National Aeronautics and
Space Administration

RADIOISOTOPE POWER SYSTEMS PROGRAM

NEPA and Launch Authorization Overview to SpaceX

Glenn Research Center

Hybrid

April 25, 2024

Contributors

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Prepared by the NASA Radioisotope Power Systems Program Office

RPS N-LAM Requirements Flow Down

RPS Program Commitment Agreement (PCA) 4: The RPS Program shall manage the NEPA and launch authorization processes for RPS missions.

NEPA

Governed by 40 CFR § 1500-1508 CEQ Regulations for Implementing the Procedural Provisions of NEPA & NPR 8580.1A Implementing the National Environmental Policy Act and Executive Order 12114

N-LAM Objective:

- Coordinate and provide NEPA documentation in advance of missions
- Coordinate and provide NEPA documentation in support of missions
- Document the RPS Program's process for National Environmental Policy Act (NEPA)

Launch Authorization

Governed by National Security Presidential Memorandum #20 (NSPM-20) on Launch of Spacecraft Containing Space Nuclear Systems and NPR 8715.26 Nuclear Flight Safety

N-LAM Objective

- Coordinate and provide Launch Authorization documentation in advance of missions
- Coordinate and provide launch authorization documentation in support of missions
- Documenting the RPS Program's process for launch authorization

NLAM: Three Elements: Independent and Interrelated

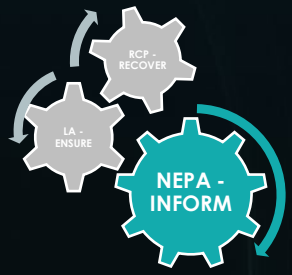
- NEPA – **INFORM** the Public of a planned action
  - RPSPO supports Missions in ensuring NEPA (nuclear) compliance

- Launch Authorization – **ENSURE** Approval Authority is informed and approves
  - RPSPO supports Missions in ensuring (nuclear) Launch Authorization is achieved

- Radiological Contingency Planning – **RECOVER** if there's a 'bad day'
  - RPSPO supports Mission & Launch Site in preparedness in event of nuclear release

Commonality: Simplify Mission actions required for use of RPS & RHU

NEPA Overview



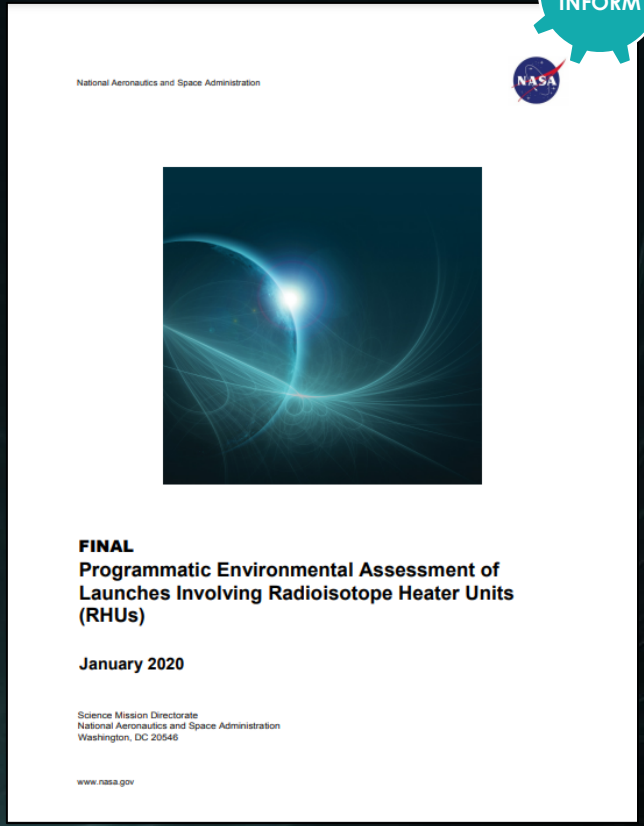
- Council on Environmental Quality (CEQ) "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act"
  - Requires all federal agencies to consider alternatives to their proposals before action is taken
  - NEPA does not require a particular result; it does not require that the best alternative from an environmental perspective be selected.
  - Requires public review and comment of agency actions

Levels of NEPA Analysis

Analysis	Decision Document
Categorical Exclusion **(CatEx)**	Record of Environmental Consideration **(REC)**
Environmental Assessment **(EA)**	Finding of No Significant Impact **(FONSI)**
Environmental Impact Statement **(EIS)**	Record of Decision **(ROD)**

