



Safety Guidance for Payloads

(with focus on special case payloads)

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June 2017



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Purpose

- This presentation provides payload safety guidance to payload projects flying on uninhabited launch vehicles regarding:
 - Applicable Safety Documents and Requirements
 - Safety Review and Approval Process Options



What is a Payload?

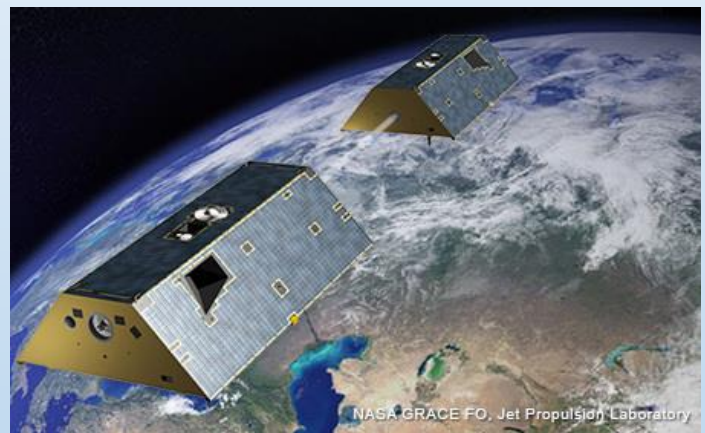
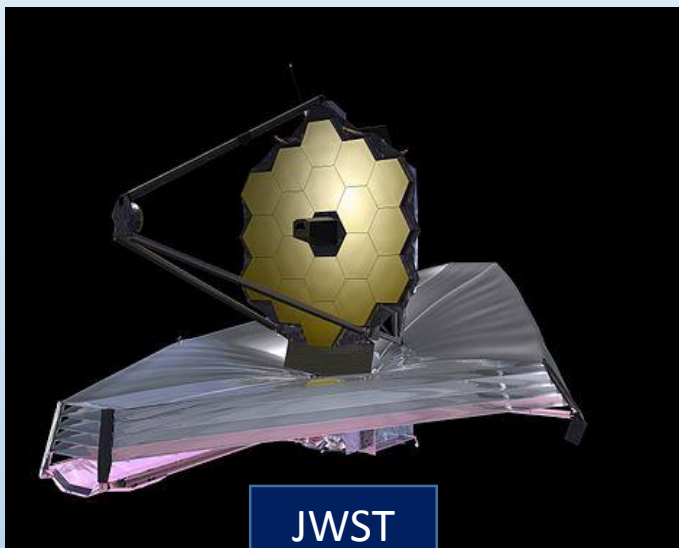
A payload is the spacecraft bus and related instruments found in the payload fairing of a launch vehicle.



