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LPL Design and Test Readiness Reviews Guidelines

Liquid Propulsion Laboratory

Version History

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Version	Brief Description	Responsible Engineer	Date of Change
1.0	Initial Release	Ulubilge Ulusoy	9/2/2020

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Design Review Basics

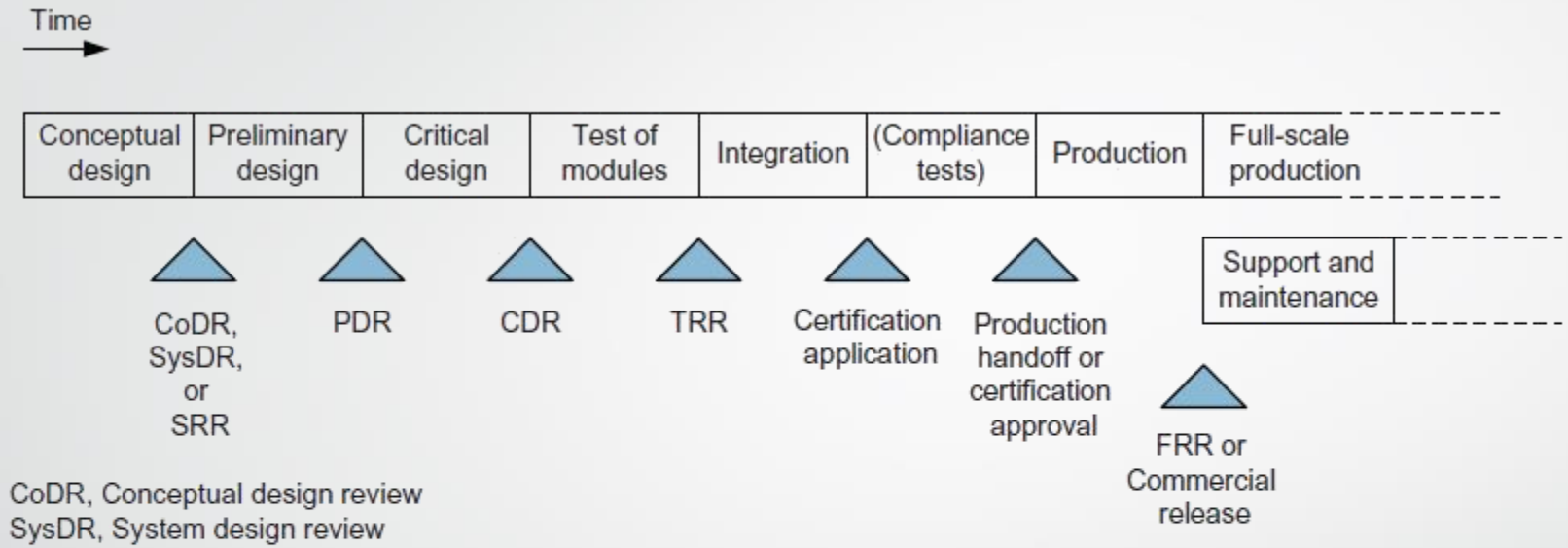

Figure 13.7:
Timeline of when some design reviews might occur.

Developing and Managing Embedded Systems and Products → You can also download the book chapter 13 from USC libraries

