SoSECIE Webinar

Welcome to the
2022 System of Systems Engineering Collaborators Information Exchange (SoSECIE)

We will start at 11AM Eastern Time

You can download today's presentation from the SoSECIE Website:

https://mitre.tahoe.appsembler.com/blog

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NDIA System of Systems SE Committee

- **Mission**
  - To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate systems engineering for Systems of Systems (SoS)
  - To identify successful strategies for applying systems engineering principles to systems engineering of SoS
- **Operating Practices**
  - Face to face and virtual SoS Committee meetings are held in conjunction with NDIA SE Division meetings that occur in February, April, June, and August

NDIA SE Division SoS Committee Industry Chairs:
Mr. Rick Poel, Boeing
Ms. Jennie Horne, Raytheon
OSD Liaison:
Dr. Judith Dahmann, MITRE

Simple Rules of Engagement

- **I have muted all participant lines for this introduction and the briefing.**
- **If you need to contact me during the briefing, send me an e-mail at sosecie@mitre.org.**
- **Download the presentation so you can follow along on your own**
- **We will hold all questions until the end:**
  - **I will start with questions submitted online via the CHAT window in Teams.**
  - **I will then take questions via telephone; State your name, organization, and question clearly.**
- **If a question requires more discussion, the speaker(s) contact info is in the brief.**

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2022 System of Systems Engineering Collaborators Information Exchange Upcoming Webinar

Sponsored by MITRE and NDIA SE Division

June 28, 2022

Model Based Systems Engineering in a Digital Environment: Creating a Virtual Testbed for Complex System Architectures

Claudeliah Roze

https://www.mitre.org/capabilities/systems-engineering/collaborations/system-of-systems-engineering-collaborators

Leveraging Set-Based Practices to make Agile Practices more effective for System-of-Systems Engineering

Brian M. Kennedy
CTO
Targeted Convergence Corporation

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Scaling Agile Practices to System of Systems Engineering is Appealing!

Agile is all the rage...

- And it is not just hype…
- Agile has consistently delivered a long list of valuable benefits to software development teams
- Agile practices are often 'simple' in nature and thus inherently appealing in a world with too much complexity

SoSE needs what Agile delivers...

- In a world where 'emergence' is a major issue, many of the Agile benefits sound particularly appealing!
- *However, as you might guess, simply applying Agile as the software teams do might not be adequate for SoSE…*

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Key Differences that impact Scaled Agile

Hardware Development...

- Physics! Hardware must obey the laws of physics, chemistry, etc.
- Manufacturing is separate from development. Hardware development doesn't deliver "product" to the customer, manufacturing does.
- Due to the many different physics areas of expertise, there is need for a lot more engineer specialization in hardware.

Software Development...

- Software can do essentially anything the developers can imagine.
- Software development works directly on the product that gets delivered to customers.
- Most experienced software engineers can do at least lightweight work in most any area, whether database, logic, user interfaces, etc.

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Key Differences that impact Scaled Agile

Hardware Development...

- Because of those specializations, it is typically necessary for teams to share key experts (which breaks several Agile techniques, like independently measuring team velocity).

- There is a fundamental difference between "the model" (software for simulating the hardware for early testing) and "the product" (the actual hardware).

Software Development...

- It is practical to have engineers dedicated to specific teams over extended periods such that they can learn their team velocity and independently schedule the team's backlog.
- The product is software such that there is rarely need for a separate model of the product. It is reasonable to develop the product itself for testing (the minimum viable product).

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Key Differences that impact Scaled Agile

System of Systems Development...

- Each system team needs different deep expertise for their different users and target situations — compounding the specialization problem.
- The different systems often have different suppliers with different corporate goals, different priorities, different timings, and different management.

Software Development...

- Although they may have a variety of target customers for different apps, the basic interfaces between software and humans or other software is fairly consistent.
- Because of all the other consistency in software Agile, it is relatively easy for separate software companies to benefit from and leverage the Agile practices of their suppliers.

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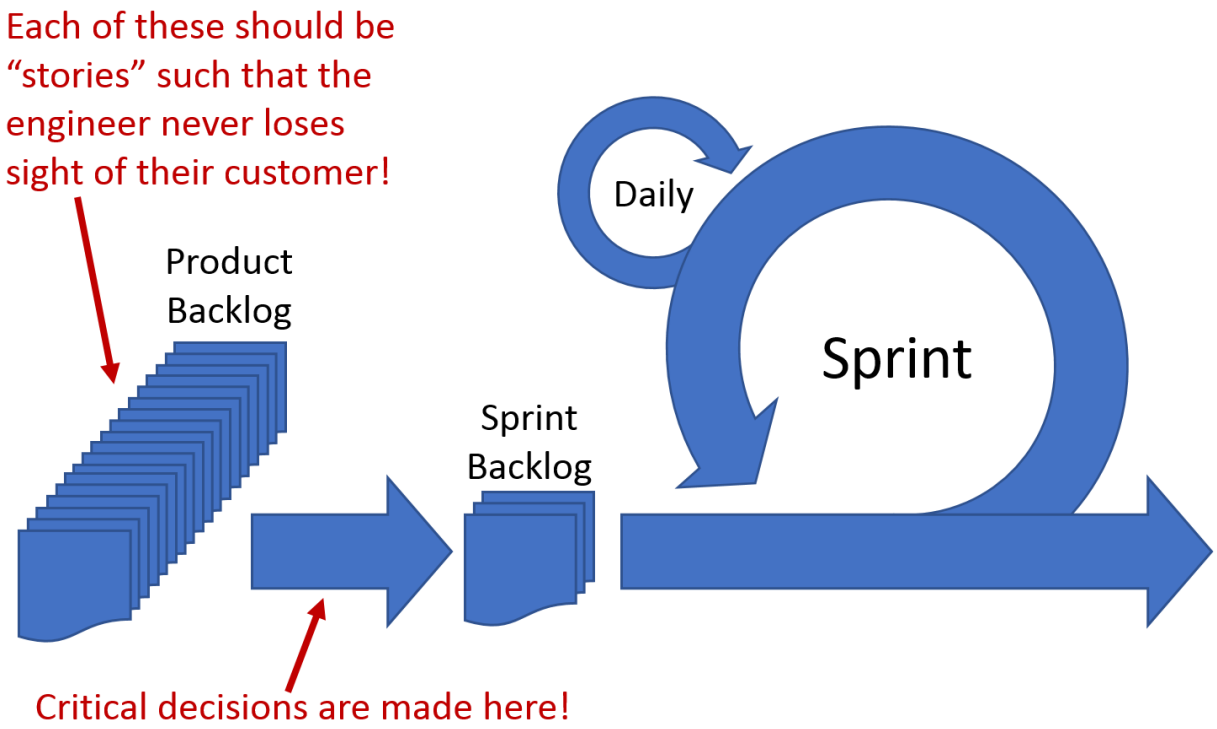
Agile's Backlogs of Stories

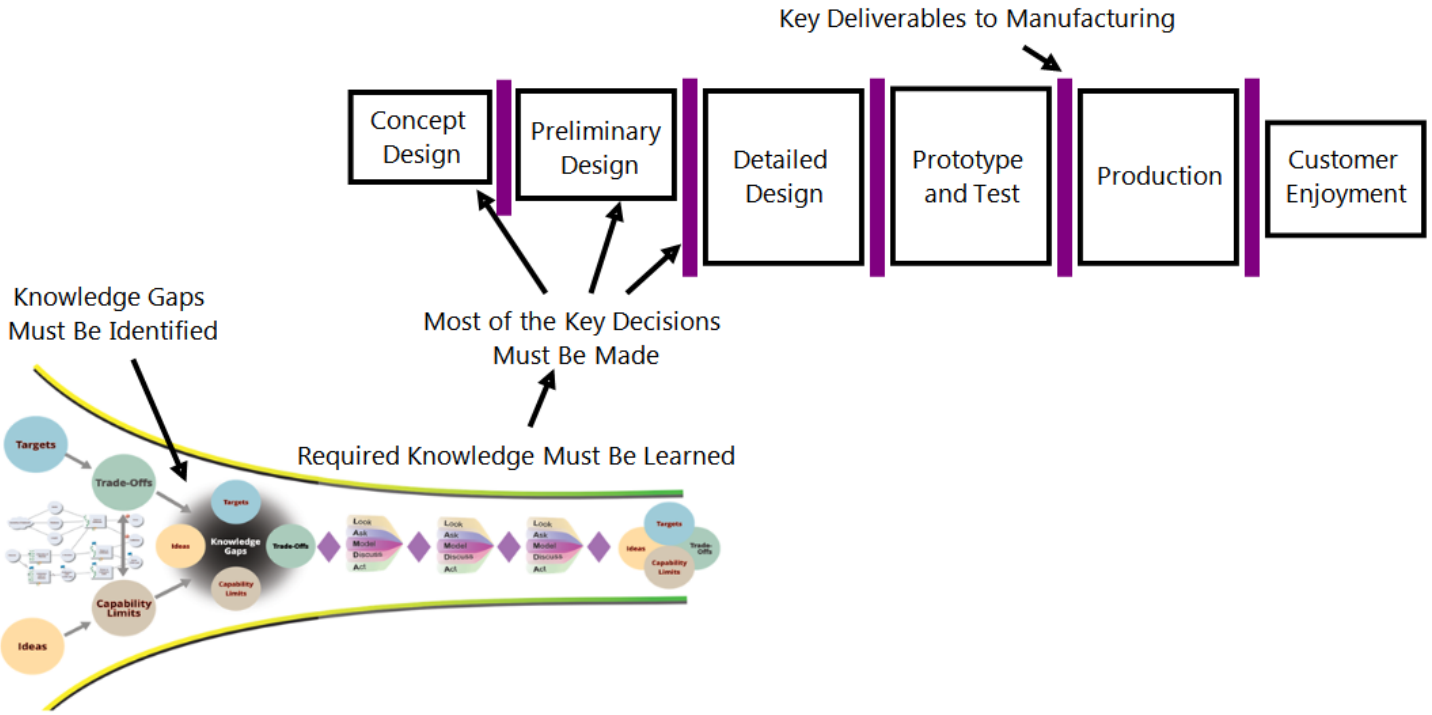
- Perhaps *the* key mechanism in Agile is the "Backlog" of "Stories" that get prioritized and planned into each "Sprint".
- Those are "stories" rather than traditional "tasks" because Agile wants the engineers to remain focused on the customers' needs in a coherent way.



