Applying Systems Modeling Language (SysML) to System Effort Estimation Utilizing Use Case Points

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Agenda

- Introduction of Concept
- Use Case Points (UCP) Method
- SysML Use Cases
- UCP for Estimation of System Engineering Effort

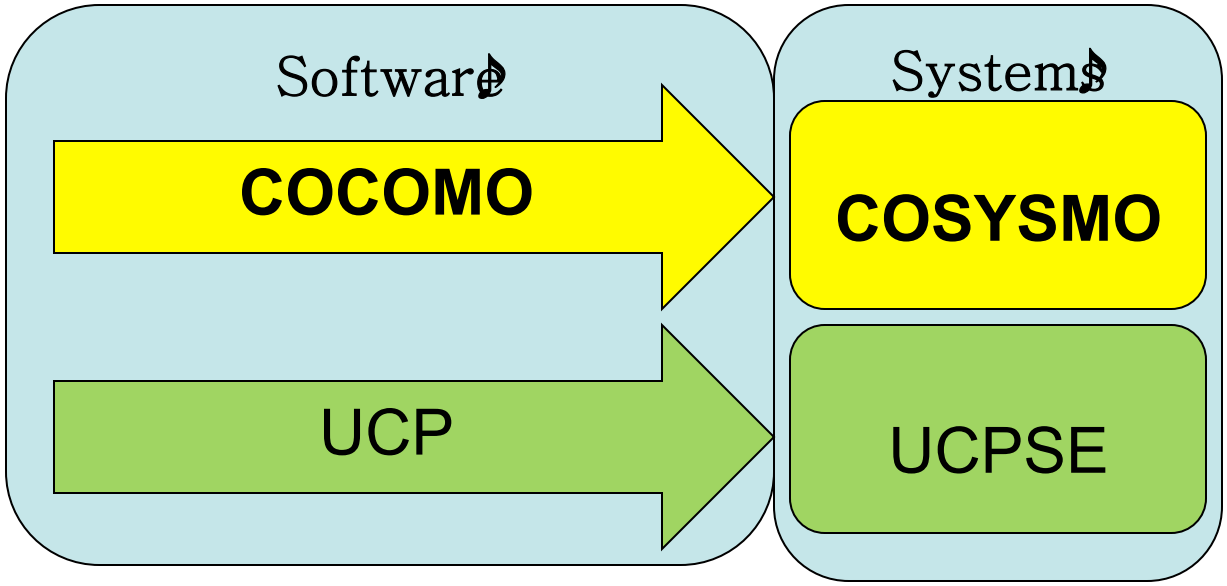
Concept Introduction

- Extend Use Case Points (UCP) estimating approach to SysML for estimating the systems engineering effort