Design Review Basics

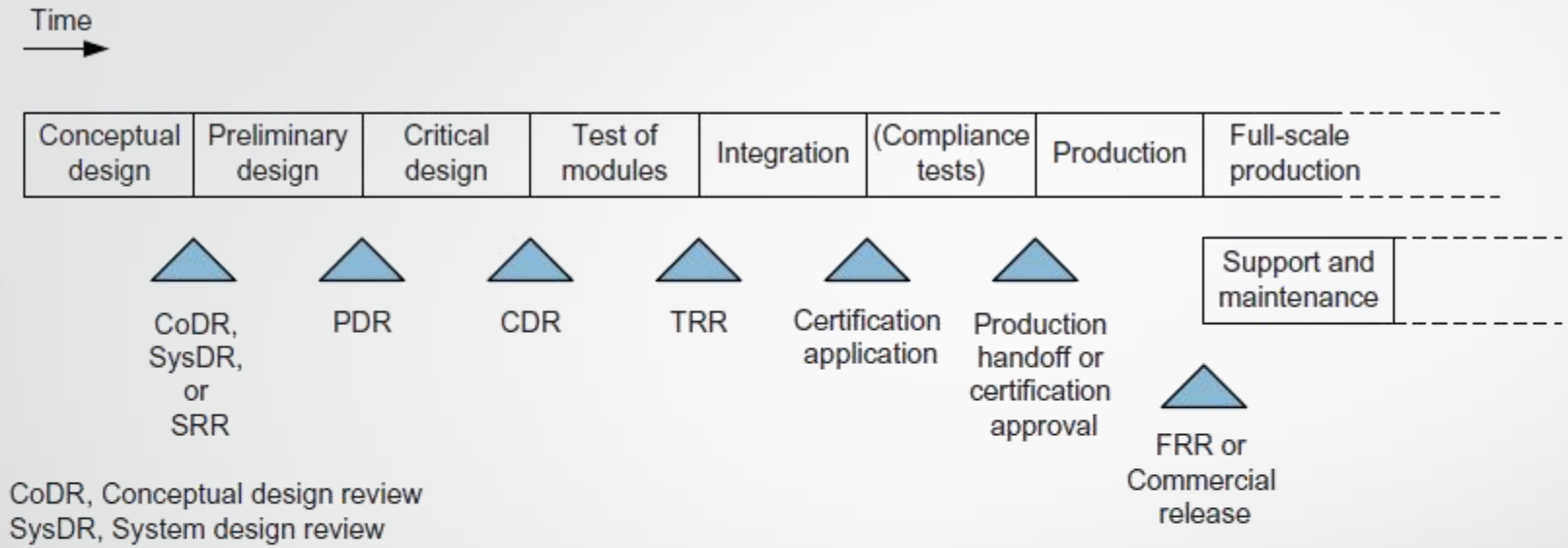

Figure 13.7:
Timeline of when some design reviews might occur.

Developing and Managing Embedded Systems and Products → You can also download the book chapter 13 from USC libraries

Design Review Basics

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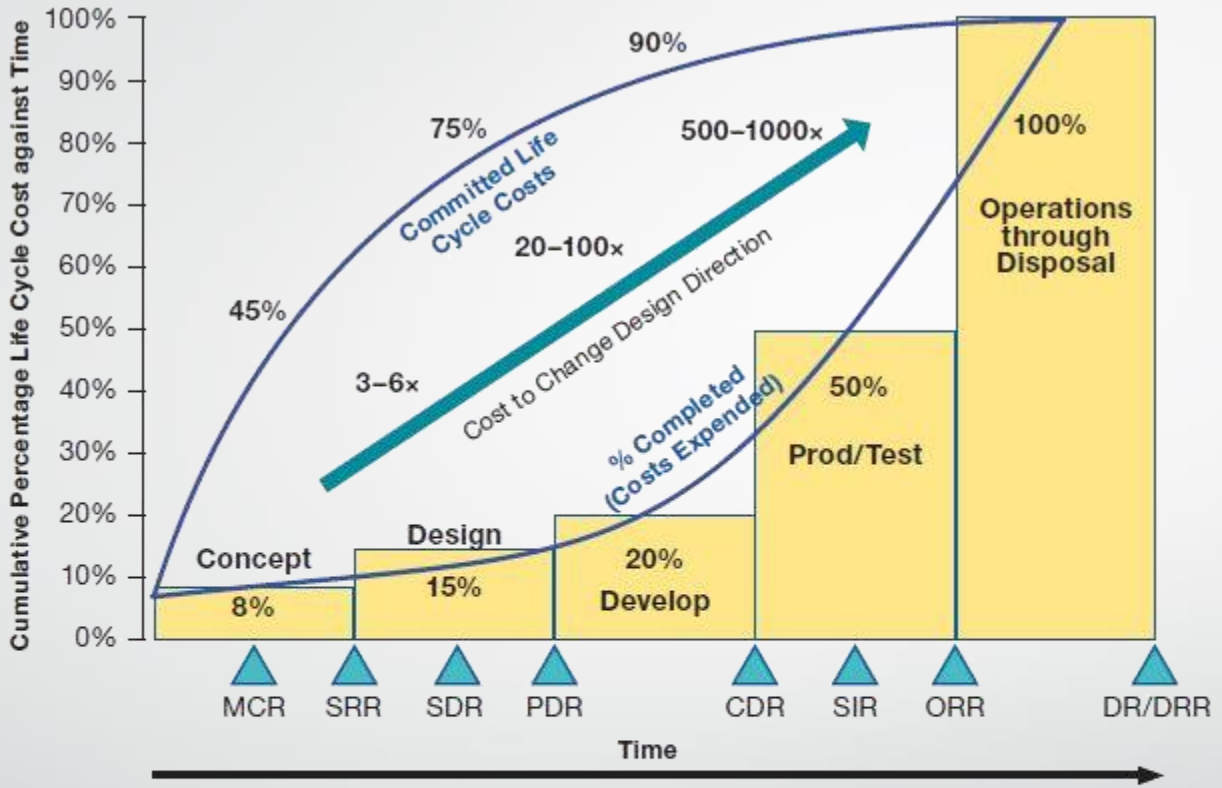
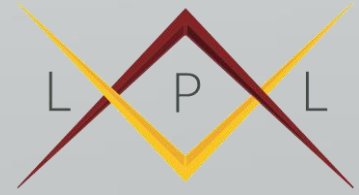


