Considerations in the Modular Design of Complex Systems

November 7-8, 2016

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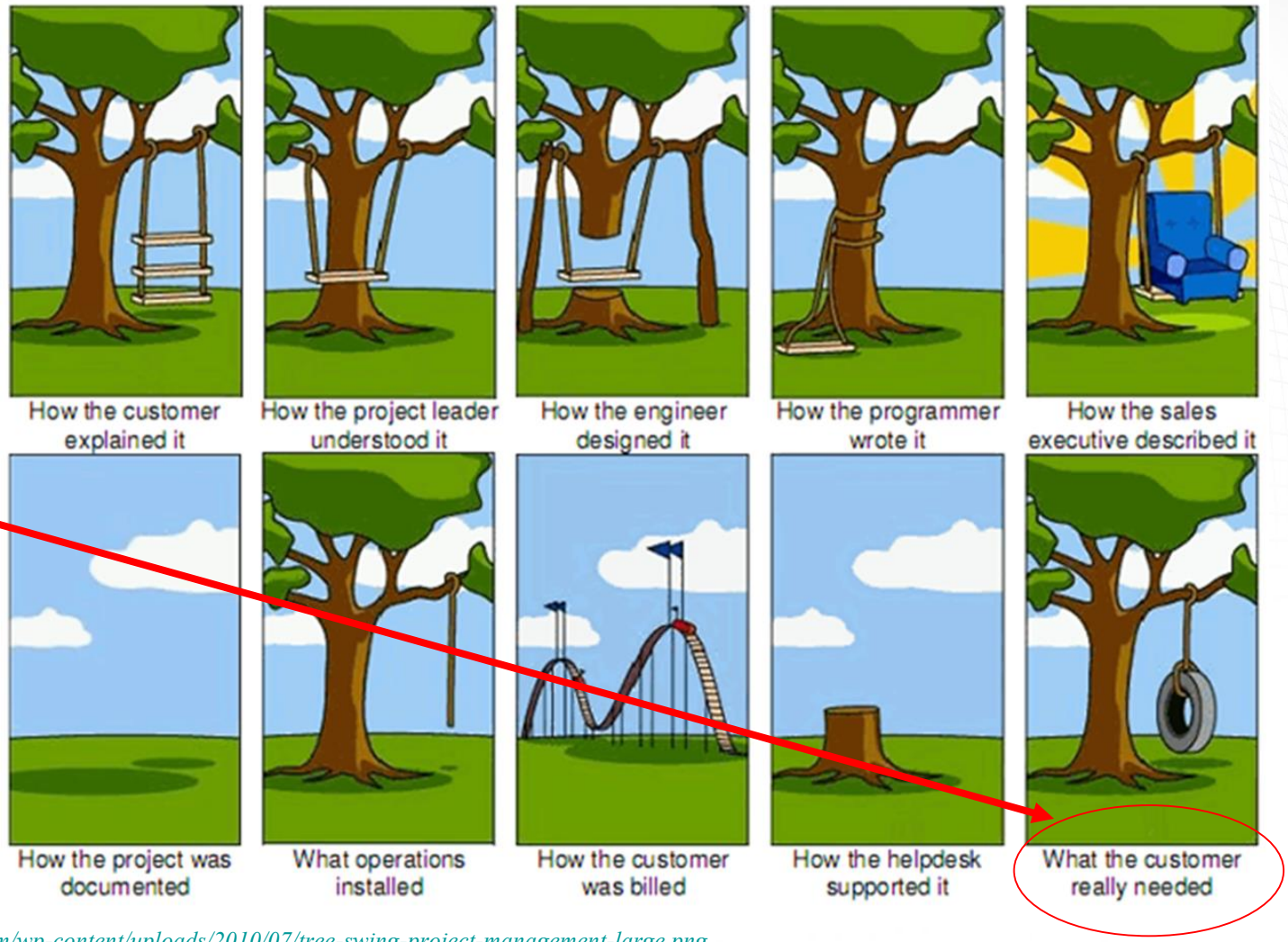
Common Mistakes on Most Projects

- Most projects start with a perceived assumption…

The Key!!

The key is to fully understand the customers needs (requirements) while meeting budget and schedule agreements.

