

Engineering Technical Review Planning Briefing

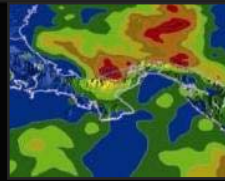
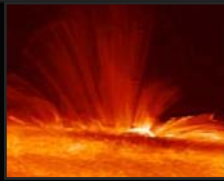
The general topics covered in the engineering technical planning briefing are 1) overviews of NASA, Marshall Space Flight Center (MSFC), and Engineering, 2) the NASA Systems Engineering(SE) Engine and its implementation , 3) the NASA Project Life Cycle, 4) MSFC Technical Management Branch Services in relation to the SE Engine and the Project Life Cycle , 5) Technical Reviews, 6) NASA Human Factor Design Guidance , and 7) the MSFC Human Factors Team. The engineering technical review portion of the presentation is the primary focus of the overall presentation and will address the definition of a design review, execution guidance, the essential stages of a technical review, and the overall review planning life cycle. Examples of a technical review plan content, review approaches, review schedules, and the review process will be provided and discussed. The human factors portion of the presentation will focus on the NASA guidance for human factors. Human factors definition, categories, design guidance, and human factor specialist roles will be addressed. In addition, the NASA Systems Engineering Engine description, definition, and application will be reviewed as background leading into the NASA Project Life Cycle Overview and technical review planning discussion.



Marshall Space Flight Center (MSFC) Engineering Technical Review Planning Briefing Presenter: Terrie Gardner/MSFC



marshall



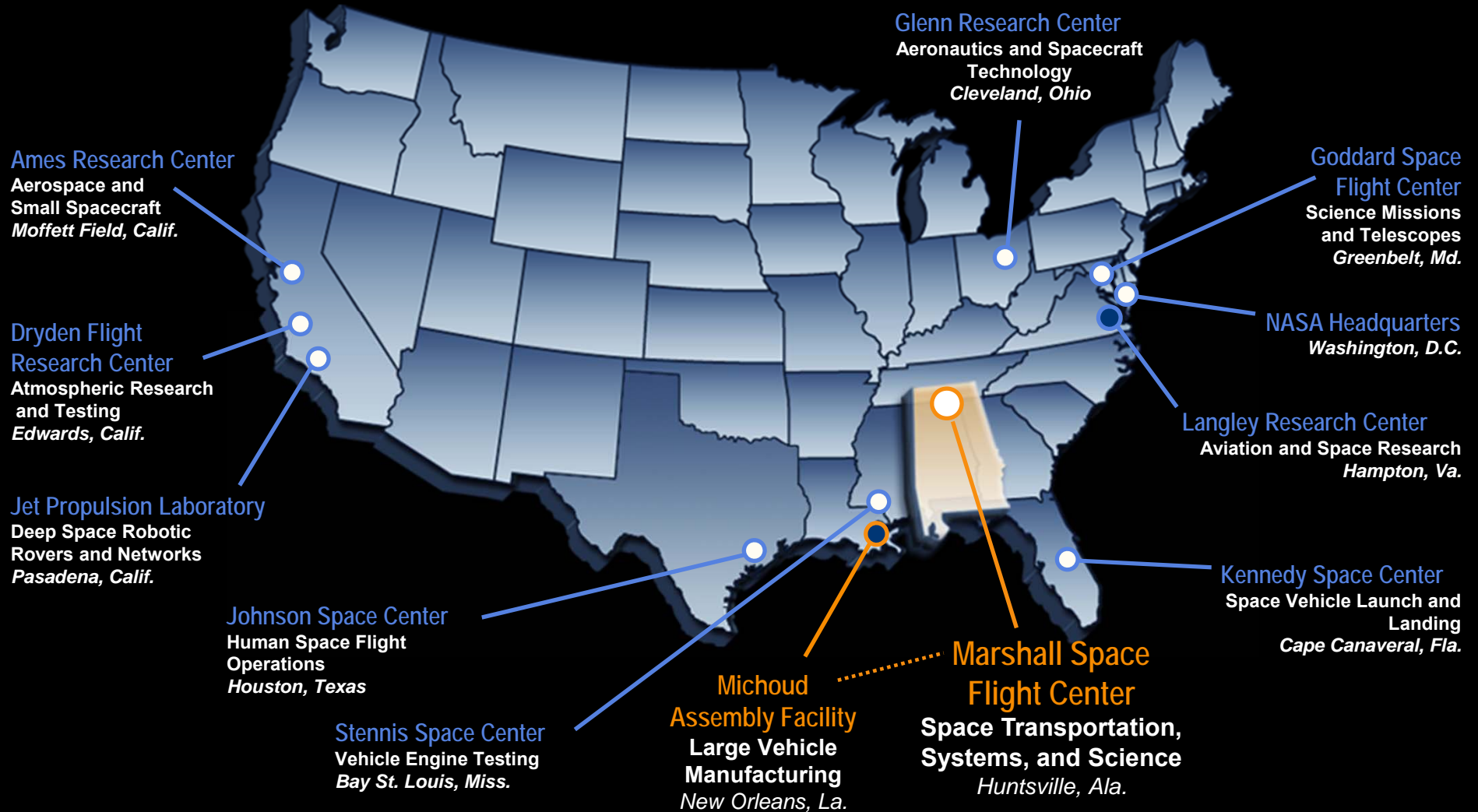
October 22, 2012

Agenda

- NASA Overview
- MSFC Overview
- Engineering Directorate, Spacecraft and Vehicle Systems Department, Systems Engineering and Integration Division Overview
- NASA Systems Engineering Engine
- NASA Project Life Cycle
- Technical Management Branch Overview
- Engineering Planning and Technical Review Team Overview
- Technical Reviews
- Human Factors
- Questions
- Closing

NASA Overview

NASA Around the Country



Marshall has a key role in NASA's mission.

MSFC Overview

A Legacy of Science and Exploration



Explorer 1



Apollo



Spacelab



Space Shuttle



Hubble Space
Telescope

Marshall continues its legacy of science and exploration.

Marshall Space Flight Center (MSFC)

- Marshall is one of NASA's 10 field centers and works under the direction of headquarters in Washington, D.C.
- The map shows the location and specialty of each center -- each with its own unique role in meeting the agency's goals.
- Marshall Space Flight Center is providing critical support in space transportation, space operations, and scientific research.
- One of Marshall's unique roles in the agency is the management of the Michoud Assembly Facility in New Orleans, Louisiana.
- It's a major space vehicle manufacturing and assembly facility and among the world's largest manufacturing sites.
- Michoud manufactured Saturn components, space shuttle external tanks and is ready to play a role in NASA's new launch vehicles.

From Exploration to Opportunity



\$2.88 billion (FY2009)
impact to
Alabama economy



Nearly 6,000 employees
(civil service and contractor,
approximate number)