RPS Programmatic NEPA Documents

- LWRHU Programmatic Environmental Assessment (PEA) (2020)
  - The programmatic document will be applied each time an RHU is used in a space mission, as long as the parameters listed below are met
    - Up to 130 RHUs for a maximum combined 351 grams of plutonium-238 oxide (Pu-238)
    - Covers launches from the KSC and CCSFS launch complexes
    - Launch vehicles that have been fully analyzed through the NASA NEPA process and have undergone the NASA launch approval process are included in this analysis



National Aeronautics and Space Administration

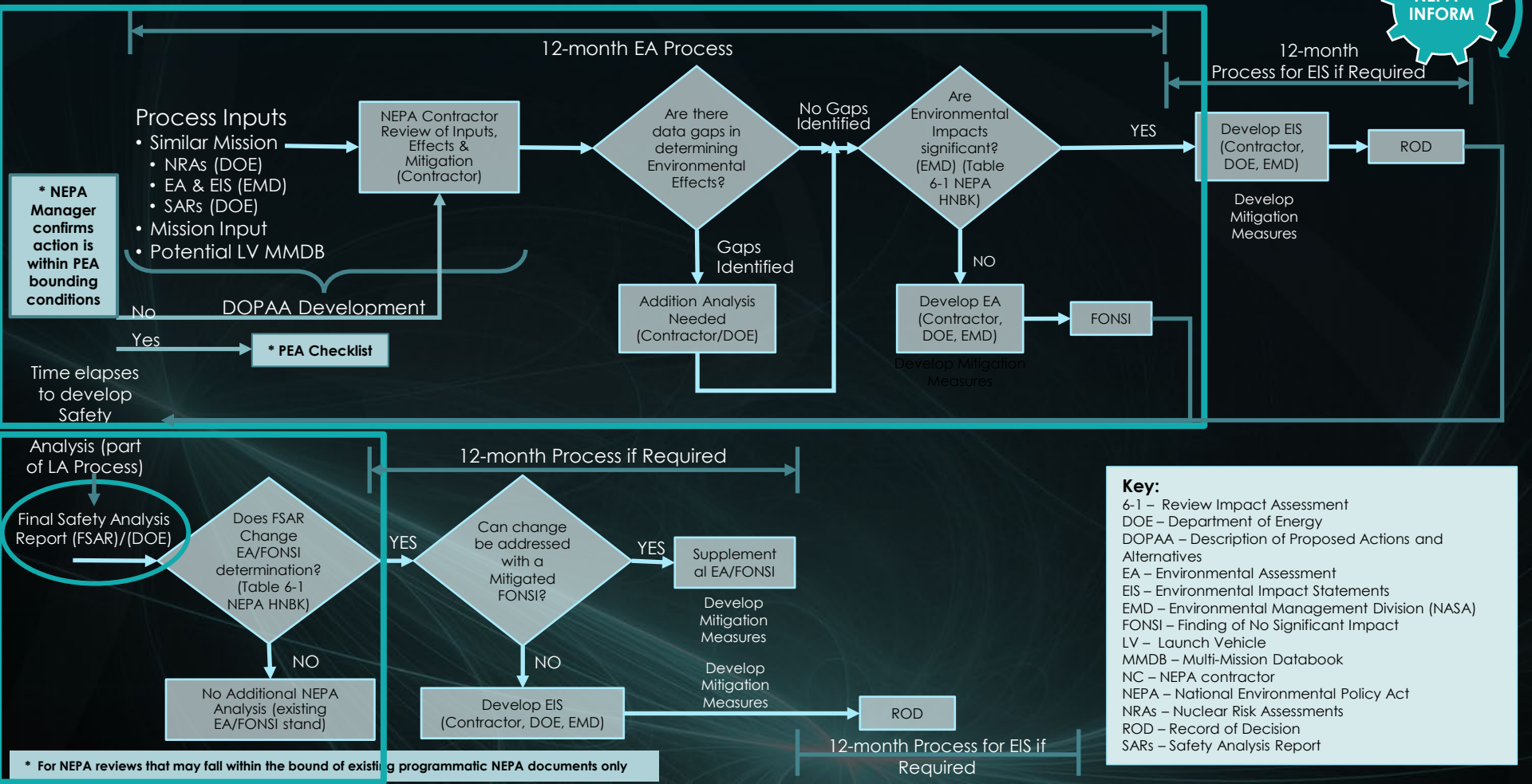
FINAL
Programmatic Environmental Assessment of Launches Involving Radioisotope Heater Units (RHUs)

