The Conversation

SE Tailored to Science and Technology

AFRL/RX Systems Engineering Team
Bob Rapson, Bob Enghauser, Jim Malas, AFRL
Carol Ventresca, Tom Archer, Bryan DeHoff, SynGenics Corporation
Bill Kesling, General Dynamics Information Technology
Gerry Hasen, Universal Technology Corporation
Bob Stroud, R. B. Stroud and Associates

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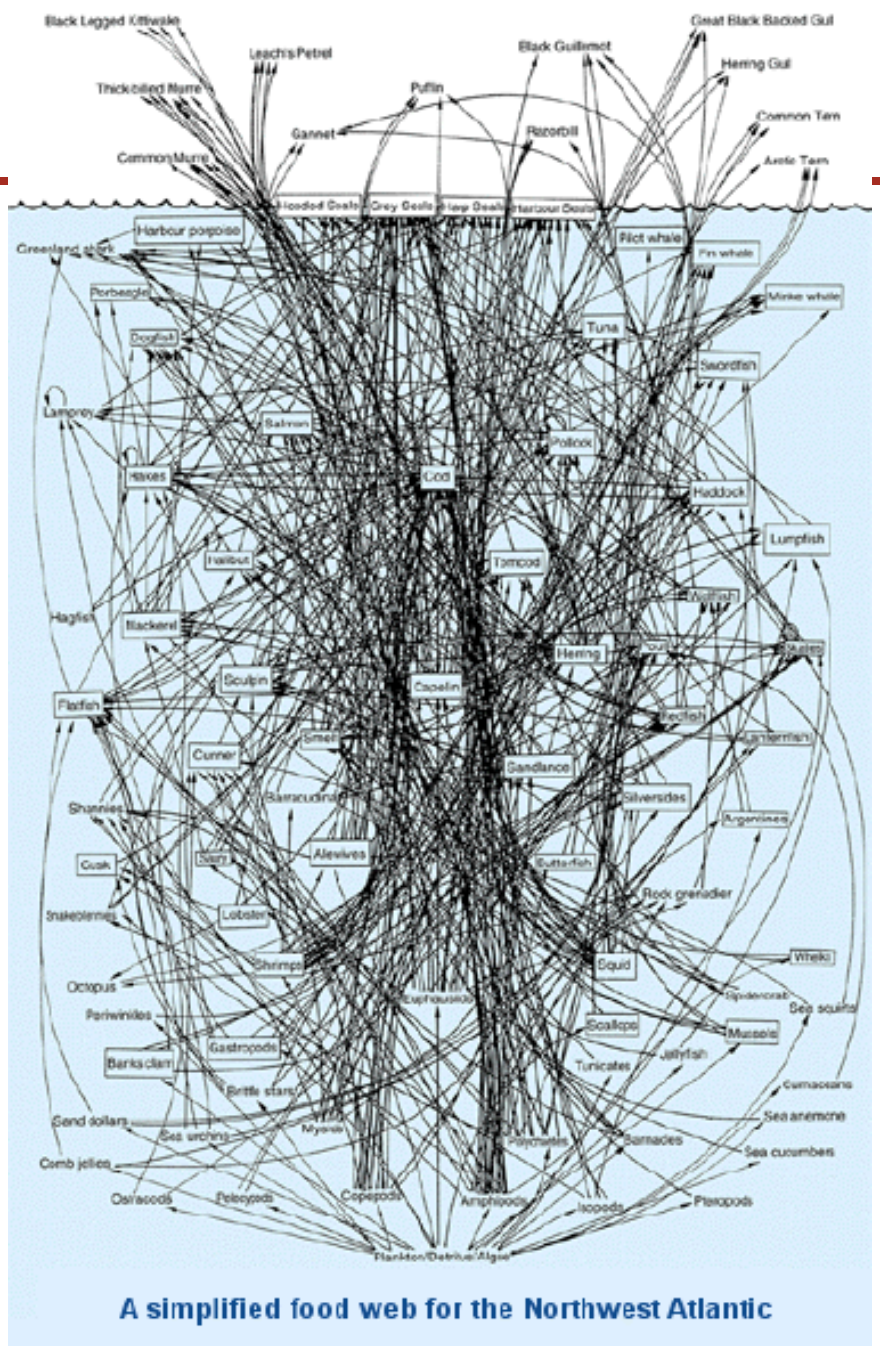
Applying Systems Engineering to the Science and Technology Phase of Acquisition

- **A recent emphasis within the DOD is to apply the essential elements of systems engineering earlier in the acquisition cycle to include even the early aspects of science and technology.**

- **The objective of S&T is to deliver the right high impact technology to the AF and our Systems Engineering approach helps assure we understand what prospective warfighters/end users want and need. It helps us identify the obstacles to implementing that technology as well.**

