



Drivers & Rating Scales

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4 Size Drivers

- 1. Number of System Requirements***
- 2. Number of Major Interfaces**
- 3. Number of Operational Scenarios**
- 4. Number of Critical Algorithms**

***Weighted by complexity, volatility, and degree of reuse**

Number of System Requirements

This driver represents the number of requirements for the system-of-interest at a specific level of design. Requirements may be functional, performance, feature, or service-oriented in nature depending on the methodology used for specification. They may also be defined by the customer or contractor. System requirements can typically be quantified by counting the number of applicable “shall’s” or “will’s” in the system or marketing specification. Do not include a requirements expansion ratio – only provide a count for the requirements of the system-of-interest as defined by the system or marketing specification.

Easy	Nominal	Difficult
- Well specified	- Loosely specified	- Poorly specified
- 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

Number of Major Interfaces

This driver represents the number of shared major physical and logical boundaries between system components or functions (internal interfaces) and those external to the system (external interfaces). These interfaces typically can be quantified by counting the number of external and internal system interfaces among ISO/IEC 15288-defined system elements.

Easy	Nominal	Difficult
- Well defined	- Loosely defined	- Ill defined
- Uncoupled	- Loosely coupled	- Highly coupled
- Strong consensus	- Moderate consensus	- Low consensus
- Well behaved	- Predictable behavior	- Poorly behaved

Number of Critical Algorithms

This driver represents the number of newly defined or significantly altered functions that require unique mathematical algorithms to be derived in order to achieve the system performance requirements. As an example, this could include a complex aircraft tracking algorithm like a Kalman Filter being derived using existing experience as the basis for the all aspect search function. Another example could be a brand new discrimination algorithm being derived to identify friend or foe function in space-based applications. The number can be quantified by counting the number of unique algorithms needed to support each of the mathematical functions specified in the system specification or mode description document.

Easy	Nominal	Difficult
- Existing algorithms	- Some new algorithms	- Many new algorithms
- Basic math	- Algebraic by nature	- Difficult math (calculus)
- Straightforward structure	- Nested structure with decision logic	- Recursive in structure with distributed control
- Simple data	- Relational data	- Persistent data
- Timing not an issue	- Timing a constraint	- Dynamic, with timing issues
- Library-based solution	- Some modeling involved	- Simulation and modeling involved

Number of Operational Scenarios

This driver represents the number of operational scenarios that a system must satisfy. Such threads typically result in end-to-end test scenarios that are developed to validate the system and satisfy all of its requirements. The number of scenarios can typically be quantified by counting the number of unique end-to-end tests used to validate the system functionality and performance or by counting the number of use case sequence diagrams developed as part of the operational architecture.

Easy	Nominal	Difficult
- Well defined	- Loosely defined	- Ill defined
- Loosely coupled	- Moderately coupled	- Tightly coupled or many dependencies/conflicting requirements
- Timelines not an issue	- Timelines a constraint	- Tight timelines through scenario network

14 Cost Drivers

Application Factors (8)

- 1. Requirements understanding**
- 2. Architecture understanding**
- 3. Level of service requirements**
- 4. Migration complexity**
- 5. Technology Maturity**
- 6. Documentation Match to Life Cycle Needs**
- 7. # and Diversity of Installations/Platforms**
- 8. # of Recursive Levels in the Design**

Requirements understanding

This cost driver rates the level of understanding of the system requirements by all stakeholders including the systems, software, hardware, customers, team members, users, etc.

Very low	Low	Nominal	High	Very High
Poor, unprecedented system	Minimal, many undefined areas	Reasonable, some undefined areas	Strong, few undefined areas	Full understanding of requirements, familiar system

Architecture understanding

This cost driver rates the relative difficulty of determining and managing the system architecture in terms of platforms, standards, components (COTS/GOTS/NDI/new), connectors (protocols), and constraints. This includes tasks like systems analysis, tradeoff analysis, modeling, simulation, case studies, etc.

Very low	Low	Nominal	High	Very High
Poor understanding of architecture and COTS, unprecedented system	Minimal understanding of architecture and COTS, many undefined areas	Reasonable understanding of architecture and COTS, some weak areas	Strong understanding of architecture and COTS, few undefined areas	Full understanding of architecture, familiar system and COTS
>6 level WBS	5-6 level WBS	3-4 level WBS	2 level WBS	

Level of service requirements

This cost driver rates the difficulty and criticality of satisfying the ensemble of level of service requirements, such as security, safety, response time, interoperability, maintainability, the “ilities”, etc.

Viewpoint	Very low	Low	Nominal	High	Very High
<i>Difficulty</i>	Simple	Low difficulty, coupling	Moderately complex, coupled	Difficult, coupled KPPs	Very complex, tightly coupled
<i>Criticality</i>	Slight inconvenience	Easily recoverable losses	Some loss	High financial loss	Risk to human life

Migration complexity

This cost driver rates the complexity of migrating the system from previous system components, databases, workflows, environments, etc., due to new technology introductions, planned upgrades, increased performance, business process reengineering, etc.

