National Aeronautics and
Space Administration

SPACE TECHNOLOGY MISSION DIRECTORATE
SMALL SPACECRAFT TECHNOLOGY

Guidebook

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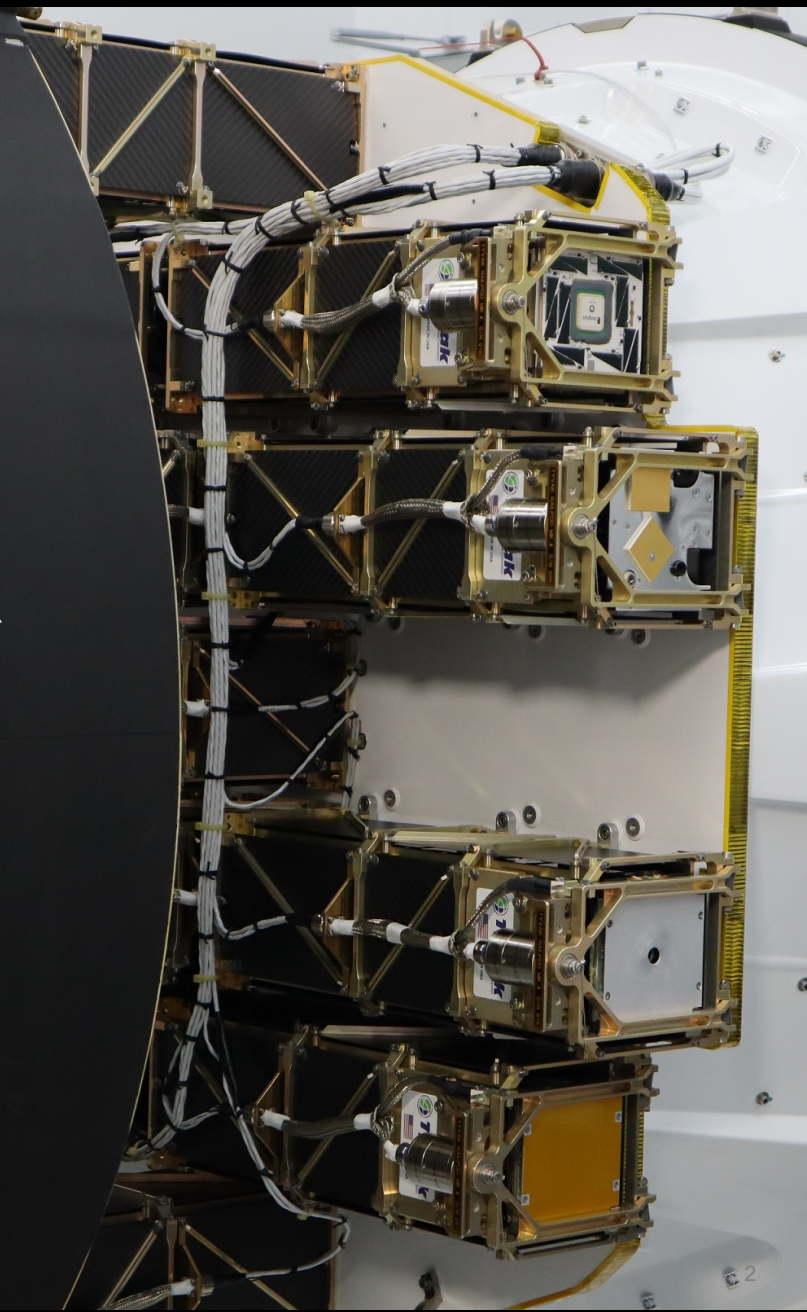
Agenda

- Overview SST Program
- Examples of Mission Technology
- SSTP Program Model
- Charter, Goals, and the NPR 7120.8 Governance Model
- Summary of Program Plan
- Purposes of Best Practices Guidebook



Overview Small Spacecraft Technology Program

https://www.nasa.gov/directorates/spacetech/small_spacecraft/smallsat_overview.html

The Small Spacecraft Technology (SST) program within NASA's Space Technology Mission Directorate, expands the ability to execute unique missions through rapid development and demonstration of capabilities for small spacecraft applicable to exploration, science and the commercial space sector. Through targeted development and frequent in space testing, the program:

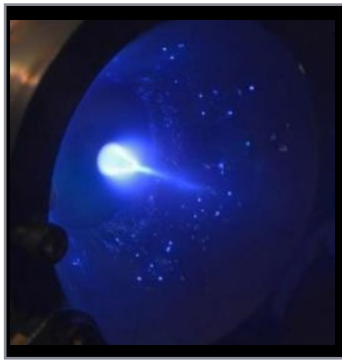
- Enables execution of missions at much lower cost than previously possible.
- Substantially reduces the time required for development of spacecraft.
- Enables new mission architectures through the use of small spacecraft.
- Expands the reach of small spacecraft to new destinations and challenging new environments.
- Enables the augmentation of existing assets and future missions with supporting small spacecraft.

