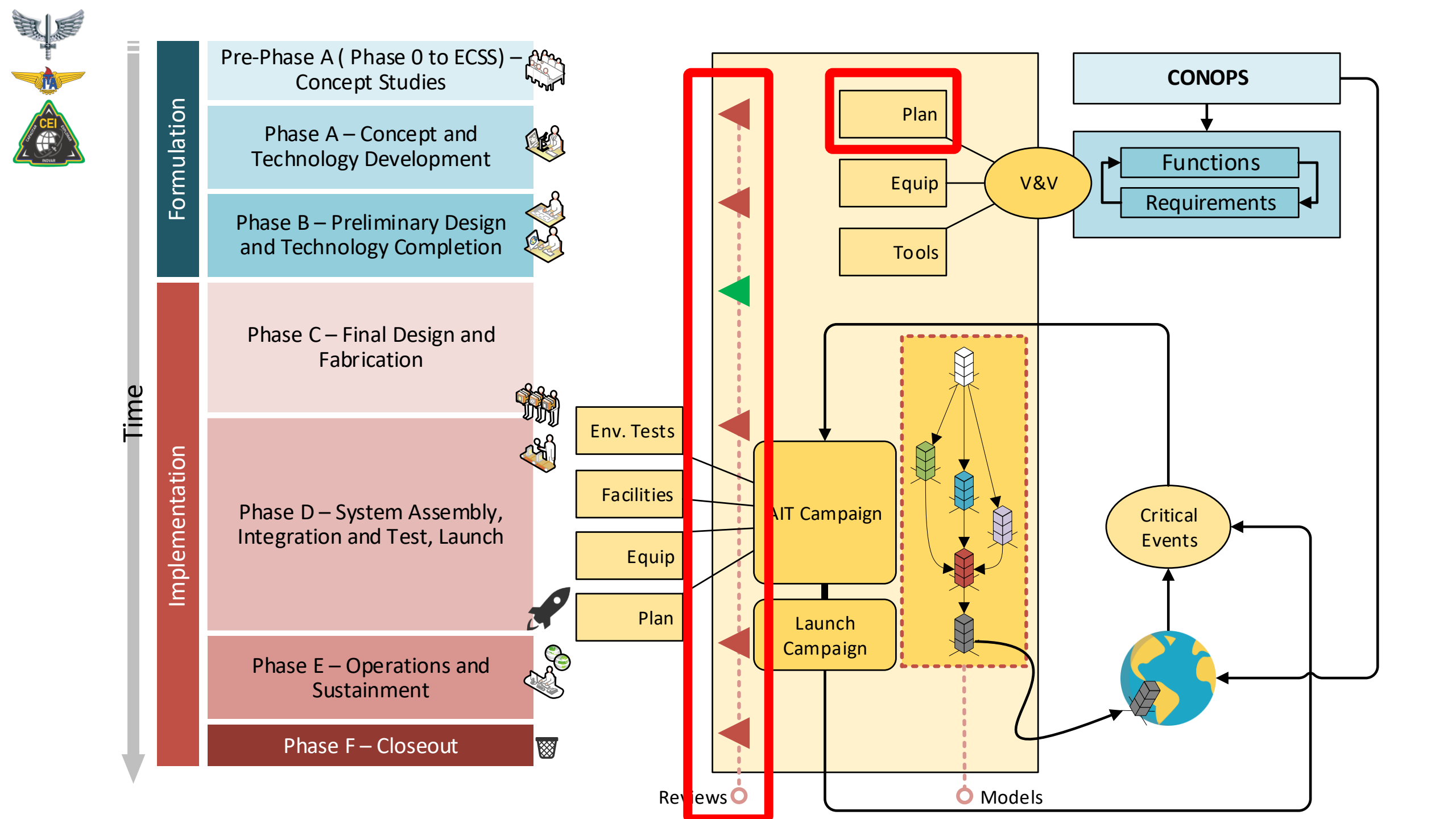
Life Cycle, Reviews & Baselines

[SIS-08][LEC-004]

Date	SES	In Class	Deliverables
Aug, 1	01	[LEC-000] Course Introduction [LEC-001] SE Review	-
Aug, 8	02	[LEC-002] Global Verification Process	[PRD-001] [redacted]
Aug, 15	03	[LEC-003] Tool and Processes to Verification	[PRD-002] [redacted] Product Tree
Aug, 22	04	[LEC-004] Life Cycle, Reviews & Baselines	[PRD-003] Revised Requirements
Aug, 29	05	[LEC-005] Model Philosophy	[PRD-004] Verifications per Requirement through the Life Cycle
Sep, 5	06	[LEC-006] Preparing to test Campaigns	[PRD-005] Models
Sep, 12	07	[LEC-007] Planning V&V	[PRD-006] Test Articles, Procedures & VCD
Sep, 19	08	[TST-001] V&V Conceptual Questions [PRD-007] DRAFT V&V Plan Presentation	[PRD-007] DRAFT V&V Plan (DVM)
Sep, 26	Week off		
Oct, 03	09	[LEC-008] AIT Process	[PRD-008] End to End Test Articles
Oct, 10	10	[LEC-009] Critical Events & Environmental Tests	[PRD-009] AIT Activities through the Life Cycle
Oct, 17	11	[LEC-010] Testing Facilities	[PRD-010] Vehicle and On-Orbit Testing
Oct, 24	12	[LEC-011] Planning AIT	[PRD-011] Facilities
Oct, 31	13	[LEC-012] GSEs [LEC-013] SCOE/OCOE	[PRD-012] AIT Flows & Activity Log
Nov, 07	14	[LEC-014] Launching Campaign	[PRD-013] GSEs
Nov, 14	15	[LEC-015] Trends / MBSE / Industry 4.0	[PRD-014] AIT Task Sheets [PRD-015] Vehicle Integration & Launching Plan
Nov, 21	16	[TST-002] AIT Conceptual Questions [PRD-016] V&V & AIT Plans Presentation	[PRD-016] V&V & AIT Plans
Nov, 28 Dez, 05	EXAM: Design of an AIT Facility to ITA's SmallSat Projects		

CONOPS


Time
Formulation
Implementation
Pre-Phase A (Phase 0 to ECSS) – Concept Studies
Phase A – Concept and Technology Development
Phase B – Preliminary Design and Technology Completion
Phase C – Final Design and Fabrication
Phase D – System Assembly, Integration and Test, Launch
Phase E – Operations and Sustainment
Phase F – Closeout
Env. Tests
Facilities
Equip
Plan
AIT Campaign
Launch Campaign
Plan
Equip
Tools
V&V
CONOPS
Functions
Requirements
Critical Events
Reviews
Models

Life cycle Objectives

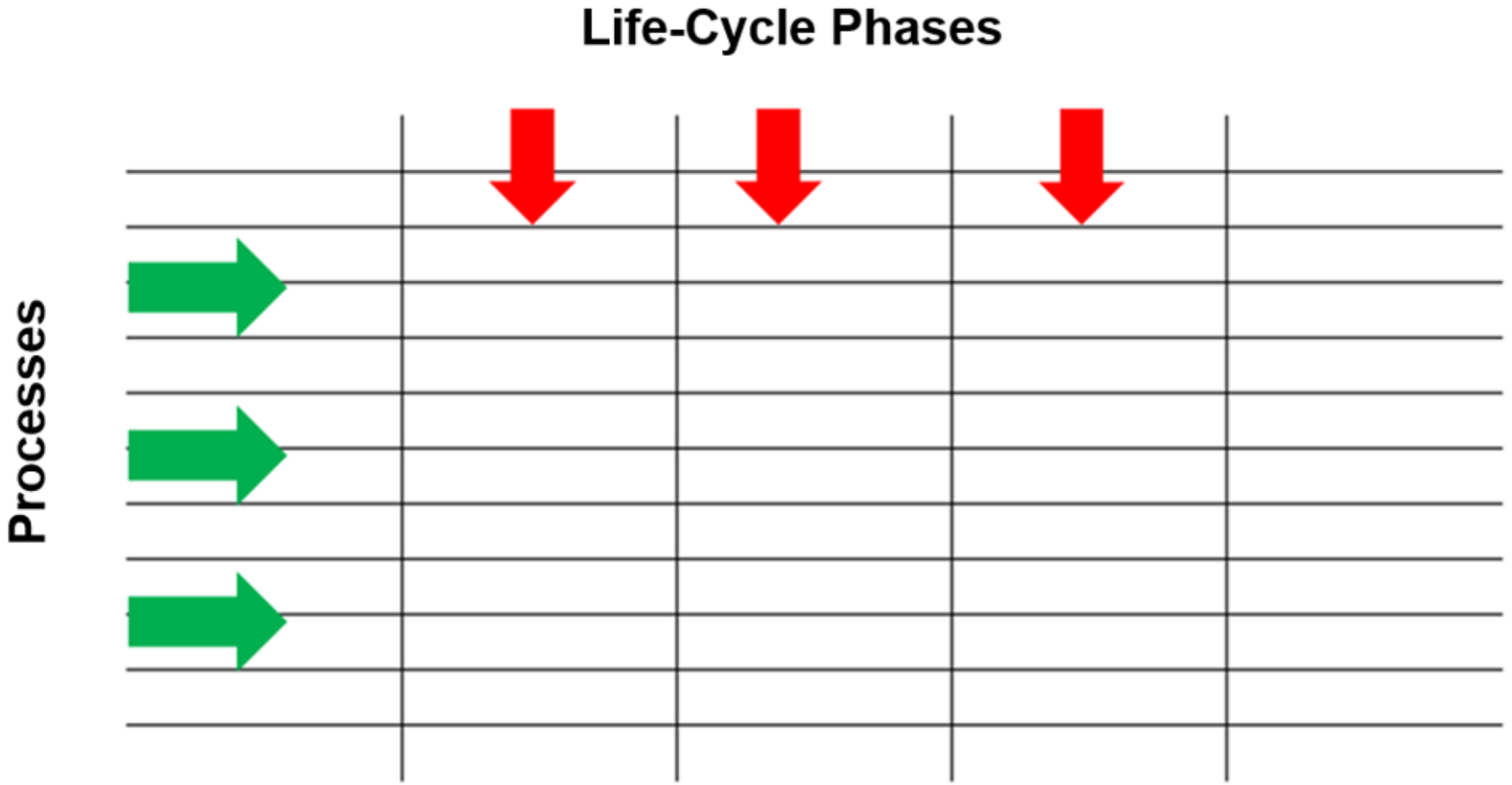
- Lifecycle phases are used to help plan and manage all major aerospace system developments.
- Everything that should be done to accomplish a project is divided into distinct *phases*, separated by *control gates*.
- For NASA the phases are lettered: Pre-Phase A, Phase A, Phase B, Phase C, Phase D, Phase E, Phase F
- Phase boundaries are defined at natural points for project progress assessment and *go/no go* decisions.
- Decomposing the project into life cycle phases organizes the development process into smaller more manageable pieces.
- Since early decisions commit later activities and more mature systems are harder to change, systems engineering done in the early phases has the greatest impact on mission success.

