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Costs of Achieving Software Technology Readiness

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Agenda

- Introduction
- Technology Readiness Levels (TRLs) and Technology Readiness Assessments (TRAs)
- Software TRL
- Software TRL Challenges
- Software TRL Costs
- Conclusions

Introduction

- **Complex systems require technology innovations to achieve sophisticated missions**
- **TRLs are used by NASA and DoD to assess the maturity of evolving technologies prior to using it in a system or subsystem**
- **Technology needs to reach a specified level of maturity before development on systems can begin**
- **The cost community needs to understand the cost impact associated with maturing technology required to meet program or mission requirements**

Introduction (cont)

- **The definition and applications is very focused on hardware**
- **Software is different**
  - Not as obvious what software technology means
- **Software brings infinite possibilities for advancement of state of the art but these possibilities require the right mix of …..**
  - Hardware
  - Tools
  - People
  - Processes
- **Identifying the critical elements of software technology can be problematic**

Technology Readiness Levels

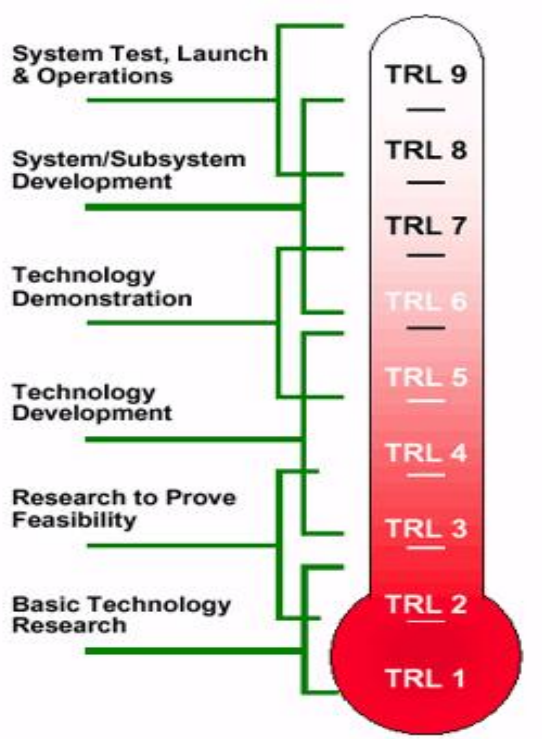
- **Technology readiness is hard for most of us to grasp**
  - Our experiences with technology are with fully matured technology
- **In 1960's President Kennedy challenged the US to land on the moon in that century**
- **At the time there were no solutions to solve problems such as**
  - Reaching earth orbit
  - Travel to the moon
  - Survival in space

- **New technology needed to be invented!**

Technology Readiness Levels

- **NASA developed, institutionalized, service adopted similar levels**

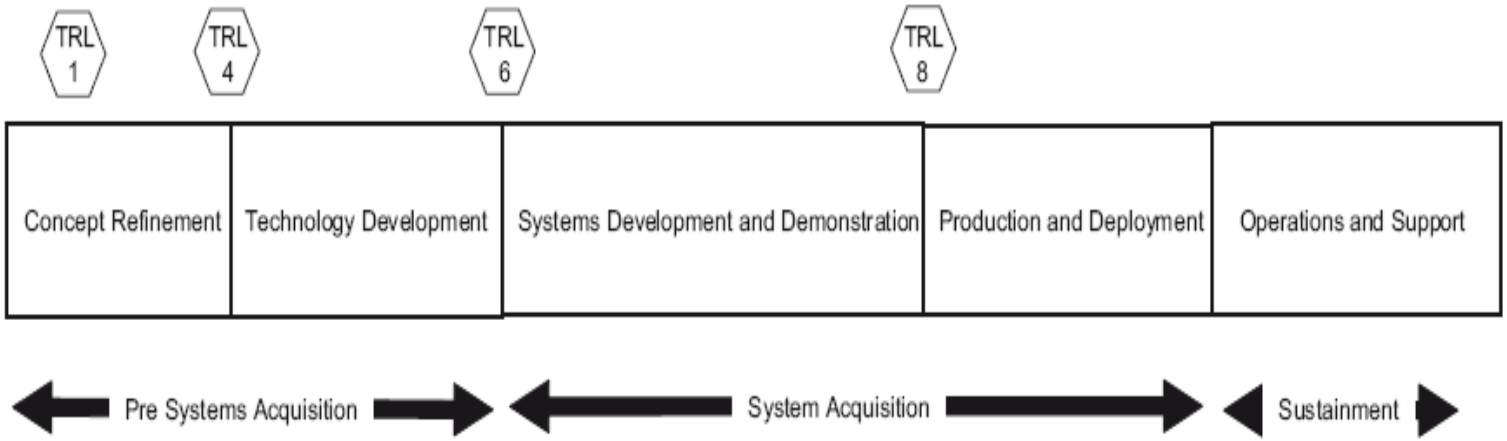
- **TRLs generalized**
  1. **An idea**
  2. **Idea good and useful**
  3. **Idea is possible**
  4. **Idea presents realistic solution**
  5. **Alpha**
  6. **Beta**
  7. **Release candidate quality**
  8. **Gold release**
  9. **Used successfully in target environment**



