A Suite of Tools for Technology Assessment

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James W. Bilbro
JB Consulting International
Huntsville, Alabama

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What is Technology?

"Technology is defined as the practical application of knowledge to create the capability to do something entirely new or in an entirely new way. This can be contrasted to scientific research, which encompasses the discovery of new knowledge from which new technology is derived, and engineering which uses technology derived from this knowledge to solve specific technical problems."

- NASA Technology Plan

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What is Technology?

"1.a. The application of science, especially to industrial or commercial objectives*. **b.** The entire body of methods and materials used to achieve such objectives."

- The American Heritage Dictionary

Or in NASA's case ***space***

•Technology development lies within the context of part a. and as such is the subject of the remainder of this presentation.
•Engineering makes use of technology within the context of part b. In this context, technology may be "old (passe)," "off-the-shelf (commercially available)," or new (at various levels of maturity {TRLs})

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What is Technology?

Technology development can best be distinguished from engineering development in that it requires venturing into the realm of unknowns - beyond the ability of individuals to make informed judgements based on their experience, i.e.-

HC SVNT DRACONES *

*The Lenox Globe (ca. 1503-07),

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Why do Technology Assessment?

- **You don't know what you don't know!**

- Failure to accurately assess technology requirements contributes significantly to schedule slip and cost overrun.
- Even "heritage" systems can require technology development when they are incorporated into a new architecture with different operational environments.
- Technology development cannot be done to schedule - breakthroughs are rarely performed "on demand".
- Having a "marching army" in place, the middle of a development program is no place to be relying on "miracles" occurring on schedule!

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The Beginning of TRL's

- The idea of ascribing levels of maturity to technology was first documented in a paper "***THE NASA TECHNOLOGY PUSH TOWARDS FUTURE SPACE MISSION SYSTEMS,"*** (Saden, Povinelli & Rosen, 1989).
- This was a significant change in emphasis on the part of NASA, where technology had previously viewed as merely having a supporting role.
- The change in role was the result of a revision in the National Space Policy stating that NASA's technology program "--*shares the mantle of responsibility for shaping the Agency's future--.*"

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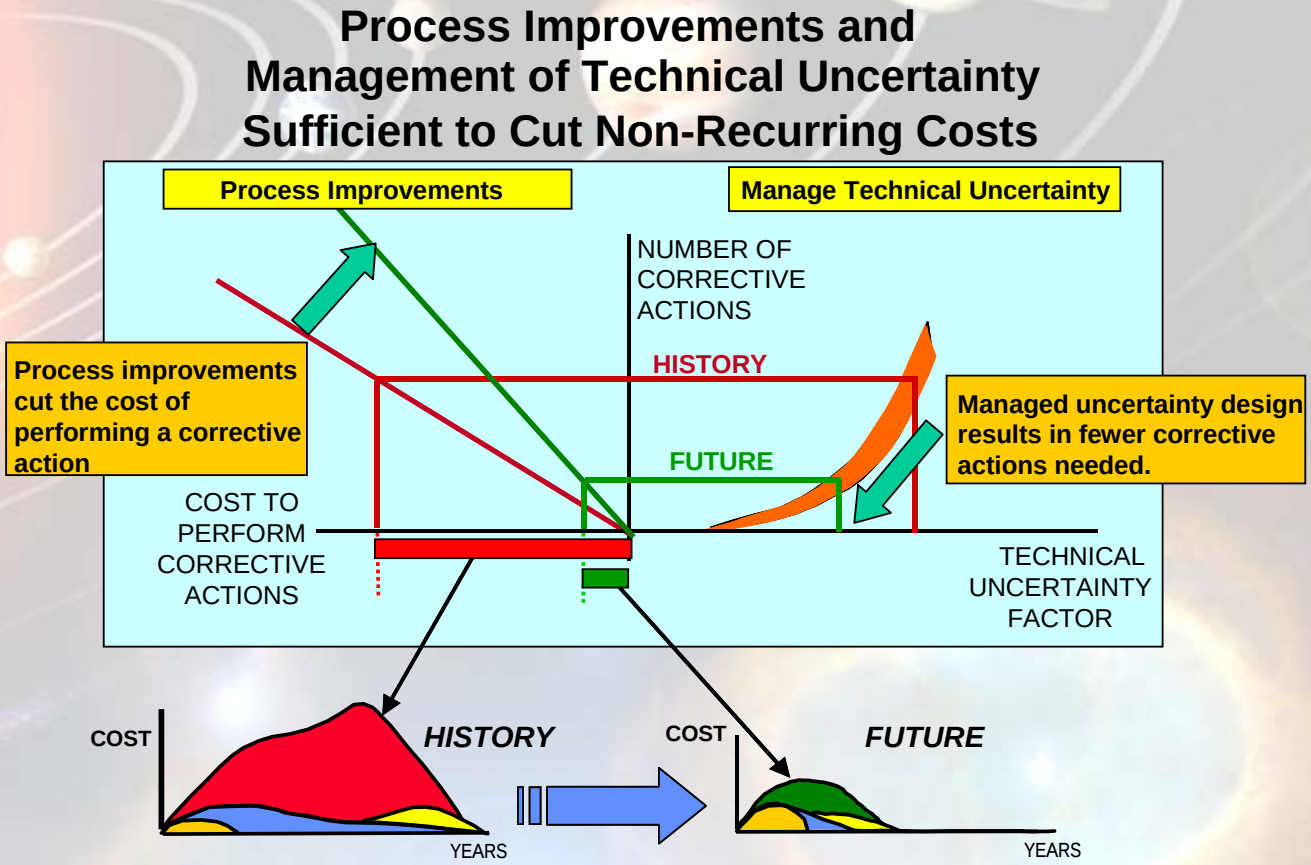

