Modeling and Simulation for Affordable System Acquisition
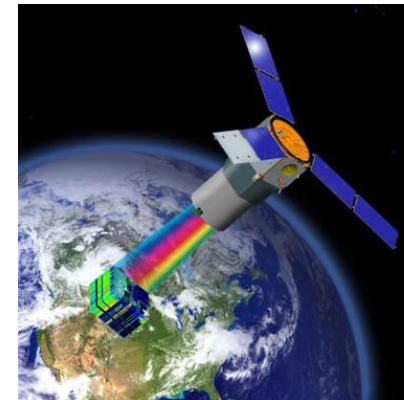
presented at

NDIA 14th Annual Systems Engineering Conference
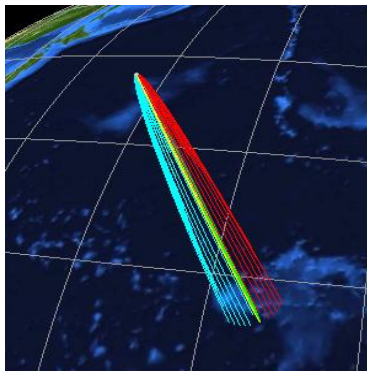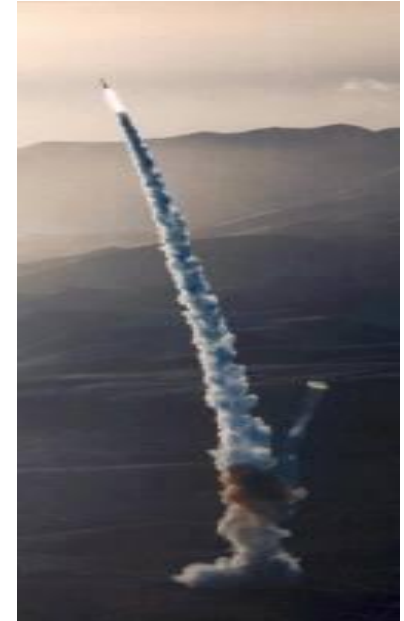
October 25-28, 2010

Deganit Armon
David Peterson
Chuck Kondrack
Advatech Pacific Inc.

Government Systems Acquisition

- **The problem**
  - ▪ **Major Government acquisition programs are**
    - Over budget
    - Behind schedule
    - Fail to meet performance objectives
  - ▪ **Causes**
    - Engineering/design issues
    - Schedule issues
    - Quantity changes
    - Changing assumptions and requirements
  - ▪ **Complex acquisition processes and methodologies**

Source: GAO report, March 2011. http://www.gao.gov/new.items/d11499t.pdf

Example – ASDS

- **Advanced SEAL Delivery System**
  - **1994 – contract award**
    - $70M
    - First boat delivery planned for July 1997
  - **2003 – first unit**
    - Development costs at $340M
    - Did not meet all operational requirements
    - Accepted by Navy into operational use
    - Significant reliability and performance issues
  - **2006 – costs reach $885M**
    - R&D, procurement, construction, O&M, military personnel
  - **2009 – program abandoned after fire damage to only unit**

Source: GAO report, May 2007. http://www.gao.gov/new.items/d07745.pdf

Affordable Systems Acquisition

- **Success depends on**
  - **A sound business case**
    - Firm requirements
    - Mature technologies
    - Knowledge-based acquisition strategy
    - Realistic cost and schedule estimates
    - Full life cycle considerations
    - Sufficient funding
  - **Early systems engineering**
    - Earlier evaluation of the factors that are contributing to cost growth
    - Continuous systems engineering analysis
  - **Effective contracting strategy**
    - Beyond the scope of this talk

System Modeling and Simulation

- **Total system design and cost**
  - Grounded in sound technical knowledge
  - Collaborative information technologies
  - Adaptable software frameworks
  - Knowledge databases

- **Enhances**
  - System interoperability
  - Trade studies and rapid alternative evaluations
  - Design productivity
  - Acquisition decision management