- Potential Benefit
  - Additional Value of Modeling Use Cases

Current System Engineering Effort Estimation Method

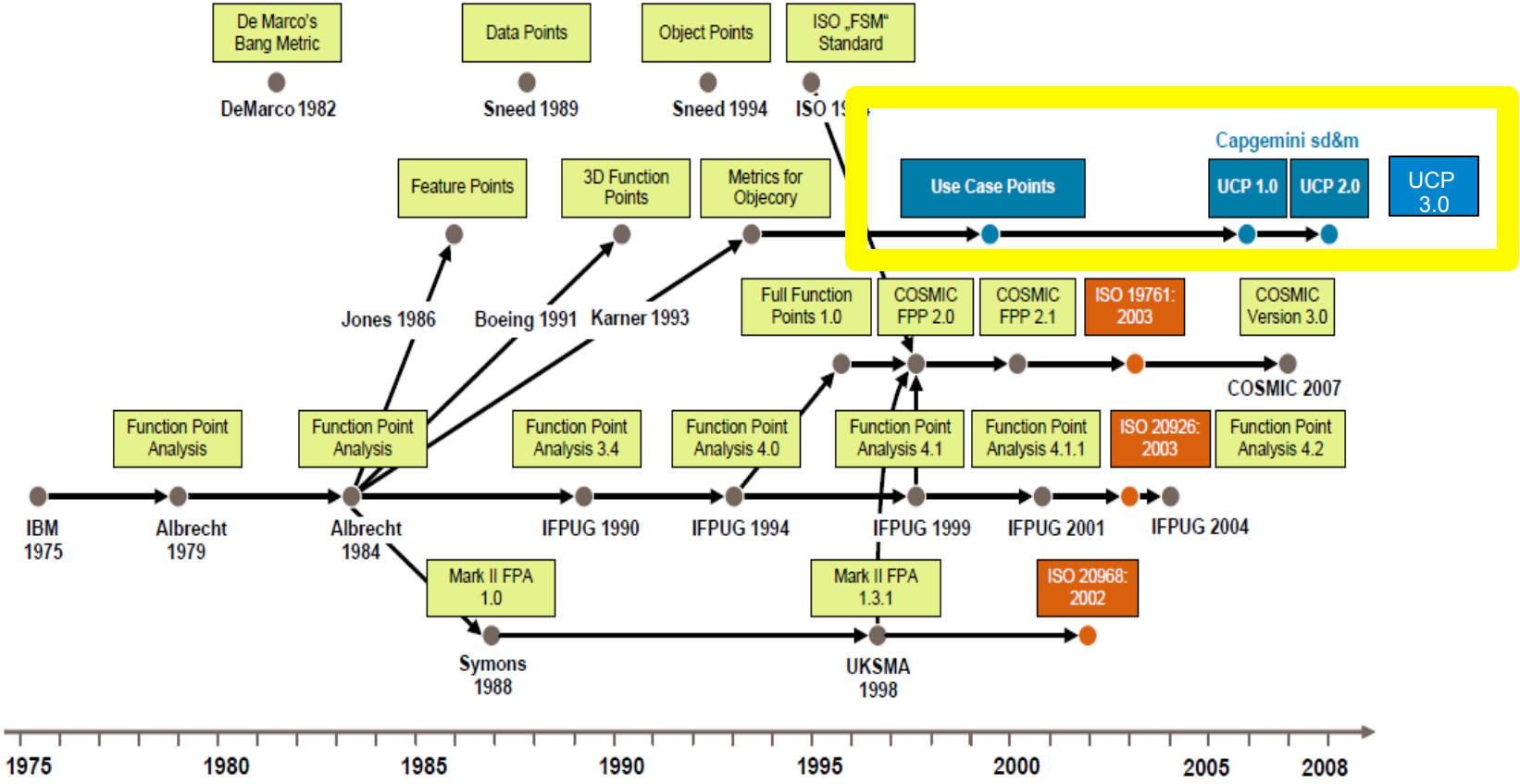
- **Constructive Systems Engineering Cost Model** (COSYSMO)
  - COSYSMO is based on **Constructive Cost Model** (COCOMO), which is a **functional point (FP)** software effort estimation technique [Valerdi 2005].



Valerdi, Ricardo. 2005. *The Constructive Systems Engineering Cost Model (COSYSMO).* Dissertation. University of Southern California.