Agile's Backlogs of Stories — Different Stories for Hardware Development

In hardware, because development targets manufacturing directly and the end user indirectly, and because models are used for learning more often than prototypes or final product, there is need for four different kinds of "stories":

1. knowledge gap identification stories
2. knowledge gap closure stories
3. decision convergence stories
4. manufacturing deliverable stories



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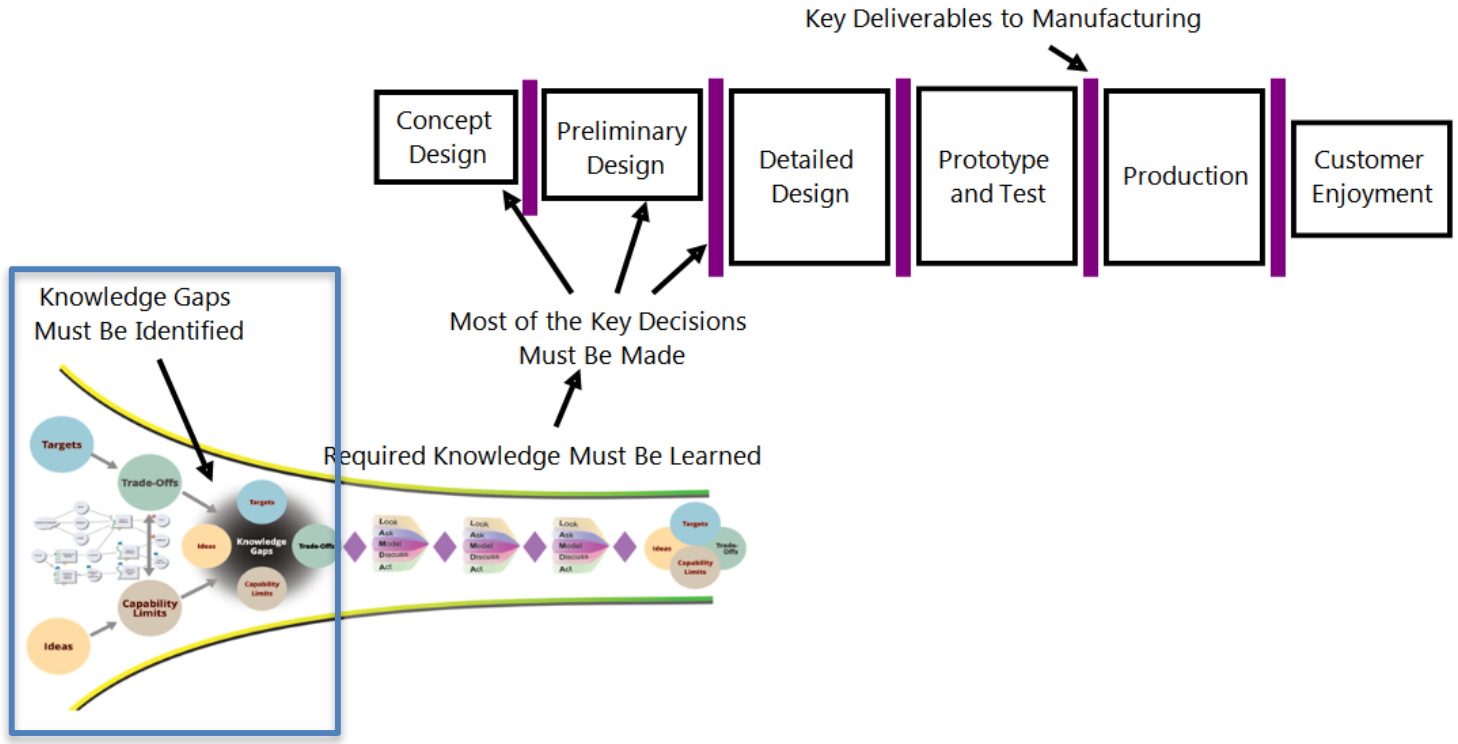
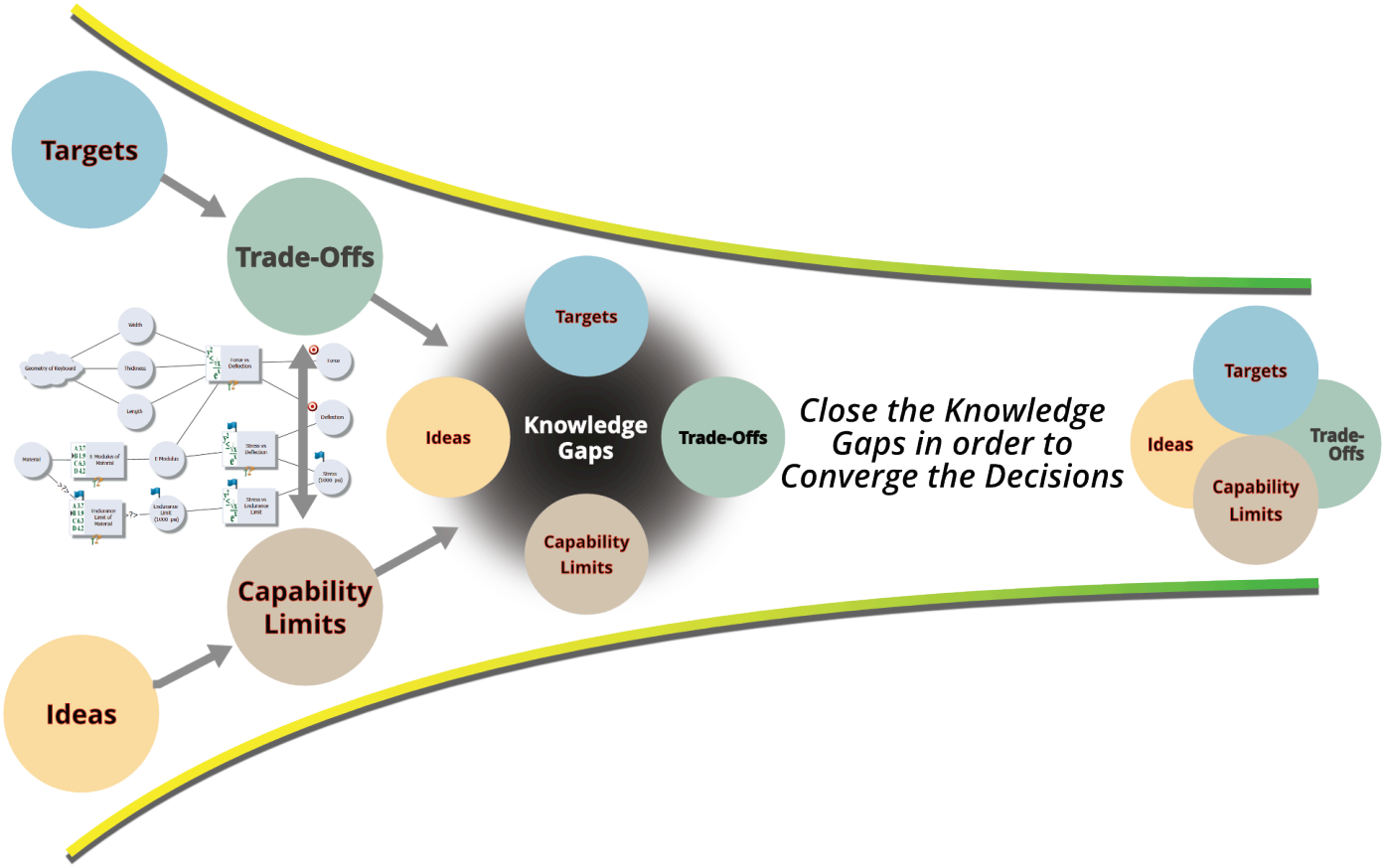


Identifying the Knowledge Gaps

We start with the Targets and the Ideas on how to achieve those Targets, map those to the Capability Limits, and that exposes the Trade-Offs that will need to be made. There will be Knowledge Gaps regarding each of those four, plus Gaps in how those four connect. We have to close those Gaps before we can make those Trade-Off Decisions.



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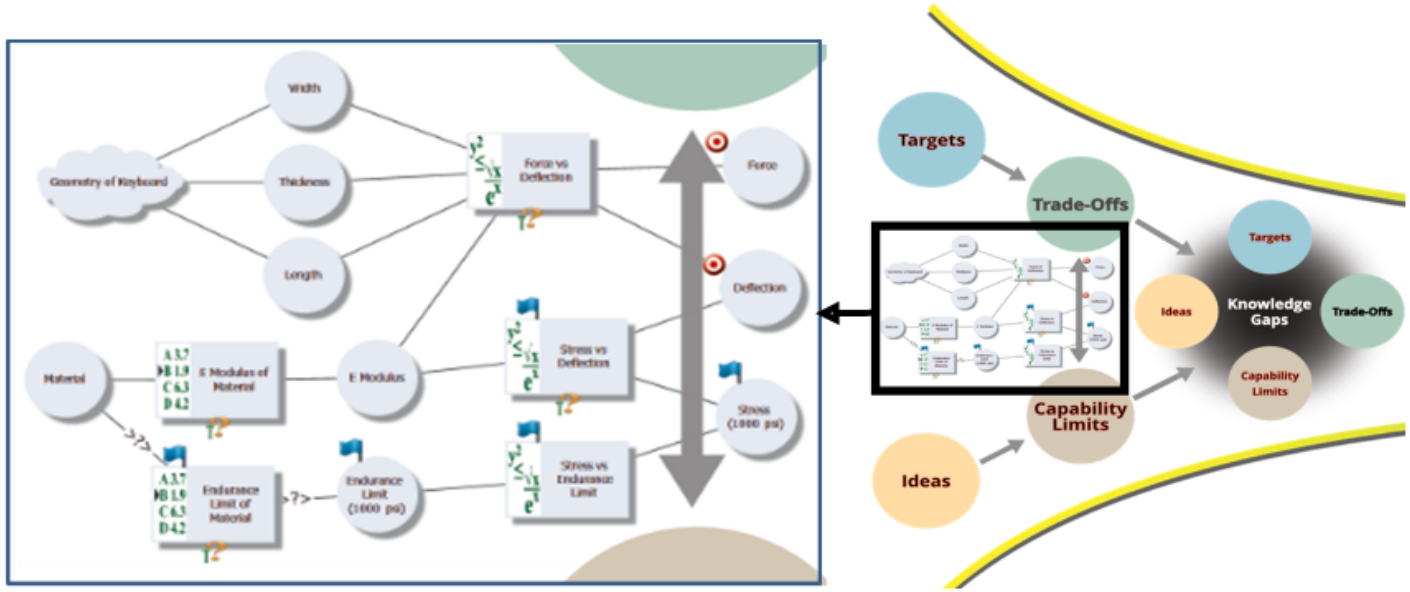
The Critical Role of the Causal Decision Map