January 2020

Science Mission Directorate
National Aeronautics and Space Administration
Washington, DC 20546

www.nasa.gov

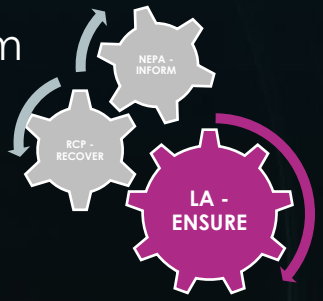
NEPA Process for RPS Missions



Key:

6-1 – Review Impact Assessment
DOE – Department of Energy
DOPAA – Description of Proposed Actions and Alternatives
EA – Environmental Assessment
EIS – Environmental Impact Statements
EMD – Environmental Management Division (NASA)
FONSI – Finding of No Significant Impact
LV – Launch Vehicle
MMDB – Multi-Mission Databook
NC – NEPA contractor
NEPA – National Environmental Policy Act
NRAs – Nuclear Risk Assessments
ROD – Record of Decision
SARs – Safety Analysis Report

National Security Presidential Memorandum 20 - Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems



- NSPM-20 replaces the prior standard employed (PD/NSC-25) for US Launch Authorization (8/2019)
- NSPM-20 major changes
  - Guidelines vary with quantity and form of material planned for use, as well as, with potential radiological risk
  - NASA Procedural Requirement (NPR) 8715.26 "Nuclear Flight Safety" published February 2022 to be compliant with NSPM-20:
    - Interagency Nuclear Safety Review Board (INSRB)
    - Reporting levels and launch authorization vary based on Tier
    - RPS mission utilize DOE SAR

Mars 2020 Mission launching from Cape Canaveral Air Force Station, Florida on July 30, 2020

NSPM-20 Tiering Criteria & Safety Guidelines

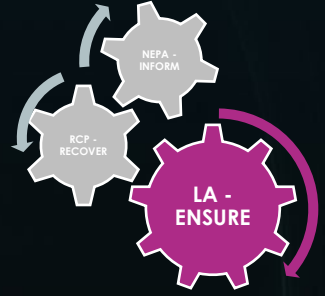
Tier	Author-izing Official (USG Mission)	Tiering Criteria			Reference Dose Range	Safety Guidelines
		A2 value	Reactor Fuel Type (if applicable)	Probability of Accident Resulting in Exposure at Specified Level		Probability of Accident Resulting in Exposure at Specified Level
Tier 1	Head of Sponsoring Agency	>1,000X* & <100,000X	not a nuclear reactor	N/A	25 mrem** to 5 rem***	< 1 in 100 at
Tier II *Mars 2020 Perseverance*	Head of Sponsoring Agency	>100,000X	a nuclear reactor using low-enriched uranium fuel	≥ 1 in 1,000,000 at	5 rem to 25 rem	< 1 in 10,000 at
Tier III	POTUS or Delegate Authorizes Launch	N/A	a nuclear reactor using any nuclear fuel other than low-enriched uranium fuel	≥ 1 in 1,000,000 at	> 25 rem	< 1 in 100,000 at

*this "floor" reflects the implementation of NSPM-20 in NASA NPR 8715.26

**if at or above 0.025 rem (equivalent to approximately one month exposure to natural background radiation)

***5 rem is approximately equivalent to 5 full body CT scans, and is the annual allowable limit for nuclear workers

Launch Authorization Process In –Place
SAR Development Process



Process Inputs
- Mission Input
  - S/C Info
  - Boundary Conditions of RPS
  - Launch Window/Conditions
- Relevant FSARs
- New Information

Development of the Safety Design Strategy (SDS) (DOE)

DOE SDS Meeting

SDS Delivery

Develop SAR (DOE)

Mission Specific SAR LVDB (LSP)

LSP Deliverable

DOE Review SAR

DOE Peer Review

DOE Final SAR

Mission SAR

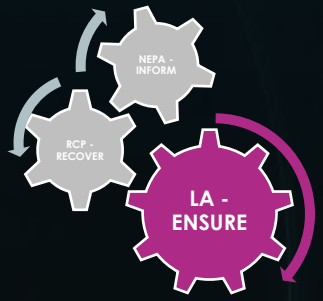
Mission SAR Delivery

Key:

DOE	Department of Energy
FSAR	Final Safety Analysis Report
LV DB	Launch Vehicle Data Book
LSP	Launch Service Program
PE	Program Executive
SAR	Safety Analysis Report
S/C	Spacecraft

