# Managing Commercial-Off-the-Shelf (COTS) Integration for High Integrity Systems: How Far Have We Come? Problems and Solutions in 2003

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# Breakout Session Goals

- **View the topic of COTS integration for high integrity systems from multiple perspectives**
  - ❖ Cost
  - ❖ Management
  - ❖ Architecture
  - ❖ Integrator
  - ❖ Vendor
  - ❖ User
- **Identify solutions and successes**
  - ❖ What factors contributed to the successes?
- **Identify ongoing and new problems and issues**
  - ❖ What factors contributed to the problems?
  - ❖ How can the problems be reduced or eliminated in the future?
- **Update survey on COTS upgrade release frequency**

# What Happened

- **Participant introductions**
  - ❖ 31 Session participants included Aerospace, industry, academia, acquirers, users, and cost estimators
- **Management perspectives**
  - ❖ “Quantitative Management of COTS-Based Systems: The Role of Cost Estimation” - Marilee Wheaton, Aerospace, Steven Wong, Northrop-Grumman (heritage TRW)
  - ❖ “Managing COTS Integration for High Integrity Systems: Observations from the COCOTS Database” – Betsy Clark, Software Metrics, Inc.
- **Technical perspectives**
  - ❖ “The Role of Architecture in Managing COTS-Based High Integrity Systems” – Rodney Davis, Command and Control Technology
  - ❖ “COTS or Development: Simulation Tools for Ground Systems Integration” – Tom Tillman, L-3 Communications
- **Lively discussion**
- **Collected data for COTS upgrade release survey**

# The Role of Cost Estimation – Marilee Wheaton and Steven Wong

- **Use CMMI Practices for Estimating Cost and Schedule**
  - ❖ Organizational Process Performance, Quantitative Project Management
- **Build and Use COTS Model and Data Baselines**
  - ❖ Number of COTS packages, COTS breakage, volatility, interdependency, defect reports
- **Meet COTS Estimating Challenges**
  - ❖ Scoping functionality, productivity, limited data
  - ❖ Separating COTS effort from development
- **Collect data on COTS Integration Activities**
  - ❖ Assessment, Understanding, Tailoring, Glue (COCOTS and SEER-SEM)
- **Keep estimates current: best, worst and expected**
  - ❖ Use estimate data for management (e.g., earned value, EAC)

# Managing COTS for High Integrity Systems – COCOTS Database Observations - Betsy Clark

- **“COTS products are associated with some risk” – Vic Basili**
- **Types of products for 11 safety critical, real-time systems**
  - ❖ Operating systems, GUI generator, DBMS, network management, communications protocols, disk array
- **Attributes considered in evaluating COTS**
  - ❖ **Performance, interoperability, robustness**
- **Reliability Solutions:**
  - ❖ Fault-tolerant architectures
  - ❖ Detailed evaluations
  - ❖ Mature components
  - ❖ Purchase of source code
  - ❖ Agreement requiring 24-hour responses to critical problems
- **Maintenance Solutions:**
  - ❖ Focus on critical components
  - ❖ Wrappers
  - ❖ Freezing configuration

# COTS or Development: Simulation Tools – Tom Tillman

- **Need satellite and range data for Command and Control Ground System development and integration that**
  - ❖ Is realistic, easily accessible, and affordable
  - ❖ Contains anomaly conditions
  - ❖ Supports mission scenario flexibility and frequent changes
- **Solutions:**
  - ❖ Simulator that allows varying satellite date
    - ☞ Measurand ranges, anomalies,reusable databases for satellite families
  - ❖ Flexible COTS simulation controls
    - ☞ Commands from ground system
    - ☞ Time control, checkpoint and restarts
    - ☞ Configurations via databases instead of software
  - ❖ Ongoing training through simulation
  - ❖ Cost Effective

# The Role of Architecture - Rod Davis

- **Problems:**
  - ❖ Loss of Control
  - ❖ Discontinuities in understanding whole system
  - ❖ Complexity with many components
- **Architectural Solutions:**
  - ❖ Build understanding through evaluation and qualification; apply influence in the market
  - ❖ Postpone detailed decisions until architecture foundations are set
  - ❖ Use open standards
  - ❖ Minimize interconnections
  - ❖ Architect and engineer for security and reliability – use patterns
  - ❖ Analysis of Alternatives
  - ❖ Document architecture implications of decisions to support evolving architecture