- **Used to develop and maintain a realistic total systems view for**
  - Systems engineers
  - Program managers
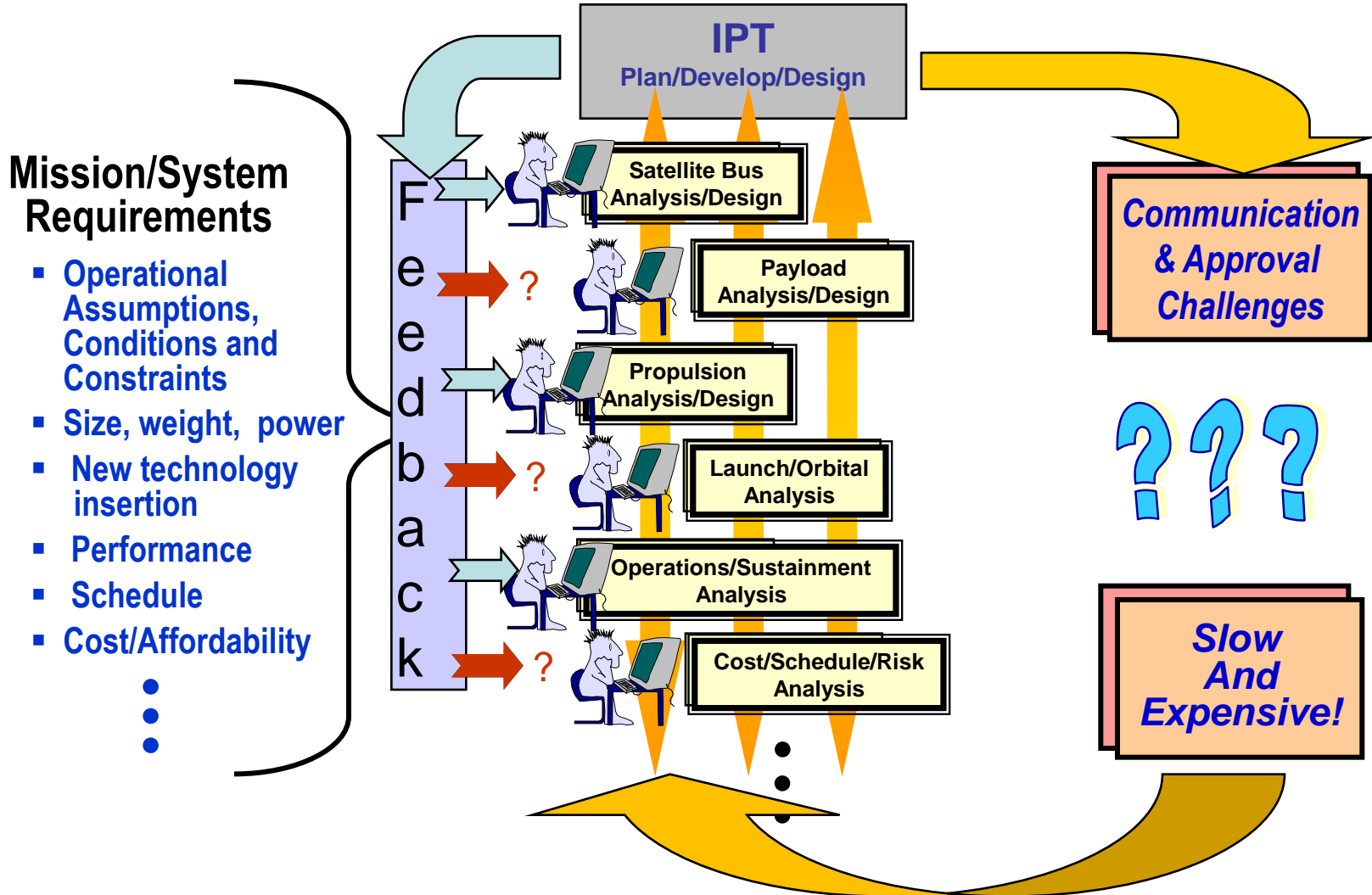 - Senior acquisition managers

Integrated System and Cost Modeling

- **Advatech Pacific, Inc. integrated systems experience**
  - Multiple integration projects since 2001
    - Hypersonic vehicles (ONR)
    - Launch vehicles (AFRL/RZST)
      - Solid, liquid and hybrid motors
      - Common Aero Vehicles (CAV) for Prompt Global Strike
      - Cost and risk model
      - ConOps
    - Space vehicles (AFRL/RVES)
      - Space mission design
      - Space radiation environment
      - Space vehicle cost
    - Rotor blade design (Army)
    - Air launch designs

Traditional Design Approach

Mission/System Requirements

- **Operational Assumptions, Conditions and Constraints**
- **Size, weight, power**
- **New technology insertion**
- **Performance**
- **Schedule**
- **Cost/Affordability**

Feedback

IPT
Plan/Develop/Design

- Satellite Bus Analysis/Design
- ? Payload Analysis/Design
- Propulsion Analysis/Design
- ? Launch/Orbital Analysis
- Operations/Sustainment Analysis
- ? Cost/Schedule/Risk Analysis

Communication & Approval Challenges

? ? ?

