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hybrid event

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Concept Design Phase Systems Risk Assessment (D-FMEA) Using Early System-Level Understanding (SLA)

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Key Take-Aways

- Applying design focus to Critical Systems enables manageable and value-added risk mitigation within Concept Design Realm.
- Design considerations stemming from a 2-hr SME discussion expedite quality completion of a Concept Design FMEA.
- Concept Design FMEAs enable preventative risk-mitigation to occur while system-level design is fluid avoiding downstream cross-functional redesign inefficiencies.
- Failure modes relating to each Dimension of Quality + Sustainability warrant mitigation within Concept Design Realm.

"At the highest-level, a design failure is the inability to optimally meet company and customer expectations!"

Overall “Design Quality”

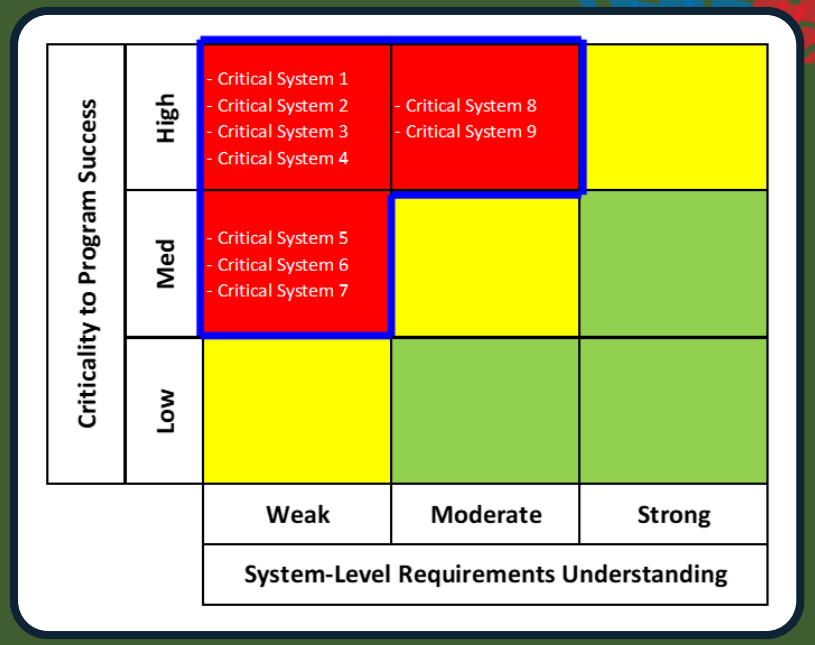
- A sound product design concept enables the potential of achieving optimal performance against Garvin’s 8 Dimensions of Quality + Sustainability.

Majority of a design’s lifecycle CO2 footprint determined in the concept phase!

Early Design Focus

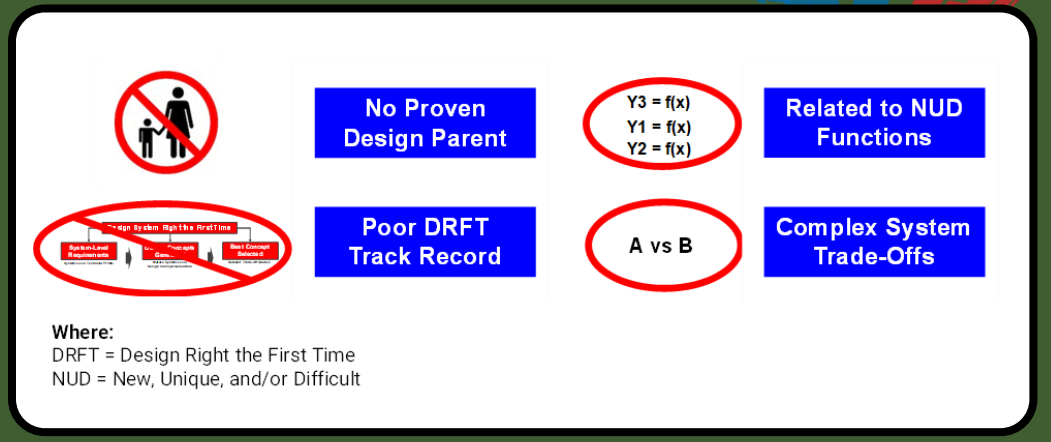
- Critical Systems are items of inherent risk of efficiently achieving a high-level of Design Quality.
- Critical Systems are system-level design elements of a new product that are:
  - Critical-to-program success
  - Unproven to be within an organization's core competency (or items very likely to have Design Quality "unknowns")

Critical System 9-Box



Critical System Characteristics

- No viable proven ‘parent’ exists to guide system-level design work.
- Past attempts to design similar systems resulted in significant redesign activity.



