PPODs
Managing Small Secondary Payloads

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Introduction

- ***What is LSP's History with Small and Auxiliary Payloads?***
- ***What has been some of the challenges with managing Auxiliary payloads?***
- ***What work has LSP provided in looking at getting Auxiliaries on Launch Vehicles?***
- ***What is a PPOD?***
- ***How will these Auxiliary Payloads be managed?***
- ***Concepts on how the selection of an Auxiliaries could be managed to fly on LV's***

Recent History of NASA's Small Satellite Missions

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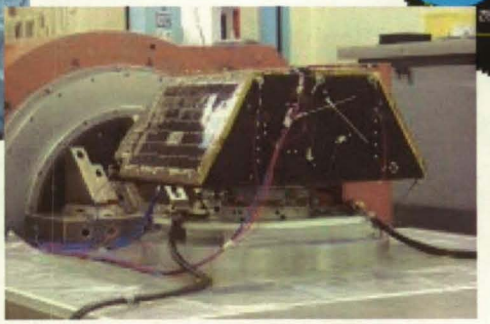
Launch Services Program

Secondary Payload	Approx. Mass	Date	Vehicle	Primary (Customer/Payload)	Type
DUVE	102 kg	07/92	Delta II/6925	NASA/GEOTail	2 Non Separating
SEDS-1	45 kg	03/93	Delta II/7925	USAF/NAVSTAR II-19	Tether
PMG	55 kg	06/93	Delta II/7925	USAF/NAVSTAR II-21	Tether + Diagnostics
SEDS-2	50 kg	03/94	Delta II/7925	USAF/NAVSTAR II-21	Tether
SURFSAT	35 kg	11/95	Delta II/7920	CSA/RADARSAT	2 Non Separating
SEDSAT	40 kg	10/98	Delta II/7326	NASA/DeepSpace-1	Separating
Orsted	61 kg	02/99	Delta II/7920	USAF/P-91	Separating
Sunsat	63 kg	02/99	Delta II/7920	USAF/P-91	Separating
ACRIM	120 kg	10/99	Taurus (T-4)	Commercial/KOMPSAT	APC/Separating
Munin	6 kg	11/00	Delta II/7320	NASA/EO-1&SAC-C	Separating
Starshine 3	100 kg	09/01	Athena I	USAF/PICOSAT/PCSat/SAPPHIRE	Separating
QuikTOMS	375 kg	10/01	Taurus (T-6)	Commercial/OrbView-4	APC/Separating
CHIPS	~85kg	01/03	Delta II/7320	NASA/ICESat	Mini-DPAF/Sep
ST-5	~120kg	03/06	Pegasus	NASA	Separating



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Auxiliary Payload Challenges

- Auxiliaries being ready and on time to fly on the day of launch
- Understanding of what is required from the secondary for inputs into testing and reports
- Knowing that they are the auxiliary and not a primary
- Funding, there are costs associated with integrating an auxiliary to the launch vehicle
- Interface requirement, the auxiliary initially indicates that all that is required is a separation circuit and later asking for a quick disconnect purge system in a Class 10K clean room
- Convincing the Primary that the auxiliary payload has been well analyzed and the mission risk mitigated

Past Studies and Agreements

- February 1992 – Memorandum of Agreement between Space System Division Delta II Systems Program Office and NASA Orbital Launch Services Project for Secondary Mission on Delta II was signed
- August 1992 – First Copy of the Secondary Payload Planner's Guide on Delta II was provided
- February 2002 – Feasibility Study was performed to integrate PPODs and BioNanoSat as a secondary on Pegasus
- April 2003 – Secondary Payload Capability Study conducted for both Atlas V and Delta IV
- 2005 – LSP provides funding for Wallops to develop the Multi Payload Adapter to support possible DARPA launch opportunities
- January 2006 - Request for Launch Services Proposal (RLSP) for the Lunar Reconnaissance Orbiter (LRO) mission included requirements for accommodating at least one secondary payload mission, with options to accommodate multiple payloads up to a total capability of 1000 kgs

Present Work

Atlas V

- **March 2007 – Submitted Statement of Work (SOW) to ULA Atlas to develop a method to integrate PPOD on the Atlas V**
  - **This study kicked off on April 23 with the first out brief at the end of June**
  - **Current plan is to complete the Atlas V development and integration, then start the Delta IV effort**
    - » **SOW to proceed to Preliminary Design Review (PDR) is in proposal phase**

Present Work

Taurus XL

- **April 2007 - Started working with Orbital Sciences Corporation in developing a method to integrate PPODs on the Taurus XL**
  - **OSC completed feasibility study and SOW is complete**
- **January 2008 – Started the development work to implement PPODs on the OCO and Glory mission – Awaiting final approval from Science Mission Directorate and Flight Planning Board to fly PPOD on these two missions**

- ***If we implement the PPOD system on these ELVs, are there opportunities to fly this system?***

