



**SYSTEMS ENGINEERING**  
Research Center

# **Estimation of Expedited Systems Engineering Schedules**

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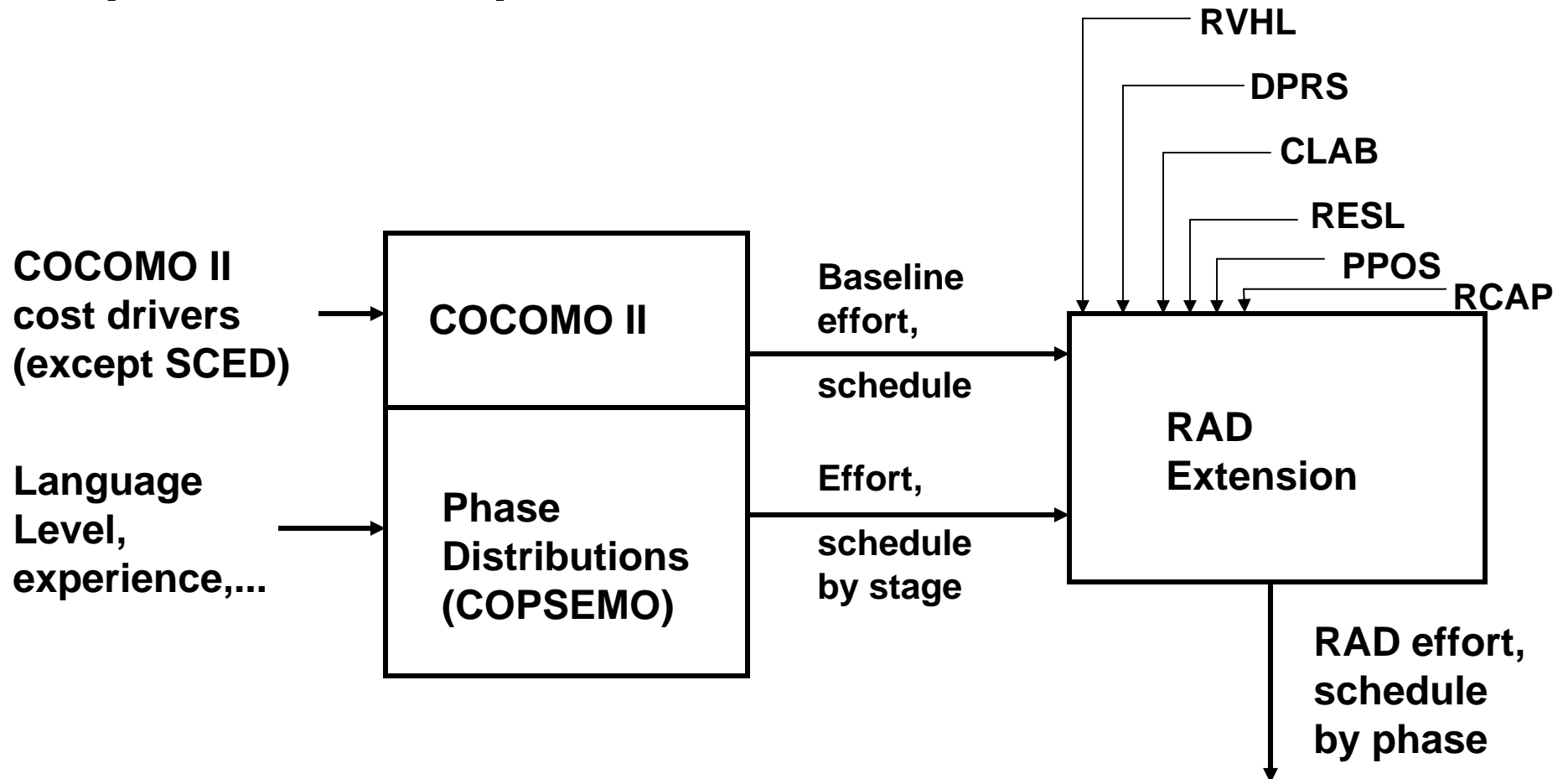
**SCEA-ISPA Joint Conference  
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# Outline