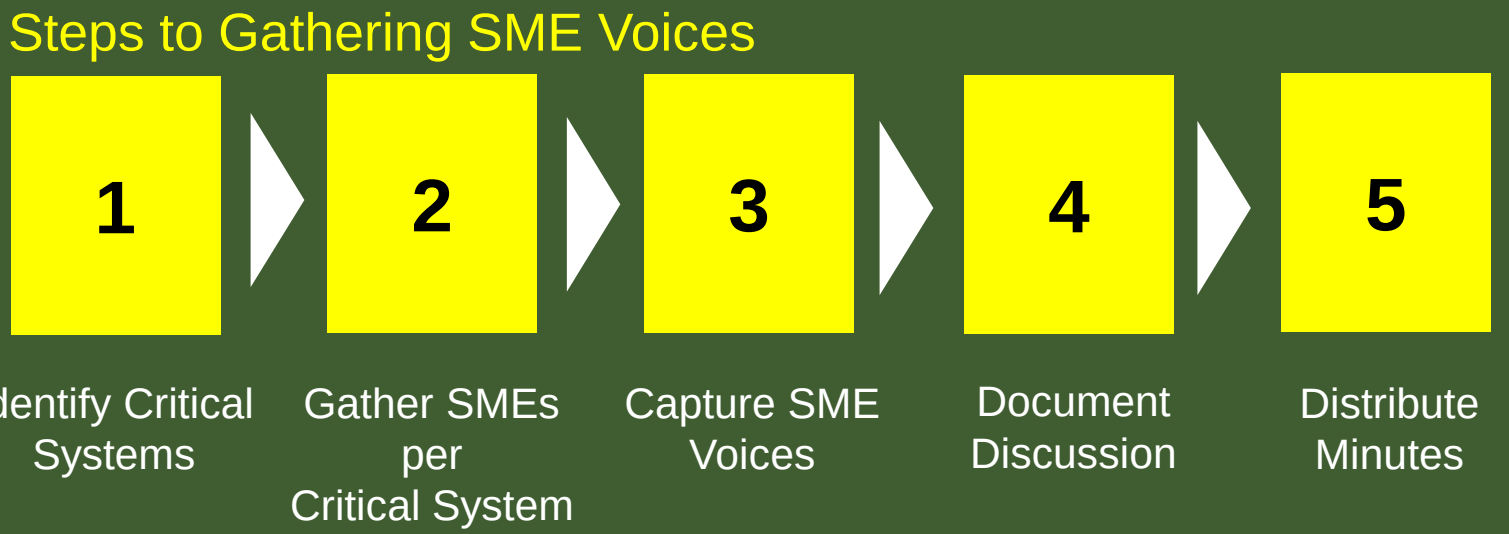
- Performance of one or more critical-NUD functions affected.
- Complex trade-offs exist across functional, subsystem, and Design Quality boundaries warranting clear system-level design ownership.

“Must place focus on inherently at-risk Critical Systems above the items *likely to be designed right anyway!*”

Early “Requirements” Focus

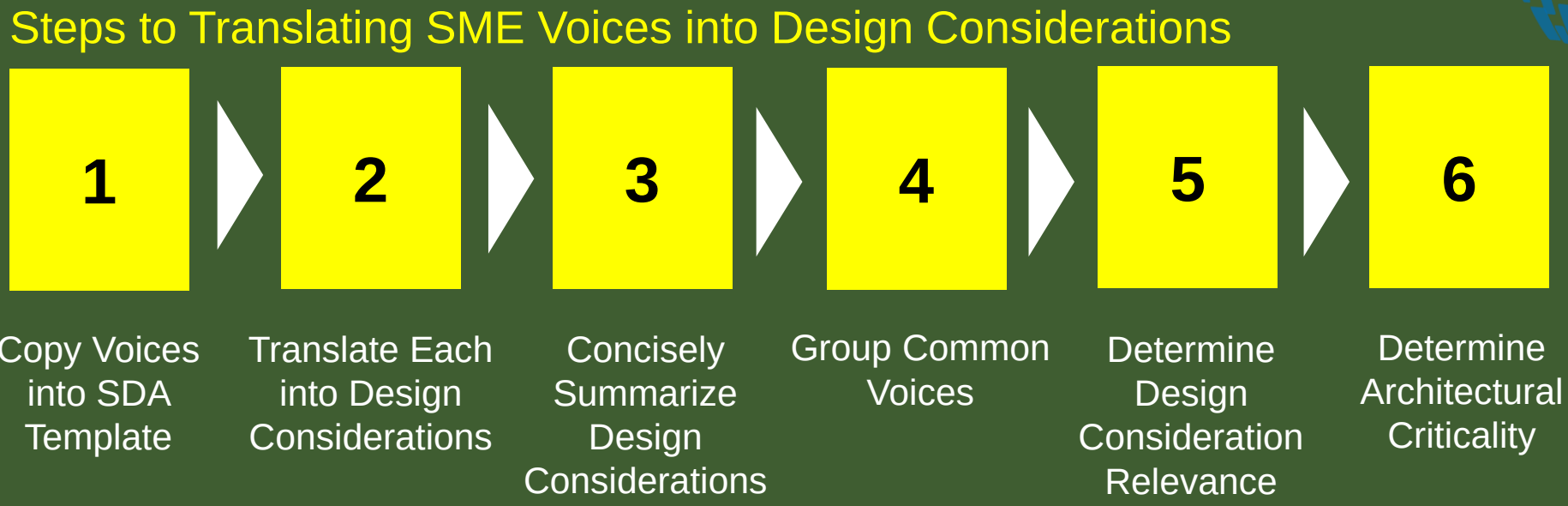
- Each **Critical System** becomes the focus of a System-Level Assessment (SLA) SME-based discussion.
  - SLA is a voice gathering initiative that enables design considerations and requirements to be efficiently and methodically harvested from a group of diverse and knowledgeable SMEs.
  - Typically, 80-120 nonobvious design considerations are gathered within 2 hrs across relevant Design Quality categories.
- Provides a detailed knowledge foundation enabling sound system-level design concept development and early risk mitigation.