MCR	Mission Concept Review	CDR	Critical Design Review
SRR	System Requirements Review	SIR	System Integration Review
SDR	System Definition Review	ORR	Operational Readiness Review
PDR	Preliminary Design Review	DR/DRR	Decommissioning/Disposal Readiness Review

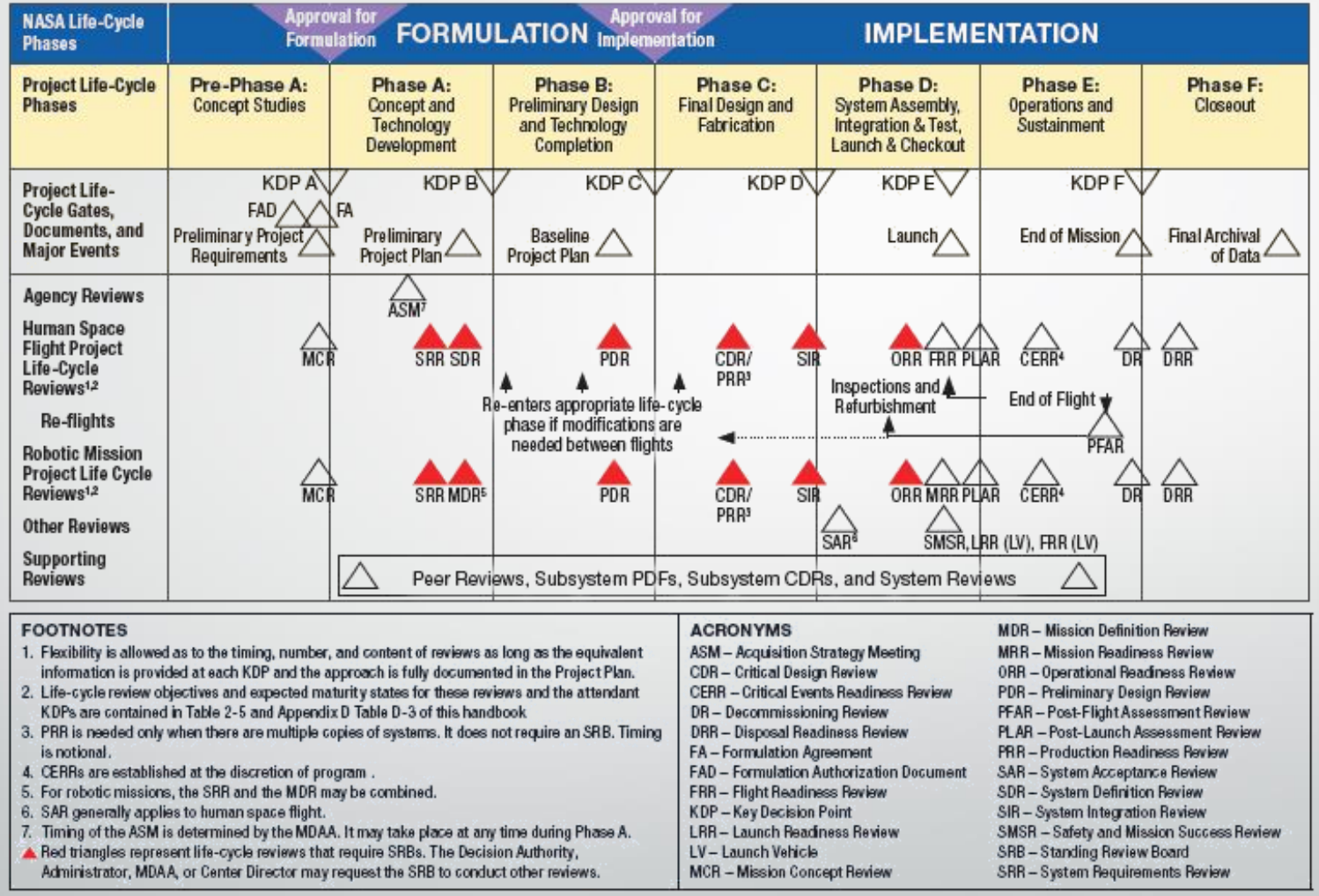
Adapted from INCOSE-TP-2003-002-04, 2015

FIGURE 2.5-1 Life-Cycle Cost Impacts from Early Phase Decision-Making

https://www.nasa.gov/connect/ebooks/nasa-systems-engineering-handbook



Design Review Basics



FOOTNOTES

1. Flexibility is allowed as 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 Project Plan.
2. Life-cycle review objectives and expected maturity states for these reviews and the attendant KDPs are contained in Table 2-5 and Appendix D Table D-3 of this handbook
3. PRR is needed only when there are multiple copies of systems. It does not require an SRB. Timing is notional.
4. CERRs are established at the discretion of program .
5. For robotic missions, the SRR and the MDR may be combined.
6. SAR generally applies to human space flight.
7. Timing of the ASM is determined by the MDAA. It may take place at any time during Phase A.

