Panel Discussion on Certification Efficiency of Composite Structure for Spacecraft – NASA Missions

Stephen Scotti*
Langley Senior Technologist for Advanced Materials & Structural Systems
NASA Langley Research Center

American Society of Composites
31st Technical Conference
20 September, 2016

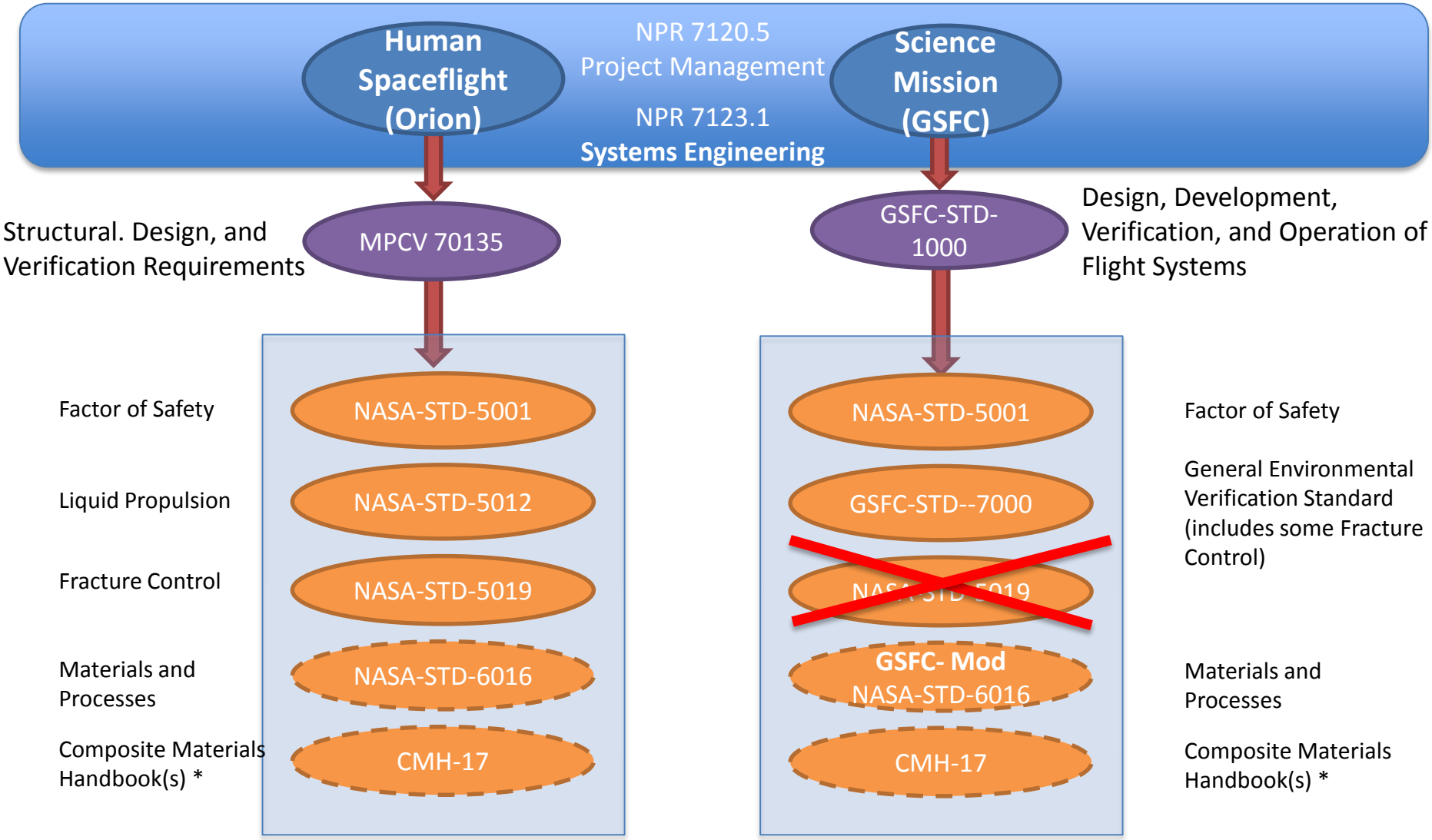
* With inputs from NASA's Materials, Structures, and NDE Capability Leadership Teams

Introduction

- NASA has several roles related to composite structures
  - Develops hardware for its missions - usually with Industry as a prime contractor
  - Develops “certification” standards for systems that perform its missions
  - Certifies flight readiness for its missions
  - Performs and sponsors research that is infused into NASA, DoD, or Civil uses

