The Evolution of Hardware Estimating

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Agenda

- **Introduction**
- **Technology – Advancing at Breakneck Speed**
- **Improving Technology – Changing How we Look at Hardware Systems**
- **How Does a Model Built in the 70's Grow to Estimate Hardware Challenges in 2007 and Beyond?**
  - Systems of Systems
  - Systems Engineering
  - Utilizing Commercial Off the Shelf (COTS) Technologies
  - Co-mingling of Obsolescent with State of the Art
- **Conclusions**

Introduction

- **In the 1970's, Frank Freiman conceived the notion that the weight of a hardware system, along with parameters indicated technology and manufacturing processes, could be used to predict cost**
  - With this, a parametric cost estimating model for hardware, PRICE H, was born
- **At the time, there were no ……**
  - Personal computers
  - E-mail
  - Text messaging
  - Cell phones
- **At the time, PRICE H was used to estimate hardware systems that were state of the art**
- **But what about today……**

Technology – Improving at Breakneck Speeds
Nintendo – a great example

Super Nintendo (1991)

GameCube (2001)

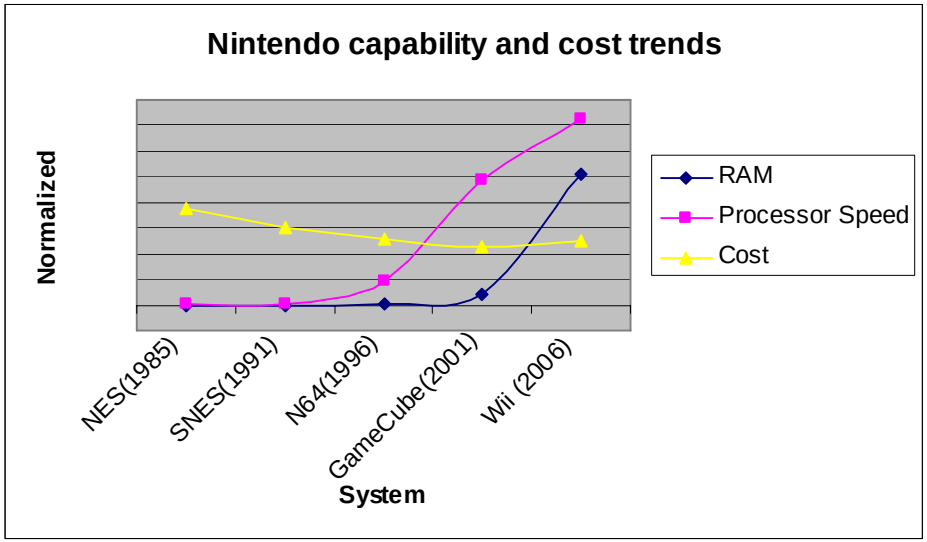
Nintendo 64 (1995)

Nintendo Entertainment System (1985)

Wii (2006)

Nintendo – Cost and Performance Trends

System	Year	RAM	Processor Speed	Cost (US$ 2006)
Nintendo Entertainment System	1985	2KB	1.79	$374.00
Super Nintendo	1991	128KB	3.58	$298.00
Nintendo 64	1996	4.5MB	93.75	$256.00
GameCube	2001	MB	485	$227.00
Wii	2006	512MB	729	$249.00



Cellular Communication

First Cell Phone – Motorola 1983

Motorola Razr 2003

Apple iPhone 2007?

Improving Technology – Changing How we Look at Hardware Systems

- **As estimators we know how to deal with technology advancement**
  - We've been doing this for years and we get it
- **The bigger question : How have jumps in technology advanced the state of the art for hardware systems in general**
- **When your computers weigh a ton it's hard to imagine capabilities promised by Future Combat Systems (FCS)**
- **When you can hold it in the palm of your hand and use it for communication, entertainment, surveillance and information collection the possibilities become endless**
- **Technological advances have moved the industry from components and systems to complex systems and Systems of Systems**

"How does a model built in the 1970's have to grow to estimate hardware challenges in 2007 and beyond?"