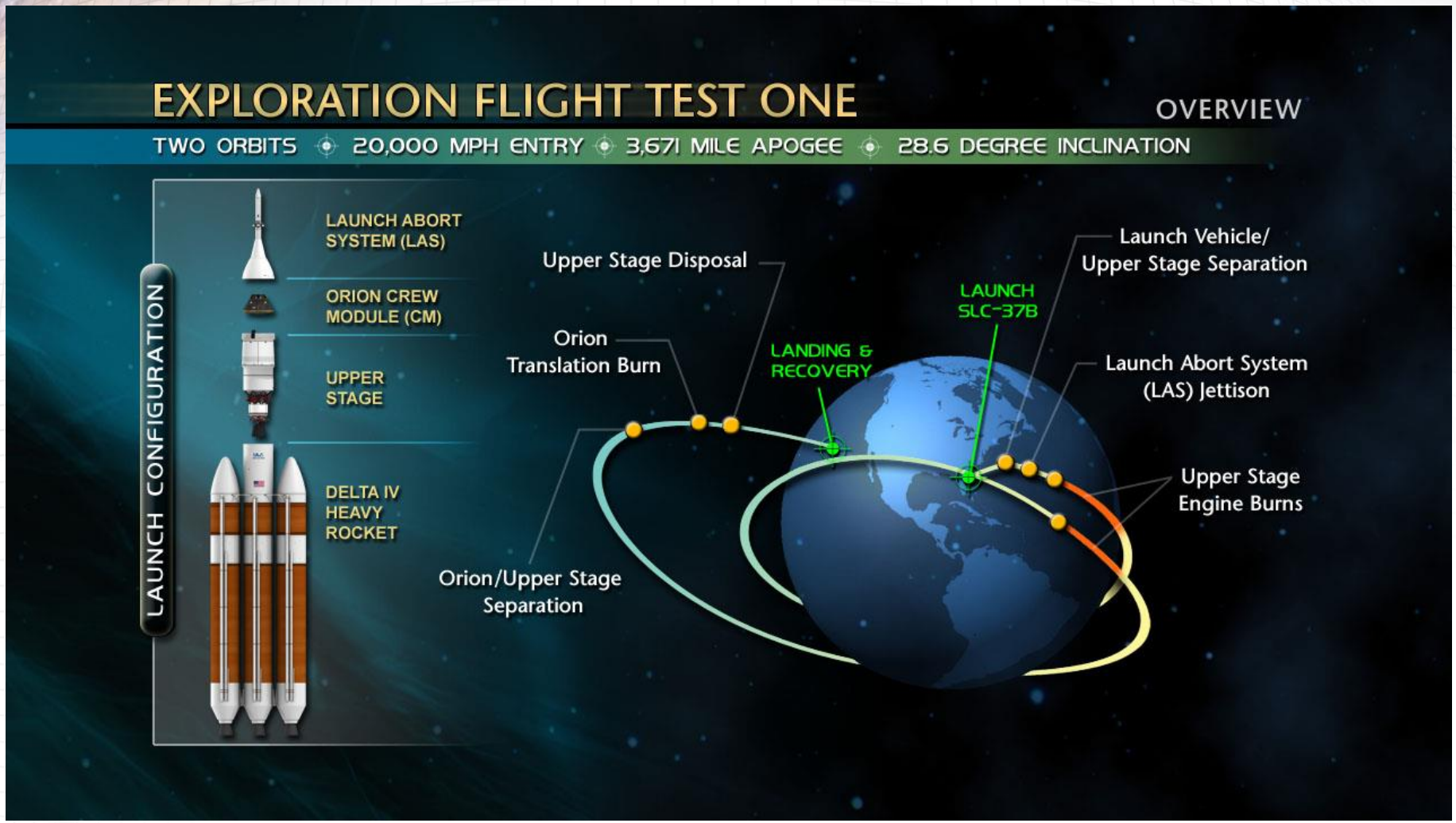


Reference: http://www.tamingdata.com/wp-content/uploads/2010/07/tree-swing-project-management-large.png

Part 1 - Identify the Concept of Operation

- A concept of operation (abbreviated ConOps) is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system.
  - *Reference: https://en.wikipedia.org/wiki/Concept_of_operations*
- At NASA-JSC it is also acceptable to use high level diagrams and/or pictures to describe what you are developing and how it will be used.
- The ConOps is also the mission plan or roadmap of what is Going to Happen, Who is doing what, Where or when will the events occur, etc.
  - The ConOps is critical in explaining what needs to be done.
  - The ConOps is the framework/outline/basis of establishing the customer's requirements.
- ConOps should drive the trade studies on what technologies are available.