**"Apply good design practices to COTS integration"**

# Conclusion

- **CBS development, integration, and sustainment have inherent uncertainties beyond the control of the acquirers, developers and users**
- **Effective CBS development and sustainment requires a change of processes and attitudes across the entire life cycle and among all parties**
  - Acquirers
  - Costers
  - Architects
  - Developers
  - Maintainers
  - Users
  - Integrators
  - Procurement
  - Contracts

# Survey on COTS Upgrade Release Frequency

1. **In your experience, what is the average duration between releases of a given COTS Product?**
   - GSAW 99 = 6.3 months
   - GSAW 00 = 8.5 months
   - GSAW 01 = 8.75 months
   - GSAW 02 = 9.6 months (range: 6 to 18)
   - GSAW 03 = 11.2 months (range: 2 to 24) (9 data points)

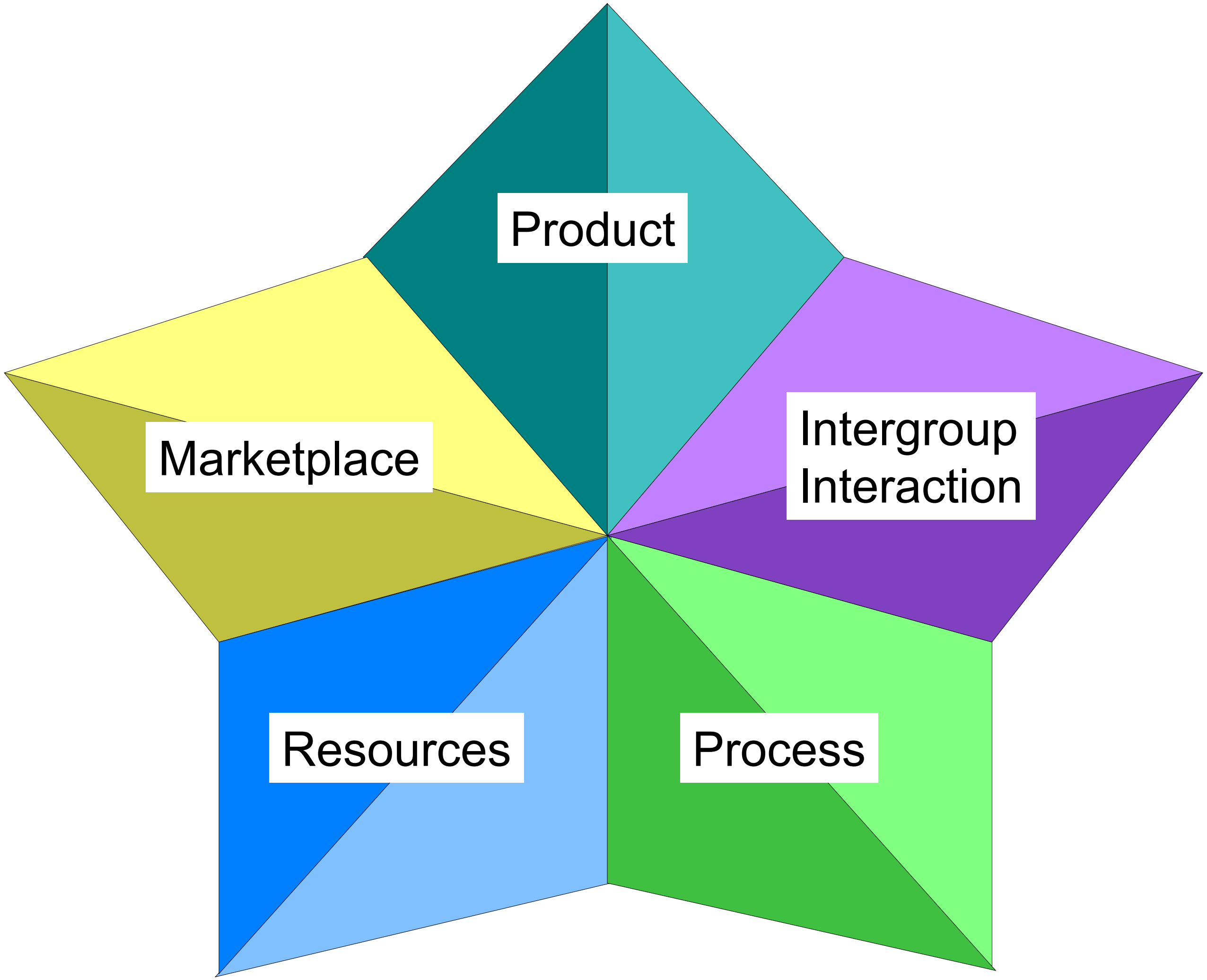
2. **For system(s) with which you have experience, how frequently are system upgrades released that incorporate COTS software upgrades?**
   - GSAW 02 = 20.5 months (range: 4 to 70)
   - GSAW 03 = 16.5 months (range: 6 to 36) (9 data points)

