THE UNIVERSITY OF
ALABAMA IN HUNTSVILLE

Analyzing Technical Measurement Guidance in Literature

RAM XIV Training Summit

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Presentation Overview

Introduction	Methodology	Results	Discussion	Conclusions
Defining Technical Measures	Systematic review and content analysis	Genesis, Timing, Quantity, Qualities, Examples	Tech Measure Guidance from Literature	Conclusions and Future Work

Technical Measures

Set of measurement activities used to provide insight into progress in the definition and development of the technical solution, ongoing assessment of the associated risks and issues, and the likelihood of meeting the critical objectives of the project.

Ex: Reliability, power required, response time

Technical Measures

Measure of Effectiveness (MOE)

- The “operational” measures of success that are closely related to the achievement of the mission or operational objective being evaluated, in the intended operational environment under a specified set of conditions; i.e., how well the solution achieves the intended purpose.

Measure of Performance (MOP)

- The measures that characterize physical or functional attributes relating to the system operation, measured or estimated under specified testing and/or operational environment conditions.

Technical Performance Measure (TPM)

- TPMs measure attributes of a system element within the system to determine how well the system or system element is satisfying specified requirements

Roedler, G. J., & Jones, C. (2005). Technical Measurement. A Collaborative Project of PSM, INCOSE, and Industry.

Technical Measures

Leading Indicators

- A measure for evaluating the effectiveness of how a specific activity is applied on a program in a manner that provides information about impacts that are likely to affect the system performance or SE effectiveness objectives.

Key Performance Parameters

- A critical subset of the performance parameters representing those capabilities and characteristics so significant that failure to meet the threshold value of performance can be cause for the concept or system selected to be reevaluated or the project to be reassessed or terminated.

Roedler, G. J., & Jones, C. (2005). Technical Measurement. A Collaborative Project of PSM, INCOSE, and Industry.