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- **Baseline: CORADMO Expedited Software Development Model**
  - RAD: Rapid Application Development
  - Expedited Schedule Drivers
  - Relation to RAD Opportunity Tree
- **Nominal Systems Engineering effort and schedule obtained from COSYSMO effort estimation model, cube-root effort-schedule relationship**
- **RAD Opportunity Tree elements reorganized around product-process-project-people-risk factors**

# COCOMO II RAD Extension (CORADMO)

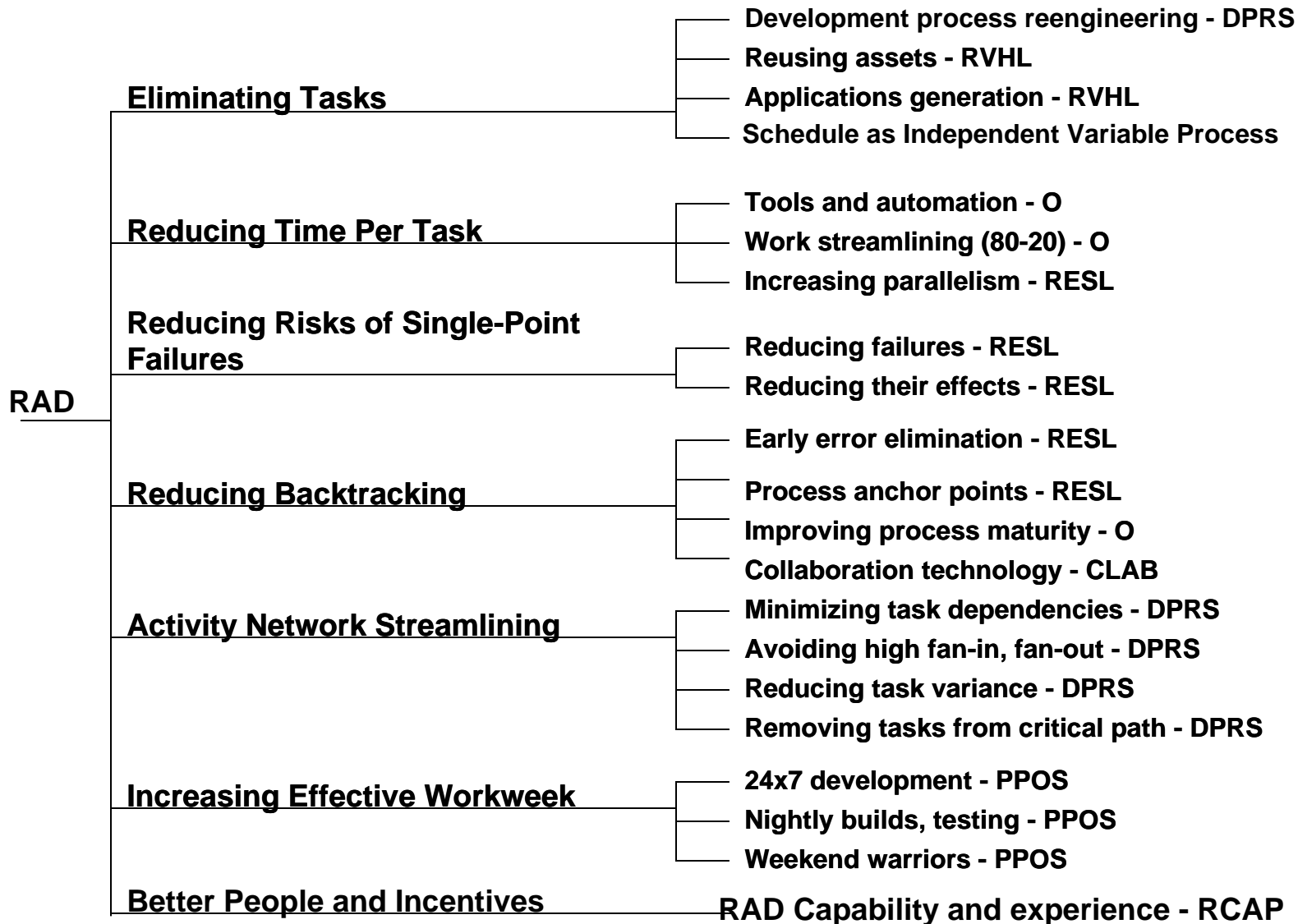


# RAD Context

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- **RAD a critical competitive strategy**
  - Market window; pace of change
- **Non-RAD COCOMO II overestimates RAD schedules**
  - Need opportunity-tree cost-schedule adjustment
  - Cube root model inappropriate for small RAD projects
    - COCOMO II: Months =  $3.7 \sqrt[3]{\text{Person-Months}}$
    - 27 PM  $\Rightarrow 3.7 * 3 = 11.1$  Months
    - Small Staff size ( $27/11.1 = 2.4$  people) reduces cost
      - But slow with respect to competition
    - Larger staff size ( $27/5$  people = 5.4 months) more competitive

# RAD Opportunity Tree



## RCAP:RAD Capability of Personnel

	RATING						
FACTOR	XL	VL	L	N	H	VH	XH
PERS-R	10%	25%	40%	55%	70%	85%	95%
PREX-R	≤2mo	4 mo	6 mo	1 yr	3 yrs	6 yrs	10 yrs
I,E, C Multipliers							
PM	1.20	1.13	1.06	1.0	.93	.86	.80
M	1.40	1.25	1.12	1.0	.82	.68	.56
P=PM/M	.86	.90	.95	1.0	1.13	1.26	1.43

PERS-R is the Early Design Capability rating, adjusted to reflect the performers' capability to rapidly assimilate new concepts and material, and to rapidly adapt to change.

PREX-R is the Early Design Personnel Experience rating, adjusted to reflect the performers' experience with RAD languages, tools, components, and COTS integration.