▲ 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.

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
LV – Launch Vehicle
MCR – Mission Concept Review
MDR – Mission Definition Review
MRR – Mission Readiness Review
ORR – Operational Readiness Review
PDR – Preliminary Design Review
PFAR – Post-Flight Assessment 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

FIGURE 3.0-1 NASA Space Flight Project Life Cycle from NPR 7120.5E

https://www.nasa.gov/connect/ebooks/nasa-systems-engineering-handbook

Design Review Basics

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TABLE 6.7-1 Purpose and Results for Life-Cycle Reviews for Spaceflight Projects

Name of Review	Purpose	Timing	Entrance/Success Criteria	Results of Review
Mission Concept Review (MCR)	The MCR will affirm the mission need and evaluates the proposed objectives and the concept for meeting those objectives.	The MCR should be completed prior to entering the concept development phase (Phase A)	The MCR entrance and success criteria are defined in Table G-3 of NPR 7123.1.	A successful MCR supports the determination that the proposed mission meets the customer need and has sufficient quality and merit to support a field Center management decision to propose further study to the cognizant NASA program Associate Administrator as a candidate Phase A effort.
System Requirements Review (SRR)	The SRR evaluates the functional and performance requirements defined for the system and the preliminary program or project plan and ensures that the requirements and selected concept will satisfy the mission.	The SRR is conducted during the concept development phase (Phase A) and before conducting the SDR or MDR.	The SRR entrance and success criteria for a program are defined in Table G-1 of NPR 7123.1. The SRR entrance and success criteria for projects and single-project programs are defined in Table G-4 of NPR 7123.1.	Successful completion of the SRR freezes program/project requirements and leads to a formal decision by the cognizant program Associate Administrator to proceed with proposal request preparations for project implementation

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Design Review Basics

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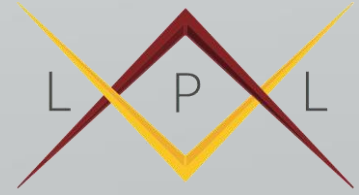
Name of Review	Purpose	Timing	Entrance/Success Criteria	Results of Review
Preliminary Design Review (PDR)	The PDR demonstrates that the preliminary design meets all system requirements with acceptable risk and within the cost and schedule constraints and establishes the basis for proceeding with detailed design. It shows that the correct design options have been selected, interfaces have been identified, and verification methods have been described. The PDR should address and resolve critical, system-wide issues and show that work can begin on detailed design.	PDR occurs near the completion of the preliminary design phase (Phase B) as the last review in the Formulation Phase.	The entrance and success criteria for the PDR are defined in Table G-6 of NPR 7123.1.	As a result of successful completion of the PDR, the design-to baseline is approved. A successful review result also authorizes the project to proceed into the Implementation Phase and toward final design.

https://www.nasa.gov/connect/ebooks/nasa-systems-engineering-handbook



Design Review Basics

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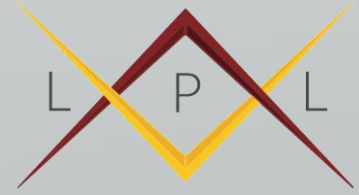
Name of Review	Purpose	Timing	Entrance/Success Criteria	Results of Review
Critical Design Review (CDR)	The CDR demonstrates that the maturity of the design is appropriate to support proceeding with full scale fabrication, assembly, integration, and test. CDR determines if the technical effort is on track to complete the system development, meeting mission performance requirements within the identified cost and schedule constraints.	CDR occurs during the final design phase (Phase C).	The entrance and success criteria for the CDR are defined in Table G-7 of NPR 7123.1.	As a result of successful completion of the CDR, the build-to baseline, production, and verification plans are approved. A successful review result also authorizes coding of deliverable software (according to the build-to baseline and coding standards presented in the review) and system qualification testing and integration. All open issues should be resolved with closure actions and schedules.