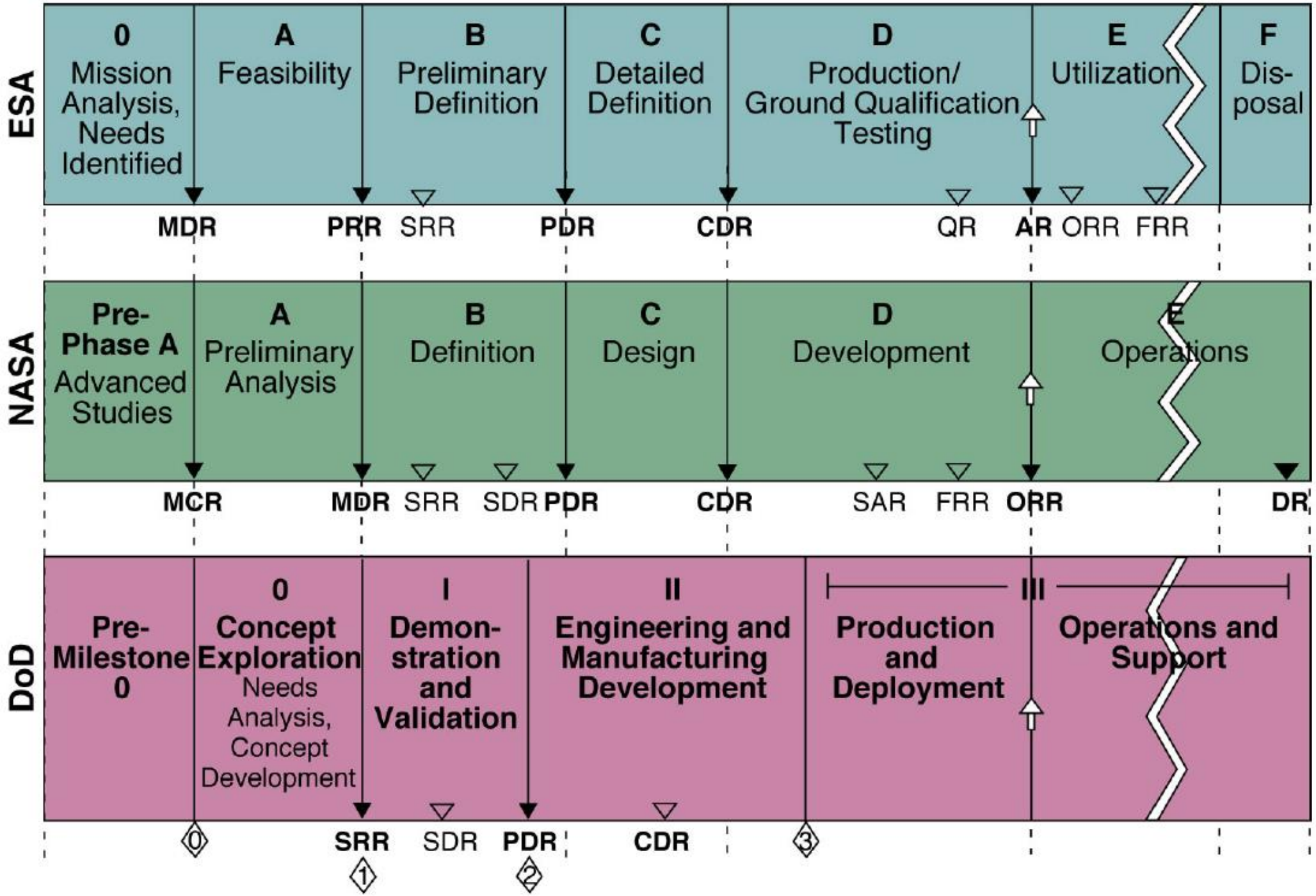
Life cycle Definitions

- A project is divided into distinct life cycle *phases.*
  - Pre-Phase A: Concept studies
  - Phase A: Concept and technology development
  - Phase B: Preliminary design and technology completion
  - Phase C: Final design and fabrication
  - Phase D: System assembly, test and launch
  - Phase E: Operations and sustainment
  - Phase F: Closeout or disposal

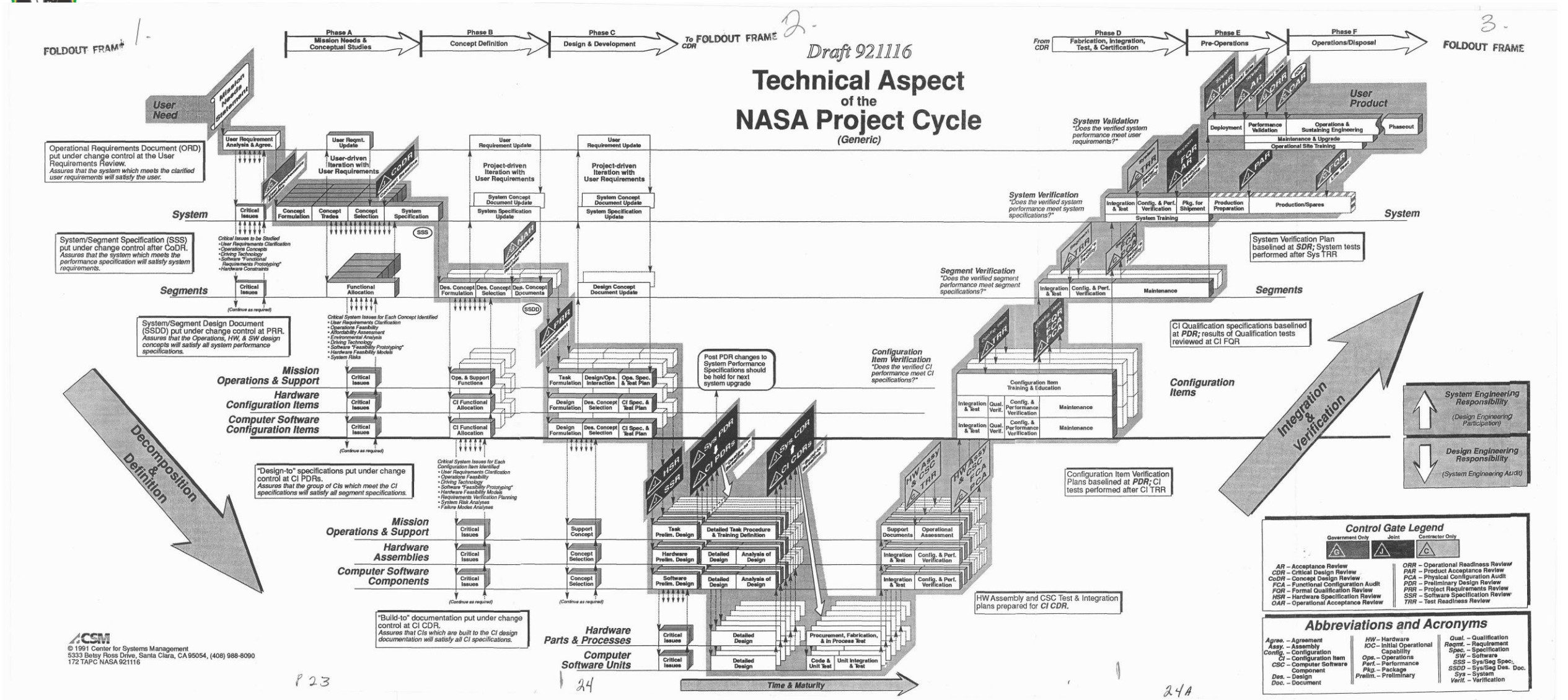
- These phases are separated by *control gates* - typically associated with a major project review, such as preliminary design review (PDR).
- Each project phase has a distinct purpose and set of products.
- **At the end of each phase a new system baseline —or an agreed-to set of requirements, designs, or documents — is established**.
- A system baseline is the point of departure for the development work in each new phase.

Systems Engineering Processes are invoked throughout the life cycle stages of a system