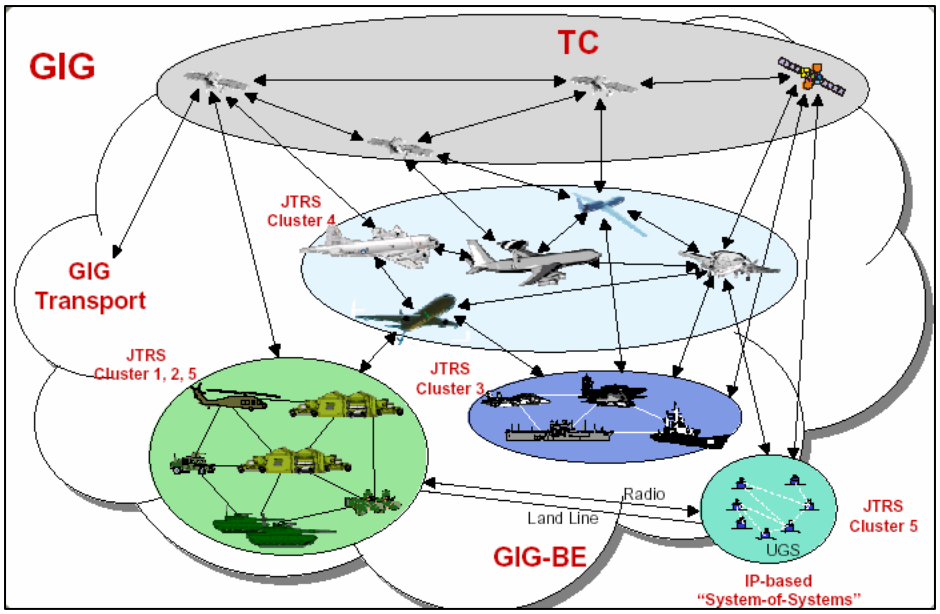
- **The hardware estimating model of the future needs to understand that components are just cogs in the wheels of complex systems**
- **The Challenge lies in the complexity made possible by increases in speed, capacity and capability of technology**
  - Deployment of Systems of Systems
  - Increased need for Systems Engineering
  - Commercial off the shelf technologies
  - Integrating commercial technology into defense systems
  - Co-mingling obsolescence with state of the art
  - Oversight and management of complex systems

What is a System of Systems

- **According to Mair [1996] a System of Systems must have most, if not all, of the following characteristics**
  - Operational independence of component systems
  - Managerial independence of component systems
  - Emergent behavior
  - Evolutionary development process
- **Starting from this definition – we expand to explicitly state that there is network centric focus that enables these independent systems to communicate effectively and efficiently**
- **Another important factor in Systems of Systems is the human component – in addition to hardware and software there are also people involved in these complex systems (adding an additional level of complexity and uncertainty)**

SoS example – WIN-T

The Win-T program is the Army's communication system for reliable, secure, and seamless video, data, imagery, and voice services that enable decisive combat actions