Pratt-Whitney Rocketdyne

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What does Technology Impact?

- Stakeholder Expectation: GAO studies have consistently identified the "mismatch" between stakeholder expectation and developer resources (specifically the resources required to develop the technology necessary to meet program/project requirements) as a major driver in schedule slip and cost overrun.
- Requirements Definition: If requirements are defined without fully understanding the resources required to accomplish needed technology developments then the program/project is at risk. Technology assessment must be done iteratively until requirements and available resources are aligned within an acceptable risk posture.
- Design Solution: As in the case of requirements development, the design solution must iterate with the technology assessment process to ensure that performance requirements can be met with a design that can be implemented within the cost, schedule and risk constraints.

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What does Technology Impact?

- Risk Management: In many respects, technology assessment can be considered a subset of risk management and as such should be a primary component of the risk assessment.
- Technical Assessment: Technology assessment is also a subset of technical assessment and implementing the assessment process provides a substantial contribution to overall technical assessment.
- Trade Studies: Technology assessment is a vital part of determining the overall outcome of Trade Studies, particularly with decisions regarding the use of heritage equipment.

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What does Technology Impact?

- Verification/Validation: The verification/validation process needs to incorporate the requirements for technology maturity assessment in that in the end maturity is demonstrated only through test and/or operation in the appropriate environment.
- Lessons Learned: Part of the reason for the lack of understanding of the impact of technology on programs/projects is that we have not systematically undertaken the processes to understand impacts.

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So – How do you do Technology Assessment?

- It is a two-step process that involves:
  - The determination of the **Technology Readiness Levels (TRLs)** (i.e. current level of maturity) of all of the systems, subsystems and components required to meet program/project requirements.
  - The determination of the **Advancement Degree of Difficulty (AD^2)** (i.e., what is required to advance the immature technologies from their current TRL to a level that permits infusion into the program/project within cost, schedule and risk constraints.

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What is a TRL?

- At its most basic, it is maturity defined at a given point in time by what has been done and under what conditions.