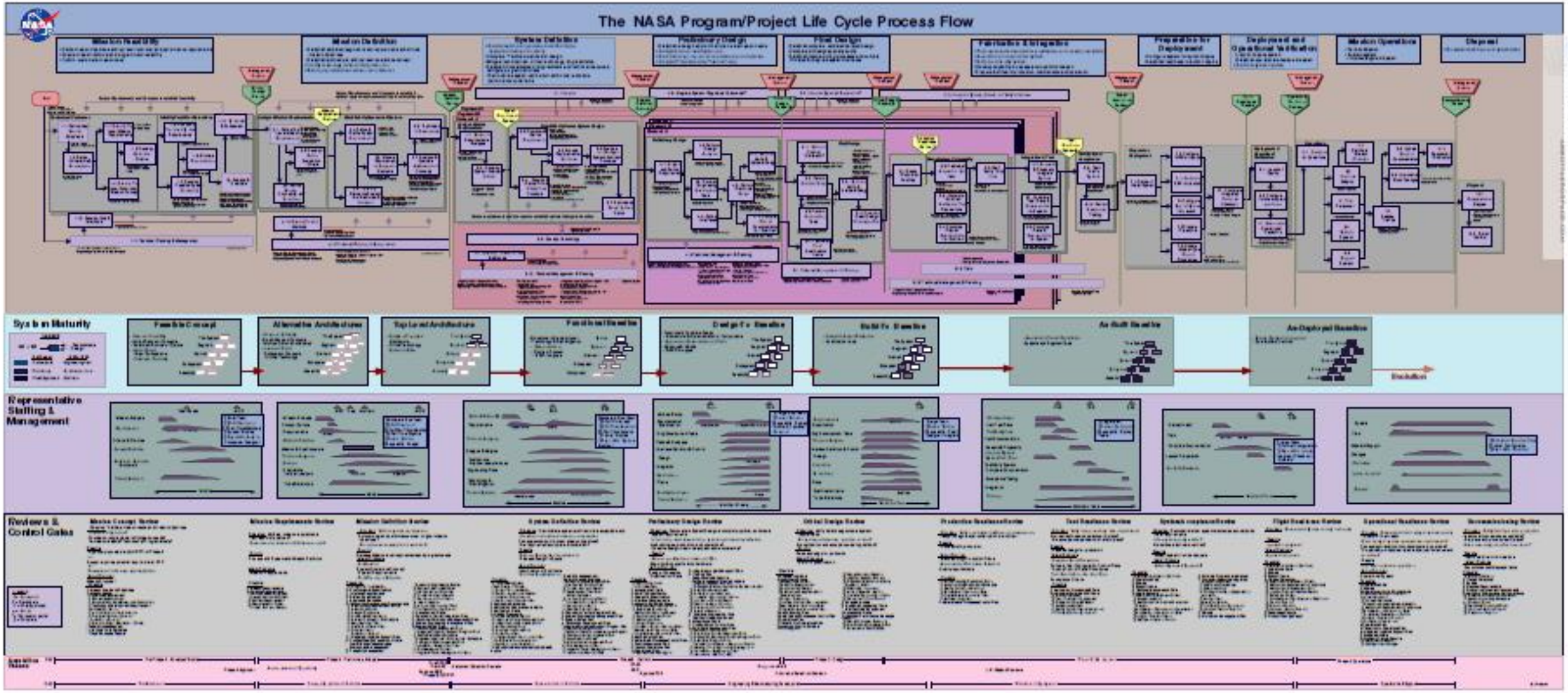



ESA
0
Mission Analysis, Needs Identified
A
Feasibility
B
Preliminary Definition
C
Detailed Definition
D
Production/ Ground Qualification Testing
E
Utilization
F
Dis-posal
MDR
PRR
SRR
PDR
CDR
QR
AR
ORR
FRR
NASA
Pre-Phase A
Advanced Studies
A
Preliminary Analysis
B
Definition
C
Design
D
Development
E
Operations
MCR
MDR
SRR
SDR
PDR
CDR
SAR
FRR
ORR
DR
DoD
Pre-Milestone 0
0
Concept Exploration
Needs Analysis, Concept Development
I
Demon-stration and Validation
II
Engineering and Manufacturing Development
III
Production and Deployment
Operations and Support
0
SRR
SDR
PDR
CDR
3
1
2

(Classical) Space Engineering uses the Vee Model



The NASA Life Cycle

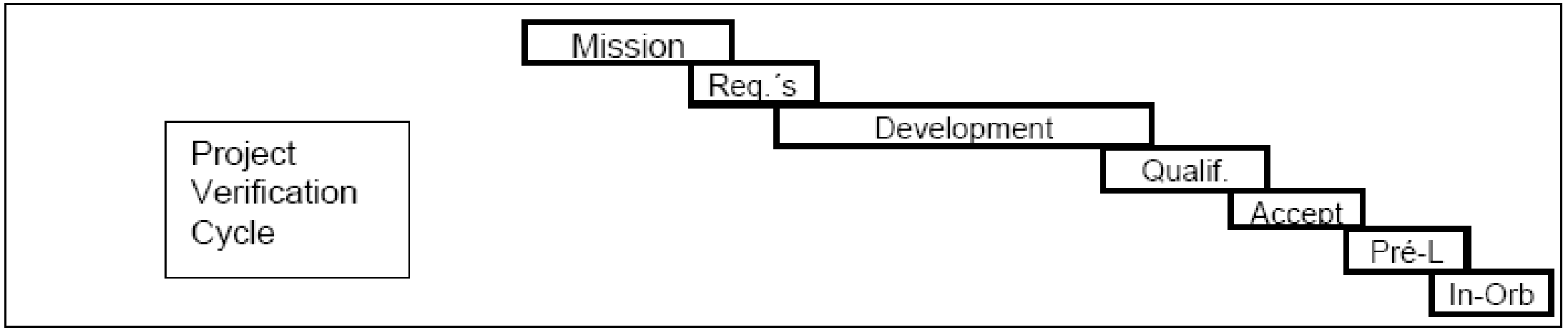


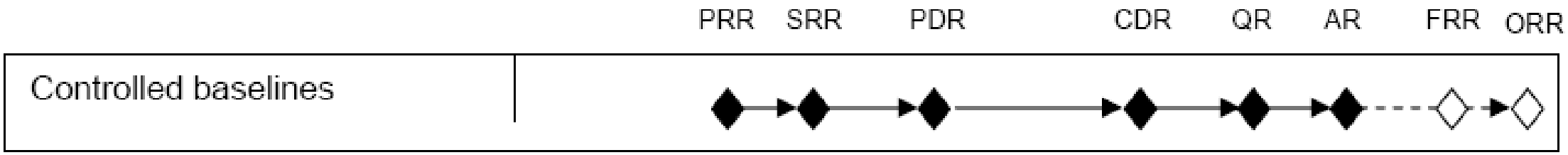
VERIFICATION STAGES/PHASES

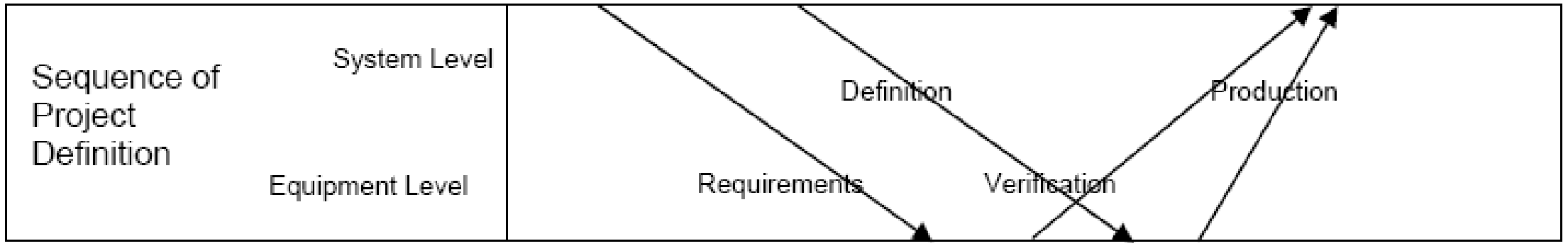
- The verification process shall be implemented in subsequent **verification stages all along the program life cycle**.
- The stages depend upon project characteristics and identify a type of verification.
- The classical verification stages/phases are:
  - I. **Development**
  - II. **Qualification**
  - III. **Acceptance**
  - IV. **Pre-launch**
  - V. **In-orbit**
  - VI. **Post-landing**

- **I.DEVELOPMENT -** In this stage the verification objective shall be to demonstrate that the design meets all applicable requirements.
- **II.QUALIFICATION -** In this stage the verification objective shall be to demonstrate that the design meets all applicable requirements and includes proper margins.
- **III.ACCEPTANCE -** In this stage the verification objective shall be to demonstrate that the item is free of workmanship defects and integration errors and is ready for subsequent operational use.
- **IV.PRE-LAUNCH -** The verification objective of the pre-launch stage shall be to verify that the article is properly configured for launch and early operations and, to the extent practicable, it is capable to function as planned for launch.
- **V.IN-ORBIT -** This stage is valid for projects whose characteristics (e.g. mission or in-orbit operations) require in-orbit verification.

VERIFICATION – EXECUTION X STAGES X BASELINES







V&V “on hands” Phase

Phase	Definition	Why V&V in this Phase?	When to Use
Development	The period during which a new design or concept is initiated, refined, implemented up to manufacturing of qualification or flight hardware.	”Is this a good technical approach?”	◆ lower risk ◆ make long lead item decisions ◆ raise TRL ◆ Does not involve QA ◆ not sufficient to close requirements
Qualification	• Prototype approach*--flight-like hardware is verified to meet the performance and design requirements. Verifications are conducted at conditions more severe than acceptance . • Protoflight approach* --actual flight hardware; applies design qualification test levels and flight acceptance test durations	“Is this a good design?”	◆ To formally close requirements, and qualify the design ◆ Use dedicated flight-like hardware, test to flight environments plus margin ◆ When you can’t use flight unit (e.g., separation system) ◆ When there are safety issues
Acceptance	Period during which the deliverable end item is shown to meet design & performance reqmts for a particular flight or mission, as well as workmanship.	”Is the system acceptable to fly?”	◆ For end-to-end testing of flight unit ◆ Verify/validate that the end item functions ◆ Focus on workmanship vs. design

*Source: NASA-STD-7002

Major V&V Baselines

Baselines

- In the context of a system review, a **baseline is also defined as a complete system description**, including requirements, designs, or documents that will have changes controlled through a formal approval and monitoring, or configuration management process.
- Since baselines capture the complete system description they are **powerful tools in ensuring the entire team is working with the same requirements, designs, constraints, assumptions, interfaces, resource allocations and team responsibilities.**