Methodology

Step 1 Identify Research Question

Step 2 Google Scholar search

Step 3 Inclusion/Exclusion Criteria

Step 4 Data Extraction

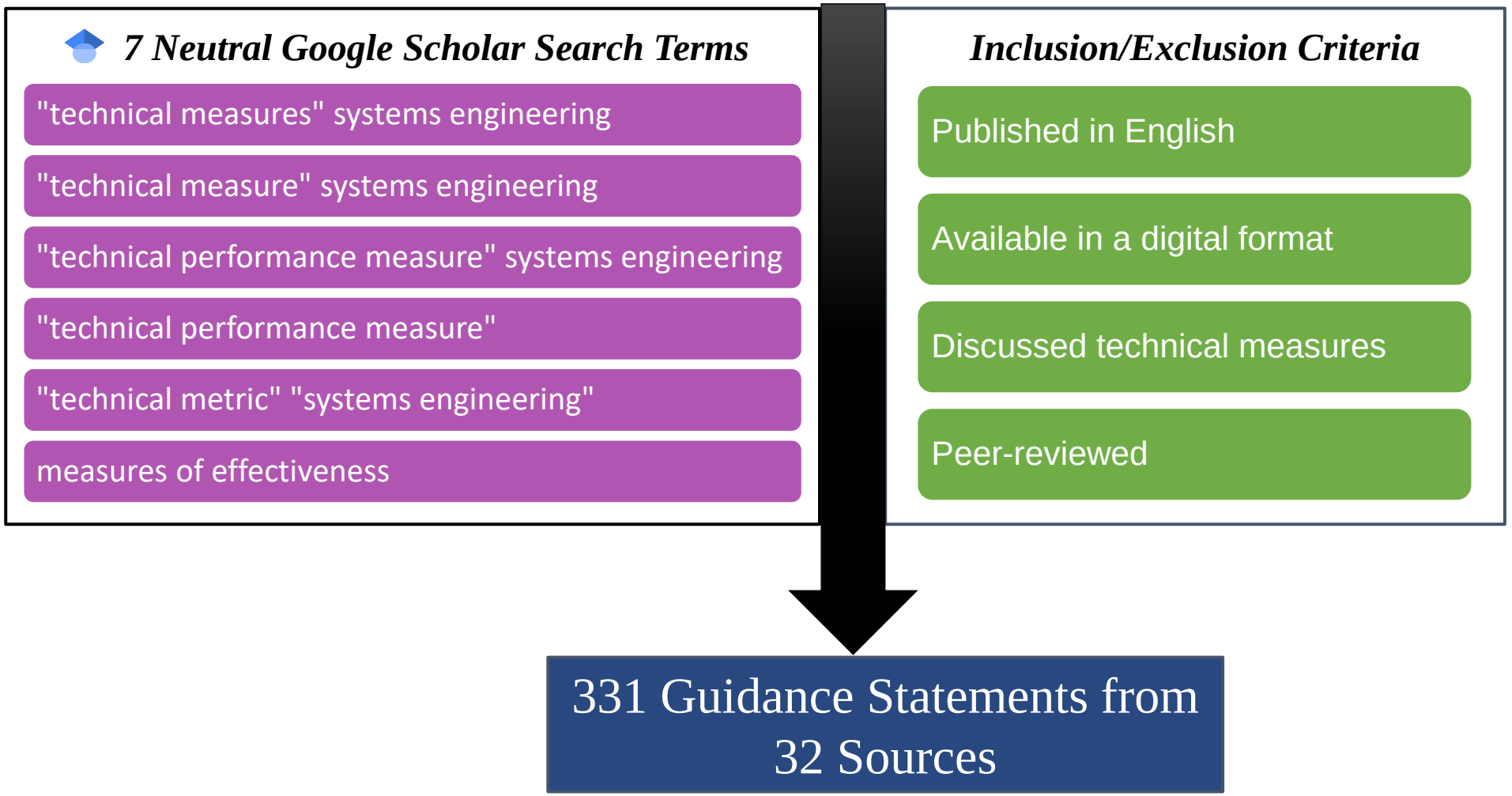
Step 5 Data Coding and Analysis

Step 6 Data Verification

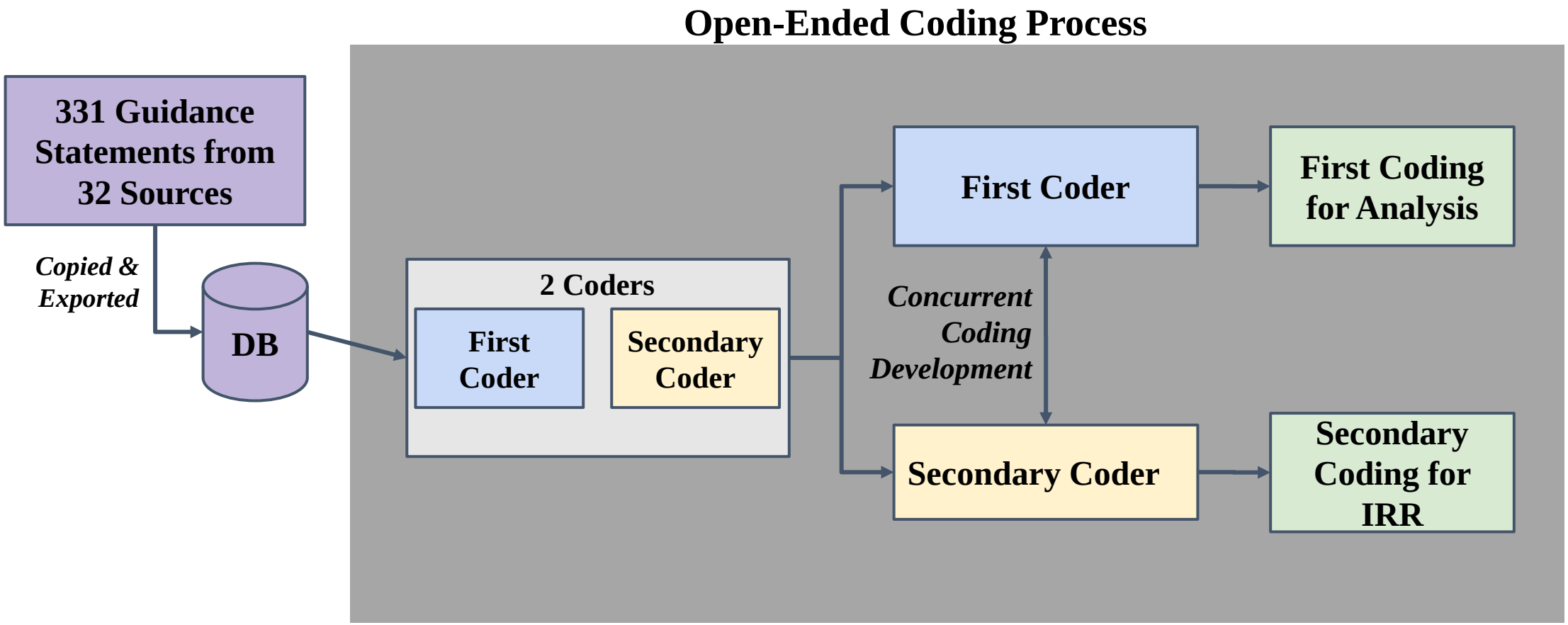
Step 1: Identify Research Question

What guidance is published on how to select technical measures for the design of large-scale complex engineered systems in academic literature?

Steps 2-3: Identify Research Question



Steps 4-5: Coding and Analysis

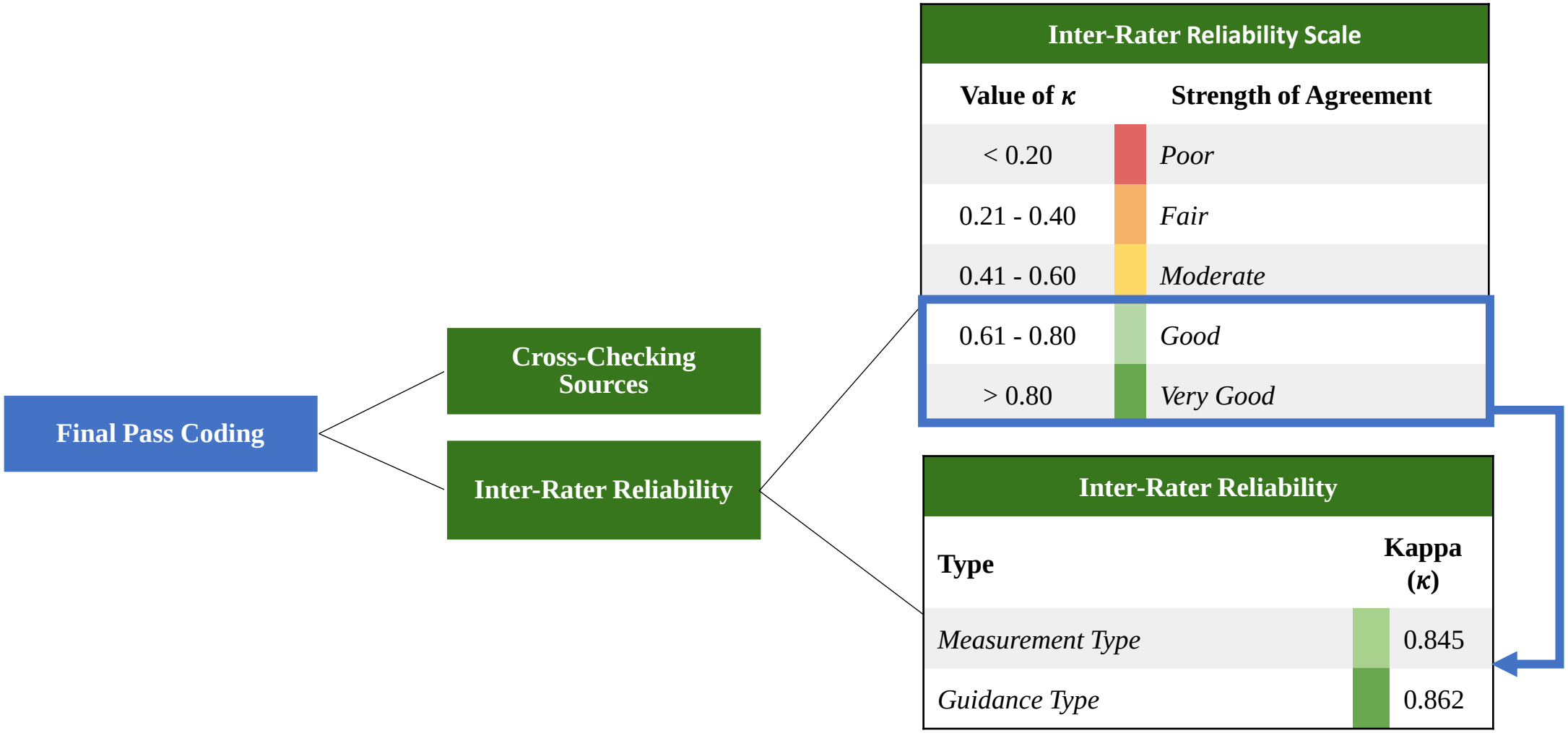


Steps 4-5: Coding and Analysis

Code Type	Codes		Example Quote	Example Code
Measurement Type	General, MOE, MOP, KPP, TPM, DPP, LI, TPP		"KPPs are used by the developer to establish the key requirements necessary to achieve the MOEs." *(Roedler and Jones, 2005)*	Genesis
Guidance Type	Genesis	Discusses where technical measures were (or were supposed to be) derived from.		
	Timing	Identifies when technical measures should be selected.		
	Qualities	Identifies attributes that technical measures should or must exhibit.		
	Quantity	Identifies how many technical measures should be selected.		
	Example	Provides sample or historical technical measures or sets of technical measures.		