Use Case Points Overview

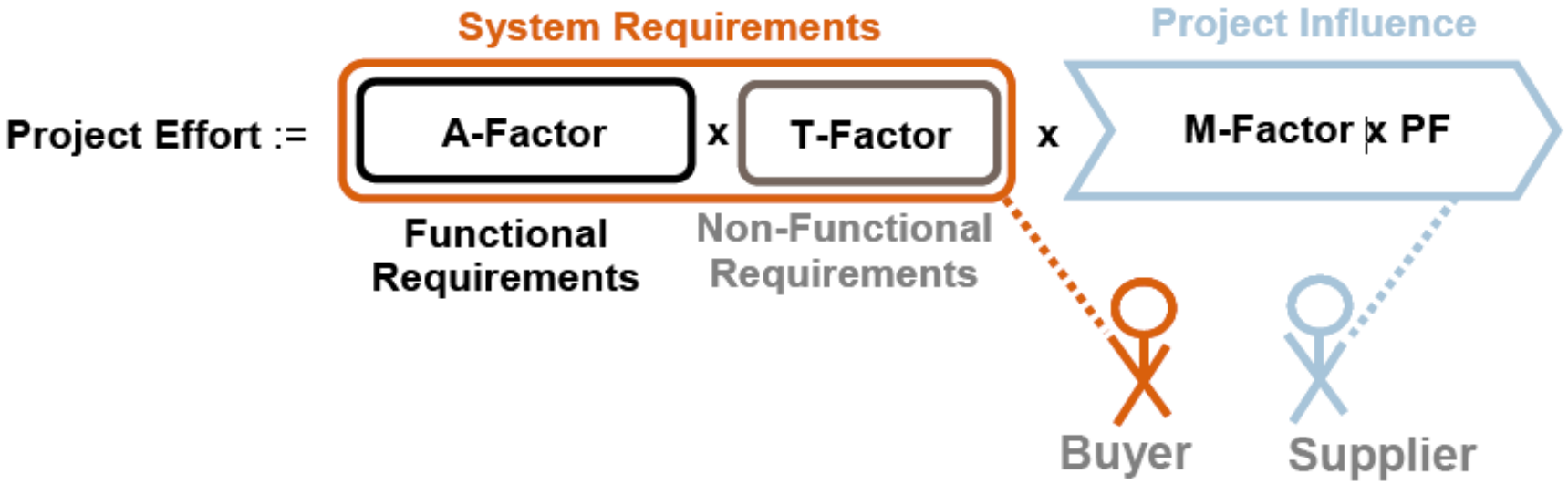
Evolution of Use Case Points (UCP)



Evolution of Functional Size Measurement (FSM) Methods. [Heltewig 2008]

Heltewig, Sebastian. 2008. *Improving the Use Case Point Method*. Dissertation, Technische Universitat Kaiserslautern.

UCP 2.0 Overview Used for Software



Estimating and Partitioning Effort with UCP 2.0 [Frohnhoff and Engeroff 2008]

Where PF = Productivity Factor (Organization Factor)

Frohnhoff, Stephan; Engeroff, Thomas: *Field Study: Influence of Different Specification Formats on the Use Case Point Method In Proceedings of ISWM / Metrikon / Mensura 2008, Munich 2008*

Functional Size of System (A-Factor)

$$A\text{-}Factor := \sum_{i=1}^{n} U_i + \sum_{j=1}^{m} A_j$$

Ui - ratings of the n use cases

- In case of *simple use cases (5 UCP), the maximum of indicator counts is at most three.*
- For *medium use cases (10 UCP), the maximum is in-between four and seven.*
- *Complex use cases (15 UCP) have at least one indicator count of eight or more.*

Aj - ratings of the m actors of the use case model

- *Each actor is rated with respect to complexity*

Frohnhoff, Stephan; Engeroff, Thomas: *Field Study: Influence of Different Specification Formats on the Use Case Point Method In Proceedings of ISWM / Metrikon / Mensura 2008, Munich 2008*

Technical Factor (T-Factor)

$$T\text{-}Factor := 0.58 + 0.01 \cdot \sum^{13} T_i \cdot W_i$$

- Technical Factors (Ti) Ratings (0-5)
  - Distributed System
  - Performance and Load Requirements
  - Efficiency of the User Interface
  - Reusability
  - Easy to Install
  - Complexity of Business Rules and Calculations
  - Easy to Use
  - Portability
  - Easy to Change
  - System Availability
  - Special Security Features
  - Direct Access for Third Parties
  - Special User Training Facilities
- Wi – Weighted Factor of Ti

Frohnhoff, Stephan; Engeroff, Thomas: *Field Study: Influence of Different Specification Formats on the Use Case Point Method In Proceedings of ISWM / Metrikon / Mensura 2008, Munich 2008*

Environment Factor (M-Factor)

$$M\text{-}Factor := \prod_{i=1}^{9}\left(1 + 0.1 \cdot W_i \cdot (3 - M_i)\right)$$