NASA TRLs

Technology Readiness Assessments

- **Document prior to system design and development that the acquisition is technically feasible**
- **DoD requires for Acquisition Category 1 (ACAT1) programs at Milestones A and B**



Technology Readiness Assessment

- **Identification of Critical Technology Elements (CTEs)**
  - New or novel technology
  - Technology to operate in environment different from any previous
- **Recommended that CTEs line up with Work Breakdown Structure (WBS)**
- **Each CTE is evaluated for technology readiness and assigned a TRL**
- **Maturation plans are developed for immature CTEs**

Software TRL

- **According to Robert Gold, there are five distinct ways software can be evaluated for technology readiness**
  - Unprecedented functionality – are the algorithms being implemented new or novel
  - Off the shelf (OTS) components – has OTS capability been proven in intended environment
  - Enabling run time – what besides the software itself (hardware, operating system functionality, middleware) is new, novel or unproven
  - Aggregation of components – are components that are not critical on their own gain criticality if their interactions prevent critical components to succeed
  - Enabling development - is the success of a component dependent on immature technology for implementation

Software TRL Challenges

- **TRLs as initially developed are hardware focused**
- **The Army has developed software TRL definitions but there are still areas of potential confusion**
- **Software components are considered CTEs if the algorithms they deliver are new and novel, but there are also other things to consider…**
  - Off the shelf software
  - Aging software
  - Supporting hardware and software

Off the shelf capability

- **IT applications are composed mostly of off the shelf applications**
- **Off the shelf components are assumed to be mature by their very nature – they are used in the field**
- **There are maturity issues that will make the OTS capability a CTE candidate**
  - Technology not proven in intended operating environment
  - Interoperability of multiple OTS capabilities
- **Additionally COTS products generally undergo a new release every 8 to 9 months with support for 3 latest releases. Does TRL persist once established**

Aging Software

- **Software never stops changing, when its off the shelf software this fact is exacerbated**
- **According to J. D. Smith, COTS products generally…**
  - Undergo new release every 8 to 9 months
  - Have active vendor support for 3 releases

- **Interfaces and interoperability issues may occur with new release**
- **COTS vendors sometimes retire solutions with new and improved alternative, sometime no alternative at all**