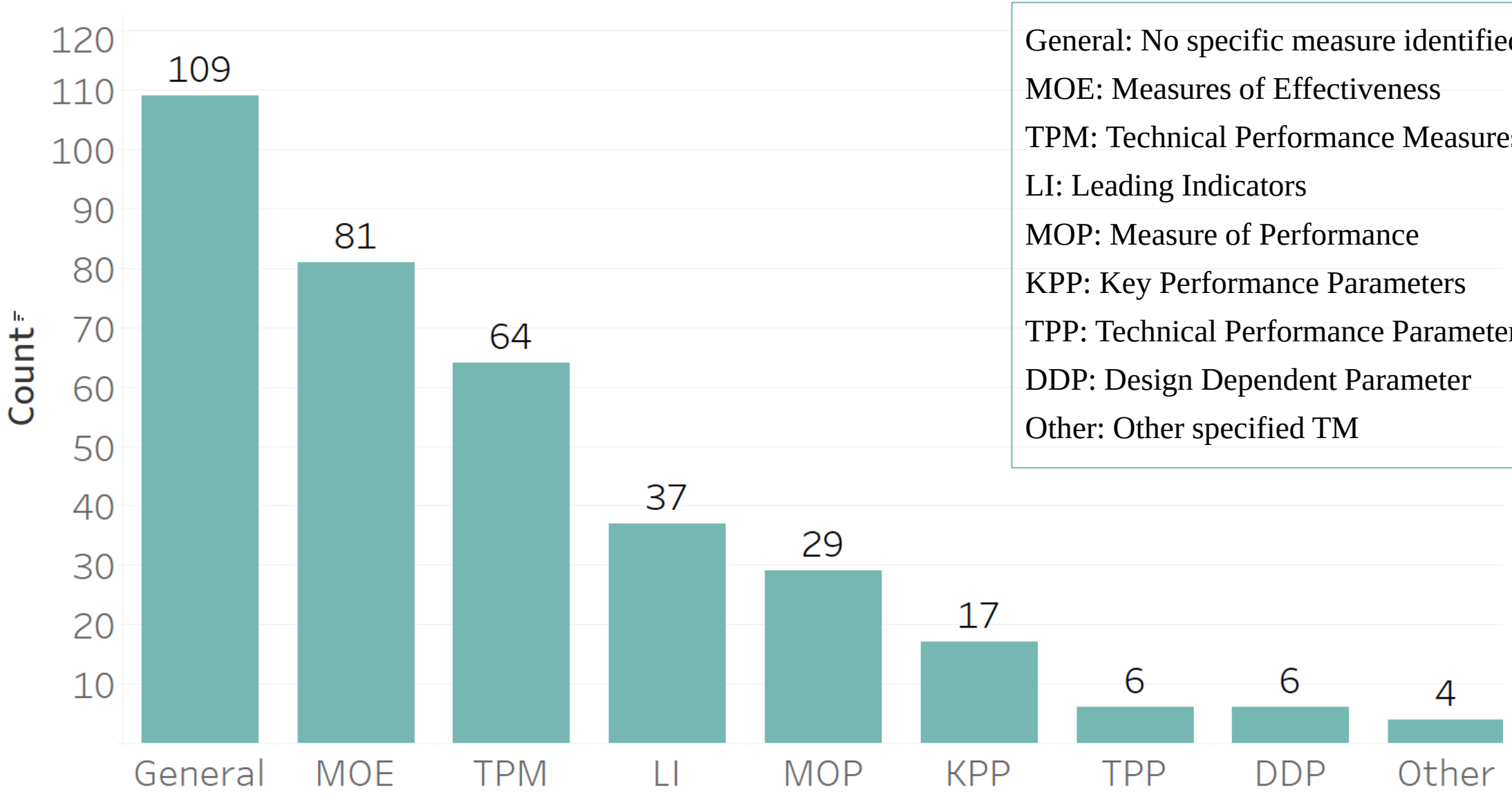
Roedler, G. J., & Jones, C. (2005). Technical Measurement. A Collaborative Project of PSM, INCOSE, and Industry.