LandSat encapsulation into the payload fairing

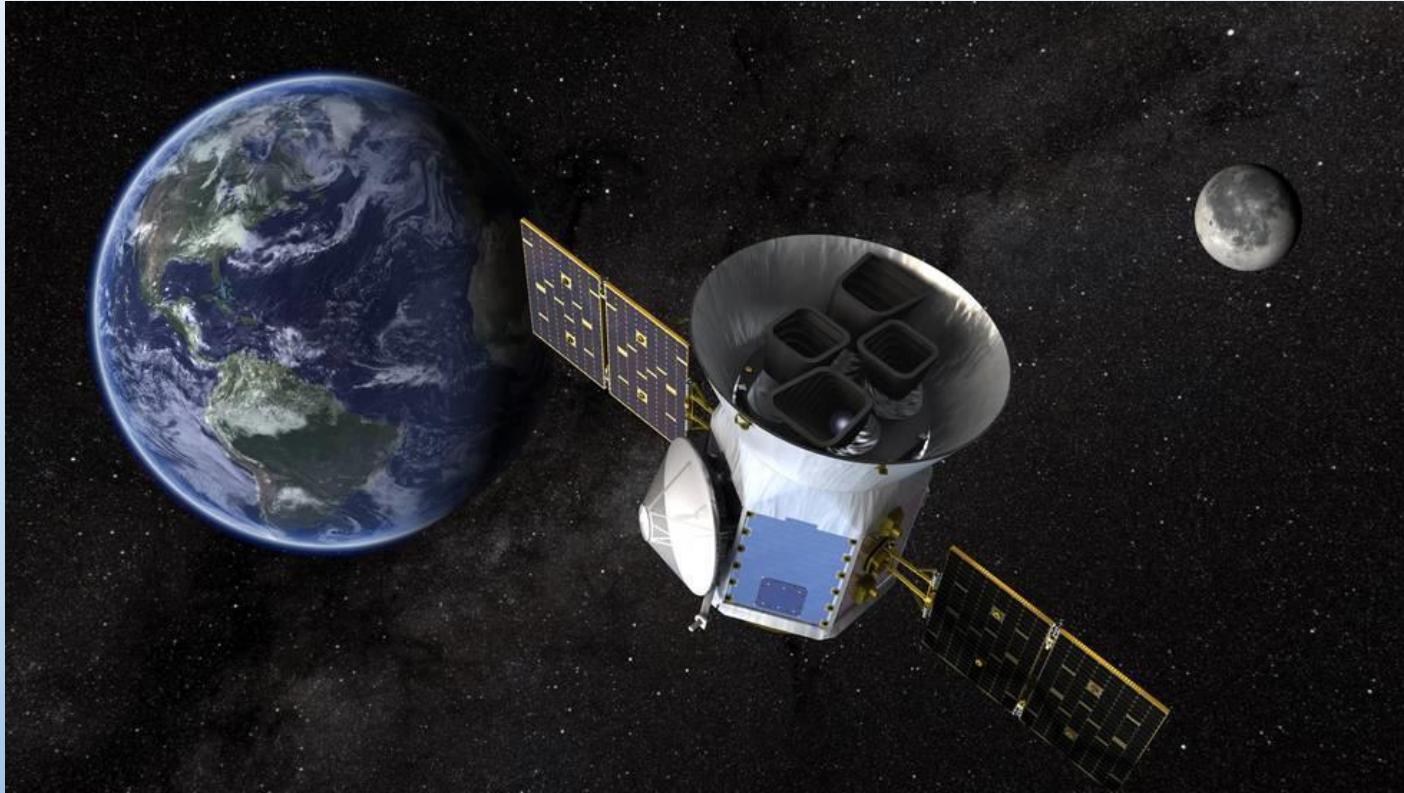


Examples





TESS



Tess is a LeoStar2 Bus with 4 cameras (instruments)

Instrumentation cameras





Special Case Payload

- A NASA special case payload is a payload flying on a vehicle procured outside of the Launch Services Program (LSP) or any payload ride-sharing with another payload.
- Examples include:
 - Foreign launch vehicle
 - USAF-procured launch vehicle
 - Commercial procured launch vehicle
 - Secondary, auxiliary, or hosted payloads



Payload Classifications

NPR 8705.4, *Risk Classification for NASA Payloads*

Characterization	Class A	Class B	Class C	Class D
Priority (Criticality to Agency Strategic Plan)	High Priority	High Priority	Medium Priority	Low Priority
National Significance	Very high	High	Medium	Low to medium
Complexity	Very high to high	High to medium	Medium to low	Medium to low
Mission Lifetime (Primary Baseline Mission)	Long, > 5 years	Medium, 2-5 years	Short, < 2 years	Short, < 2 years
Cost	High	High to medium	Medium to low	Low
Launch Constraints	Critical	Medium	Few	Few to none
In-Flight Maintenance	N/A	Not feasible or difficult	Maybe feasible	May be feasible and planned
Alternative Research Opportunities or Re-flight Opportunities	No alternate of re-flight opportunities	Few or no alternative re-flight opportunities	Some or few alternative or re-flight opportunities	Significant alternative or re-flight opportunities
Examples	Cassini, JWST	MRO, MSL	Explorer Payloads, GLORY	CYGNSS



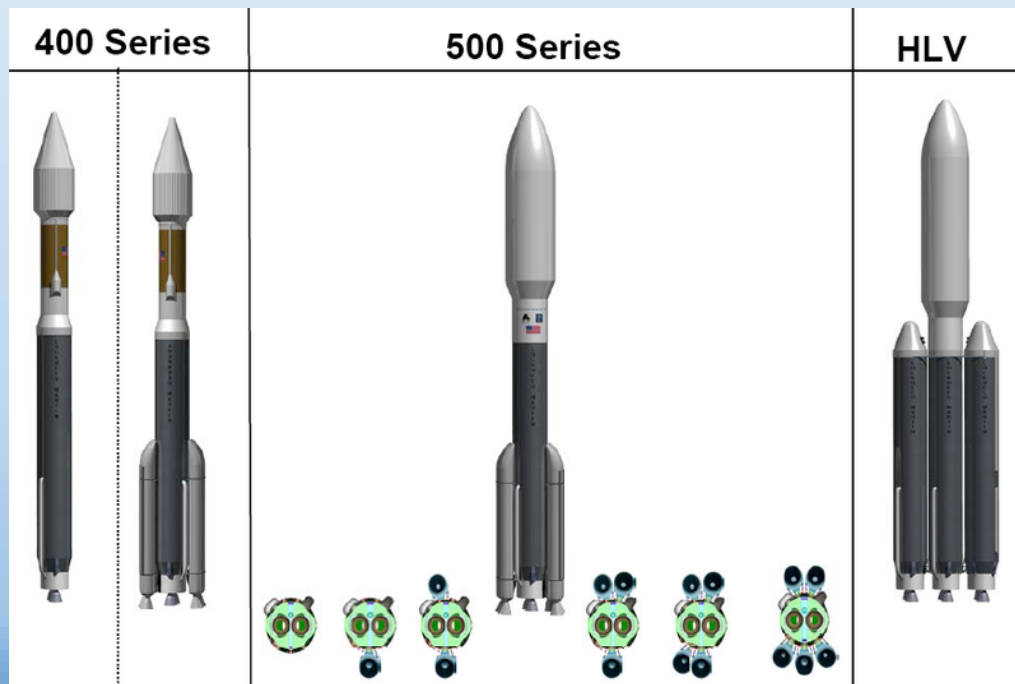
Payload Project Categorization (NPR 7120.5)