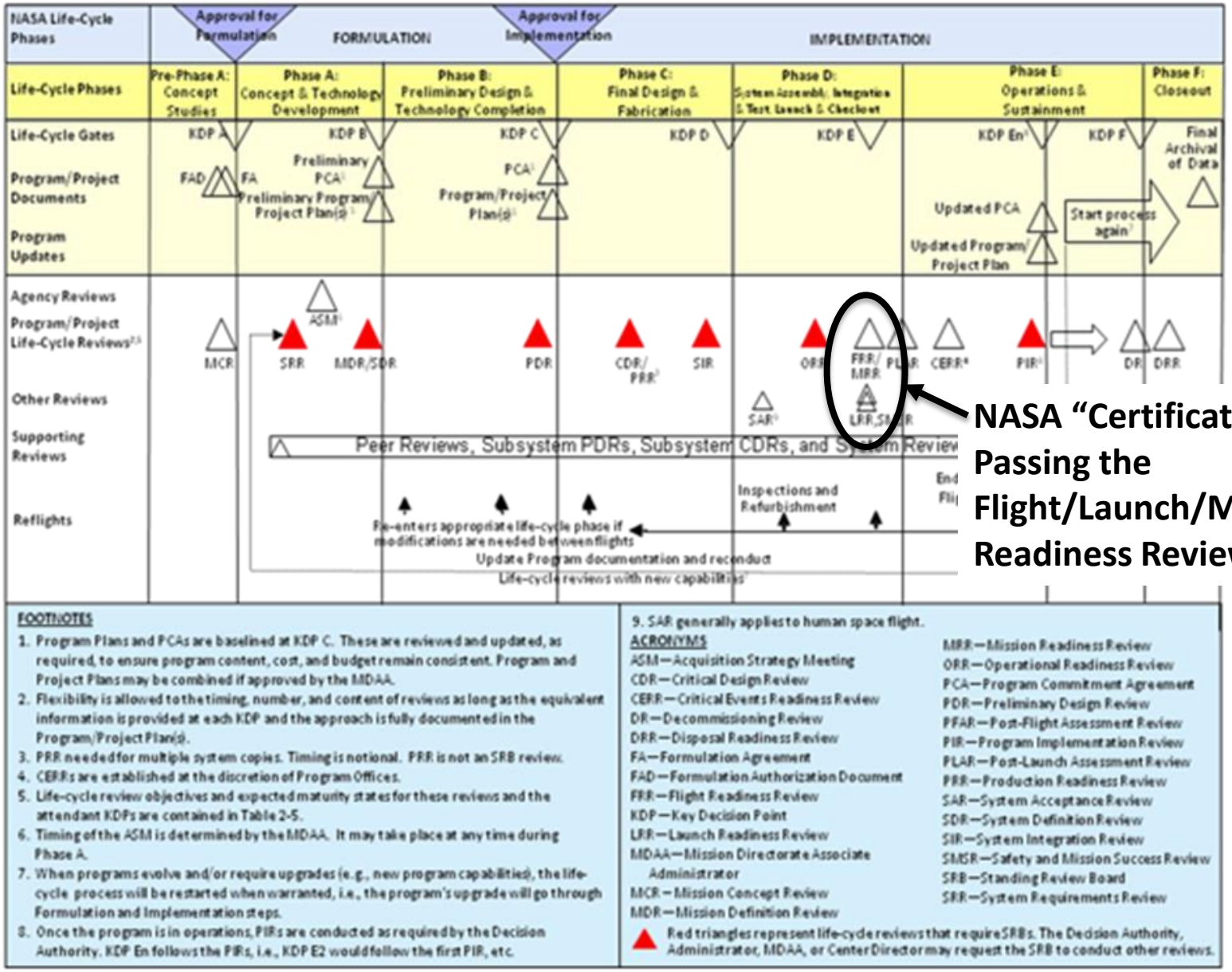
- NASA Science Missions (e.g., Hubble Space Telescope) and Human Spaceflight Missions (e.g., Space Shuttle or Orion) generally use different “certification” standards

