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Boosting COSYSMO to derive a comprehensive Acquisition benchmarking tool

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Who am I?

Christer Fröling

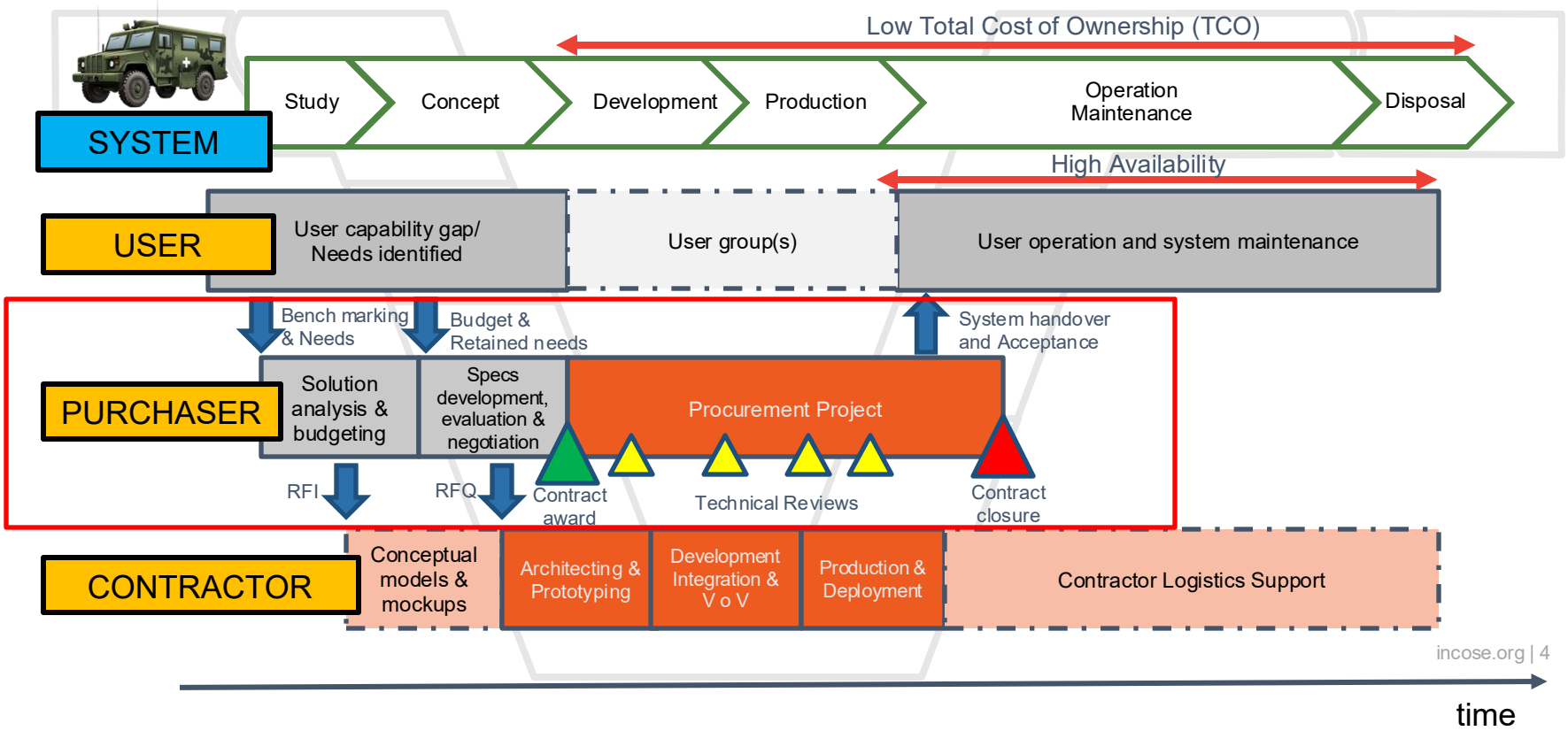
Christer Fröling is a Swedish citizen acting in the role of the **CEO for Reuse Company Scandinavia**. He has over **two decade of experience in** successful implementation of **Systems Engineering (SE)** and its sub-disciplines in a variety of roles and technical domains.

Christer specializes as a **principal consultant in applying SE and "design thinking"** into organizations willing to adopt change and implement a **knowledge driven** and **Lean SE approach** focusing on information quality, knowledge buildup with special focus on **Public Acquisition** within the defense, energy and transport sectors.

