# Risk Management & System Mission Assurance

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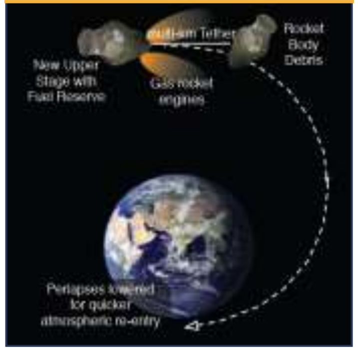
# About me

Debris Removal Thesis



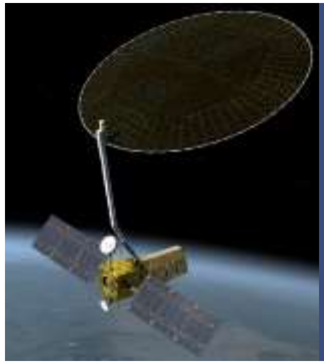

DANDE-UNP

Hermes ELaNa I

RocketSat

- University of Colorado, B.S. -> Ph.D. ('14)
  - Astrodynamics
- Designed or tested several microsat & CubeSat ADCS systems
- Led formation flying mission

- NASA-JPL, NASA-ISRO SAR Mission



SAR mission with ISRO

Earth deformation
Land/Sea Ice
Biomass

- Deployment activity lead of 9m boom, 12m reflector
- 12Tb SSR from Airbus, SE

Design and electronically set off 4th of July fireworks (~2 tons!) show for small Kansas town

https://www.youtube.com/watch?v=iECzsNrXm8c

# How would YOU describe Mission Assurance?

**Do you even know what it is?**

# Definition(s)

- **Activities that help improve chances of mission success**

- **Aerospace:** The disciplined application of proven scientific, engineering, quality, and program management principles toward the goal of achieving mission success

- **DoD:** A process to protect or ensure the continued function and resilience of capabilities and assets - including personnel, equipment, facilities, networks, information and information systems, infrastructure, and supply chains - critical to the performance of DoD MEFs in any operating environment or condition

- **Wikipedia:** Mission Assurance is a full life-cycle engineering process to identify and mitigate design, production, test, and field support deficiencies threatening mission success

# Where does MA Occur?

- Mission Assurance activities are spread across all elements of a project
  - Engineering
    - System level analysis … all the way to … Individual component selection
  - Communication
    - Risk Management*
    - Reviews could be considered part of MA
    - Failure reports
    - Lessons learned
    - Etc.

- Many organizations have an independent assessment group/team perform MA to keep a separated perspective from project pressures (e.g. cost, schedule, "I know what I'm doing")

**more in a few slides*

# Two Fundamental Approaches (1/3)

**Class A – D**

- Created in 1986 by the DoD for "one-of-a-kind space equipment"
- Used by DoD and NASA
- Process: Define the Class of the mission, follow the guidelines for that Class

| | Class A | Class B | Class C | Class D |
|---|---|---|---|---|
| Priority / significance | High | High | Medium | Low |
| Complexity | Very high / High | High / Med | Med / Low | Med / Low |
| Cost | High | High / Med | Med / Low | Low |
| Examples | ISS, JWST | MSL, GPS | Explorer | variable |

(many) ISS Payloads

NASA / DoD SmallSat Science Missions

MARCO (Mars CubeSat mission), LunarFlashlight

Starlink

Planet Labs

UNP Missions

Hobbyists / High schools / etc.

How to handle this variability?

Variable MA

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## Constraint – Based

- Created in ~2019 by AFRL for "resource constrained missions…[to] enable faster and cheaper evolution"
- Still being adopted, used by parts of AFRL and Aerospace Corporation
- Process: Define scope and constraints on mission, trade scope + resources to achieve driving constraint

