Ecosystem Cost Impact of an Open Standard

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Discussion Points

- Motivation
- Opportunity
- Operationalization
- Preliminary Results

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Software is becoming a key component of combat aircraft...

- “The technological revolution in design tools, electronics, and propulsion technology has given aircraft designers the opportunity to create weapon systems of increasingly greater lethality and capabilities. This is especially true for combat aircraft such as the F-22A, the F/A-18E/F, and the F-35, whose complexity is substantially higher than that of their predecessors. For example, the F-16, the initial lightweight fighter of the 1970s, had 15 subsystems and thousands of interfaces but less than 40 percent of its functions managed by software. Today, the F-35 has 130 subsystems, hundreds of thousands of interfaces, and more than 90 percent of its functions managed by software. Furthermore, newer fighter aircraft include sophisticated electronic warfare capabilities, perform with higher thrust engines, and can evade the enemy radar far better than can legacy fighters such as the F-14, F-15, and F-16.” (RAND study, 2008)
The Open Standard: FACE

FACE is a technical standard that defines a common operating environment supporting portability and reuse of software components across Department of Defense (DoD) aviation systems.

- The Open Group

FACE is intended to provide the following:
- An open technical standard that defines/specifies a reference architecture
- Standardized, open APIs at key interfaces
- A process for conformance testing and verification
- A repository of FACE-standard conformant software
Motivation

- Extensive literature on
  - Software engineering costs at the firm level
  - The general role of open standards

- However, less is known about
  - The impact of open standards on software development costs
  - .. Especially from an ecosystem (inter-firm) perspective
Opportunity

- To address, we are ..
  - Looking at established factors underlying software engineering costs (e.g. Boehm, 1984; Boehm et al., 2000; Valerdi et al., 2003)
  - Considering modifications for industry/ecosystem factors (e.g. the firm’s role within it)

- Collectively this allows us to look at the impact of open standards on an extended ecosystem-aware framework

- And thereby contribute to the literature on
  - Ecosystems
  - Open standards
  - Software development costing
Drivers of Software Engineering Costs

- Potentially hundreds of factors can potentially affect software development costs (DeMarco 1982)
  - **people factors**: such as experience, skills and team size;
  - **process & tool factors**: such as programming language, methods and tools;
  - **product factors**: such as complexity and application type;
  - and **environmental factors**: such as memory, storage and timing constraints

- But only a few of these may affect software costs within a given environment (Banker et al 1991, Kitchenham 1992, Mukhopadhyay and Kekre 1992),

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Operationalization

Context
- Implementation of an open standard by the military avionics industry over the next few years.
- This is a highly secretive/closed and competitive industry..
  - Limited cost data availability
  - Fertile ground for open standard impact

Approach – Use Experts
1. Using a combination of the Delphi Method & Analytical Hierarchy Processing (AHP)
   - Capture expert’s estimation of the influence of
     - Current project software engineering effort drivers
     - Equivalent drivers under FACE
   - .. across a selection of prototypical business scenarios
2. Supplement findings with interviews/discussions with members of industry and government
3. Gain access to firm cost data

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Analytical Hierarchical Process (AHP)  
(Saaty, 1980)

- Structured technique for organizing and analyzing complex decisions
- Leverages group expert knowledge
- Uses a series of pairwise comparisons to score the relative significance of choices

- Precedence for using to build/modify cost models (e.g. COSYSMO - Valerdi, R., Boehm, B., Reifer, D. 2003; also Lee 1993; Finnie, Wittig & Petkov 1993)
What does Pairwise Comparison look like?

- To what extent do each of these drivers determine how romantic a restaurant is?
- In other words .. what is the relative importance of a restaurant having each?

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<thead>
<tr>
<th>Courteous Staff is</th>
<th>very much less important than</th>
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<tbody>
<tr>
<td>Comfortable Seating.</td>
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<td>Cheap Wine.</td>
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Example – What does Pairwise Comparison look like?

- In each case you are completing a comparison, e.g. Courteous Staff is _________ Comfortable Seating.

- You are comparing the term on the top left to the terms on the left side of the matrix one by one in the context of things restaurants have and their relative effect on how romantic a restaurant is.

- So .. Is having **Courteous Staff** equally important to **Cheap Wine**?

### Courteous Staff is ...

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Radial Chart of AHP Results – Effort Driver Rankings by Firm Type

Business Scenario: Legacy Aircraft Upgrade

Effort drivers:
- # and Diversity of Platforms/Installations
- Application Experience
- Complexity of Integration
- Complexity of Migrating from Legacy Platform
- Complexity and Extent of Testing Required
- Development Schedule Constraints
- Product Type (e.g., Mission Critical)
- Required Software Reliability
- Requirements Understanding
- Requirements Volatility
- Similarity to Previous Products

Firm Type/Role:
- System Integrator
- Avionics Supplier
Questions
Appendix
Cost Models

- **COCOMO**: Constructive Cost Model
- **COSYSMO**: Constructive Systems Engineering Cost Model
- **NEMO**: NAVAIR ESLOC Model (accounts for code growth)

- **Typical Cost Model**
  - Driven by size & programming language
  - Adjusted by code reuse and use of COTS
  - Further adjusted by effort drivers that capture people, process, and tools factors...
- **E.g.** Effort = $\alpha \ast (\text{size})^\beta \ast \sum EM_i$
Bibliography

- Boehm, B. W., R. Madachy, et al. (2000). *Software Cost Estimation with Cocomo II with Cdom, Prentice Hall PTR.*