the data you gather on flight is correct?
- Fundamentally you are answering the question of will your BalloonSat survive without you for 4 hours
- Consider doing a full mission simulation to show (never guess) that you can meet your mission
And one reminder, test early, test often.

DANDE did 3 months of 56 hour DITL tests before they got it right.
Announcements:

- Good examples to look at from 2011
  - Team 05
  - Team 07

- Good examples to look at from 2010
  - Team 01
  - Team 02
  - Team 04
  - Team 05
  - Team 09
2.0 Requirements Flow-Down Chart

Mission Statement: Our BalloonSat *Aliquid In Spatio* will ascend to approximately 30 kilometers into the atmosphere to determine if bacterial microbes that inhabit the surface of the earth are able to withstand the harsh environment of near space, as well as to attempt to discover if there are bacterial microbes that inhabit the tropopause.

Objective 1 (Derives from Mission Statement): Our BalloonSat will measure the inside temperature, outside temperature, and humidity of the BalloonSat during the flight to assess the environment.

Objective 2 (Derives from Mission Statement): Our BalloonSat will also carry our bacterial samples into near space to test them if they can survive in that harsh environment.

Objective 3 (Derives from Mission Statement): Our BalloonSat will carry a sterile petri dish and expose it to the atmosphere at the altitude of the tropopause to see if any bacteria live in that environment.

Requirement 0.1 (Derives from O1) We will run the HOBO datalogger for the entirety of our flight to gather inside and outside temperature as well as humidity data from the start to finish of our flight.

Requirement 0.2 (Derives from O2) We will carry three different sets of bacteria to test if they can survive. We will expose one set of bacteria to all of the effects of near space: low temperature, low pressure, and radiation. We will then expose one set of bacteria to just the radiation by sealing it so it retains pressure and by heating it so it does not go to low
**OBJECTIVE**

The mission of Team Solkraft is to test the effectiveness of different types of solar panels (monocrystalline and polycrystalline) under conditions on the ground and up to near-space conditions of approximately 30 km.

**MISSION REQUIREMENTS LEVEL 0**

<table>
<thead>
<tr>
<th>Requirement Number</th>
<th>Requirement</th>
<th>Where it comes from</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 0.1</td>
<td>The solar panels on the BalloonSat shall be exposed to near-space conditions</td>
<td>Mission Objective</td>
</tr>
<tr>
<td>M 0.2</td>
<td>Team Solkraft shall measure the internal and external temperature with varying altitude</td>
<td>Mission Objective</td>
</tr>
<tr>
<td>M 0.3</td>
<td>Team Solkraft shall measure the light intensity with varying altitude</td>
<td>Mission Objective</td>
</tr>
<tr>
<td>M 0.4</td>
<td>Team Solkraft shall test for variations in solar cell output under varying climate conditions</td>
<td>Mission Objective</td>
</tr>
<tr>
<td>M 0.5</td>
<td>Team Solkraft shall meet the requirements for the request for proposal</td>
<td></td>
</tr>
<tr>
<td>M 0.6</td>
<td>Team Solkraft shall make sure no one is hurt during construction and testing</td>
<td></td>
</tr>
</tbody>
</table>

**MISSION REQUIREMENTS LEVEL 1**

<table>
<thead>
<tr>
<th>Requirement Number</th>
<th>Requirement</th>
<th>Where it comes from</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 1.1</td>
<td>The solar panels shall be attached to the angled sides of the BalloonSat</td>
<td>M 0.1 M 0.4</td>
</tr>
<tr>
<td>M 1.2</td>
<td>Team Solkraft shall be able to record the altitude of the BalloonSat using data from EOSS GPS</td>
<td>M 0.2, M 0.3</td>
</tr>
<tr>
<td>M 1.3</td>
<td>Team Solkraft shall be able to record and save data during the flight</td>
<td>M 0.2, M 0.3, M 0.4</td>
</tr>
<tr>
<td>M 1.4</td>
<td>Team Solkraft shall maintain a minimum internal temperature of</td>
<td>M 0.5</td>
</tr>
</tbody>
</table>
1.1 Mission Statement: Project Omni shall launch a balloon satellite sponsored by the University of Colorado’s Gateway to Space class in order to measure the received signal strength of ground based very high frequency (VHF) transmissions at high altitude.

2.1 Level 0 Requirements:

<table>
<thead>
<tr>
<th>Number</th>
<th>Details</th>
<th>Derived From</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0.1</td>
<td>Project Omni shall measure the signal strength of a VOR transmission from high altitude.</td>
<td>Mission Statement, Mission Overview</td>
</tr>
<tr>
<td>P0.2</td>
<td>The mass of Project Omni shall not exceed 864 grams.</td>
<td>Mission Statement, Mission Overview</td>
</tr>
<tr>
<td>P0.3</td>
<td>Project Omni shall fly a Canon A3400-IS digital camera to take and store images and videos from the flight.</td>
<td>Mission Statement, Mission Overview</td>
</tr>
<tr>
<td>P0.4</td>
<td>The total cost of the flight shall not exceed $180.</td>
<td>Mission Statement, Mission Overview, Budget</td>
</tr>
<tr>
<td>P0.5</td>
<td>Project Omni shall measure internal and external temperature, acceleration on three-axes, as well as pressure and relative humidity and record this data to an SD.</td>
<td>Mission Statement, Mission Overview</td>
</tr>
<tr>
<td>P0.6</td>
<td>All parts of Project Omni will be kept intact during flight and post-flight with the intent of being reusable.</td>
<td>Mission Statement, Mission Overview</td>
</tr>
<tr>
<td>P0.7</td>
<td>Project Omni shall maintain an internal temperature greater than 0°C.</td>
<td>Mission Statement, Mission Overview</td>
</tr>
</tbody>
</table>

2.2 Level 1 Requirements

The following are the level 1 requirements for the mission. Each requirement was derived from the previously stated level 0 requirement. Project Omni shall fully meet each of the requirements stated below.

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Derived From</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1.1</td>
<td>Project Omni shall fly a VHF receiver capable of receiving frequencies from 108.0Mhz to 117.975Mhz and shall be tuned to 112.20Mhz at launch and during flight.</td>
<td>P0.1</td>
</tr>
</tbody>
</table>
Questions?

Colorado Space Grant Consortium
Foam Core:

- When cutting foam core, remember you are cutting through three layers
- Best to cut each layer individually
- Go slow, use metal edge ruler
- Be mindful of blade

- Foam Core Document
When cutting foam core, remember you are cutting through three layers. Best to cut each layer individually. Go slow, use metal edge ruler. Be mindful.
Foam Core:
Foam Core:

- Draw centerlines between inner and outer lines
- All edge cuts are at 45 degree angles to the centerline
- Cut inside edges first and only through top paper and foam not bottom paper (hinge)
- Cut outside edges last but all the way through
- Go Slow and don’t cut the tables
- Please dispose of Xacto blades properly
- Don’t forget to account for insulation
Foam Core:

- Don’t forget about switches, LEDs, etc
**Foam Core:**

- Glue it together and strengthen corners

- Please don’t go overboard, weight is still an issue
Foam Core:

- After gluing, cover your seams with aluminum tape.
- Do not glue top lid of box. Tape only for easy access after flight without destroying your box to open it.
Foam Core:

- Balloon attachment tube hole should run through center of box on non-opening side

- Make hole diameter as close to tube diameter as possible

- Secure with paper clip

- Make sure paper clip does not interfere with inner diameter
One Minute Reports:

- Go to Switzerland