Today's Agenda

- Background & Purpose
- Public Acquisition Challenges
- COSYSMO model overview
- Enhancing COSYSMO for Public Acquisition
- Assessing Requirements & SE Effort
- Managing Risk: TRL & CMMI
- Estimating Cost: The TCO Approach
- Evaluation Example
- Key Takeaways & Recommendations

A “typical” system life cycle - From idea to scrapped system

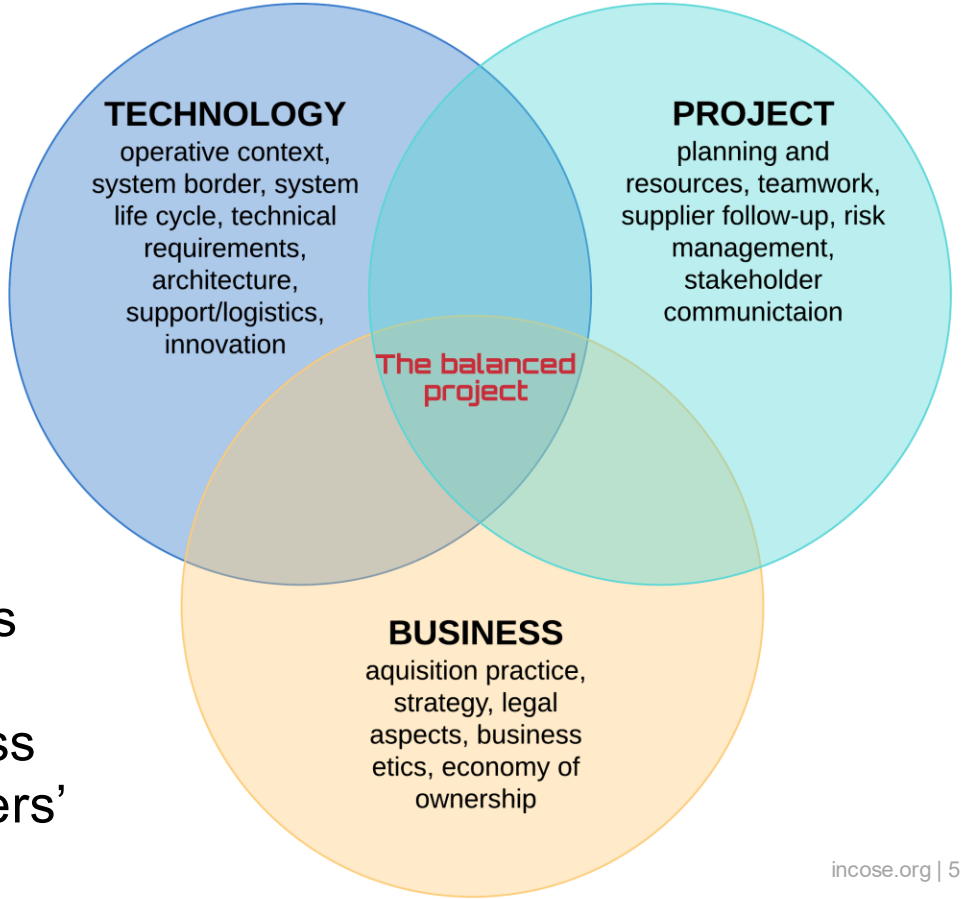


Background & Purpose

Acquisition goals: Select the best contractor based on;

- **Cost** (or price)
- **Technology** (quality), and
- **Risk**

…while fulfilling local regulations and national laws for a fair, transparent, and efficient process achieving best value for taxpayers' money