Viewpoints	Nominal	High	Very High	Extra High
Legacy contractor	Self; legacy system is well documented	Self; original development team not available; most documentation available	Different contractor; limited documentation	Original contractor out of business; no documentation available
Sites/ Installations	Single site; new system; legacy system is completely replaced or non-existent	2-3 sites; parallel operation of new & legacy systems required	4-5 sites; current operational capabilities cannot be degraded	>6 sites; current operational capabilities cannot be degraded
Operating environment	Facility meets all environmental operating environments	Facility does not meet all operational environment requirements	Multiple agency coordination required	Multiple agency coordination required
Legacy components retained	0%	<25%	25% to 50%	>50%
Transition down time requirement	Not an issue	1 day or more	Between 1 day and 1 hour	1 second or less

Technology Risk

The maturity, readiness, and obsolescence of the technology being implemented. Immature or obsolescent technology will require more Systems Engineering effort.

Viewpoint	Very Low	Low	Nominal	High	Very High
<i>Lack of Maturity</i>	Technology proven and widely used throughout industry	Proven through actual use and ready for widespread adoption	Proven on pilot projects and ready to roll-out for production jobs	Ready for pilot use	Still in the laboratory
<i>Lack of Readiness</i>	Mission proven (TRL 9)	Concept qualified (TRL 8)	Concept has been demonstrated (TRL 7)	Proof of concept validated (TRL 5 & 6)	Concept defined (TRL 3 & 4)
<i>Obsolescence</i>			<ul style="list-style-type: none"> - Technology is the state-of-the-practice - Emerging technology could compete in future 	<ul style="list-style-type: none"> - Technology is stale - New and better technology is on the horizon in the near-term 	<ul style="list-style-type: none"> - Technology is outdated and use should be avoided in new systems - Spare parts supply is scarce

Documentation match to life cycle needs

The breadth and depth of documentation required to be formally delivered based on the life cycle needs of the system.

Viewpoint	Very low	Low	Nominal	High	Very High
<i>Breadth</i>	General goals	Broad guidance, flexibility is allowed	Streamlined processes, some relaxation	Partially streamlined process, some conformity with occasional relaxation	Rigorous, follows strict customer requirements
<i>Depth</i>	Minimal or no specified documentation and review requirements relative to life cycle needs	Relaxed documentation and review requirements relative to life cycle needs	Amount of documentation and reviews in sync and consistent with life cycle needs of the system	High amounts of documentation, more rigorous relative to life cycle needs, some revisions required	Extensive documentation and review requirements relative to life cycle needs, multiple revisions required

and diversity of installations/platforms

The number of different platforms that the system will be hosted and installed on. The complexity in the operating environment (space, sea, land, fixed, mobile, portable, information assurance/security). For example, in a wireless network it could be the number of unique installation sites and the number of and types of fixed clients, mobile clients, and servers. Number of platforms being implemented should be added to the number being phased out (dual count).

Viewpoints	Nominal	High	Very High	Extra High
Sites/ installations	Single installation site or configuration	2-3 sites or diverse installation configurations	4-5 sites or diverse installation configurations	>6 sites or diverse installation configurations
Operating environment	Not a driving factor; office environment	Moderate environmental constraints; controlled environment (i.e., air conditioning)	Ruggedized mobile land-based requirements; some information security requirements	Harsh environment (space, sea airborne) sensitive information security requirements
Platforms	<3 types of platforms being installed and/or being phased out/replaced	4-7 types of platforms being installed and/or being phased out/replaced	8-10 types of platforms being installed and/or being phased out/replaced	>10 types of platforms being installed and/or being phased out/replaced
	Homogeneous platforms	Compatible platforms	Heterogeneous, but compatible platforms	Heterogeneous, incompatible platforms
	Typically networked using a single industry standard protocol	Typically networked using a single industry standard protocol and multiple operating systems	Typically networked using a mix of industry standard protocols and proprietary protocols; single operating systems	Typically networked using a mix of industry standard protocols and proprietary protocols; multiple operating systems

of recursive levels in the design

The number of levels of design related to the system-of-interest (as defined by ISO/IEC 15288) and the amount of required SE effort for each level.