Steps 6: Data Verification



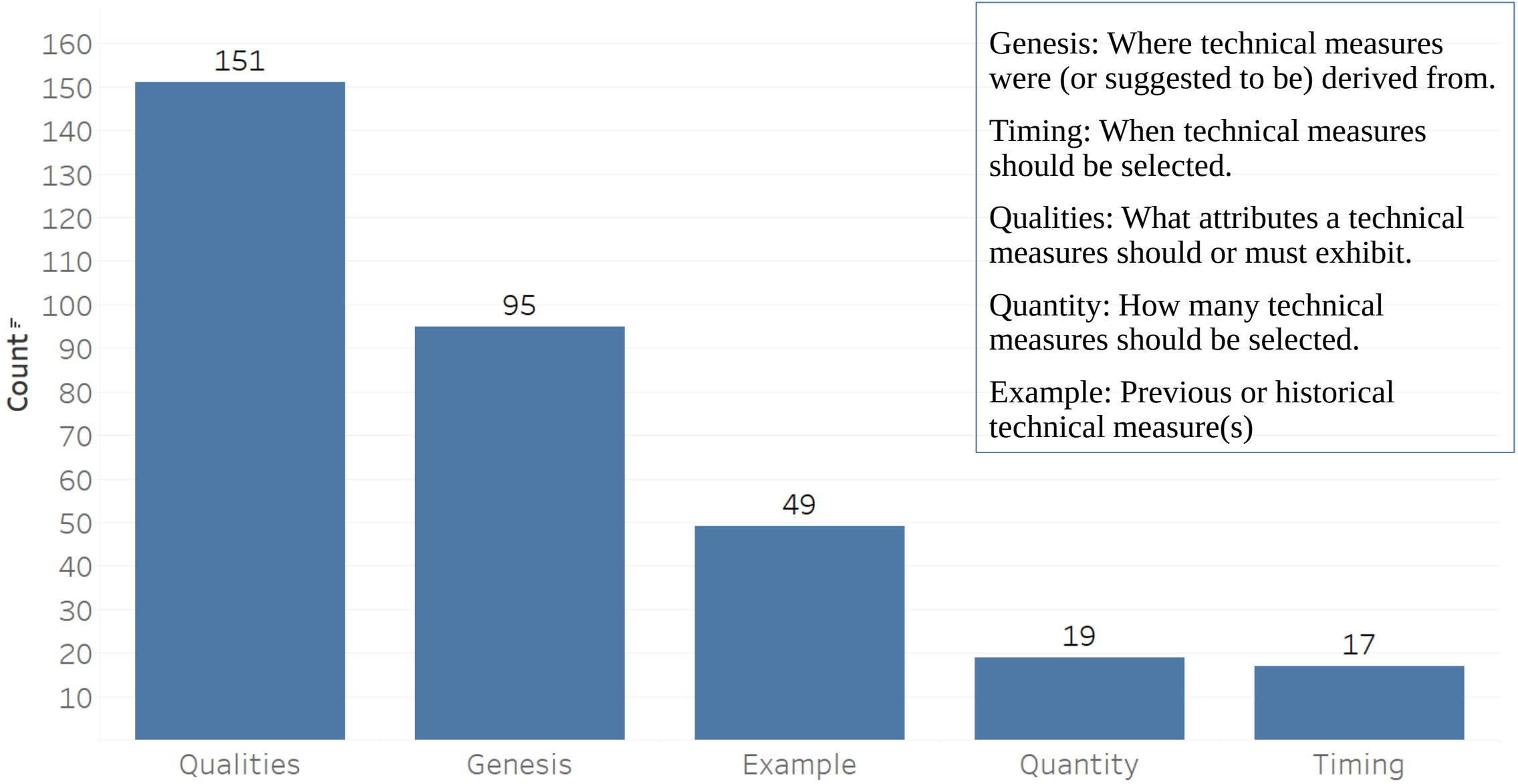
Results & Discussion

Technical Measures



General: No specific measure identified
MOE: Measures of Effectiveness
TPM: Technical Performance Measures
LI: Leading Indicators
MOP: Measure of Performance
KPP: Key Performance Parameters
TPP: Technical Performance Parameter
DDP: Design Dependent Parameter
Other: Other specified TM

Guidance Statements



Genesis: Where technical measures were (or suggested to be) derived from.

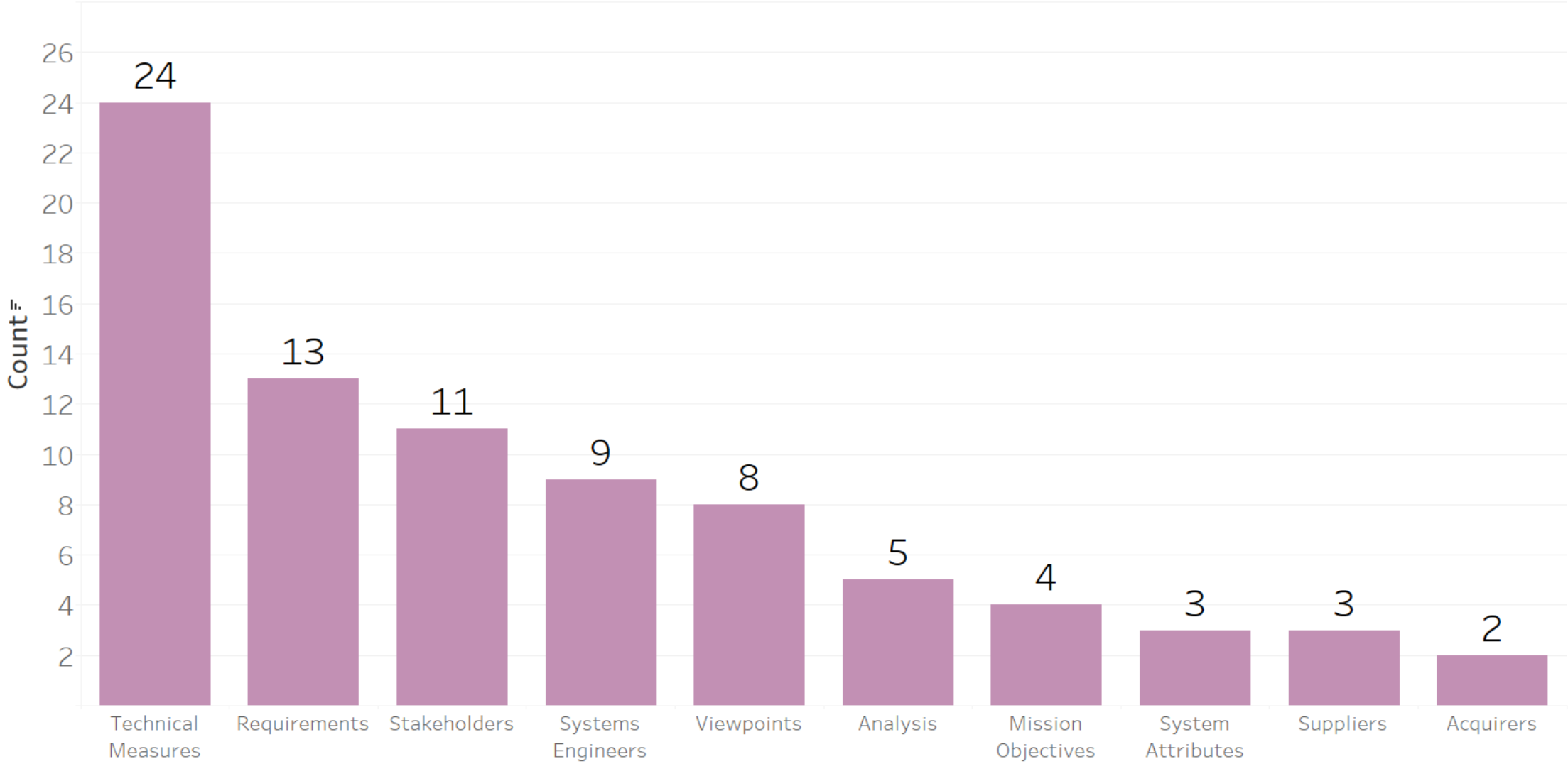
Timing: When technical measures should be selected.

Qualities: What attributes a technical measures should or must exhibit.

Quantity: How many technical measures should be selected.