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TRL Descriptions

Technology Readiness Level - (TRL)	Definition	Hardware Description	Software Description	Exit Criteria
1	Basic principles observed and reported	Scientific knowledge generated underpinning hardware technology concepts/applications.	Scientific knowledge generated underpinning basic properties of software architecture and mathematical formulation.	Peer reviewed publication of research underlying the proposed concept/application
2	Technology concept or application formulated	Invention begins, practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture.	Practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture. Basic properties of algorithms, representations & concepts defined. Basic principles coded. Experiments performed with synthetic data.	Documented description of the application/concept that addresses feasibility and benefit
3	Analytical and/or experimental critical function or characteristic proof-of-concept	Analytical studies place the technology in an appropriate context and laboratory demonstrations, modeling and simulation validate analytical prediction.	Development of limited functionality to validate critical properties and predictions using non-integrated software components	Documented analytical/experimental results validating predicitions of key parameters

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What is AD^2?

- The TRL is just one part of the equation – and the initial assessment establishes the baseline for the program/project.

- The more fundamental question is what is required (in terms of cost, schedule and risk to move the technology from where it is to where it needs to be.

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What is an Advancement Degree of Difficulty (AD^2)?

- **AD2** is a method of dealing with the other aspects beyond TRL, it is the description of what is required to move a system, subsystem or component from one TRL to another.
- It takes into account:
  - Design Readiness Level
  - Manufacturing Readiness Level (MRL)
  - Integration Readiness Level (IRL)
  - Software Readiness Level (SRL)
  - Operational Readiness Level
  - Human Readiness Levels (HRL) (skills)
  - Capability Readiness Levels (CRL) (people and tools)
  - organizational aspects (ability of an organization to reproduce existing technology)
  - Etc.

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What is an Advancement Degree of Difficulty (AD^2)?

Degree of Difficulty	Description
9	100% Development Risk - Requires new development outside of any existing experience base. No viable approaches exist that can be pursued with any degree of confidence. Basic research in key areas needed before feasible approaches can be defined.
8	80% Development Risk - Requires new development where similarity to existing experience base can be defined only in the broadest sense. Multiple development routes must be pursued.
7	60% Development Risk - Requires new development but similarity to existing experience is sufficient to warrant comparison in only a subset of critical areas. Multiple development routes must be pursued
6	50% Development Risk - Requires new development but similarity to existing experience is sufficient to warrant comparison in only a subset of critical areas. Dual development approaches should be pursued in order to achieve a moderate degree of confidence for success. (Desired performance can be achieved in subsequent block upgrades with high degree of confidence.)
5	40% Development Risk - Requires new development but similarity to existing experience is sufficient to warrant comparison in all critical areas. Dual development approaches should be pursued to provide a high degree of confidence for success.
4	30% Development Risk - Requires new development but similarity to existing experience is sufficient to warrant comparison across the board. A single development approach can be taken with a high degree of confidence for success.
3	20% Development Risk - Requires new development well within the experience base. A single development approach is adequate.
2	10% Development Risk - Exists but requires major modifications. A single development approach is adequate.
1	0% Development Risk - Exists with no or only minor modifications being required. A single development approach is adequate.

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When do you do a Technology Assessment (TA)?

- It is extremely important that a Technology Assessment process be defined at the beginning of the program/project.
- It is also extremely important that it be performed at the earliest possible stage (concept development) and repeated periodically throughout the program/project through PDR.
- Inputs to the process will vary in level of detail according to the phase of the program/project in which it is conducted.
- Even though there is a lack of detail in pre-phase A, the TA will drive out the major critical technological advancements required.

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How do you start?

Define Your Terms!