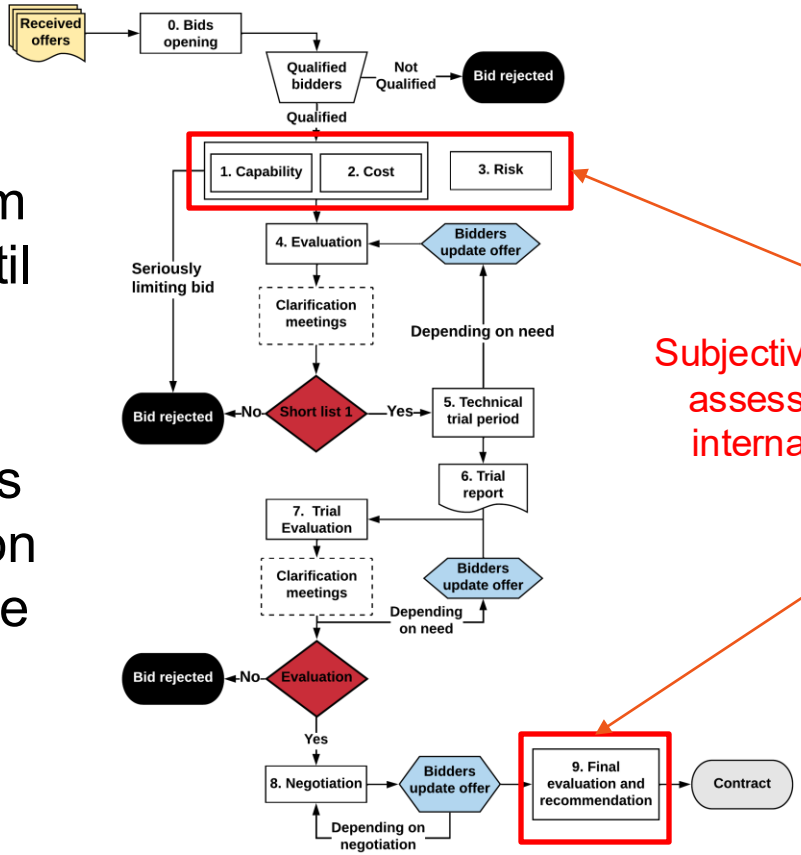
Background & Purpose

- Public acquisition requires structured, evidence-based evaluation methods
- Can the COSYSMO model enable SE-based **cost** and **risk estimations** which can be tailored to acquisition needs?
- Will combining this with TRL and CMMI methodologies add organizational and technical maturity insights?
- Can GtWR-based requirement quality analysis improve the COSYSMO assessment with a more efficient and repeatable method?

Example of an evaluation process

From bid(s) to contract

- Multiple steps to evaluate and perform a down selection until a final bid selection can be made
- Multiple stakeholders perform evaluation on the bidder's response and suggested solution



Subjective and sometimes biased assessment with often limited internal evaluation guidelines

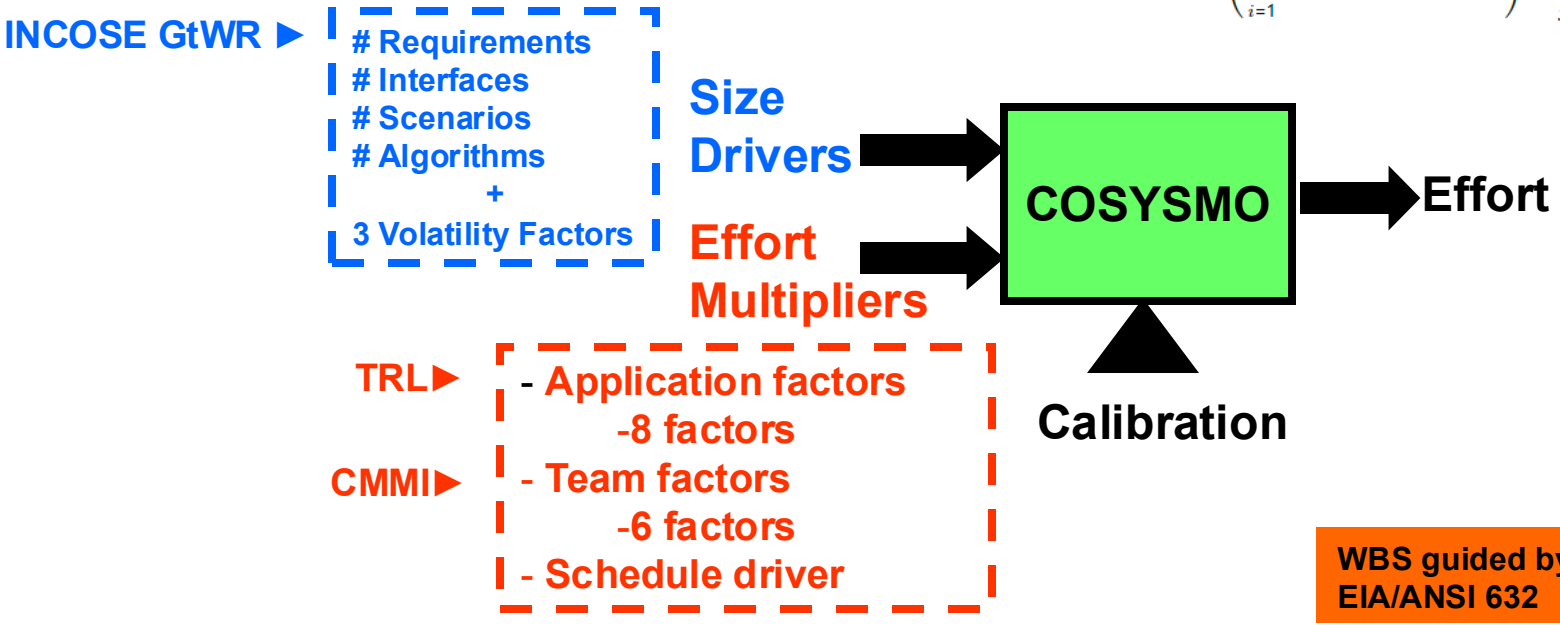
Public Acquisition Challenges

- **Tension** between cost focus and technical (quality) assurance
- **Subjective/not controlled** bid assessments hinder fair bid comparisons
- **Strict legal laws & regulations** limit evaluation flexibility
- **Hard to evaluate** bidders proposed project and delivery performance
- **SMEs often disadvantaged** despite offering quality at fair cost
- **Hard to foster innovation** since it stipulates few detailed requirements
- **Lack of skills** within the procurement organization