Priority Level	LCC < \$250M	\$250M < LCC < \$1B	LCC > \$1B, significant radioactive material, or human spaceflight
High	Category 2	Category 2	Category 1
Medium	Category 3	Category 2	Category 1
Low	Category 3	Category 2	Category 1



Typical NASA Payload

- A typical NASA payload project is launched on a launch vehicle procured by LSP as the primary payload.



Atlas

Falcon





Typical Payloads Using LSP



- Spaceflight projects using LSP follow:
 - NPR 8715.7, *Expendable Launch Vehicle (ELV) Payload Safety Program*
 - NASA-STD 8719.24, *NASA Expendable Launch Vehicle Payload Safety Requirements (Annex)*
- Category 1, 2, and 3 payloads typically use LSP to procure a launch vehicle and also follow NPR 7120.5.
- Class A, B, and most C payloads, as well as co-manifested Class Cs and Ds, typically use LSP to procure a launch vehicle.

Note: Foreign launch vehicles under cooperative programs may also be used for any NASA payload or instrument.



NASA Payloads on a Foreign Launch Vehicle

- Follow NPR 8715.7 and NASA-STD 8719.24
- AND
- Foreign safety review and approval process
 - Foreign Payload Processing Facility requirements
 - Foreign Launch Vehicle specific requirements
 - Foreign Range Safety requirements





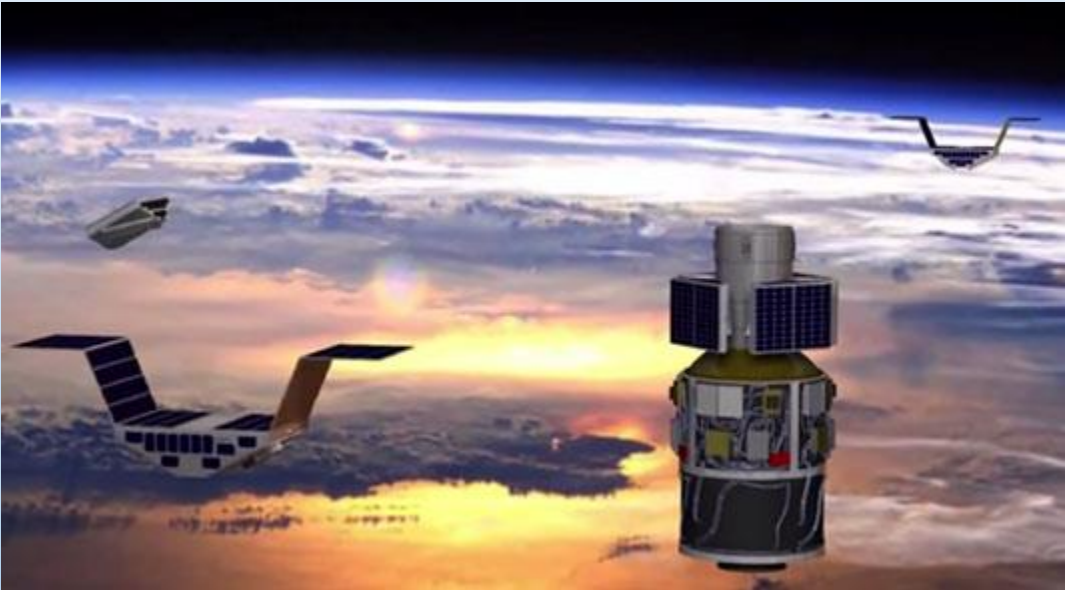
Launching With Other Payloads

- When multiple payloads are processed and launched on a single launch vehicle, an integrated hazard analysis should be performed (Payload to Payload).
- As with all payloads, multiple payloads also require some level of payload to launch vehicle and launch vehicle to payload analysis.