Example ConOps – Orion EFT-1 Mission

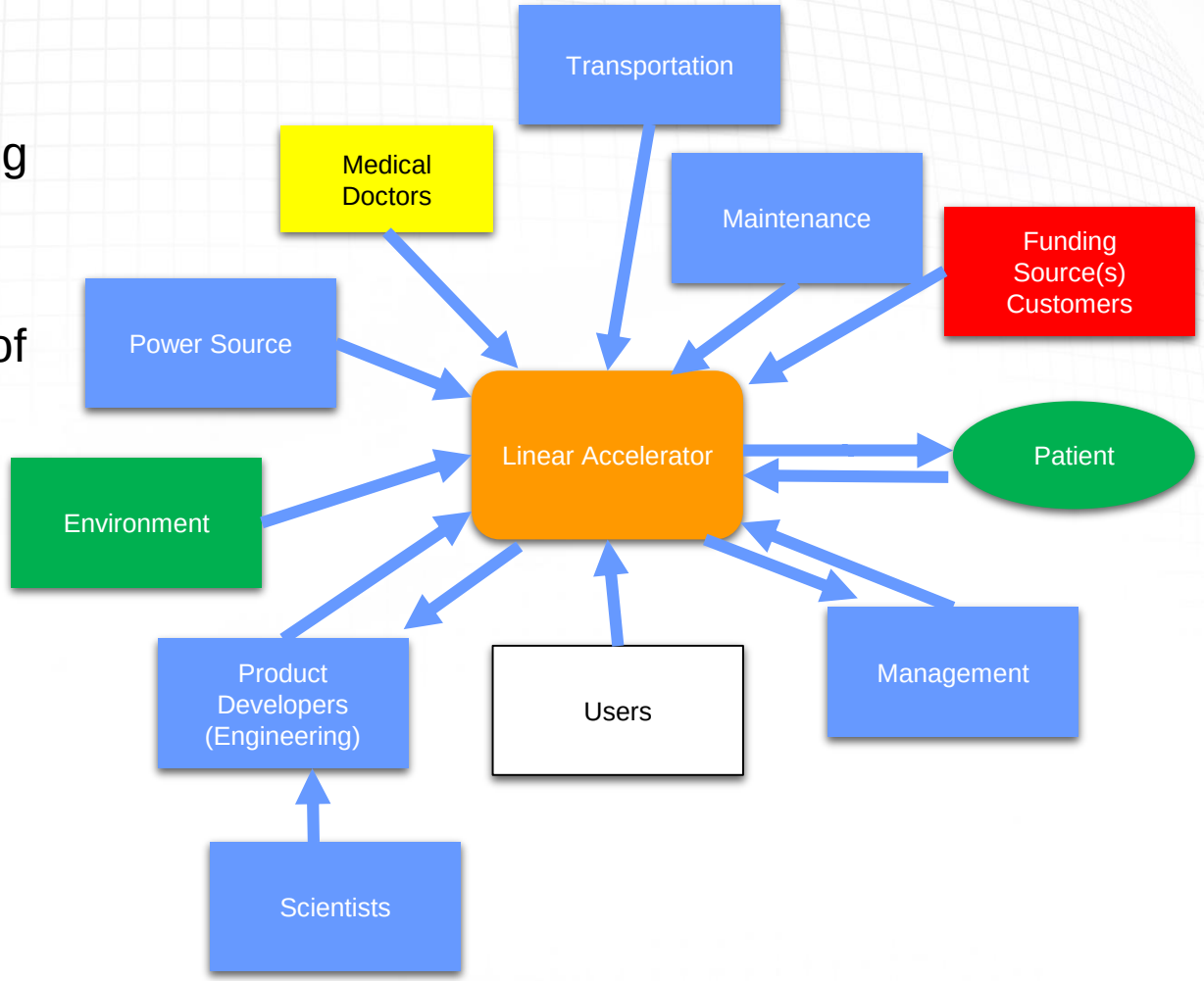


Reference: https://fpd.larc.nasa.gov/assets/eft-1_mission_diagram.jpg

Part 2 - Identify the Stakeholders

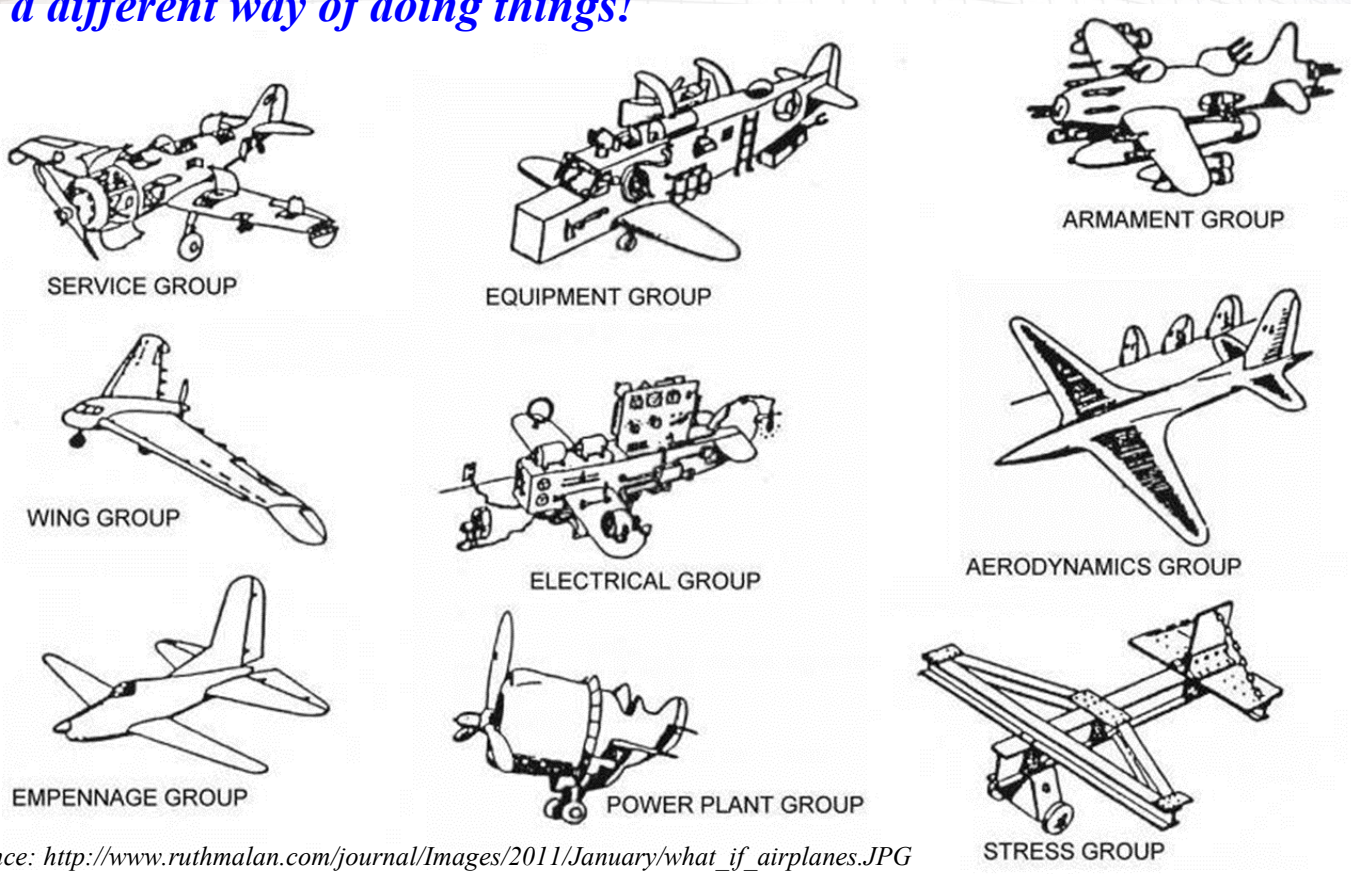
- A system **context diagram** in systems engineering is a **diagram** that defines the boundary between the system, or part of a system, and