- Environment Factor (Mi) Ratings (0-5)
  - Lead Analyst Capability
  - Collaboration (Team Players)
  - Personnel Continuity
  - Quality of Rough Specification and T-Architecture
  - Process Model (Maturity)
  - Required Development Schedule
  - Stable Requirements
  - Number of Decision Makers
  - Integration Dependency
- Wi – Weighted factor for each Mi
- PF - Productivity Factor *of an Organization (requires historical data)*

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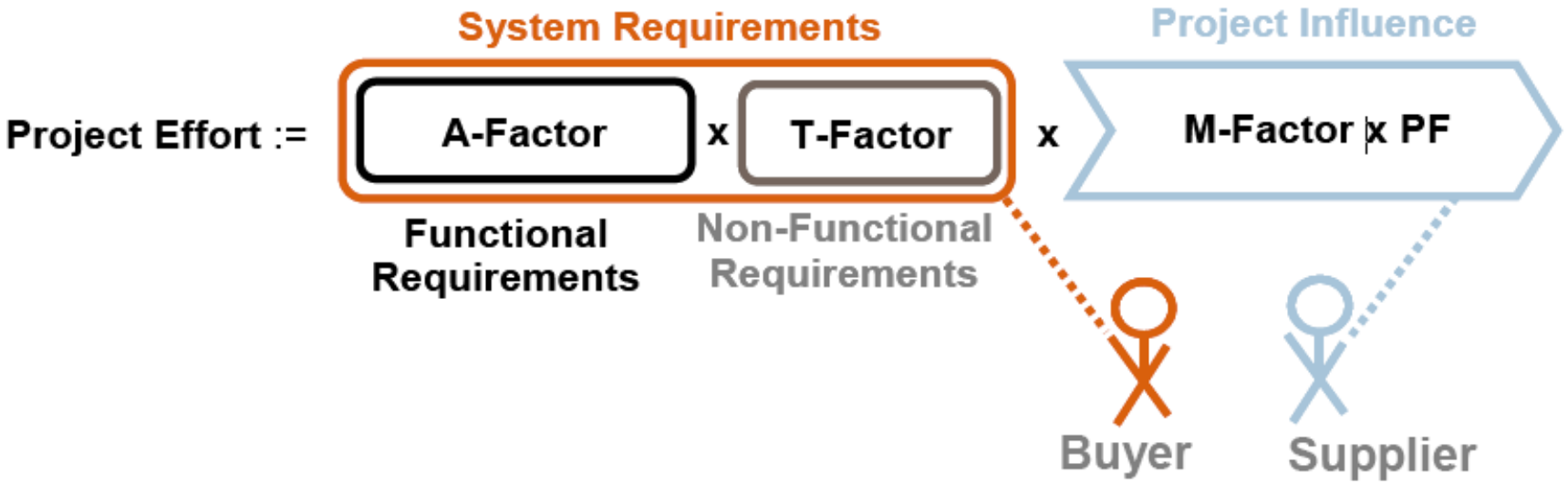

