

An Integrated Approach to Managing Technology Maturation Costs

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- **Introduction**
 - Technology maturation costs
- **Integrated design and cost tools**
- **Using integrated tools to manage technology maturation and new technology insertion**
- **Modeling technology maturation costs**
- **Summary**



- **Goal**

- Extend the useful life of an ongoing program
 - Evolve system capabilities
 - Preserve system capabilities

- **Motivation**

- Obsolescence
- Customer requests
- Technology Roadmap

- **Methods**

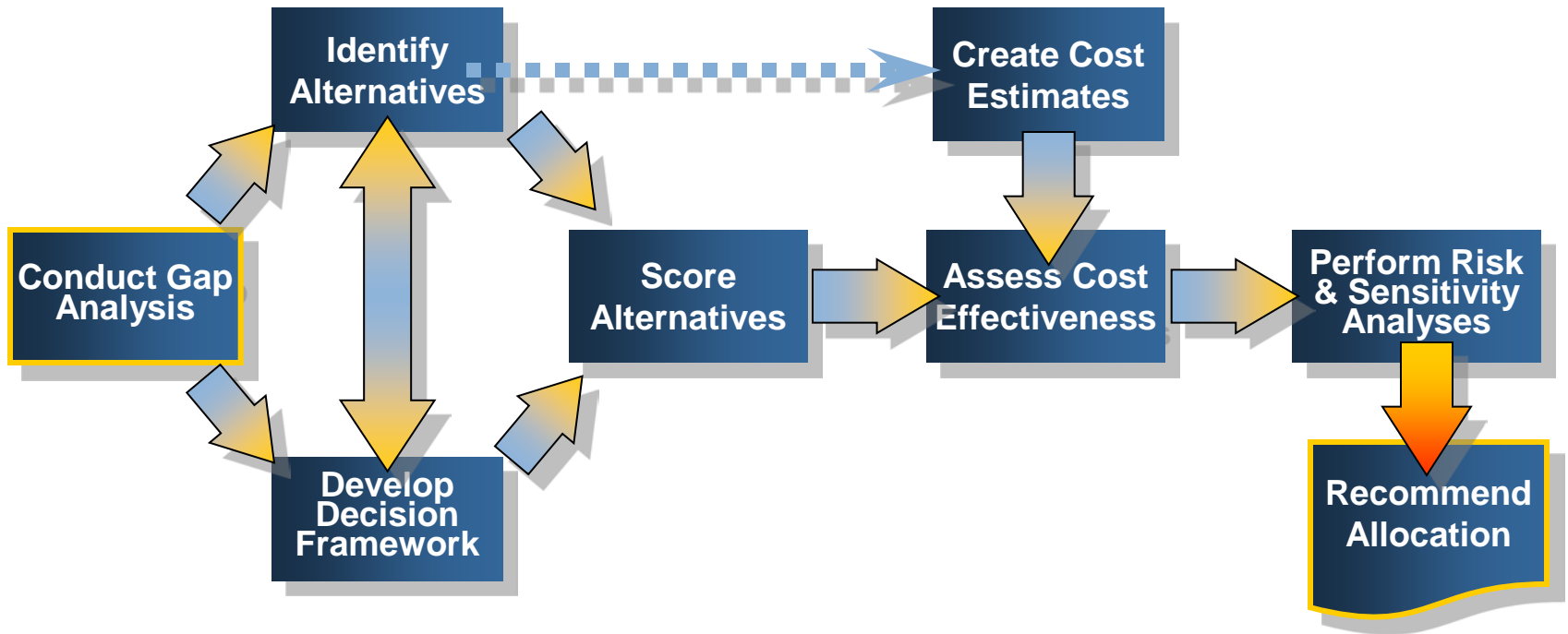
- Technology maturation
- New technology insertion

- **Challenges**

- Rigorous planning process to maintain
 - Cost
 - Schedule
 - Performance
 - Reliability, maintainability, sustainability



- **Correct quantification of technology maturation costs**
 - New programs development
 - New technology insertion into a mature program
- **Timely analysis, accounting for impacts on**
 - Cost
 - Schedule
 - Risk
- **Investment and schedule requirements**
 - New technology takes longer and costs more
- **Key to successful technology insertion**
- **Mature the technology before insertion into the program**
 - Mature technology does not guarantee a mature system!