https://www.nasa.gov/connect/ebooks/nasa-systems-engineering-handbook



LPL Review Process

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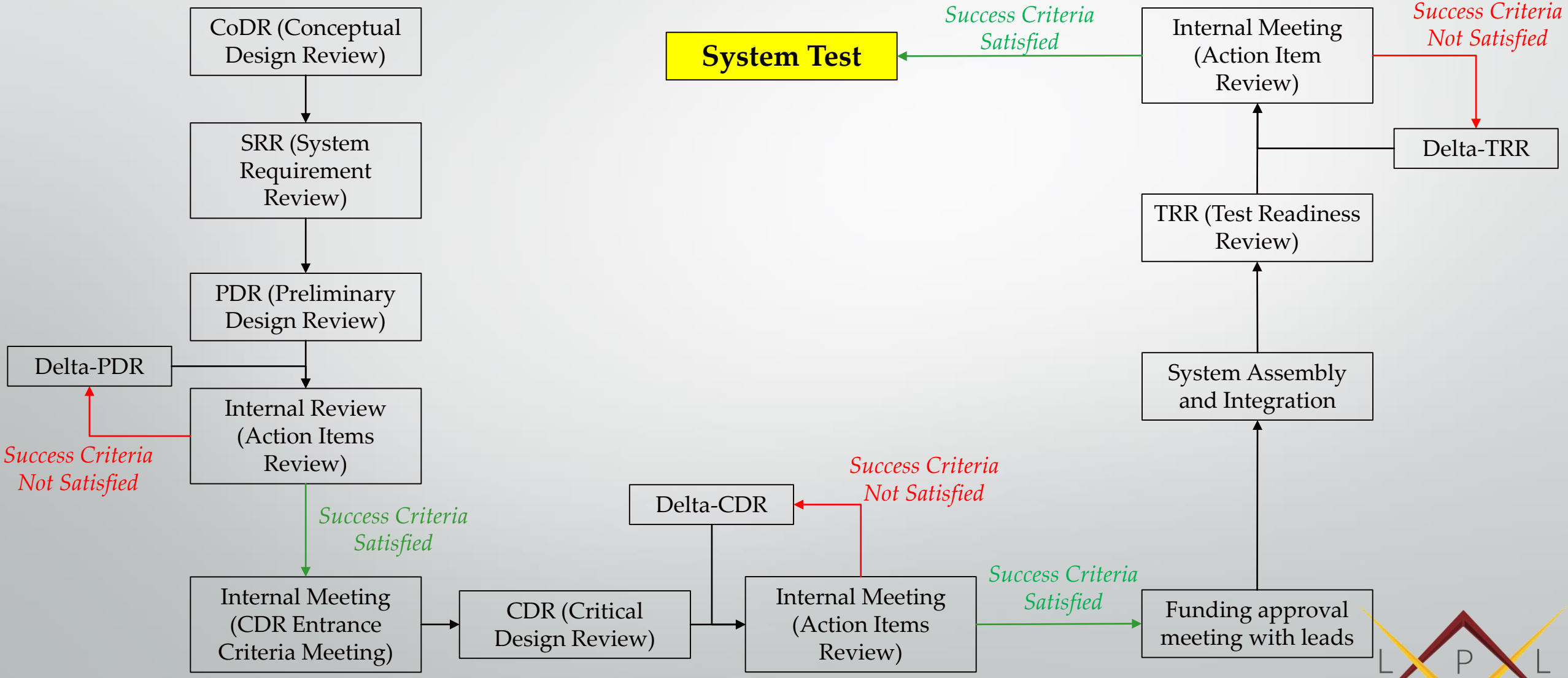

Delta-PDR, Delta-CDR and Delta-TRR are the creating reviews for not successful criteria during PDR, CDR and TRR instead of doing whole review again.

Conceptual Design Review (CoDR) Guidelines

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Note: Success criteria means, these bullet points needs to be satisfied to proceed with design solution.

It should be noted that all items may not apply in all cases, and that additional items may apply in some cases.

Acronyms

TBD: *To be determined*
TBR: *To be resolved*

Success Criteria Guidelines:

- Time: ~1 hour (max.)
  - *30 min. presentation (max.)*
  - *30 min discussion (max.)*
- Explain:
  - What is the problem?
    - Problem definition
    - Initial Requirements
  - What are the possible solutions?
    - Descriptions of options
    - Trade study with rationale
    - Pro's and Con's
    - Rough cost and schedule estimations with 30% buffer
    - Preliminary risk assessments of solutions
      - Any design challenges?
      - Any cost overruns?
      - Any schedule delays?
      - Any safety hazards?
      - Any possible problems?
    - TBD and TBR items identified

Success Criteria Guidelines:

- *Answer to these questions:*
  - Is it really need a new design to solve this problem?
  - What are the top level requirements of the problem solution?
  - Is COTS (Commercial off-the-shelf) solutions are available?
  - Is this problem unique or it is common in the industry?
  - If this is common problem in the industry, how they are solving it?
  - If you selected a specific solution, explain why you chose the solution?
  - How you are planning to manufacture your solutions?

If you don't know or not sure about the answers of these questions, ask to experienced members of alumni before or during the meeting.

Note: At the end of the meeting leads and alumni should vote regarding the future of the design solution.

For more information check **Table G-3** from the document.

System Requirements Review (SRR) Guidelines

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Note: Success criteria means, these bullet points needs to be satisfied before doing the PDR

It should be noted that all items may not apply in all cases, and that additional items may apply in some cases.