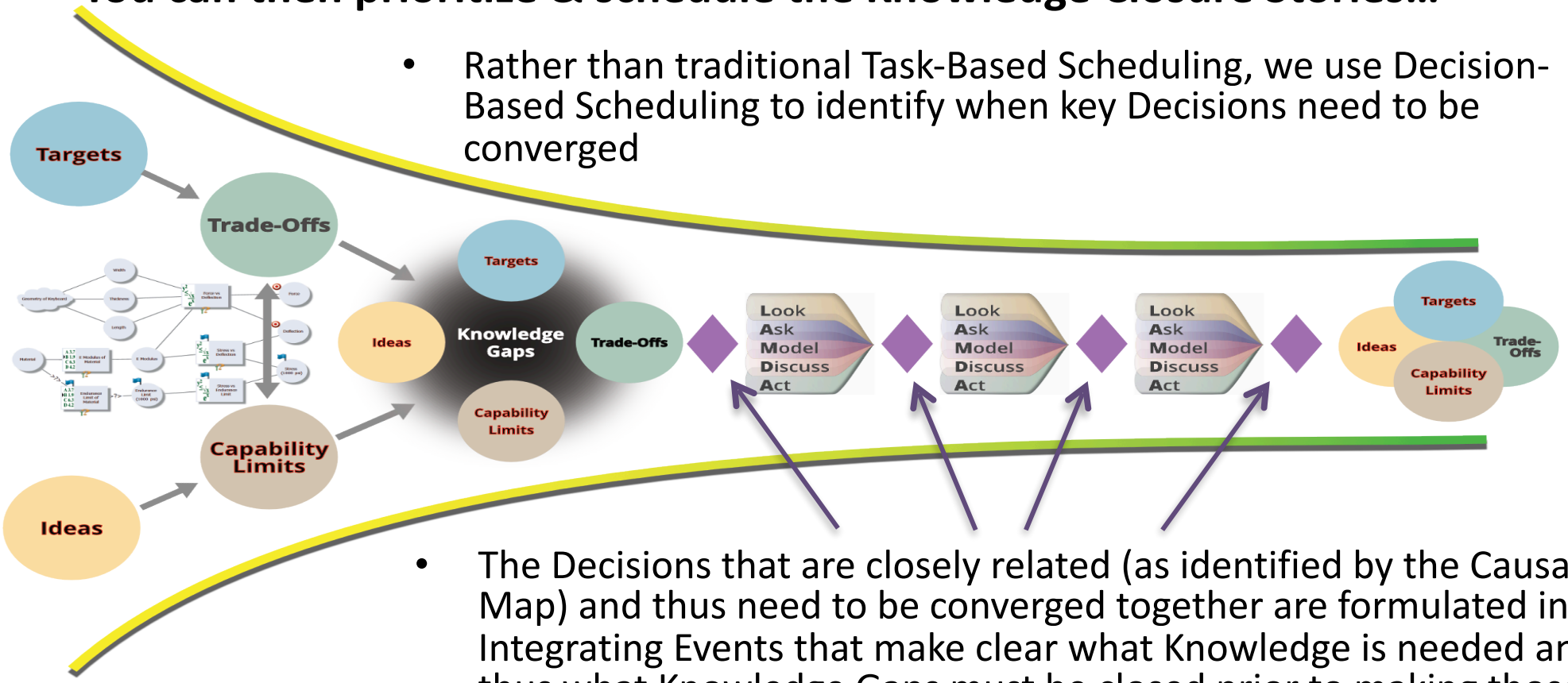
The Causal Map makes those first three kinds of story concrete. And making stories concrete is key to being able to apply the Agile practices effectively.

Hence, we assert that the Causal Map (or something similar) is key to the effective application of Agile to hardware teams.



You can then prioritize & schedule the Knowledge Closure Stories…

- Rather than traditional Task-Based Scheduling, we use Decision-Based Scheduling to identify when key Decisions need to be converged



- The Decisions that are closely related (as identified by the Causal Map) and thus need to be converged together are formulated into Integrating Events that make clear what Knowledge is needed and thus what Knowledge Gaps must be closed prior to making those decisions in order to avoid rework later.

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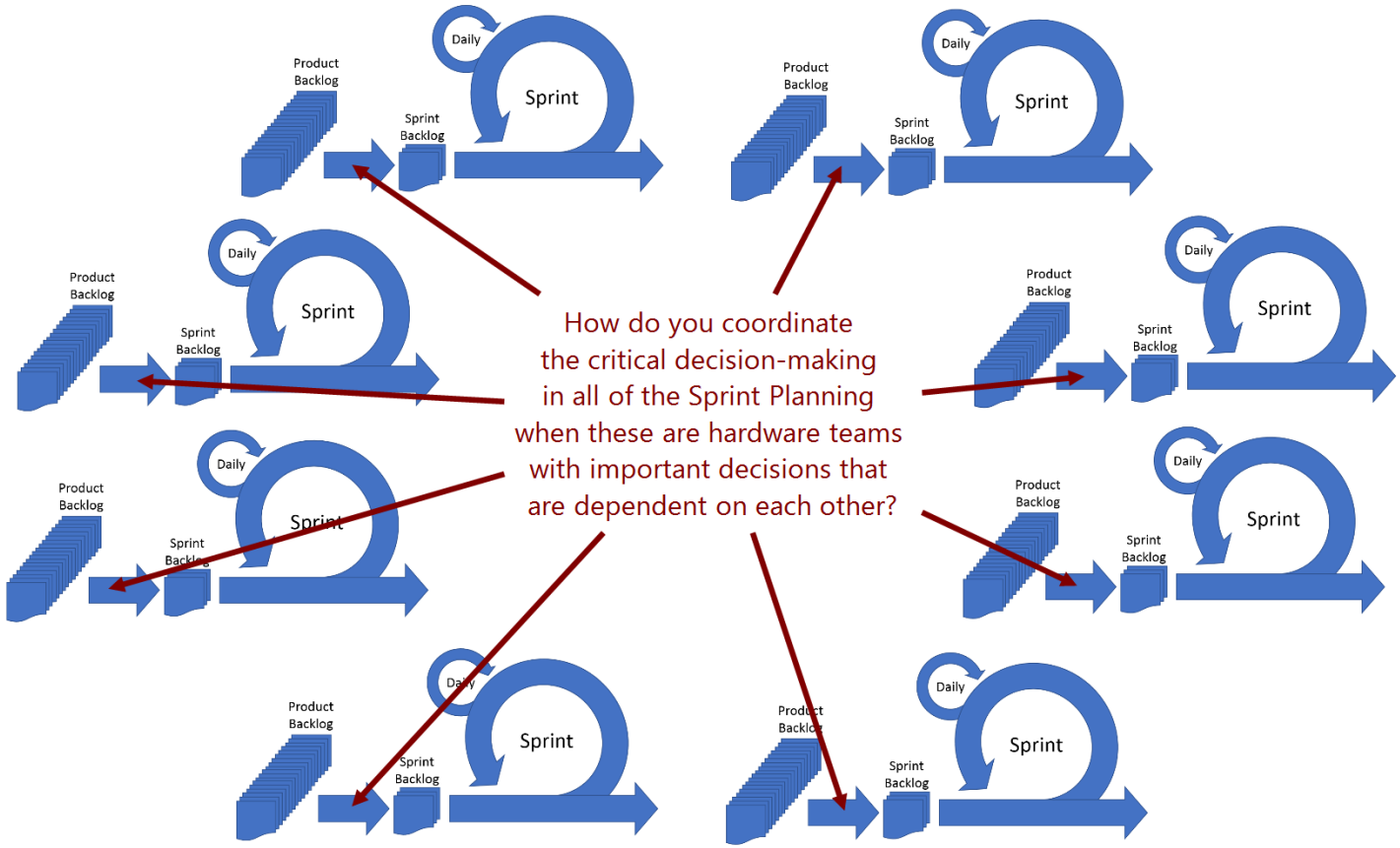
Agile's Backlogs of Stories — Different Stories for Hardware Development

With Hardware Development teams needing to be split and/or needing to share experts with specialized areas of expertise, there is often need to supplement traditional Agile practices with some ability to manage across team lines.

The Causal Map can come to the rescue by being a visual model of the stories in the Backlogs.



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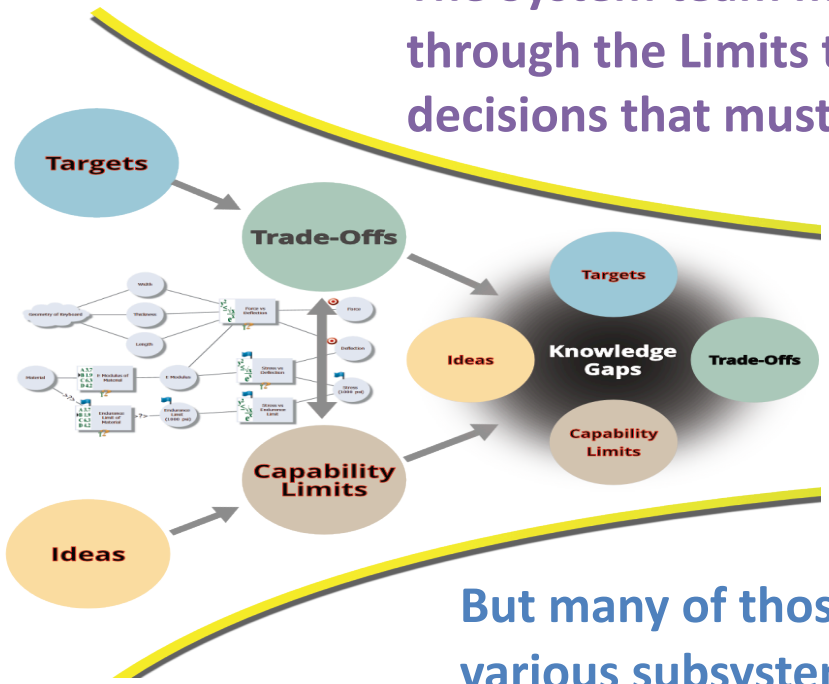
But that must be Coordinated across Subsystem Teams…

The System team maps the Targets and Ideas through the Limits to identify the Trade-Off decisions that must be made…



and identify the Knowledge Gaps that need to be closed to establish that "Success is Assured".