3rd largest employer
in the Huntsville – Madison
County area



4.5 million square feet
of space occupied
in Huntsville

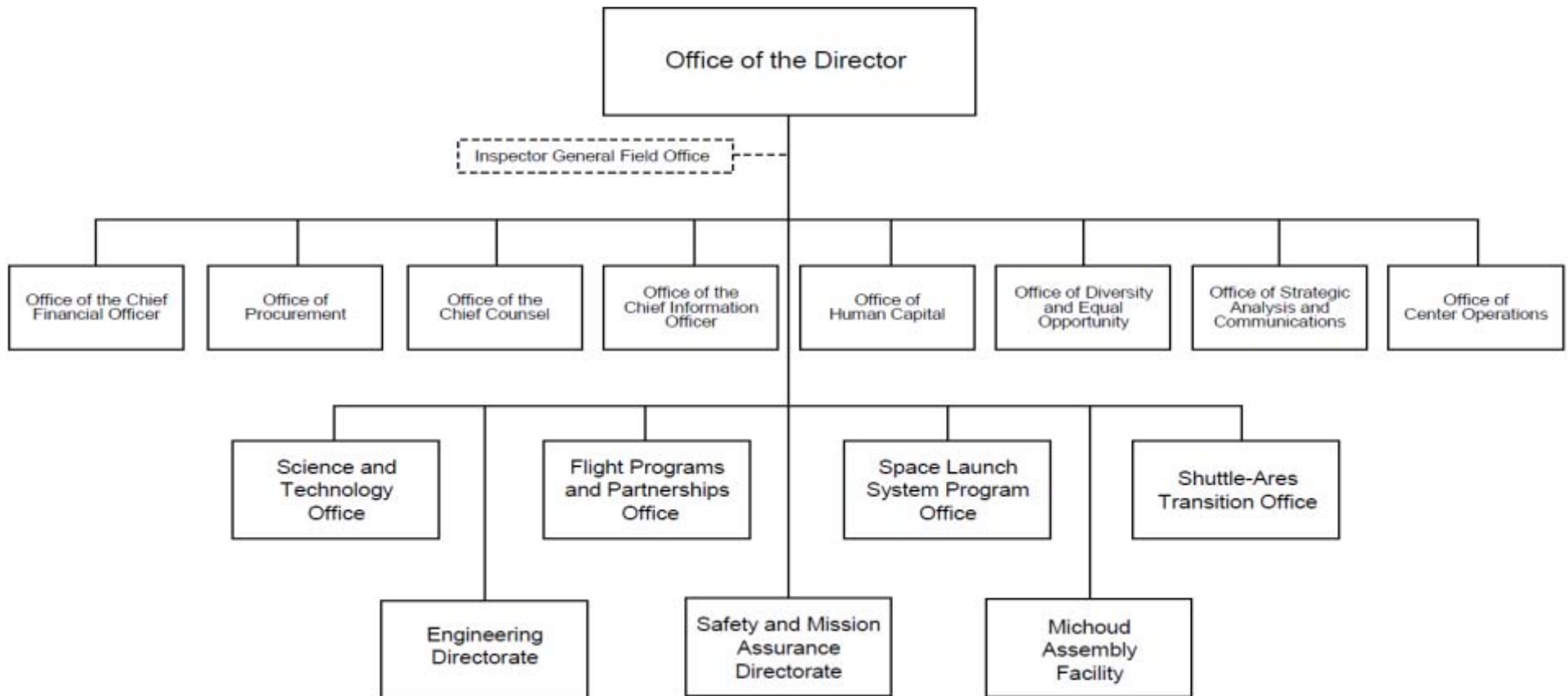


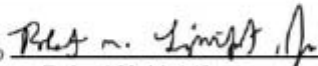
2.2 million square feet
of manufacturing space at
Michoud Assembly Facility

Marshall impacts the community.

Marshall Space Flight Center (MSFC) Organization

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GEORGE C. MARSHALL SPACE FLIGHT CENTER



APPROVED 
Robert M. Lightfoot
Director, MSFC
DATE November 14, 2011

Marshall's Role in Space Exploration



**Lifting from
Earth**

**Living and Working
in Space**



**Understanding
Our World
and Beyond**



***Marshall makes significant contributions
to America's space program.***

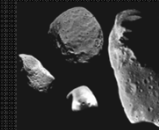
Lifting from Earth – Exploration Program Destinations

**Beyond LEO – NASA's
Space Launch System**

**Earth's
Moon**



**Near-Earth
Asteroids**



**Mars and Its
Moons**



**Low Earth Orbit (LEO)
– Commercial Space
Transportation**



The need for flexible, evolvable and affordable systems.

Lifting from Earth – The Space Launch System

SLS – America’s Heavy Lift Rocket

- Safe, affordable and sustainable
- Carries the Orion Multi-Purpose Crew Vehicle (MPCV)
- Supports national missions beyond Earth orbit
- Does not preclude back-up for ISS transportation
- Initial lift capacity of 70 metric tons (mt) evolving to 130 mt
- Builds on Saturn, Shuttle and Ares



Solid Rocket
Motor Test



Friction Stir
Welding



Shell Buckling
Test



Upper Stage
J-2X Engine



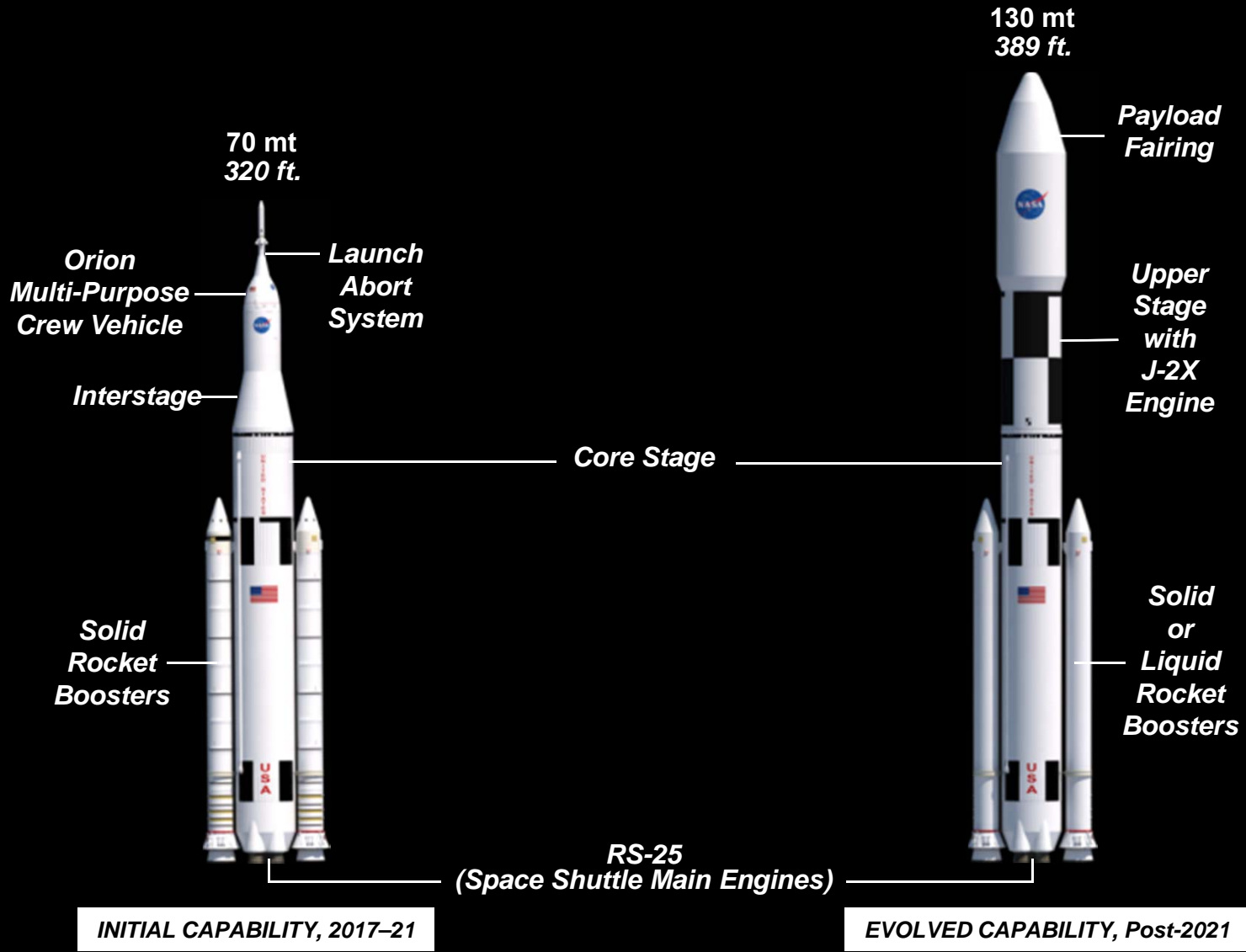
J-2X Engine
Tests



Core Stage
RS-25 Engines

*Marshall's capabilities and facilities are
launching the future of space vehicle development.*