The program achieves its objectives through:

- Identification and investment in the development of new subsystem technologies to enhance or expand the capabilities of small spacecraft.
- Sponsorship of flight demonstrations of new technologies, capabilities and applications for small spacecraft.
- Promotion of the use of small spacecraft as platforms for testing and demonstrating technologies and capabilities that might have more general applications in larger-scale spacecraft and systems.

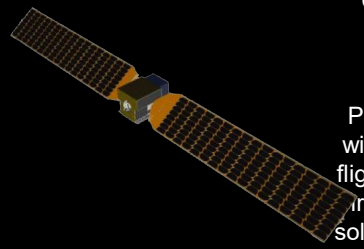
Program-funded projects may be executed at academic institutions, in the private sector, at NASA centers, as public-private partnerships, or cooperative agreements.

Example of Missions Technology



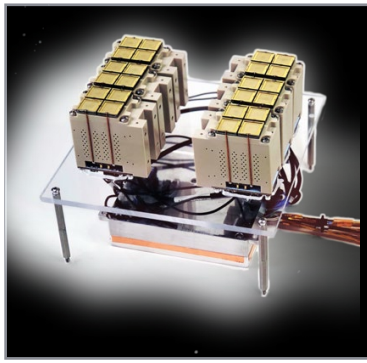
Dual Propulsion Experiment (DUPLEX)

Public-private partnership with CU Aerospace to flight test two fiber fueled CubeSat propulsion systems



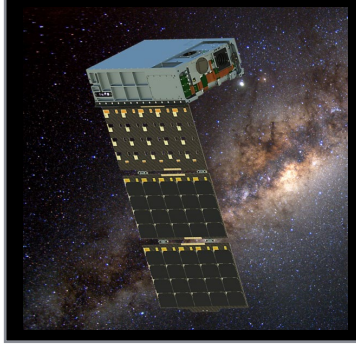
Courier Solar Electric Propulsion (SEP) Demonstration

Public-private partnership with ExoTerra Resource to flight test a micro Hall effect thruster, power system, and solar arrays for a micro SEP system



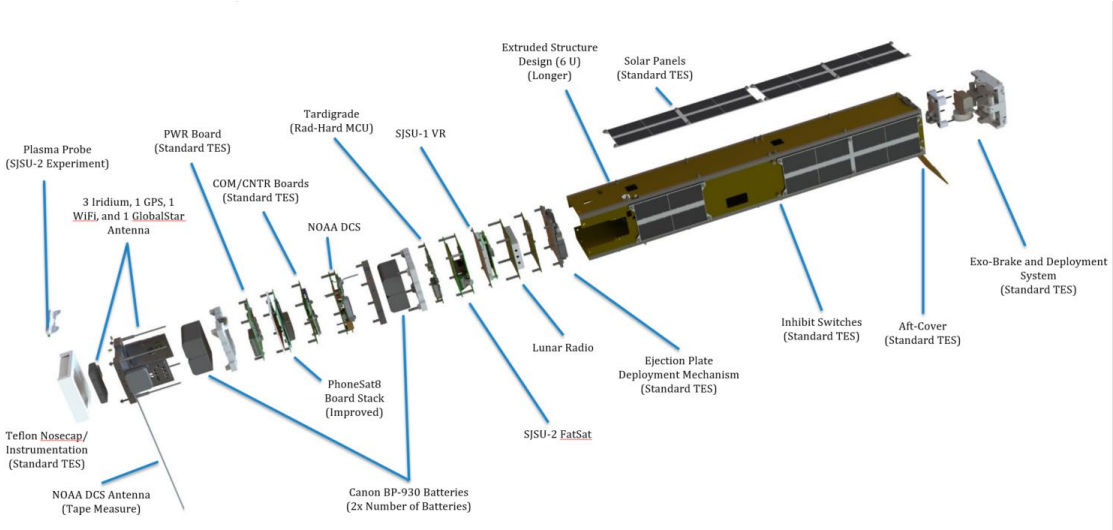
Tiled Ionic Liquid Electrospray (TILE) Propulsion Demonstration

Public-private partnership with Accion to flight test an extremely compact modular electric propulsion system that uses non-volatile ionic salt propellant.