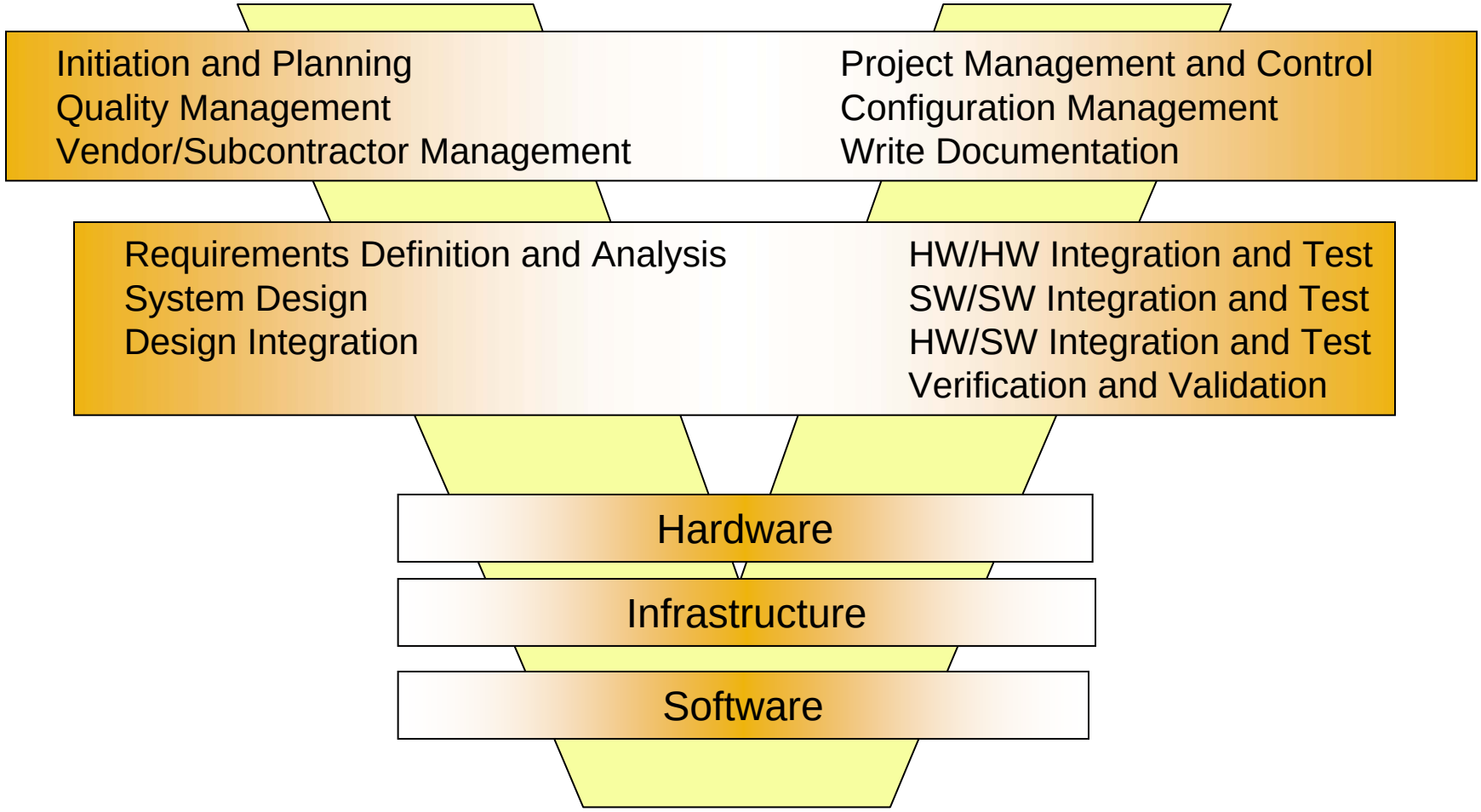


- **Communication between platforms and across services**
- **Time from detection to engagement acceptable**
- **Opportunities are not missed**
- **"The Cloud has been lifted from the battlefield"**

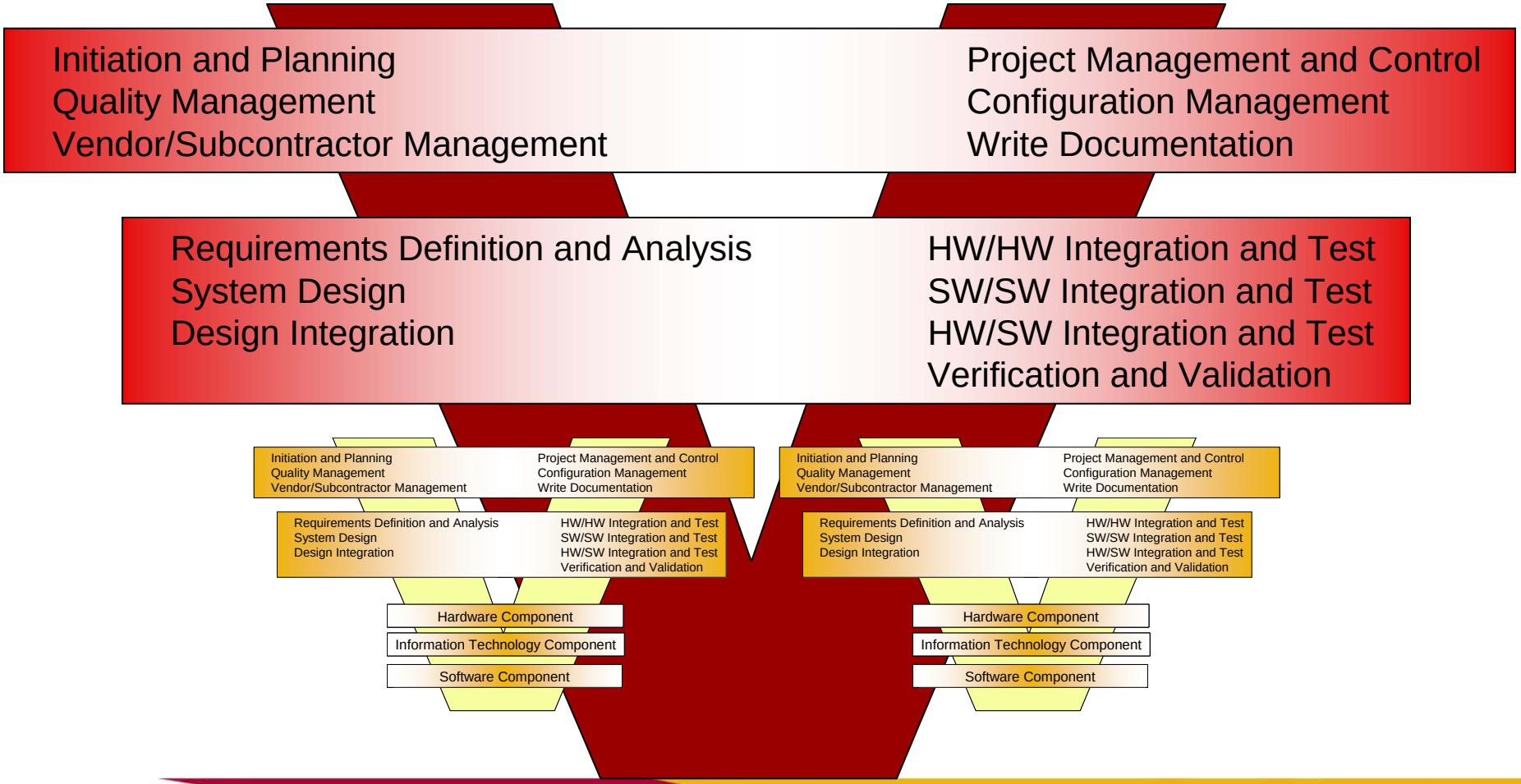
How Does SoS Differ from any System?