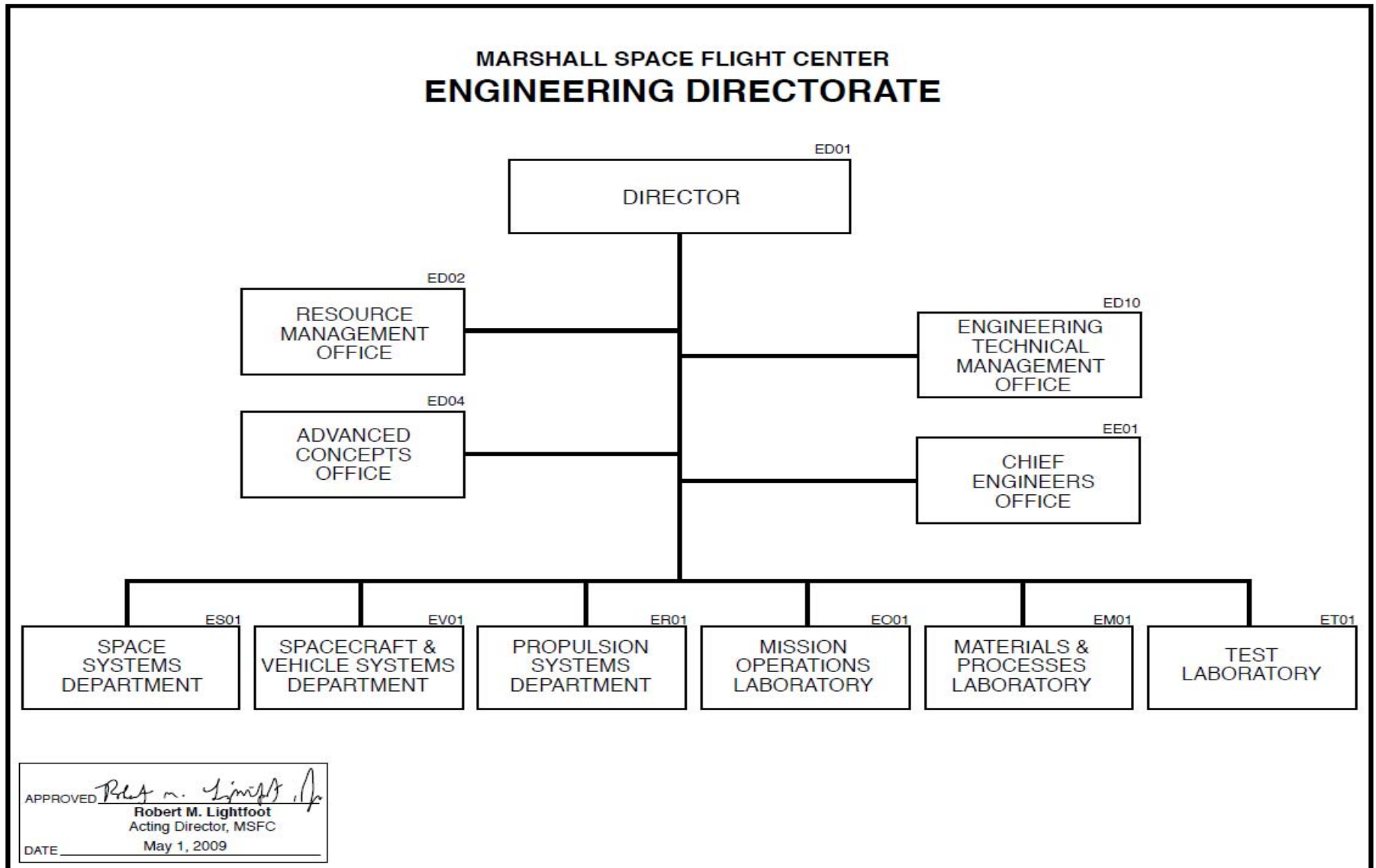
Lifting from Earth



Flexible, Modular Configuration for Exploration Missions

Engineering Directorate, Spacecraft and Vehicle Systems Department, Systems Engineering and Integration Division Organization Overview

MSFC Engineering Directorate



The Spacecraft and Vehicle Systems Department Mission

The Spacecraft and Vehicle Systems Department, Engineering Directorate, plans, performs and directs the technical Design, Analysis, Test, Evaluation, Verification, Integration, and Research & Development of the state of the art Spacecraft and Launch Vehicle Systems.

The Spacecraft and Vehicle Systems Department Organization

Spacecraft & Vehicle Systems Department (EV01)

Resource Management Office (EV02)

Flight Mechanics & Analysis Division (EV40)

Control Systems Design & Analysis Branch (EV41)

Guidance, Navigation & Mission Analysis Branch (EV42)

Integrated Systems Health Management & Sensors Branch (EV43)

Natural Environments Branch (EV44)

Systems Engineering & Integration Division (EV70)

Technical Management Branch (EV71)

Systems Design & Definition Branch (EV72)

Systems Test & Verification Branch (EV73)

Systems Analysis Branch (EV74)

Structural Design and Analysis Division (EV30)

Dynamics, Loads & Strength Branch (EV31)

Structural & Mechanical Design Branch (EV32)

Aerosciences Branch (EV33)

Thermal Analysis & Control Branch (EV34)

Systems Engineering & Integration (SE&I) Division

Systems Engineering & Integration Division

Technical Management Branch

- Technical work planning
- Schedules
- WBS/PBS development
- Design Reviews
- Design & Development Plans
- CoFR Planning
- Management of Design
- knowledge management
- Risk management
- TPM collection, analysis & reporting

System Design & Definition Branch

- System synthesis
- System architecture
- concept Functional analysis
- Functional Decomposition
- Requirement definition
- Requirement flow down & traceability
- Requirement analysis
- Requirement compliance
- Interface definition
- Interface Requirements
- Interface control & management
- design integration
- "Design-to" environments definition & coordination
- integrated environments
- LRU determination

System Test & Verification Branch

- Verification & validation planning, requirements/success criteria
- Acceptance planning
- Certification planning
- Qualification planning
- Test integration
- Special test equipment requirements & design coordination
- Test data analysis
- Test planning & preparation
- Test reporting
- Vehicle checkout
- System development test planning (ground & flight)
- Flight evaluation

System Analysis Branch

- Integrated design analysis (multi-system, multi-discipline)
- Human Factors
- Electrical Power & Energy Management
- Mass Properties
- Physical integration analysis
- Probabilistic design analysis
- Sensitivity analysis
- Uncertainty analysis

Systems Engineering Definitions

- Systems engineering is a methodical, disciplined approach for the design, realization, technical management, operations, and retirement of a system.
- Systems engineering is the art and science of developing an operable system capable of meeting requirements within often opposed constraints.
- Systems engineering is a holistic, integrative discipline, wherein the contributions of structural engineers, electrical engineers, mechanism designers, power engineers, **human factors engineers**, and many more disciplines are evaluated and balanced, one against another, to produce a coherent whole that is not dominated by the perspective of a single discipline.