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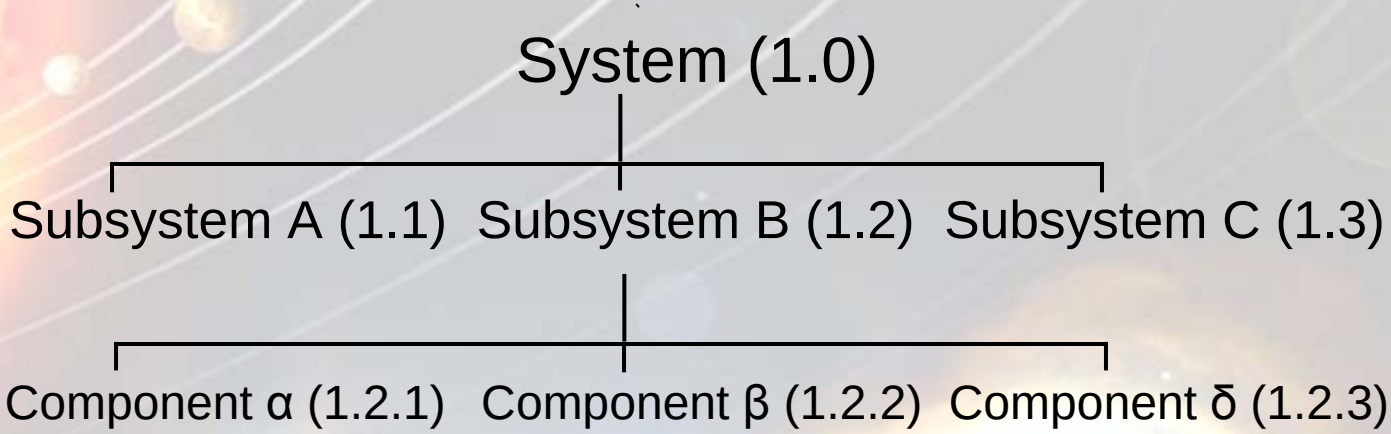
Develop a Work Breakdown Structure (WBS)



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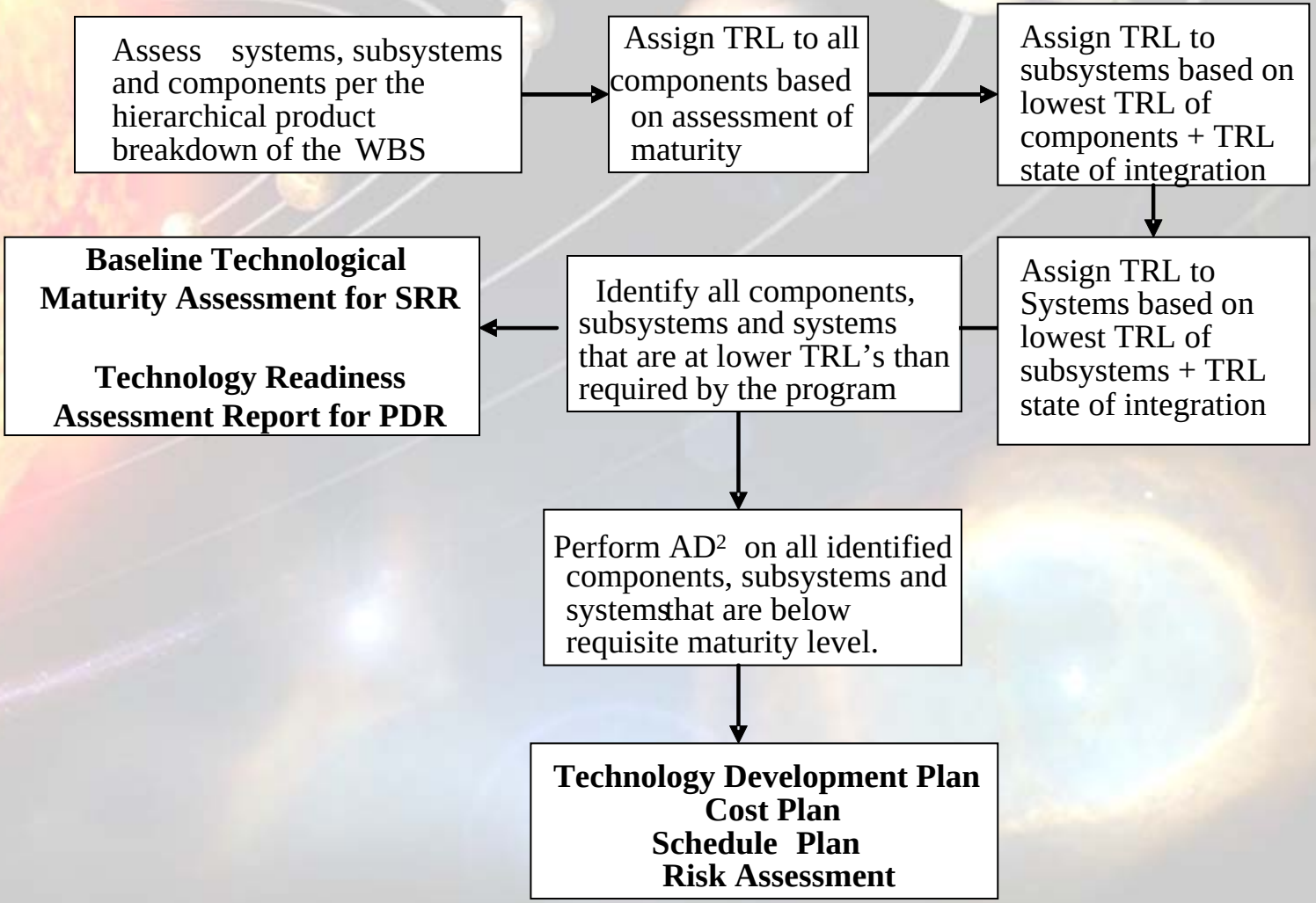
Start the Process