Example: Previous or historical technical measure(s)

Genesis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Technical Measures
Requirements
Stakeholders
Systems Engineers
Viewpoints
Analysis
Mission Objectives
System Attributes
Suppliers
Acquirers

Genesis Guidance

	Technical Measure						Other				Person					
"are derived from"	KPP	LI	MOE	MOP	MOS	TPM	a viewpoint	mission objectives	requirements	analysis	stakeholder	supplier	acquirer	systems engineers	parameters	total
KPP								1					1			2
LI						1								3		4
MOE	1			2		1	5	2	1	1	9		1			23
MOP			7			1			1			1			2	12
MOS																0
TPM	1		3	2	1		2		5	1		2		3		20
…																
total	2		10	4	1	3	7	3	7	2	9	3	2	6	2	

Genesis Guidance

Technical Measure

Person

Other

"are derived from"	KPP	LI	MOE	MOP	MOS	TPM	a viewpoint	mission objectives	requirements	analysis	stakeholder	supplier	acquirer	systems engineers	parameters	total
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LI						1								3		4
MOE	1			2		1	5	2	1	1	9		1			23
MOP			7			1			1			1			2	12
MOS																0
TPM	1		3	2	1		2		5	1		2		3		20
…																
total	2		10	4	1	3	7	3	7	2	9	3	2	6	2	

Genesis Guidance

Technical Measure

Person

Other

"are derived from"	KPP	LI	MOE	MOP	MOS	TPM	a viewpoint	mission objectives	requirements	analysis	stakeholder	supplier	acquirer	systems engineers	parameters	total
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LI						1								3		4
MOE	1			2		1	5	2	1	1	9		1			23
MOP			7			1			1			1			2	12
MOS																0
TPM	1		3	2	1		2		5	1		2		3		20
…																
total	2		10	4	1	3	7	3	7	2	9	3	2	6	2	

Genesis Guidance

Technical Measure

Person

Other

"are derived from"	KPP	LI	MOE	MOP	MOS	TPM	a viewpoint	mission objectives	requirements	analysis	stakeholder	supplier	acquirer	systems engineers	parameters	total
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MOE	1			2		1	5	2	1	1	9		1			23
MOP			7			1			1			1			2	12
MOS																0
TPM	1		3	2	1		2		5	1		2		3		20
…																
total	2		10	4	1	3	7	3	7	2	9	3	2	6	2	

Genesis Guidance

Technical Measure

Person

Other

"are derived from"	KPP	LI	MOE	MOP	MOS	TPM	a viewpoint	mission objectives	requirements	analysis	stakeholder	supplier	acquirer	systems engineers	parameters	total
KPP								1					1			2
LI						1								3		4
MOE	1			2		1	5	2	1	1	9		1			23
MOP			7			1			1			1			2	12
MOS																0
TPM	1		3	2	1		2		5	1		2		3		20
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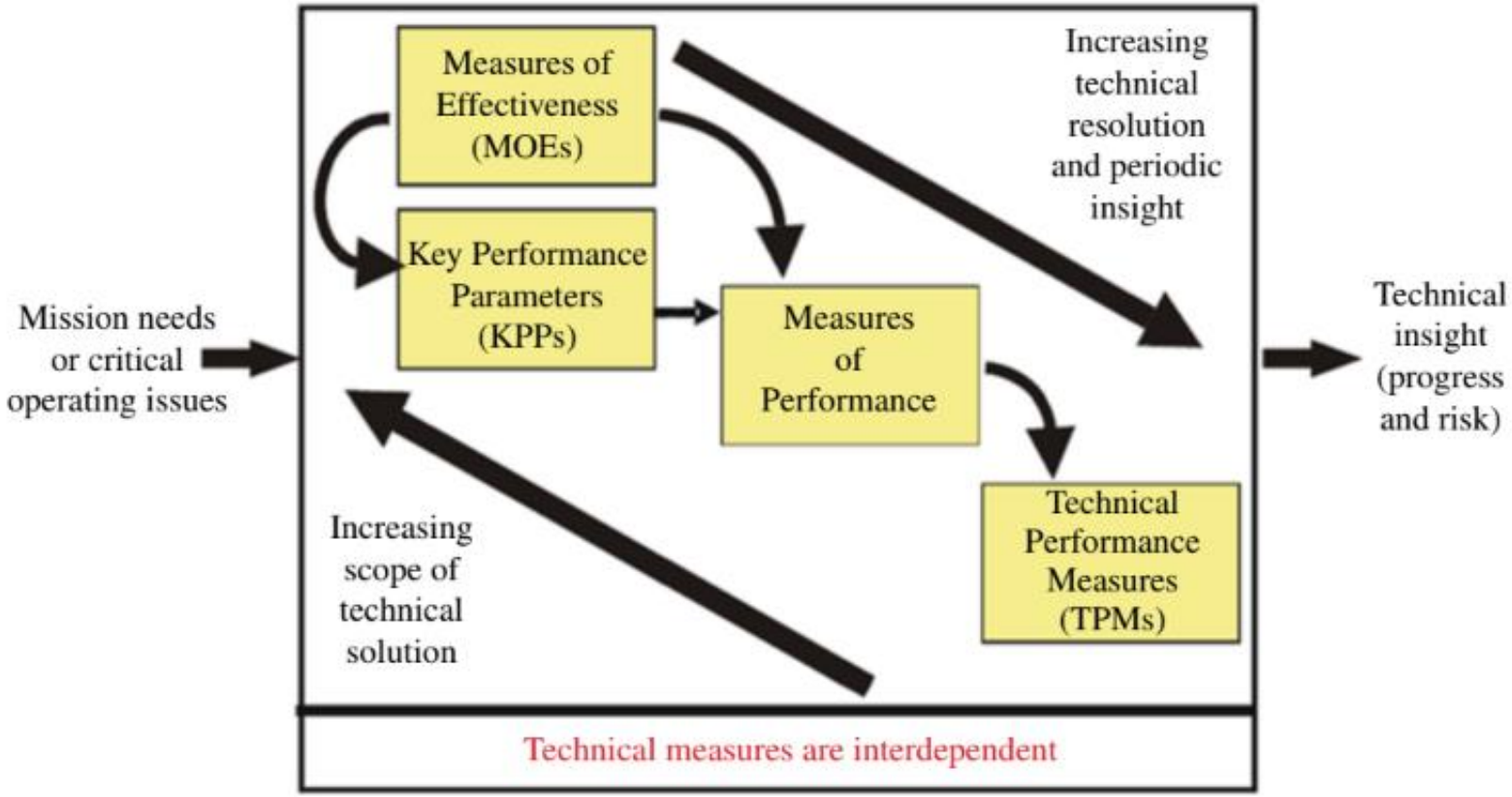
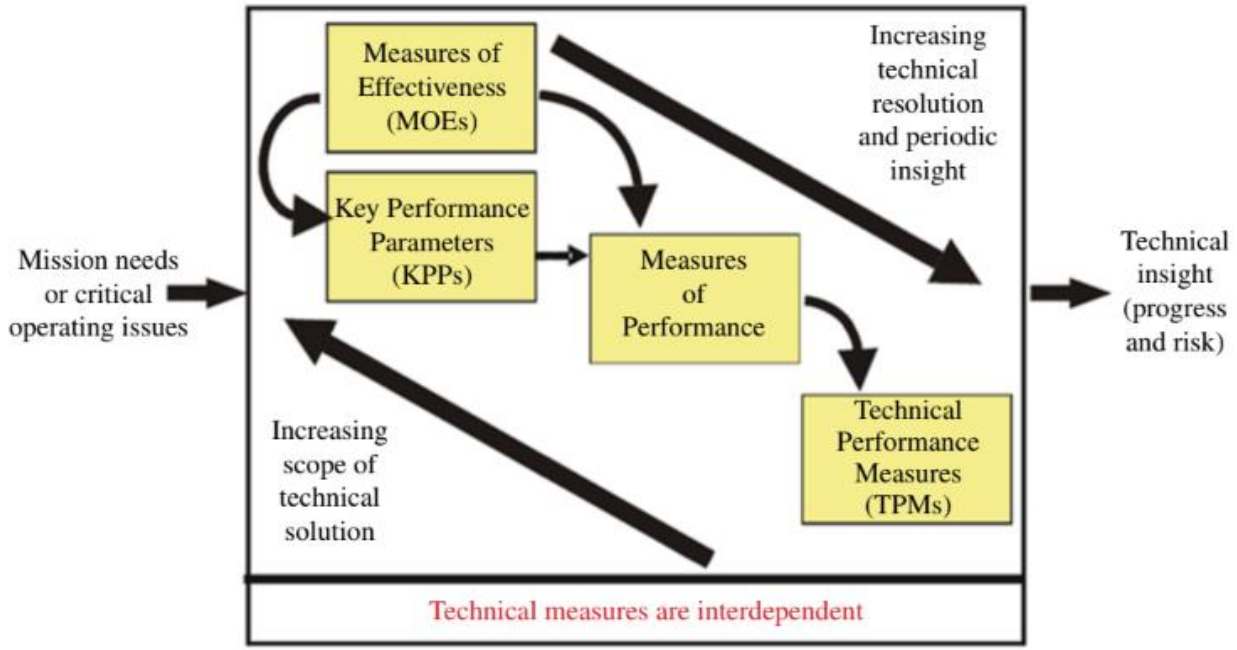
total	2		10	4	1	3	7	3	7	2	9	3	2	6	2	