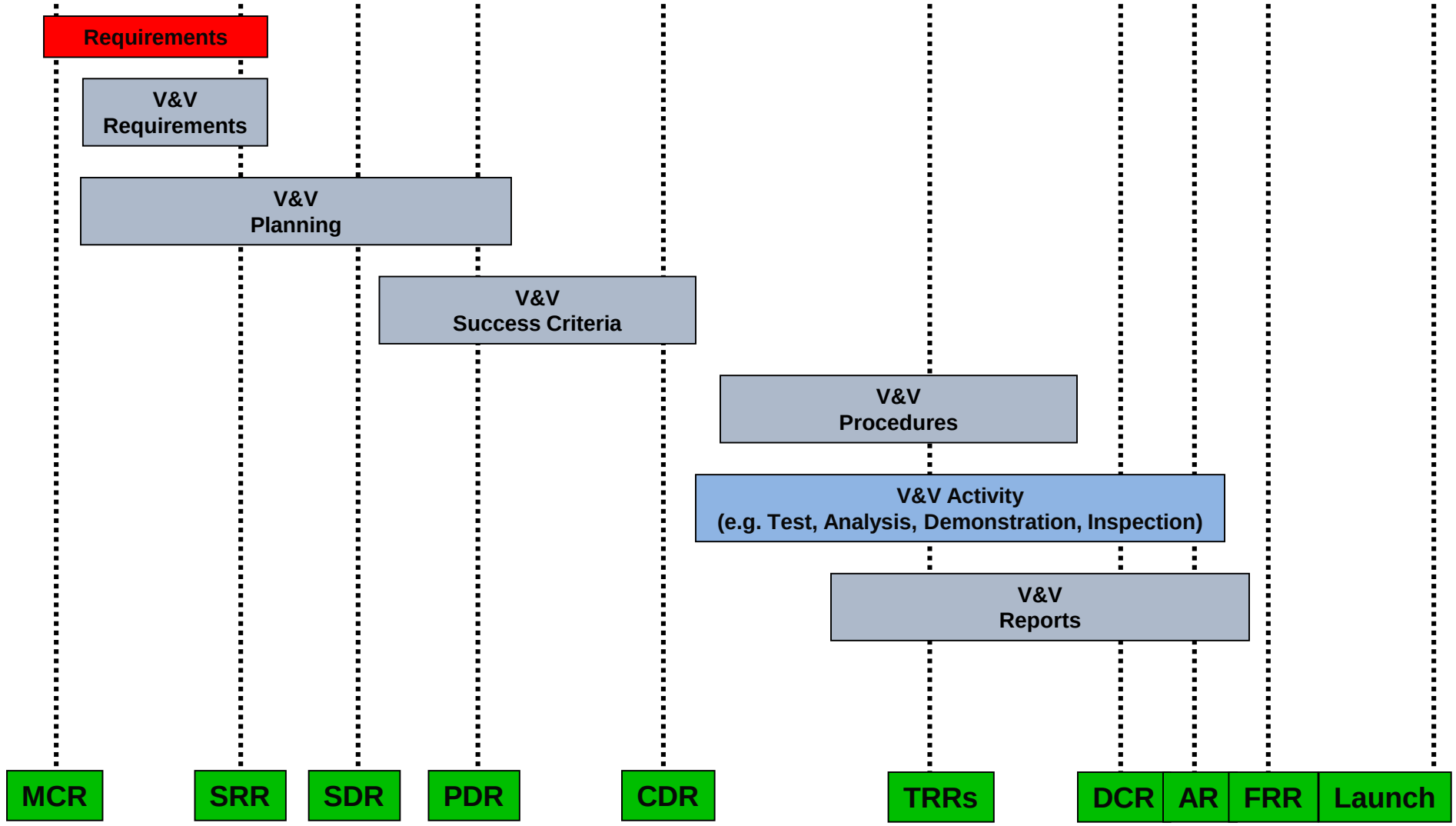
Intelligent use of baselines to provide stable reference

- Baselines are powerful tools to ensure the entire project team is working with the same definitions (requirements, designs, constraints, assumptions, interfaces, resource allocations and team responsibilities.)
- **Change control is very formal. Includes impact analysis**. A baseline is supposed to be:
  - **Mature** – passed in reviews that assessed the completeness, correctness and maturity appropriate for the current project milestone
  - **Stable** – the rate of change of the information is near zero
  - **Reference** for all teams in the project
- The proper maturity level is critical for a baseline to be a stable reference.
- Thus, to use baselines in an intelligent manner:
  - achieve the necessary **maturity and stability**
  - otherwise, the formality of **change control** will not be cost-effective.
  - Maturity and stability takes time. Balance them with time and resources.

Major V&V Baselines

- V&V Requirements
- V&V Planning
- V&V Sucess Criteria
- V&V Procedures
- V&V Reports
- V&V Compliance Assessment

V&V vs. Lifecycle Milestones



V&V Requirements

DEFINITION

- Identification of “what” is required to satisfy each of the stated requirements
- The basis of the V&V program

CONTENT

- Method ~ the method by which the requirement is to be V&V (e.g. test, analysis, inspection, similarity)
- Level ~ the level at which the V&V occurs on the product (e.g. system, subsystem, component)
- Phase ~ the purpose of the V&V activity to be performed (e.g. qualification, acceptance)

MSFC Standard Data Requirements Description (DRD):

STD/SE-VVREQ, “Verification/Validation Requirements”

Baselining V&V Requirements

WHEN:

The V&V requirements are baselined following SRR. Updated and maintained via Change Request.

CONTENT:

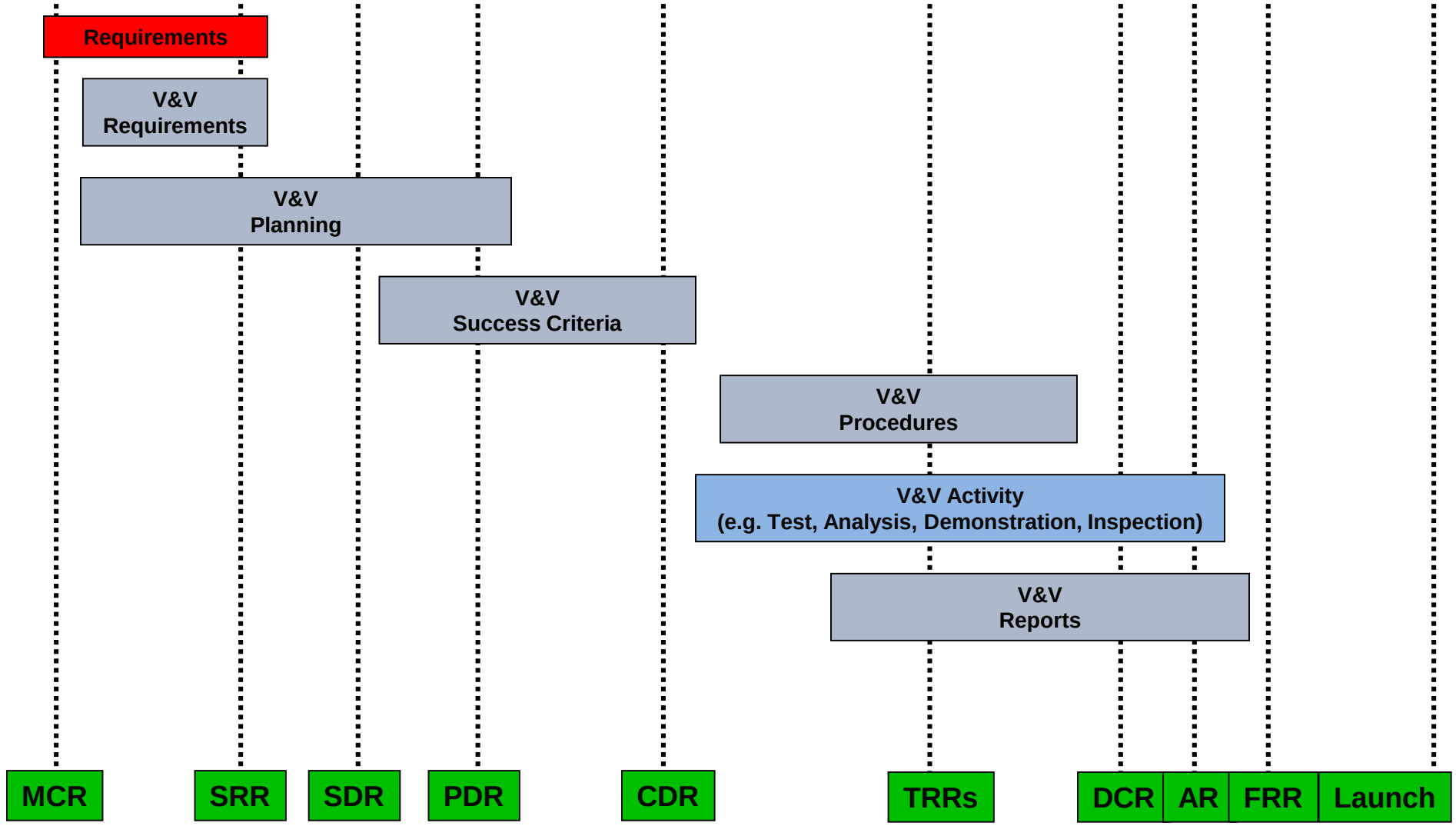
It must contain the following:

- Traceability back to the requirement (by number, title, or both)
- Method, phase, and level -- It also may include additional information, such as:
  - The actual requirement text
  - Which organization/Program/Partner performs the verification (e.g. IRD) - For interfaces, it may be a joint responsibility

PRODUCT FORM:

Often seen as a V&V Requirements Matrix (VRM) in the Requirements Document or Specification
On some projects, one may see it referred to as a V&V Cross Reference Matrix (VCRM)
On certain Projects, it has been an appendix to the V&V Plan; not recommended due to baselining requirements and V&V Plan at different milestone reviews.
Some Projects prefer to have a Section 3.0 of a Requirement Document, and a mirroring Section 4.0 where V&V Requirements are spelled out in textual form; not recommended because it is repetitive.

V&V vs. Lifecycle Milestones



V&V Planning

DEFINITION

- Planning provides detailed description of the overall V&V activities, approach, and organizational structure for implementing the V&V Program

CONTENT

- Basic content includes V&V approach, facilities, GSE, preliminary description of V&V events, time correlated sequence of activities, etc.
- Can be stand-alone Plan or part of the SEMP or Project Plan

MSFC Standard Data Requirements Description (DRD):

STD/SE-VVPLAN, “Verification/Validation Planning”

MSFC Integrated Document Library – MSFC Data Requirements Management System

Baselining V&V Planning

WHEN:

- The V&V planning is baselined following PDR.
- Updated and maintained via Change Request.