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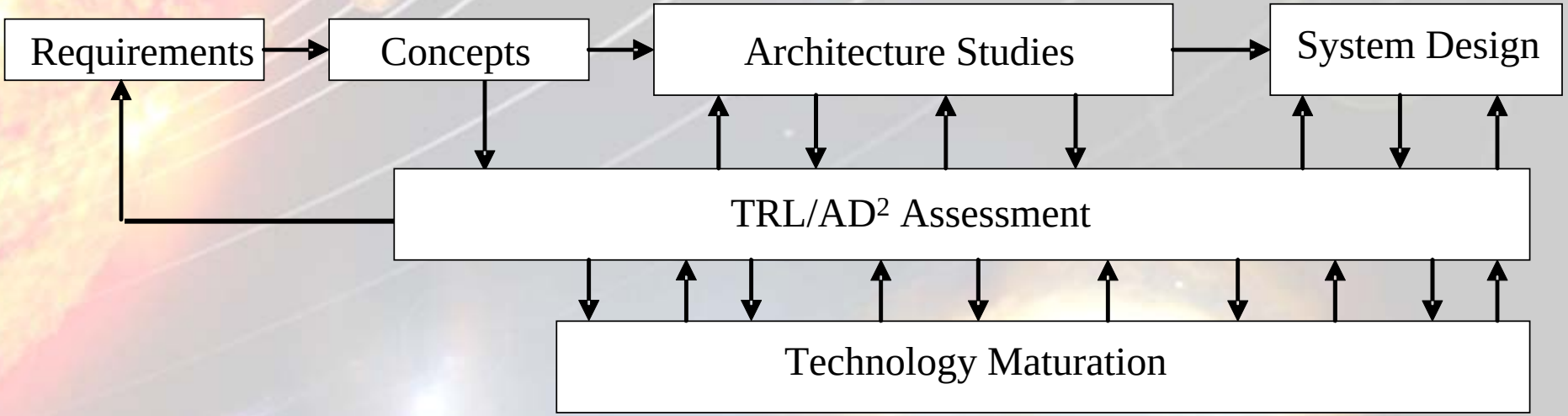
Architectural Study & Technology Assessment Interaction



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Summary

- **The TRL assessment provides the baseline maturity at the start of a program/project and is the basis for the preparation of the Technology Readiness Assessment Report required for delivery at PDR.**

- **The AD2 assessment provides the basis for the development of the Technology Development Plan and for improved accuracy of the development of program/project cost, schedule and risk.**

- **Technology Assessment is vital to program/project success!**

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Helpful Tools

- **TRL Calculator**
- **AD2 Calculator**