INCOSE Handbook Guidance TM



[1] INCOSE Systems Engineering Handbook, 4th ed., INCOSE-TP-2003-002-04 2015.

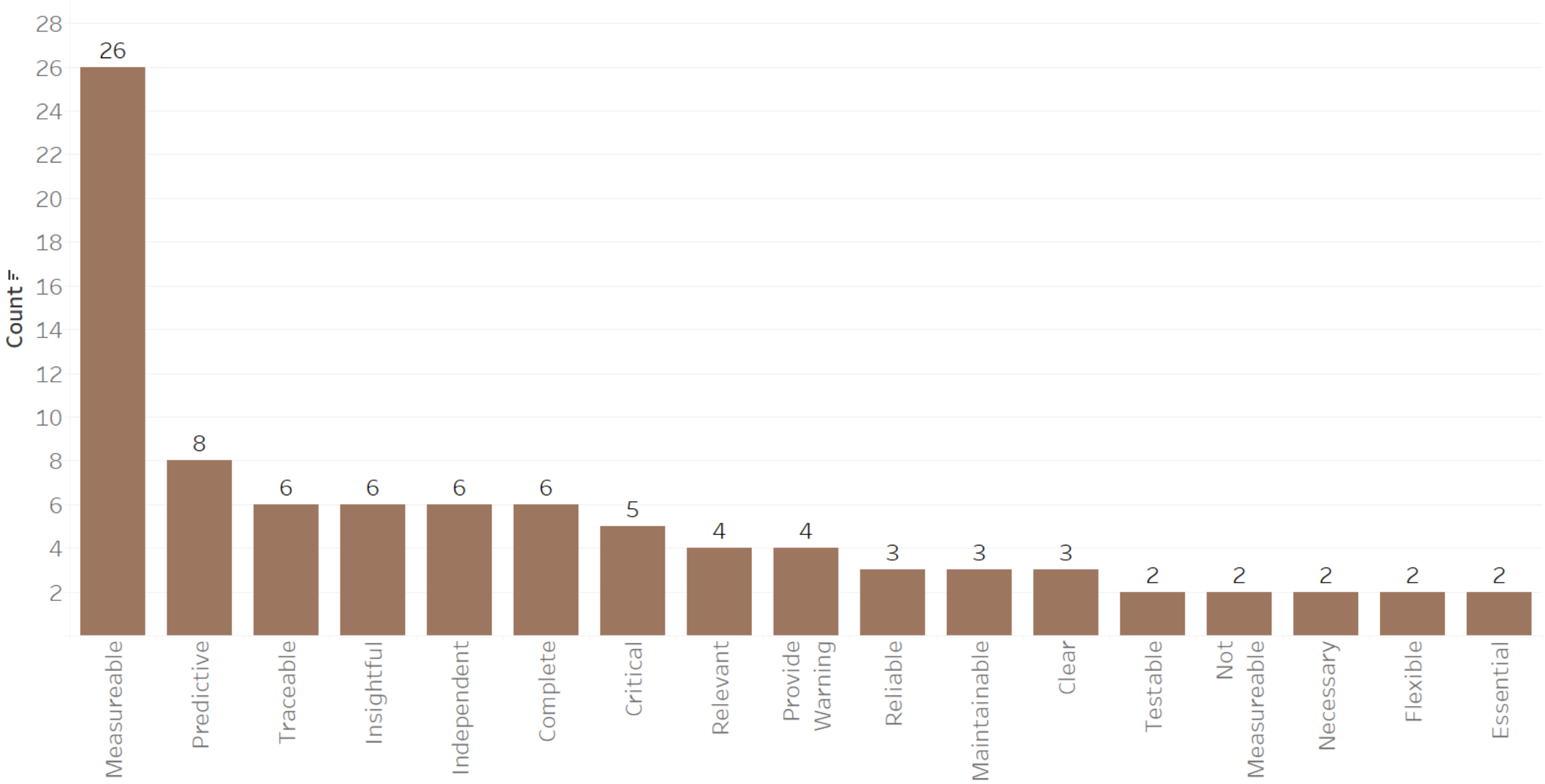
Genesis Guidance: Technical Measures



"are derived from"