# Two Fundamental Approaches (2/3)

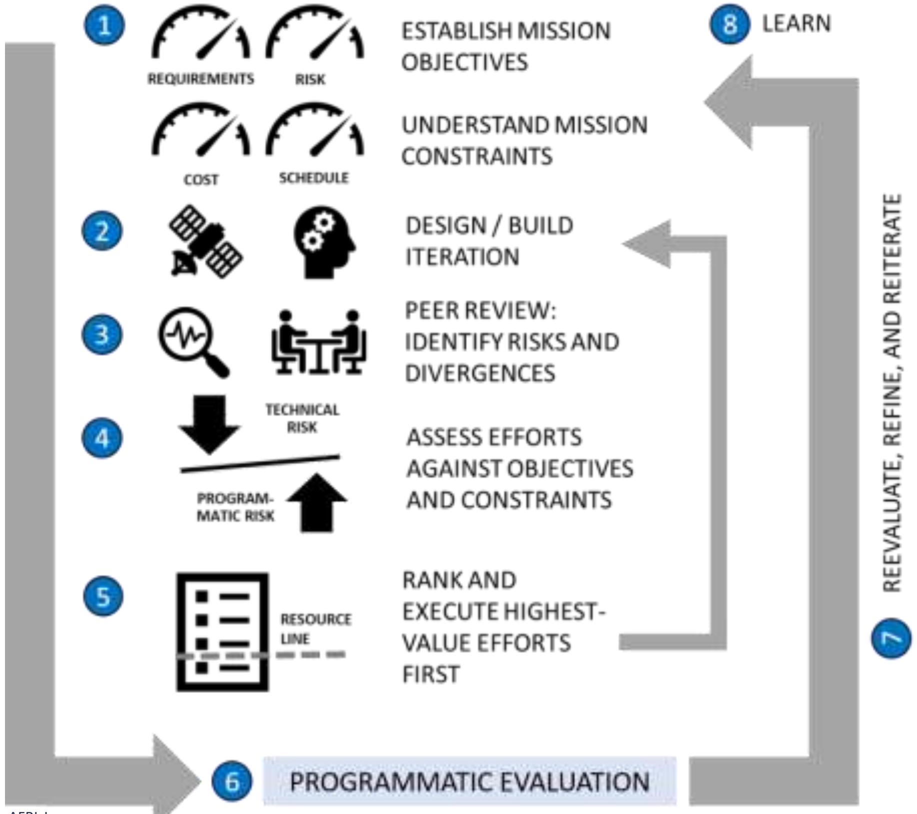
## Class A – D Practices

| Category | Process |
|---|---|
| 1. Program Execution | (1) Design Assurance<br>(2) Requirement Analysis and Validation<br>(3) Parts, Materials and Processes<br>(4) Environmental Compatibility<br>(5) Reliability Engineering<br>(6) System Safety<br>(7) Configuration/Change Management<br>(8) Integration, Test and Evaluation |
| 2. Risk, Oversight and Assurance | (9) Risk Assessment and Management<br>(10) Independent Reviews<br>(11) Hardware Quality Assurance<br>(12) Software Assurance<br>(13) Supplier Quality Assurance |
| 3. Triage, Information and Lessons Learned | (14) Failure Review Board<br>(15) Corrective/Preventative Action Board<br>(16) Alerts, Information Bulletins |

NASA Image

Grab and build-up Practices that have biggest *bang-for-buck* given Constraints

## Constraint – Based Practices




AFRL Image

# Two Fundamental Approaches (3/3)

**Class A – D**

- Works well and is defined
  - Significant info behind practices (see References)
- Rigorous
- Understood in community
- Does not really fit for
  - Constellations
  - “New Space” / Crafters / Sub-Class D
- Too heavy handed for many costs, timelines, and team sizes

**Constraint – Based**

- Does well at conveying trade space to balance technical + programmatic elements
- More informal
  - Does not preclude use of Class A – D methods
  - Does not blanket apply all practices
- Not well understood throughout community
- Still in development
  - Not a full MA architecture
  - Requires significant experience to employ correctly

# Key MA Things a UNP School Can Do

### TEST

- *The hardware doesn't lie*
- FlatSat as early as you can, develop software early and iterate to increase functionality, prove that your system is working

### ANALYSIS

- Understand if problems need further refinement (help understand what matters and what is hard)
- Design system to work based upon models (orbit, CAD, etc.) and simulation (downlink times, FEM, etc.)
- Then do more design & testing based upon analysis results

### MARGIN

- If you can have an idea of what is needed and how the system performs (both from spec sheets, analysis, or test) you can define margin
- Use of healthy margin can solve issues (e.g. lots of link margin, pointing requirements drop)

### OFF-RAMPS

- Define alternate ways to solve the problem; may be performance reductions for cost/timeline reductions
- Don't solve a problem if you can work around it!