## RCAP Example

**RCAP = Nominal    PM = 25, M = 5, P = 5**

**The square root law: 5 people for 5 months: 25 PM**

**RCAP = XH            PM = 20, M = 2.8, P = 7.1**

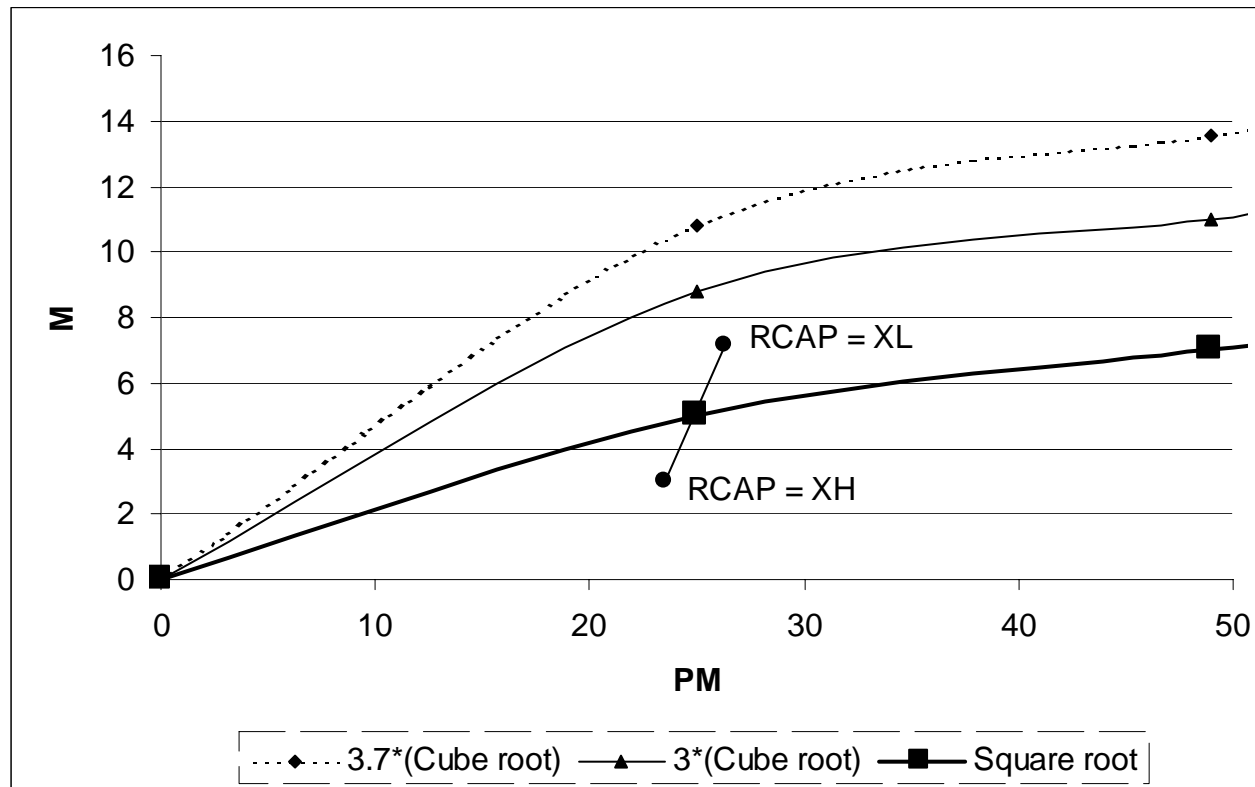
**A very good team can put on 7 people and finish in 2.8 months: 20 PM**

**RCAP = XL            PM = 30, M = 7, P = 4.3**

**Trying to do RAD with an unqualified team makes them less efficient (30 PM) and gets the schedule closer to the cube root law:**