Systems Engineering Engine

NASA Systems Engineering (SE) Engine

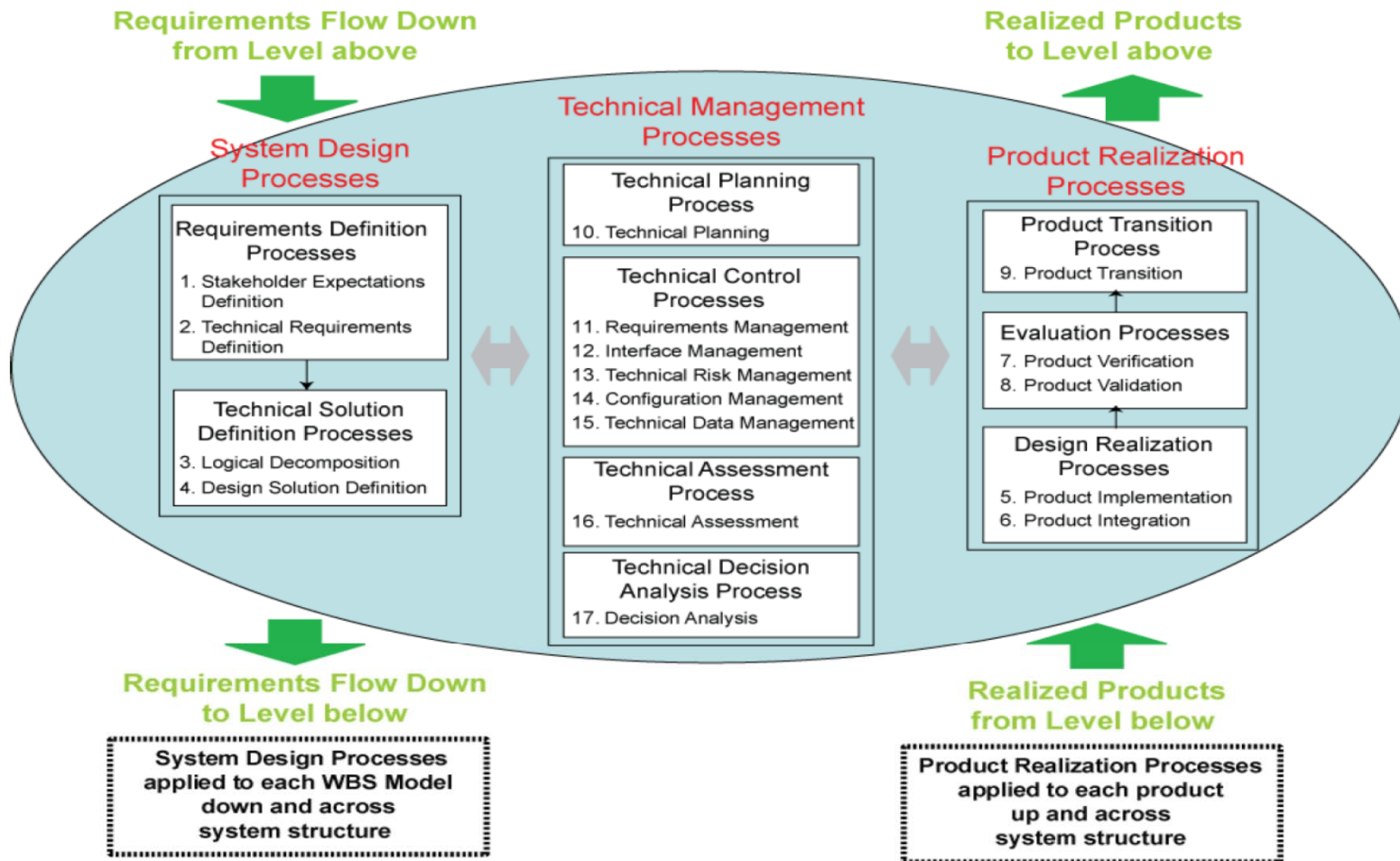


Figure 3-1 – SE Engine

SE Engine Description

- **Contains core set of common technical processes and requirements to be used by NASA projects in engineering system products during the product life cycle.**
- **The 17 common technical processes are enumerated according to their description in the NASA Interim Directive 7123_69, NASA Systems Engineering Processes and Requirements .**
- **SE common technical processes model illustrates the use of:**
 - (1) The system design processes for —top down design of each product in the system structure**
 - (2) The product realization processes for —bottom up realization of each product in the system structure**
 - (3) The technical management processes for planning, assessing, and controlling the implementation of the system design and product realization processes.**
 - (4) Guide technical decision making (decision analysis)**

SE Engine Definition

The SE common technical processes model is referred to as an —SE engine:

- To stress that these common technical processes are used to drive the development of the system products
- To stress that these common technical processes are used to drive the development of associated work products required by management to satisfy the applicable product-line life-cycle phase exit criteria
- While meeting stakeholder expectations within cost, schedule, and risk constraints.