X-NAV Autonomous Navigation Demonstration

Public-private partnership with Blue Canyon Technologies for a CubeSat autonomous navigation solution to reduce need for navigational aid from ground stations on Earth.



SST Program Model

7120.8 Program Management is for Research and Technology projects:

- Technology projects: attempting to solve a specific problem or address a practical need
- Research projects: performing basic research or applied research with unpredictable outcomes.

Success, Failure, Risk:

- Mission Success can be defined as creating a new capability, investigating the feasibility of a new architecture, discovering capability limits, or exploring the trade space.
- Mission Failure is defined as flight test data was not obtained. Independent assessments at key decision points replace reviews in accordance with a risk-tolerance approach. Economically appropriate efforts are made to understand risks, but cost and schedule are not used to eliminate all uncertainty in technical risks. SST invests in projects that have high-risk/high-reward, acknowledging only a minority will be transformative.

SST invests in Technology Gaps:

Supports NASA's strategic efforts to identify future investment

This Guidebook for Technology Development Projects (Guidebook)

The Guidebook provides recommended practices for the research and technology (R&T) development projects sponsored by NASA STMD's Small Spacecraft Technology (SST) Program.

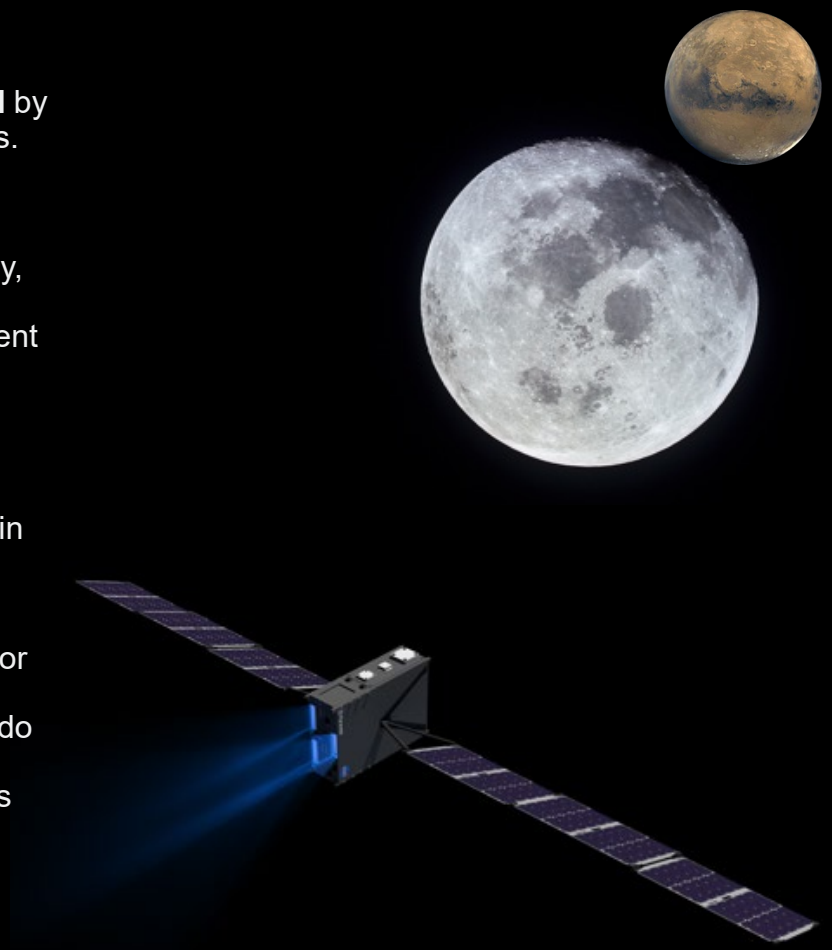
Many of the recommended practices derive from **lessons learned** by small spacecraft developers over the course of many R&T projects.

Lessons and best practices include such things as: various work processes that help to execute projects more effectively, methods and practices that advance technology more reliably and affordably, and experiences to help project members recognize, avoid and overcome pitfalls commonly encountered in technology development projects.

The intent is to capture successful experiences to make them available for benefit of others.

This Guidebook aims to improve likelihood of project success within the greater risk tolerance and tighter budgetary and schedule constraints typical of R&T projects.

