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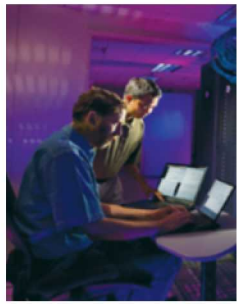

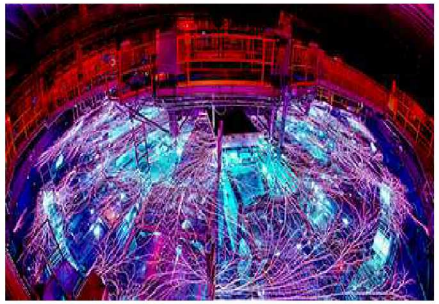

Warhead Complexity Analysis Process for Decision and Cost Analysis

Jonell N. Samberson, PhD

MORS 86th Symposium | 18-21 June 2018 | NPS – Monterey, CA

WG27 Decision Analysis | June 19, 2018 | ID 38287

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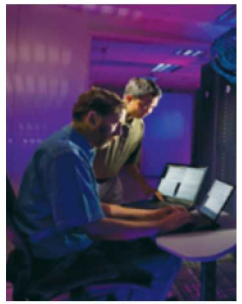

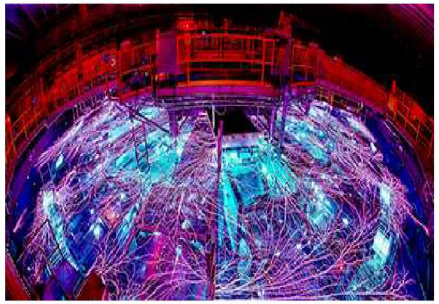

Warhead Complexity Analysis Process for Decision and Cost Analysis

Jonell N. Samberson, PhD

MORS 86th Symposium | 18-21 June 2018 | NPS – Monterey, CA

WG26 Decision Analysis | June 20, 2018 | ID 38285

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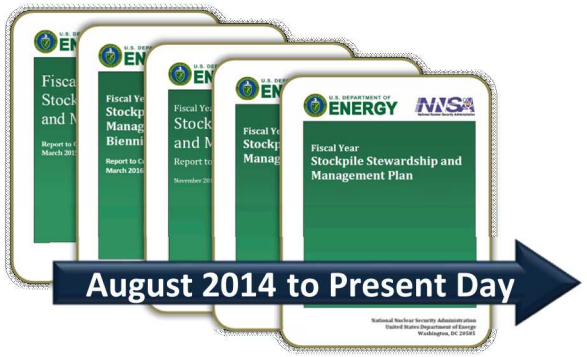
Background

- National Nuclear Security Administration (NNSA) has the unique challenge of putting forth a 25-year strategic program of record for congress

- A collaborative, multi-site analysis group, the Enterprise Modeling & Analysis Consortium (EMAC), developed and refined the process, tools, and approach NNSA needed

- Scope, Complexity, Options, Risks, Excursions (SCORE) model and analysis process formed to support NNSA's early planning cost estimates



Lewis, F. D., et al (2016). Planning the Future: Methodologies for Estimating U.S. Nuclear Stockpile Cost. *Cost Engineering,58(5) pp. 6-12.*

SCORE Process Motivation

- Improve the fidelity and repeatability of enterprise-level complexity analysis, including:
  - Developing a common language to use across programs
  - Ability to perform trade studies in order to understand the importance of work scope parameters
  - Tool and process which include input from subject matter experts (SMEs)
  - A systematic approach to capture work scope, complexity, and uncertainty
  - Enable capture of full program scope with differentiation at the appropriate level of detail
  - Standard output reports and charts that can be used by decision makers

Traceable work scope definition & assumptions supported by a technical community of experts

Slide 4

SJN16 Review ordering based on the middle slides

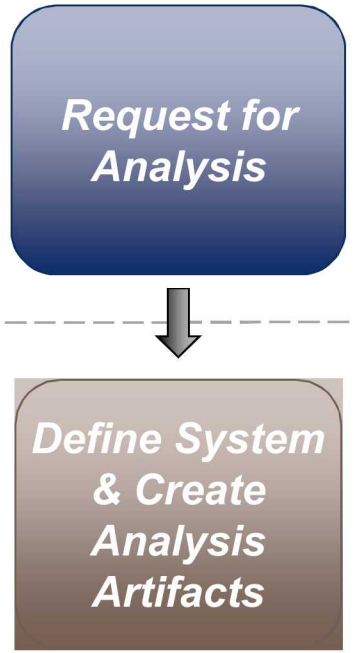
Samberson, Jonell Nicole, 6/14/2018

Complexity Analysis Process Flow

CUSTOMER

SCORE TEAM

STAKEHOLDERS



Define System & Create Analysis Artifacts

- Define the complex system(s)
- Identify elements of the systems
- Gather available historical work scope and cost data at the appropriate level
- Review and group the elements according to the discovered data