Acronyms

TBD: *To be determined*
TBR: *To be resolved*

Success Criteria Guidelines:

- Time: ~1 hour (max.)
  - *30 min. presentation (max.)*
  - *30 min discussion (max.)*
- Show:
  - Action items from CoDR
  - Resolution of action items
- Explain:
  - The functional and performance requirements defined for the system
  - Preliminary approaches have been determined for how requirements will be verified and validated
  - TBD and TBR items

2.4 Distinctions between Product Verification and Product Validation

From a process perspective, the Product Verification and Product Validation processes may be similar in nature, but the objectives are fundamentally different:

- Verification of a product shows proof of compliance with requirements—that the product can meet each "shall" statement as proven though performance of a test, analysis, inspection, or demonstration (or combination of these).
- Validation of a product shows that the product accomplishes the intended purpose in the intended environment—that it meets the expectations of the customer and other stakeholders as shown through performance of a test, analysis, inspection, or demonstration.

https://www.nasa.gov/sites/default/files/atoms/files/nasa_systems_engineering_handbook_0.pdf

https://www.nasa.gov/seh/appendix-c-how-to-write-a-good-requirement
https://www.nasa.gov/seh/appendix-d_requirements-verification-matrix
https://www.nasa.gov/seh/appendix-e_creating-the-validation-plan
https://www.nasa.gov/seh/appendix-i-verification-and-validation-plan-outline

For more information check **Table G-4** from the document.

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Preliminary Design Review (PDR) Guidelines

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Note: Entrance criteria means, these bullet points needs to be satisfied before doing the PDR

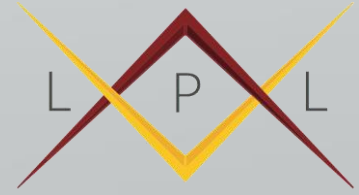
Entrance Criteria Guidelines:

- System Requirements Determined
- PDR Data package created
  - Agenda
  - Presentation
  - Technical Report
- PDR agenda completed
- PDR presentation completed
  - Check success criteria for required content
- PDR technical report completed
  - All detailed calculations that is summarized in PDR presentation
- PDR meeting scheduled
  - Members, alumni, professors and industry people notified *(a week before, latest)*
- Internal review for PDR completed
- Technical report sent out to attendees before the PDR *(a day before, latest)*

Presentation Guidelines:

- **Templates**
  - General
  - Balerion
  - Hydra and J&J
  - WFTS
- **Fonts**
  - Times New Roman
  - Palatino Linotype
  - Roboto
- **Sizes**
  - Headline → 32-40
  - Text → 10-20
- **Image requirements**
  - No blurry images
  - Add black or cardinal color shape outline

For more information check **Table G-6** from the document.



Preliminary Design Review (PDR) Guidelines

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Note: Success criteria means, these bullet points needs to be satisfied to complete the PDR stage

It should be noted that all items may not apply in all cases, and that additional items may apply in some cases.

Acronyms

TBD: *To be determined*
TBR: *To be resolved*

Success Criteria Guidelines:

- Time: ~ 2-3 hours
  - *Do it in multiple days if it is more than 2 hours. Divide in 2 hours period for each day.*
- High-level summary
- Team breakdown
- Purpose of the design
- Functional description and block diagram
- Top-Level Requirements and Preliminary Responses (Compliance of the design)
  - Functional and performance
  - Subsystem requirements (hardware/software requirements)
  - System and subsystem level test requirements
  - System and subsystem level analysis requirements
  - Single Point Failure (SPF) policy
  - Safety requirements
  - Cost requirements
  - Deadline requirements
  - Confidence/risk levels for each
  - Documentation requirements
- Make or buy (*or find spare*) decision and rationale
- Preliminary safety analysis
- Preliminary cost analysis(w/ margins)
- Preliminary schedule analysis(w/ margins)
- Preliminary manufacturability plans
  - Rough timeline and possible locations
- Preliminary assembly and system integrations plans

Success Criteria Guidelines:

- Preliminary test plans *(what kind of tests will be performed by the system?)*
  - Rough timeline and possible locations
  - Environmental and safety requirements of possible locations
- Technical Milestones
- Subsystem descriptions
  - Design options decision and rationale
    - Trade-studies
    - Baseline Equations/theory for each subsystem (*Top-level summary of the equations, calculations and results*)
    - Preliminary computer-based analysis *(Structural, thermal, etc.)*
    - Preliminary hardware and software tests *(Independent component tests)*
    - Show margins comply with requirements
    - Design issues and possible suggestions
  - Preliminary CAD *(and rough dimensions)*
- TBD and TBR items are clearly identified
  - Plans and timelines to solve these issues
- Schedule of CDR meeting
- Summary
- Discussion

→ *All details regarding subsystem designs should be included into PDR report (+ into the back up slides).*

For more information check **Table G-6** from the document or https://llis.nasa.gov/lesson/655.