Opportunities

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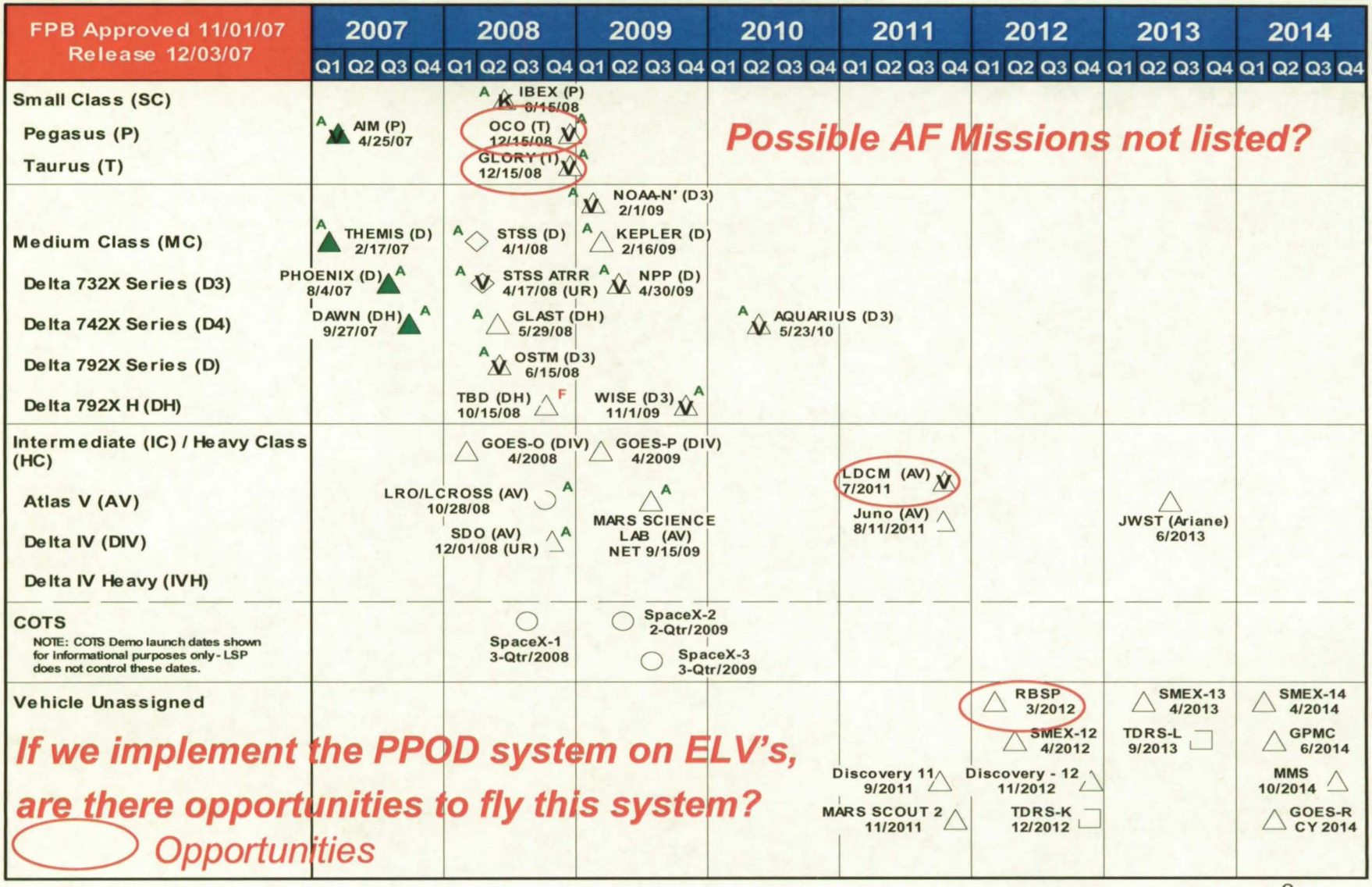
Launch Services Program



So, What is the PPOD?

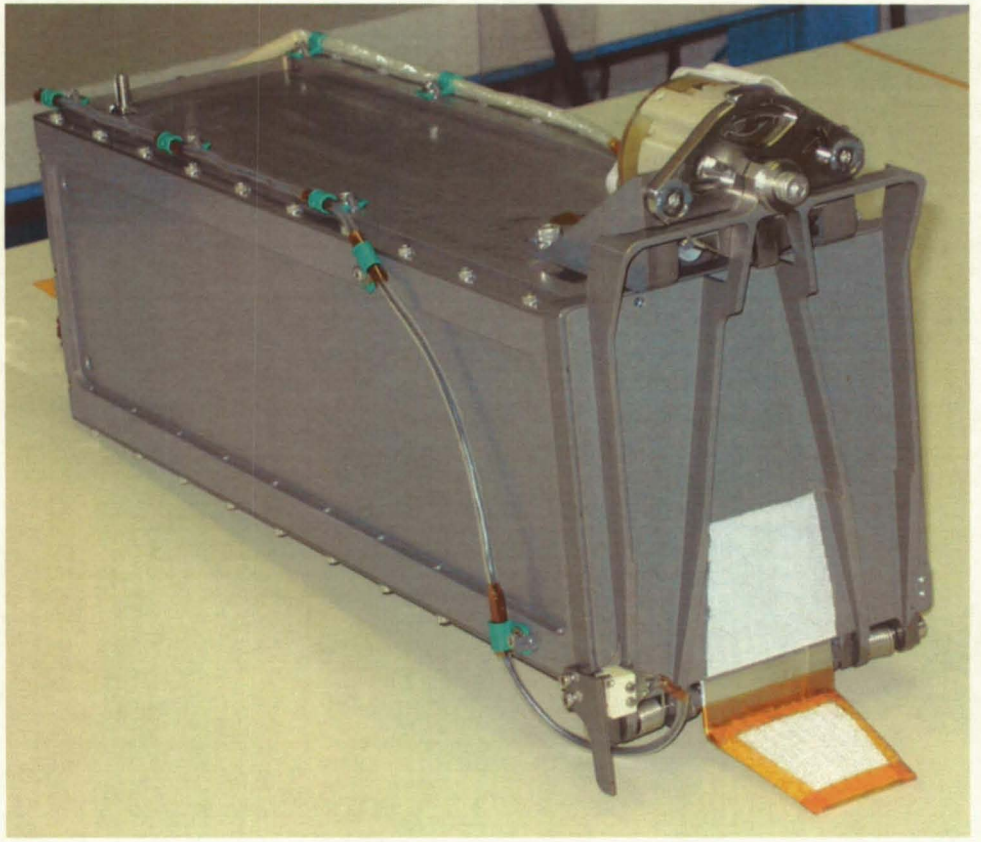
PPOD Concept

- The Concept for PPOD on LV's is to perform a source development and not a point solution
  - This would allow late change out of payloads without having to re-run analysis
  - Once the LV knows that a PPOD will fly on their mission, the information for that PPOD is already known even if the payloads in side are not
- The PPOD to LV ICD will call out the tolerances for mass and CG for the payload
  - When the payloads are being designed, they will need to be designed to the PPOD standard
- Standardization is key to reducing integration time and cost