Viewpoint	Very Low	Low	Nominal	High	Very High
Number of levels	1	2	3-5	6-7	>7
Required SE effort	Ad-hoc effort	Maintaining system baseline with few planned upgrades	Sustaining SE for the product line, introducing some enhancements of product design features or optimizing performance and/or cost	Maintaining multiple configurations or enhancements with extensive pre-planned product improvements or new requirements, evolving	Maintaining many configurations or enhancements with extensive pre-planned product improvements, new requirements rapidly evolving

14 Cost Drivers (cont.)

Team Factors (6)

- 1. Stakeholder team cohesion**
- 2. Personnel/team capability**
- 3. Personnel experience/continuity**
- 4. Process capability**
- 5. Multisite coordination**
- 6. Tool support**

Stakeholder team cohesion

Represents a multi-attribute parameter which includes leadership, shared vision, diversity of stakeholders, approval cycles, group dynamics, IPT framework, team dynamics, trust, and amount of change in responsibilities. It further represents the heterogeneity in stakeholder community of the end users, customers, implementers, and development team.

Viewpoint	Very Low	Low	Nominal	High	Very High
Culture	<ul style="list-style-type: none">▪Stakeholders with diverse expertise, task nature, language, culture, infrastructure▪Highly heterogeneous stakeholder communities	<ul style="list-style-type: none">▪Heterogeneous stakeholder community▪Some similarities in language and culture	<ul style="list-style-type: none">▪Shared project culture	<ul style="list-style-type: none">▪Strong team cohesion and project culture▪Multiple similarities in language and expertise	<ul style="list-style-type: none">▪Virtually homogeneous stakeholder communities▪<u>Institutionalized</u> project culture
Communication	<ul style="list-style-type: none">▪<u>Diverse</u> organizational objectives	<ul style="list-style-type: none">▪<u>Converging</u> organizational objectives	<ul style="list-style-type: none">▪<u>Common shared</u> organizational objectives	<ul style="list-style-type: none">▪Clear roles & responsibilities	<ul style="list-style-type: none">▪<u>High</u> stakeholder <u>trust</u> level

Personnel/team capability

Basic intellectual capability of a Systems Engineer to analyze complex problems and synthesize solutions.

Very Low	Low	Nominal	High	Very High
15 th percentile	35 th percentile	55 th percentile	75 th percentile	90 th percentile

Personnel experience/continuity

The applicability and consistency of the staff at the initial stage of the project with respect to the domain, customer, user, technology, tools, etc.

	Very low	Low	Nominal	High	Very High
Experience	Less than 2 months	1 year continuous experience, other technical experience in similar job	3 years of continuous experience	5 years of continuous experience	10 years of continuous experience
Annual Turnover	48%	24%	12%	6%	3%

Process capability

The consistency and effectiveness of the project team at performing SE processes. This may be based on assessment ratings from a published process model (e.g., CMMI, EIA-731, SE-CMM, ISO/IEC 15504). It can also be based on project team behavioral characteristics, if not assessment has been performed.

	Very low	Low	Nominal	High	Very High	Extra High
Assessment Rating (Capability or Maturity)	Level 0 (if continuous model)	Level 1	Level 2	Level 3	Level 4	Level 5
Project Team Behavioral Characteristics	Ad Hoc approach to process performance	Performed SE process, activities driven only by immediate contractual or customer requirements, SE focus limited	Managed SE process, activities driven by customer and stakeholder needs in a suitable manner, SE focus is requirements through design, project-centric approach – not driven by organizational processes	Defined SE process, activities driven by benefit to project, SE focus is through operation, process approach driven by organizational processes tailored for the project	Quantitatively Managed SE process, activities driven by SE benefit, SE focus on all phases of the life cycle	Optimizing SE process, continuous improvement, activities driven by system engineering and organizational benefit, SE focus is product life cycle & strategic applications

Multisite coordination

Location of stakeholders, team members, resources, corporate collaboration barriers.

Viewpoint	Very low	Low	Nominal	High	Very High	Extra High
Collocation	International , severe time zone impact	Multi-city and multi-national, considerable time zone impact	Multi-city or multi-company, some time zone effects	Same city or metro area	Same building or complex, some co-located stakeholders or onsite representation	Fully co-located stakeholders
Communications	Some phone, mail	Individual phone, FAX	Narrowband e-mail	Wideband electronic communication	Wideband electronic communication, occasional video conference	Interactive multimedia
Corporate collaboration barriers	Severe export and security restrictions	Mild export and security restrictions	Some contractual & Intellectual property constraints	Some collaborative tools & processes in place to facilitate or overcome, mitigate barriers	Widely used and accepted collaborative tools & processes in place to facilitate or overcome, mitigate barriers	Virtual team environment fully supported by interactive, collaborative tools environment

Tool support

Coverage, integration, and maturity of the tools in the Systems Engineering environment.

Very low	Low	Nominal	High	Very High
No SE tools	Simple SE tools, little integration	Basic SE tools moderately integrated throughout the systems engineering process	Strong, mature SE tools, moderately integrated with other disciplines	Strong, mature proactive use of SE tools integrated with process, model-based SE and management systems

Questions or Comments?

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