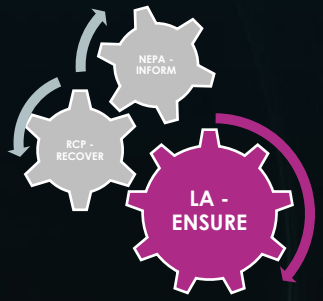
- DOE Deliverable
- INSRB Deliverable
- LSP Deliverable
- Formal Meeting Between DOE and INSRB
- Work Being Performed

RPS Programmatic Documented Safety Analysis (DSA)



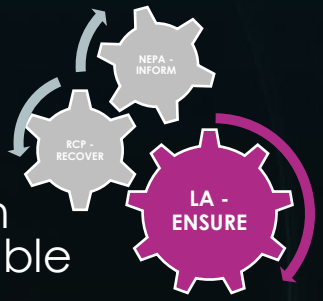
- RHU DSA
- Provide decision-maker(s) with broad characterization of potential risks associated with the bounding of 130 RHUs or 1 step 2 general purpose heat source (GPHS) at KSC or CCSFS based on mission parameters. DSA provides information on:
  - Explosion overpressures
  - Impact velocities
  - Thermal conditions (e.g., solid and liquid propellant flame temperatures)
  - Reentry conditions (velocity, reentry angles)
  - Gravity assist maneuvers (velocity, reentry angles)

Nuclear Launch Authorization Plan (NLAP)



- Outlines the mission's support for ensuring the US Government Nuclear Flight Safety and Launch Authorization Process, as required by NASA Procedural Requirement (NPR) 7120.5
- Typically includes the following information:
  - Approach
  - Organizations involved
  - Required documentation for obtaining launch authorization
  - Schedule
  - NPR 8715.26 requirements matrix
  - Summary of tentative RCP milestones and deliverables
    - Codification of RCP milestones and deliverables occur via the signing of the *Mission* KSC-PLN-1903 and the NASA HQ RCP Plan
  - May serve as preliminary tiering documentation

Types of Databooks



1. Multi-Mission Databook (MMDB)
   - Describes generic launch vehicle (LV) configurations, launch complex(s) and vehicle-centric info expected to be applicable across multiple missions
   - Provides general accident environments analysis and probabilistic risk assessment for a specific launch vehicle without any specific mission or spacecraft
2. Safety Analysis Report (SAR) Databook
   - MMDB chapters updated for exact launch vehicle configuration
   - Incorporates final mission and spacecraft designs
   - Utilizes latest mission timeline and trajectory
   - Incorporates Mission unique LV and FTS designs
   - Failure modes are evaluated in more detail and closely examined through expert elicitations with the Launch Service Contractor
   - Update all accident environment analyses to address all the changes

Radiological Contingency Planning

- RPSPO supports Mission & Launch Site in preparedness in event of nuclear release

New Horizons launching from Cape Canaveral Air Force Station, Florida on January 19, 2006

Acronym List

- ATLO – Assembly, Test, and Launch Operations
- ATP – Authority to Proceed
- CatEx – Categorical Exclusion
- CCSFS – Cape Canaveral Space Force Station
- CDR – Critical Design Review
- CEQ – Council On Environmental Quality
- DOE – Department of Energy
- DOPAA – Description of Proposed Actions and Alternatives
- DSA – Documented Safety Analysis
- EA – Environmental Assessment
- EIS – Environmental Impact Statement
- EMD – Environmental Management Division (NASA)
- FONSI – Finding of No Significant Impact
- FQAR – Flight Qualification and Acceptance Review
- FSAR – Final Safety Analysis Report
- FTS – Flight Termination System
- ICD – Interface Control Document
- LA – Launch Authorization
- LSRD – Launch Systems Requirement Document
- LVC – Launch Vehicle Contractor
- LSP – Launch Services Program
- LV – Launch Vehicle
- LV DB – Launch Vehicle Data book
- LWRHU – Light Weight Radioisotope Heater Unit
- MMDB – Multi-Mission Data book
- NC – NEPA contractor
- NEPA – National Environmental Policy Act
- NLAM – NEPA and Launch Authorization Management
- NLAP – Nuclear Launch Authorization Plan
- NRAs – Nuclear Risk Assessments
- PDR – Preliminary Design Review
- PE – Program Executive
- PEA – Programmatic Environmental Assessment
- REC – Record of Environmental Consideration
- PHPF – Payload Hazardous Processing Facility
- RHU – Radioisotope Heater Unit
- ROD – Record of Decision
- RPSPO – Radioisotope Power Systems Program Office
- S/C – Spacecraft
- SAR – Safety Analysis Report
- SDS – Safety Design Strategy
- SER – Safety Evaluation Report
- SRR – Systems Requirement Review