	KPP	LI	MOE	MOP	MOS	TPM
KPP			0			
LI						
MOE						
MOP	0		7			
MOS						
TPM	1		3	2		
…						
total						

Qualities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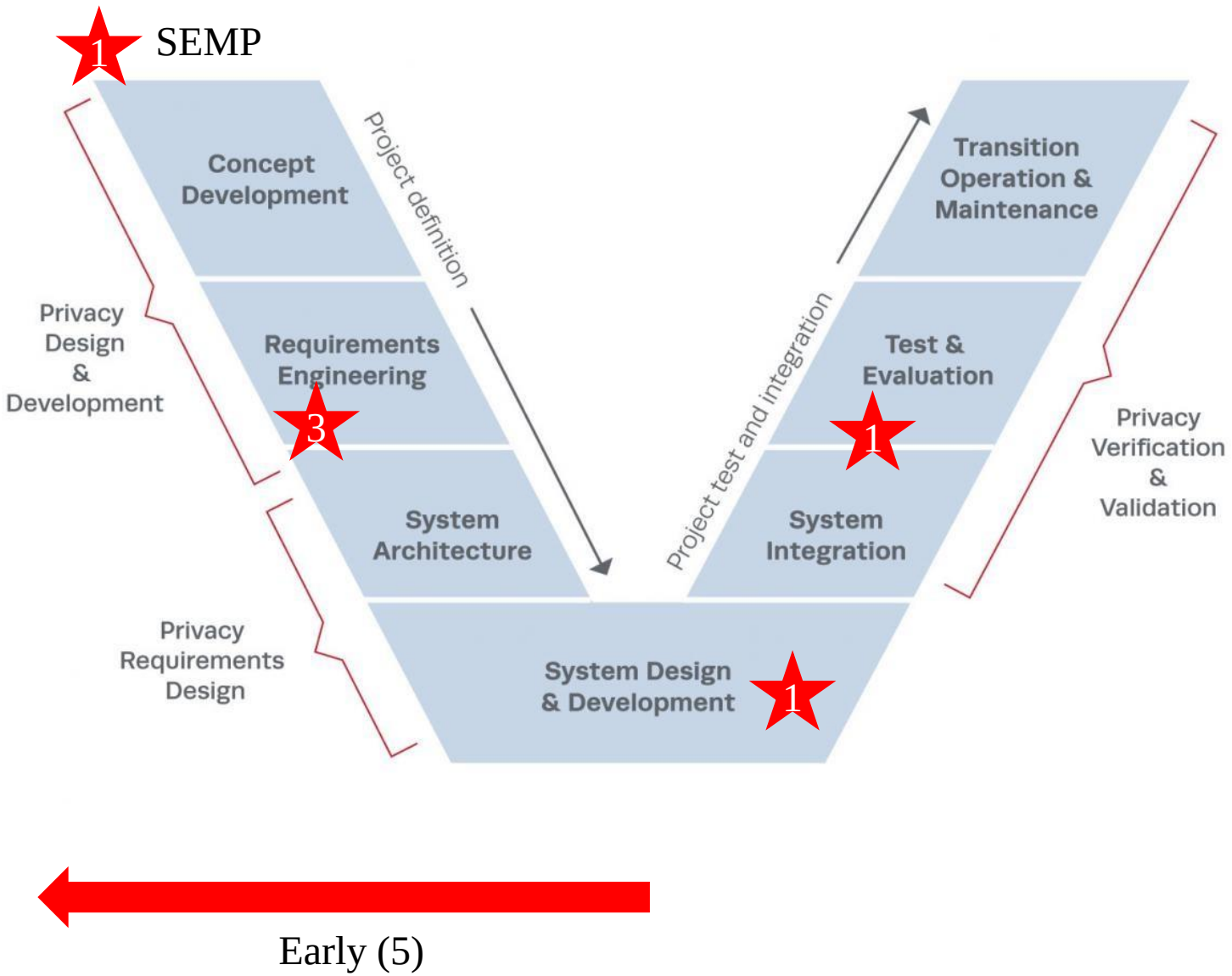
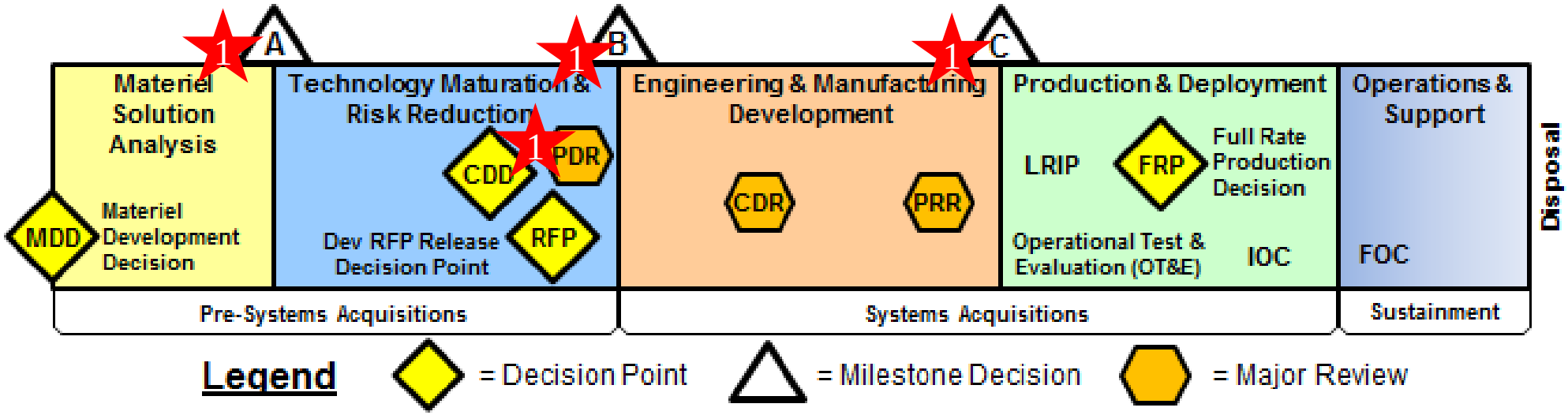
3
3
2
2
2
2
2
Measureable
Predictive
Traceable
Insightful
Independent
Complete
Critical
Relevant
Provide Warning
Reliable
Maintainable
Clear
Testable
Not Measureable
Necessary
Flexible
Essential