This Guidebook is not intended to contradict existing NASA, legal or contractual requirements nor is it intended to add any new requirements; rather, where relevant standards and requirements do exist the Guidebook may provide guidance for interpreting and tailoring requirements or may suggest waivers where requirements are not relevant to R&T projects.



SST Program Charter, Goals, and the NPR 7120.8 Governance Model

SST project personnel – whether on projects executed at a NASA Center or on a grant or contract - need to be familiar with the SST Program Plan and the NPR 7120.8 NASA Research and Technology Program and Project Management Requirements in order to avoid errors due to not adhering to requirements or by applying unnecessary practices not needed for NPR 7120.8 projects. This section highlights a few important requirements for SST projects under NPR 7120.8 that contrast with NPR 7120.5 and that may be unfamiliar to those coming from experience with NPR 7120.5. For other R&T projects that are not sponsored by SST Program, this section may be useful especially if the project if formulated elsewhere under the requirements of NPR 7120.8.

The SST Program Plan (Doc. No. SSTP.PP.01) provides projects guidance on the program's policies for project management and execution. SST program and projects are formulated and managed in accordance with the structure and requirements of NPR 7120.8 for R&T projects. NPR 7120.8 governs all aspects of R&T project formulation, requirements, roles, and management principles. See subsequent later chapters in this Guidebook for respective details

