Payload Design Process

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Systems Engineering Life Cycle

- Identify AND DOCUMENT the payload requirements
- Identify approaches to meeting the requirements
- Select the best approach
- Design → Build → Test the payload
- Document the payload and its operation
- Install the payload
- Operate the payload
- Considerations/Contraints
- Some Payload Ideas

Identify Payload Requirements 1

- For this project the team is both customer and provider
- Nevertheless: A single team = customers + providers
- Identify the customer's needs – the payload's purpose
  - E.g. "I need a camera to take pictures in space"
- Identify the provider's requirements – What <u>else</u> is needed to meet the CUSTOMER'S needs?
  - Derived Requirements, e.g. "The camera must work at low pressure"

Identify Payload Requirements 2

- Requirements include constraints, limitations
  - "…but it can't be bigger than, smaller than, heavier than…etc
- Try to keep requirements separate from the solution
  - Thinking about both at the same time can make the requirements grow or make the solution seem too complicated
- BUT……Sometimes you may need to change a requirement after you start working on a solution
  - Too expensive/impractical/impossible to meet initial requirement

Identify Payload Requirements 3

- Document the requirements
  - Multiple intra – team requirements documents if necessary
- Communicate requirements changes to the entire team
- YOUR REQUIREMENTS DOCUMENT IS YOUR DESIGN ROAD MAP

Identify Approaches

- Identify possible approaches
- Example: Customer needs a camera payload
  - Design from scratch? Buy a camera? Use a cell phone?
- Study tradeoffs between approaches
  - To evaluate tradeoffs, look at your REQUIREMENTS
  - Each approach has a BENEFIT and a COST
    - A Nikon D90 is a very good camera BUT: expensive, heavy
    - My cell phone is cheap BUT: not enough pixels, small battery
  - Consider doing experiments to evaluate approaches

Select the Best Approach

- This always involves choosing the best mix of:
  - Quality, Speed of Implementation, Cost
- Remember your Design Road Map
- "Better faster cheaper" – Improve one; others suffer?
  - Better: more expensive; take longer?
  - Faster: lower quality; more expensive? (Why?)
  - Cheaper: lower quality; take longer; more expensive long run (Why?)

Design – Build – Test 1

- Complete the design – Work out ALL the details
- Document the design. Make sketches and notes
  - This is your BUILD ROAD MAP
- Plan required testing BEFORE you build
- Obtain materials
- Build ⟷ Test
- Make improvements – Document changes -Test
- Document final design & operating procedures
- Consider a Failure Modes and Effects Analysis
  - What could go wrong and what would the effects be?

Design – Build – Test 2

- Document the instructions for payload installation
- Document the instructions for payload pre-flight activation/operation
  - Pull – tab to connect batteries?
- Document the instructions for payload post-flight operation
  - Securing data
  - Analyzing data

Considerations/Constraints

- Safety
- Function (what does it need to do?)
- Electrical power requirements
- Size, Shape, Weight
- Environment: press, temp, accel, radiation
- Duration of flight
- Materials compatibility: Some may react w/ others
- Survivability of components
- Electrical heating

Payload Ideas

- Measure some aspect of the environment
  - Characterize the environment
  - Describe the flight
  - Test some hypothesis about the environment
- Use the environment: microgravity, press, temp
- Environmental components = forms of energy

Chemical, **O**ptical, **M**echanical, **E**lectrical, **T**hermal, **M**agnetic, **A**coustic, **N**uclear

P. Stein

Payload Ideas

- Measure the duration of microgravity
- Make a video of an interesting object(s)
- Protect a raw egg
- Measure the voltage induced in a coil of wire by movement through the earth's magnetic field
- Measure variation with alt of the earth's mag field
- Measure acceleration and calc speed + distance
- Calculate dynamic pressure (Q) and the time of occurrence and magnitude of "max Q"

Some Tech Info

- Typical electronic subsystems
  - Sensors
  - Data acquisition and recording
  - Actuators
  - Controllers
  - Electrical power
  - Software
  - Thermal insulation