But many of those Knowledge Gaps may require the expertise of various subsystem teams (some in suppliers' organizations)…

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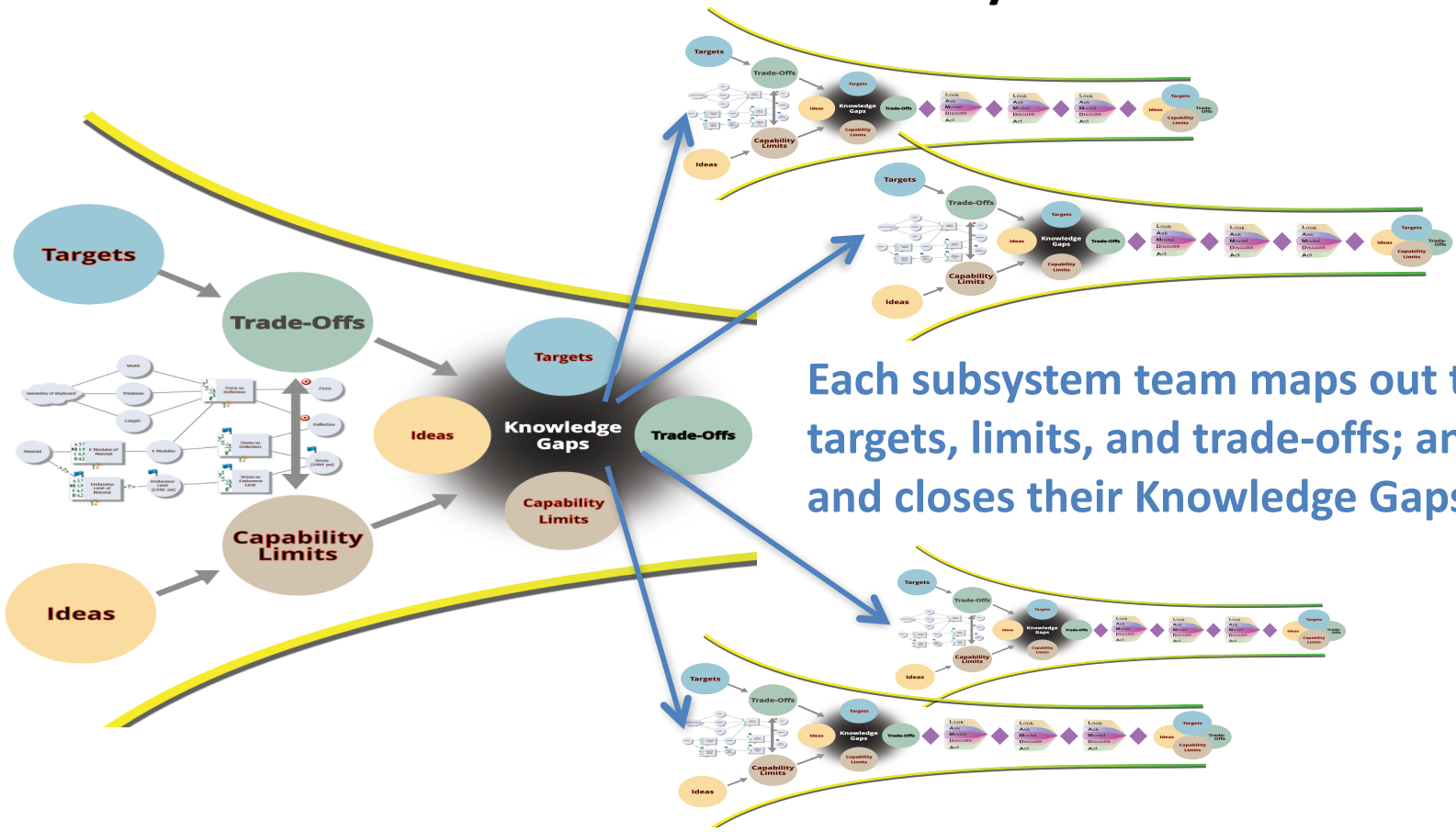
But that must be Coordinated across Subsystem Teams…



Each subsystem team maps out their subsystem targets, limits, and trade-offs; and then identifies and closes their Knowledge Gaps.

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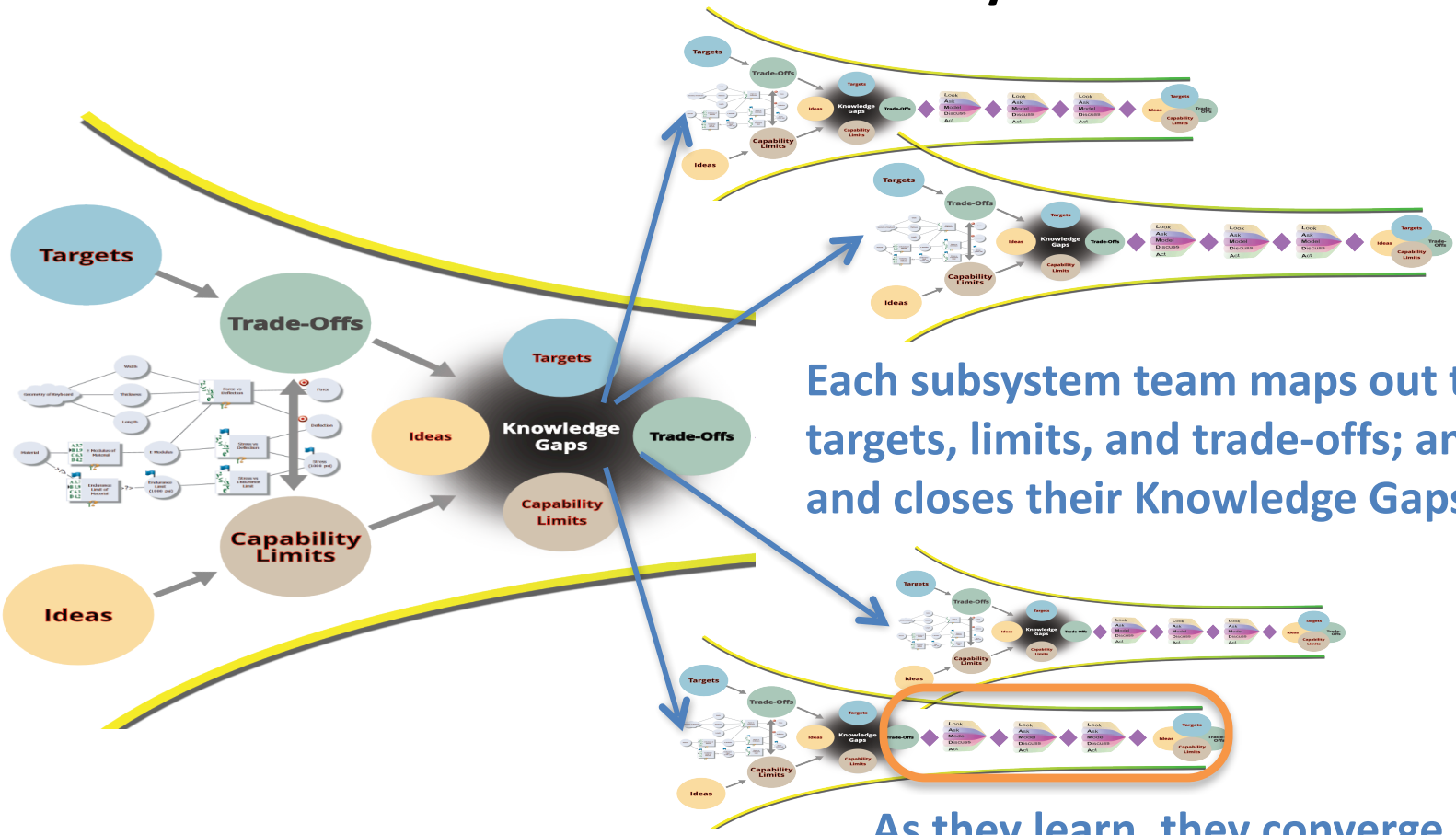
But that must be Coordinated across Subsystem Teams…



Each subsystem team maps out their subsystem targets, limits, and trade-offs; and then identifies and closes their Knowledge Gaps.

As they learn, they converge decisions that may impact others' design spaces.

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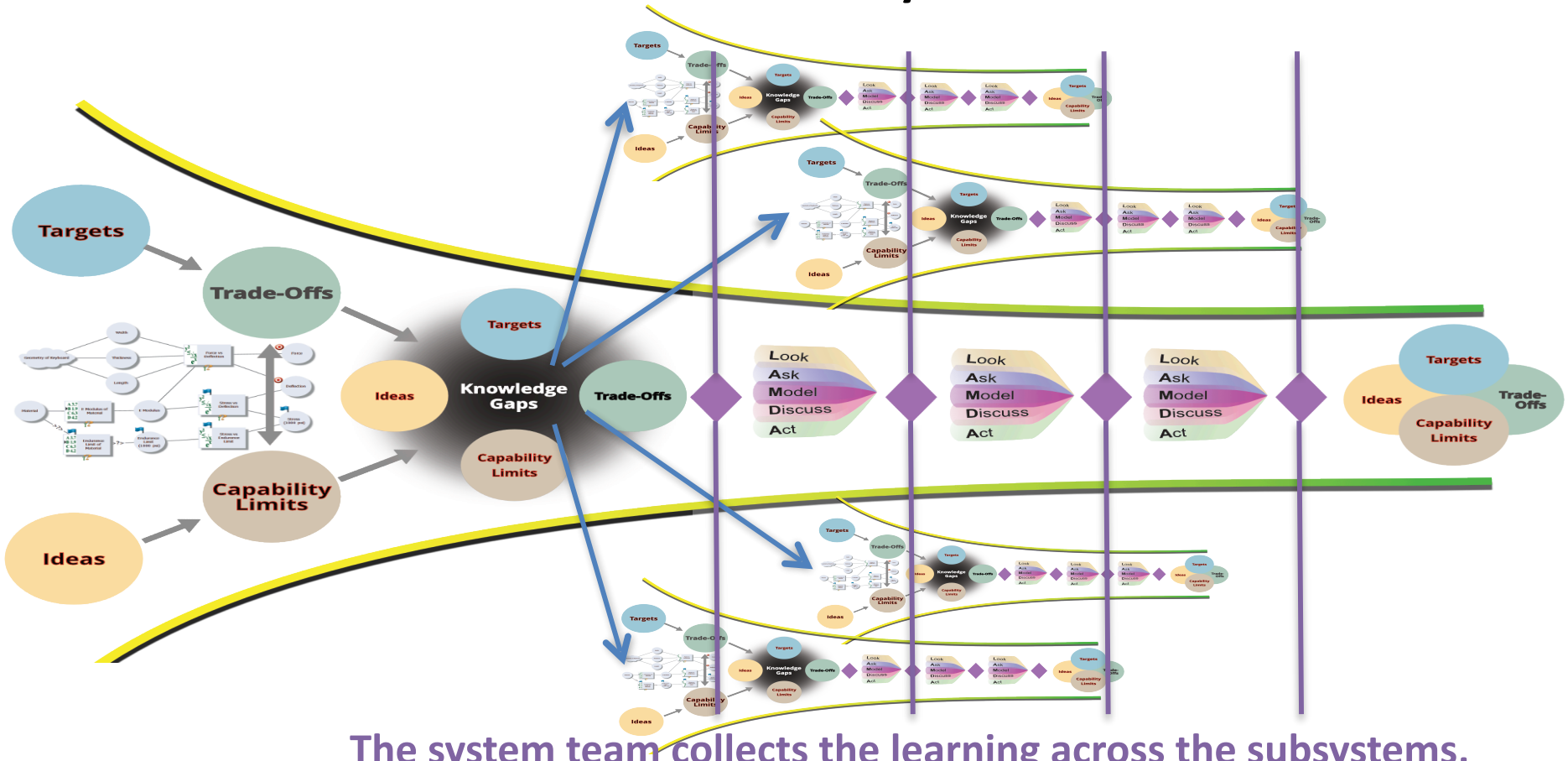

The system team collects the learning across the subsystems, makes system decisions, and communicates those to other teams.