Timing



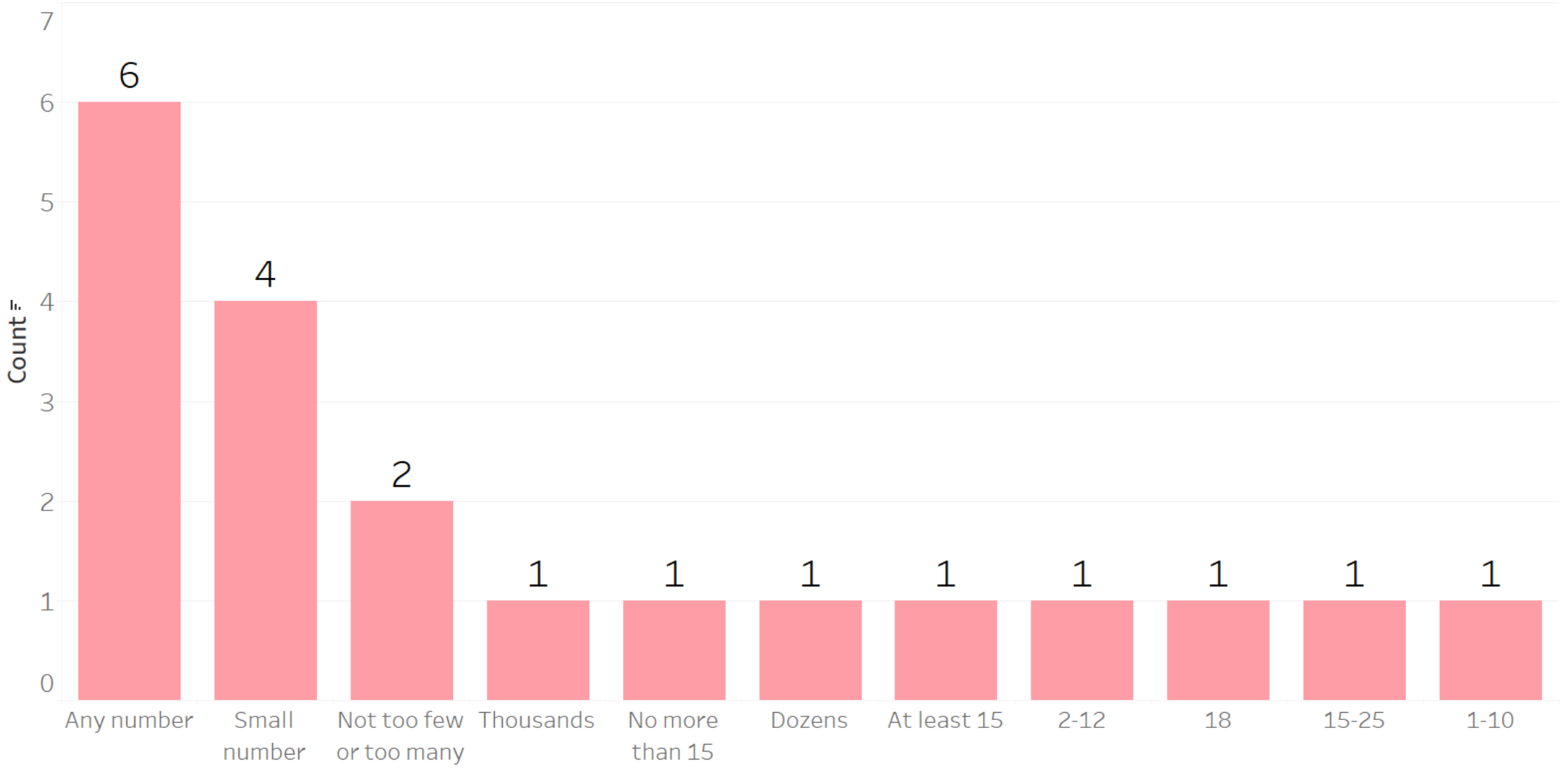
Early (5)

Timing (continued)



Early (5)

Quantity


Count
7
6
5
4
3
2
1
0
6
4
2
1
1
1
1
1
1
1
Any number
Small number
Not too few or too many
Thousands
No more than 15
Dozens
At least 15
2-12
18
15-25
1-10

Example Guidance

Examples typically suggested one or more technical measures, sometimes for specific systems or contexts:

"Cost may also be considered a KPP." *(Roedler and Jones, 2005)*

"Typical TPMs for a cryogenic liquid rocket engine system such as the RL60 include weight, Isp, pump and turbine efficiencies, and many others." *(Arborgast et. al, 2005)*

"The current set of leading indicators include: Requirements Trends, System Definition Change Backlog Trend, Interface Trends, Requirements Validation Trends, Requirements Verification Trends, Work Product Approval Trends, Review Action Closure Trends, Risk Exposure Trends, Risk Handling Trends, …" *(Gerst and Rhoedes, 2010)*

Roedler, G. J., & Jones, C. (2005). Technical Measurement. A Collaborative Project of PSM, INCOSE, and Industry.
Arborgast, T., Doughty, D., Hoffman, K., & Marable, R. (2003). Enhanced Systems Engineering Practices as Applied to the Pratt & Whitney RL60 Demonstrator Engine. In 39th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit (p. 4488).
Gerst, K. J., & Rhodes, D. H. (2010). Strengthening Systems Engineering Leading Indicators for Human Systems Integration Considerations–Insights from the Practitioner Community. In Proceedings.

Summary

Genesis

- TMs derived from other technical measures, people, or other

Timing

- Generally points to early selection of TM before important decisions are made

Quantity

- Varies widely but points towards a "small number of TM" somewhere below 25

Qualities

- Measurable, predictive, traceable, insightful
- Relate heavily to the definition of a technical measure

Examples

- Provides examples of TM used previously or suggested TMs

Conclusion

Currently, technical measure selection is decided by a systems engineer based on individual experience and best practices.

As systems become more complex, technical measure selection will likely have to adapt. A selection guide applicable to various systems could be used by practitioners for technical measure selection.

This research provides an aggregation and analysis of selection guidance in published literature. This will help to identify informative and grounded guidance needed to ensure that the technical measures selected lead to effective design and decision making.

Limitations and Future Work

1

Use of Published Sources

Using data other than published sources may result in different findings, as not all practices may be documented and not all documented practices may be followed.

2

Source Quantity

This study examined 32 sources. Additional sources will be examined in future work.

3

Public Sources

This research was limited to publicly available sources. Data from private sources could yield different results due to groups being more willing to be transparent with their practices.

4

Sources from 1995 - 2022

Finally, our study used sources from 1995 to 2022 Therefore, some results from our study could point to guidance that is no longer used in practice. The median publication date for the sources used was 2008.

References

- Arborgast, T., Doughty, D., Hoffman, K., & Marable, R. (2003). Enhanced Systems Engineering Practices as Applied to the Pratt & Whitney RL60 Demonstrator Engine. In 39th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit (p. 4488).
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