WKM9

Define System & Create Analysis Artifacts

- Common analysis and reference terms across all documents and communications

Analysis Artifacts

1. WBS Code & Element Mapping
2. Reference Cost Data
3. Model Input Files
4. Design Definitions
5. Complexity Estimates
6. Assumptions

WBS Code	Element Name
1.X.1	Systems Engineering and Integration
1.X.2	Systems Test and Qualification
1.X.3	Systems Production
1.X.4	Nuclear Components
1.X.4.1	Component A
1.X.4.2	Component B
1.X.5	Non-Nuclear Components
1.X.5.1	Widget 1

WBS Code	Element Name	Reference System	Phase	Design Choices					
				New Design			Reuse Design		
				Low	Mode	High	Low	Mode	High
1.X.5.1	Widget 1	System Alpha	SE&I	110	120	180	90	100	110
			T&Q	110	120	140	90	100	110
			PD	100	110	120	60	70	80
			Prod	100	110	120	60	70	80

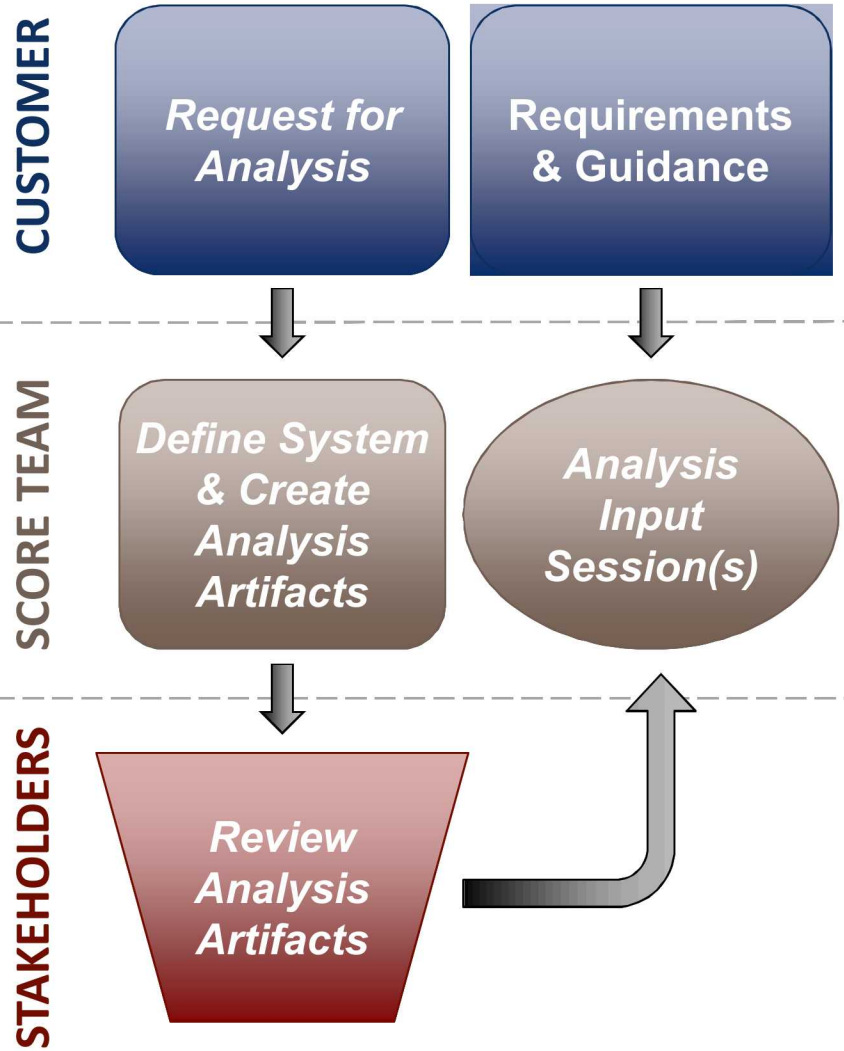
SE&I: Systems Engineering and Integration | T&Q Test and Qualification | PD: Process Development | Prod: Production

Element Name	Work Scope	Phase	New Design		
			Low	Mode	High
Widget 1	Design requires one additional type A electrical connection	SE&I	Minimal challenges	Some challenges	Major challenges