Application of SE Engine Processes within System Functions

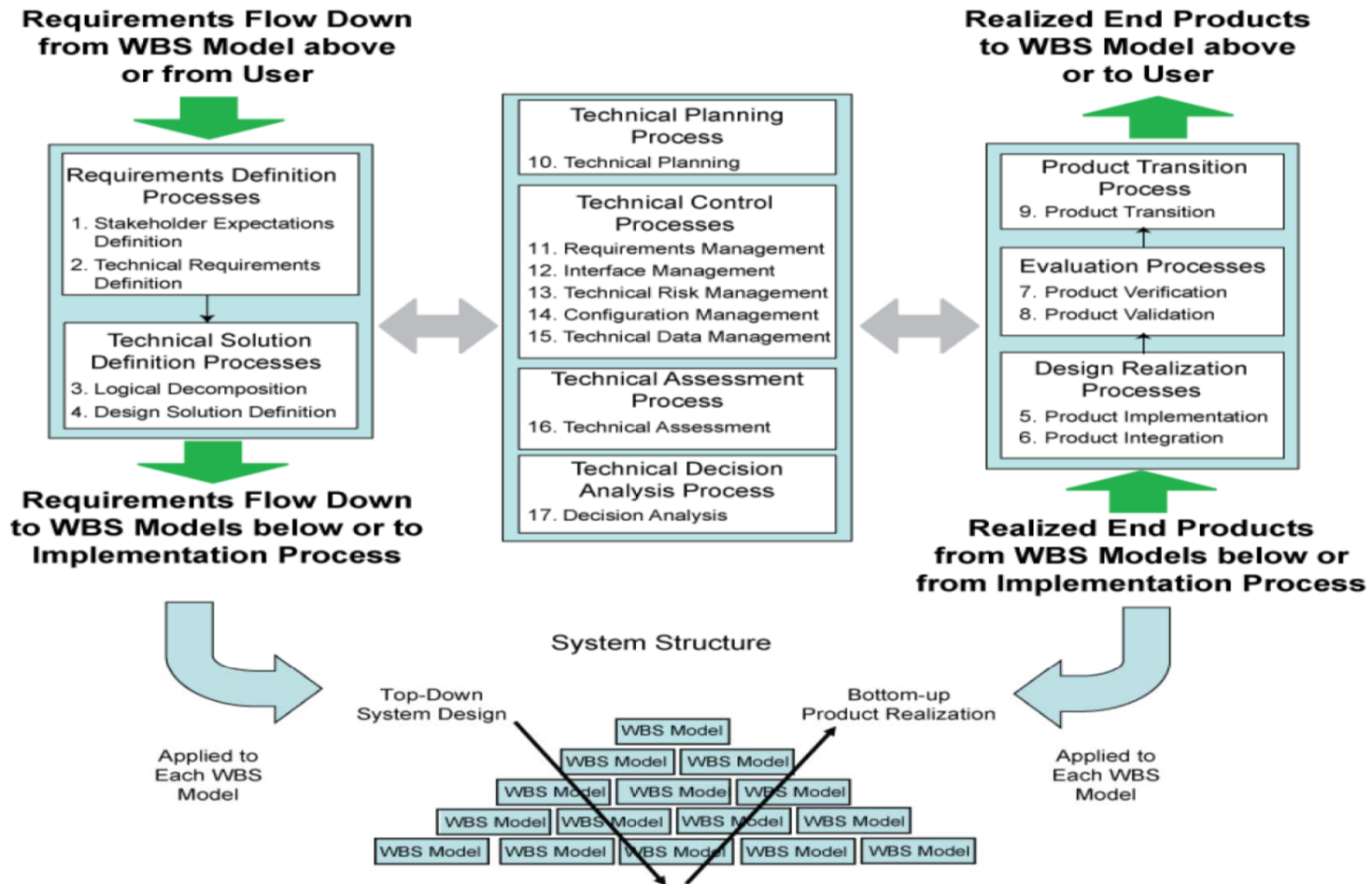
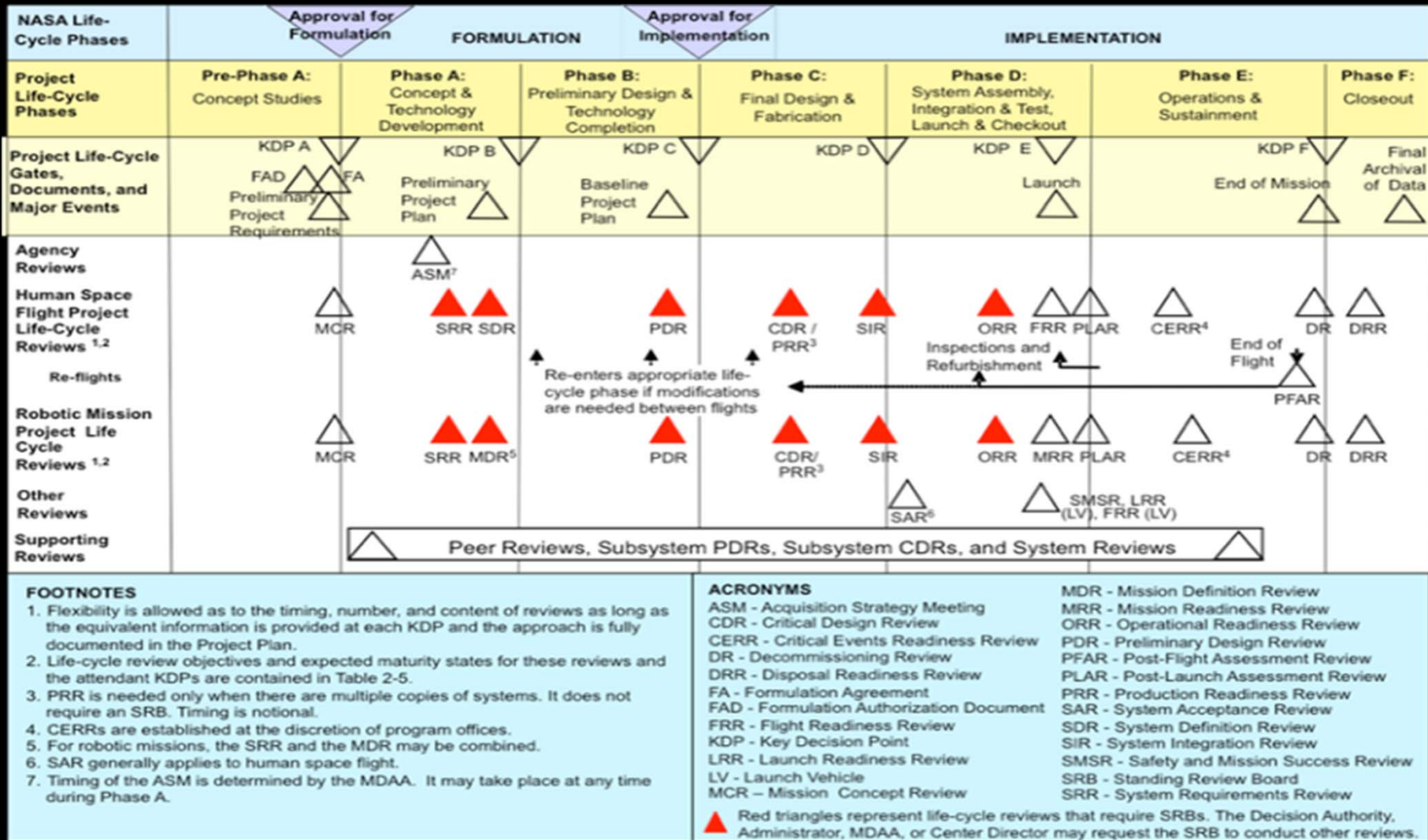


Figure 3-2 – Application of SE Engine Processes within System Structure

SE and the Work Breakdown Structure Models

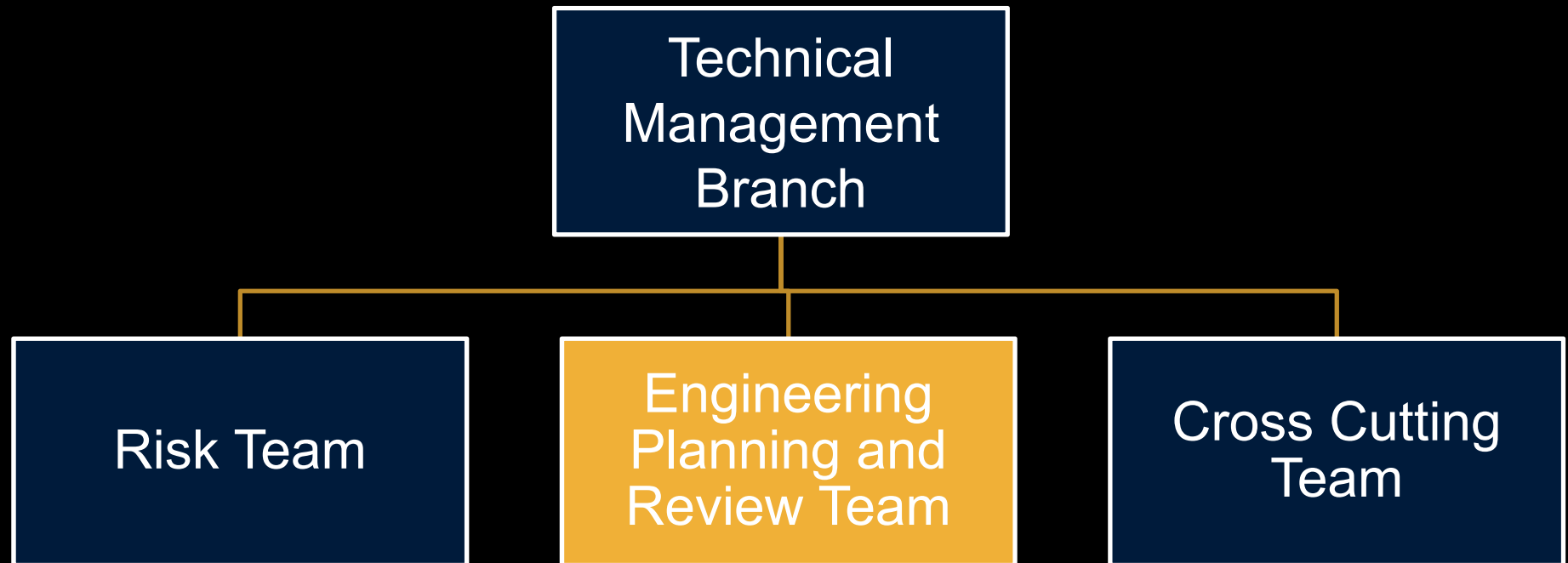
The common technical processes are used to **define the WBS models** of the system structure in each applicable phase of the relevant product-line life cycle **to generate work products and system products needed** to satisfy the exit criteria of the applicable phase. **System engineering continues well into the operations and maintenance phase of a project, i.e., after the system products are delivered.**

NASA Project Life Cycle



NPR 7120.5E, NASA Space Flight Program and Project Management Requirements

Technical Management Branch Organization



Technical Management Branch Services

•The Technical Management Branch provides systems design with the following products and services:

- Multidiscipline leadership

- Technical Guidance

- Technical Planning

 - Production and maintenance of technical plans such as the SEMP and Development Plans for the program/projects

 - Management of communication across interfaces

 - Technical Plan Implementation Assessments

- Milestone Technical Review Planning

- Decision Process Support

- Risk Management

- Technical Performance Metrics

Engineering Planning and Review Team Services

- Expertise

- Technical and Review Plan Development and Maintenance
- Drafting, negotiating, and baselining of technical plans such as a program or project's Systems Engineering Management Plan (SEMP)
- Mission Concept Review (MCR) Plan
- Other Review plans (i.e., SRR, SDR, PDR, CDR, DCR, etc.).