- **Major planning steps associated with technology insertion activities**
- **Applicable across sectors**
 - Government programs
 - Commercial sectors
- **Applicable throughout program life cycle**
 - Continuously
 - One-time effort
- **Process implemented using integrated tools**

- **Integrated System Modeling and Cost (ISCM)**
 - Provides user insight into alternative concepts and their impacts on
 - Performance
 - Operations
 - Cost
 - Schedule
 - Risk
 - Reliability

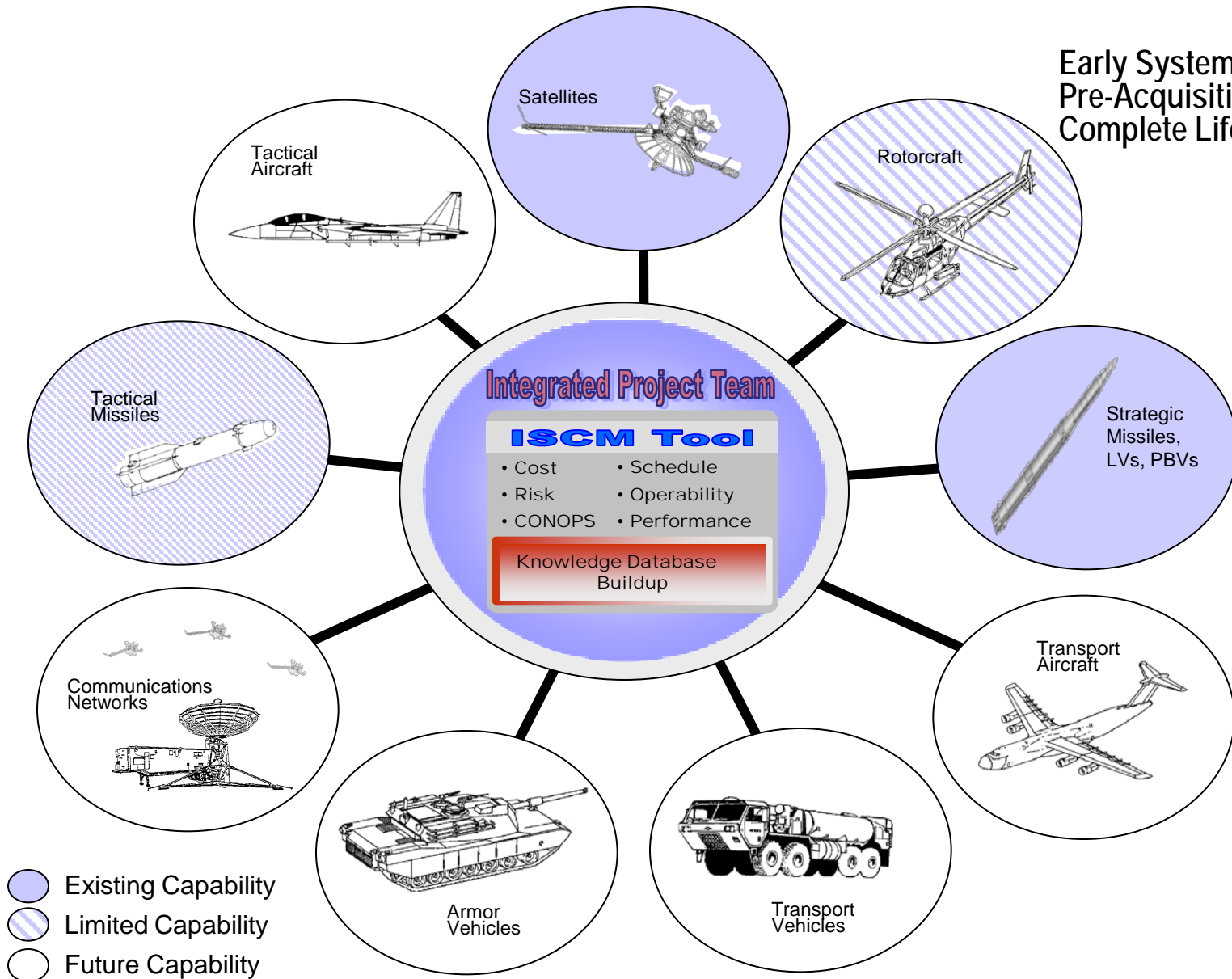
- **Efficient approach to evaluating new technologies**



ISCM Tool Suite Vision



Early Systems
Pre-Acquisition
Complete Lifecycle





- **Integrated analysis**

- Cost and schedule analysis integrated with technology evaluation
- All parameters evaluated in a coordinated process
- Impacts of technology insertion assessed in real time
- Planning activities converge to develop a defensible set of recommendations.