PPOD Overview

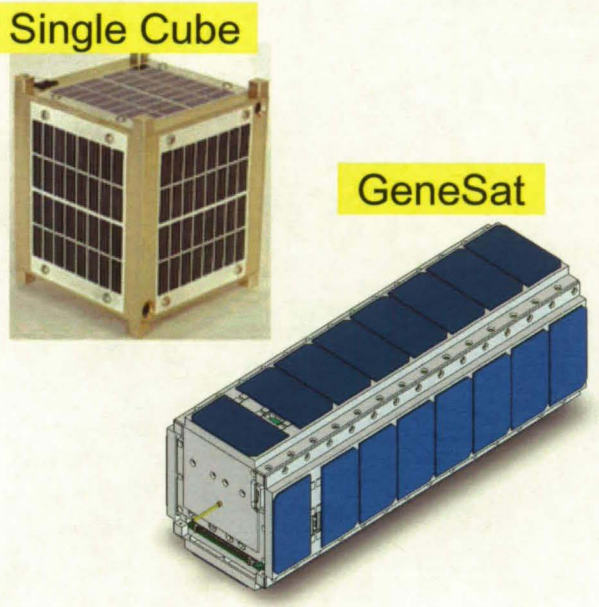
- The Poly Pico satellite Orbital Deployer (PPOD) was developed by California Polytechnic State University (Cal Poly) in support to the Stanford University CubeSat program

- PPOD is a standard deployment system
  - Standard deployer ensures all CubeSat developers conform to common physical requirements, to minimize cost and development time
- The PPOD is the interface between the launch vehicle and CubeSats
  - The PPOD is versatile, with its small profile and ability to mount in a variety of configurations

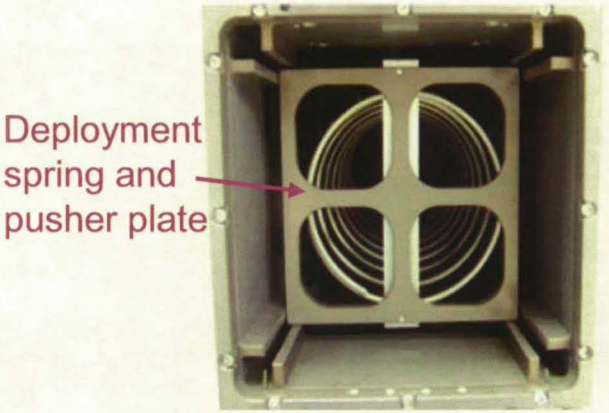


PPOD Overview

- **The PPOD utilizes a tubular design and can hold up to 34cm x 10cm x 10cm of hardware**
  - **The most common configuration is three Pico satellites of equal size; however, the capability exists to integrate Pico satellites of different lengths**
  - **PPOD (empty) is ~2.5 kg**
  - **Typical CubeSats are ~1 kg each**
    - » **Up to 3 kg for a triple like GeneSat**
    - » **Working to have total mass at <10kg**



- **The tubular design creates a predictable linear trajectory for the CubeSats resulting in a low spin rate upon deployment**
  - **The satellites are deployed from the PPOD by means of a spring and glide along smooth flat rails as they exit the PPOD**
  - **After a signal is sent from the Launch Vehicle (LV), a spring-loaded door is opened and the CubeSats are deployed by the main spring**



Flight History and NASA Involvement

- The PPOD system has flown on 3 different types of Launch Vehicles to date:
  - Eurockot, 2003
  - Dnepr, 2006, 2007
  - Minotaur, 2006 – NASA GeneSat mission (Ames)
- Upcoming launches scheduled for NASA PPOD missions:
  - Minotaur, 2008
  - Falcon, 2008

How will it be Managed as an Auxiliary Payload?

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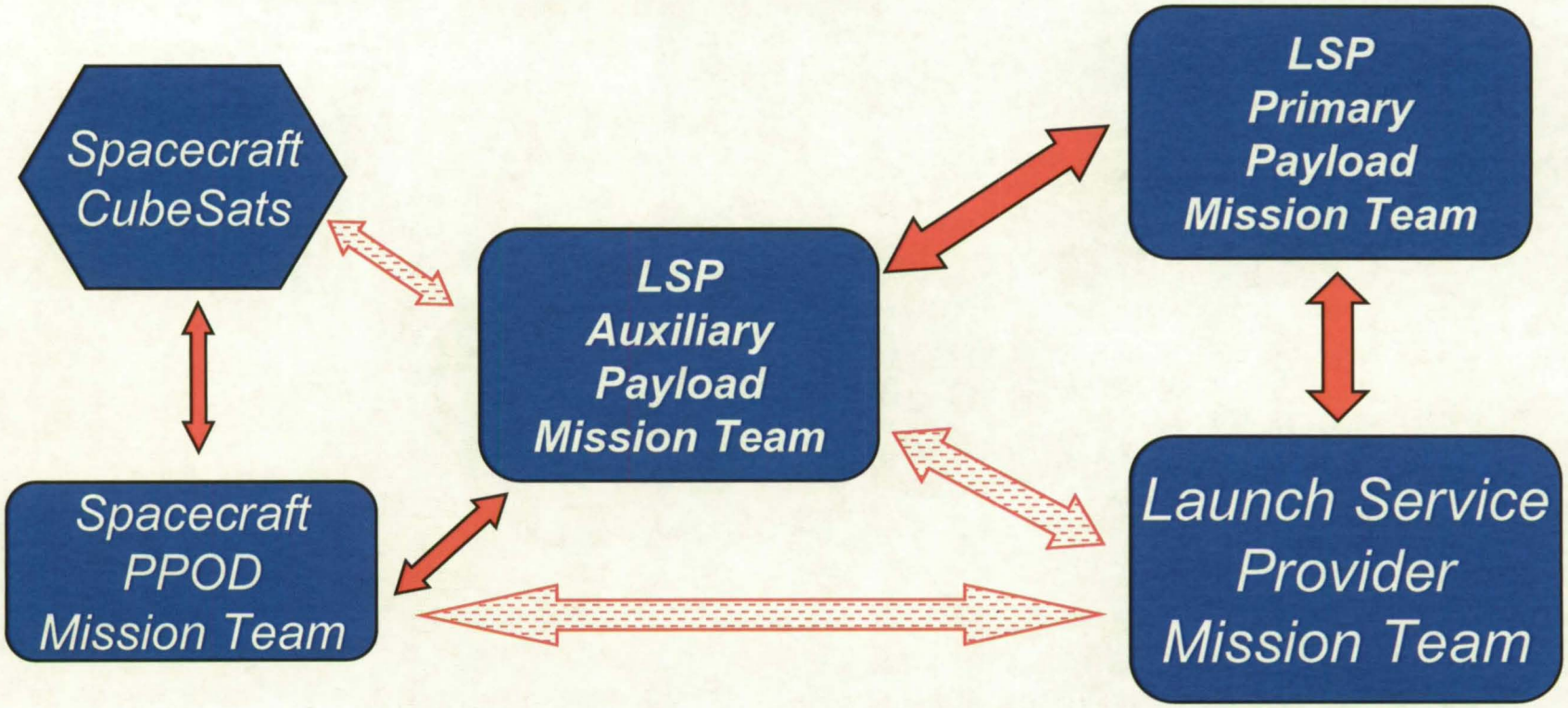
System Design Requirements