Multiple Payloads Performing the Same Mission

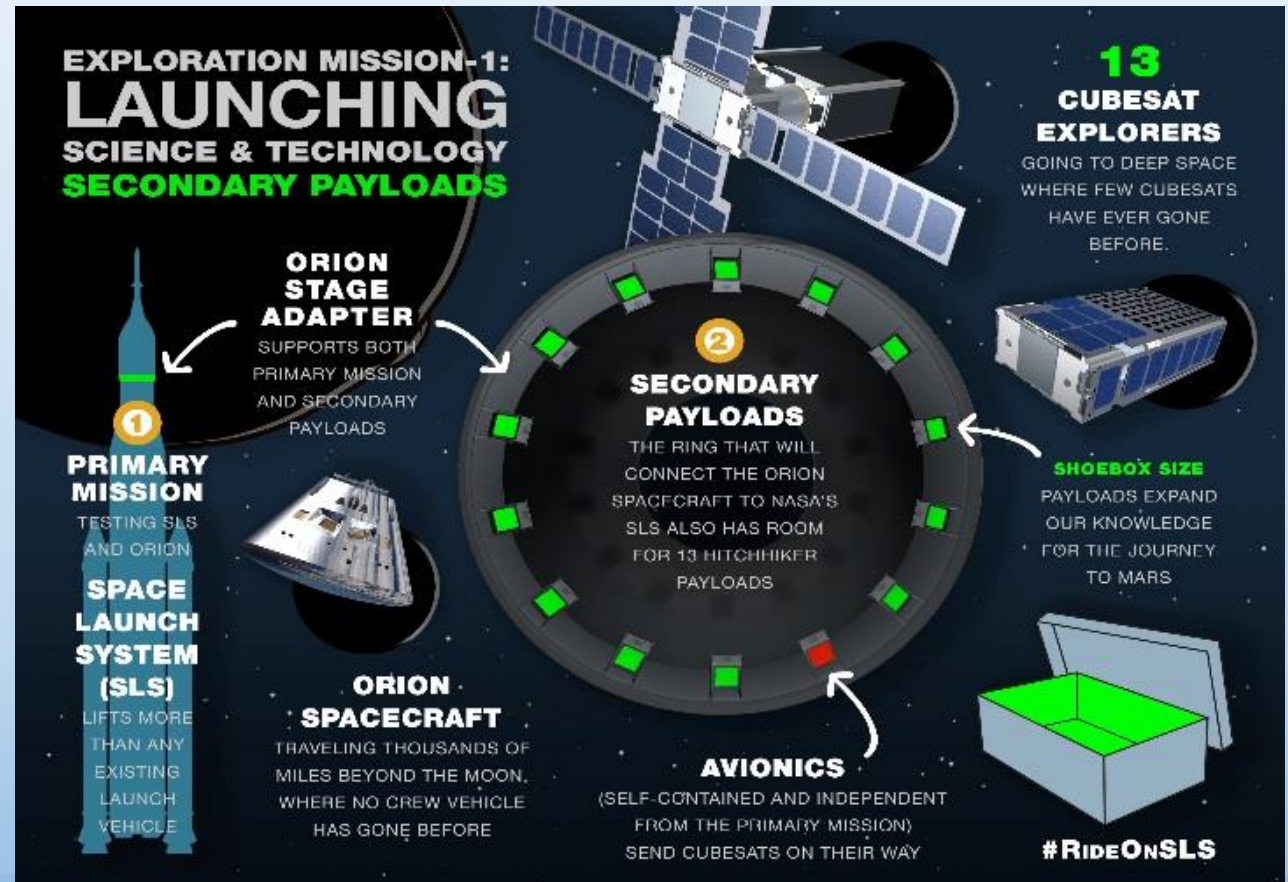
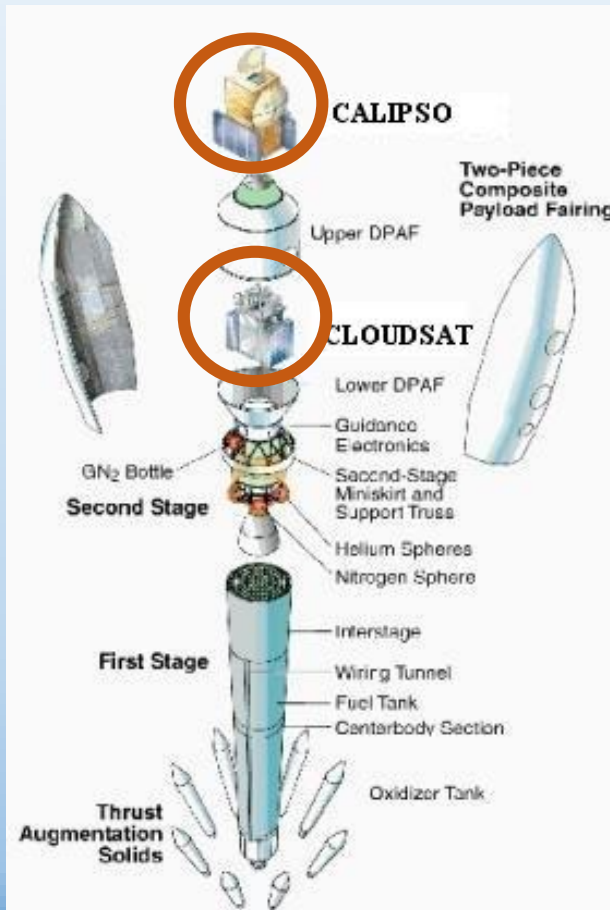
- Example: CYGNSS (8 satellites launched on a Pegasus rocket)