# Survey on number of COTS products

3. For system(s) with which you have experience,How many COTS products are in your system?
   - ❖ GSAW 03 = 37 (range: 1 to 150) (9 data points)

4. For system(s) with which you have experience, what percentage of COTS products are upgraded?
   - ❖ GSAW 03 = 58% (range: 5% to 100%) (9 data points)

# Backup Charts



# Issue Dimensions

**Key for following charts:**

- **"Gn" indicates GSAW 2001 issue and ranking**
- **"A" indicates 2000 Aerospace study issue**

# New Issues

- Is COTS usage really cost effective?
- When and if to upgrade
- How to capture lessons learned – Can product reviews be shared?
- How is cost of maintenance measured?
- Integrating COTS into project lifecycle particularly spiral development process
- Technology exportability issues
  - ❖ Maintenance, requirements traceability
- COTS products within the development environment

# Highest Scoring “Top 3” Issues (13 ballots)

- Accurately costing all aspects of CBS development and maintenance
- Incompatibilities among COTS products
- Processes fro trading cost, schedule, requirements, and O&M concepts against COTS capabilities
- Requirements vs. COTS capabilities
- Adverse effects of product upgrades on system
- Rapid technology turnover and limited support of past releases
- Integration of multiple COTS products
- Cost vs. benefit of upgrading
- Dropped of de-emphasized platforms and products

# “COTS Survey” – Participants 2003 and Previous Years

- Be sure to include all COTS-related costs, especially those not included in the cost model estimates (e.g., licenses, training)
- Expect glue code to have a lower productivity than custom software
- Cost of COTS versus custom development needs to be evaluated for the full life cycle (not just development)
  - ❖ Distribution of costs will be different for COTS and custom development projects

**“Despite discussion to the contrary, using COTS is still cheaper and more effective than building”**

# Emerging Issues from Kohl

- **COTS ‘certification’**
  - ❖ What is it?  Approaches to achieve it?
  - ❖ How to measure or validate it?
  - ❖ As compared to custom built software ‘certification’
- **COTS content at major milestone reviews**
  - ❖ SRR, SDR, PDR, CDR, TRR, etc
  - ❖ What content should be presented at each review?
- **COTS impacts to lifecycle processes**
  - ❖ Changes to existing processes (requirements, evaluation)
  - ❖ Differences in sequence of activities
  - ❖ Milestone review impacts (see 2nd bullet)

# Product Issues

- **Requirements vs. COTS capabilities (G1)**
- **Integration of**
  - ❖ Multiple COTS products (G2)
    - ☞ Incompatibilities among COTS products (A)
  - ❖ COTS products with new/reuse software (G5)
- **COTS independent architecture (G3)**
  - ❖ Designing architectures for COTS evolution (A)
  - ❖ Designing in safety, security, supportability (A)
- **Mission risk (G6)**
- **Cross platform portability (G11)**
- **Standards:  good, bad, ugly? (G14)**
- **API breakage ("unplug and replay") (G15)**
- **Dormant functionality or features (G18)**
- **Adverse effects of product upgrades on system (A)**