Comparison of Human Spaceflight and Science Requirement Trees for Composites



* Superseding MIL-HDBK-17

NASA Project Lifecycle



NASA "Certification" is Passing the Flight/Launch/Mission Readiness Review

FOOTNOTES

1. Program Plans and PCAs are baselined at KDP C. These are reviewed and updated, as required, to ensure program content, cost, and budget remain consistent. Program and Project Plans may be combined if approved by the MDAA.
2. 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 Program/Project Plan(s).
3. PRR needed for multiple system copies. Timing is notional. PRR is not an SRB review.
4. CERRs are established at the discretion of Program Offices.
5. Life-cycle review objectives and expected maturity states for these reviews and the attendant KDPs are contained in Table 2-5.
6. Timing of the ASM is determined by the MDAA. It may take place at any time during Phase A.
7. When programs evolve and/or require upgrades (e.g., new program capabilities), the life-cycle process will be restarted when warranted, i.e., the program's upgrade will go through Formulation and Implementation steps.
8. Once the program is in operations, PIRs are conducted as required by the Decision Authority. KDP En follows the PIRs, i.e., KDP E2 would follow the first PIR, etc.
9. SAR generally applies to human space flight.

ACRONYMS

ASM—Acquisition Strategy Meeting
CDR—Critical Design Review
CERR—Critical Events Readiness Review
DR—Decommissioning Review
DRR—Disposal Readiness Review
FA—Formulation Agreement
FAD—Formulation Authorization Document
FRR—Flight Readiness Review
KDP—Key Decision Point
LRR—Launch Readiness Review
MDAA—Mission Directorate Associate Administrator
MCR—Mission Concept Review
MDR—Mission Definition Review
MRR—Mission Readiness Review
ORR—Operational Readiness Review
PCA—Program Commitment Agreement
PDR—Preliminary Design Review
PFAR—Post-Flight Assessment Review
PIR—Program Implementation Review
PLAR—Post-Launch Assessment Review
PRR—Production Readiness Review
SAR—System Acceptance Review
SDR—System Definition Review
SIR—System Integration Review
SMSR—Safety and Mission Success Review
SRB—Standing Review Board
SRR—System Requirements Review

▲ Red triangles represent life-cycle reviews that require SRBs. The Decision Authority, Administrator, MDAA, or Center Director may request the SRB to conduct other reviews.

Comments on NASA Composite "Certification"

- Structural requirements

	Human Spaceflight	Science
Allowables	A-Basis*	B-Basis
Static Factor of Safety	1.4/1.5** (2 at discontinuities)	1.5
Fracture Control	All Structures	Damage Protection Plan
Proof Test	All Structures	All Structures

- Many additional materials requirements (e.g., Flammability, outgassing, fluid compatibility, radiation, atomic oxygen)
- NASA approves verification/substantiation of meeting technical requirements by Technical Authority and in control boards (M&P, Fracture Control)
- Building Block Approach required for Fracture Critical components
  - Damage Threat Assessment, Damage Protection Plan, etc.
  - Nondestructive evaluation (NDE) is an important element in acceptance and damage tolerance verification
- Probabilistic approaches are possible but much be approved by the Technical Authority

Technology R&D Suggestions

- **Structural Materials for Space Application**
  - Development and qualification of structural polymer matrix composites (PMC's) for NASA unique space exploration applications designed to achieve ultra lightweight, high strength, high stiffness, and thermal material performance as low as -423°F and as high as 600°F
  - Cost effective development and verification of properties (as required by 6016) at the *required environmental conditions*

- **Materials reliability – Advanced Computational and Analytical Tools**
  - Develop new analytical methods and predictive durability and damage tolerance models for complex parts and advanced manufacturing processes
  - Additive Manufacturing Technologies - Characterization and test methods for evaluation of material properties and environmental effects on material systems
  - Development and validation of computationally designed structural material systems/structural elements (e.g., complex joint designs)

Technology R&D Suggestions - Continued

- **NDE for Composites and Bonded Structure**
  - Improves NDE techniques for complicated material forms and structures
  - Rapid inspection of large areas and dealing with correspondingly large sets of acquired data by maturing computational NDE technologies

- **Multi-disciplinary multi-physics analyses with emphasis on verification and validation**
  - Development and implementation of algorithms to update existing analysis codes on massively parallel computer systems
  - Development of automated methods to efficiently pass data across disciplines when performing multi-disciplinary analysis

- **Maturing Probabilistic Engineering to quantify structural reliability**
  - NASA Standards and Program Structural Requirements allow for alternative approaches such as probabilistic methods, but NASA lacks the personnel actively working/understanding these processes
  - Replacing traditional Factor of Safety practices to enable low mass designs
  - Provides Technical Authority with a tool to make risk-based decisions on requests for waivers and deviations of requirements