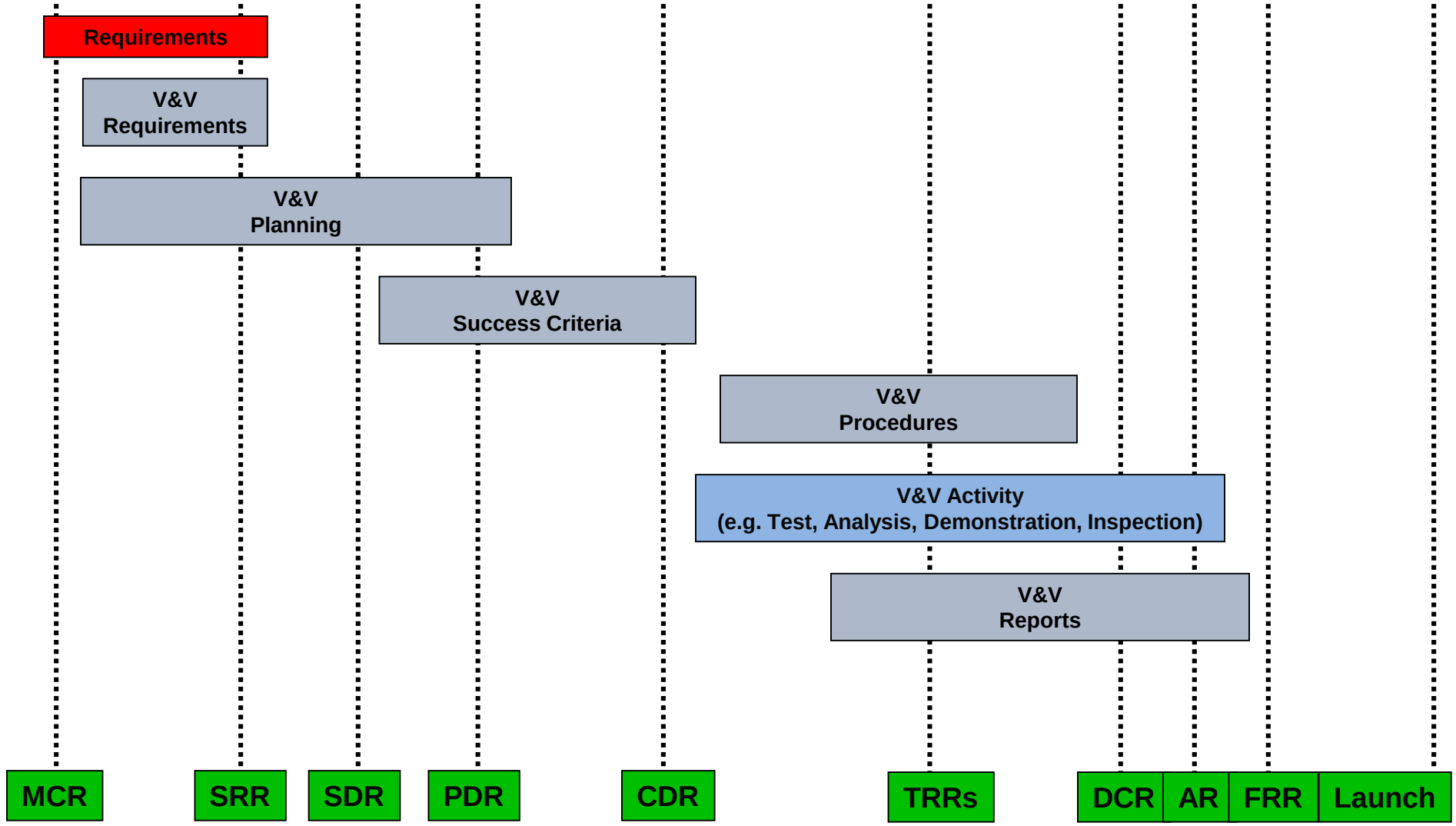
CONTENT:

Information provides a detail description of the verification/validation approach and structure for implementing the verification/validation program, as well as detail descriptions for the planned verification/validation requirements.

PRODUCT FORM:

- Stand alone V&V Plan
- Part of the SEMP or Project Plan
- In database form, can be detailed, descriptive statements outlining the V&V activities

V&V vs. Lifecycle Milestones



V&V Success Criteria

DEFINITION

- Establishes the detailed criteria by which the V&V activity is considered complete (or successfully accomplished)

CONTENT

- Pass/fail criteria
- Performance criteria
- Test limits
- Tolerances, Margins
- Constraints

MSFC Standard Data Requirements Description (DRD):

STD/SE-VVSC, “Verification/Validation Success Criteria”

MSFC Integrated Document Library – MSFC Data Requirements Management System

Baselining V&V Success Criteria

WHEN:

The V&V success criteria is baselined ~90 days before V&V activity begins.
Supports writing/approval of the V&V procedure
Updated and maintained via Change Request.

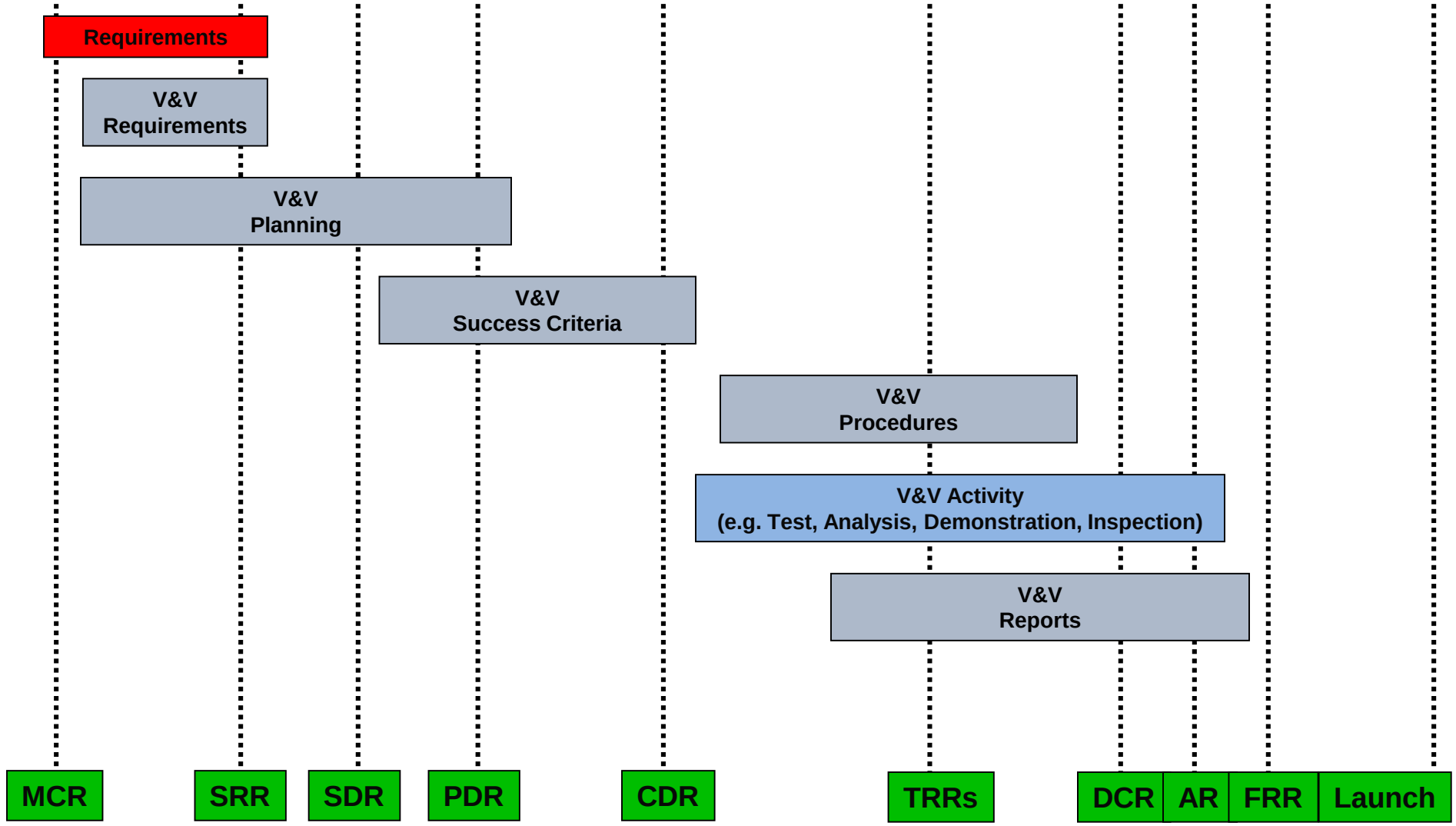
CONTENT:

Detail success criteria (i.e. test limits, tolerances, specifications, margins) used in determining acceptability of the results of each verification/validation activity

PRODUCT FORM:

Stand alone V&V success criteria document (e.g. VRSD)
Part of Verification Requirement Definition Sheets (VRDSs)
In database form, can be detailed, success criteria section for a particular V&V activity

V&V vs. Lifecycle Milestones



V&V Procedures

DEFINITION

- Procedures define the detailed instructions to be followed in conducting the identified V&V activities (test, inspection, or demonstrations).

CONTENT

- Objectives established for the particular test, inspection, or demonstrations.
- Criteria to be verified, including values, with tolerances, for acceptance or rejection and traceability back to the applicable verification success criteria.
- Description of steps and operations, in sequence.
- Support equipment & confirmation it has been calibrated
- Identification of hazardous situations or operations.

MSFC Standard Data Requirements Description (DRD):

STD/SE-VVPROC, “Verification/Validation Procedures”

MSFC Integrated Document Library – MSFC Data Requirements Management System

Baselining V&V Procedures

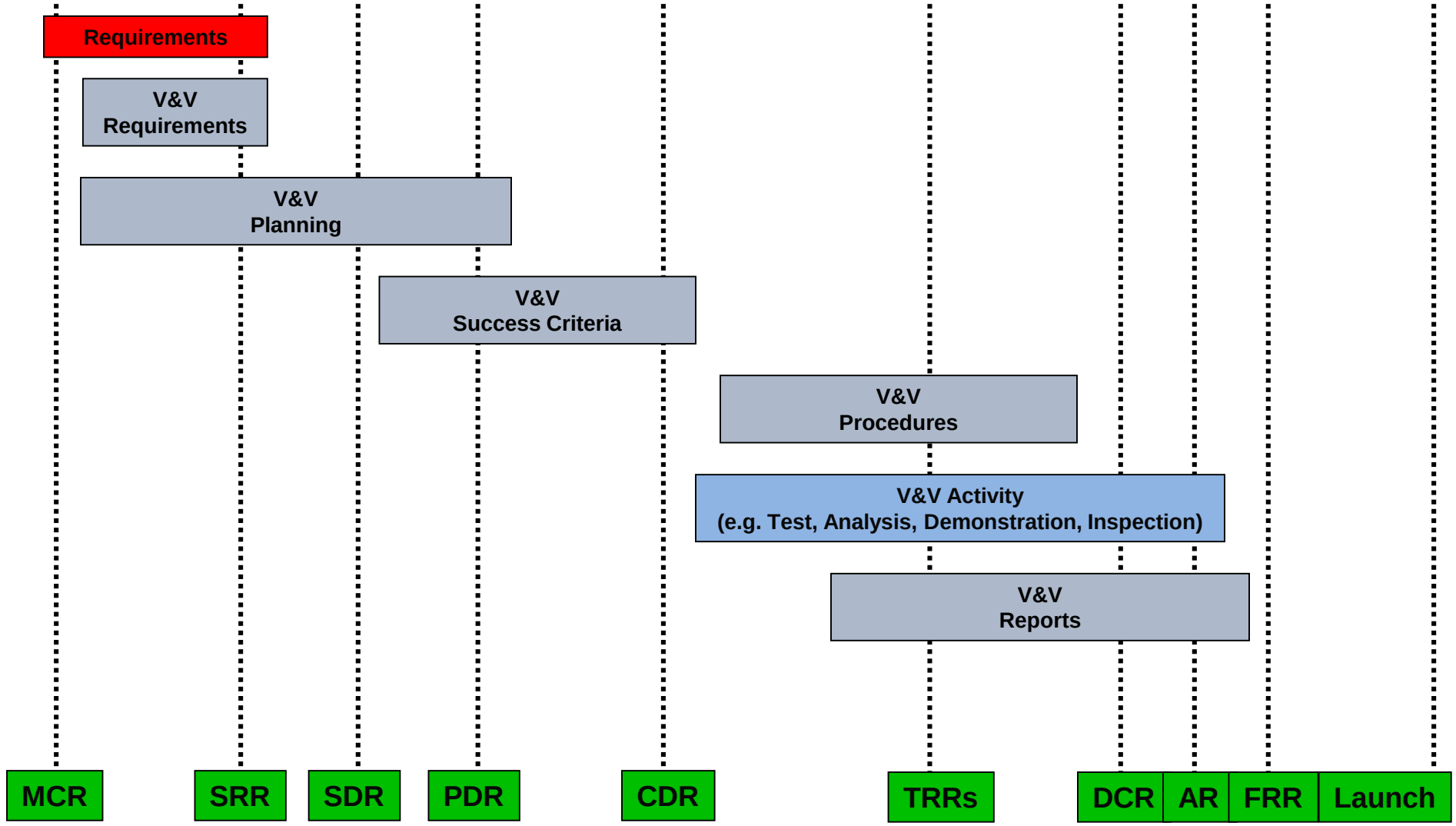
WHEN: The V&V procedure is baselined ~30 days before V&V activity begins.