COSYSMO model overview

Dr. Ricardo Valerdi, University of Southern California (USC)

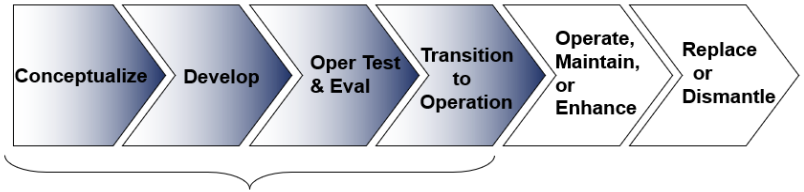
$$\text{SE Effort (Person-Months)} = A \cdot \left(\sum_{i=1}^{n} \text{SizeDriver}_i \cdot \text{Weight}_i \right)^{E} \cdot \prod_{j=1}^{m} \text{EffortMultiplier}_j$$



COSYSMO model overview

- Inputs include “size drivers” as well as “effort multipliers” that could be used to analyse the SE effort of a project
- Original focus on development type SE, **not public acquisition**

Could the model provide an evidence based and comparable outcome, even though not providing an exact prediction at this early stage?

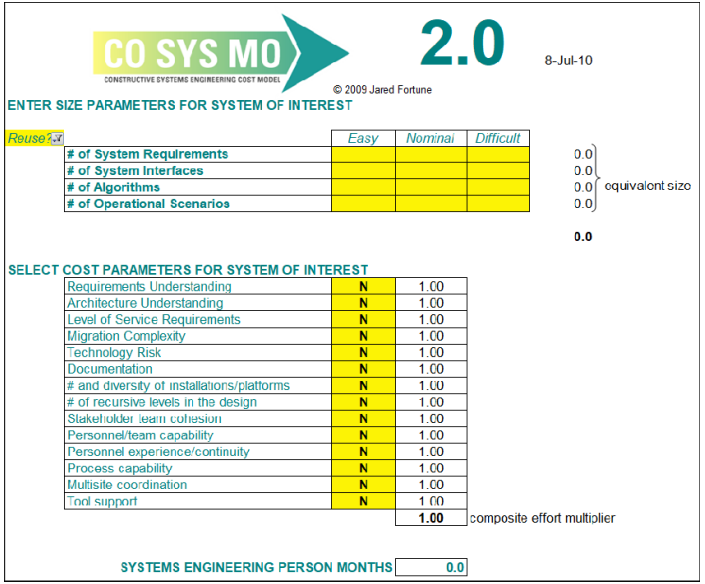


COSYSMO life cycle focus

Using COSYSMO for Public Acquisition

TASKS to adapt COSYSMO included:

- **Align the SE workshare** between the Contractor and Purchaser
- **Ensure data integrity** to secure the needs of public acquisition laws
- **Support calibration** using expert judgment and historical data (if any)
- **Enable comparable bid** scoring using standardized templates and input rules



Assessing the size drivers to ensure better SE Effort estimates

INPUT:

- Requirements categorized as **Easy**, **Nominal**, or **Difficult** by COSYSMO
  - INCOSE GtWR used to assess quality via 28 selected and aligned metrics
- Metrics analysed **correctness** and limited **completeness & consistency**

OUTPUT:

- Requirements quality analysis improves the standard COSYSMO size estimation with a nonbiased result using INCOSE GfWR
- Tool support (needed) enhances work efficiency and transparency

How to manage risk in the public acquisition bid phase?