- **Top-Level requirements were established:**
  - **PPOD shall not impact the primary payload (physically or functionally)**
  - **PPOD shall not impact heritage avionics qualification status or architecture (focus of concern is the affect of a localized added mass)**
  - **PPOD shall not impact the performance or reliability of the existing hardware and vehicle design**
  - **Design solution shall minimize interfaces with flight critical hardware**
  - **Implementation shall be non-mission specific**
  - **Integration and test design shall not interfere or disrupt normal Launch Vehicle or primary payload operations**
  - **Integration shall allow for full PPOD testability**
  - **Standard integration and test flow shall not be impacted by PPOD integration**

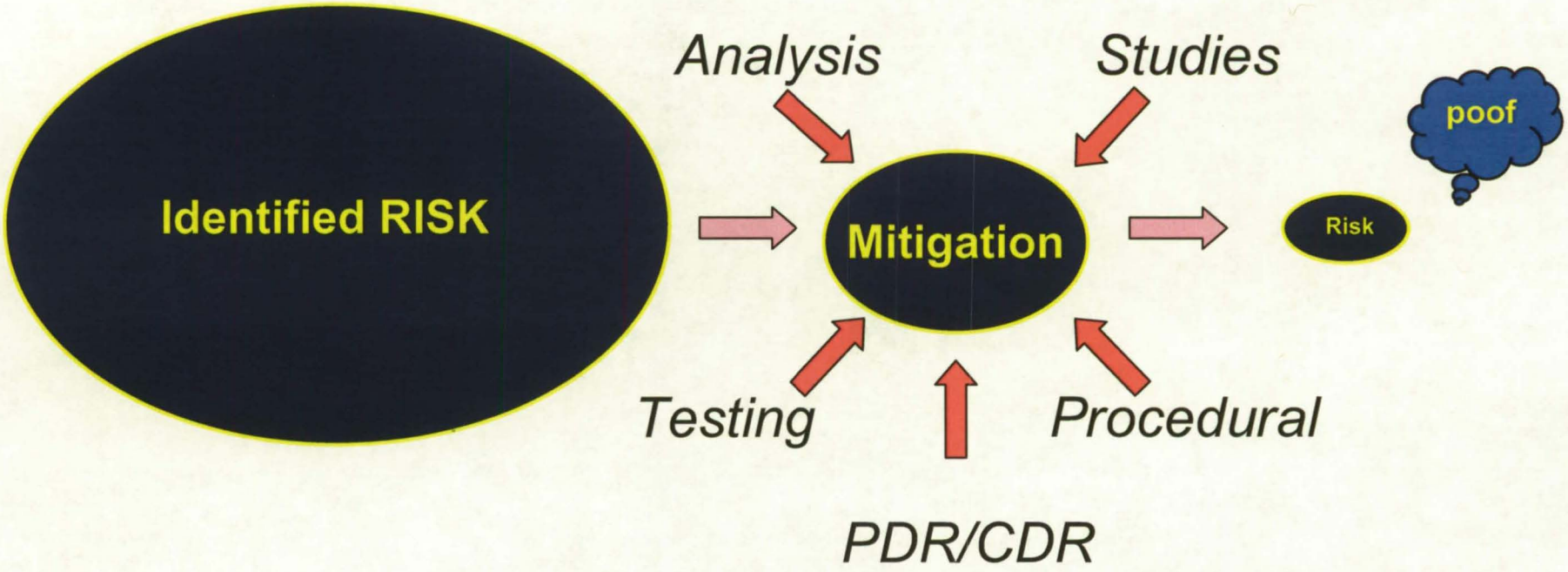
Management Structure

- With Auxiliary PPOD systems being a low cost solution to fly experiments, management and the technical team needs to be different then the current classical way of integration
- Synergy from the primary payloads needs to incorporate to ensure that Auxiliary Payload requirements are met



Auxiliary Payload Risk

- The Primary Payload will see the Auxiliary as an element of risk to their mission
- These risks have to be managed so they can be reduced or even mitigated completely for the Primary to accept the Auxiliary onto the mission



Auxiliary Payload Risk

- **Launch Services Program Risk Management Plan LSP-PLN-353.01 is the document that is used to manage risk**

