Managing COTS Integration for High Integrity Systems: Observations from the COCOTS Database

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March 5, 2003

GSAW 2003

This work is sponsored by the FAA's Software Engineering Resource Center

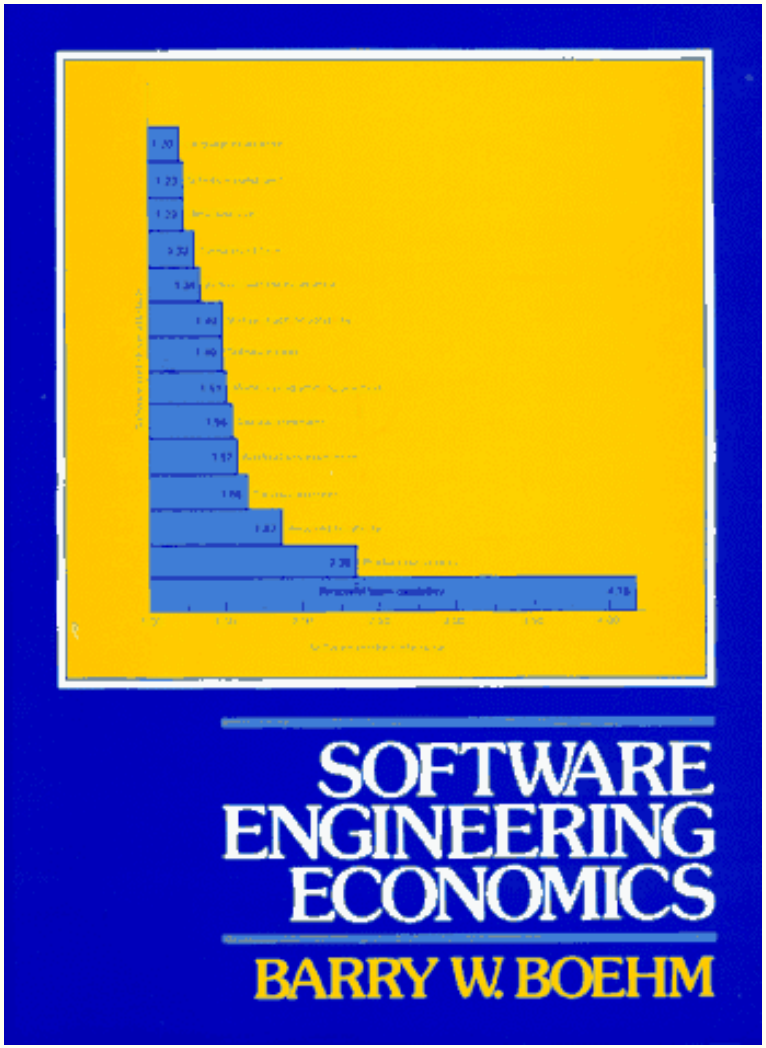
smi Software Metrics, Inc.

Topics Covered

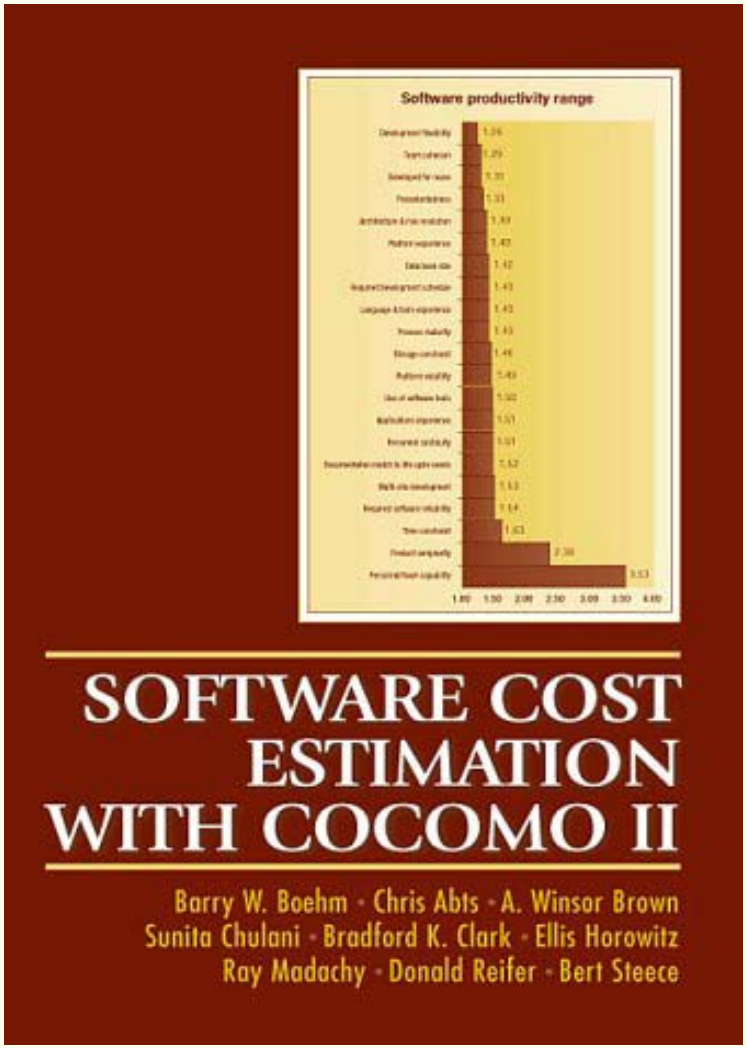
- Background
- Some empirical observations about the use of COTS in high integrity systems
  - Types of products
  - Attributes considered in evaluating COTS
  - Strategies observed
- Conclusions