Traditionally this is done as a separate risk analysis activity. Now we used:

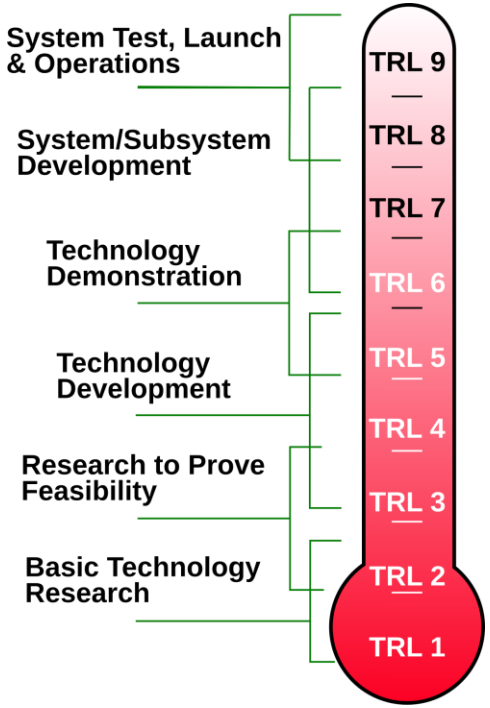
- **TRL** to identify maturity and technical debt in the proposed solution(s)
  - Bidders provided evidence-based TRL with growth roadmaps and cost estimates.
- **CMMI** to assess process maturity and project delivery capability
  - Bidders provided self-assessments and supporting documentation
- The data modified COSYSMO's effort multipliers accordingly
- The risk were addressed separately from cost and capability since it became an effort multiplier on the proposed project and solution

Managing Risk using best practice methods

TRL (technology readiness levels) measures technology maturity

- A low TRL (1–3) means the technology is still in research or proof-of-concept
- A high TRL (8–9) means the technology is fully validated and operational

Low TRL → more unknowns → higher effort multipliers in COSYSMO
High TRL → more predictable → lower SE cost



Managing Risk using best practice methods

CMMI (Capability Maturity Model Integration) is a process improvement framework for organizations

- **CMMI** defines maturity levels (1–5) describing how well an organization's processes are defined, managed, measured, and optimized (in this case the contractor)
- In COSYSMO, one of the effort multipliers is **Process Maturity**, which directly relates to an organization's CMMI Level.
- **Low CMMI Level (1–2)** means that the processes are weak → More potential rework, higher requirements volatility, more integration problems → Higher SE effort multiplier in COSYSMO
- **High CMMI Level (3–5)** means stable, repeatable processes → Less potential rework, better requirements management, smoother integration → Lower SE effort multiplier in COSYSMO

Estimating Cost: The Total Cost of Ownership approach

TCO captures acquisition, operation, maintenance, and disposal costs

- Bidders submited **cost breakdowns** in the bid phase
  - System, support and project WBS based templates
- COSYSMO model “verified” supplier cost estimates for consistency
  - Identified gaps and/or hidden risks in the bid proposal
  - Improved visibility of the long-term financial impact

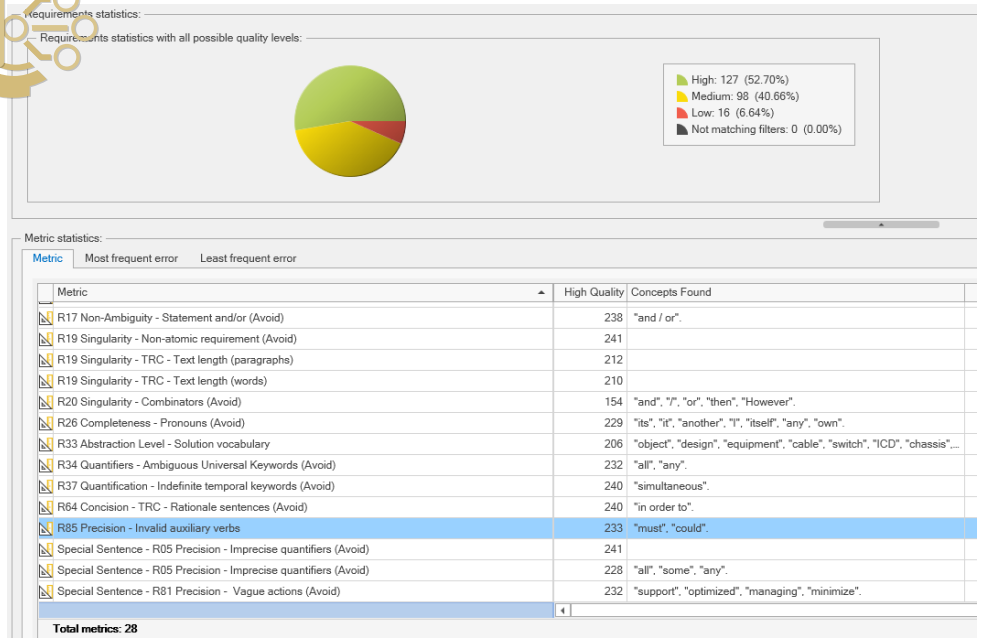
Evaluation Example

- Bidders' response were compared using a matrix with weighted criteria linked to selected requirements
- Included TRL, CMMI, requirement quality analysis, and cost estimates
- Standardized Excel templates ensure comparable input, easy access and efficient process, exported/imported in a Db for CM control
- Supports objective supplier selection through controlled comparation
- Tree model visualization improves decision-making clarity
- Can be reused and enhanced to control the selected supplier TCO cost development after contract award