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POWER TO EXPLORE

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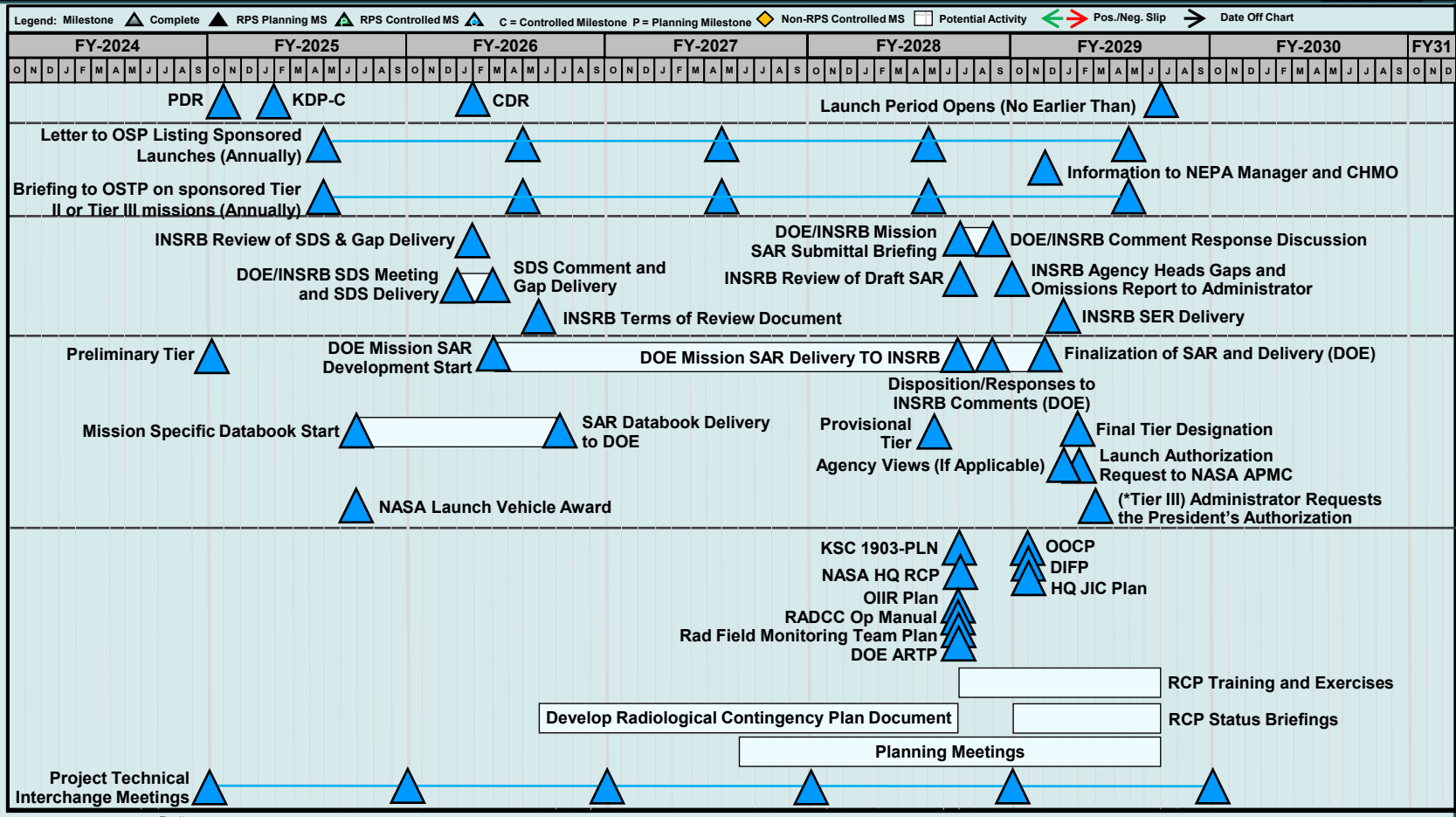
nasa-rps@mail.nasa.gov