Background

- Empirical observations come from COCOTS database
- Constructive COTS Model
  - Estimation tool
  - Analysis tool
- Part of the COCOMO suite of tools
  - Open model
  - In the public domain



COCOMO 81
(1981)



COCOMO II
(2000)

COCOTS

- Sponsored by FAA's Software Engineering Resource Center (SERC)

- Calibrated with data from twenty projects
  - 11 can be classified as "high integrity"
  - 9 are other (business, support systems)

“High Integrity” COTS-Based Systems in COCOTS Database

- Classification based on whether or not system is safety-critical
- Most of these systems operate 24/7
- Eleven total
  - 5 are Air Traffic Management (FAA)
  - 3 are Air-to-Ground Communication (FAA)
  - 1 is Radar Processing (FAA)
  - 1 is Missile Tracking (Air Force)
  - 1 is Satellite Control (NASA)

Questions Asked about COTS and High Integrity Systems

- What types of COTS products do they use?
- What attributes do they consider when selecting a product?
- What strategies do they use to ensure system integrity?

Defining COTS

- Commercial-Off-The-Shelf Software
  - Sold, leased, licensed at advertised prices
  - Source code unavailable
  - Periodic releases with feature growth and fixes
  - Eventual obsolescence, end of life
- Each part of this definition has implications

Implications

Sold, leased, licensed at advertised prices

- Market forces play an important role
- Success or failure is no longer simply a technical issue
- Is it in the vendor's interest to be cooperative?
- Will the vendor be in business in a few years?

Implications -2

Source code unavailable

- If the source code is available for modification, ***from an estimating perspective***, this is a case of reuse
  - Effort is a function of lines of code to be understood, added, modified, deleted
- Without source code, activities change
  - Assessing/evaluating
  - Tailoring (using vendor-provided mechanisms)
  - Writing glue code
- These are the activities that are modeled by COCOTS

Implications - 3

Periodic releases with feature growth and fixes
Eventual obsolescence, end of life

- Requires continual upgrades to avoid end of life
- You have no control over product evolution
- Maintenance complexity grows very quickly with the number of COTS products

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  - Types of products
  - Attributes considered in evaluating COTS
  - Strategies observed
  - Lessons learned
- Conclusions

Types of COTS Products

Type of Product	Projects Using
operating system(s)	91%
GUI generator	73%
DBMS	55%
network management	27%
communications protocol	18%
disk array	18%
data warehouse, device drivers, telemetry processing, off-line analysis tools, C++ class library	9%

Something interesting is going on…

- The 9 projects that were NOT classified as “high integrity” almost never mentioned operating systems and other infrastructure as COTS
  - Why not?
- What they did mention were higher-level applications
  - e.g., Oracle Financials
- Which leads to another interesting part of the definition of COTS

Revisiting the Definition of COTS

- People view “COTS” as products that are associated with some risk
  - Point made by Vic Basili during keynote address at ICCBSS 2003
- For our set of high integrity systems, operating systems are viewed as a source of risk and are subject to risk-mitigation activities, e.g.
  - Assessment before buying
  - Purchasing source code
- Not the case for the other (non high-integrity) systems