Launch Services Risk Exposure Matrix

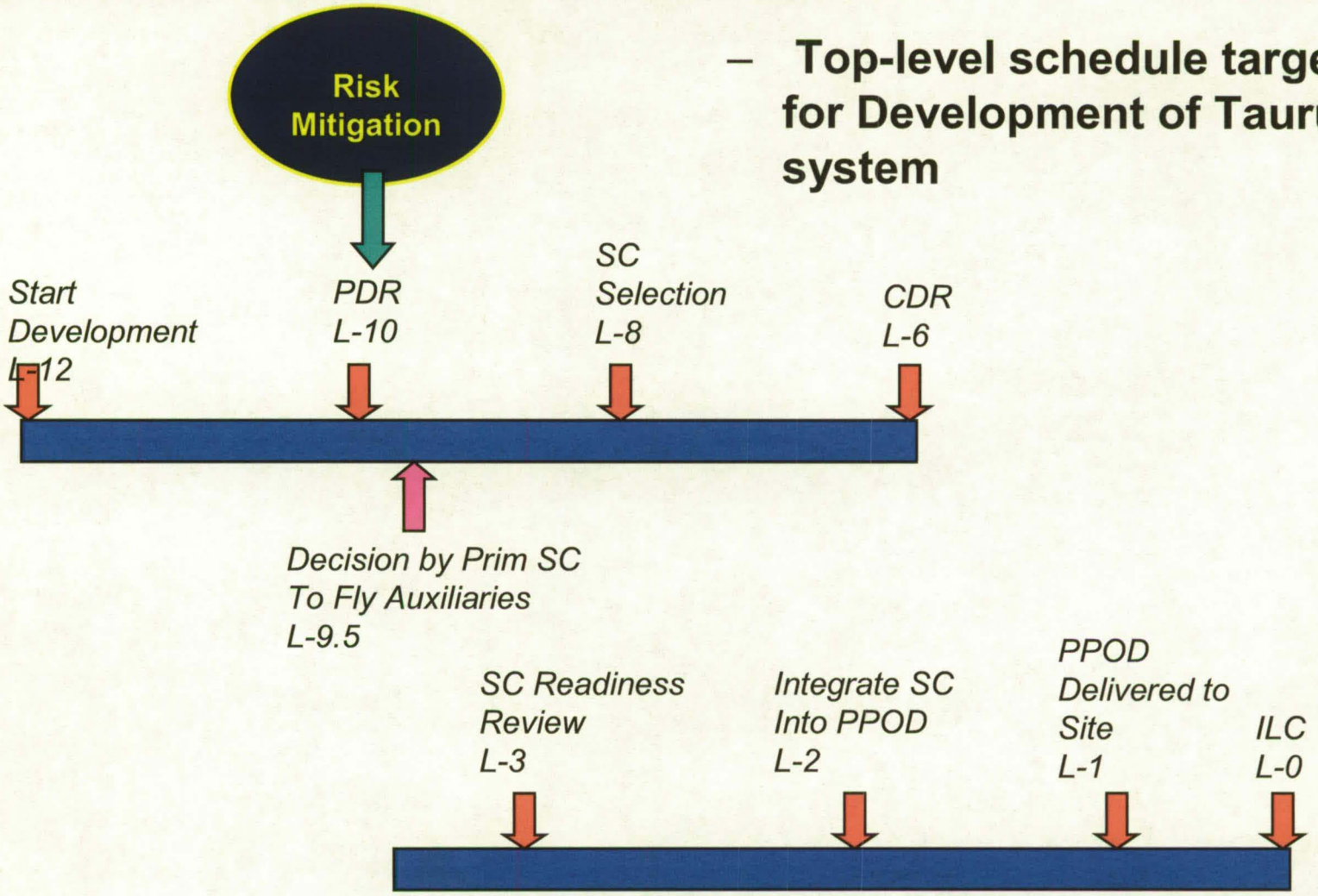
Probability of Occurrence	1	2	3	4	5
5 91-<100%	1x5	2x5	3x5	4x5	5x5
4 51-90%	1x4	2x4	3x4	4x4	5x4
3 11-50%	1x3	2x3	3x3	4x3	5x3
2 6-10%	1x2	2x2	3x2	4x2	5x2
1 1-5%	1x1	2x1	3x1	4x1	5x1

Impact

- Identify the Risk –
  - Statements of risk
  - List of Risks
- Each Risk will be analyzed to determine classification and prioritization
- Plan – Decide what should be done about risk
  - Mitigation strategy and plans
  - Acceptance rationale and tracking requirements
- Track - Monitor risk metrics and verify/validate mitigation actions
  - Report status on risk and migration plan
- Control - Decide to re-evaluate and replan mitigations, close risks, invoke contingency plans, or continue to track risks
  - Risk Decisions