- **Acquisition Strategy Differences**
  - Capability based rather than a specific platform
  - Many and diverse stakeholders
    - Multiple services / DARPA
    - Lead system integrator (LSI)
    - Multiple primes for component systems
    - Different motivations/priorities/values/business practices
  - More political
- **Software Differences**
  - Network centric – communication protocols key
  - Requirements are emergent not pre-specified
  - Standards crucial – especially for software interfaces
  - Large dependency on Commercial Off the Shelf Software
- **Hardware Differences**
  - Requirements are emergent not pre-specified
  - Varying ages and technologies of component systems

Traditional System



Systems of Systems



System Engineering

According to the Encyclopedia Britannica….

System engineering is a technique of using knowledge from various branches of engineering and science to introduce technological innovations into the planning and development stages of a system

Systems engineering is not so much a branch of engineering as it is a technique for applying knowledge from other branches of engineering and disciplines of science in an effective combination

Clearly the need for System Engineers increases when we start talking about Complex Systems and Systems of Systems

Focus on System Engineering

- **System Engineering role expands substantially with System of System projects**
- **Involvement of System Engineering from cradle to grave is essential for success**
- **System Engineers play key role in:**
  - System Requirements Analysis and Definition
  - System Architecture and Interface Specifications
  - Modeling and Simulations
  - Integration and Test
  - Technical Oversight of the Project

Commercial off the Shelf Technologies

- **Deployment of complex systems is made possible by the fact that much of the needed technology has already been developed and tested**
- **Off the shelf components need to engineered into the system**
- **Often existing components need to be modified for particular uses**
  - Add additional functionality
  - Increase security
  - Remove or disable undesirable features
- **Integration and test must be accomplished to ensure that off the shelf and home grown components co-exist and meet system requirements**

Integrating Commercial Technologies into Defense Systems

- **Department of Defense budget has been decreasing over the last decade**
- **For the three major defense contractors in the US, commercial business now exceeds DoD business**
- **More of contractor R&D money is devoted to the development of commercial technologies, processes and practices than those devoted specifically to military systems**
- **Where it makes sense – these technologies are being used in military systems**
  - Adaptations and/or additional certifications are often required to ensure that commercial technologies satisfy military operating requirements

Co-Mingling Obsolescence with State of the Art

- **Complex systems are generally emergent**
- **These systems often are made up with technologies that span the spectrum with respect to maturity**
- **Interfaces must be designed to bridge technological gaps**
- **Care must be take to ensure that older technologies don't mask the increased capability of newer technologies they are interfaced with**
- **Managing the refresh of complex systems must be done in a way that optimizes benefit while minimizing time to accomplish re-integration efforts**
- **Immaturity of state of the art technologies is also a consideration**

What is PRICE doing to advance this research?

- **TruePlanning**
  - Cost estimating framework for integrating at the System and System of System Levels
  - Incorporates components for
    - Software Estimating
    - Hardware Estimating
    - System Estimating
    - System of System Estimating
  - Implements relationships that drive System and System of System costs (outside of wt/sloc/complexity relationships) including:
    - Requirements
    - Interfaces
    - Vendors/Subcontractors
    - Operational Scenarios
    - Stability
    - Experience/Expertise of SE's

Conclusion

- **Technology today makes last centuries impossibilities this centuries mundane**
- **Increased speed, capacity, resolution, bandwidth have led to the possibility of ever increasing complexity in the systems we develop**
- **Estimators are now faced with the challenges of estimating not only the costs of individual components but also with the development of systems that make these components work together in many different ways.**
- **New challenges require understanding**
  - Systems of Systems
  - System Engineering roles
  - Off the shelf integrations
  - Transferring commercial technologies to military platforms
  - Co-mingling technologies of various maturity levels
  - Oversight and management of complex projects

Cost Models

TruePlanning®
by PRICE® Systems

Scalability from Component to System of Systems Estimates