SLA – Gathering SME Knowledge



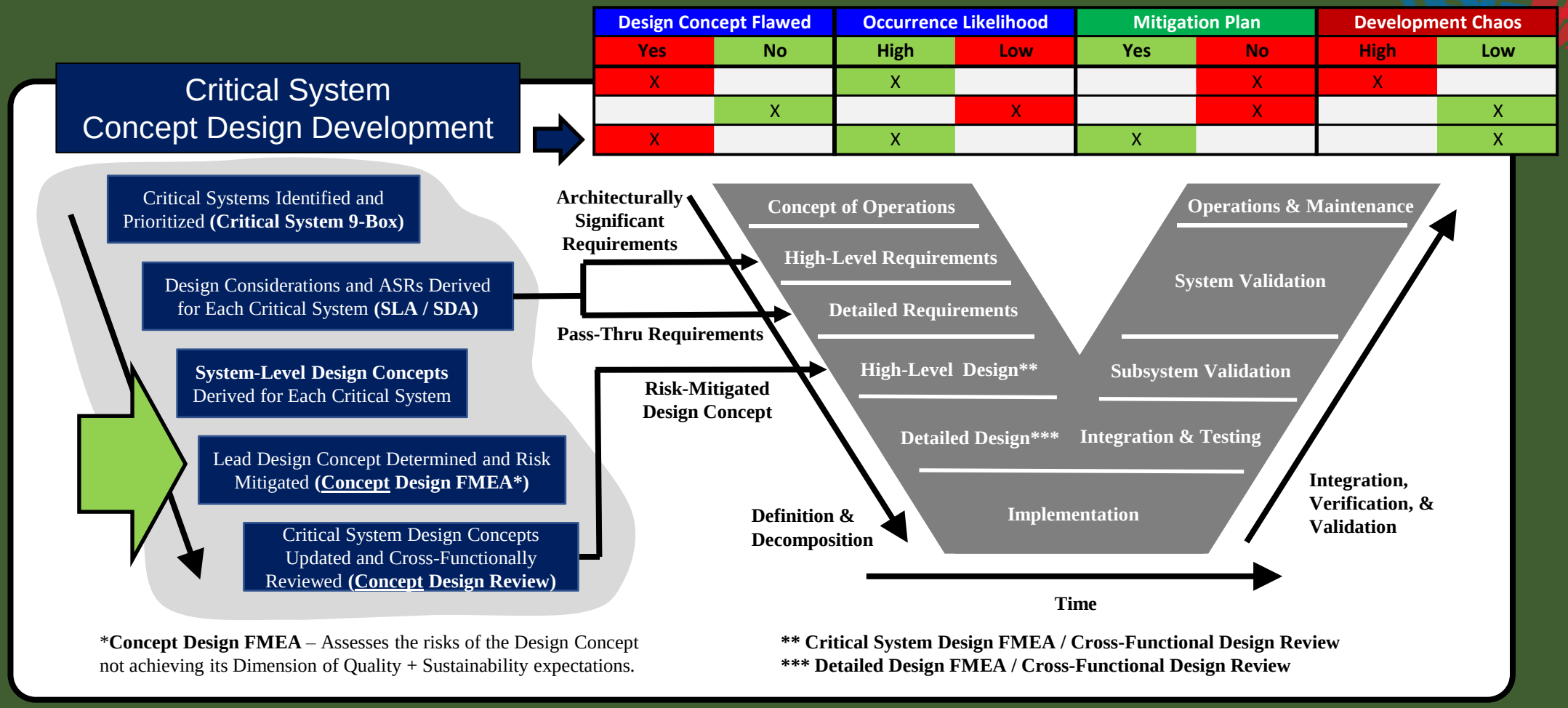
- 2 hr Systems Engineer-facilitated discussion – critical to gather voices efficiently given extreme demand on SME's time.
- Sometimes 4 hrs required for very complex Critical Systems.