LA Lifecycle Schedule - Activities and Milestones

Example July 2029 Launch Date



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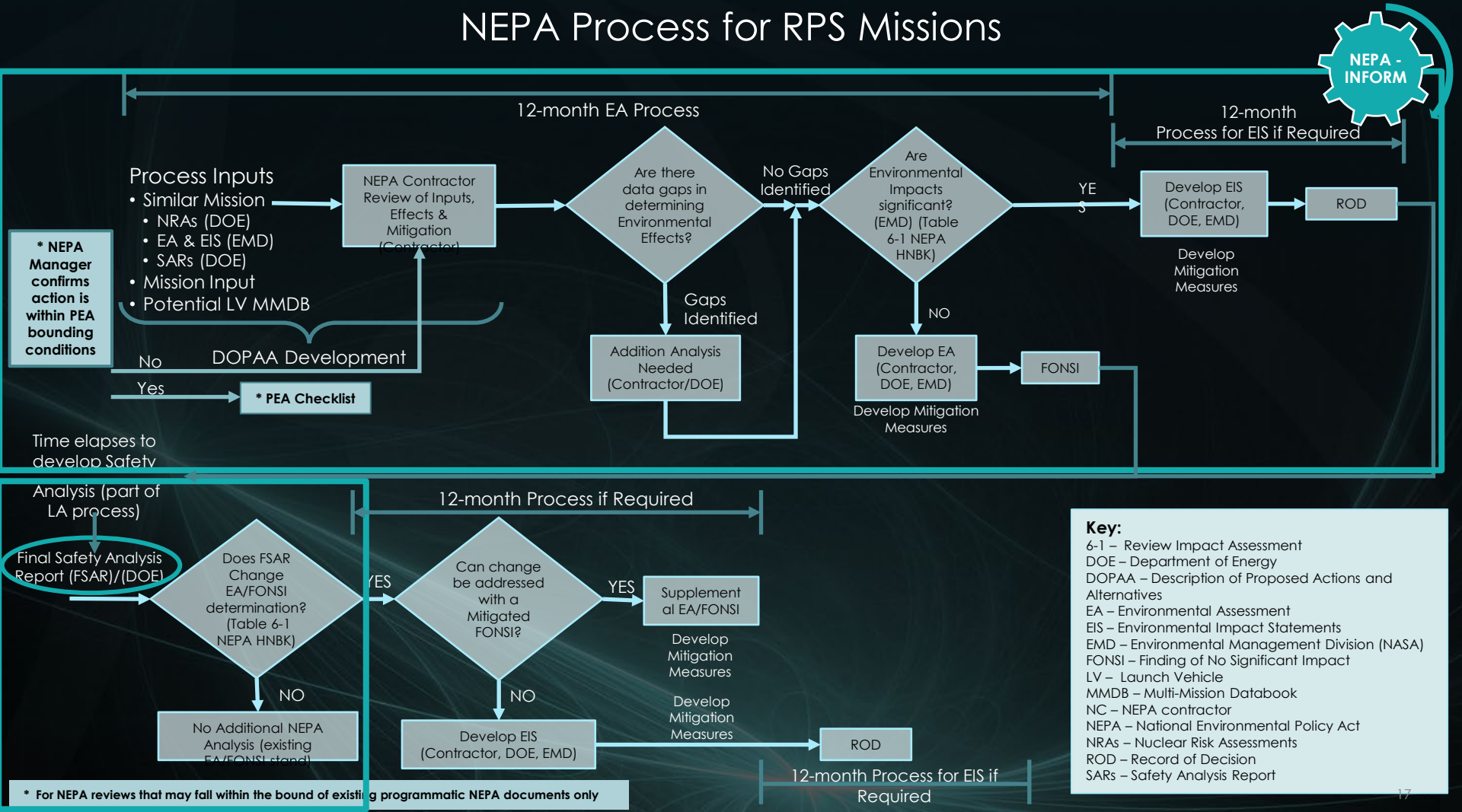
NEPA Process for RPS Missions



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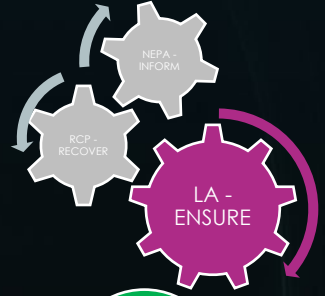
Launch Authorization Process In –Place
SAR Development Process



Process Inputs
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  - Boundary Conditions of RPS
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- New Information

Development of the Safety Design Strategy (SDS) (DOE)

DOE/ INSRB SDS Meeting

SDS Deliver y

INSRB included if higher than Tier 1

INSRB Review of SDS * (INSRB)

SDS Comment and Gap Delivery

Develop SAR (DOE)

Mission Specific SAR LVDB (LSP)