its environment, showing the entities that interact with it.
- Stakeholders can/will influence the requirements of the Project.
- Not knowing all of the stakeholder has the risk of impacting design, cost, schedule, etc.

Example…Context Diagram



Working with Different Groups

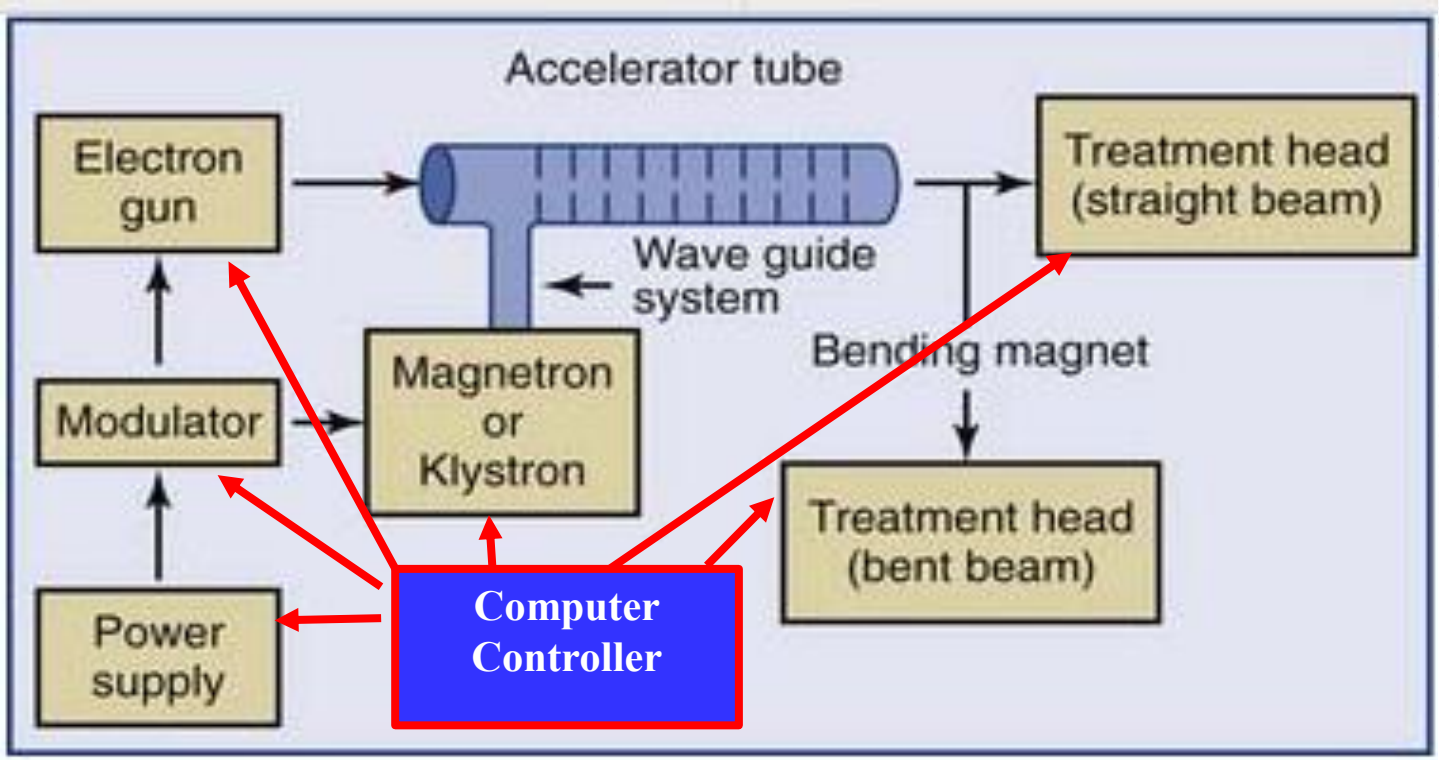
***Everyone** has a different way of doing things!*