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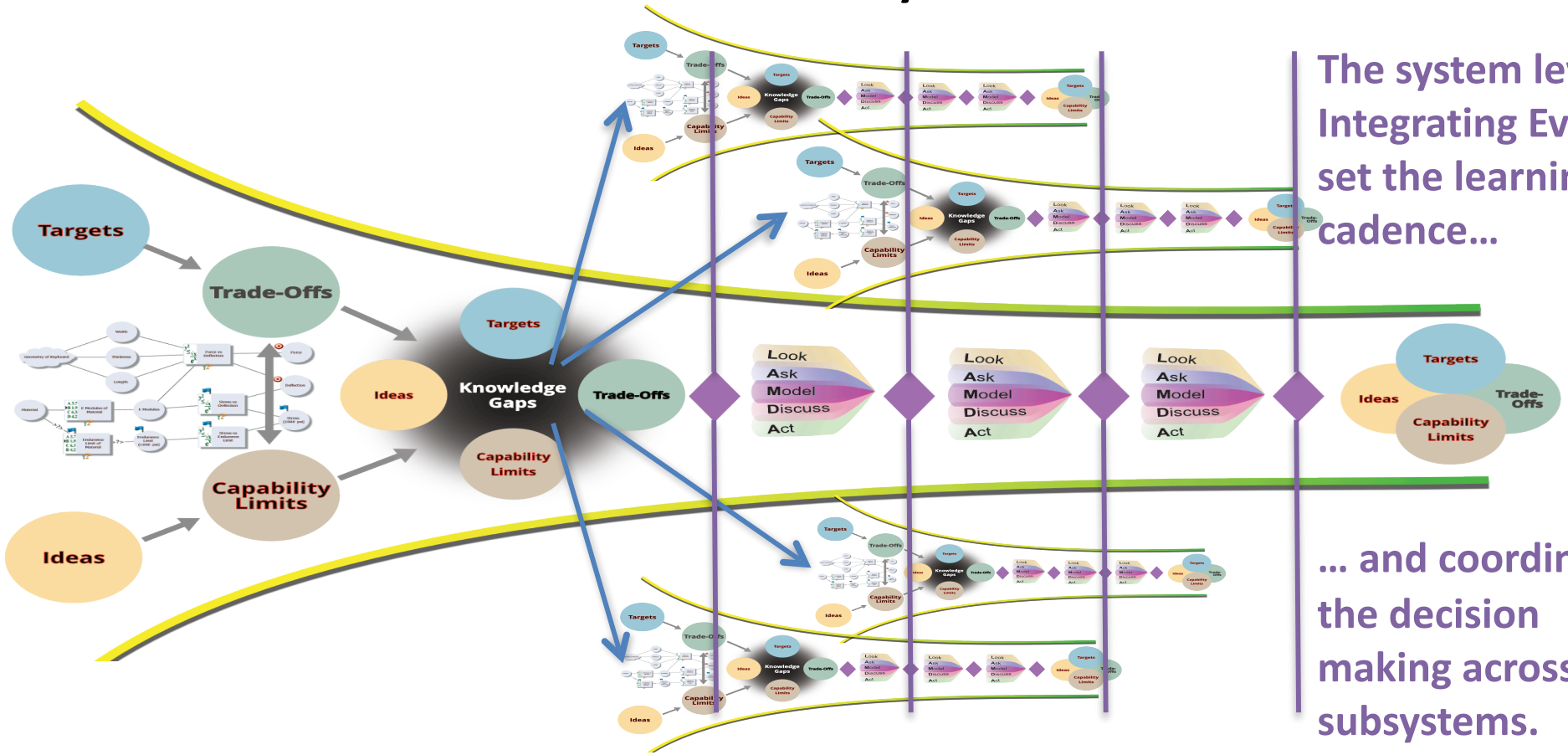

The system level Integrating Events set the learning cadence…

… and coordinate the decision making across the subsystems.

** Integrating Events are NOT the same as program milestones, but may be pulled by them.*

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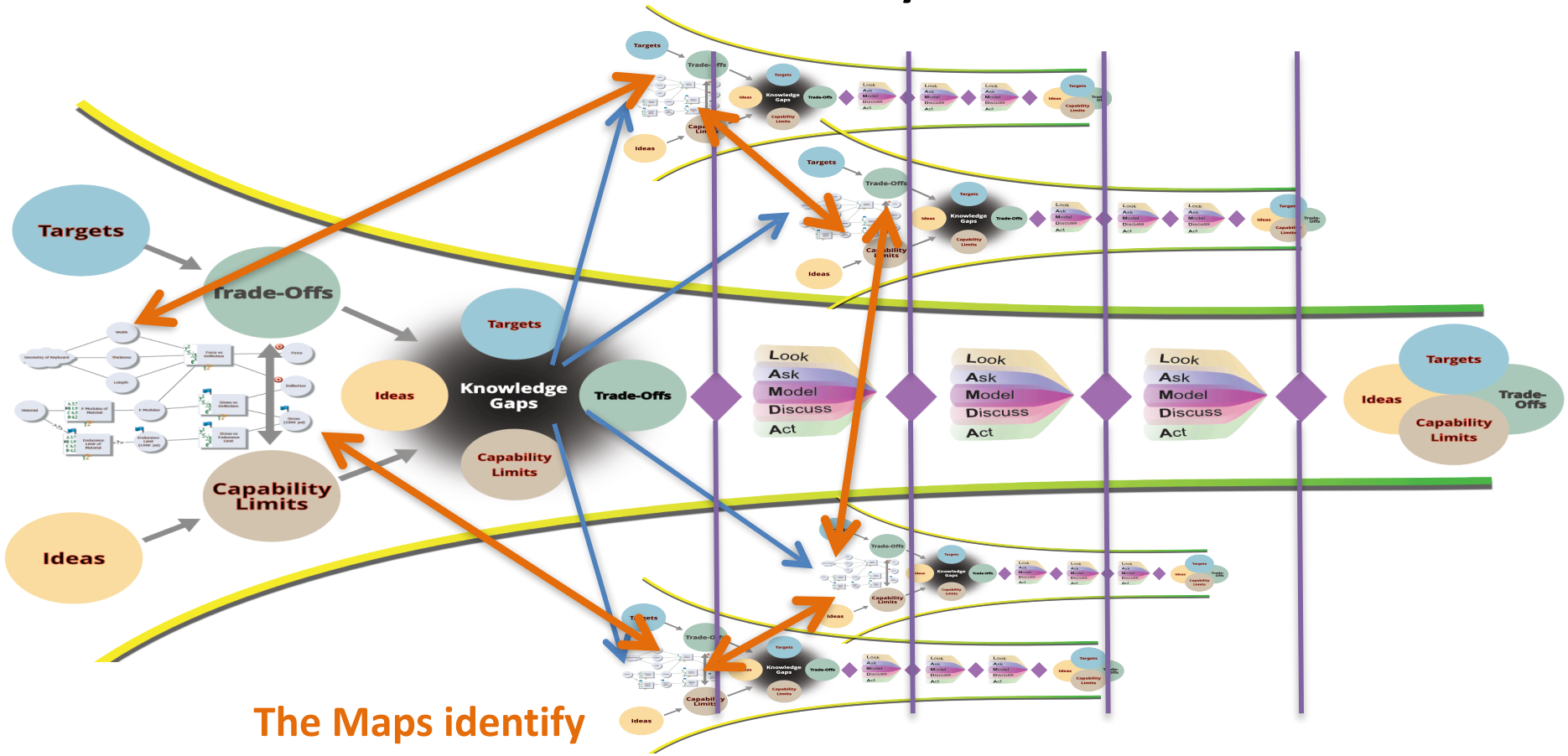

The Maps identify the "Interface Decisions" that are shared across teams, calling for collaboration.