Slide 7

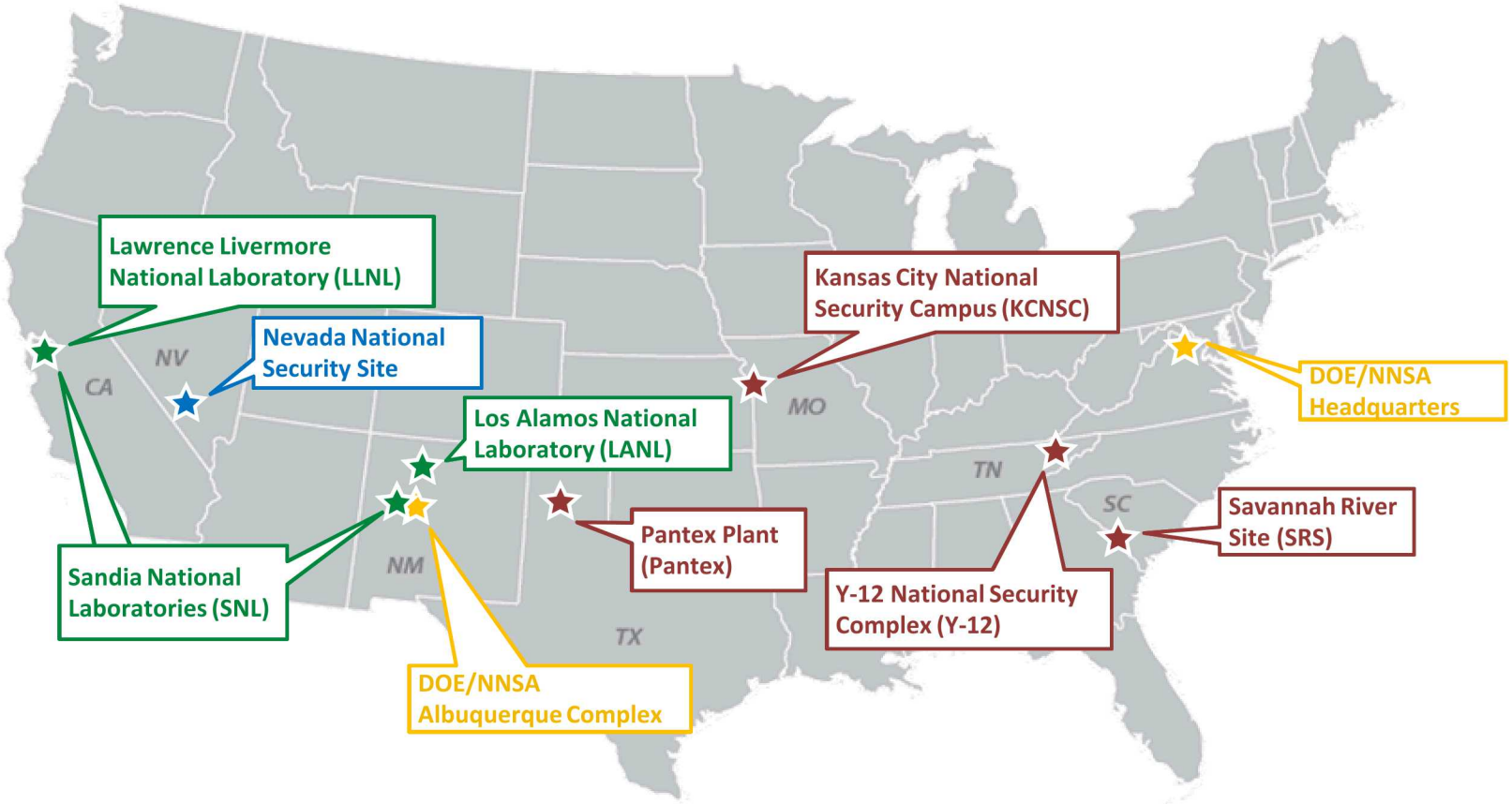
WKM9 Welch, Kimberly M, 6/13/2018

Complexity Analysis Process Flow

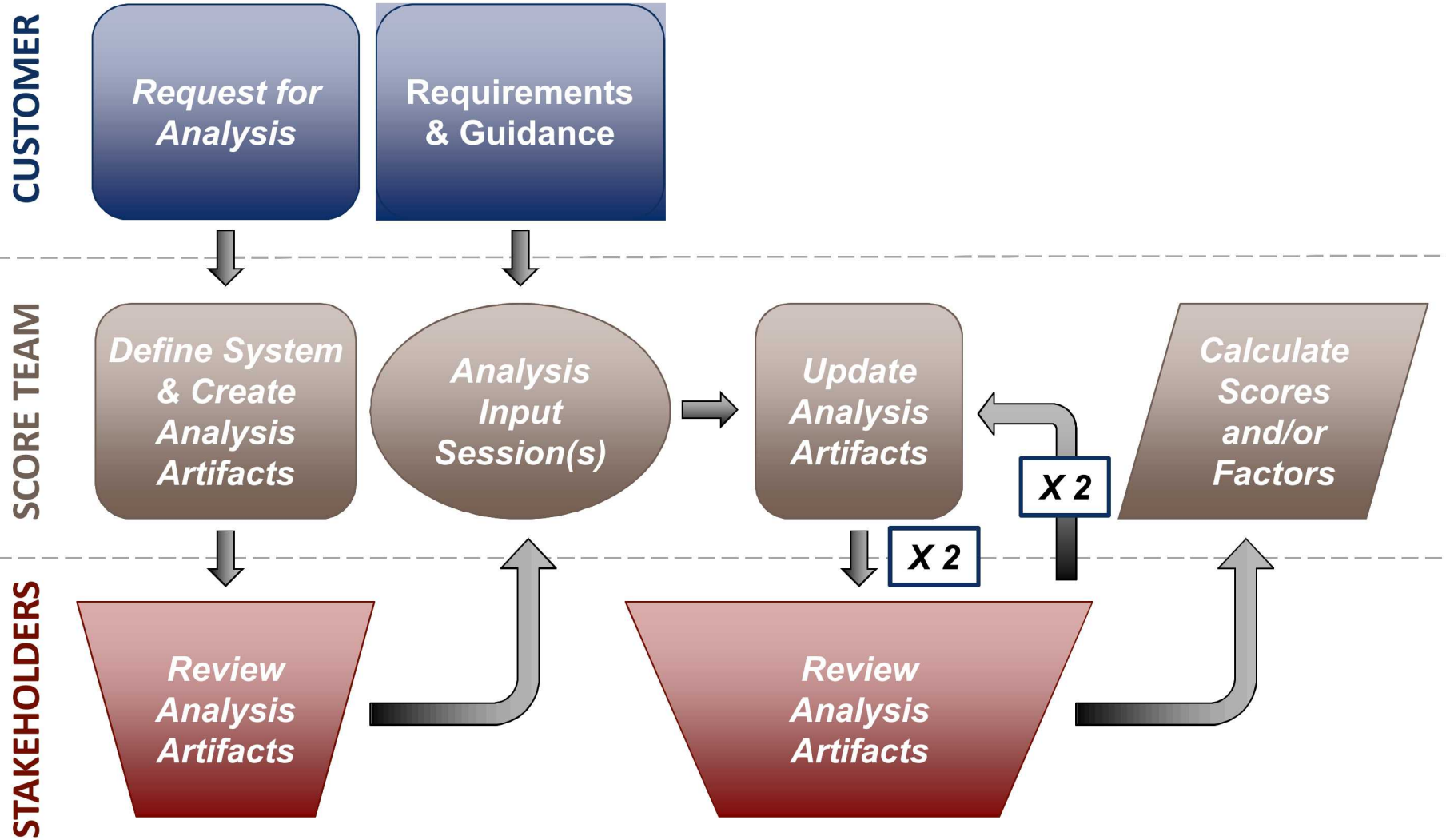


Analysis Input Session

- Technical evaluation of the analysis artifacts with the entire stakeholder community
  - ~50 people over one week for the NNSA analysis session