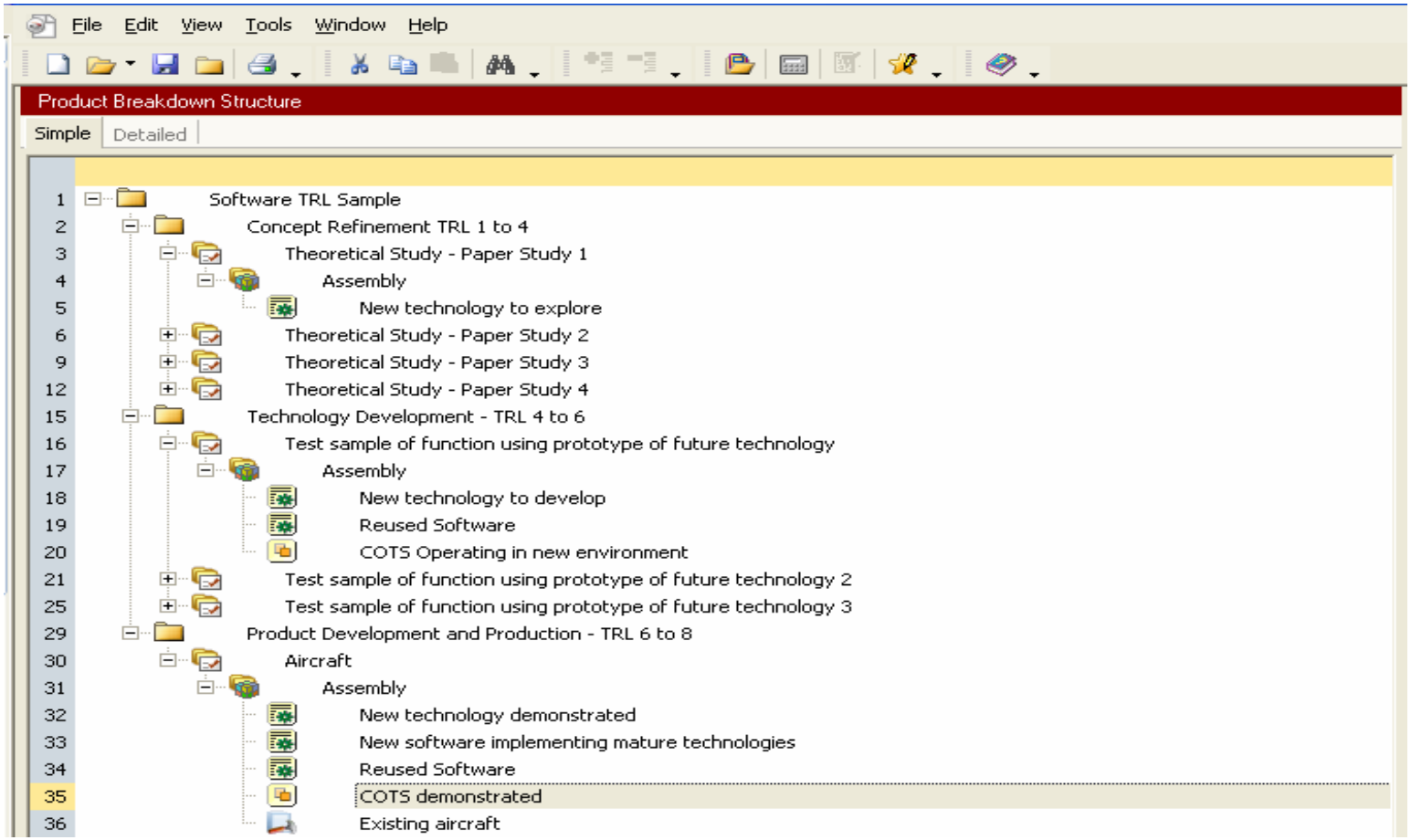
Supporting hardware and software

- **Software does not stand alone**
  - Requires hardware to execute
  - Requires software for support (Operating system, Databases, etc)
- **Software itself may not be a CTE but consideration needs to be given to ….**
  - IT that supports the software
  - Interfaces with software systems that support the software
  - Legacy capability when backward compatibility is crucial

Software TRL Costs

- **Even when some of the technology is immature, there needs to be a plan for the program**
- **Modeling techniques can be used to analyze costs of moving from a low TRL to the point where its ready for development**
- **Analysis is partitioned into 3 part**
  - Costs for theoretical studies to prove a concept (TRL 1-4)
  - Costs for development of the technology (TRL 6-8)
  - Costs for development and production of the system incorporating new technology with existing technology

Product Breakdown Structure for Technology Maturity Progression



From TRL 1 to 4

- **Paper studies and laboratory experiments**
- **Limited set of activities need to be accomplished**
  - Requirements analysis and high level design (1-2)
  - Some low level design and code development (3-4)
- **Cost driver recommendations**
  - Size reflects new technology only – based on assessment of desired capability through analogous experience
  - New design high
  - Complexity high
  - Operating environment not important
  - External integration not important