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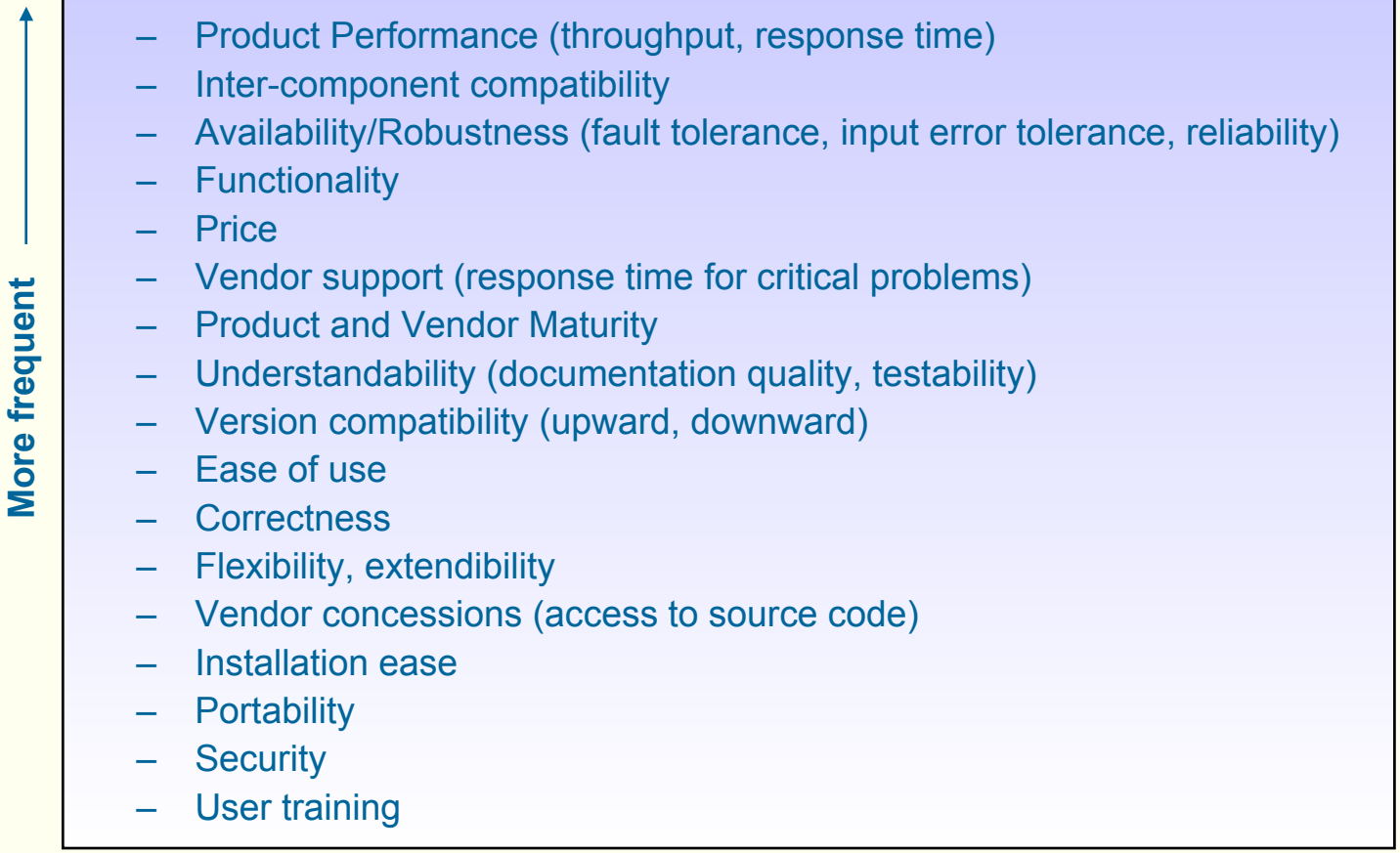
Attributes Considered in Selecting COTS Products: "High Integrity" CBS

- Rank Order by Frequency



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Strategies Observed to Ensure System Availability/Reliability

- Fault-tolerant architectures
- Detailed evaluations before purchasing COTS
- Use of mature components
- Support agreements requiring 24-hour response time for critical problems
- Purchase of source code

Maintenance Challenges

- Managing COTS volatility (new versions over time)
  - Lots of time spent analyzing impact of upgrading to new versions
- Initial observations suggest a non-linear impact of the sheer number of products on maintenance complexity
  - Multiple configurations make this much worse

Strategies to Address Maintenance

- Glue code wrappers
  - Used to hide functionality to allow upgrades without impacting rest of system

  "We wanted to be able to replace a product without damage. As an example, we have a wrapper around the data base. It could be a flat file, relational…the custom application doesn't care."
- Freezing configuration (not upgrading any COTS products) while purchasing source code for critical components
- Distinguishing between critical and non-critical components with focus on the former to avoid end-of-life

Conclusions: COTS and High Integrity Systems

- Observations from the COCOTS Database
  - Types of Products
    - Infrastructure
    - GUI generators
    - DBMS
  - Attributes Evaluated
    - Product performance
    - Interoperability
    - Availability/fault tolerance
  - Challenges faced
    - Ensuring reliability and availability in the initial system
    - Maintenance
  - Strategies
    - Variety of strategies including detailed evaluations, purchase of source code, use of mature components
    - Maintenance strategies ranged from freezing the configuration to use of wrappers to minimize negative impact of upgrades

Plea for more data!

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Questions?