CYGNSS satellites leaving the dispenser



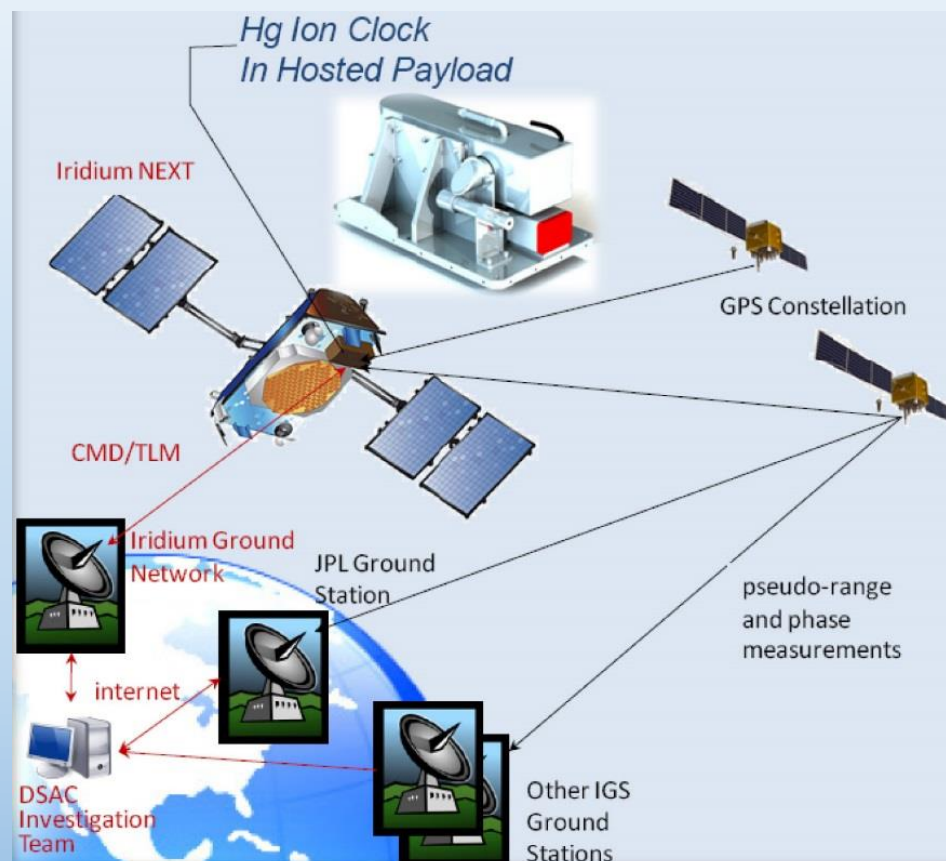
Examples of Secondary Payloads





Hosted Instrument or Payload

- Example: Hg Ion Clock
 - NASA instrument
 - Commercial satellite bus
 - Iridium NEXT
 - (Thales Alenia's Elite Bus 1000)





Payloads Using NPR 7120.5

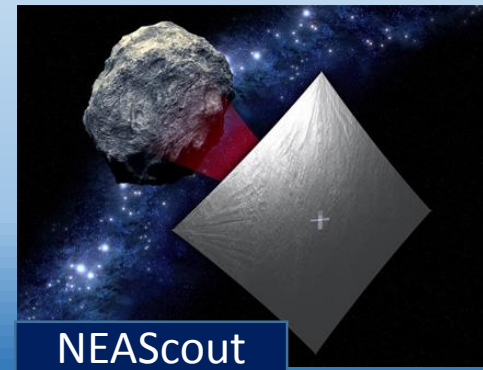
- As required by NPR 7120.5, Category 1, 2, and 3 and Class A, B, C, and D payload projects must follow NPR 8715.7 and NASA-STD 8719.24.
 - NPR 8715.7 covers safety roles and responsibilities and the safety review and approval process.
 - NASA-STD 8719.24 contains payload safety requirements
 - Used in lieu of AFSPCMAN 91-710
 - Comprehensive and Tailorable
- The payload project manager notifies the ELV Payload Safety Manager of the project and provides the safety POC.



Payloads Using NPR 7120.8

- Payload projects using NPR 7120.8, *NASA Research and Technology Program and Project Management Requirements*, shall follow NPR 8715.7.*
- The payload project or program SMA Technical Authority (TA) consults with the ELV Payload Safety Manager to discuss NPR 8715.7 tailoring possibilities and safety requirements.