- Implementation of Plans

- Review Plan direction, implementation, and coordination
- Technical Plan Implementation Assessment

- Administrative

- RID Tool Support
- Review and RID Tool Training
- RID Tool Account maintenance during program reviews
- Track and monitor RID review process to assure closure of open RIDs

Technical Reviews

Technical Review Definition

•A technical review is an evaluation of the project, or element thereof, by a knowledgeable group for the purposes of:

- a. Assessing the status of and progress toward accomplishing the planned activities.
- b. Validating the technical tradeoffs explored and design solutions proposed.
- c. Identifying technical weaknesses or marginal design and potential problems (risks) and recommending improvements and corrective actions.
- d. Making judgments on the activities' readiness for the follow-on events, including additional future evaluation milestones to improve the likelihood of a successful outcome.
- e. Making assessments and recommendations to the project team, Center, and Agency management.
- f. Providing a historical record that can be referenced of decisions that were made during these formal reviews.
- g. Assessing the technical risk status and current risk profile.

Technical Review Execution Guidance

- The technical team shall execute the required technical review in accordance with the review entry and success criteria guidance in governing documentation.
- Reviews are considered complete when the following are accomplished:
 - a. Agreement exists for the disposition of all Review Item Discrepancies (RIDs) and Request for Actions (RFA).
 - b. The review board report and minutes are complete and distributed.
 - c. Agreement exists on a plan to address the issues and concerns in the review board's report.
 - d. Agreement exists on a plan for addressing the actions identified out of the review.
 - e. Liens against the review results are closed, or an adequate and timely plan exists for their closure.
 - f. Differences of opinion between the project under review and the review board(s) have been resolved, or a timely plan exists to resolve the issues.
 - g. A report is given by the review board chairperson to the appropriate management and governing program management committees (PMCs) charged with oversight of the project.
 - h. Appropriate procedures and controls are instituted to ensure that all actions from reviews are followed and verified through implementation to closure.

Entrance and Success Criteria

Reference: NID 7123.69, NASA Systems Engineering Processes and Requirements

Table G-7 – PDR Entrance and Success Criteria

Preliminary Design Review	
Entrance Criteria	Success Criteria
<ol style="list-style-type: none"> 1. Successful completion of the SDR or MDR and responses made to all SDR or MDR RFAs and RIDs, or a timely closure plan exists for those remaining open. 2. A preliminary PDR agenda, success criteria, and charge to the board have been agreed to by the technical team, project manager, and review chair prior to the PDR. 3. PDR technical products listed below for both hardware and software system elements have been made available to the cognizant participants prior to the review: <ol style="list-style-type: none"> a. Updated baselined documentation, as required. b. Preliminary subsystem design specifications for each configuration item (hardware and software), with supporting trade-off analyses and data, as required. The preliminary software design specification should include a completed definition of the software architecture and a preliminary database design description, as applicable. c. Updated technology development maturity assessment plan. d. Updated risk assessment and mitigation. e. Updated cost and schedule data. f. Updated logistics documentation, as required. g. Applicable technical plans (e.g., technical performance measurement plan, contamination control plan, parts management plan, environments control plan, EMI/EMC control plan, payload-to-carrier integration plan, producibility/manufacturability program plan, reliability program plan, quality assurance plan). h. Applicable standards. i. Safety analyses and plans. j. Engineering drawing tree. k. Interface control documents. l. Verification/validation plan. m. Plans to respond to regulatory requirements (e.g., Environmental Impact Statement), as required. n. Disposal plan. o. Technical resource utilization estimates and margins. p. System-level safety analysis. q. Preliminary limited life items list (LLIL). 	<ol style="list-style-type: none"> 1. The top-level requirements—including mission success criteria, TPMs, and any sponsor-imposed constraints—are agreed upon, finalized, stated clearly, and consistent with the preliminary design. 2. The flow down of verifiable requirements is complete and proper or, if not, an adequate plan exists for timely resolution of open items. Requirements are traceable to mission goals and objectives. 3. The preliminary design is expected to meet the requirements at an acceptable level of risk. 4. Definition of the technical interfaces is consistent with the overall technical maturity and provides an acceptable level of risk. 5. Adequate technical interfaces are consistent with the overall technical maturity and provide an acceptable level of risk. 6. Adequate technical margins exist with respect to TPMs. 7. Any required new technology has been developed to an adequate state of readiness, or back-up options exist and are supported to make them a viable alternative. 8. The project risks are understood and have been credibly assessed, and plans, a process, and resources exist to effectively manage them. 9. Safety and mission assurance (e.g., safety, reliability, maintainability, quality, and EEE parts) have been adequately addressed in preliminary designs and any applicable S&MA products (e.g., PRA, system safety analysis, and failure modes and effects analysis) have been approved. 10. The operational concept is technically sound, includes (where appropriate) human factors, and includes the flow down of requirements for its execution.

Technical Review Stages

- **Review Planning**
- **Checkpoint**
- **Review Logistics and Preparation (Includes Training)**
- **Kickoff**
- **Review Execution**
- **Reporting to Management**
- **Review Item Discrepancy (RID) Burndown/RID Positioning Process**
- **Review Complete**