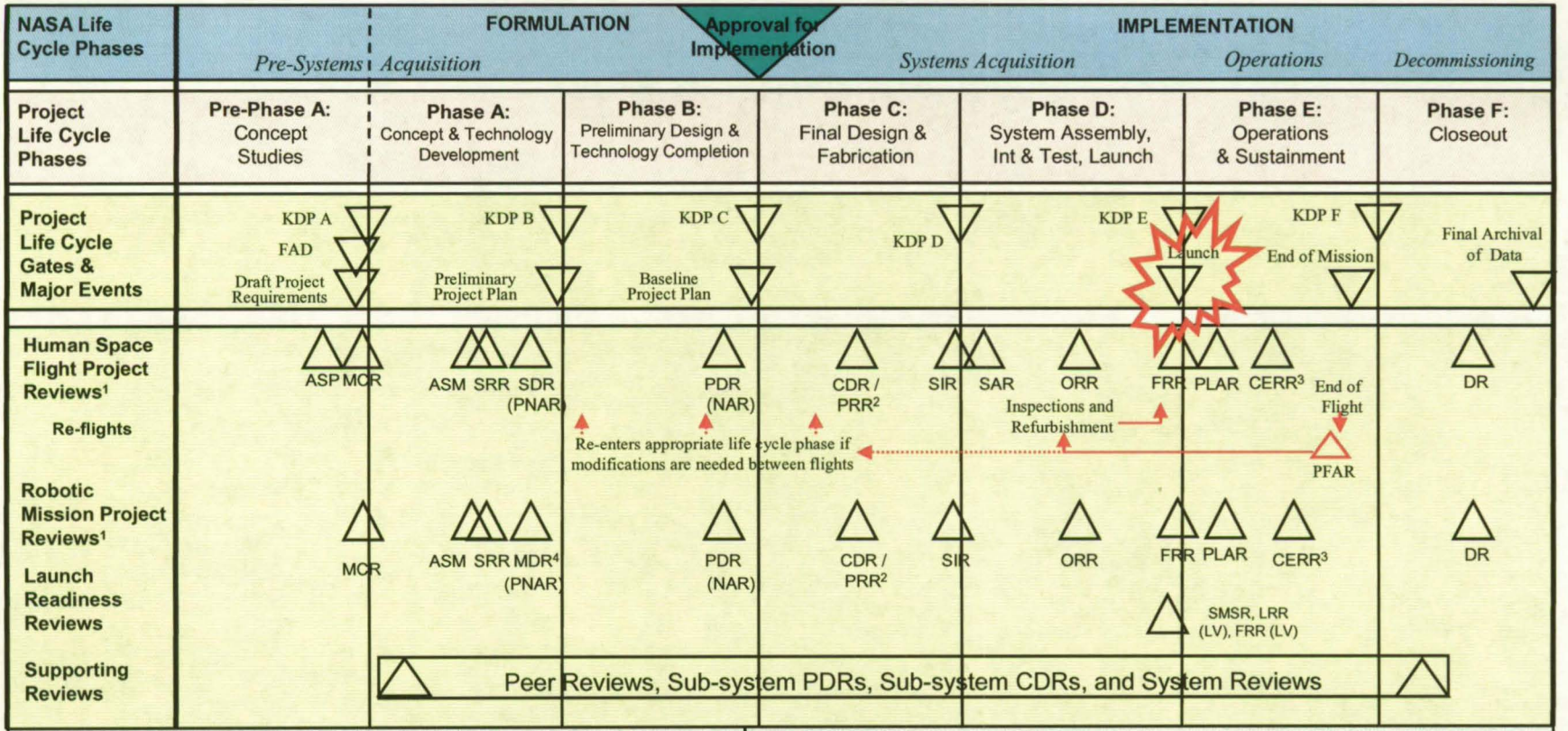
Managing Schedule

– **Top-level schedule targets for Development of Taurus system**



The NASA Project Life Cycle

NPR 7120.5D, Figure 2-4



FOOTNOTES

1. Flexibility is allowed to the timing, number and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Project Plan
2. PRR needed for multiple system copies. Timing is notional.
3. CERRs are established at the discretion of Program Offices.
4. For robotic missions the SRR and the MDR may be combined.

ACRONYMS

ASP—Acquisition Strategy Planning Meeting
ASM—Acquisition Strategy Meeting
CDR—Critical Design Review
CERR—Critical Events Readiness Review
DR—Decommissioning Review
FAD—Formulation Authorization Document
FRR—Flight Readiness Review
KDP—Key Decision Point
LRR—Launch Readiness Review
MCR—Mission Concept Review
MDR—Mission Definition Review
NAR—Non-Advocate Review
ORR—Operational Readiness Review
PDR—Preliminary Design Review
PFAR – Post-Flight Assessment Review
PLAR—Post-Launch Assessment Review
PNAR—Preliminary Non-Advocate Review
PRR—Production Readiness Review
SAR – System Acceptance Review
SDR—System Definition Review
SIR—System Integration Review
SMSR—Safety and Mission Success Review
SRR—System Requirements Review

Why Develop Auxiliary Carriers?

NASA's Strategic Goals

Strategic Goal 1: Fly the Shuttle as safely as possible until its retirement, no t later than 2010.

Strategic Goal 2: Complete the International Space Station in a manner consistent with NASA 's International Partner commitments and the needs of human exploration.

Strategic Goal 3: Develop a balanced overall program of science, exploration, and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration.

Strategic Goal 4: Bring a new Crew Exploration Vehicle into service as soon as possible after Shuttle retirement.

Strategic Goal 5: Encourage the pursuit of appropriate partnerships with the emerging commercial space sector.

Strategic Goal 6: Establish a lunar return program having maximum possible utility for later missions to Mars and other destinations.

"To pioneer the future in space exploration, scientific discovery, and aeronautics research."

~ NASA's Mission

LSP's Vision: To be the recognized leader in launch services

LSP's Mission: Leadership and expertise in providing on -orbit, on-time, on-cost launch services

"Everyone in the Launch Services Program strives to meet our customers ' needs by providing mission assurance through reliable expertise. "