SDA – Translating SME Voices



- 3-5 hrs per Critical System to translate voices – Systems Engineer to translate off-line / review with CS owner.
- Each design consideration assessed for inclusion / exclusion from design concept – may evolve into future requirement.

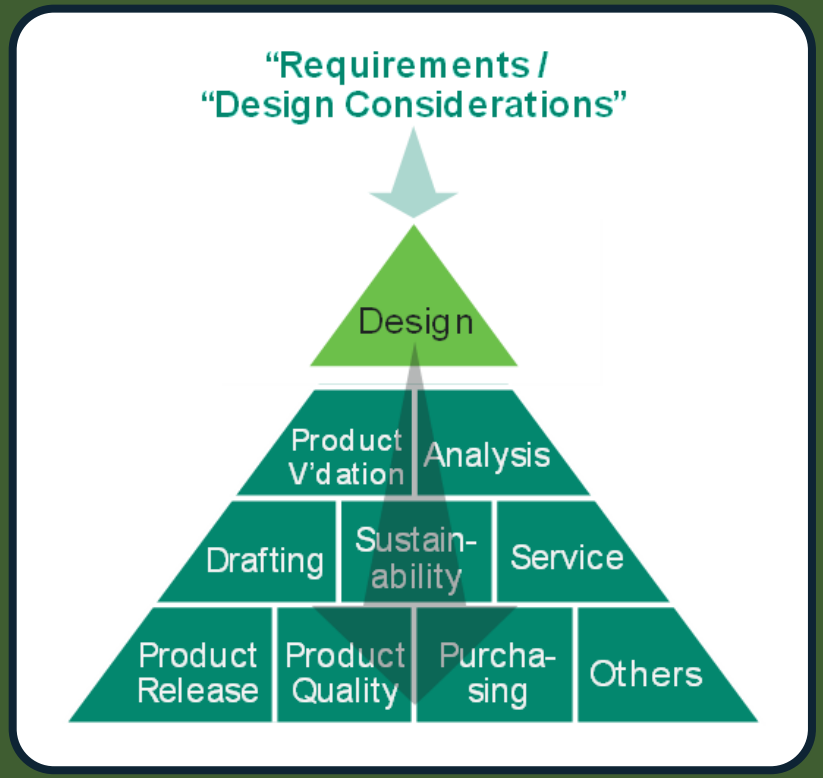
Executing “Left Wing” of Vee



“ALL design concepts have pros and cons…meaning that ALL concepts have cons that warrant up-front mitigation!”

Design Pyramid

- A Concept Design FMEA ensures each design consideration receives an adequate up-front assessment while design freedom exists.
- If a redesign is required later in the design process, every cross-functional entity is adversely affected.



Streamlines Design Process

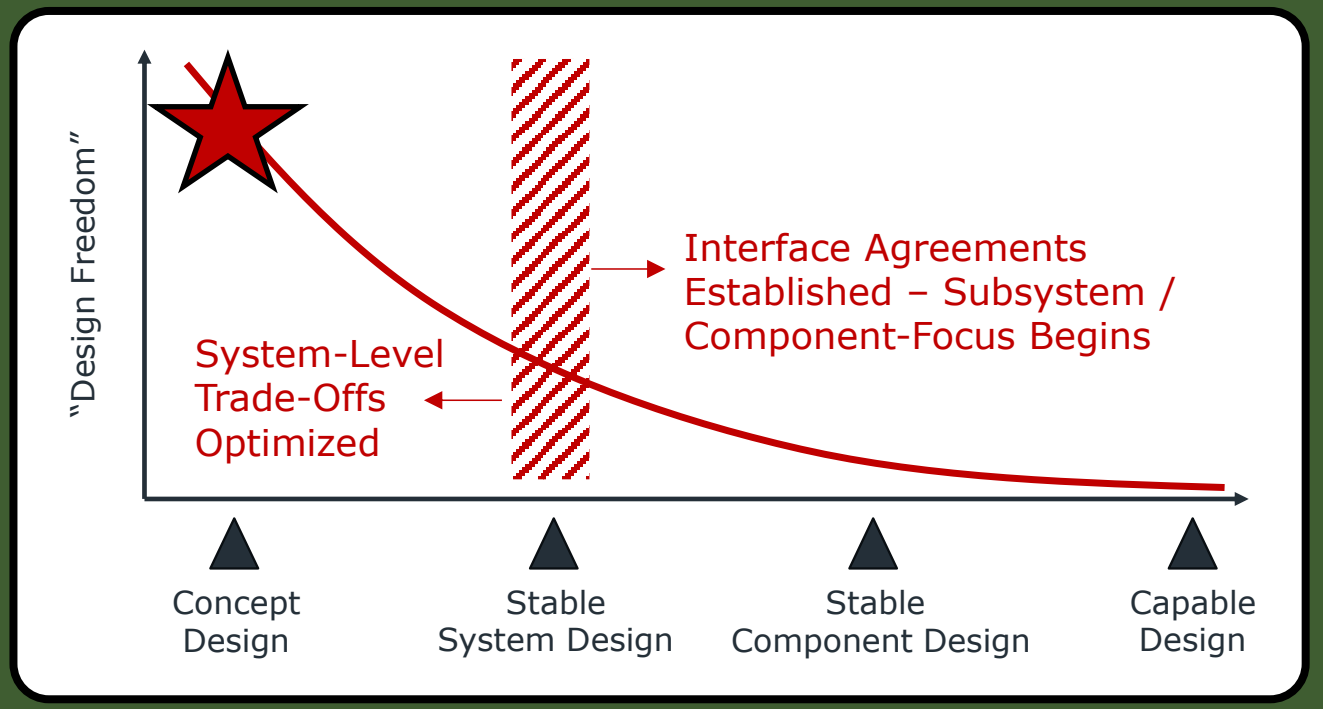
- Using SLA / SDA to establish a cross-Design Quality understanding of a Critical System:
  - Quickly provides the Design Engineer (and their team) with a system-level understanding typically more-detailed than traditional CONOPS.
  - Enhances the quality and completeness of the design concept by considering a broad range of cross-functional perspectives and ideas.
  - Minimizes the potential for a costly and time-consuming redesign by discovering and uncovering requirement-based knowledge.
  - Provides a foundation against which design concept trade-studies and other support tools can be completed and expedited.