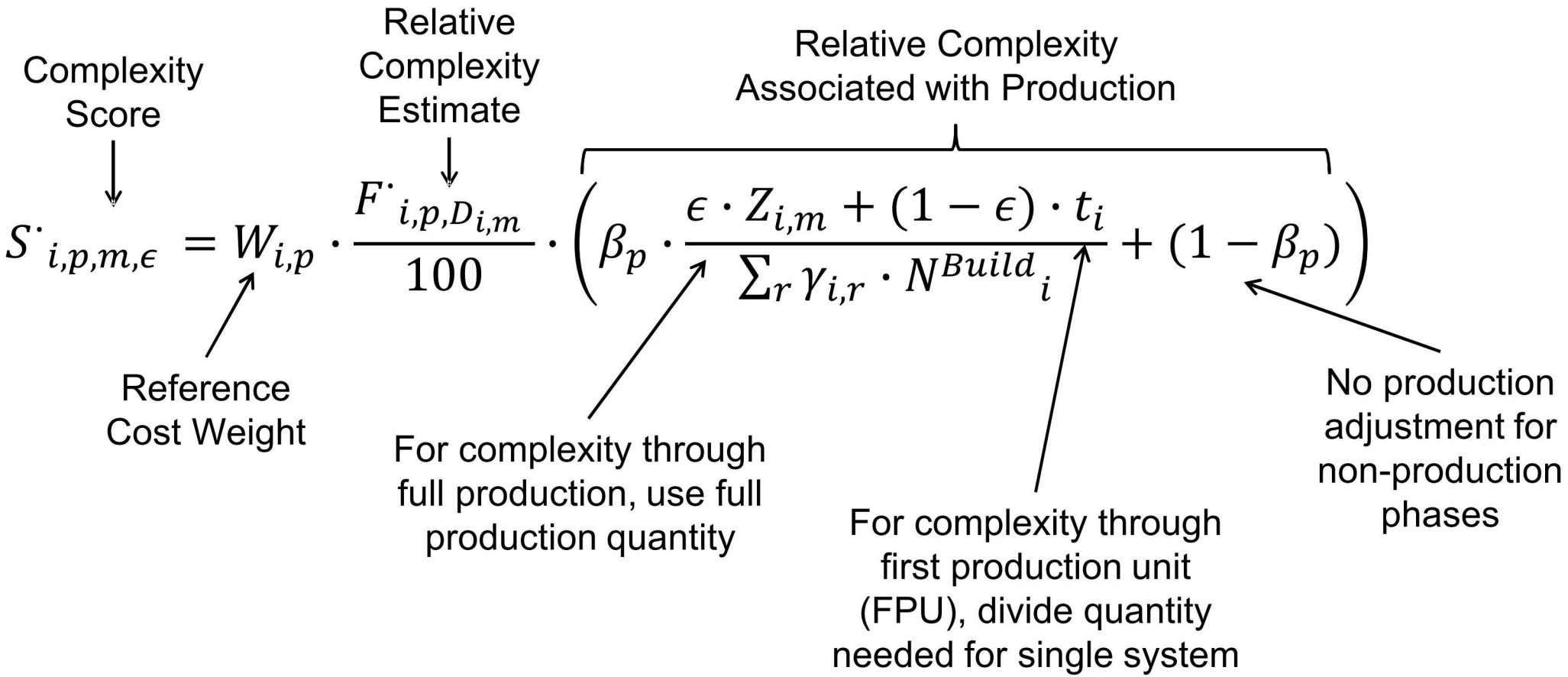
Complexity Analysis Process Flow



WWKM12

Calculate Scores and/or Factors

- Tool performs sampling and calculates a complexity score at various levels of detail



Slide 11

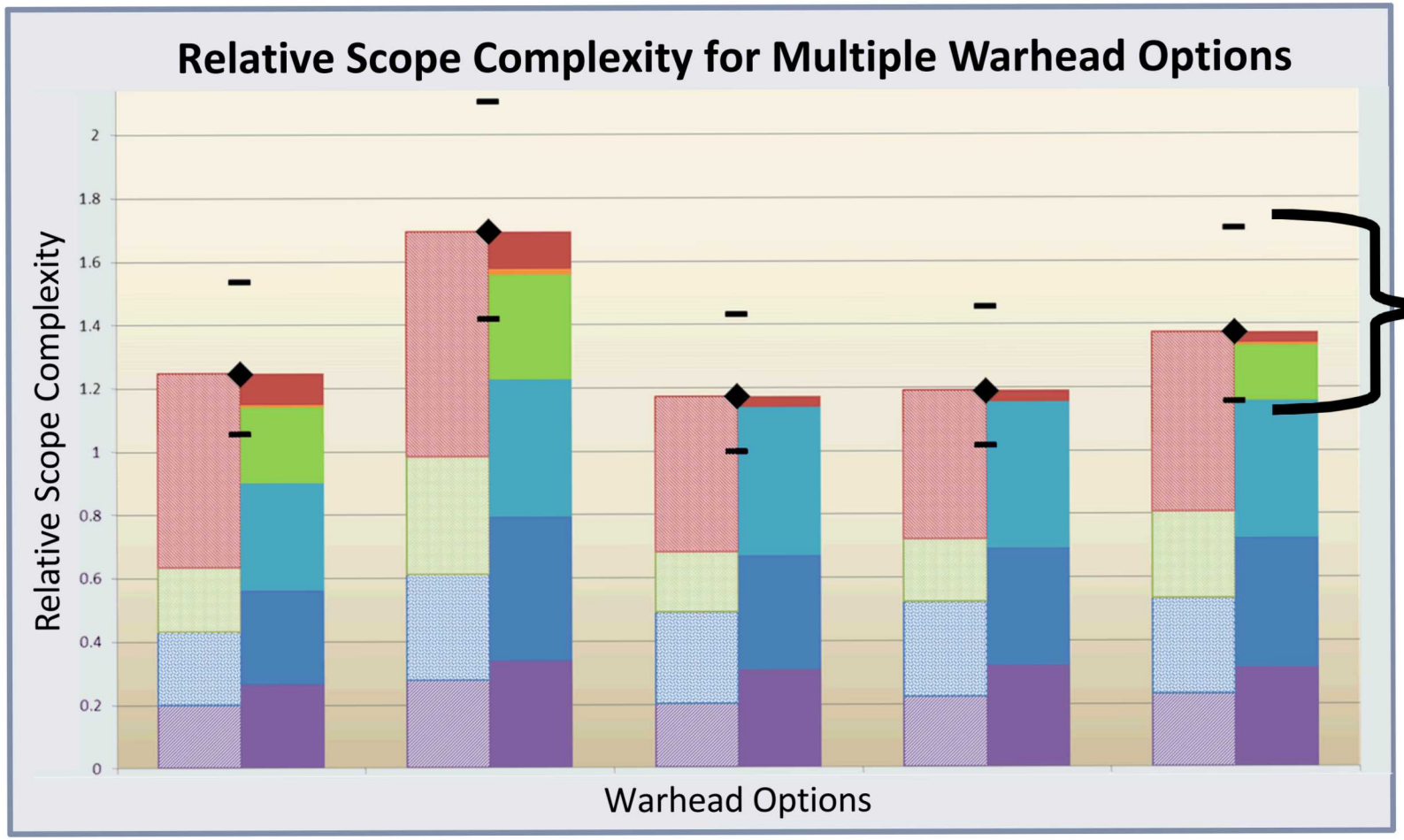
WKM11 IS there a takeaway or bullet on this chart that says something like "tool performs sampling and calculates complexity at various levels of the system (rollup)"?
Welch, Kimberly M, 6/13/2018