~ Steve Francois

LSP's Goals

Goal 1: Maximize successful delivery of spacecraft to space

Goal 2: Assure launch services for all customers – now and in the future

Goal 3: Promote evolution of a competitive space market

Goal 4: Continually enhance LSP's core capabilities

2007 Path to the Future

Manifesting Process for CubeSats on NASA missions

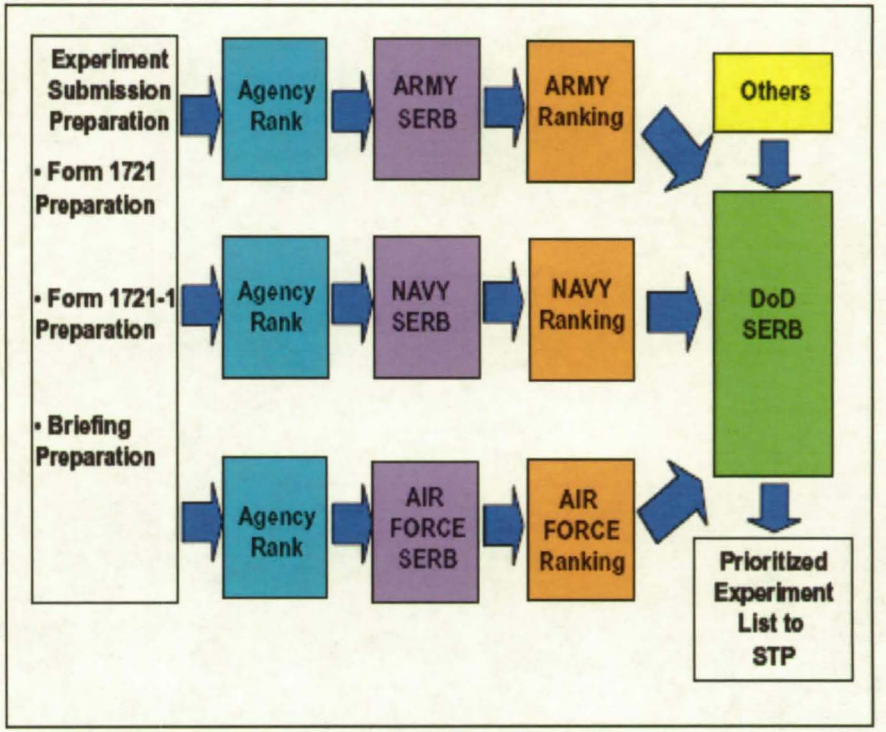
IN DEVELOPMENT

Manifesting Auxiliary Payloads

- With the increase in the CubeSat spacecraft in the space community, LSP is developing the capabilities to fly these payloads on ELV missions with excess margin
  - Who will fly and who will determine which one will be manifested?
- Since these missions are not the traditional NASA payload (SMEX, Explorers, etc), the current process which NASA manifests missions is not the best method to manifest

Manifesting Auxiliary Payloads

- The Space Development and Space Wing uses a process called SERB (Space Experiments Review Board) to prioritize missions
- The SERB reviews all the DoD-sponsored science experiments submitted via the service boards (i.e., Army, Navy, and Air Force) and other related organizations, e.g., the MDA, and prioritize them according to various criteria. The experiment ranking is based on military relevance 60%, service priority 20%, and technical merit of experiment 20%.



Manifesting Auxiliary Payloads

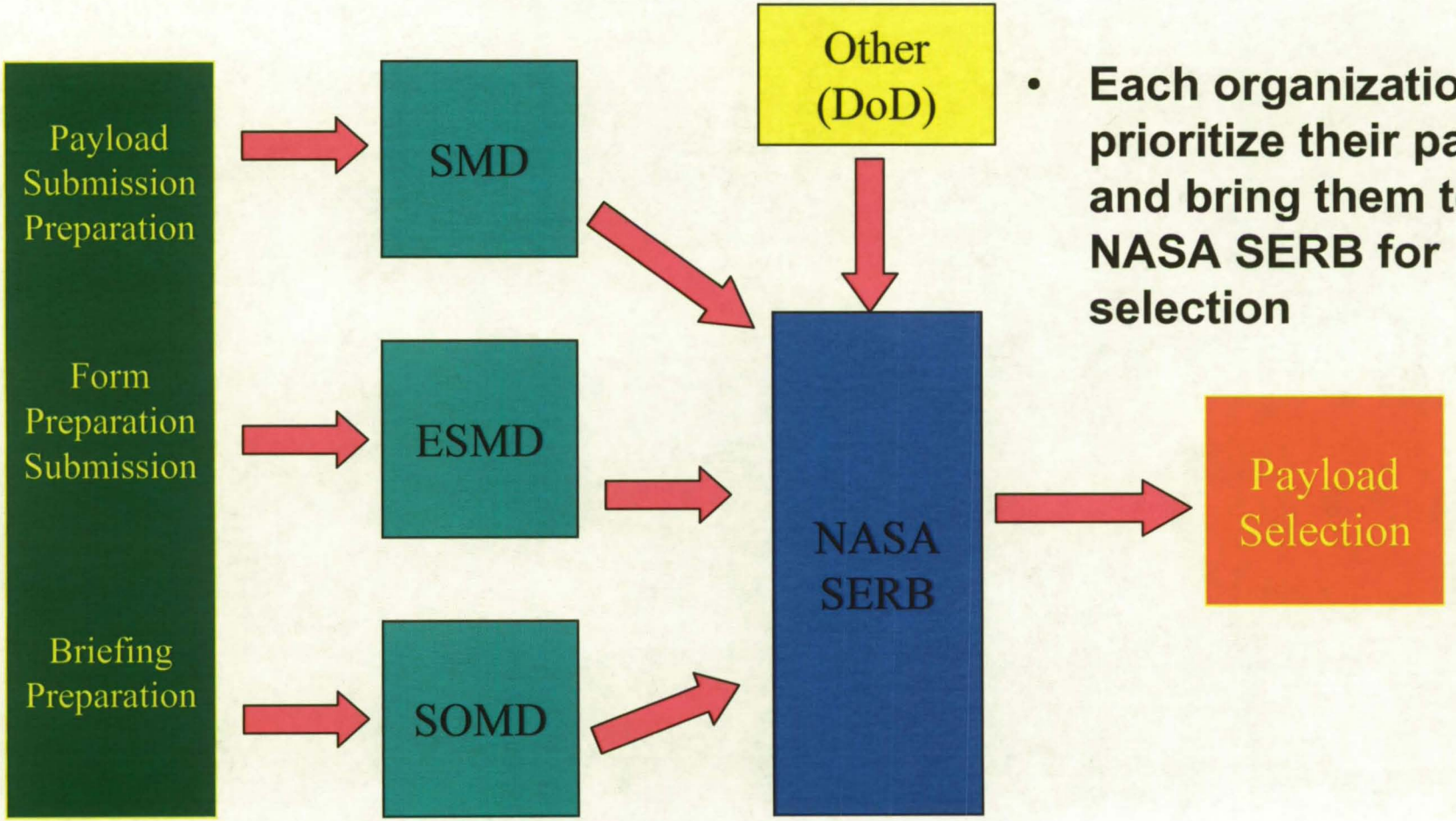
- The Space Development and Space Wing SERB process has been a successful method to determine the priorities for their small payloads
- With this success, NASA should adopt a method similar to the SD&TW model in the selection and manifest of our small payloads
  - By adopting this model, NASA and DoD will be working to the same process
  - Having the same process will allow NASA and DOD a better partnership with respect to small auxiliary payloads
  - One difference between the DoD SERB and a NASA process is that DoD provides funding for the experiment. This will not be the case for the NASA spacecraft
    - » The auxiliary payload will be responsible for their own funding