CONTENT:

Identification of item/article being subjected to test, inspection, or demonstrations.
Identification of objectives established for the particular test, inspection, or demonstrations.
Characteristics and criteria to be verified, including values, with tolerances, for acceptance or rejection and traceability back to the applicable verification success criteria.
Description of steps and operations, in sequence, to be taken.
Identification of measuring and recording equipment to be used, specifying range, accuracy, and type and any special instructions for operating such equipment.
Confirmation that required support equipment has been calibrated and certification of the calibration is still valid.
Identification that any support equipment has been verified prior to use with flight hardware.
Layouts, schematics, or diagrams showing identification, location, and interconnection of item/article, support equipment, and measuring equipment.
Identification of hazardous situations or operations.
Precautions and safety instructions to ensure safety of personnel and prevent degradation of verification article and supporting equipment.
Environmental and/or other conditions to be maintained with tolerances.
Constraints on test, inspection, or demonstration.
Instructions for handling non-conformances and anomalous occurrences during activity.

PRODUCT FORM: Stand alone V&V procedure for a test, inspection, or demonstration

V&V vs. Lifecycle Milestones



V&V Reports

DEFINITION

- The V&V Report identifies the data that documents the results of each individual V&V activity.
- Also referred to as Compliance Data

CONTENT

- Can be packaged as an as-run procedure, memo, assessment, test report, inspection report, analysis, etc.
- Any identified anomalies, deviations, waivers

MSFC Standard Data Requirements Description (DRD):

STD/SE-VVREP, “Verification/Validation Reports”

MSFC Integrated Document Library – MSFC Data Requirements Management System

V&V Reports

WHEN:

The V&V report is generated ~30 days after completion of the V&V activity.

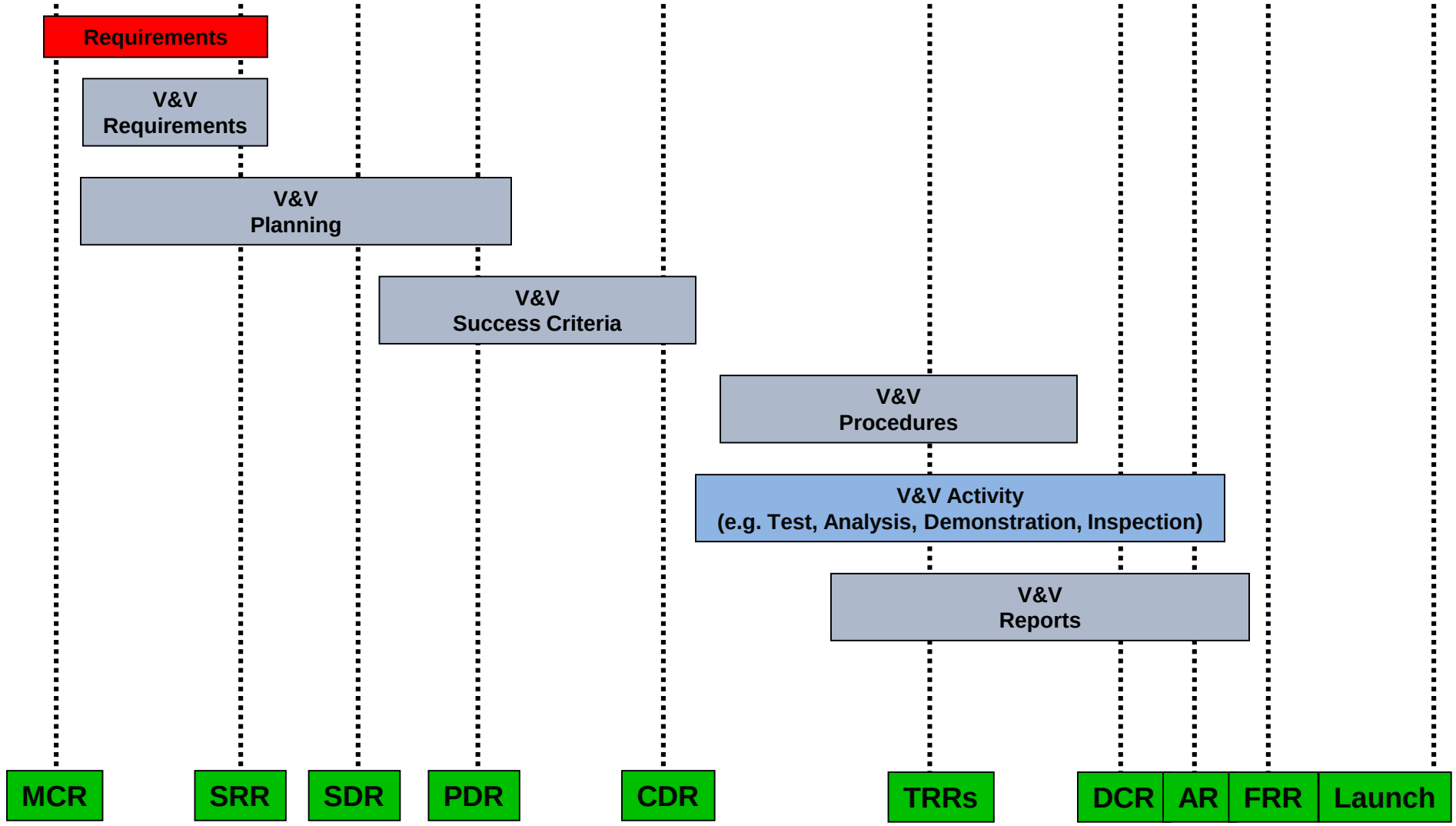
CONTENT:

Conclusions and recommendations relative to success of the verification/validation activity.
Concurrence by the appropriate discipline (e.g. safety, thermal, structures, etc.).
Description of deviations from nominal results, failures, approved corrective actions and procedures, and retest.
Traceability back to the requirement and/or verification/validation success criteria.
Copy of as-run procedure (as appropriate).
Identification of test configuration and any differences from the flight configuration.
Specific results of each procedure including automated test segments, each analysis, or other verification/validation activity.
Performance data, plots, and pictures (as appropriate).
Models used in analysis.

PRODUCT FORM:

Stand alone V&V report (e.g. Test Report, Inspection Report, Thermal Analysis, Stress Analysis, etc.)
Certificate of Compliance (CoC)

V&V vs. Lifecycle Milestones



V&V Compliance Assessment

DEFINITION

- A Compliance Assessment is done to identify, evaluate, and correlate the submitted V&V reports against the requirements levied on the system of interest.

CONTENT

- Traceability of V&V reports back to requirements
- V&V Report Assessment
- Non-Conformance Tracking
- Requirement Status (i.e. open, closed)

MSFC Standard Data Requirements Description (DRD):

STD/SE-VVC, “Verification/Validation Compliance Assessment”

MSFC Integrated Document Library – MSFC Data Requirements Management System

V&V Compliance Assessment

WHAT:

Compliance is the process of identifying, assessing, and correlating the submitted V&V reports against the requirements, aka verification closure

CONTENT: Contents of a general compliance package:

Identification of the requirement(s) and associated V&V requirements to be satisfied
Identification and traceability of the V&V reports to each requirement
Assessment of the V&V reports to determine compliance
Identification of any non-conformances
Often submitted with a Verification Compliance Notice (VCN)