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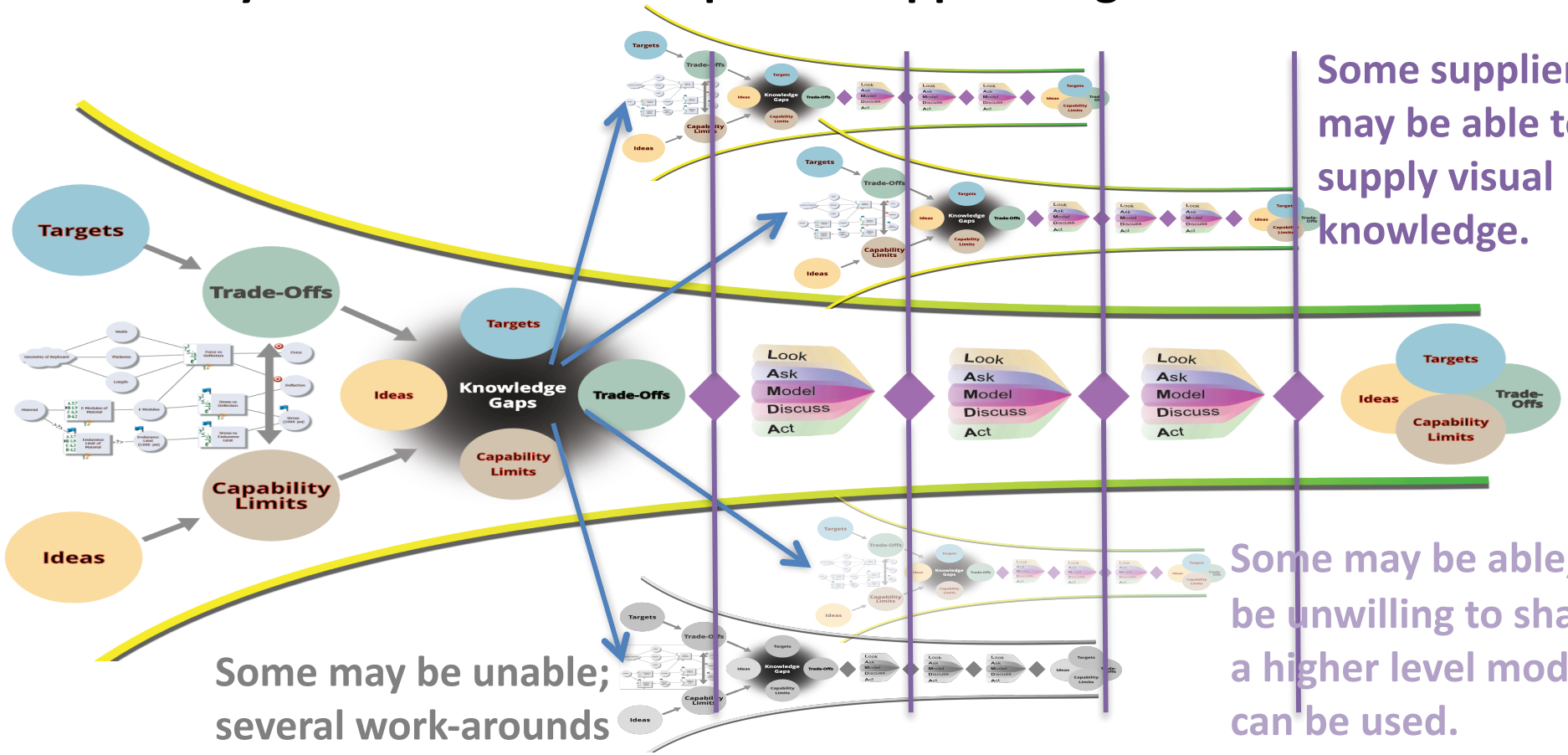
Often Subsystem Teams are in separate Supplier Organizations…



Some suppliers may be able to supply visual knowledge.

Some may be able, but be unwilling to share – a higher level model can be used.

Some may be unable; several work-arounds are possible…

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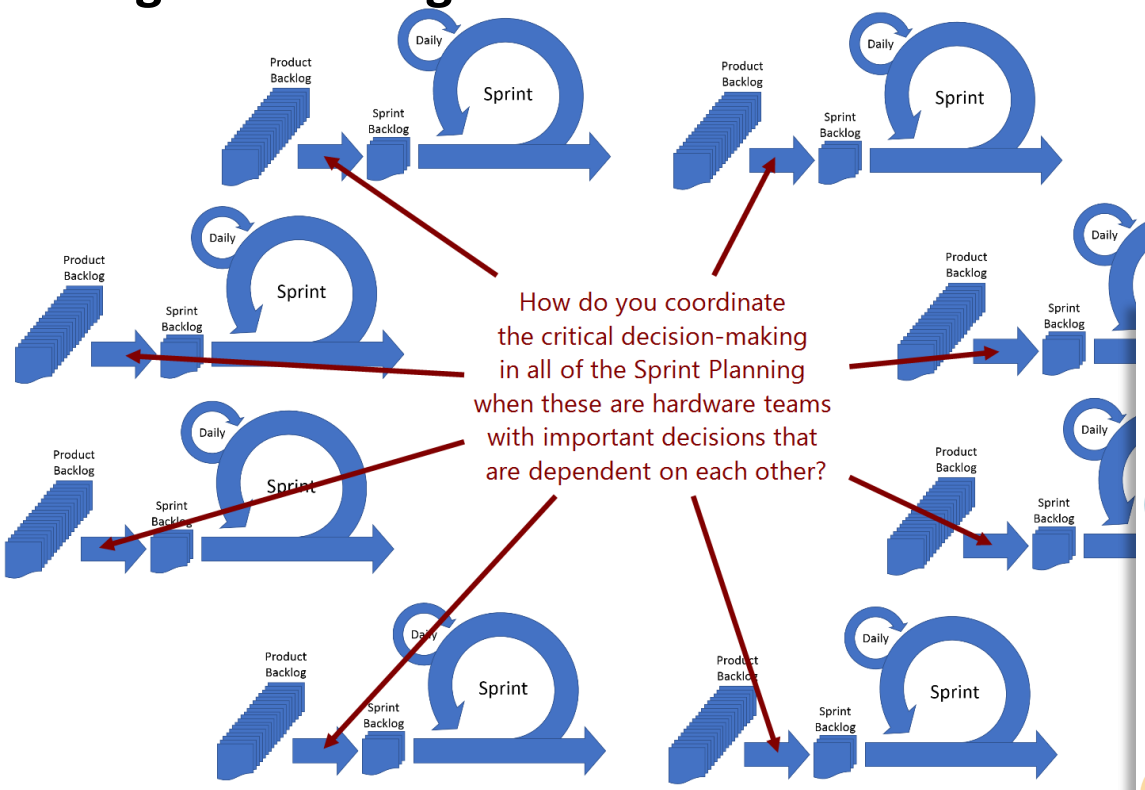
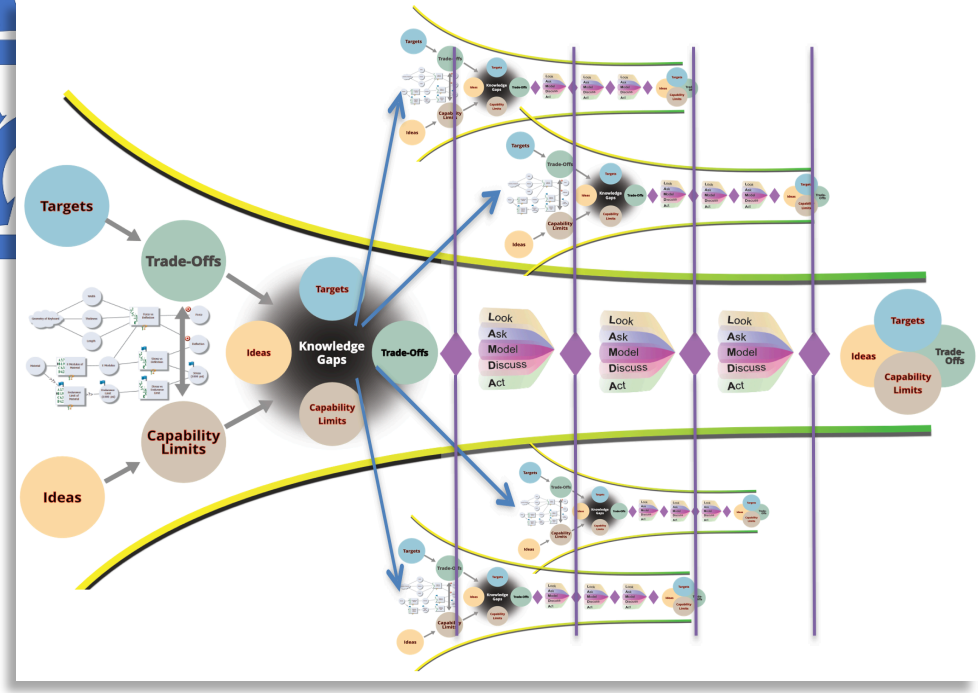
Agile's Backlogs of Stories — Coordinated via Causal Maps & Integrating Events





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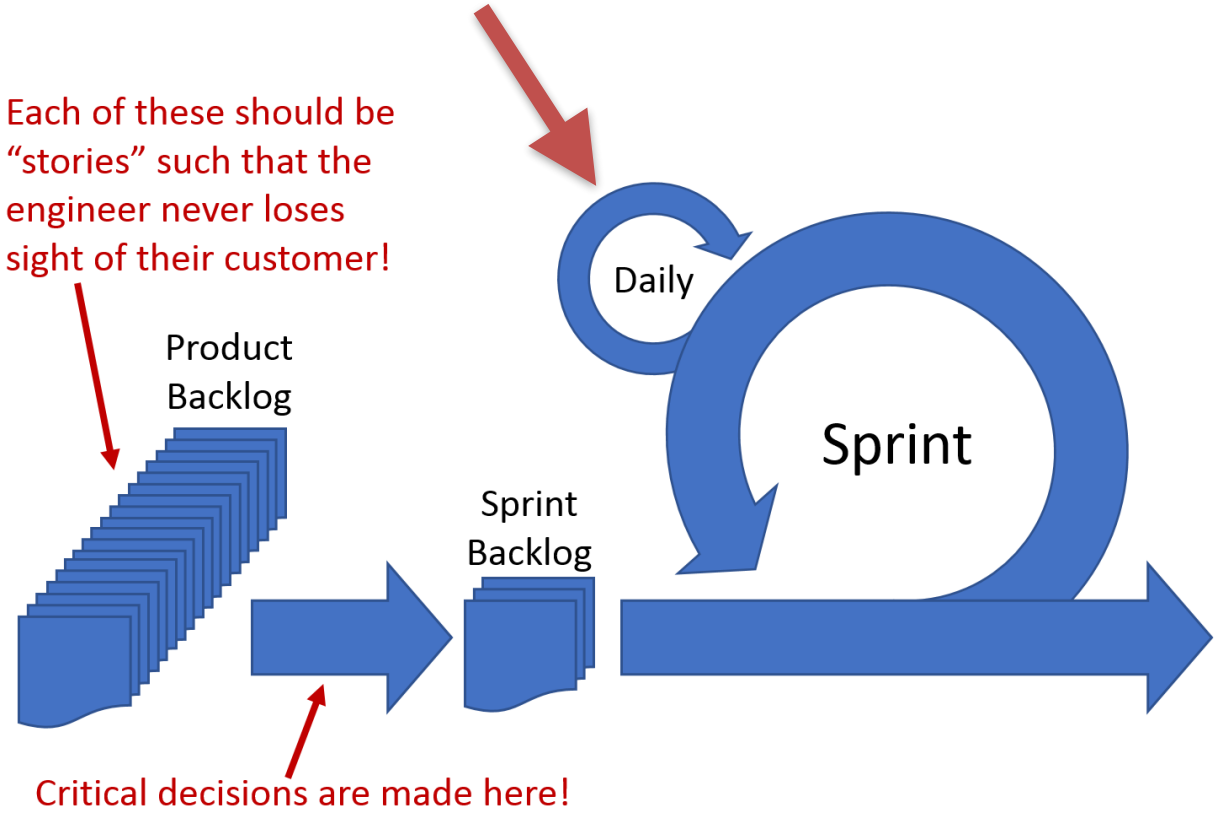
Agile's Daily Stand-Ups is Another Key Mechanism

- For software there's much less need for separate visual models.
- For hardware, those separate visual models are the primary focus of all the early collaboration that needs to be happening in the Daily activities.