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Software and UCP

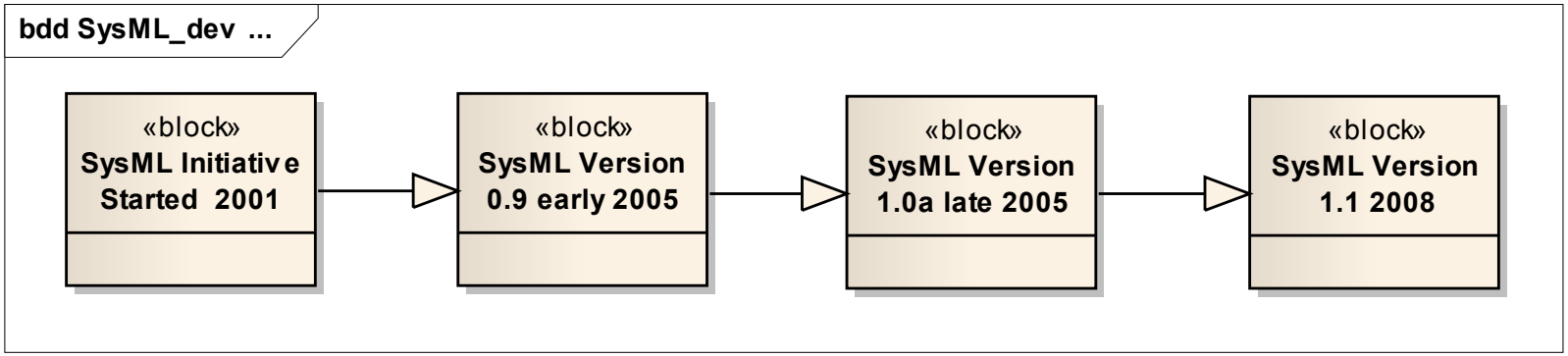
- From Literature Review:
  - UCP method is known in Software community but not highly utilized [Vijay and Manoharan 2009]
- Reason for not being highly utilized
  - Use Cases are not consistently developed [Smith 1999]
  - Comments from OMG RFI Survey 2009 also stated the inconsistent development of models (diagrams) was a general issue

Vijay, J. Frank and C. Manoharan. 2009. “Initial Hybrid Method for Analyzing Software Estimation, Benchmarking and Risk Assessment Using Design of Software”. Journal of Computer Science 5 (10): 717-724. 2009 Science Publications.

Smith, John. 1999. “The Estimation of Effort Based on Use Cases”. IBM Rational Software.