**(but not quite:  $3 \sqrt[3]{30 \text{ person-months}} = 9.3 \text{ months} > 7 \text{ months}$ )**

# Effect of RCAP on Cost, Schedule





# Outline

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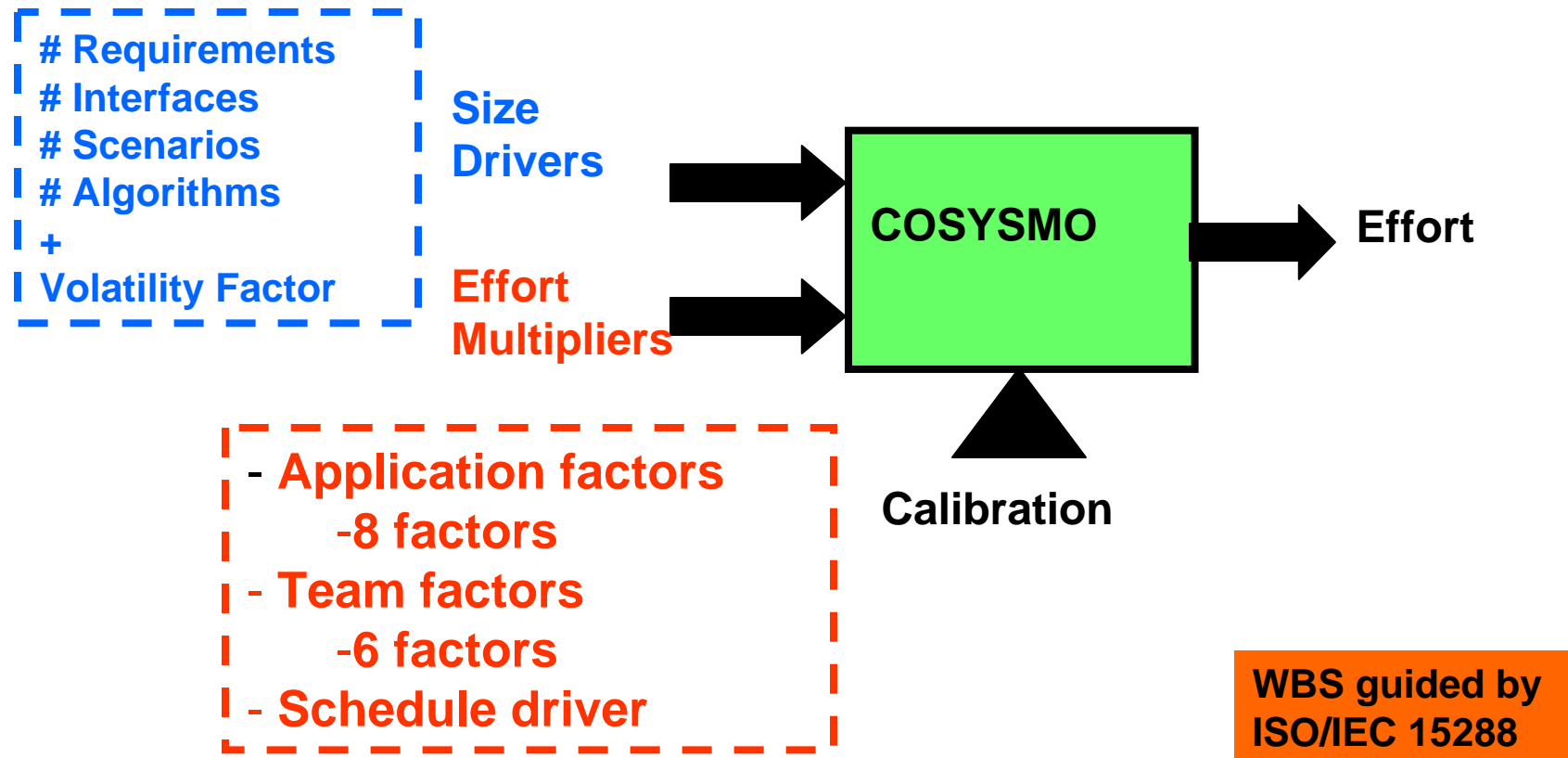
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# Basic Expedited SE Model Form

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- **Estimate SE effort using COSYSMO**
- **Estimate nominal SE schedule as  $1.5 * \text{cube root (SE effort)}$** 
  - **Software, VLSI development schedule =  $3 * \text{cube root (SE effort)}$**
  - **Roughly 50% of development schedule needed for SE**
- **Estimate deviations from nominal schedule using multipliers for product, process, project, people, and risk acceptance factors**
  - **Very Low, Low factor ratings slow down schedule**
  - **High, Very High and Extra High factor ratings speed up schedule**
  - **Factor ratings generally a weighted average of several elements**

# COSYSMO Operational Concept



# COSYSMO Cost Drivers - Application

TOC	COSYSMO Application Factor Selection											See Embedded Comments for Descriptions and Selection Criteria