Slow And Expensive!

Integrated Design Approach

Feedback

ISCM Tool Suite
System/Sub-system

Mission/System Requirements

- **Operational Assumptions, Conditions and Constraints**
- **Size, weight, power**
- **New technology insertion**
- **Performance**
- **Schedule**

Integration Core Module

Knowledge Database

Structural Module

Payload Module

Propulsion Module

Trajectory Module

Operations Module

Cost/Risk Module

Single User Interface

In Days / Weeks Not Months

Potential Solutions

Developing Integrated Tools

- **Integrated tool development requires**

  - Domain knowledge

  - Understanding of CONOPS, engineering, cost, schedule and other tools
    - Integrated "as-is"
    - Enhanced with added capabilities

  - Understanding the data flow
    - Without integrated tools, this is done via
      - Email
      - File transfer
      - "Sneakernet"

  - Human engineering
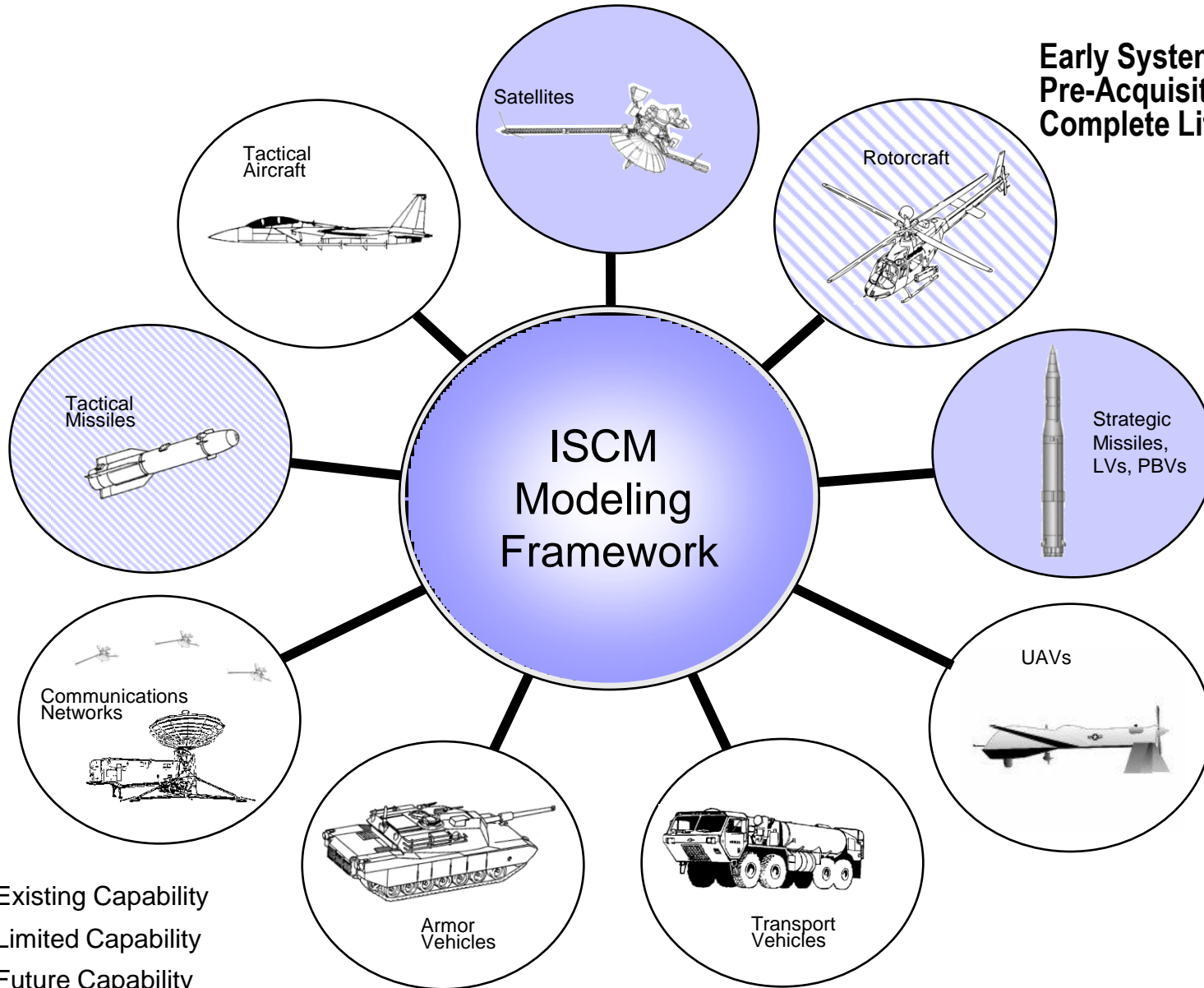   - Coaxing the process out of domain experts