** See backup chart on NPR 7120.8*





Sub-Class D Payloads

- Usually smaller and less expensive
 - Minisatellite (100–500 kg) (220 – 1,102 lb)
 - Microsatellite (10–100 kg) (22 – 220 lb)
 - Nanosatellite (1–10 kg) (2.2 – 22 lb)
 - Picosatellite (0.1–1 kg) (0.2 – 2.2 lb)

Note: Single unit CubeSats are Picosatellites

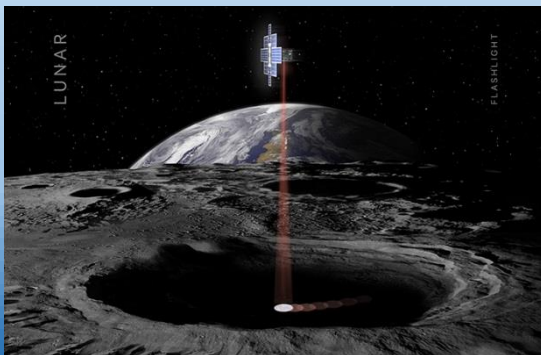
- Often used in research and technology demonstration type missions under the Space Technology Mission Directorate
- Typically looking for inexpensive transportation to space
 - Possibly sub-orbital
 - Ridesharing
 - Venture Class launch vehicle





Sub-Class D Payloads (continued)

- Usually less complex technically and organizationally
- Usually have fewer hazards than Class A, B, C, or D payloads
- May be following NPR 7120.8 vs. NPR 7120.5
- CubeSats are considered a Sub-Class D payload
- Teams working on sub-class D payloads may be unfamiliar with payload safety requirements and processes.



Lunar
Flashlight
CubeSat



Sub-Class D Payload Size, Complexity, and Hazards Vary

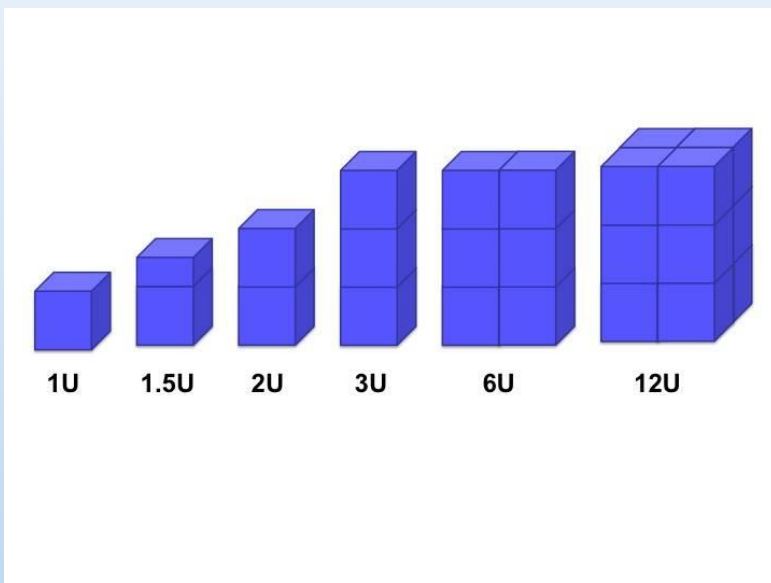
- Sizes range from a moderate size payload to a single CubeSat
- CubeSats
 - Multiple unit sizes have become more common
 - Up to 12U
 - CubeSat limited weight increasing over time
 - CubeSats are still limited in size
 - CubeSats were non-hazardous; now some present hazards
- Increasing in technical complexity
- Increasing in number of hazards



6U
CubeSat
Dellingr



CubeSat Classifications



- 1U (10 cm x 10 cm x 10 cm)
less than 1 kg
- 2U (10 cm x 10 cm x 20 cm)
less than 2 kg
- 3U (10 cm x 10 cm x 30 cm)
less than 3 kg
- 12U is approximately the size of
a shoebox



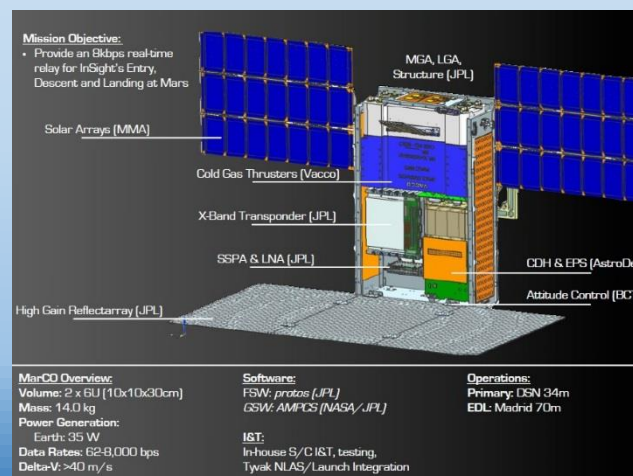
1U size CubeSat



Payload Safety Program Responsibility

- NASA will safeguard people and resources from hazards associated with payloads, payload-to-launch vehicle integration, and ground support equipment by eliminating the hazards or reducing associated risks.
- Payload safety for all payloads --- regardless of size

Loading the
Multi Mission
Radioactive
Thermoelectric
Generator into
Mar Science
Laboratory



MARCO CubeSat



Communication

- NASA payload projects and the ELV Payload Safety Manager must communicate to plan for successful payload safety.
- For special case mission, the Payload Project/Program SMA TA consults with the ELV Payload Safety Manager.
- For typical payloads, the Payload Project Manager consults with the ELV Payload Safety Manager.