- **Cost methodology**

- Appreciation of historical factors
- Cost growth factors
- Technical readiness levels

- **Cost estimating methodologies often fail to account for the process of maturing technology**

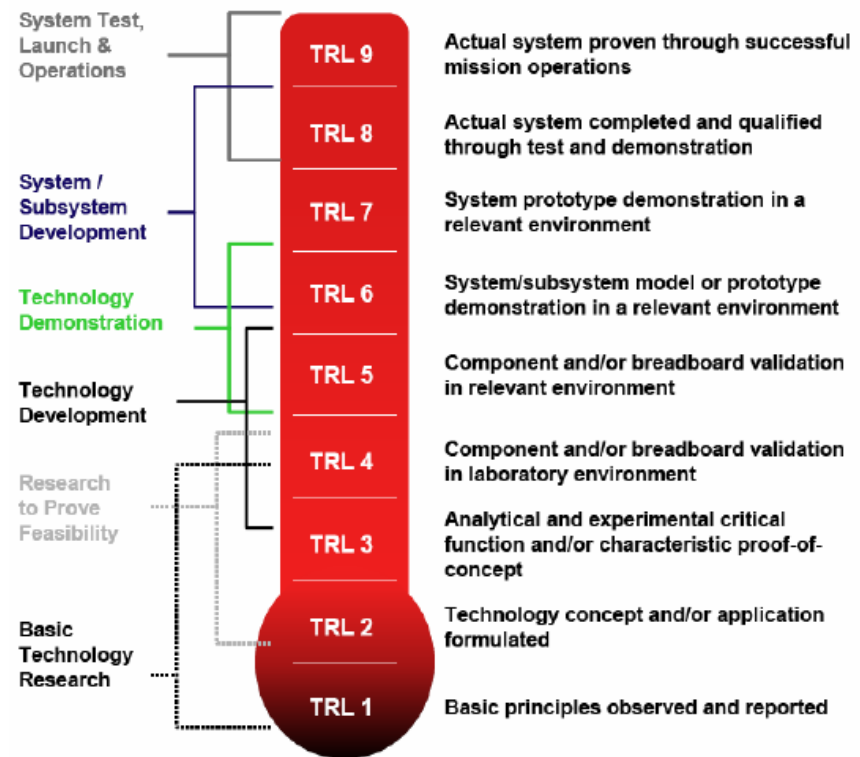
- **Accounting for the process of maturing technology leads to**
 - More accurate cost estimates
 - Better schedule estimates
 - Higher probability of success

- **Goals**
 - Assess Technical Readiness Level
 - Forecast expected costs using time to mature the technology
 - Apply methodology to components, systems, programs



- **TRLs are a measurement of the maturity of a technology based on a one point scale**

- Rated from 1 – 9
- 1-3 ranges are generally considered basic research, laboratory applications
- 4 and beyond is considered for system applications/ technology development
- 5-7 are used extensively in prototype and research applications
- 8-9 are used extensively in production systems and re-flights



Source: 2008 NASA Cost Estimating Handbook, Pg 6-21



- **Technical Maturity Cost Factors**

- Developed from historical SAR data (DoD, NASA)
 - Rate of maturity is unique to technology types
 - Time is a factor and is dependent on investment
 - Three basic groups exist
 - low, medium, high (slow to fast)
 - Applied in ISCM

- **Other TRL correction factors**

- Commercial models provide adjustment factors
 - PRICE
 - SEER
- NASA Instrument Cost Model (NICM)
 - Adjustment resulting from research by Ray Covert
 - Applied in ISCM



Research by:

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Mr. Joe Hamaker, previous head of NASA Cost