Risk-Mitigated Design Concept

- Requirement and design consideration-knowledge provides a framework for quickly assessing a design concept's risks of not meeting customer expectations.
- A "response" (via D-FMEA) to each "design consideration" also minimizes the potential for bias to overwhelm the concept design process.
- By assessing performance-risk against each Design Quality category, holistic risk mitigation is enabled while the system-level design concept is still fluid.

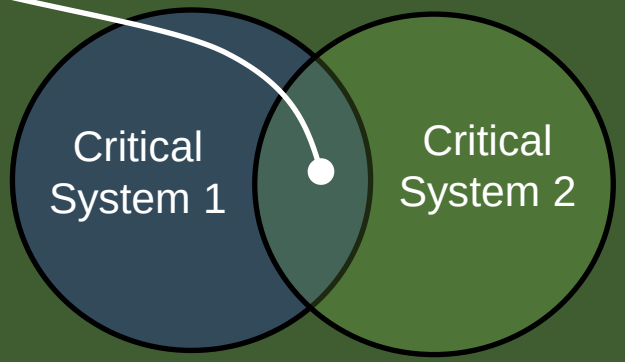
System-Level Design Freedom

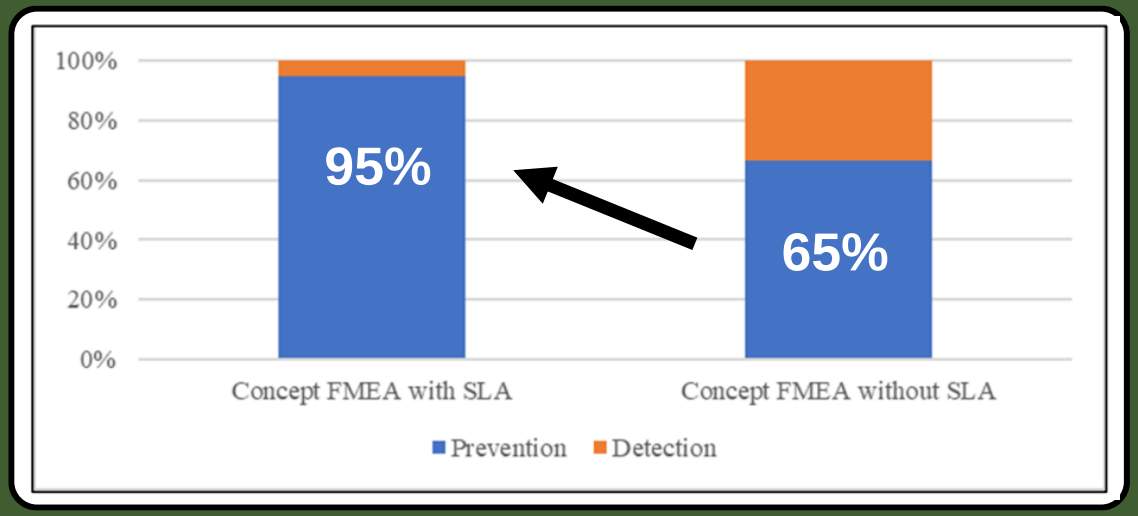
- Efficient resolution of design concept vulnerabilities and trade-offs must occur when system-level design freedom exists.