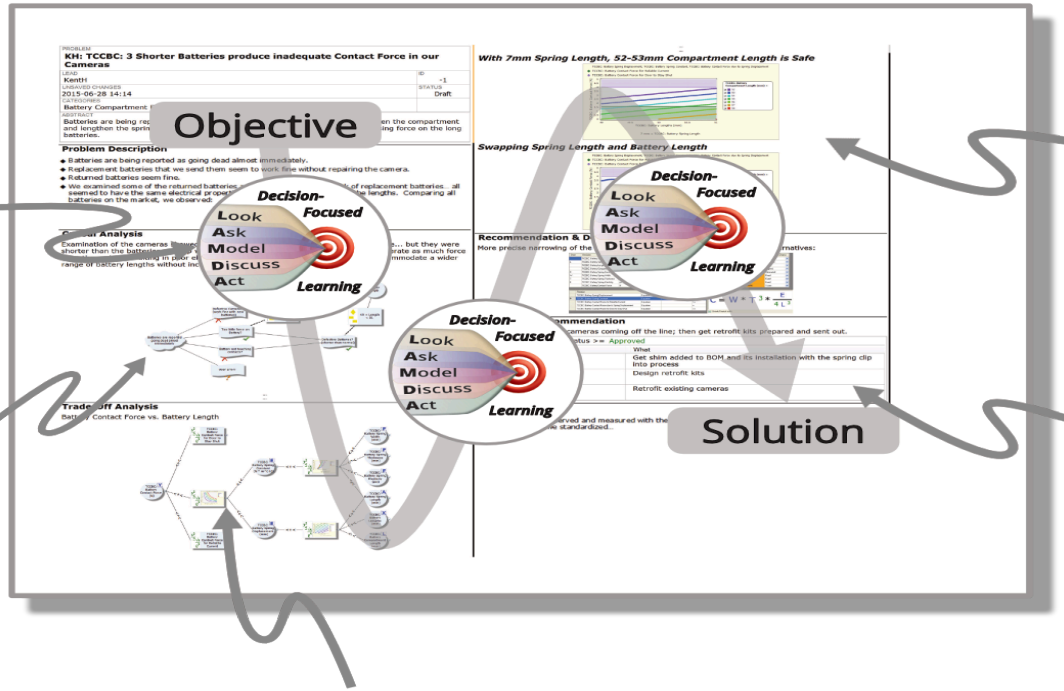


The Knowledge Gap Closure and Decision Convergence Stories are told in K-Briefs

- K-Briefs (aka. Knowledge Briefs) collect together all the Visual Models that together tell the LAMDA-Learning story to facilitate efficient Discussion

LAMDA guides efficient, collaborative learning.

Causal Maps identify the decisions, trade-offs and knowledge gaps.



Trade-Off Charts enable optimized decisions and validated knowledge for reuse.

Decision-Based Schedules establish timing and priorities.

Decision Maps provide the knowledge for convergence.

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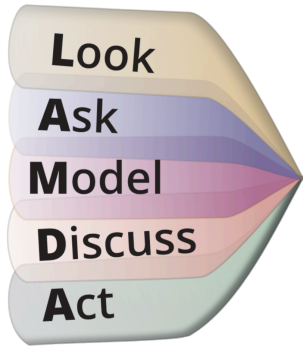
Briefly, LAMDA is 5 Elements of an Efficient Collaborative Learning Process

- Whenever you are in a 'heated' meeting or people are disagreeing, we want you to be thinking:
  - These are smart people.
  - If they are disagreeing, it is probably because they have different assumptions, different knowledge gaps, or are otherwise miscommunicating.



- In those situations, think "LAMDA":
  - Can we just go **Look** at the real thing in its real environment? Can we measure it?
  - Can we go **Ask** someone who might have a different perspective or a different set of assumptions or who might be able to close some of the knowledge gaps?
  - Can we **Model** this visually to eliminate the miscommunication or expose the knowledge gaps or assumptions?
  - Who else needs to be pulled into this **Discussion**?
  - Can we **Act** on what we have Discussed so far and measure the impact to validate or invalidate some of the assumptions or close some of the knowledge gaps?

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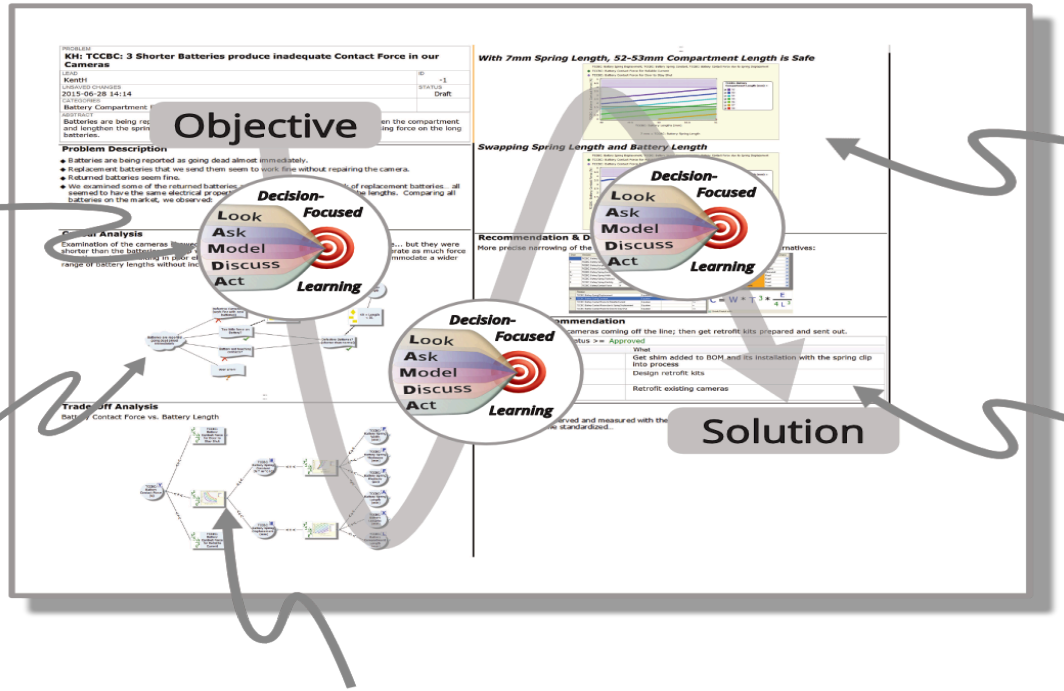

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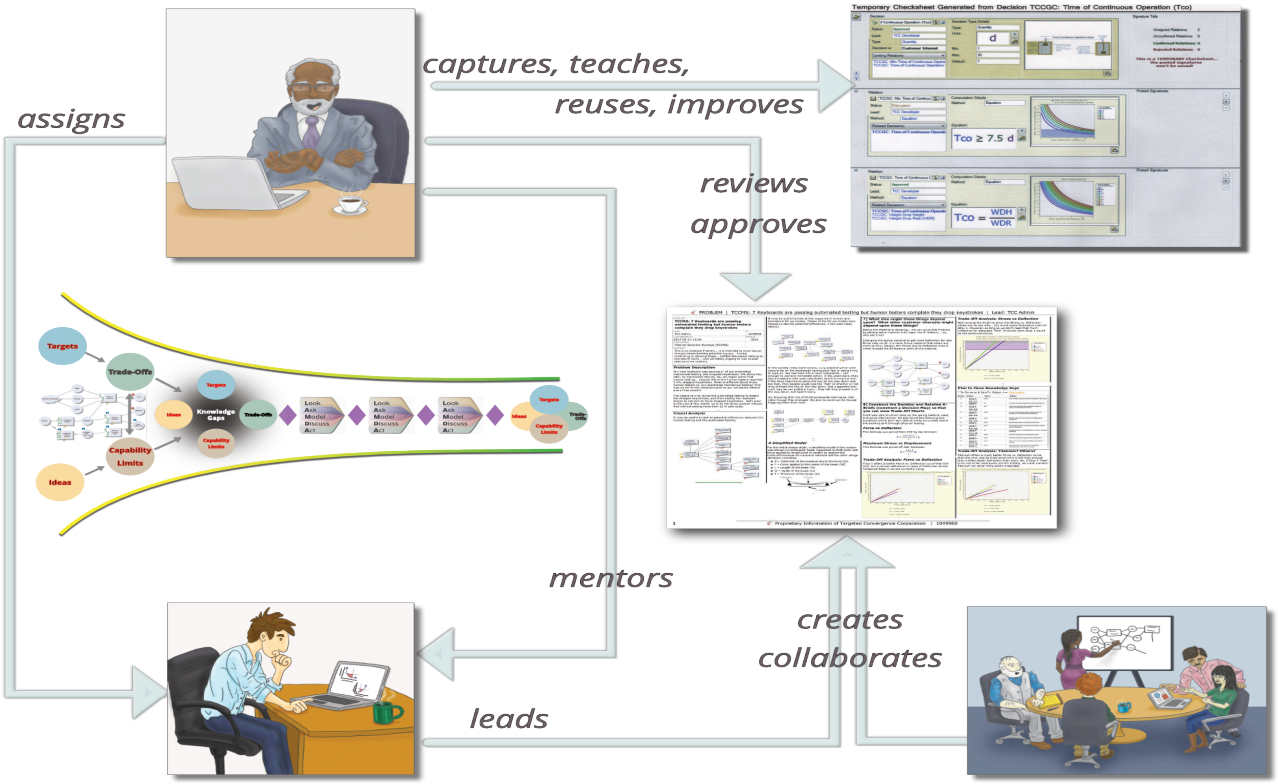
The Knowledge Gap Closure and Decision Convergence Stories are told in K-Briefs

- Around each K-Brief is a Cadenced Mentoring process…
- Each K-Brief not only has a Lead, but also a Mentor assigned
- The Mentoring happens on a rapid Cadence, embracing the principles typically associated with Agile processes (regular short stand-up meetings, sprints, reviews, etc.)
- The mentor role includes identification of the knowledge that should be made part of the larger organization's best practices…