SysML and Use Case Overview

SysML Evolution

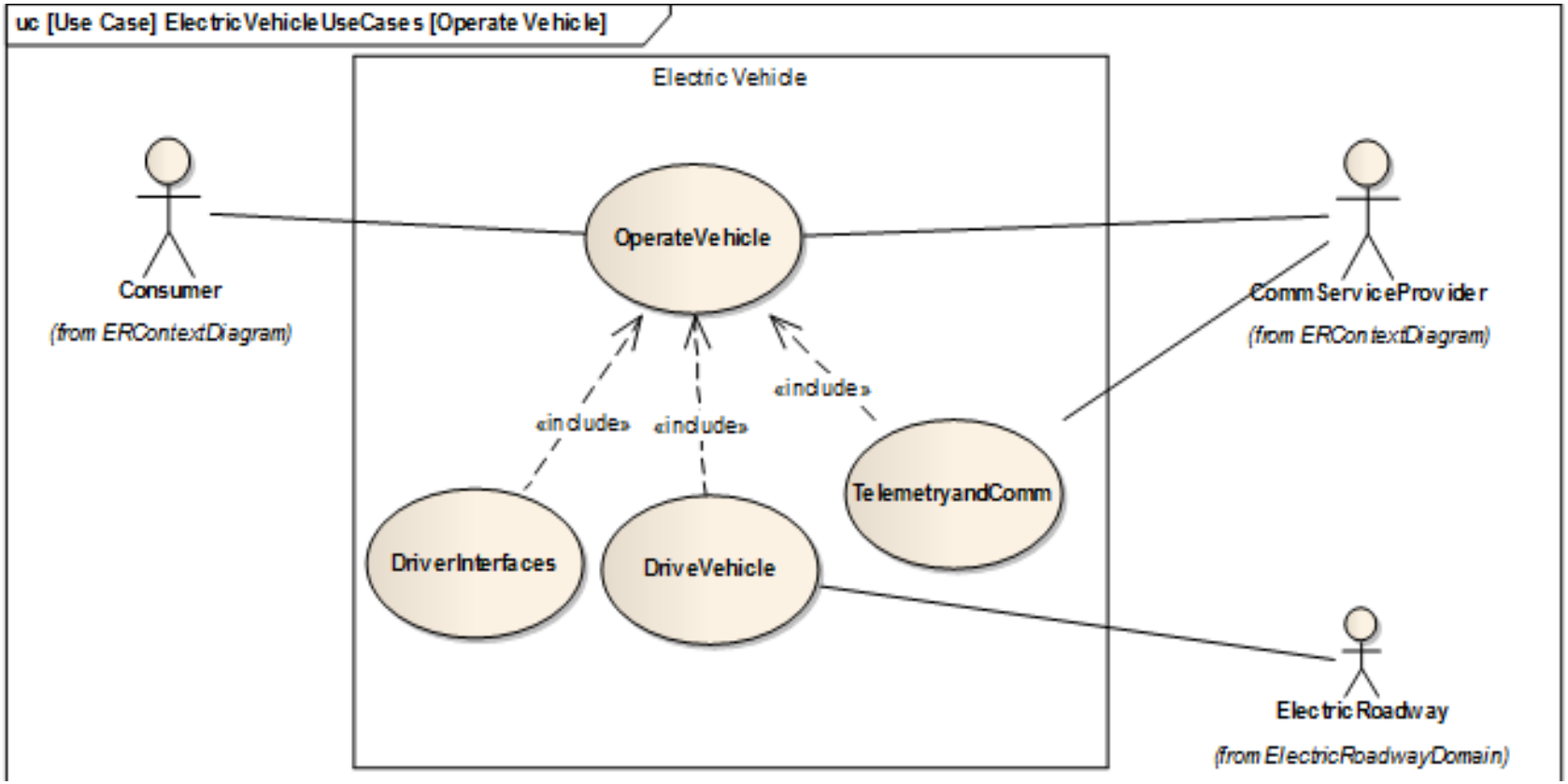


Evolution with User Input

SysML Use Cases

- OMG RFI Survey in 2009
  - Question 3: To what extent were the following diagram types used relative to the total modeling effort?
    - Use Case Diagrams 3.81 out of 5 (where 5 was High Use)
  - Question 4: What value did each of the following diagram types and associated modeling concepts contribute to the modeling effort?
    - Use Case Diagrams were given 3.84 out of 5 Value (where 5 is High Value)
- Use Case Diagrams are utilized and viewed as medium to high value
- This concept could add value to the development of Use Case Diagrams

Example Use Case in SysML



Example Screen Shots: UCP for Systems Engineering

Technical Factors	Weight
Distributed System	0
Response Adjectives	0
End-User Efficiency	0
Complex processing	0
Reusable code	0
Easy to install	0
Easy to use	0
Portable	0
Easy to change	0
Concurrent	0
Security features	0
Access for third parties	0
Special training required	0
Technical Complexity Factor	0

System Technical Factors (Ti)

Actors	Weighting Factor	Number of Each	Extended Rate
Simple Actors: external systems	1	0	0
Average Actors: hardware devices or timers	2	0	0
Complex Actors: humans	3	0	0
	Actor Weight		0

Use Cases - all includes, extends, and generalizes	Weighting Factor	Number of Each	Extended Rate
Simple Use Case: 3 or less pathways	5	0	0
Average Use Case: 4 - 7 pathways	10	0	0
Complex Use Case: More than 7 pathways	15	0	0
	Use Case Weight		0
UUCP - Unadjusted use-case points			0

Functional Size of System (Ai)