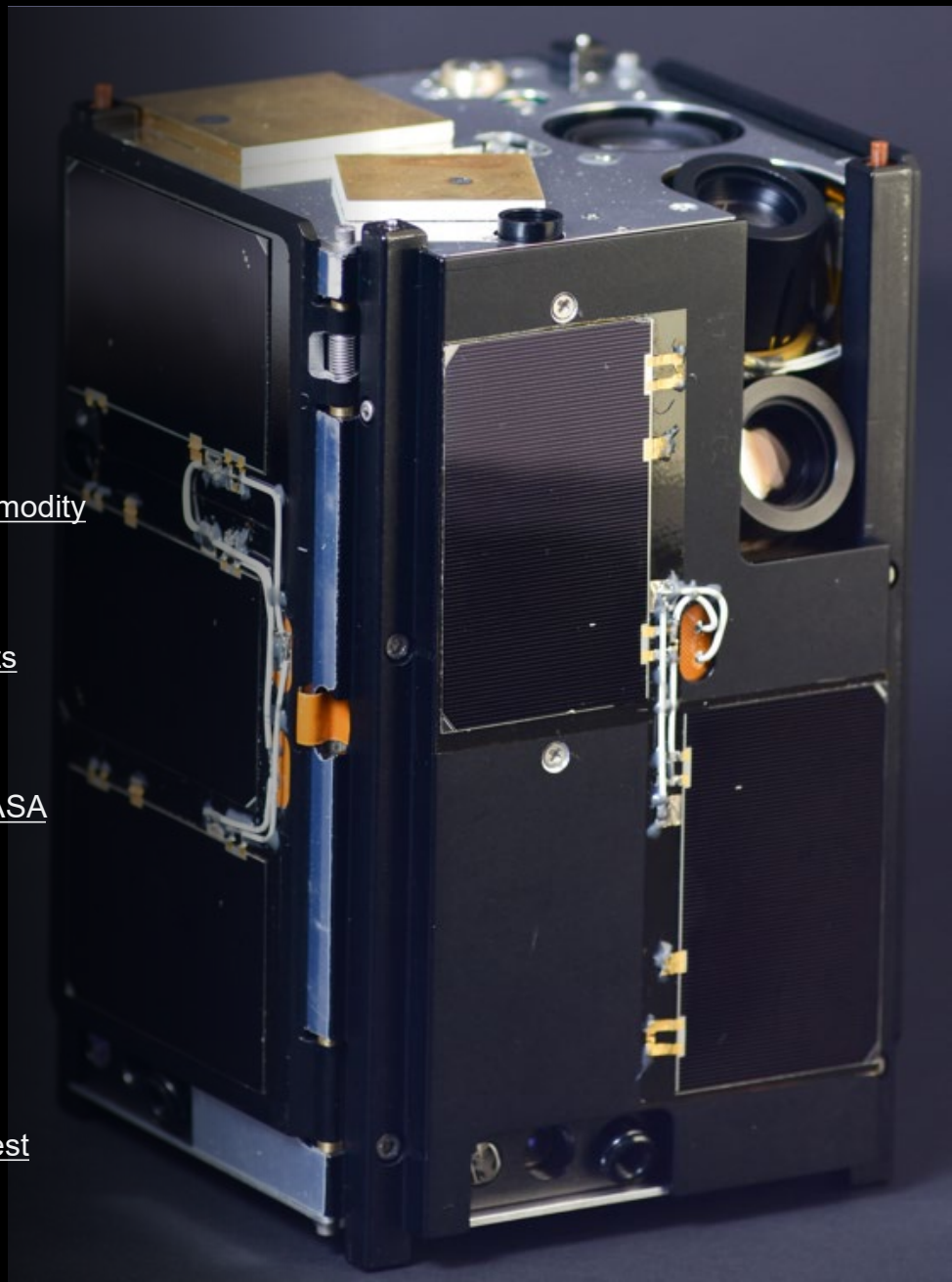
SSTP Guidebook guiding pinciples

All SST R&T development projects are managed in consideration of two guiding principles:

- **“<u>No Compromise to Safety</u>”** - Safety and protection of high-valued assets are paramount. Projects adhere to all relevant NASA, or company/university, launch service provider and range safety policies and practices. These apply in the lab, to personnel, to property, to procured services and elements, and during integration with the launch vehicle, on-orbit operations, limitation of orbital debris, and disposal. These policies are frequently referred to as “**do no harm**”. Projects are to comply with all legal, NASA safety, or launch provider safety requirements. Projects comply with Quality Assurance requirements for all *identified safety-critical items*.

- **“<u>Apply Systems Engineering and Quality Assurance Practices as Informed by Risk</u>”** – *For non-safety-critical items,* projects apply common industry and/or NASA best practices that enhance likelihood of technical success and do so with consideration of programmatic and technical risks. Acting as good stewards of the taxpayer’s dollars, SST project managers determine the best approach for developing, and demonstrating technologies without unnecessarily spending time and money where not likely to enhance technical success. Application of every known mission assurance edict at any cost to eliminate all technical risk is wasteful. SST projects develop and demonstrate technology - in the lab or on orbit - using “**risk-informed assurance**”; i.e. projects assess technical and programmatic risks and selectively apply engineering, mission, and quality assurance processes balanced with technical, cost and schedule consequences. This approach is sometimes called “right-sized quality assurance”.

R&T Project Guidelines and Recommended Practices



Quality and Mission Assurance

SST projects select and apply quality management and mission assurance requirements when appropriate and as based on **quantitative risk analysis.** Technical hazards may be identified through reliability analyses, such as Failure Modes and Effects Criticality Analyses (FMECAs) and single-point failure (SPF) analyses. Technical hazards may arise from any of several elements during a project life cycle

NPR 8735.2 NASA's Hardware Quality Assurance Program Requirements for Programs and Projects for safety-critical elements. R&T projects may also (but are not required to) apply selected requirements appropriate for non-safety-critical hardware and software if the project determines beneficial based on technical risk analysis (on a "risk-informed" basis) and regard to project goals, risk posture and cost/schedule constraints

SST projects implemented outside of NASA (in academia or the private sector) follow the quality and mission assurance practices at their respective entity. SST program may inquire about the entity's policies and procedures and may include additional quality and mission assurance requirements in a contract, grant or cooperative agreement