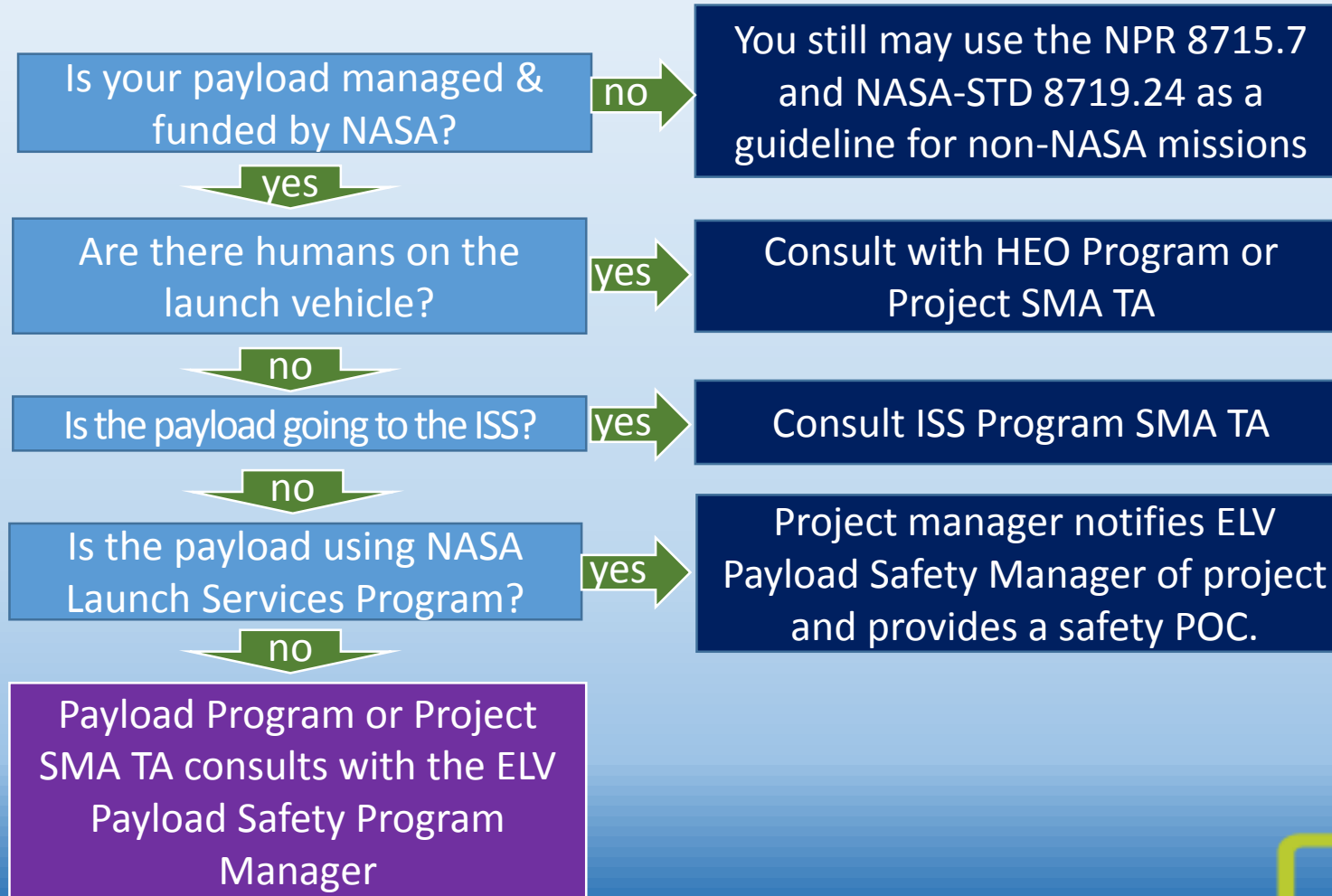


Payload SMA Technical Authority (TA) Responsibility for Special Case Payloads

- The Payload Project (or Program) SMA TAs for a special case payload consult with their project, the NASA ELV Payload Safety Manager, and the launch services SMA TA (as applicable) in determining the project's safety review and approval process.
- The Payload Project will follow:
 - NPR 8715.7, or
 - A tailored version of NPR 8715.7, or
 - An equivalent process meeting NPR 8715.3, *NASA General Safety Program Requirements*
- Low-hazard NASA Sub-class D and small auxiliary payloads
 - Typically do not follow the complete untailored payload safety review and approval process laid out in NPR 8715.7
 - Typically do not tailor the entire NASA-STD 8719.24 for their project



Payload Safety Guidance





Why Consult with the ELV Payload Safety Manager?