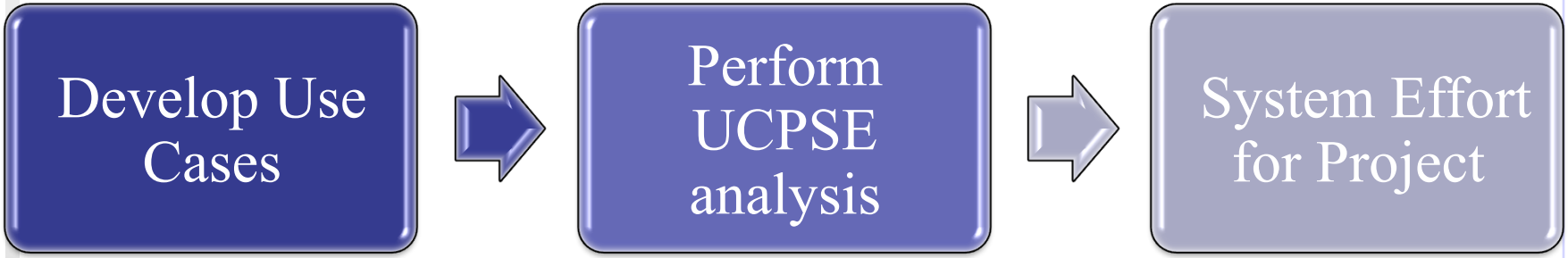
Project Participants	Weighting	Rating	Extended Rate
Use of a formal process	1.5	0	0.0
Application experience	0.5	0	0.0
Object Oriented experience	1.0	0	0.0
Lead analyst capability	0.5	0	0.0
Motivation	1.0	0	0.0
Stability of requirements	2.0	0	0.0
Number of part-time workers	-1.0	0	0.0
Difficulty of programming	-1.0	0	0.0
Environmental Complexity Factor - ECF			0.0

Project Participants
For the first four factors, 0 means no experience in the subject, 3 means average, and 5 means expert.
For the fifth factor, 0 means no motivation for the project, 3 means average, and 5 means high motivation.
For the sixth factor, 0 means extremely unstable requirements, 3 means average, and 5 means unchanging requirements.
For the seventh factor, 0 means no part-time technical staff, 3 means average, and 5 means all part-time technical staff.

Environment Factor (Mi)

Output of UCP for Systems Engineering

UCP (Use Case Points)	0.00
Person hours/UCP *	20
Estimated hours	0.0
Estimated hrs/week	38
Project Staff	15
Estimated Calendar Months	0.0



What kind of results should we expect?

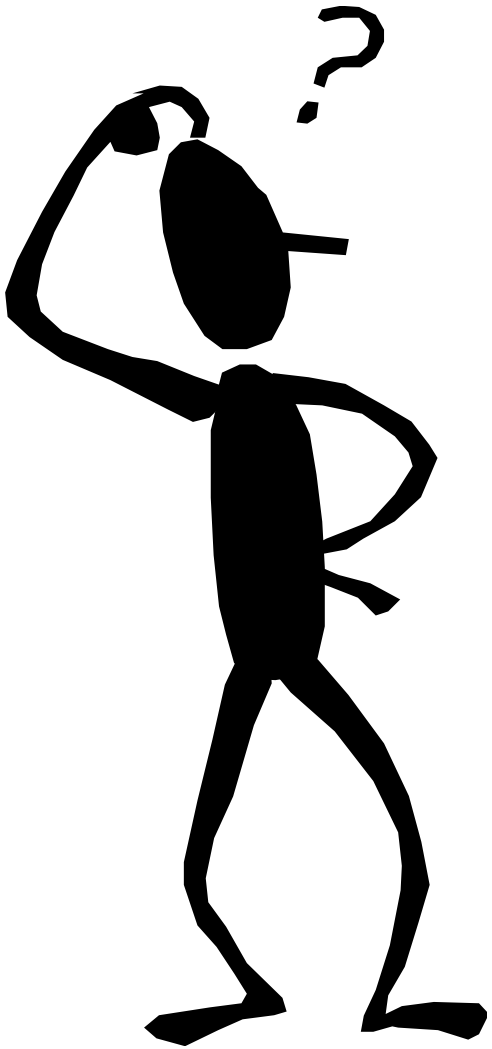
UCP 3.0 has shown promise of a relative deviation from actual effort of only **-12%** (underestimated) [Heltweig 2008]

Heltewig, Sebastian. 2008. *Improving the Use Case Point Method*. Dissertation, Technische Universitat Kaiserslautern.

Future Research

- Investigate why UCP Method is not (or perceived to not be) more highly utilized in estimating software effort
- Evaluate UCP 3.0 and develop concept of applying method to Systems Engineering effort estimation
- What can this research learn from COSYSMO

Questions?



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