WKM14 Or maybe a definition of a score. For example "Scores are calculated which represent the relative complexity to be compared across options with the same reference basis."
Welch, Kimberly M, 6/13/2018

WKM12 I would add a graphic or example output on this chart or on the next chart. I put the unclassifeid graphic that I have here for your use.
Welch, Kimberly M, 6/13/2018

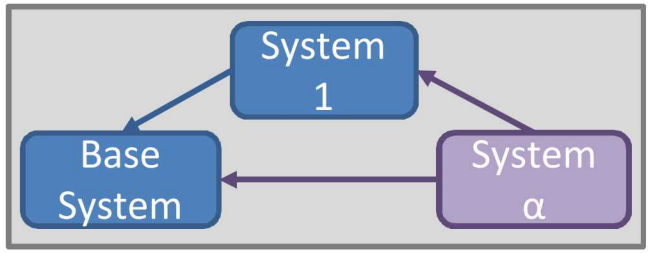
Calculate Scores and/or Factors

- Tool performs sampling and calculates a complexity score at various levels of detail



Calculate Scores and/or Factors

Score	*	Reference Conversion Factor	=	Factor



WBS Code	Element Name	System α Reference System
1.X.1	Systems Engineering	Base System
1.X.2	Widget A	Base System
1.X.2	Widget B	System 1
1.X.3	Widget 1	N/A
1.X.3	Widget 2	Base System
1.X.4.1	Component A	System 1
1.X.4.1	Component B	System 1
1.X.4.2	Component 1	New Scope