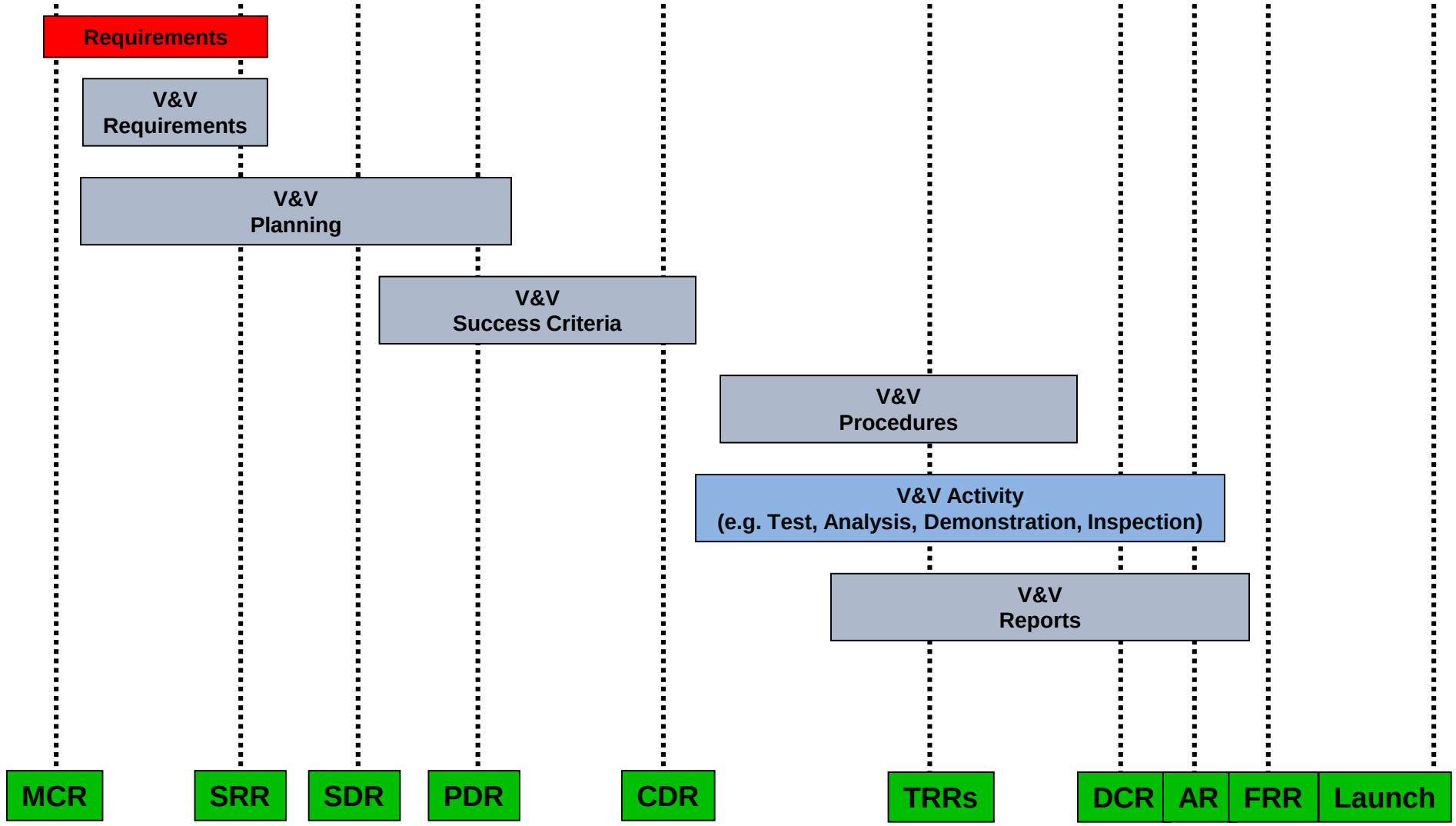
BY WHOM: Compliance is done by the requirement "owner", along with other Stakeholders as documented in the V&V Plan. See the sample Approval Flow diagram on the following page.

WHEN:

Update status throughout the program lifecycle.

Final compliance package and report (often documented in a Verification Requirements Compliance Document (VRCD)) completed following Flight Readiness Review (FRR).

V&V vs. Lifecycle Milestones



VERIFICATION MODEL

- **1.Planning**:
  - resources required,
  - the sequence of activities,
  - the data to be produced,
  - collation of required information,
  - selection of specific activities and assessment criteria, and
  - generation of verification-specific hardware or software.
- **2.Execution**: verification methods employed.
- **3.Control/Data**: results obtained in the process.

VERIFICATION GENERAL GUIDANCE

- **1. PROJECT TYPE**, especially for flight projects.
- **Verification methods and timing depend on**:
  - **The type of flight** article involved (e.g., an experiment, payload, or launch vehicle).
  - **Project cost and schedule implications**
- Verification activities can be significant drivers of a project's cost and schedule; these implications should be considered early in the development of the verification program.
- Trade studies should be performed to support decisions about verification methods and requirements and the selection of facility types and locations.

1. Risk implications

- Risk management must be considered in the development of the verification program.
- Qualitative risk assessments and quantitative risk analyses (e.g., a Failure Mode and Effects Analysis (FMECA)) often identify new concerns that can be mitigated by additional testing, thus increasing the extent of verification activities.
- Other risk assessments contribute to trade studies that determine the preferred methods of verification to be used and when those methods should be performed.
- The project manager/systems engineer must determine what risks are acceptable in terms of the project's cost and schedule.

2. **Availability of verification facilities/sites** and transportation assets to move an article from one location to another (when needed).
   - This requires coordination with the Integrated Logistics Support.
3. **Acquisition strategy** (i.e., in-house development or system contract).
4. **Degree of design inheritance** and hardware/software reuse.

Appendix I: Verification and Validation Plan Outline

Sample Outline

The Verification and Validation (V&V) Plan needs to be baselined after the comments from PDR are incorporated. In this annotated outline, the use of the term "system" is indicative of the entire scope for which this plan is developed. This may be an entire spacecraft, just the avionics system, or a card within the avionics system. Likewise, the terms "end item," "subsystem," or "element" are meant to imply the lower-level products that, when integrated together, will produce the "system." The general term "end item" is used to encompass activities regardless of whether the end item is a hardware or software element.

The various sections are intended to move from the high-level generic descriptions to the more detailed. The sections also flow from the lower-level items in the product layer to larger and larger assemblies and to the completely integrated system. The sections also describe how that system may be integrated and further verified/validated with its externally interfacing elements. This progression will help build a complete understanding of the overall plans for verification and validation.

1.0 Introduction

1.1 Purpose and Scope

This section states the purpose of this Verification and Validation Plan and the scope (i.e., systems) to which it applies. The purpose of the V&V Plan is to identify the activities that will establish compliance with the requirements (verification) and to establish that the system will meet the customers' expectations (validation).

1.2 Responsibility and Change Authority

This section will identify who has responsibility for the maintenance of this plan and who or what board has the authority to approve any changes to it.

1.3 Definitions

This section will define any key terms used in the plan. The section may include the definitions of verification, validation, analysis, test, demonstration, and test. See appendix B of this handbook for definitions of these and other terms that might be used.

2.0 Applicable and Reference Documents

2.1 Applicable Documents

These are the documents that may impose additional requirements or from which some of the requirements have been taken.

2.2 Reference Documents

These are the documents that are referred to within the V&V Plan that do not impose requirements, but which may have additional useful information.

2.3 Order of Precedence

This section identifies which documents take precedence whenever there are conflicting requirements.

3.0 System Description

3.1 System Requirements Flowdown

This section describes where the requirements for this system come from and how they are flowed down to subsystems and lower-level elements. It should also indicate what method will be used to perform the flowdown and bidirectional traceability of the requirements: spreadsheet, model, or other means. It can point to the file, document, or spreadsheet that captures the actual requirements flowdown.

3.2 System Architecture

This section describes the system that is within the scope of this V&V Plan. The description should be enough so that the V&V activities will have the proper context and be understandable.

3.3 End Item Architectures

This section describes each of the major end items (subsystems, elements, units, modules, etc.) that when integrated together, will form the overall system that is the scope of this V&V Plan.

3.3.1 *System End Item A*

This section describes the first major end item/subsystem in more detail so that the V&V activities have context and are understandable.

3.3.n *System End Item n*

Each end item/subsystem is separately described in a similar manner as above.

3.4 Ground Support Equipment

This section describes any major ground-support equipment that will be used during the V&V activities. This may include carts for supplying power or fuel, special test fixtures, lifting aids, simulators, or other type of support.

3.5 Other Architecture Descriptions

This section describes any other items that are important for the V&V activities but which are not included in the sections above. This may be an existing control center, training facility, or other support.

4.0 Verification and Validation Process

This section describes the process that will be used to perform verification and validation.

4.1 Verification and Validation Management Responsibilities

This section describes the responsibilities of key players in the V&V activities. It may include identification and duty description for test directors/conductors, managers, facility owners, boards, and other key stakeholders.

4.2 Verification Methods

This section defines and describes the methods that will be used during the verification activities.

4.2.1 *Analysis*

Defines what this verification method means (See *Appendix B* of this handbook) and how it will be applied to this system.

4.2.2 *Inspection*

Defines what this verification method means (See *Appendix B* of this handbook) and how it will be applied to this system.

4.2.3 *Demonstration*

Defines what this verification method means (See Appendix B of this handbook) and how it will be applied to this system.

4.2.4 *Test*

Defines what this verification method means (See Appendix B of this handbook) and how it will be applied to this system. This category may need to be broken down into further categories.

4.2.4.1 *Qualification Testing*

This section describes the test philosophy for the environmental and other testing that is performed at higher than normal levels to ascertain margins and performance in worst-case scenarios. Includes descriptions of how the minimum and maximum extremes will be determined for various types of tests (thermal, vibration, etc.), whether it will be performed at a component, subsystem, or system level, and the pedigree (flight unit, qualification unit, engineering unit, etc.) of the units these tests will be performed on.

4.2.4.2 *Other Testing*

This section describes any other testing that will be used as part of the verification activities that are not part of the qualification testing. It includes any testing of requirements within the normal operating range of the end item. It may include some engineering tests that will form the foundation or provide dry runs for the official verification testing.

4.3 Validation Methods

This section defines and describes the methods to be used during the validation activities.

4.2.1 *Analysis*

Defines what this validation method means (See Appendix B of this handbook) and how it will be applied to this system.

4.2.2 *Inspection*

Defines what this validation method means (See Appendix B of this handbook) and how it will be applied to this system.

4.2.3 *Demonstration*

Defines what this validation method means (See Appendix B of this handbook) and how it will be applied to this system.

4.2.4 *Test*

Defines what this validation method means (See Appendix B of this handbook) and how it will be applied to this system. This category may need to be broken down into further categories such as end-to-end testing, testing with humans, etc.)

4.4 Certification Process

Describes the overall process by which the results of these verification and validation activities will be used to certify that the system meets its requirements and expectations and is ready to be put into the field or fly. In addition to the verification and validation results, the certification package may also include special forms, reports, safety documentation, drawings, waivers, or other supporting documentation.

4.5 Acceptance Testing

Describes the philosophy of how/which of the verification/validation activities will be performed on each of the operational units as they are manufactured/coded and are readied for flight/use. Includes how/if data packages will be developed and provided as part of the delivery.

5.0 Verification and Validation Implementation

5.1 System Design and Verification and Validation Flow

This section describes how the system units/modules will flow from manufacturing/coding through verification and validation. Includes whether each unit will be verified/validated separately, or assembled to some level and then evaluated or other statement of flow.