Evaluation Example

COSYSMO Size parameters

- NOTE: System requirements developed by the Purchaser
- A tailored set of INCOSE GfWR metrics were used to analyse and provide the **#System Requirements** COSYSMO size estimates
- Other estimated size parameters based on developed OpsCon; scenarios, interfaces, etc were provided by the Purchaser



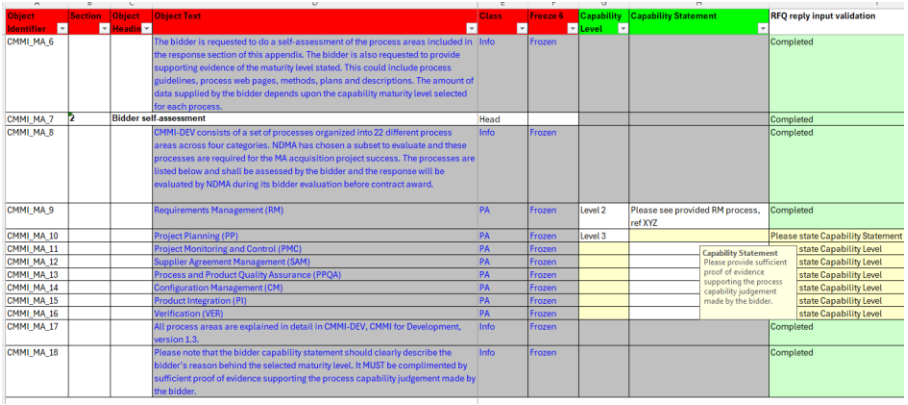
EASY	Nominal	Difficult
- Simple to implement	- Familiar	- Complex to implement or engineer
- Traceable to source	- Can be traced to source with some effort	- Hard to trace to source
- Little requirements overlap	- Some overlap	- High degree of requirements overlap
Quality score: HIGH	Quality score: MEDIUM	Quality score: LOW

Evaluation Example

Bidder response

- All bidders received tailored and structured response sheets (in Excel) to capture the data in a controlled and efficient way (kept in a Db based SE tool)

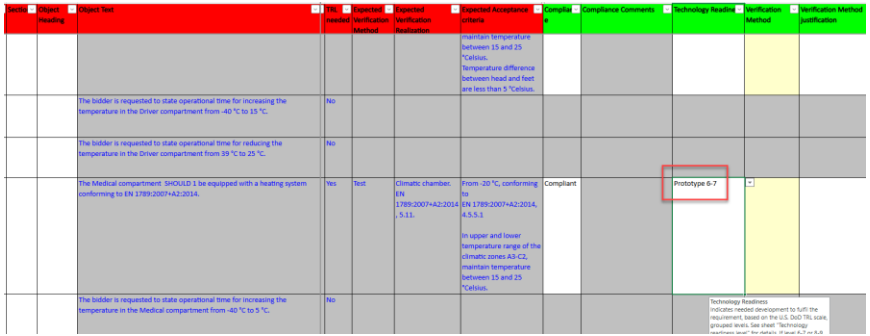
Bidder CMMI self assessment response sheet:



Object Identifier	Section	Object Heading	Object Text	Class	Freeze 6	Capability Level	Capability Statement	RFQ reply input validation
CMMI_MA_6			The bidder is requested to do a self-assessment of the process areas included in the response section of this appendix. The bidder is also requested to provide supporting evidence of the maturity level stated. This could include process guidelines, process web pages, methods, plans and descriptions. The amount of data supplied by the bidder depends upon the capability maturity level selected for each process.	Info	Frozen			Completed
CMMI_MA_7	2	Bidder self assessment		Head				Completed
CMMI_MA_8			CMMI-DEV consists of a set of processes organized into 22 different process areas across four categories. NDMA has chosen a subset to evaluate and these processes are required for the MA acquisition project success. The processes are listed below and shall be assessed by the bidder and the response will be evaluated by NDMA during its bidder evaluation before contract award.	Info	Frozen			Completed
CMMI_MA_9			Requirements Management (RM)	PA	Frozen	Level 2	Please see provided RM process, ref XYZ	Completed
CMMI_MA_10			Project Planning (PP)	PA	Frozen	Level 3		Please state Capability Statement
CMMI_MA_11			Project Monitoring and Control (PMC)	PA	Frozen			state Capability Level
CMMI_MA_12			Supplier Agreement Management (SAM)	PA	Frozen			state Capability Level
CMMI_MA_13			Process and Product Quality Assurance (PPQA)	PA	Frozen			state Capability Level
CMMI_MA_14			Configuration Management (CM)	PA	Frozen			state Capability Level
CMMI_MA_15			Product Integration (PI)	PA	Frozen			state Capability Level
CMMI_MA_16			Verification (VER)	PA	Frozen			state Capability Level
CMMI_MA_17			All process areas are explained in detail in CMMI-DEV, CMMI for Development, version 1.3.	Info	Frozen			Completed
CMMI_MA_18			Please note that the bidder capability statement should clearly describe the bidder's reason behind the selected maturity level. It MUST be complimented by sufficient proof of evidence supporting the process capability judgement made by the bidder.	Info	Frozen			Completed