Reference: http://www.ruthmalan.com/journal/Images/2011/January/what_if_airplanes.JPG

- **System Engineering involves identifying the entire system, identifying roles and responsibilities on the team, and getting everyone to work together towards a common goal.**
- **One of the reasons for doing Trade Studies…Allows everyone to develop consensus!**

Part 3 – Identify the System



Reference: http://clinicalgate.com/radiotherapy-for-head-and-neck-cancer-radiation-physics-radiobiology-and-clinical-principles/

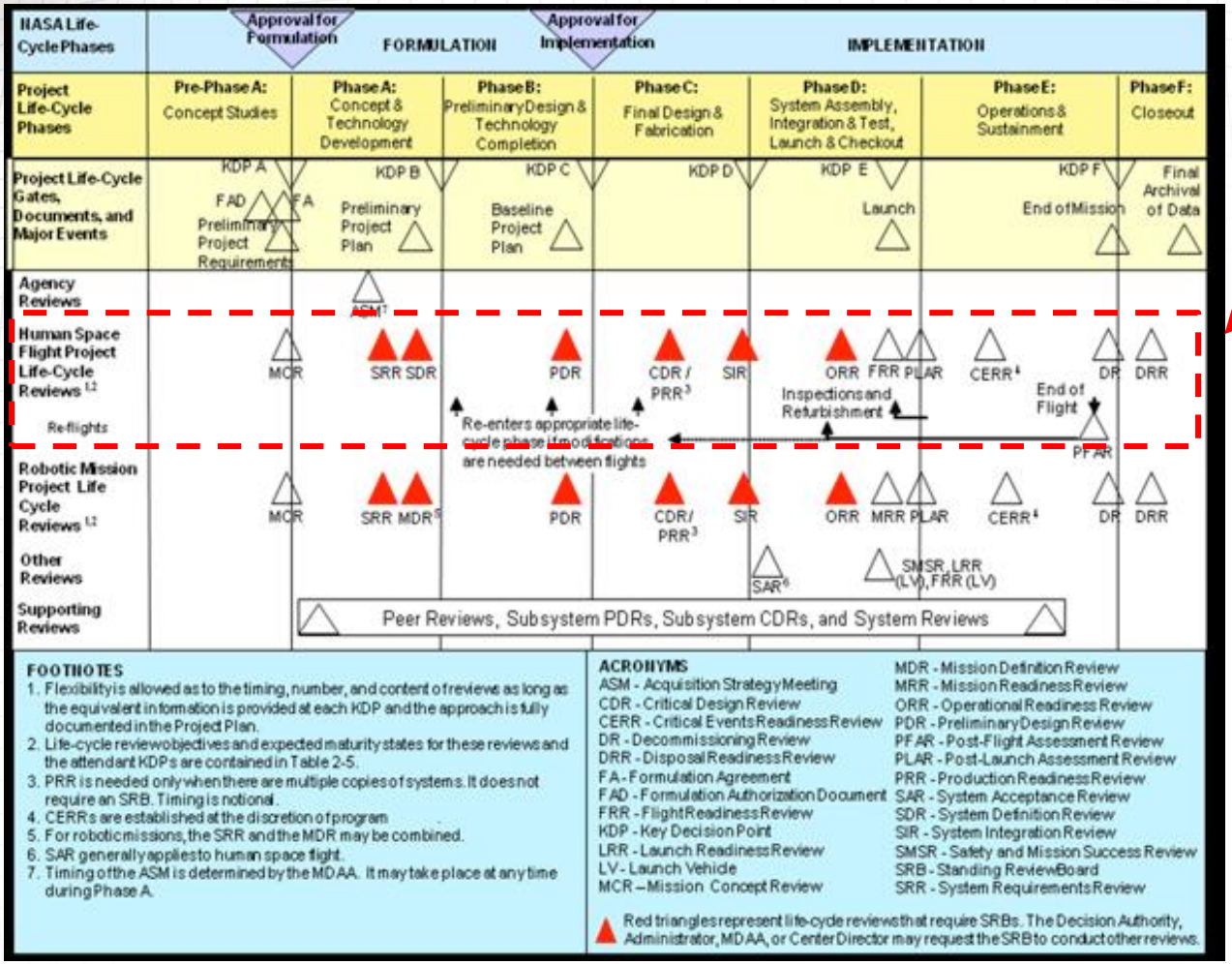
- Breaking down the system into subsystems
  - What subsystem(s) already exist or need to be developed?
  - How will the entire system be powered?
  - What computer system is needed to monitor/control the entire system?