Case Study – Fuel Cell System

- Using SLA to complete a Critical System Concept D-FMEA:
  - Reduced the time required by > 80% (4.5 vs. 32-80 hrs)
  - Resulted in a much higher percentage of “prevention items” (or those risks efficiently addressed by a design change)
  - Resulted in assigning many prevention items to other Critical Systems
  - Addressed several “unknowns”

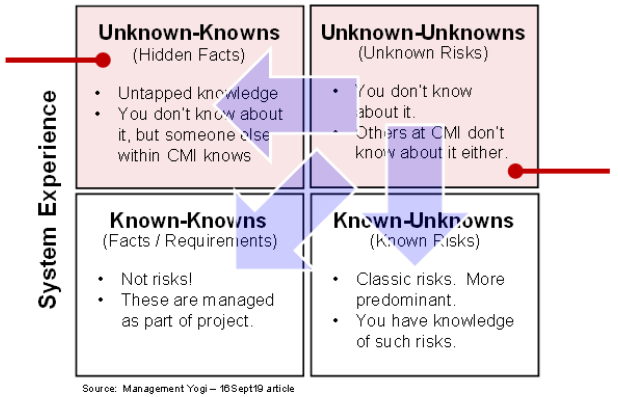




“Unknowns” Mitigated

- SLA methodology repeatedly highlights “unknown” (or nonobvious) design considerations – such items pose inherent redesign risk if not “considered” early in the design process.

Many failures during the product development process or warranty-related issues have been quite foreseeable by SMEs within the business.



Cross-functional SMEs best positioned to identify “Design Considerations” outside an organization’s existing core competency.

nonobvious [2]

in British English

(ˌnɒnˈɒbvɪəs)

ADJECTIVE

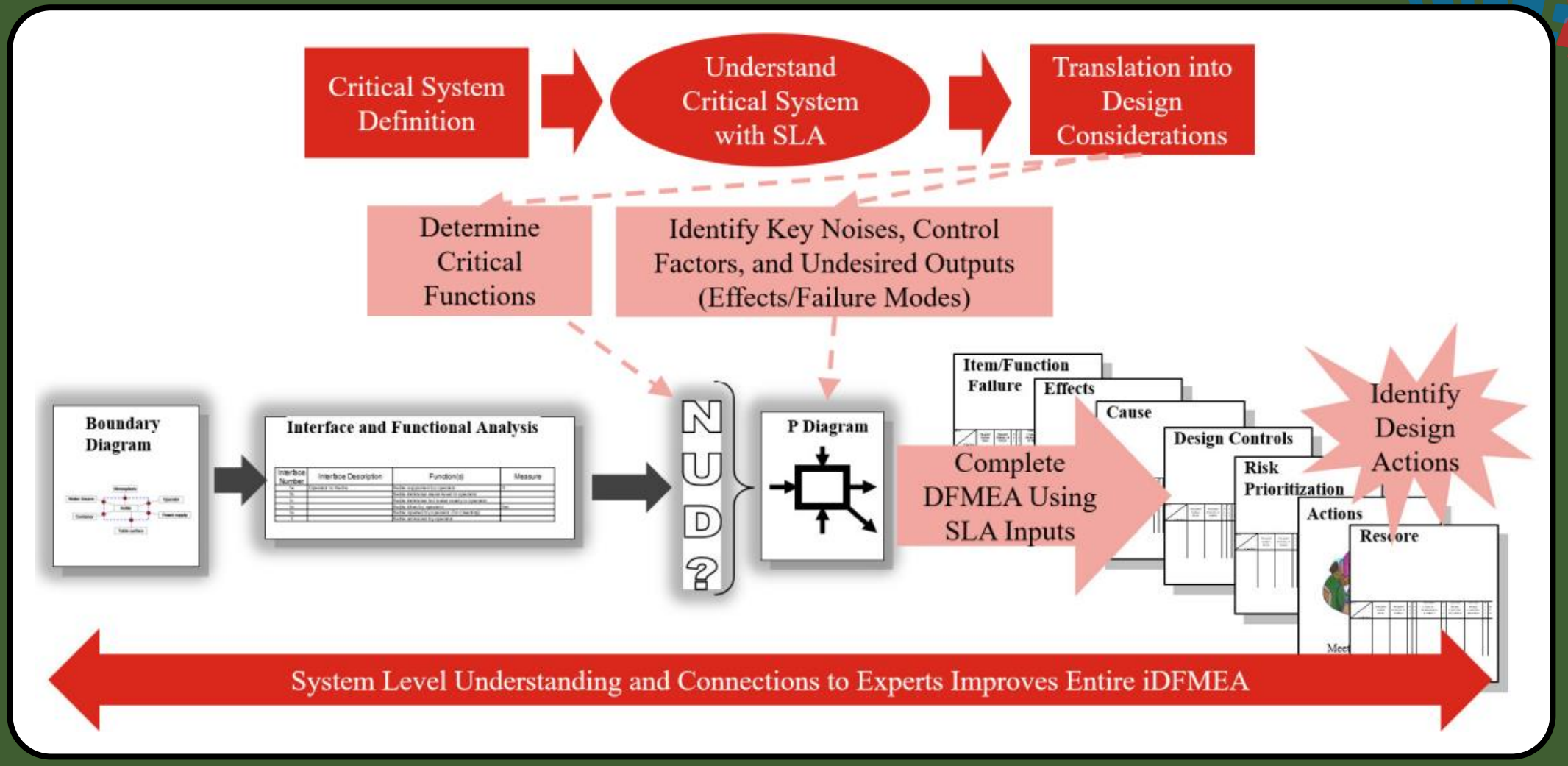
1. not obvious or evident
2. *patent law* sufficiently inventive to warrant a patent