COSYSMO Application Factor Description	Identifier	Current Prod. Range	Suggested Prod. Range	VLOW (VL)	LOW (L)	NOM (N)	HIGH (H)	VHIGH (VH)	XHIGH (XH)	Rating Selected	Resulting Multiplier	Application Factor Rating Selection Comments
Requirements Understanding	RQMT	1.73	1.73	1.40	1.20	1.00	0.90	0.81	****	N	1.00	
Architecture Complexity	ARCH	1.66	1.66	1.28	1.14	1.00	0.88	0.77	****	N	1.00	
Level of Service (KPP) Requirements	LSVC	2.50	2.50	0.66	0.83	1.00	1.33	1.65	****	N	1.00	
Migration Complexity	MIGR	1.50	1.50	****	****	1.00	1.25	1.50	****	N	1.00	
No. and Diversity of Installations/Platforms	INST	1.50	1.50	****	****	1.00	1.25	1.50	****	N	1.00	
No. of Recursive Levels in the Design	RECU	1.50	1.50	0.82	0.91	1.00	1.12	1.23	****	N	1.00	
Documentation to Match Lifecycle Needs	DOCU	0.67	0.67	0.82	0.91	1.00	1.12	1.23	****	N	1.00	
Technology Maturity	TMAT	2.50	2.50	1.75	1.37	1.00	0.85	0.70	****	N	1.00	Select the Rating from the pulldown that best represents the Rating program being estimated in the Mode or in the SE Data Collection Mode that best characterizes the program for which you are providing the estimate.