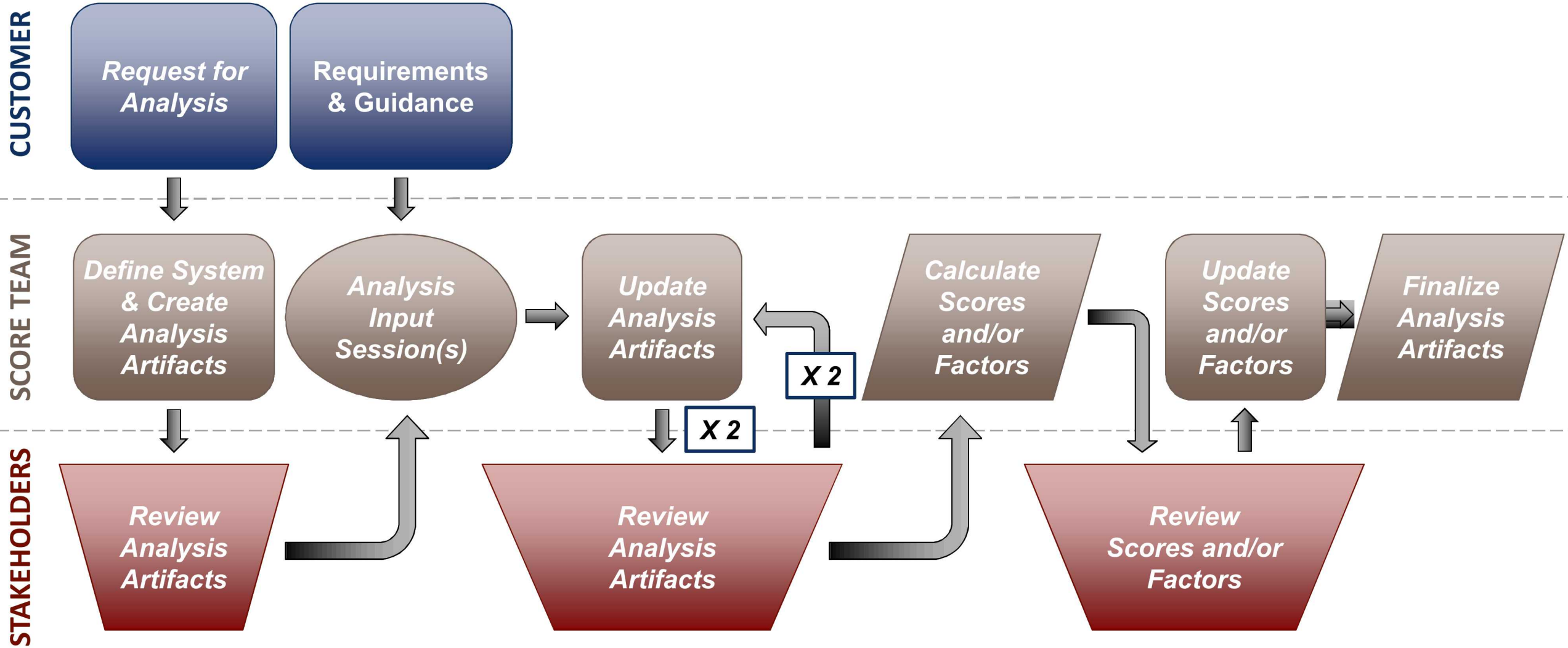
WBS Code	Element Name	Phase	Base System Reference Cost	System α Complexity Estimate Mode	System 1 Complexity Estimate Mode
1.X.2	Widget A	SE&I	30	120	-
		T&Q	10	140	-
		PD	8	50	-
1.X.2	Widget B	SE&I	25	150	180
		T&Q	15	140	200
		PD	12	50	100
1.X.2 Total			100		

$$\{1.X.2\ \text{Factor}\} = \underbrace{1.2 * \frac{30}{100} + 1.4 * \frac{10}{100} + 0.5 * \frac{8}{100}}_{\text{Widget A}}$$

$$+ \underbrace{1.5 * 1.8 * \frac{25}{100} + 1.4 * 2.0 * \frac{15}{100} + 0.5 * 1.0 * \frac{12}{100}}_{\text{Widget B}} = \boxed{1.7}$$