Review Planning Life Cycle

18 Months									
10 Months			2 Months			6 Months			
16 Weeks		16 Weeks		8 Weeks		6 Weeks		1 Week	
16 Weeks		1 Week		1 Week		4 Weeks		20 Weeks	
Development Phase				Execution Phase			Closeout Phase		
Features	Planning Stage		Checkpoint Stage	Preparation Stage	Review Stage	Pre-Board Stage	Board Stage	Reporting Stage	Burndown Stage
	ATP	Plan Complete	Checkpoint	Kickoff	Dispositions Complete	Pre board	Board	CMC	Review Complete
Objectives	• Develop and approve Milestone Review Plan		• Determine readiness to proceed to the review	• Finalize review plans • Compile data package • Prepare for Kickoff	• Hold Kickoff • Generate, screen & disposition RIDs	• Hold Preboard to disposition RIDs and decide if criteria met	• Hold Board to disposition RIDs and determine Go/No-go	• Report review outcomes to external stakeholders	• Conduct activities to close RIDs • Improve Process
Primary Participants	• PM (Decision Makers) • CE / LSE		• Product Developers • Checkpoint Board	• Product Developers • Review Teams • Board & Preboard • SRB	• Product Developers • Review Teams • Screening Teams • SRB	• RID Sponsors • Pre-Board • SRB	• RID Sponsors • Board • SRB	• PM • CE • PMC • CMC	• Actionees
Primary Activities	• Determine Plan Parameters • Baseline the Plan		• Provide data item status • Conduct Dry Run • Conduct Checkpoint • Identify Participants	• Deliver Documents • Participant Training • Conduct Dry Run • Conduct Kickoff	• Review Documents • Write Pre-RIDs • Conduct Tabletops • Conduct Screening • Define Impacts • Develop Dispositions	• Conduct Dry Run • Conduct Pre-Board	• Conduct Dry Run • Conduct Board	• Prepare Review Report • Deliver External Briefings • Conduct PAL Sessions	• RID Closure Activity • Revise Review Plan for As-run
Primary Products	• Program Decision Memo • Review Plan • ToR		• Checkpoint Plan • Checkpoint Package • Go/no-go decision • Checkpoint Actions	• Training Package • Data Package • Pre-Declared RIDs • Kickoff Presentation • Kickoff Actions	• Pre-RIDs • Tabletop Schedule • RIDs	• Pre board Presentation • Approved RIDs • Preboard Decisions / Minutes / Actions	• Board Presentation • Approved RIDs • Board Decisions/ Minutes / Actions	• Review Report / Presentations	• RID Closure Data • As-run Review Plan
Support Participants	• Review Director • Plan Doc Owner • Data Mgmt. Support • IT Support		• Review Director • RID Coordinator • Data Mgmt. Support • Logistics Support • IT Support	• Review Director • RID Coordinator • Data Mgmt. Support • Logistics Support • IT Support	• Review Director • RID Coordinator • Data Mgmt. Support • Logistics Support • IT Support	• Review Director • RID Coordinator • Data Mgmt. Support • Logistics Support • IT Support	• Review Director • RID Coordinator • Data Mgmt. Support • Logistics Support • IT Support	• Review Director • Data Mgmt. Support • Logistics Support	• Review Director • RID Coordinator • Data Mgmt. Support
Support Activities	• Establish Core Team • Conduct CT Logistics • Develop Plan Inputs • Conduct Tabletop • Manage Change Pkg		• Plan Review Logistics • Prepare Checkpoint Package • Conduct IT Logistics • Train Support Staff	• Plan Kickoff Logistics • Prepare Kickoff Presentation • Conduct Kickoff Logistics	• Conduct Review Logistics • Provide Review Support • Plan Pre-Board Logistics	• Prepare Preboard Presentations • Conduct PB Logistics • Provide PB Support • Plan Board Logistics	• Prepare Board Presentations • Conduct Board Logistics	• Prepare Pause & Learn Presentations • Compile Lessons Learned	• Make improvements to RID tool • Prepare As-Run Plan • Manage Change Pkg • Track RID Burndown
Support Products/ Services	• Core Team Wiki • Plan Change Package / Presentations		• CP Dropped item Q list • CP Distro Lists/ Invites • CP Portal / Drop Box • Product QA Checklist	• KO Distro Lists / Invites • KO Badges/ Sign-in • KO A/V Services • KO Graphics Services • KO Facilities Services • KO Borrowed Items List • KO Food Services	• Distro Lists / Invites • Badges/ Sign-in • A/V Services • Facilities Services • Borrowed Items List • Food Services	• PB Distro Lists / Invites • PB Badges/ Sign-in • PB A/V Services • PB Graphics Services • PB Facilities Services • PB Borrowed Items List • PB Food Services	• Bd Distro Lists / Invites • Bd Badges/ Sign-in • Bd A/V Services • Bd Graphics Services • Bd Facilities Services • Bd Borrowed Items List • Bd Food Services	• Lessons Learned	• RID Tool enhancements • Plan Change Package / Presentations

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Example Review Approach

- Review is focused on the adequacy of the technical approach focused on the program and vehicle integration
- MPR 7123.2A milestone success criteria and safety criteria are used to guide the assessment
- Review teams addressed program and vehicle integration of the system requirements, design definition and safety by assessing each of the success criteria from their perspective
- RIDs written against not meeting criteria – not against documents

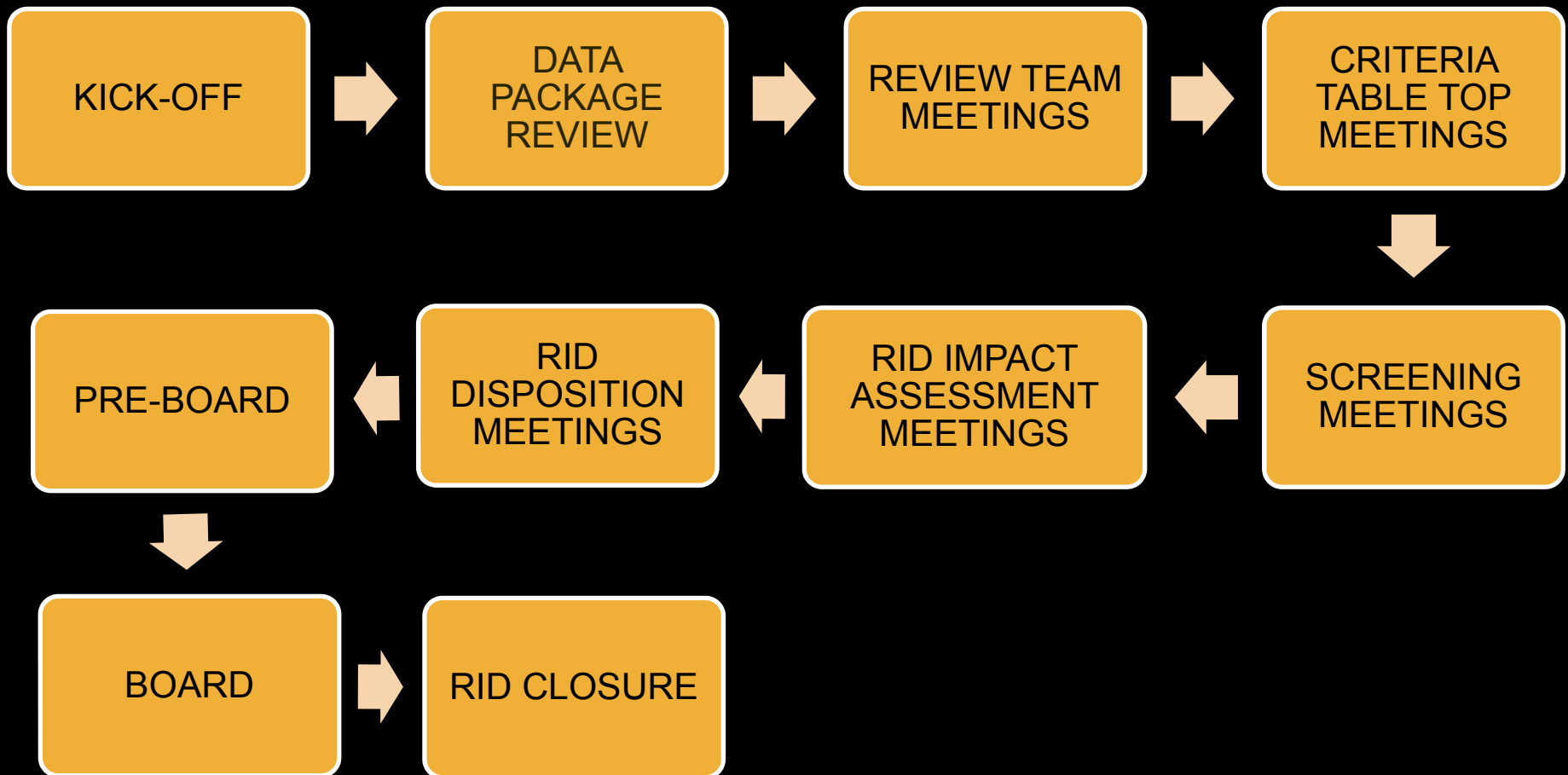
Example Team Approach

- **Discipline Review Teams**
 - Organized by functional teams
 - Review teams to represent the implementation of the program, technical and safety organizations
 - Review Team Leads and team members are independent of the program or project being reviewed
 - Review teams served as dispositioning team for RIDs originating or assigned to their team
- **Screening Committee**
 - Led by Lead System Engineer
 - Membership included the review team leads
- **Pre-Board**
 - Chaired by the Chief Engineer
 - Membership defined in Program/Project Review Plan or in a memorandum
- **Board**
 - Chaired by the Program Manager
 - Membership defined in Program/Project Review Plan or in a memorandum
-