Integrated Tool Suite

- **Integrated projects had much in common**

  - Common philosophy – integrated engineering tools

  - Common methodology – software framework

  - Related domains – space vehicles, launch vehicles

  - Overlapping areas of modeling – design, cost, ConOps

  - Overlapping functionality – trade study tools

- **Realization dawned**

  - Individual tools could be consolidated into one tool suite !

ISCM Tool Suite Vision

Early Systems and Pre-Acquisition … Complete Lifecycle

- Satellites
- Rotorcraft
- Tactical Aircraft
- Tactical Missiles
- ISCM Modeling Framework
- Strategic Missiles, LVs, PBVs
- Communications Networks
- UAVs
- Armor Vehicles
- Transport Vehicles

Existing Capability
Limited Capability
Future Capability

Development Effort

- **Modeling, Simulation and Analysis (MS&A) software**

  - Complete view of the total life-cycle of the system
    - Performance
    - Operations & Maintenance
    - Cost
    - Schedule
    - Risk assessment

  - Collaborative trade study environment
    - Develop early and use throughout the acquisition process

  - Current focus on
    - Spacecraft systems
    - Launch vehicles
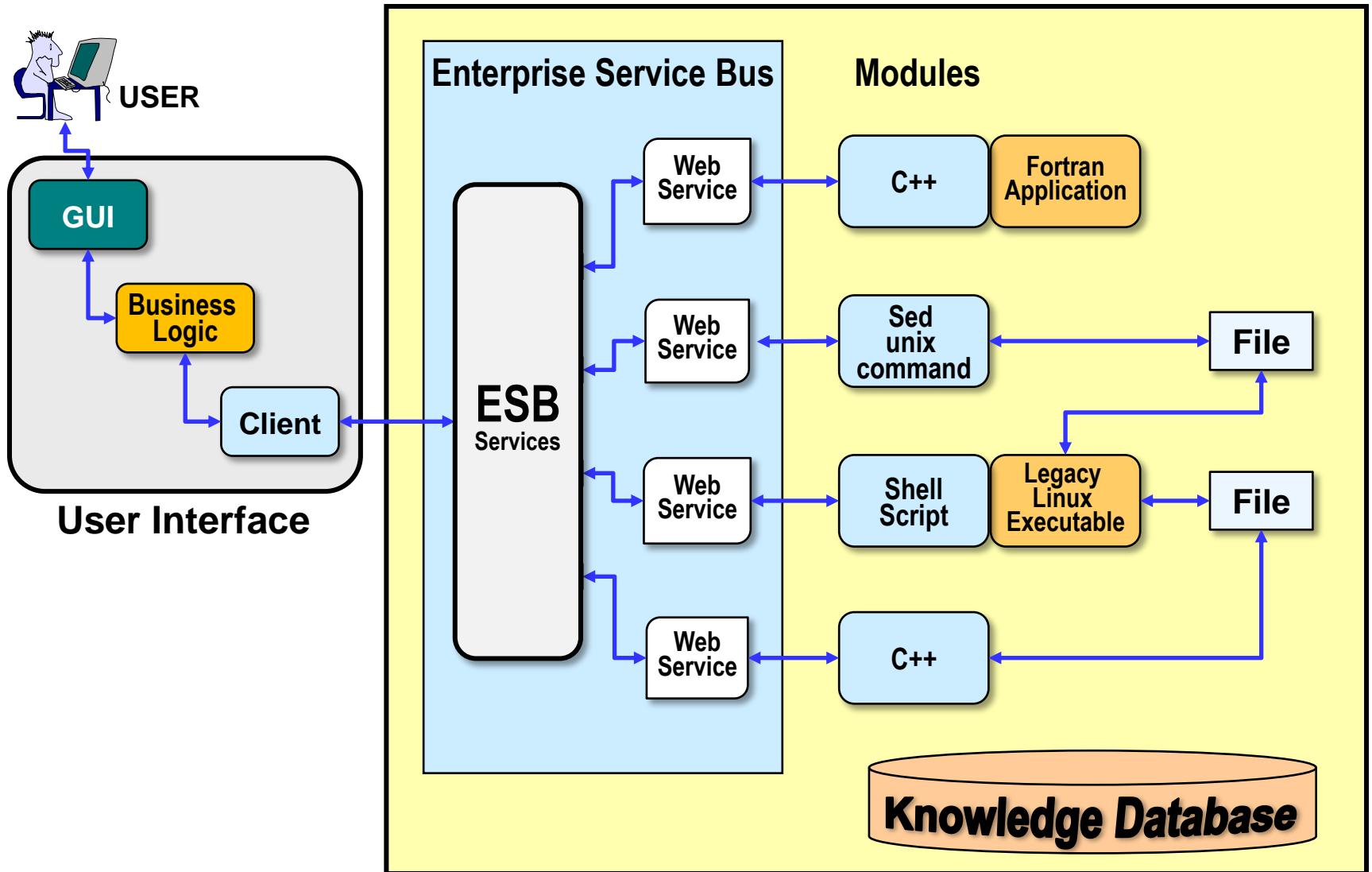   - Strategic missiles