Productivity Range (PR) is the Highest Number / Lowest Number and is an indication of the "Relative Degree of Influence" of this parameter on SE effort as currently

The "Suggested" column has no immediate impact in the COSYSMO SE Costing Mode. However, for the COSYSMO SE Data Collection Mode, it serves as a means of collecting your inputs as to what you think the "Relative Degree of Influence" of this parameter should be based upon your overall experience (not specific to the past program being characterized). If you agree with the "Current" number, do nothing. If you disagree, simply overwrite the current number with a new number n (>1.0) in the appropriate cell.

4. Parameters I / 5. Parameters II / 6a. Staffing Table / 6b. Staffing Chart / 7. Labor Distribution / Local SE Data Repository / **8a. Application Factors** / 8t

# Product Factor Elements

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- **Product simplicity (of interfaces, legacy migration, -ilities)**
  - Very Low: Extremely complex; Extra High: Extremely simple
- **Ability to reuse product elements**
  - Very Low: None; Extra High: over 90%
- **Ability to defer low-impact aspects**
  - Very Low: None; Extra High: over 90%
- **System definition via models vs. documents**
  - Very low: None; Extra High: over 90%
- **Technology maturity of key capabilities**
  - Very Low: >0 Level 1-2 or >1 Level 3; Extra High: All >Level 7

# Process Factor Elements

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- **Concurrency of OpCon, Rqts., Architecture, V&V**
  - **Very Low: Highly sequential; Extra High: Fully concurrent**
- **Process streamlining**
  - **Very Low: Heavily Bureaucratic; Extra High: Fully streamlined**
- **General SE tool support (coverage, maturity, integration: CMI)**
  - **Very Low: Simple tools, weak CMI; Extra High: Very strong CMI**

# Project Factor Elements

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- **Collaboration support**
  - **Very Low: Globally distributed; weak communications, data sharing**
  - **Extra High: Largely collocated; very strong communications, data sharing**
- **Single-domain models, methods, processes, tools (MMPTs)**
  - **Very Low: Simple MMPTs, weak CMI; Extra High: Very strong CMI**
- **Multi-domain models, methods, processes, tools (MMPTs)**
  - **Very Low: Simple MMPTs, weak CMI; Extra High: Very strong CMI**

# People Factor Elements

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- **General-SE Knowledge, Skills, and Agility (KSA)**
  - **Very Low: Very weak KSA; Extra High: Extra strong KSA**
- **Single-domain Knowledge, Skills, and Agility (KSA)**
  - **Very Low: Very weak KSA; Extra High: Extra strong KSA**
- **Multi-domain Knowledge, Skills, and Agility (KSA)**
  - **Very Low: Very weak KSA; Extra High: Extra strong KSA**
- **Team compatibility**
  - **Very Low: Continuous strong conflict**
  - **Extra High: Very strong leadership, commonality of interests**



# Risk Acceptance Factor

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- **Risk Acceptance**
  - **Very Low: Highly risk-averse; Extra High: Highly risk-accepting**

# Current Model Status

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- **Results similar to CORADMO for software-intensive systems**
  - **Considered useful for planning**
  - **Preparing Delphi exercise for relative parameter influence ranges for systems engineering**
  
- **Need further data for hardware-intensive systems**
  - **Good data and driver ratings hard to find**