Example Review Schedule

Description	Start	Stop
Data Package Delivered	2/1/2012	2/1/2012
Pre-declared RID Cutoff	2/1/2012	2/1/2012
Data Package Available	2/6/2012	2/6/2012
Kickoff Meeting	2/15/2012	2/16/2012
Data Package Review	2/16/2012	2/23/2012
Team Meetings	2/16/2012	2/23/2012
Pre-RID Submittal	2/16/2012	2/26/2012
Pre-RID Cutoff	2/26/2012	2/26/2012
Tabletop Meetings (discuss Pre-RIDs)	2/27/2012	3/6/2012
RID Integrated Screening	2/29/2012	3/8/2012
Document Developer/Actionee Response	3/9/2012	3/12/2012
RID Disposition Meetings	3/13/2012	3/19/2012
Pre-Board Preparation	3/20/2012	3/23/2012
Pre-Board	3/26/2012	3/27/2012
Board Preparation	3/28/2012	3/28/2012
Board	3/29/2012	3/29/2012

Example Review Process



Human Factors

NASA Systems Engineering Handbook Human Factors Definition

Human factors engineering is the discipline that studies the human-system interfaces and provides requirements, standards, and guidelines to ensure the human component of the integrated system is able to function as intended.

Four Categories of Human Factors

- The first is anthropometry and biomechanics—the physical size, shape, and strength of the humans.
- The second is sensation and perception—primarily vision and hearing, but senses such as touch are also important.
- The environment is a third factor—ambient noise and lighting, vibration, temperature and humidity, atmospheric composition, and contaminants.
- Psychological factors comprise memory; information processing component such as pattern recognition, decisionmaking, and signal detection; and affective factors—e.g., emotions, cultural patterns.

Reference: NASA/SP-2007-6105

Human Factors Engineering in the System Design Process

- Stakeholder Expectations

- Requirements Definition

- ❑ NASA-STD-3001, NASA SPACE FLIGHT HUMAN SYSTEM STANDARD
VOLUME 1: CREW HEALTH
- ❑ NASA-STD-3001, NASA SPACE FLIGHT HUMAN-SYSTEM STANDARD
VOLUME 2: **HUMAN FACTORS**, HABITABILITY, AND ENVIRONMENTAL HEALTH
- ❑ NASA/SP-2010-3407, HUMAN INTEGRATION DESIGN HANDBOOK (HIDH)

- Technical Solution

- Usability Evaluations of Design Concepts

- Verification

Reference: NASA/SP-2007-6105

What does a Human Factors Specialist do at NASA?

The human factors specialist supports the systems engineering process by representing the users' and maintainers' requirements and capabilities throughout the design, production, and operations stages.

Human Factor Specialist Roles

- Identify applicable requirements based on Agency standards for human-system integration during the requirements definition phase.
- Support development of mission concepts by providing information on human performance capabilities and limitations.
- Support task analysis and function allocation with information on human capabilities and limitations.
- Identify system design features that enhance usability. This integrates knowledge of human performance capabilities and design features.
- Support trade studies by providing data on effects of alternative designs on time to complete tasks, workload, and error rates.
- Support trade studies by providing data on effects of alternative designs on skills and training required to operate the system.
- Support design reviews to ensure compliance with human-systems integration requirements.
- Conduct evaluations using mockups and prototypes to provide detailed data on user performance.
- Support development of training and maintenance procedures in conjunction with hardware designers and mission planners.
- Collect data on human-system integration issues during operations to inform future designs.

MSFC Human Factors Team

- This team is the discipline center of expertise at Marshall.
- The team's specialties are worksite design, usability, and human modeling.
- The team has mockup development and use expertise, as well as CAD-based simulation.
- We create human:systems interaction requirements, identify verification methods, and complete verification.

•MSFC HFE deals with a broad range of human interface design considerations

- Worksite design
 - Work, reach, & visual envelopes
 - Lighting
 - Tools & support equipment
- Human:Computer Interaction
 - Displays design
 - Usability testing
- Human:Robotic Interaction
- Effects of special space environments
 - Vibration (during launch)
 - Weightlessness
 - Ability to perform work tasks
- Habitability; not strictly HFE, but is system-level HF

•Tools

- Mockups

- Wood, foamcore, plastic, metal
- Fidelity appropriate to information needed
 - Typically, higher as design matures



•Ares rocket Upper Stage instrument unit; wood

- Human modeling



•Ares; evaluation of connector panel access

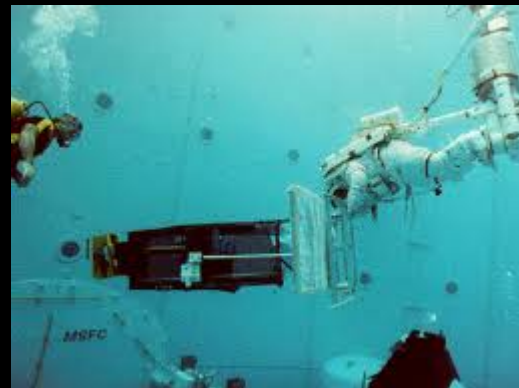


- Motion capture

•Motion capture: simple task analysis



- Neutral buoyancy



•MSFC Neutral Buoyancy Simulator (closed)

•History

• Skylab (first American Station) Crew systems

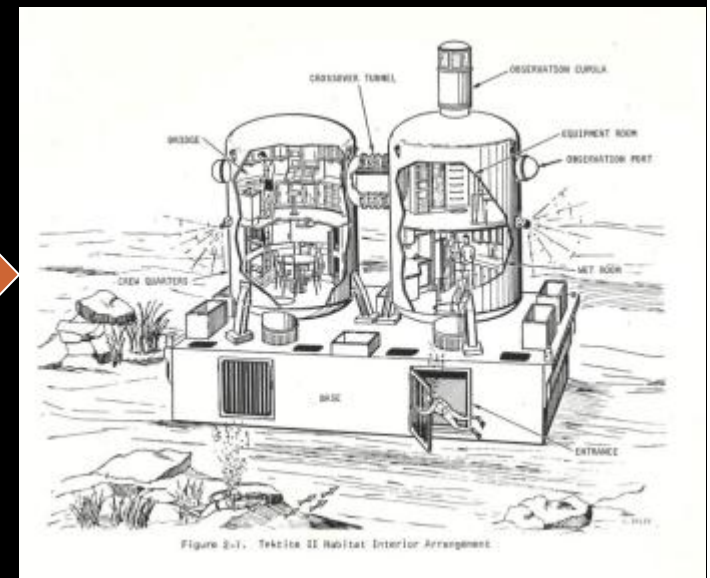
- Life support
- Crew quarters
- Deconditioning mitigation
- Displays and controls
- Maintenance
- Procedures & training
- Skylab design:
 - Tektite underwater lab for habitability studies



•Skylab, 1973-4

• Shuttle

- Payloads (science)
 - Procedures & training
 - Displays & controls
 - Maintenance
- Hubble EVA
 - Maintenance



•Tektite II, 1970

•Recent

- International Space Station

- Module design for crew use: similar to Skylab design work
- Physical design for experiments (payloads) and subsystems, such as life support
 - For operation and maintenance
- EVA design



•Nodes 2 & 3:
•MSFC

- Constellation (moon program)

- Worksite design for ground crews assembling Ares rocket
- Vibration effects on astronaut task performance

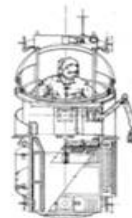


•Robot arm
delivery: MSFC
design

- Deep-space habitability studies

- Single-person spacecraft studies

•FlexCraft



•Space habitat
concept evaluation



NASA Community of Practice Human Factors Link

<https://nen.nasa.gov/web/hf>

Questions

Closing Remarks