LSP Deliverable

DOE Review SAR

DOE Peer Review

DOE Final SAR and SER

Mission SAR

Mission SAR Delivery

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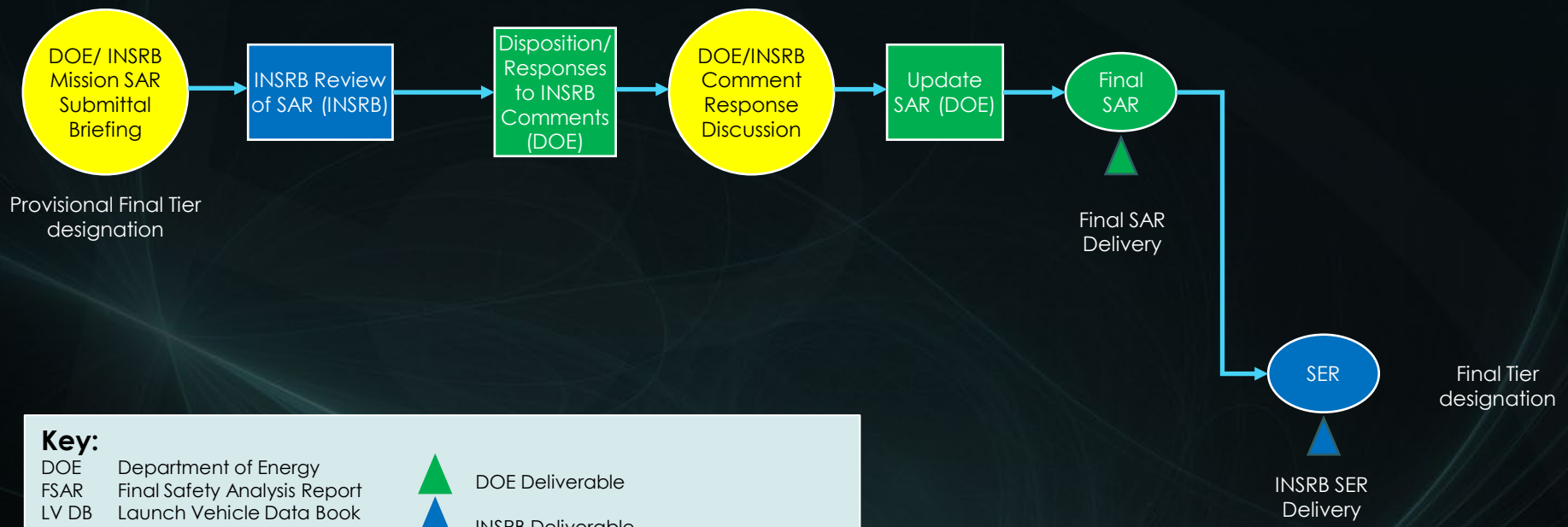
- DOE Deliverable
- INSRB Deliverable
- LSP Deliverable
- Formal Meeting Between DOE and INSRB
- Work Being Performed

Core Launch Authorization Mission Team: Participate in regular status calls to be led by RPS Program

Mission Specific Program Executive
DOE Executive
RPSP Launch Authorization Lead (NLAM)
Mission Specific Launch Authorization Rep
KSC Launch Service Program Rep
DOE Safety Expert

* INSRB completes review of SDS to provide gaps and comments on adequacy of safety analysis plan and alignment to NSPM-20

Launch Authorization Process In-Place
Final SAR and SER Process – Tier II and III



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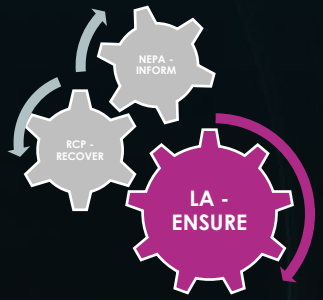
- Work Being Performed

INSRB review – Review the SAR in alignment with the NSPM-20

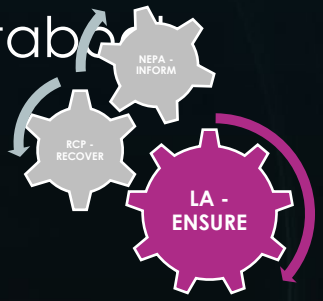
- SAR submittal briefing with INSRB
- INSRB provides comments on SAR Review (SAR delivery/briefing + 30-days)
- Comment response Discussion with INSRB (Comment delivery + 30-days)
- Finalize SAR (3-months)
- INSRB issues SER (1-month post Final SAR)