# Process Issues - Developer

- **Robust initial and periodic COTS product evaluation (A)**
- **Prototyping in a system context (A)**
- **Testing in operational context (G12)**
  - Regression testing of upgrades in system context (A)
- **Adapting software and systems engineering processes for CBS development and maintenance (A)**
- **Still need systems and software engineering (A)**
- **Need enhanced CM processes (A)**
- **Planning for COTS upgrades and evolution during development and maintenance (A)**
- **Selection of hardware platforms with availability of COTS software as key criterion (A)**

# Process Issues - Customer and User

- **Acquisition and support strategies (G16)**
- **Adapting customer/user processes to CBS acquisition, operations and maintenance (A)**
- **Processes for trading cost, schedule, requirements, and O&M concepts (A) against COTS capabilities**
  - ❖ Need requirements prioritization (A)
- **Need contracts compatible with CBS development and maintenance (A)**
- **Standardized processes for safety certification and security accreditation of CBS needed (A)**
- **Standardized license processes to ensure suitability of licenses and maintaining currency (A)**

# Resource Issues

- **Cost vs. benefit of upgrading (G7)**
- **Acquiring and maintaining CBS skills (G9)**
- **Accurately costing all aspects of CBS development and maintenance (A)**
- **Optimal scheduling of upgrades (A)**
- **Increased computer resources for upgrades (A)**
- **Modifying COTS is a BAD idea! (A)**
- **Need cost and schedule management reserves (A)**
- **Reallocating time and effort across life cycle (A)**
  - ❖ More time for evaluation, prototyping and analysis (A)
  - ❖ Less time for implementation; more time for integration (A)

# Marketplace Issues

- **Product maturity (G4)**
  - ❖ Dropped or de-emphasized platforms and products(A)
  - ❖ Changes in fees and fee structure for licenses and services (A)
- **Marketplace maturity (G8)**
  - ❖ Vendor volatility (A)
- **Vendor responsiveness (G17)**
  - ❖ Changes in type and quality of vendor support (A)
- **Definition of COTS (=“for sale”) (G19)**
- **Suitability of licenses for user application (e.g., expiring keys, export restrictions) (A)**
- **Release schedule, content and quality unpredictable (A)**
- **Rapid technology turnover and limited support of past releases (A)**

# Intergroup Interaction Issues

- Customer resistance to COTS--NIH (G10)
- Excessive customer bias toward COTS (A)
- Vendor relationships (G13)
- Establishing and maintaining active partnership between customer, developer and user (A)
- Need flexible and efficient responses to unexpected impacts by customer/user (A)

# Resources

- **CeBASE COTS**
  - ❖ http://www.cebase.org/
  - ❖ http://www.cebase.org/www/cots/index.html
- **CeBASE COTS Lessons Learned site**
  - ❖ http://fc-md.umd.edu/ll/index.asp
- **SEI's COTS-Based Systems Initiative**
  - ❖ http://www.sei.cmu.edu/cbs/
- **International Conference on COTS-Based Software Systems (ICCBSS - "ice cubes")**
  - ❖ http://seg.iit.nrc.ca/iccbss/

# Aerospace Publications

- **Richard J. Adams and Suellen Eslinger, "Lessons Learned from Using COTS Software on Space Systems," *CROSSTALK* (Vol. 14, No. 6), June 2001, pp. 25-30.**
  - ❖ Available from http://www.stsc.hill.af.mil/

- **Richard J. Adams and Suellen Eslinger, "COTS-Based Systems: Lessons Learned from Experiences with COTS Software Use on Space Systems," *Software Technology Conference (STC) 2001 Proceedings*, May 2001.**
  - ❖ Available from http://www.stsc.hill.af.mil/
  - ❖ Includes paper and briefing charts

# Aerospace Publications (Continued)

- **Suellen Eslinger, "Software Acquisition and Software Engineering Best Practices," Aerospace Technical Report No. TR-2000(8550)-1.**
  - ❖ Available on-line at http://www.aero.org/publications/papers/tech-reports.html

- **Richard J. Adams and Suellen Eslinger, "COTS-Based Systems: Lessons Learned from Experiences with COTS Software Use on Space Systems," Aerospace Technical Report No. TR-2001(8550)-01, September 2001.**
  - ❖ Available on-line at http://www.aero.org/publications/papers/tech-reports.html