Part 4 – Define the Project Life Cycle

- The Project Life Cycle refers to a series of activities which are necessary to fulfill project goals or objectives. *(Reference: https://www.uakron.edu/pmo/plc/)*
- Every project, whether large or small, has a process that governs the project life cycle from inception, delivery, and usage.
  - "Learn the Process so that you can wisely deviate from it!", (NASA-JPL/Gentry Lee)
  - Main Thoughts:
    - Every Project is "tailorable" based on the needs of the stakeholder(s) and development team.
    - In order to effectively tailor the project process, you need a Project Manager/Engineer/Developer with Knowledge, Skill(s), and Experience who understands what events should and need to occur in order to meet the stakeholder(s) requirements.
- Most Project Life Cycles are directly related to a Project Schedule.
  - Most NASA Agencies use the NASA Procedural Requirements (NPR 7120.5, Rev. E) as a guide.
    - The NPR is used to establish Technical Reviews to ensure the project has met entrance and exit criteria for success.
  - The Project Manager establishes and maintains the project schedule!
    - Schedules are tools that are used to **communicate** to the Stakeholders and to the Team what has been completed and what needs to happen next.

Part 4 (Continued) - Example Project Milestone Schedules

- *From NASA Procedural Requirements (NPR) 7120.5, Rev. E, NASA Space Flight Program & Project Management*



NASA-JSC usually follows something similar to this profile.

Reference: NPR 7120.5E, Figure 2-5

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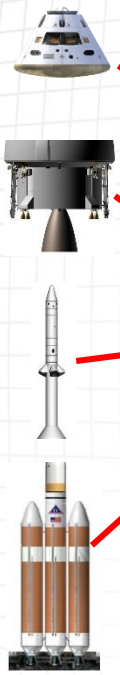
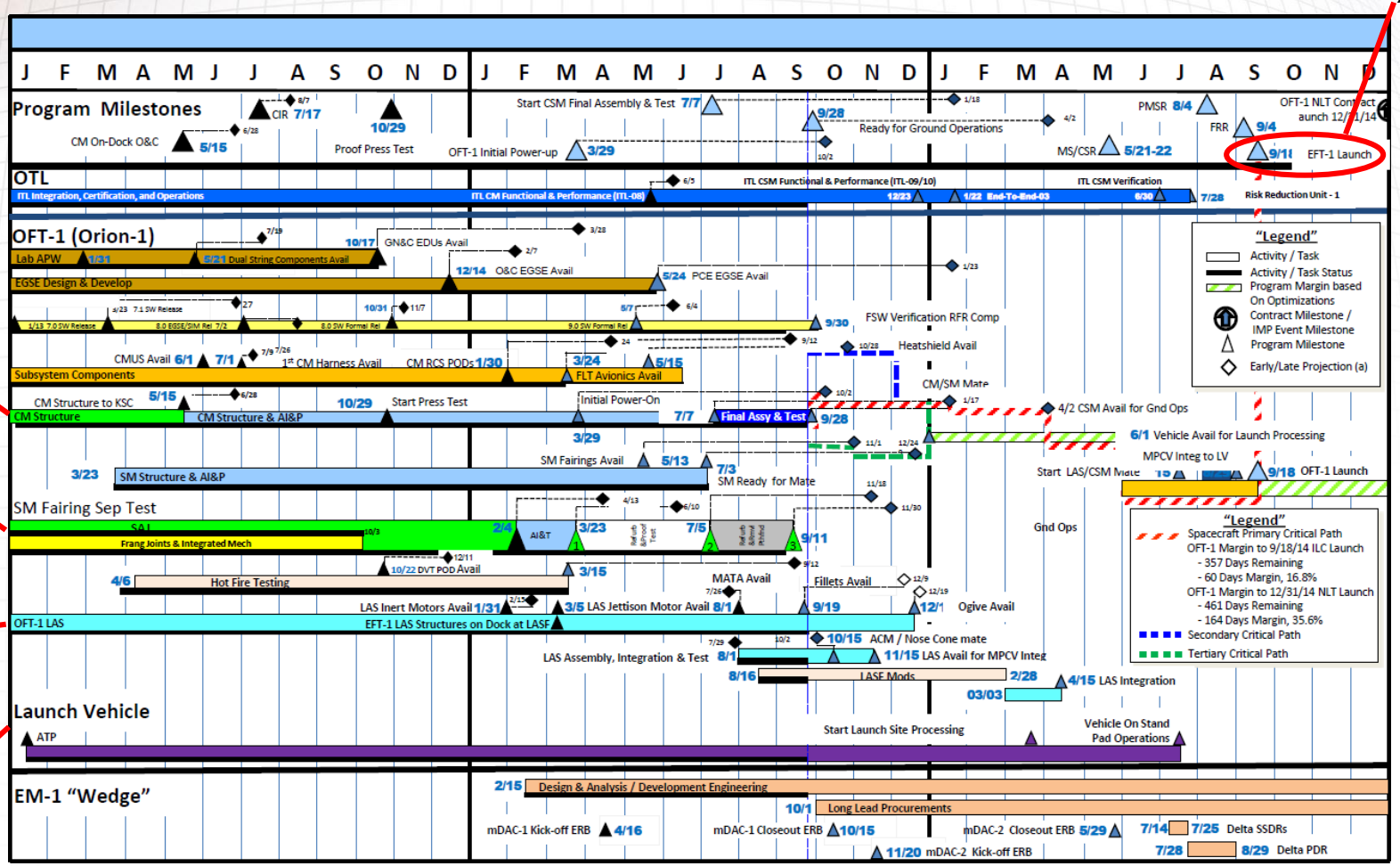
Part 4 (Continued) – Define the Project Life Cycle (Example - Schedule for Orion EFT-1)