Using SLA:

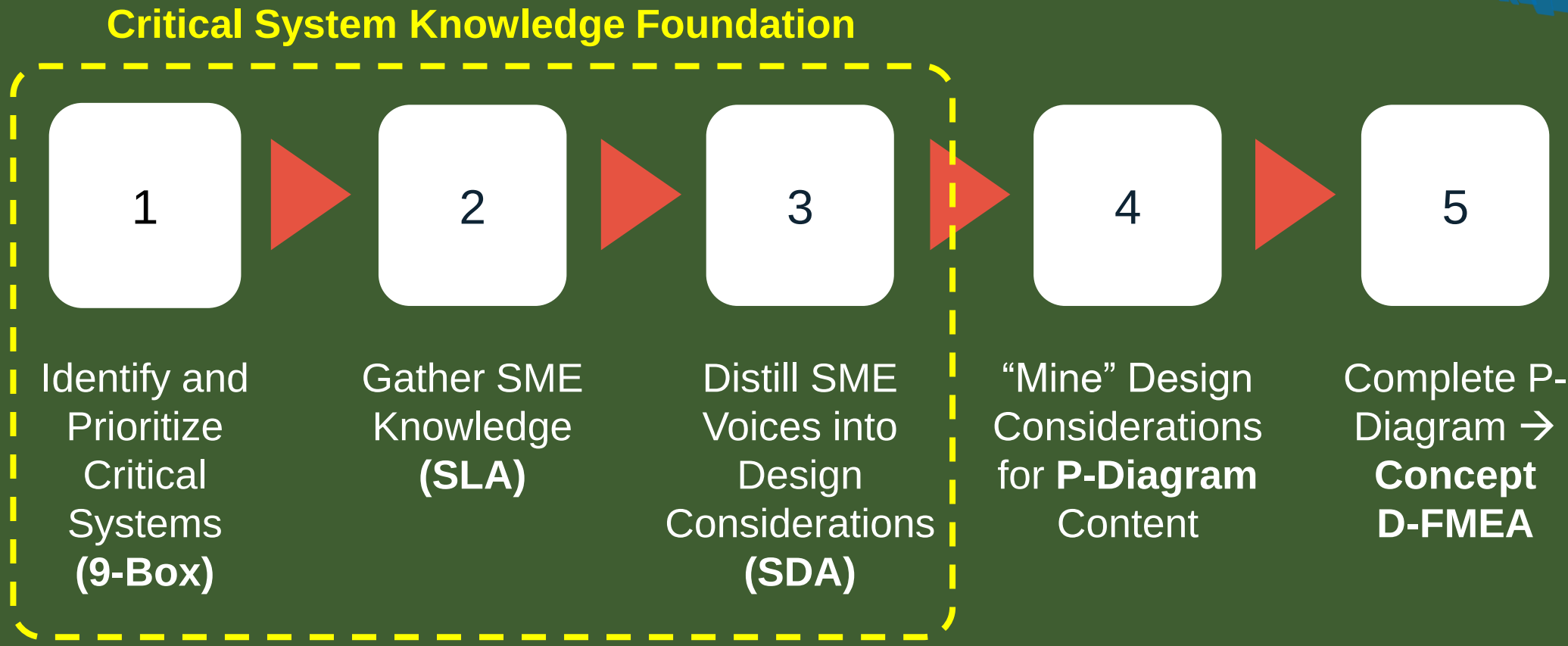
- 170% more patents than traditional program.
- ~90% of patents system-level-in-nature.[1]

[1] Genter, Bauer – SAE 2023-01-1517
[2] www.collinsdictionary.com

SLA / SDA → P-Diagram → FMEA



Concept Design FMEA Flow



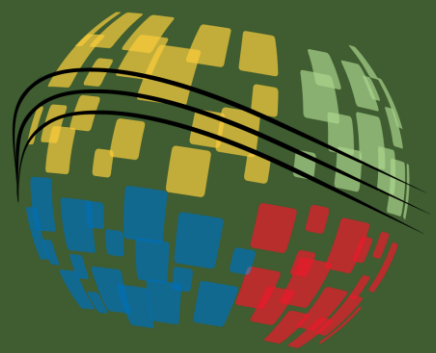
SLA / SDA Content Example

80-120 SME Voices
(2 hr Discussion)