  - Expanding to other domains

ISCM Process Flow


```
Orbit and Mission Definition → SV Design (SMAD Based) → SV Cost, Schedule & Risk

SV Design Parameters → SV Ops Cost

Mission Parameters → SV Life Cycle Schedules & Labor Costs

Orbit Parameters
LV Payload Parameters → LV Selection / Design → LV Weight → LV Cost Schedule & Risk → LV ConOps & Cost

Radiation Environment
```

Trade Study and Optimization Capability

Integration Environments

- **Different frameworks used for different projects**

  - Phoenix ModelCenter

  - TechnoSoft Adaptive Modeling Language (AML)

  - Simulia iSIGHT

- **Each has strengths and weaknesses**

  - All have licensing costs

- **Alternative**

  - Develop multi-disciplinary architecture for integrated system

  - Service oriented architecture (SOA)

  - Open source software

Architecture View

USER

Enterprise Service Bus

Modules

GUI

Business Logic

Client

ESB Services

Web Service → C++ — Fortran Application

Web Service → Sed unix command ↔ File

Web Service → Shell Script ↔ Legacy Linux Executable ↔ File

Web Service → C++

User Interface

Knowledge Database

User Perspective

- **Intuitive interface**

- **Model tree on left**
  - Data flows from one model to the next

- **Work area on right**
  - For selected model
  - Input fields
  - Calculated values
  - Editable defaults
  - Parameters selection for trade studies

- **Models and trade studies can be saved to knowledge database for future reference**

Model Building

- **Additional modules can be added as necessary**

  - Identify input and output

  - Identify interaction with other modules

  - Define business logic for interaction

  - Create dynamic user interface

  - V&V

- **Essentially a computer programming task**

  - Requires understanding of model building

  - Java code

Advantages of Integrated MS&A

- **Rigorous systems engineering**
  - Traceable
  - Repeatable
  - Robust

- **Trade studies looking at systems alternatives**

- **Rapid identification of system and subsystem design concepts that meet mission requirements**
  - Limit late design changes

- **Identify technologies and areas of investments**

- **Identify risks early**
  - Proactive mitigation

Application – Business Case

- **Supported a study to determine whether to invest in a new technology**

- **ISCM was used to determined costs of several alternative scenarios**

- **Study performed in several iterations over six weeks**
  - Alternative designs
  - Cost and schedules
  - Cost breakdowns (e.g. recurring vs. non-recurring)

- **Cost estimates used as input to a Return on Investment (ROI) analysis**

Summary

Integrated MS&A Support for Affordable Systems Acquisition

- Links system performance with total Life Cycle Cost estimates
- Provides trade study traceability so that process is repeatable
- Addresses the principal cost/affordability drivers
  - System design and complexity
  - Mission requirements and constraints
  - Technology maturity and cost growth
  - Design, Development, Test and Evaluation (DDT&E) concepts
  - Operations and Sustainment (O&S) concepts
- Addresses key aspects of a system acquisition and management
  - Planning & Development
  - Technology (existing and proposed)
  - Engineering, Design & Manufacturing
  - Production
  - Operations & Sustainment
  - Disposal
- Level of risk identified with each estimate

Related Talk

Early Development Planning Leads to Affordable Systems

Presented by: **Mr. Charles Kondrack**

Track 4 – Early Systems Engineering

Right after this talk at 11:25 in Mission I