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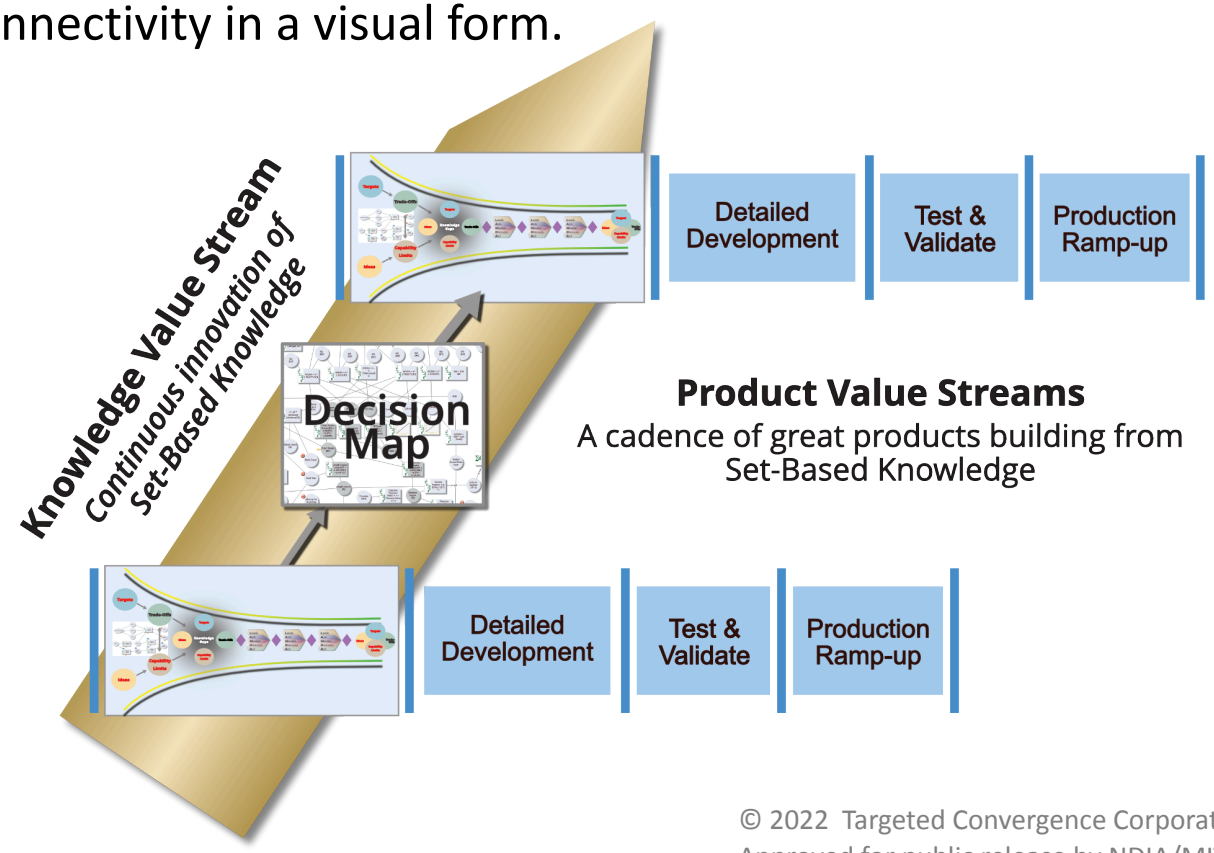
Establishing the Knowledge Value Stream

- Those best practices, and growing knowledge, flow from project to project, and from subsystem to subsystem within each project, by virtue of the Causal Decision Maps that provide the connectivity in a visual form.



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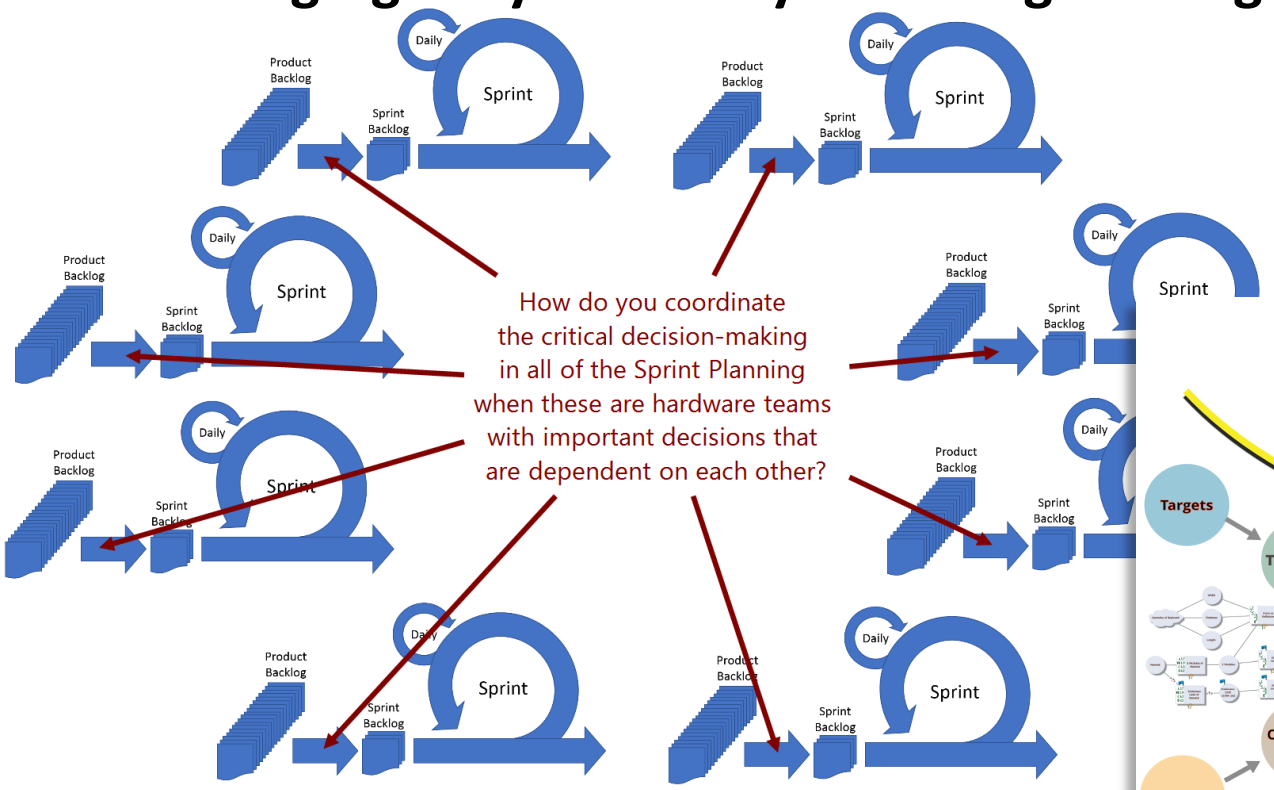
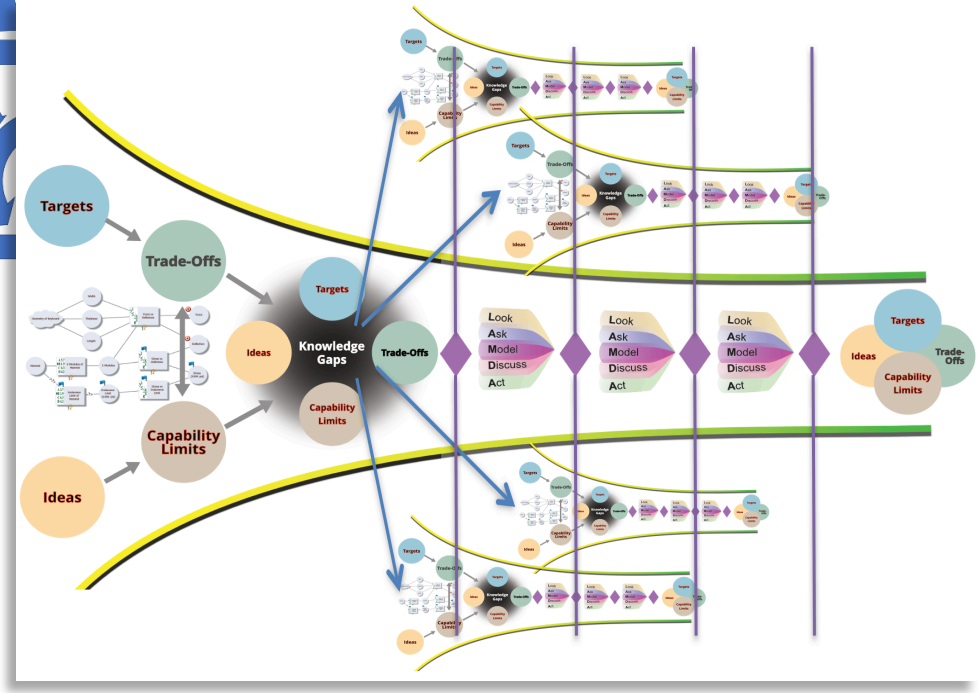
Enabling Agile System of Systems Engineering



- Mentored Cadence of K-Briefs
- Causal Decision Maps
- Integrating Events
- Set-Based Convergence



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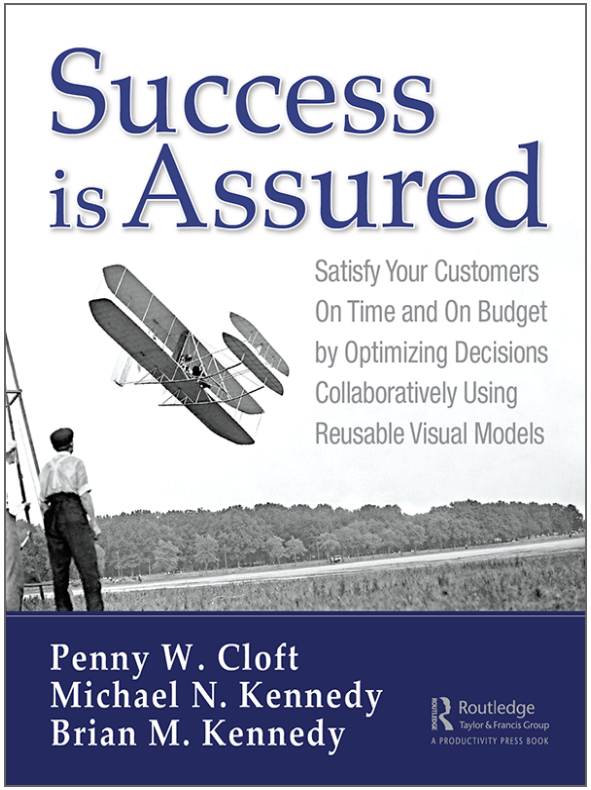
Any Questions??

- There's a short (2-minute) video trailer on our book at:
  http://SuccessIsAssured.com/



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