Dr. Hamid Habib-Agahi, JPL NICM II Model

Ray Covert, MCR LLC

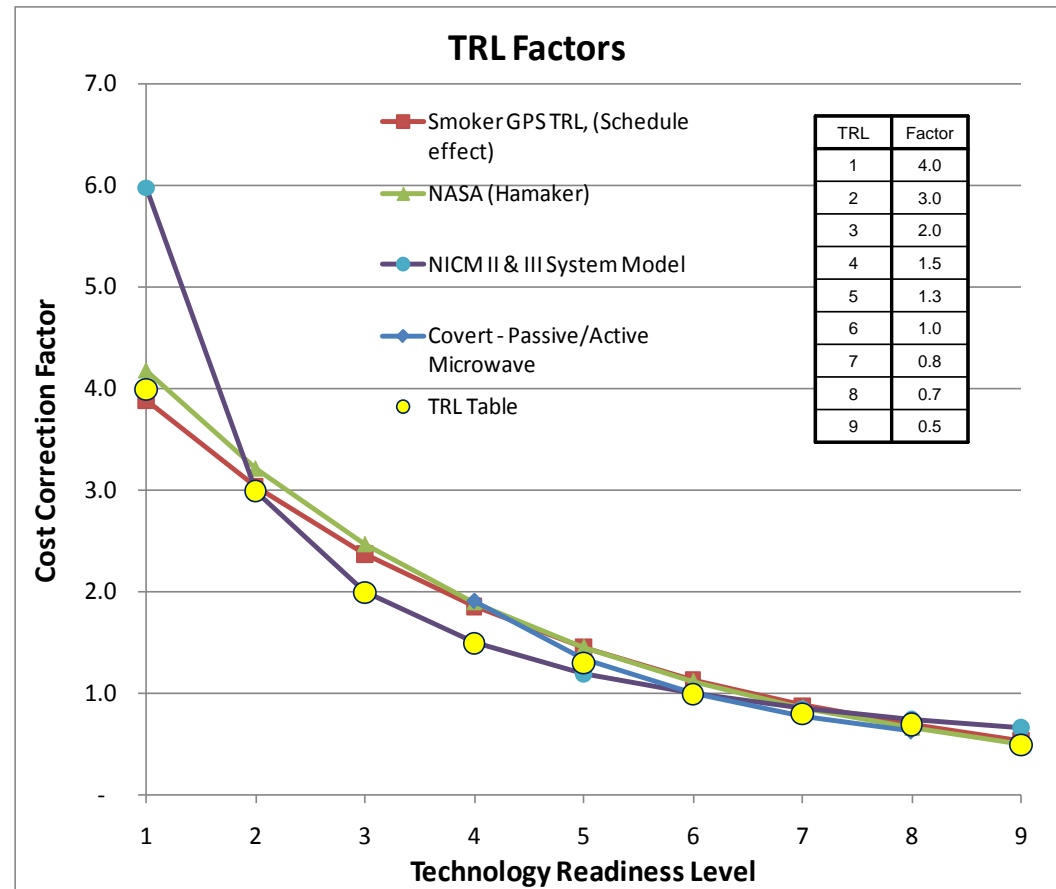


Figure 1. Cost correction factors based upon historical data.

Correction Factors show surprising similarity



● SAR Data

- Average Months to Mature Technology Varies

TRL Change	Ground Sys-2	A/C w/Instr-2	Missile Sys-2	Space Sys-4
Level 4 to 5	29.4	22.5	36.5	15.3
Level 5 to 6	26.3	13.0	13.5	42.8*
Level 6 to 7	21.6	55.5 ⁺	19.5	24.8*
Level 7to 8	51.7	66.6	17.6	41.8
Level 4 to 8	129.0	157.6	87.1	124.7

* Both GPS and IUS appear to have taken longer to close out CDR issues and GPS had a production contract delay and movement to a new launch vehicle due to Challenger.

+ Both JSTARS and AWACS appear to have had significant development problems post CDR as evidenced by the 55.5 months to a production decision.

A/C – Aircraft

AWACS – Airborne Warning and Control System

CDR – Critical Design Review

GPS – Global Positioning System

JSTARS – Joint Surveillance and Target Attack Radar System



- **Differs by program**
- **Differs by TRL**
 - **Defined by System Level TRL based on Key Engineering Milestones**
 - Provides for Exit Criteria for each TRL
 - Consistent with Maturity through Testing
 - Works well with different types of programs
 - Spacecraft
 - Missiles & Launch Vehicles
 - Aircraft Systems
 - Ground Systems
- **Methodology allows for maturing an initial early cost estimate**
 - Based on past observed rates of cost growth to key milestones
 - Time anticipated to those milestones for new programs
- **Need for future research**
 - Schedule probability distributions
 - Testing impacts on schedules



- **Cost**
 - Start with a TRL 5-6 for the CER's assumption
 - Correct costs for TRL variance after initial estimates are developed
 - Using one of the methods described
 - Apply risk

- **Schedule**
 - Initial schedules are based on program development (givens)
 - No clear factors have been applied to TRL time to mature
 - Some historical data exist
 - Research is ongoing and becoming available

- **Cost and Schedule Integration**
 - Joint cost and schedule assessment provides a robust forecast for program cost and schedule



- **ISCM was initially developed as an approach to the evaluation of spacecraft and launch vehicles throughout the complete life-cycle of the system**
- **Integration of advanced cost and schedule modules**
 - Allows program managers to evaluate the impact of technology maturation and insertion into a program in near real time.
 - Provides program managers with an analytically well-founded means for prioritizing investment decisions to deploy mission-essential capabilities to the Government.
- **Approach is applicable to, and has been demonstrated in other domains beyond space**



- Ref.-1** The Application of TRL Metrics to Existing Cost Prediction Models “A Practitioners Guide to Applying Cost Correction Factors to Technology” by Patrick Malone, Roy Smoker, Henry Apgar, and Larry Wolfarth , submitted to 978-1-4244-7351-9/11/\$26.00 ©2011 IEEE.
- Ref.-2** Smoker, R. and Smith, S. “Approach to Use of Selected Acquisition Reports for Measurement of TRLs and Associated System Cost Growth” 2008, pg 2
- Ref.-3** Covert, R. “NASA Instrument Cost Model Review and Re-Regression, July 2008
- Ref.-4** Joe Hamaker JPL Presentation of TRL Impact on Cost as Estimated for the JIMO Effort March 2009



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