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Delta-PDR Guidelines

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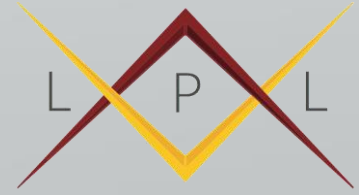
Note: Success criteria means, these bullet points needs to be satisfied to complete the PDR stage

Acronyms

TBD: *To be determined*
TBR: *To be resolved*

Success Criteria Guidelines:

- Time: ~1 hour (max.)
- ***Content of the delta-PDR comes from the page 11.*** *The main purpose of the delta-PDR is to complete the missing aspects of the actual PDR before proceeding the next phase of the design.*
- Explain purpose (Action item list from PDR that caused the delta-PDR)
- Show resolution of action items
- Resolution of all action items needs to be accepted by attendees.
- *Action items can be identified as TBD or TBR items for next review if it is accepted by attendees.*



Critical Design Review (CDR) Guidelines

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Note: Entrance criteria means, these bullet points needs to be satisfied before doing the CDR

Entrance Criteria Guidelines:

- System requirements finalized
- All action items from PDR addressed
- PDR success criteria satisfied
- CDR Data package created
  - Agenda
  - Presentation
  - Technical Report
- CDR agenda completed
- CDR presentation completed
  - Check "success criteria" for required content
- CDR technical report completed
  - All detailed calculations that is summarized in CDR presentation
- CDR meeting scheduled
  - Members, alumni, professors and industry people notified (*a week before, latest*)
- Internal review for CDR completed
- Technical report sent out to attendees before the CDR (*a day before, latest*)

Presentation Guidelines:

- **Templates**
  - General
  - Balerion
  - Hydra and J&J
  - WFTS
- **Fonts**
  - Times New Roman
  - Palatino Linotype
  - Roboto
- **Sizes**
  - Headline → 32-40
  - Text → 10-20
- **Image requirements**
  - No blurry images
  - Add black or cardinal color shape outline

For more information check **Table G-7** from the document.

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Critical Design Review (CDR) Guidelines

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Note: Success criteria means, these bullet points needs to be satisfied to complete the CDR stage

It should be noted that all items may not apply in all cases, and that additional items may apply in some cases.

Acronyms

TBD: *To be determined*
TBR: *To be resolved*

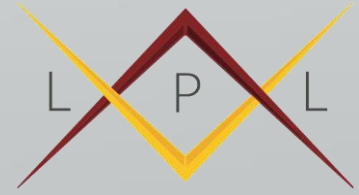
For more information check **Table G-7** from the document or https://llis.nasa.gov/lesson/657.

Success Criteria Guidelines:

- Time: >3 hours
  - *Do it in multiple days. Divide in 2 hours period for each day.*
- Team breakdown
- High-level summary *(Design selection/overall summary)*
- Updated functional description and block diagram
- Disposition of Preliminary Design Review (PDR) action items
- Functional requirements and compliance of the design, presented in matrix format with traceability references *(Show requirements and justification/verification)*
  - Functional and performance
  - Subsystem requirements (hardware/software requirements)
  - System and subsystem level test requirements
  - System and subsystem level analysis requirements
  - Single Point Failure (SPF) policy
  - Safety requirements
  - Cost requirements
  - Deadline requirements
  - Confidence/risk levels for each
  - Documentation requirements
- Safety and mission assurance
  - System and subsystem level safety precautions
  - Nominal (safe) conditions of operations
  - Hazardous conditions of operations
  - Catastrophic conditions of operations
- Preliminary system and subsystem level test and simulation data *(Justification and verification of the design)*
- Manufacturability *(Show how to create the design in real life)*
- System implementation plans
  - Integration and assembly (build)
  - Component testing
  - Subsystem level testing

Success Criteria Guidelines:

  - Logistics
- Detailed system test plans
  - Proposed testing campaigns
  - Timeline and designated locations
  - Test setup plans
  - Environmental and safety requirements of test locations
  - Logistics
    - Transportation
    - Member/Alumni arrangements
    - Etc.
- Detailed CAD and Technical Drawings *(Be sure to check the GD&T drawing templates)*
  - Approved technical drawings *(presented in backup – appendix– slides)*
- Detailed subsystem descriptions
  - Final subsystem design selection
  - Failure modes
  - Margins
  - Top-level summary of results *(calcs and baseline equations should be in the report)*
  - Cost/component breakdown
    - Parts
    - Manufacturer
    - Alternative Manufacturer
    - Lead time (margins)
    - Cost
    - Etc.
- TBD and TBR items are clearly identified
  - Plans and timelines to solve these issues
- Detailed Schedule to final product
  - Including margins
- Summary
- Discussion