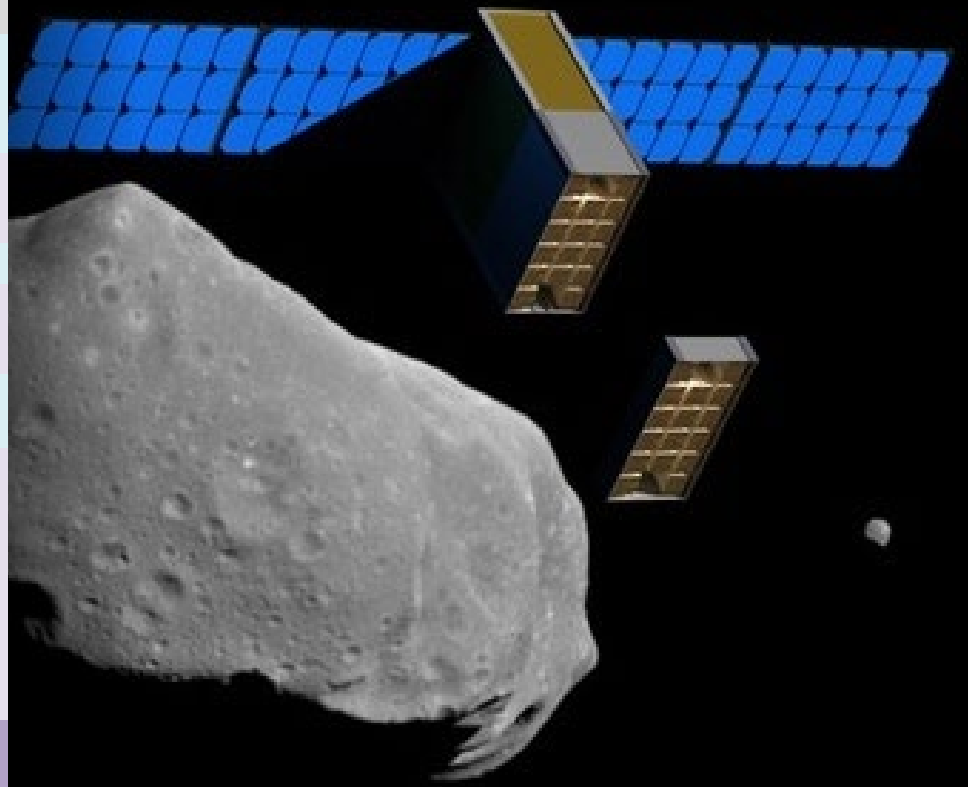
Procurement Quality Assurance

Recommended practices for procurement of components, subsystems and services for R&T projects – especially for projects to demonstrate technology in space. When applying the requirements of the FAR and of NPR 8730.5 and of the previous revision NPR 8735.2B, NASA projects, procurement personnel and procurement SMA TA often apply requirements in ways disproportionate to R&T project size, complexity and risk tolerance. This happens in their pursuit of project excellence because of lack of familiarity with procurement requirements for R&T projects and greater familiarity with NPR 7120.5 Spaceflight projects, and often results in unnecessary procurement delay, complexity and cost. R&T projects benefit by understanding and efficient procurement processes optimized to reduce time and cost in balance with their higher risk tolerance, smaller size and lower complexity - in contrast to processes applied to NASA NPR 7120.5 Spaceflight projects.

For SST R&T projects demonstrating technology in space that are implemented NASA Centers and that include safety-critical hardware or software delivered to the NASA Center, it is NASA policy to prescribe requirements for independent assurance of compliance through Government contract quality assurance functions as required by Federal Acquisition Regulation (FAR) Part 46, FAR Part 12, NASA FAR Supplement (NFS) Part 1846, and NPD 8730.5, NASA Quality Assurance Program Policy. The purpose of Government contract quality assurance is to ensure that supplies and services acquired under Government contract conform to contract requirements. Procurement quality assurance requirements should be levied only in consideration of the project risk, scope, and worst credible consequence of safety-critical element failure. This process is called risk-informed quality assurance

Project Reviews Recommended Practices

Phase	Activity	Output(s)
Pre-formulation	Preliminary planning (NPR 7120.8 Sect 4.2.5) (often omitted from SST projects which proceed from ATP)	Scope, from SST Program
ATP (KDP)	SST approval of proposed project to enter Formulation Phase (NPR 7120.8 Sect 4.2.6)	Approval, Preliminary Project Plan
Formulation	NPR 7120.8 Sect 4.2.7)	
Project Approval (KDP)	SST approval to enter Implementation Phase (NPR 7120.8 Sect 4.2.8)	Approval, Final Project Plan
Implementation	NPR 7120.8 Sect 4.2.9	Life cycle reviews per approved Project Plan
Continuation Assessments (if in plan/contract/grant, or upon subsequent direction)	NPR 7120.8 Sect 4.2.10.3	Continuation approval, if required
Independent Assessments (if required, or upon subsequent direction)	NPR 7120.8 Table 4-1	Independent assessments, if required
Status telecons, quad charts (for small lab demo projects)	NPR 7120.8 Sect. 4.2.10.2 informal reviews for lab projects	Quad charts (typical) as planned
SRR/SDR* (large flight demo projects)	Internal review conducted by project. Tailored from NPR 7123.1 Appendix G-4	NPR 7123.1 success criteria, as in approved project plan
CDR* (large flight demo projects)	Internal review conducted by project. Tailored from NPR 7123.1 Appendix G-7	NPR 7123.1 success criteria, as in approved project plan
MRR/FRR* (large flight demo projects)	Internal review conducted by project. Tailored from NPR 7123.1 Appendix G-13	NPR 7123.1 success criteria, as in approved project plan
Closeout Review (KDP)	NPR 7120.8 Sect 4.2.11	Closeout Report, New Technology Report

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