*System α is **70** percent more complex than the Base System for WBS 1.X.2.*

Complexity Analysis Process Flow



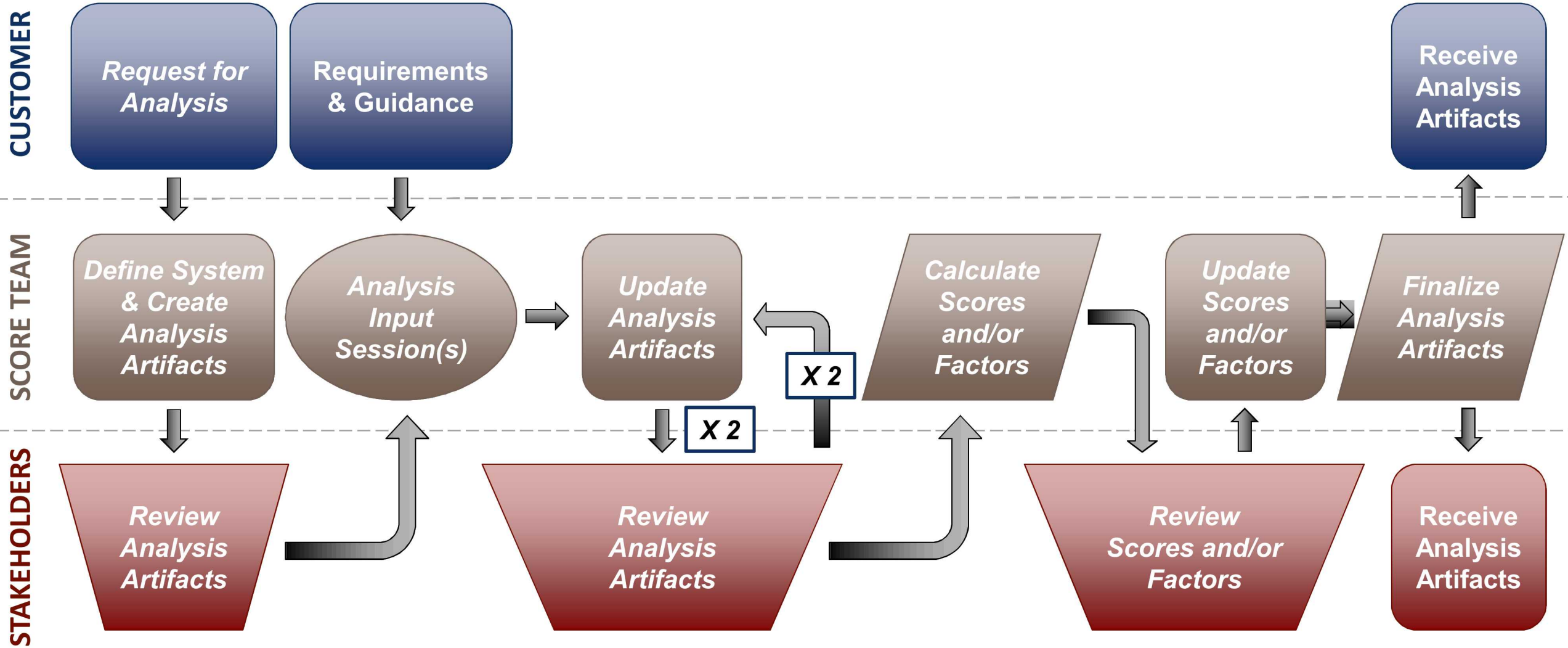
Finalize Analysis Artifacts

Analysis Artifacts

1. ***WBS Code & Element Mapping***
2. ***Reference Cost Data***
3. ***Model Input Files***
4. ***Design Definitions***
5. ***Complexity Estimates***
6. ***Assumptions***

- Products generated throughout the process provide traceability and justification to support analysis and the resulting cost estimates
- Data produced from this process can be easily regenerated and compared to future complexity analysis estimates
- Data use from this process can be easily leveraged for other projects

Complexity Analysis Process Flow



Challenges

SYSTEMS ANALYSIS & DECISION SUPPORT

SJN2

- Decomposing a complicated product(s) into a common language across programs
- Availability of historical cost data and work scope
- Unintentional bias by using complexity estimates from a previous analysis as a starting point for the current analysis
- Coordinating ~50 stakeholders to be present for the full one week session
- Getting full participation during the review process
- Identifying the correct stakeholder for each piece of information
- Assuring all stakeholder voices are heard but they do not cause unintentional bias
- Capturing the correct information a SME will find valuable during the review process
- Capturing information in real-time and but also a widely distributable format

Slide 17

SJN2 order these to follow the process flow diagram

Samberson, Jonell Nicole, 6/13/2018

Summary and Conclusions

- Tool and processes have provided a systematic approach that has greatly improved the fidelity, traceability, and repeatability of early planning cost estimates

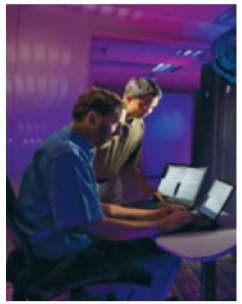
- Tool and processes have been successfully applied to multiple areas:
  - Warhead options down select
  - Component and warhead level early planning cost estimates
  - Warhead platform interface early planning cost estimates

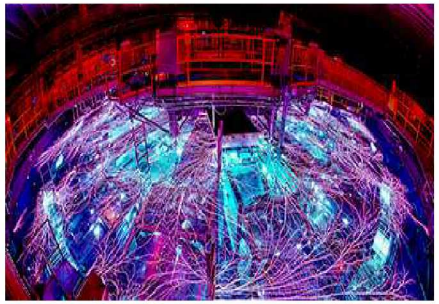
- Tools and processes can be applied to many complex problems

SCORE's analogous approach hinges on expert knowledge and valid reference systems

Slide 18

WKM16 Not sure if SCORE needs to be referenced so much on this slide. I think you can be generic.
Welch, Kimberly M, 6/13/2018



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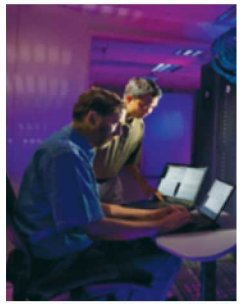

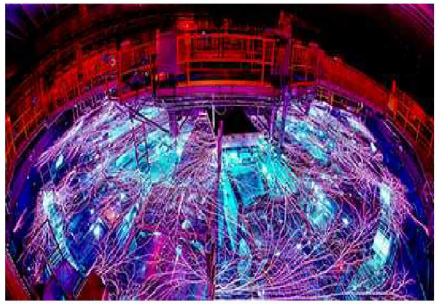

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