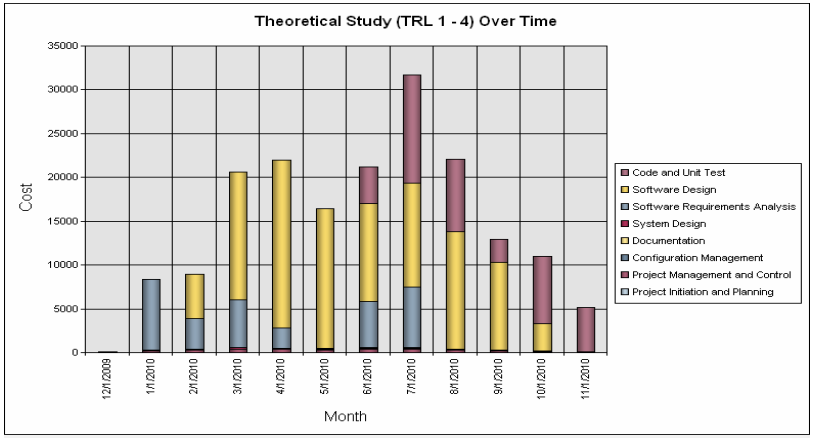
From TRL 4 to 6

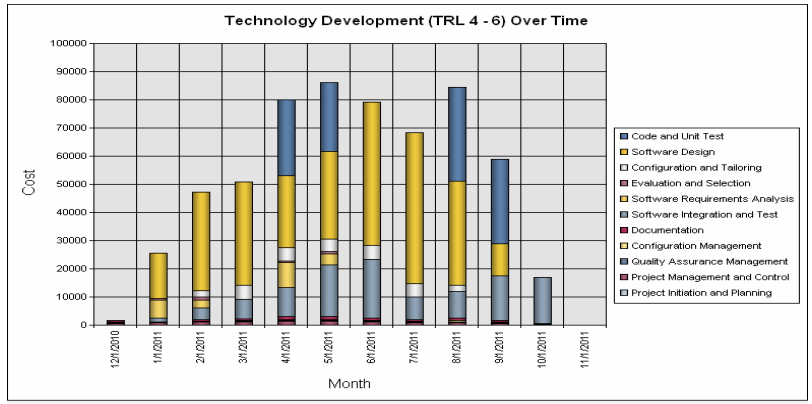
- **Technology is developed and tested in lab and operational like environments**
- **Additional activities**
  - Coding and unit test occurs
  - Integration and test of new technology or COTS product with mature technologies and legacy capabilities
  - If hardware or other IT represents CTEs for software, hw/sw integration should be included
- **Cost driver recommendations**
  - Size of new technology should be less new and more reused or modified
  - Size of elements or OTS that are integration critical important
  - New design for new technology reduced
  - Operating environment is important
  - External integration is important

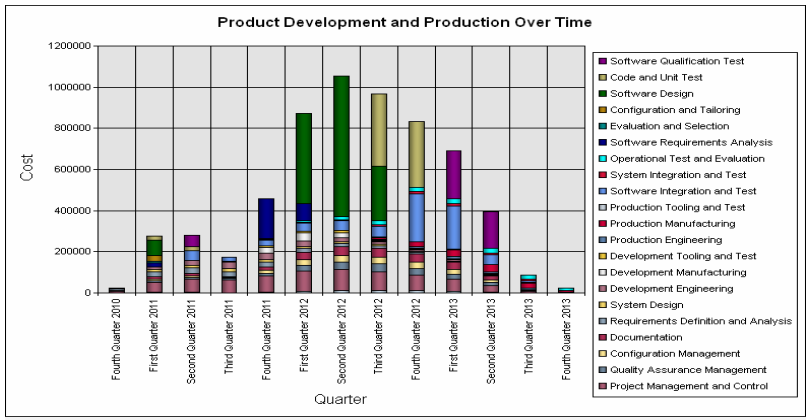
Beyond TRL 6

- **More of a traditional estimate from this point on**
- **Cost driver recommendations**
  - New technology should be modified or reused, not new
  - New design for new technology should be low
  - Integration complexities lower for integrations already tested
  - Take credit for experience of personnel if applicable

Costs and activity spread







Conclusions

- **It is important that projects respect the risks associated with new technologies and use TRAs to mitigate these risks**
- **Software is increasingly called upon to deliver new technology presenting new CTE identification challenges beyond 'new and novel'**
  - Off the shelf software
  - Aging software
  - Supporting hardware and software
- **Once CTEs have been identified, parametric estimating techniques exist to estimate the costs of maturing and using new software technologies**