- The ELV Payload Safety Manager:
 - Provides clarification of safety requirements and ensures compliance
 - Assists with safety review processes and ensures safety processes and requirements match project hazards and complexity
 - Provides safety assistance for payload projects having limited resources
 - Possesses experience with similar hazard mitigation strategies and documentation



Payload Hazards

- Determining the payload related hazards that might exist is the first step to avoiding mishaps and injury during payload processing.
- Qualitative System Safety Analysis (i.e. PHA, FTA, FMEA) are acceptable analysis methods used to identify payload hazards.
- Experienced payload system safety engineers can readily identify many common payload hazards.



Common Payload Hazards

- Actuating Mechanisms
- Asphyxiation
- Collision Contact
- Electrical Fire
- Electrical Shock
- Gravity (dropping hardware or falling)
- Hazardous Materials
- Hydrazine Lines leak/burst
- Inadvertent Movement of the Payload
- Inadvertent Thruster Firing
- Ionizing Radiation
- Li-Ion Battery
- Material Handling
- Non-Ionizing Radiation
- Non-Li-Ion Battery
- Ordnance
- Pressure Vessels
- Propellant Fuel Tank Leak
- Reaction Wheels
- Solid Rocket Motors
- Structural
- Temperature



Eliminating and Controlling Hazards

- Even when not fully implemented, NASA-STD 8719.24 Annex may be used as a guide to abate hazards.
- Experienced payload system safety engineers can assist with payload hazard mitigation.
- Hazard Report Form NF 1825 is helpful in characterizing hazards and documenting abatement controls.
- Sample hazard reports with verifications are available by request.



Flexibility Through Tailoring

- The payload safety review and approval process in NPR 8715.7 may be tailored.
- The Annex to NASA-STD 8719.24 Annex contains ELV payload safety requirements and is also tailored for each project.
 - Volume 3: Payload and GSE design requirements.
 - Volume 6: Payload processing requirements.
 - Chapters are categorized to cover primary payload subsystem hazards.
 - Non-applicable sections or chapters may be removed.
- The flexibility of tailoring allows the appropriate level of safety to be applied to missions of any payload classification.



Summary

- All payloads, regardless of size, may involve hazards.
- For special case payloads, the SMA TA must contact the ELV Payload Safety Manager to discuss safety review and approval process and safety requirements.
- For typical payloads using LSP, the Project Manager notifies the ELV Payload Safety Manager of the project and provides safety POC information.
- NPR 8715.7 provides an efficient safety review and approval process that may be tailored to match any payload project's scope and schedule.
- NASA-STD 8719.24 contains all payload safety requirements.



Resources

- ELV Payload Safety Program Office
 - Cal Staubus: calvert.a.staubus@nasa.gov
 - Rachel Willenbring: rachel.c.willenbring@nasa.gov
- ELV Payload Safety Program Website:
<https://kscsma.ksc.nasa.gov/elvpayloadsafety/default.html>



Backup



NASA Payload Contracts

- NASA Contract, Grant, Cooperative Agreement, or Other Agreement Officers shall ensure that requirements documentation provided by the program manager, project manager. Or hteir designee that is necessary to comply with this NPR san obtain the approval of relevant authourites is incorporated in the contracts and agreements(s) governing each payload (Requirement).



Proposed Change for NPR 7120.8

- NPR 7120.8 add a sub-paragraph e. under P.2 Applicability:
- *e. R&T projects flying on expendable launch vehicles comply with NPR 8715.7 Expendable Launch Vehicle (ELV) Payload Safety Program.*
- Justification: To assist in making research and technology payloads (spacecraft) that are not following NPR 7120.5 aware that they must meet the intent of NPR 8715.7 (see NPR 8715.7 paragraphs 1.5 and 1.6). Essentially the SMA Technical Authority for the R&T payload project is to consult with the NASA ELV Payload Safety Manager in determining how they will perform safety for their project. NPR 7120.5 already references NPR 8715.7. NPR 7120.8 does list NPR 8715.7 in section L.3.



Topics to be discussed with the NASA ELV Payload Safety Program Manager?

- Who is the launch provider? Is the launch vehicle procured through NASA Launch Services Program?
- Is the launch vehicle non-crewed or supplying ISS?
- Is the payload ridesharing on a launch vehicle
- Who is the project's primary safety engineer contact?
- Is the payload hosted on another spacecraft?
- What payload related hazards are known?
- What is contained in the mission contracts regarding safety?