Manifesting Auxiliary Payloads

- **Selection of a Mission**
  - Once a year, each Directorate (SMD, SOMD, ESMD, and SD&TW) will bring forward their sponsor auxiliary payload that they would like to be ranked
  - Once a mission has been identified to have available margin to fly an auxiliary payload, one is selected from the ranking list
- **Evaluation Process will be used to determine which mission will be selected to accommodate one of the slots**
  - Each candidate SC shall be graded on a set of evaluation criteria
    - » 50% - Does the SC meet the Visions and Goals of the Agency
    - » 25% - The technical advancement
    - » 25% - Educational

Method to Evaluated Auxiliary Payloads on ELV's

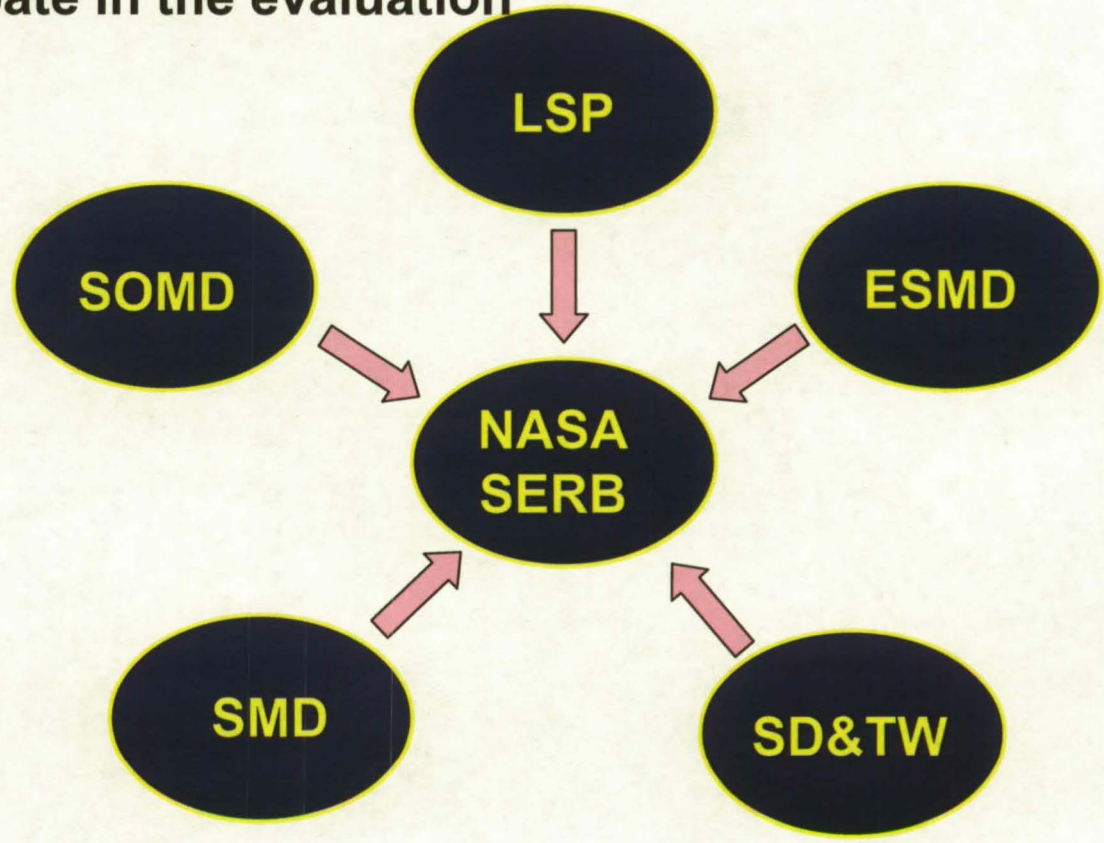
- **Each organization shall provide a POC to the board that will work with the their auxiliary payload to coordinate the preparation and submission**



- **Each organization will prioritize their payloads and bring them to the NASA SERB for selection**

Development of the NASA SERB

- The NASA SERB will consist of five organizations
- Each organization shall provide two representatives to participate in the evaluation
- Launch Services Program acts as the SERB Committee Chair for the Evaluation process
- Each payload will be evaluated by the selection criteria



Work Still Needing to be Performed

- Continue the Management of the PPOD development of ELV's
- Continue the coordination with the Primary to show the mitigation of Mission Risk
- Bring overall concept and manifesting processes to a special Flight Planning Board (following a preliminary design review)
- Develop the NASA SERB Process and Schedule
  - Pre- Manifest
  - Manifest
  - Post Manifest

Work Still Needing to be Performed

- Develop the Auxiliary Payload Manifesting Policy
- Selection Criteria
  - » 50% - Does the SC meet the Visions and Goals of the Agency
  - » 25% - The technical advancement
  - » 25% - Educational
- Brief each of the Stakeholders and incorporate comments
- Submit for Process to the Fight Planning Board for approval
- How will the Integration team support the mission
  - – Use the same team as the primary?
- LSP continues to investigate new and innovative ways to increase our capability to place NASA payloads in orbit