Capability Statement
Please provide sufficient proof of evidence supporting the process capability judgement made by the bidder.

Technical requirements with bidder TRL statement:



Sectio	Object Heading	Object Text	TRL reached	Expected Verification Method	Expected Verification Realization	Expected Acceptance criteria	Compliar e	Compliance Comments	Technology Readine	Verification Method	Verification Method Justification
						maintain temperature between 15 and 25 °Celsius. Temperature difference between head and feet are less than 5 °Celsius.					
		The bidder is requested to state operational time for increasing the temperature in the Driver compartment from -40 °C to 15 °C.	No								
		The bidder is requested to state operational time for reducing the temperature in the Driver compartment from 39 °C to 25 °C.	No								
		The Medical compartment SHOULD 1 be equipped with a heating system conforming to EN 1789:2007+A2:2014.	Yes	Test	Climatic chamber. EN 1789:2007+A2:2014 , 5.11.	From -20 °C, conforming to EN 1789:2007+A2:2014, 4.5.5.1 In upper and lower temperature range of the climatic zones A3-C2, maintain temperature between 15 and 25 °Celsius.	Compliant		Prototype 6-7		
		The bidder is requested to state operational time for increasing the temperature in the Medical compartment from -40 °C to 5 °C.	No								

+ System (unit) price, project WBS and support cost response sheets

Evaluation Example

The evaluation matrix

- The Purchaser developed an evaluation matrix based on the procurement needs and selected strategy
- Quality sub-criteria were scored (e.g., 1–10 scale) by selected evaluators
- Then normalized to the max quality/price points.
- Different bids were then compared to find the best bid

Object Identifier	Section	Object Heading	Object Text	Normed Weight	B03_Grade step 1	*B03_Grade step 1 Adjusted*	B13_Grade step 1	*B13_Grade step 1 Adjusted*
Eval_1	1	System Evaluation			6,435	*8,964*	6,480	*9,399*
Eval_2	1.1	Capability		0,500	4,949	*8,473*	5,841	*10,000*
Eval_6	1.2	Cost		0,300	9,555	*10,000*	7,641	*7,997*
Eval_9	1.3	Risk		0,200	5,470	*8,636*	6,334	*10,000*
Eval_63	1.3.1	Capability Maturity Model Integration (CMMI)		0,200	5,200		5,900	
Eval_64	1.3.2	Technical Readiness Level (TRL)		0,600	4,702		6,566	
Eval_202	1.3.2.1	Should		0,500	5,016		6,389	
Eval_203	1.3.2.2	Shall		0,500	4,387		6,742	
Eval_78	1.3.3	CLS Service Network		0,200	8		6	