### REVIEWS

- Get input and insight
- Show you are making progress and understand your system enough to progress forwards

### RVM

- Define your level of depth to verification methods
- Test matrix (5 tests), analysis e.g. 1 node for 100M nodes, vendor healthy skepticism

**MA includes, but is not necessarily adding redundancy, high reliability, FMECA, etc.**

# How would YOU describe Risk Management?

**…one of the Key Things a UNP School Can Do**

# Risk Management

- Process to Identify | Capture & Track | Classify | Handle Risk

**Risk** = anything that affects Schedule, Cost, Scope

- Purpose: to understand, and convey, what might be an issue and how/if you want to mitigate
- Paranoia = concern about extreme scenarios / many faults deep / low probability occurrences / things you cannot control
  - To be avoided

- In UNP we want projects to:
  - Perform Risk Management for their programs (https://en.wikipedia.org/wiki/Risk_management)
  - Mitigate risks as best as possible

In reality, your team and the PMO will trade between Schedule/Cost/Scope to get to an *implementable* system

# Risk Management

## Identify

- Does a part, system, failure, etc. pose a risk?
- Generally, any team member should feel enabled to Identify a Risk and bring it up to the team for assessment

## Capture & Track

- Document the Risk so that it can be tracked and conveyed. (as simple as an excel)
- A UNP program generally will have < 15 significant risks
- Risk wording should be "*IF <event occurs> THEN <element impacted>*". The impacted element should generally be related back to scope/performance reduction, timeline change, or cost change

## Classify

- Determine the impact/importance of the risk
- **Likelihood**
  - Example way to define (you can do it differently): It will occur, It might occur, It is unlikely to occur
- **Severity**
  - Example way to define (you can do it differently): Mission Ending/Cost increase of 20%/Miss Launch, Mission Disabling/Cost increase of 10%, Loss of Individual Pass Objective, Minimal

## Classifying

- Method by which you deal with the Risk
- **Mitigate**: actively reduce the risk
- **Watch**: keep tracking and if it gets to an undesirable point (Severity or Likelihood) then re-assess
- **Accept**: do nothing about the risk and know that it may occur

# References

- Traditional Approach to Mission Assurance
  - Aerospace Report TOR-2011(8591)-21 – this is more or less the standard for what practices mean
    - NASA NPR 8705.4 – the definition of the Class System (A – D)
      - DOD-HDBK-343 – original Class definition, document is no longer used
  - Aerospace Report TOR-2016-02946-RevA – this covers Do No Harm for launch

- Constraint – Based Approach to Mission Assurance
  - Aerospace Report TOR-2021-00133 (derived from below papers)
    - B. Braun, L. Jasper, "How Satellites are Moving Beyond the Class System: Class Agnostic Development and Operations Approaches for Constraints-Driven Missions," SmallSat Conference, Logan, UT, Aug 7-12, 2021. Paper No. SSC21-XIII-09.
    - L. Jasper, B. Braun, L. Hunt, "New Constraint-Driven Mission Construct for Small Satellites and Constrained Missions," IEEE Aerospace Conference, Big Sky, MT, Mar 7 – 14, 2020. Paper No. 2.0409.
  - Aerospace Report TOR-2017-01689 – Improving Mission Success of CubeSats
    - Generally a good report on what has worked
  - NASA's Goddard Center GSFC-HDBK-8007 Mission Success Handbook for Cubesat Missions
    - An alternate perspective…not quite as actionable

# Conclusions

- Don't kill yourself with MA
  - Identify what is hard & what matters for your mission and put your focus there
  - Software is ALWAYS a stumbling block and one of the key things to get right… the more time you have developing and iterating on hardware the better.
- Risk Management doesn't need to be burdensome and is can be a great tool to understand where you might have problems, communicate those, and get stakeholders to decide how to invest time
  - We track risks to understand & decide what to do about it (not so we can be negative Nancys)
- Ask the PMO for help and input!

# Questions?