Delta-CDR Guidelines

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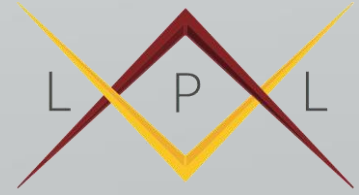
Note: Success criteria means, these bullet points needs to be satisfied to complete the delta-CDR stage

Acronyms

TBD: *To be determined*
TBR: *To be resolved*

Success Criteria Guidelines:

- Time: < 2 hours
- ***Content of the delta-CDR comes from the page 14.*** *The main purpose of the delta-CDR is to complete the missing aspects of the actual CDR before proceeding the next phase of the design.*
- Explain purpose (Action item list from CDR that caused the delta-CDR)
- Show resolution of action items
- Resolution of all action items needs to be accepted by attendees.
- *Action items can be identified as TBD or TBR items for next review if it is accepted by attendees.*



Test Readiness Review (TRR) Guidelines

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Note: Entrance criteria means, these bullet points needs to be satisfied before doing the TRR

Entrance Criteria Guidelines:

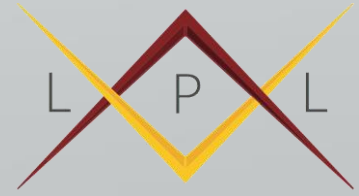
- CDR success criteria satisfied
- Funding approved by leads
- System assembled and integrated
- The objectives of the testing have been clearly defined and the definition approved by leads
- Test plan document created (see the template)
- Test plans, test procedures, test environment are approved by leads
- TRR Data package created
  - Agenda
  - Presentation
  - Technical Report
- TRR agenda completed
- TRR presentation completed
  - Check "success criteria" for required content
- TRR meeting scheduled
  - Members, alumni, professors and industry people notified

Presentation Guidelines:

- **Templates**
  - General
  - Balerion
  - Hydra and J&J
  - WFTS
- **Fonts**
  - Times New Roman
  - Palatino Linotype
  - Roboto
- **Sizes**
  - Headline → 32-40
  - Text → 10-20
- **Image requirements**
  - No blurry images
  - Add black or cardinal color shape outline

For more information check **Table G-10** from the document.

*Note: TRR should be done separately for **cold-flow testing campaign** and **hot-fire (static-fire) test.***



Test Readiness Review (TRR) Guidelines

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Note: Success criteria means, these bullet points needs to be satisfied to complete the TRR stage and to conduct test

It should be noted that all items may not apply in all cases, and that additional items may apply in some cases.

Acronyms

TBD: *To be determined*
TBR: *To be resolved*

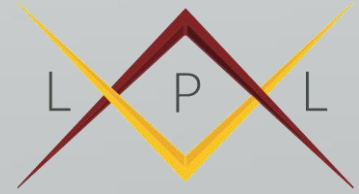
Success Criteria Guidelines:

- Time: >3 hours
  - *Do it in multiple days. Divide in 2 hours period for each day.*
- Test requirements assessed and addressed
  - Functional and performance
  - Safety
  - System
  - Operations and logistics
  - Schedule and cost
- Test success and failure criteria determined
- Risks have been identified, credibly assessed, and appropriately mitigated.
- Test plans created
- Safety procedures created (including the extreme cases as well – injury, catastrophic failure, etc.)
- Test procedures created
- Test environment determined
- Configuration of test items determined
- Logistics determined
  - Transportation
- Required trainings for test personnel determined and presented
  - Operational trainings
  - Health and safety trainings

Success Criteria Guidelines:

- The test cases have been analyzed and are consistent with the test plans and objectives
- Test matrix created with success and failure criteria
- Post-test plans determined for success and failure of the test
  - Success plans (what and how to do it)
    - Preserve test articles
    - Data analysis
  - Failure plans (what and how to do it)
    - Recover test articles
    - Data analysis
    - Failure investigation
- Preliminary test and simulation data presented
- TBD and TBR items are clearly identified
  - Plans
  - Timelines
- Schedule and cost of the test presented
- Summary
- Discussion

For more information check **Table G-10** from the document.



Delta-TRR Guidelines

USC Viterbi School of Engineering

Note: Success criteria means, these bullet points needs to be satisfied to complete the TRR stage and to conduct test

Acronyms

TBD: *To be determined*
TBR: *To be resolved*

Success Criteria Guidelines:

- Time: < 2 hours
- ***Content of the delta-TRR comes from the page 17.*** *The main purpose of the delta-TRR is to complete the missing aspects of the actual TRR before proceeding the next phase of the design.*
- Explain purpose (Action item list from TRR that caused the delta-TRR)
- Show resolution of action items
- Resolution of all action items needs to be accepted by attendees.
- *Action items can be identified as TBD or TBR items for next review if it is accepted by attendees.*