5.2 Test Articles

This section describes the pedigree of test articles that will be involved in the verification/validation activities. This may include descriptions of breadboards, prototypes, engineering units, qualification units, protoflight units, flight units, or other specially named units. A definition of what is meant by these terms needs to be included to ensure clear understanding of the expected pedigree of each type of test article. Descriptions of what kind of test/analysis activities will be performed on each type of test article is included.

5.3 Support Equipment

This section describes any special support equipment that will be needed to perform the verification/validation activities. This will be a more detailed description than is stated in Section 3.4 of this outline.

5.4 Facilities

This section identifies and describes major facilities that will be needed in order to accomplish the verification and validation activities. These may include environmental test facilities, computational facilities, simulation facilities, training facilities, test stands, and other facilities as needed.

6.0 End Item Verification and Validation

This section describes in detail the V&V activities that will be applied to the lower-level subsystems/elements/end items. It can point to other stand-alone descriptions of these tests if they will be generated as part of organizational responsibilities for the products at each product layer.

6.1 End Item A

This section focuses in on one of the lower-level end items and describes in detail what type of verification activities it will undergo.

6.1.1 Developmental/Engineering Unit Evaluations

This section describes what kind of testing, analysis, demonstrations, or inspections the prototype/engineering or other types of units/modules will undergo prior to performing official verification and validation.

6.1.2 Verification Activities

This section describes in detail the verification activities that will be performed on this end item.

6.1.2.1 *Verification by Testing*

This section describes all verification testing that will be performed on this end item.

6.1.2.1.1 Qualification Testing

This section describes the test environmental and other testing that is performed at higher than normal levels to ascertain margins and performance in worst-case scenarios. It includes what minimum and maximum extremes will be used on qualification tests (thermal, vibration, etc.) of this unit, whether it will be performed at a component, subsystem, or system level, and the pedigree (flight unit, qualification unit, engineering unit, etc.) of the units these tests will be performed on.

6.1.2.1.2 Other Testing

This section describes all other verification tests that are not performed as part of the qualification testing. These will include verification of requirements in the normal operating ranges.

6.1.2.2 *Verification by Analysis*

This section describes the verifications that will be performed by analysis (including verification by similarity). This may include thermal analysis, stress analysis, analysis of fracture control, materials analysis, Electrical, Electronic, and Electromechnical (EEE) parts analysis, and other analyses as needed for the verification of this end item.

6.1.2.3 *Verification by Inspection*
This section describes the verifications that will be performed for this end item by inspection.

6.1.2.4 *Verification Demonstration*
This section describes the verifications that will be performed for this end item by demonstration.

6.1.3 Validation Activities

6.1.3.1 *Validation by Testing*
This section describes what validation tests will be performed on this end item.

6.1.3.2 *Validation by Analysis*
This section describes the validation that will be performed for this end item through analysis.

6.1.3.3 *Validation by Inspection*
This section describes the validation that will be performed for this end item through inspection.

6.1.3.4 *Validation by Demonstration*
This section describes the validations that will be performed for this end item by demonstration.

6.1.4 Acceptance Testing
This section describes the set of tests, analysis, demonstrations, or inspections that will be performed on the flight/final version of the end item to show it has the same design as the one that is being verified, that the workmanship on this end item is good, and that it performs the identified functions properly.

6.n End Item n
In a similar manner as above, a description of how each end item that makes up the system will be verified and validated is made.

7.0 System Verification and Validation

7.1 End-Item Integration
This section describes how the various end items will be assembled/integrated together, verified and validated. For example, the avionics and power systems may be integrated and tested together to ensure their interfaces and performance is as required and expected prior to integration with a larger element. This section describes the verification and validation that will be performed on these major assemblies. Complete system integration will be described in later sections.

7.1.1 Developmental/Engineering Unit Evaluations
This section describes the unofficial (not the formal verification/validation) testing/analysis that will be performed on the various assemblies that will be tested together and the pedigree of the units that will be used. This may include system-level testing of configurations using engineering units, breadboard, simulators, or other forms or combination of forms.

7.1.2 Verification Activities
This section describes the verification activities that will be performed on the various assemblies.

7.1.2.1 *Verification by Testing*
This section describes all verification testing that will be performed on the various assemblies. The section may be broken up to describe qualification testing performed on the various assemblies and other types of testing.

7.1.2.2 *Verification by Analysis*
This section describes all verification analysis that will be performed on the various assemblies.

7.1.2.3 *Verification by Inspection*
This section describes all verification inspections that will be performed on the various assemblies.

7.1.2.4 *Verification by Demonstration*
This section describes all verification demonstrations that will be performed on the various assemblies.

7.1.3 Validation Activities

7.1.3.1 *Validation by Testing*
This section describes all validation testing that will be performed on the various assemblies.

7.1.3.2 *Validation by Analysis*
This section describes all validation analysis that will be performed on the various assemblies.

7.1.3.3 *Validation by Inspection*
This section describes all validation inspections that will be performed on the various assemblies.

7.1.3.4 *Validation by Demonstration*
This section describes all validation demonstrations that will be performed on the various assemblies.

7.2 Complete System Integration
This section describes the verification and validation activities that will be performed on the systems after all its assemblies are integrated together to form the complete integrated system. In some cases this will not be practical. Rationale for what cannot be done should be captured.

7.2.1 Developmental/Engineering Unit Evaluations
This section describes the unofficial (not the formal verification/validation) testing/analysis that will be performed on the complete integrated system and the pedigree of the units that will be used. This may include system-level testing of configurations using engineering units, breadboard, simulators, or other forms or combination of forms.

7.2.2 Verification Activities
This section describes the verification activities that will be performed on the completely integrated system

7.2.2.1 *Verification Testing*
This section describes all verification testing that will be performed on the integrated system. The section may be broken up to describe qualification testing performed at the integrated system level and other types of testing.

7.2.2.2 *Verification Analysis*
This section describes all verification analysis that will be performed on the integrated system.

7.2.2.3 *Verification Inspection*
This section describes all verification inspections that will be performed on the integrated system.

7.2.2.4 *Verification Demonstration*
This section describes all verification demonstrations that will be performed on the integrated system.

7.2.3 Validation Activities
This section describes the validation activities that will be performed on the completely integrated system.

7.2.3.1 *Validation by Testing*
This section describes all validation testing that will be performed on the integrated system.

7.2.3.2 *Validation by Analysis*
This section describes all validation analysis that will be performed on the integrated system.

7.2.3.3 *Validation by Inspection*
This section describes the validation inspections that will be performed on the integrated system.

7.2.3.4 *Validation by Demonstration*
This section describes the validation demonstrations that will be performed on the integrated system.

8.0 Program Verification and Validation

This section describes any further testing that the system will be subjected to. For example, if the system is an instrument, the section may include any verification/validation that the system will undergo when integrated into its spacecraft/platform. If the system is a spacecraft, the section may include any verification/validation the system will undergo when integrated with its launch vehicle.

8.1 Vehicle Integration

This section describes any further verification or validation activities that will occur when the system is integrated with its external interfaces.

8.2 End-to-End Integration

This section describes any end-to-end testing that the system may undergo. For example, this configuration would include data being sent from a ground control center through one or more relay satellites to the system and back.

8.3 On-Orbit V&V Activities

This section describes any remaining verification/validation activities that will be performed on a system after it reaches orbit or is placed in the field.

9.0 System Certification Products

This section describes the type of products that will be generated and provided as part of the certification process. This package may include the verification and validation matrix and results, pressure vessel certifications, special forms, materials certifications, test reports or other products as is appropriate for the system being verified and validated.

Appendix A: Acronyms and Abbreviations

This is a list of all the acronyms and abbreviations used in the V&V Plan and their spelled-out meaning.

Appendix B: Definition of Terms

This section is a definition of the key terms that are used in the V&V Plan.

Appendix C: Requirement Verification Matrix

The V&V Plan needs to be baselined after the comments from PDR are incorporated. The information in this section may take various forms. It could be a pointer to another document or model where the matrix and its results may be found. This works well for large projects using a requirements-tracking application. The information in this section could also be the requirements matrix filled out with all but the results information and a pointer to where the results can be found. This allows the key information to be available at the time of baselining. For a smaller project, this may be the completed verification matrix. In this case, the V&V Plan would be filled out as much as possible before. See Appendix D for an example of a verification matrix.

Appendix D: Validation Matrix

As with the verification matrix, this product may take various forms from a completed matrix to just a pointer for where the information can be found. Appendix E provides an example of a validation matrix.

Class Ending

Example VRM

METHOD

1.0 Test
- 1.1 Functional
- 1.2 Environmental

2.0 Analysis
3.0 Demonstration
4.0 Inspection
5.0 Validation of Records
6.0 Similarity
7.0 Review of Design Documentation

LEVEL

a. Component
b. Subsystem
c. System

PHASE

D Development
Q Qualification
A Acceptance
P Prelaunch
F Flight
N/A Not Applicable

VERIFICATION REQUIREMENTS MATRIX

SECTION 3.0 PARA. NO.	VERIFICATION BY LEVEL AND METHOD PHASE D	Q	A	P	F	N/A	NOTES
3.0						X	
3.1						X	
3.1.1	7						
3.1.2			1.1bc, 4bc				
3.2						X	
3.2.1	2c						
3.2.2	2c						
3.2.3	2c						
3.2.4						X	
3.3						X	
3.3.1	2c		1.1c				
3.3.2	2c		1.1c				1
3.3.3	2c						
3.4	7		4a				
3.4.1	2a		1.1a				2
3.4.2	2a		1.1a				
3.4.3	2a		1.1a				
3.4.4			2b,1.1a				
3.4.5	2a		1.1a				
3.4.6	7		5a				
3.4.7	2a	5a	5a				
3.4.8	2a		1.2a				
3.4.9	2a		5a				
3.4.10	7		4a,1.1c				
3.5	7						
3.5.1	2b						
3.5.2	2b	1.2b					
3.5.3	7						
3.5.3.1	2b						
3.6	7						
3.6.1	7,2b						
3.6.2	7		4a,5a				
3.6.2.1	2b						

Homework

- Add a Collumn Phase and indicate the verification stage/phase
- ~~Create an associate Spreadsheet, indicating per phase what is being verified (requirements/functions/level(in case of subsystem – the subsystem)) through the lifecycle.~~
- Due Aug. 29th

Grading Criteria:

1. Coherent Phase Assignment
2. ~~Identification of the requirement function (if functional)~~
3. ~~Phase View Spreadsheet organization and cohesion with the understanding of the phase.~~