SAR Databook Contents/Contributors



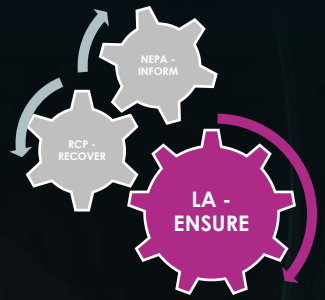
- Databook comprised of 9 chapters:
  - Chapter 1: Introduction (Mission)
    - Purpose of databook development (NSPM-20 and NPR 8715.26 and nuclear risk assessment requirements), mission objectives, launch information (site, vehicle, timeframe), SAR databook organization, analytical ground rules and assumptions
  - Chapter 2: Mission Overview (Mission)
    - Purpose, phases, critical events, communications, instrumentation
  - Chapter 3: Launch Vehicle Description (LSP & LVC)
  - Chapter 4: Spacecraft Description (Mission)
    - General configuration, spacecraft stage descriptions, mass properties and spacecraft coordinate system, instrumentation, ordnance components, tank quantities and pressures, RPS/RHU installation details
  - Chapter 5: Launch Complex Description (LSP & LVC)
  - Chapter 6: Flight Safety System (LSP, LVC & Range)
  - Chapter 7: Mission Timeline & Trajectory (LSP & LVC)
  - Chapter 8: Accident Probability Analysis (LSP & ASCA, Inc.)
    - Exception: section 8.6 developed by JPL
  - Chapter 9: Accident Environments (JPL)
    - Exception: section 9.4 developed by both LVC and JPL
  - Additional details can be located in LWRHU User's Guide

Typical Information Needed from the Mission for SAR Database



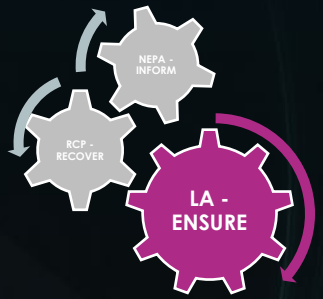
- Spacecraft and Mission Overview
  - Description of spacecraft flight system, including any upper boost stages, the cruise stage, the aeroshell (heatshield and backshell), and the payload in launch configuration, and information about Assembly, Test, and Launch Operations (ATLO).
  - Description of the mission overview, including launch period and windows, and any potential earth flyby(ies)
- Flight System Configuration
  - Detailed drawings, material properties of components and attachment points, thermal/g-load failure for any large mass or important component
  - Any upper boost stages (e.g. Star 48, etc.)
    - Detailed configuration with dimensions, including propellant type and tank information (propellant and tank mass, tank material, tank thickness, ullage volume, and burst pressure)
  - Cruise stage
    - Detailed configuration with dimensions, including propellant type and tank information (propellant and tank mass, tank material, tank thickness, ullage volume, and burst pressure)
  - Aeroshell
    - Detailed configuration of the heatshield and backshell with dimensions, each layer thickness, material properties, bondline failure temperature and heatshield g-load failure criterion
    - Aeroshell interface configuration with the internal structure(s)
    - Backshell and heatshield interface configuration
    - Parachute(s) mortar(s) configuration with mortar propellant mass
  - Lander and any other elements inside the aeroshell
    - Detailed configuration of the lander with dimensions, including the RPS

Typical Information Needed from the Mission for SAR Databook (Cont.)



- Spacecraft Coordinate System
  - Definition of Spacecraft Coordinate System
  - Relation of the Spacecraft coordinate system to the launch vehicle coordinate system (if available)
- Spacecraft Mass Properties
  - Mass Properties of spacecraft flight system (cruise stage/aeroshell/lander) including the center of gravity (CG), the moment of inertia at launch, with and without propellant
  - Provide a description including location, mass and material of any heavy or dense object such as Ballast or Balance Masses planned for the spacecraft. Indicate if these masses are ejectable or fixed
- Spacecraft Thermal Properties
  - Expected launch temperatures and operating temperature of select and key components
- Propellant System Description
  - Provide Propellant System description details that include 1) Type and quantity of propellants used, 2) Propellant Tank size, expected operating pressure, burst pressure, tank wall thickness, mass of tank and material, 3) any solid rocket motors used as part of the propellant system, and 4) location
- Pressurant Tank System Description
  - Provide Pressurant System description details that include 1) Type and quantity of pressurant tanks used, 2) Pressurant Tank size, expected operating pressure, burst pressure, tank wall thickness, mass of tank and material, and 3) location

Typical Information Needed from the Mission for SAR Databook (Cont.)



- Spacecraft/Launch Vehicle Adaptor Configuration
- Interplanetary Trajectory
  - Earth flyby information (if applicable)
  - Trajectory Correction Maneuvers (TCMs) location and time
  - Configuration of the spacecraft
  - Long term reentry probabilities
  - Note: full trajectory to escape is needed which will be provided by LV provider in coordination with the mission
- Changes of spacecraft configuration from launch for any of the following events:
  - After separation from LV
  - Earth flyby(ies) if any
  - Long term reentry (accidental)