+20% “SHALL Consider” Statements
(3-5 hrs to Translate Voices Off-Line)

Cylinder Block Design Consideration Management	
SLA SME Voices (from SLA tab)	**Detailed Design Consideration**
- When machining a ductile iron cylinder block, burr management at drilling intersections must be carefully managed. Where grey iron has flakey chips, ductile iron chips are more "stringy" and may require post-processing during the manufacturing to effectively remove "hanging burrs" that could come loose under lube system pressure pulsations.	- Adequate measures SHALL be taken when designing and manufacturing the cylinder block to ensure no "hanging burrs" exist at the intersection of oil system drillings. **Note**: If burrs exist during engine operation, they can break loose due to fatigue generated by pressure pulsation loading within the oil system. When this occurs, they can flow downstream and fail bottom-end bearing systems.

P-Diagram Content Example



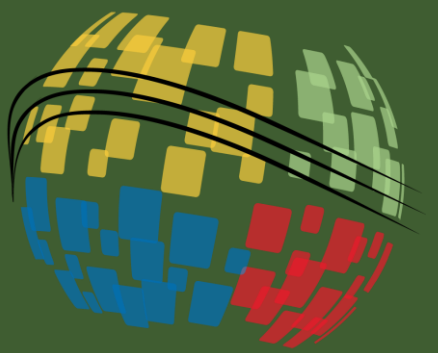
"SHALL Consider" Statements
(Knowledge Foundation for ALL Design Tools)

"Mined" P-Diagram Content
(Info Flows into D-FMEA)

	P-Diagram Content			
Detailed Design Consideration	**Control Factor**	**Potential Design Control**	**Noise Factor**	**Output / Function**
- Adequate measures SHALL be taken when designing and manufacturing the cylinder block to ensure no "hanging burrs" exist at the intersection of oil system drillings. **Note**: If burrs exist during engine operation, they can break loose due to fatigue generated by pressure pulsation loading within the oil system. When this occurs, they can flow downstream and fail bottom-end bearing systems.	- 'Manufacturing post-process to remove burr at drilling interface before block wash - Inspection process	- Angle of drill intersection - Drill diameters of intersecting drillings - Drawing specification of "acceptable interface quality"	- Presence of burr - Size of burr	Oil System Cleanliness upon Engine Build

Summary

- Critical Systems place a practical and manageable up-front focus on a product's most-critical and at-risk design elements.
- All Design Quality elements have failure modes requiring potential mitigation in the design concept phase.
- SLA workflow practically enables the "left wing" of the vee, and consistently highlights inherently at-risk "unknowns" early in design process avoiding costly and time-consuming redesigns.
- SLA methodology provides a knowledge foundation that expedites the quality execution of ALL concept design support initiatives including concept development.



Any Questions?

Thank You!

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David Genter. With a 37-year tenure at Cummins Inc., David Genter has held pivotal roles, showcasing his leadership and technical expertise. His significant contributions lie in his specialization designing various internal combustion (IC) engine and electrified drivetrain systems. His leadership in Design Quality and commitment to sustainable practices have led to significant industry innovations. David's Systems Design Engineering (SDE) methodology has transformed system-level design and requirements development. As an SAE International instructor and Subject Matter Expert, he disseminates his groundbreaking techniques. Currently, as Director of Systems Design Engineering, he applies SDE to complex, new technology projects, like a hydrogen generator program. Genter's extensive patent portfolio underscores his enduring impact on engineering.

Stephanie Goerges Bauer. Stephanie is a Systems Engineer with a passion for getting the design right the first time. Her 29-year career in the aerospace and automotive industries includes work in controls, reliability, Design for Six Sigma, and platform strategy where she was recognized with the Chairman's Quality Award. She is a dedicated mentor and a strategic leader in Systems Engineering, establishing vital metrics and forums across global technical centers. She was a System Design and Management Fellow at the Massachusetts Institute of Technology and won the Best Thesis Award for her research in applying System Theoretic Process Analysis to Design for Reliability.

Shamil Baldeosingh. With 12+ years at Cummins, I began my career in Service Engineering, gaining invaluable customer insights. I carried this customer-centric approach into my next role in the Electronics Engineering organization, leading the development of a global software release process. In 2017, I transitioned to Corporate Reliability, where I interact and influence multiple business units and own the global DFMEA process for Cummins. My dedication to our customers fuels my drive to focus on significant risks, help tailor and translate the intent of our processes, and encourage engineers to be more intentional in what they do.

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