Example of a bidder evaluation tree model with weighed score

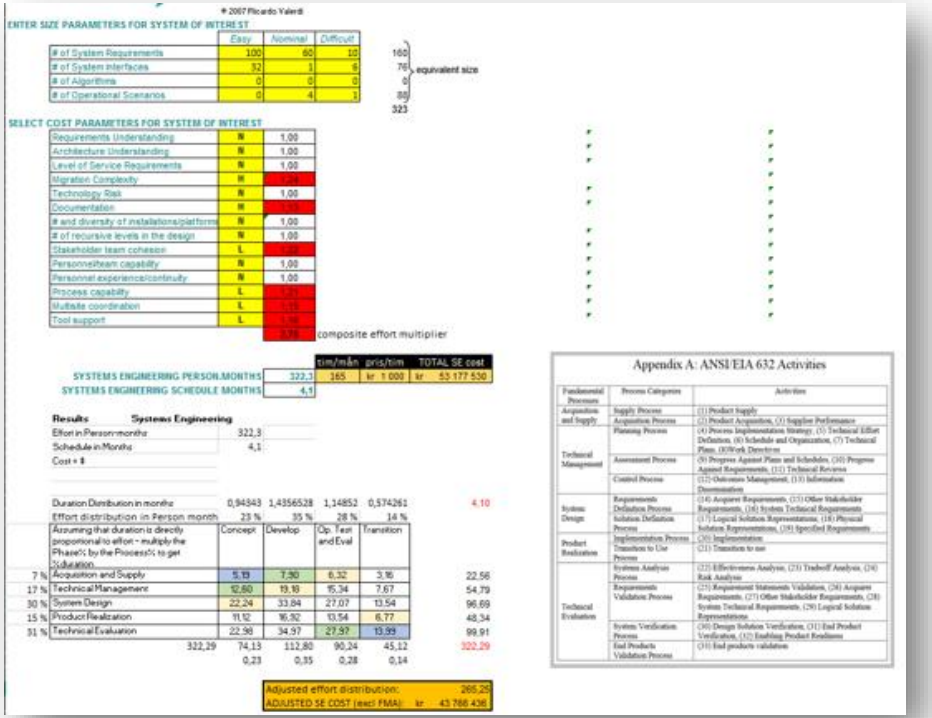
$$\text{Price Score} = \text{Max Price Points} \times \left(\frac{\text{Lowest Bid}}{\text{Bidder's Price}} \right)$$

Evaluation Example (summary)

One sheet per bidder!

COSYSMO model tailored for public acquisition

- System requirements and basic architecture developed by the Purchaser
- The size parameters where adjusted based on requirements quality analysis and bidders' proposal & response;
  - **Compliance** and **TRL statements**
- The effort were adjusted based on bidder **CMMI validated self assessment** (and possible quality audit on site)
- The total effort model were split based on workshare estimate: Contractor vs. Purchaser to get the “true” SE effort/cost



Key takeaways

- COSYSMO can become a structured, transparent acquisition benchmarking tool during bid evaluation and negotiations
- Combining TRL, CMMI, and GtWR improved and enhanced risk, system and bid evaluation
- Model calibration and evidence-based inputs are essential
- TCO (not price) focus supports sustainable acquisition
- This method can be further enhanced with modern AI based techniques, model tailorization and calibration

Let's connect

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Abstract. The combination of the Constructive Systems Engineering Cost Model (COSYSMO) version 2.0 with the Capability Maturity Model Integration (CMMI) creates a groundbreaking approach to optimizing public sector acquisition. This methodology enhances cost estimation accuracy, supplier evaluation, and risk management by also incorporating the comprehensive SE frameworks from ANSI/EIA 632, Total Cost of Ownership (TCO), and Technology Readiness Levels (TRL). The proposed model addresses the complexities inherent in public acquisition by aligning technical and organizational assessments with evidence-based metrics.

To adapt COSYSMO 2.0 for public sector use, the model uses metrics derived from INCOSE's Guide to Writing Requirements (GtWR), enabling the segmentation of requirements into 'easy,' 'nominal,' and 'hard' categories. The classification, based on an analysis of bidder submitted Request for Information (RFI) and Request for Quote (RFQ) documentation, creates a comparable and baselined Total Cost of Ownership (TCO) cost estimations. The inclusion of requirement quality analysis using the correctness, completeness, and consistency metrics per INCOSE's standards supports a robust quality assessment of requirements early in the process, helping the contracting agencies to make a robust and fair decision answering:

Who is the best supplier from a technical, economical and project perspective and what risks are associated with the different potential contractors?

Keywords: COSYSMO, GtWR, Public Acquisition, Risk, CMMI, TRL, LCC, TCO

Introduction

The COSYSMO 2.0 cost model calibration process is a cornerstone of this integration, ensuring the model reflects the unique context of public acquisitions (Valerdi, 2006). Calibration involves collecting historical project data from prior projects and aligning key cost drivers such as requirements complexity, team size, and schedule constraints from real-world scenarios. This iterative adjustment enhances the accuracy of cost predictions by tailoring COSYSMO's baseline parameters to the acquisition environment, particularly when estimating the costs associated with different technical maturity levels of the proposed solutions.

The challenge for organizations performing public acquisition is the lack of valid historical data for this calibration since; no acquisition is equal in size and complexity, the time elapsed and the arm's length distance between the acquirer and supplier makes the calibration a virtually impossible challenge. But measures and activities can be taken to use the model as a cornerstone and base for a comparable assessment of different bids from multiple possible suppliers before signing a contract. The actual data received is collected through a controlled and comparable process. A more correct TCO estimate can be obtained after the contract is signed. This based on the initial data and then eventually updated when the system design and contractual relationship has matured.

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