Launch Date: December 5, 2014

Orion Sub-Systems

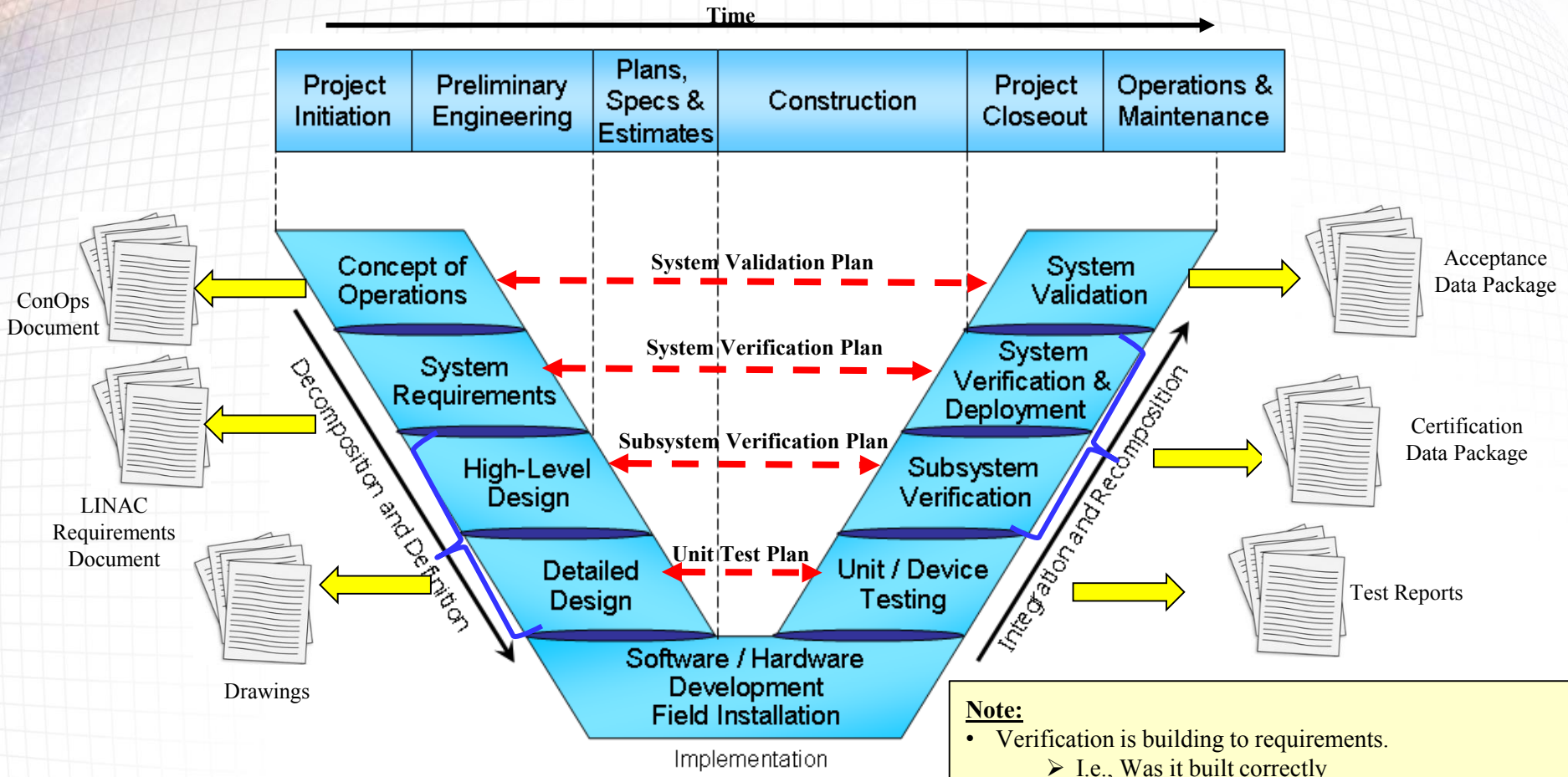




http://www.palisade.com/images3/casestudy/aerospace/LockheedMartin_NASA_OrionProgramSummaryMasterSchedulePSMS.png

Part 5 – Start the Process

- Regardless the level of "Schedule Tailoring" and Design Characterization, most projects will follow the Systems Engineering "V-Model" process.



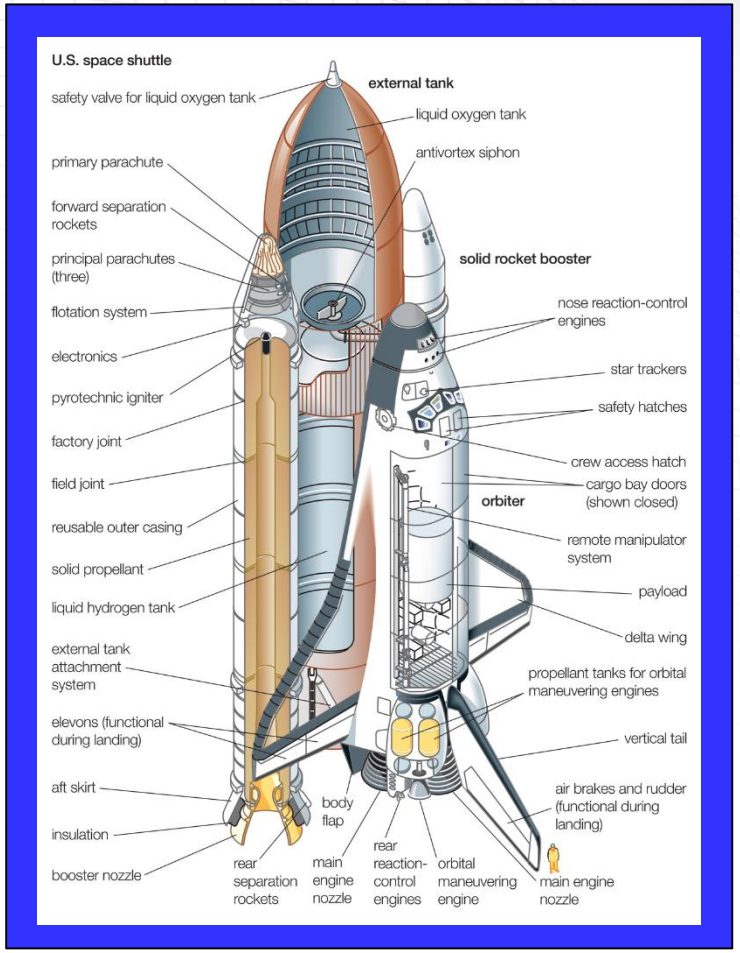
Note:

- Verification is building to requirements.
  - I.e., Was it built correctly
- Validation is building to the customer's expectations!
- Remember the common mistakes on most projects! (Page 2)

Reference: http://ops.fhwa.dot.gov/publications/regitsarchguide/73useprojimp.htm, Figure 44.

Summary

- *The Space Shuttle is one of the most complex machines ever built and has more than 2.5 million parts…(Reference: http://spaceflight.nasa.gov/shuttle/upgrades/upgrades5.html)*
  - All projects whether small or large have their own levels of complexity!
  - The key to success in Design, Development, Test, & Evaluation (DDT&E) on any project is to:
    - **Part 1:** Identify the Concept of Operation – How will the system be used in the field.
    - **Part 2:** Identify the Stakeholders – Who will be involved?
    - **Part 3:** Identify the System
    - **Part 4:** Define the Project Life Cycle – Project Schedule
    - **Part 5:** Start the Process
- Don't forget about the Paperwork!
  - *"We can lick gravity, but sometimes the paperwork is overwhelming!" (by Werner Von Braun)*
- Questions & Answers



Reference: https://s-media-cache-ak0.pinimg.com/originals/66/61/54/666154c8a699c9d7fbff6e2ac7cfedb7.jpg

Reference: http://www.jobinterviewtools.com/blog/wp-content/uploads/2010/01/dreamstimemedium_19473030-300x300.jpg