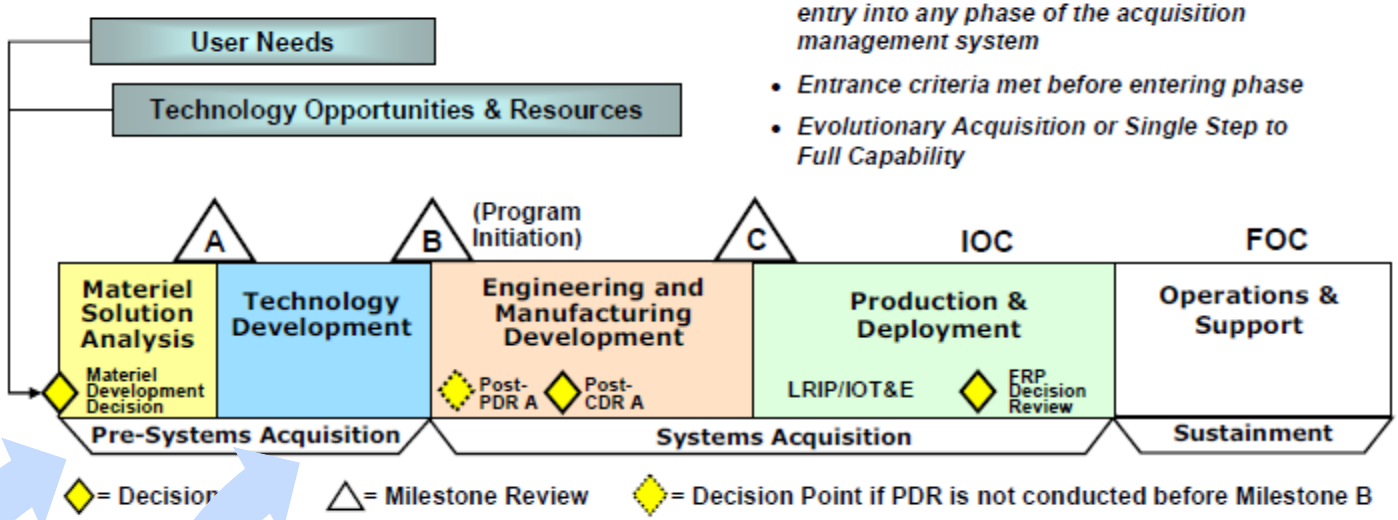
Instead of the Wall Chart

Systems Engineering is the key to solving complex problems



Lavigne, David, "Chap 2, Mairine Mammals and Fisheries: The Role of Science in the Culling Debate" Marine Mammals; fisheries, tourism and management issues. Gale, N, Hindell, M, and Kirkwood, R Ed. Csiro Publishing, 2003, Pg 40.

The DOD Acquisition Cycle (Simplified)

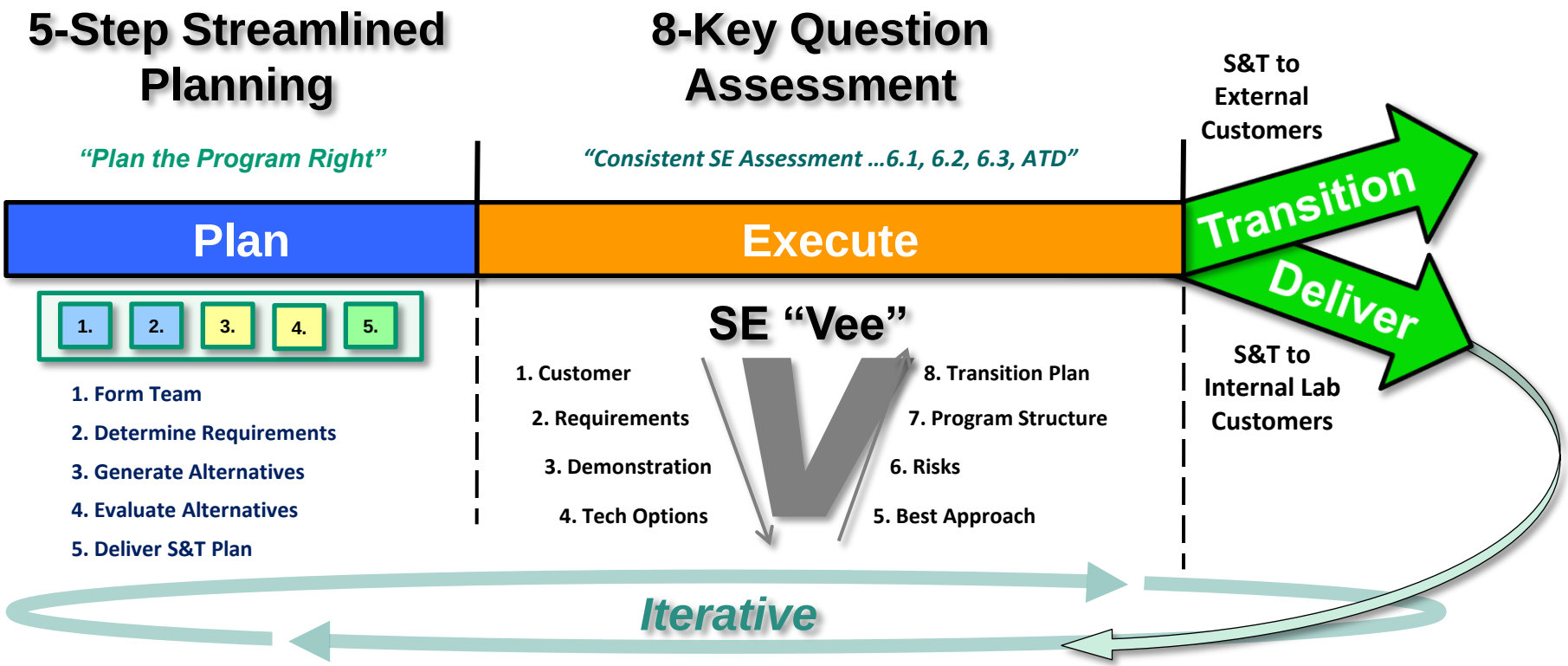


- *The Materiel Development Decision precedes entry into any phase of the acquisition management system*
- *Entrance criteria met before entering phase*
- *Evolutionary Acquisition or Single Step to Full Capability*

Science and Technology Life Cycle

DODI 5000.2, pg 12.

Simplified S&T Life Cycle



Systems Engineering and Its Place in S&T

…technique of using knowledge from various branches of engineering and science to introduce technological innovations into the planning and development stages of a system.

…more of a planning and design function.

Probably the most important aspect of systems engineering is its application to the development of new technological possibilities.

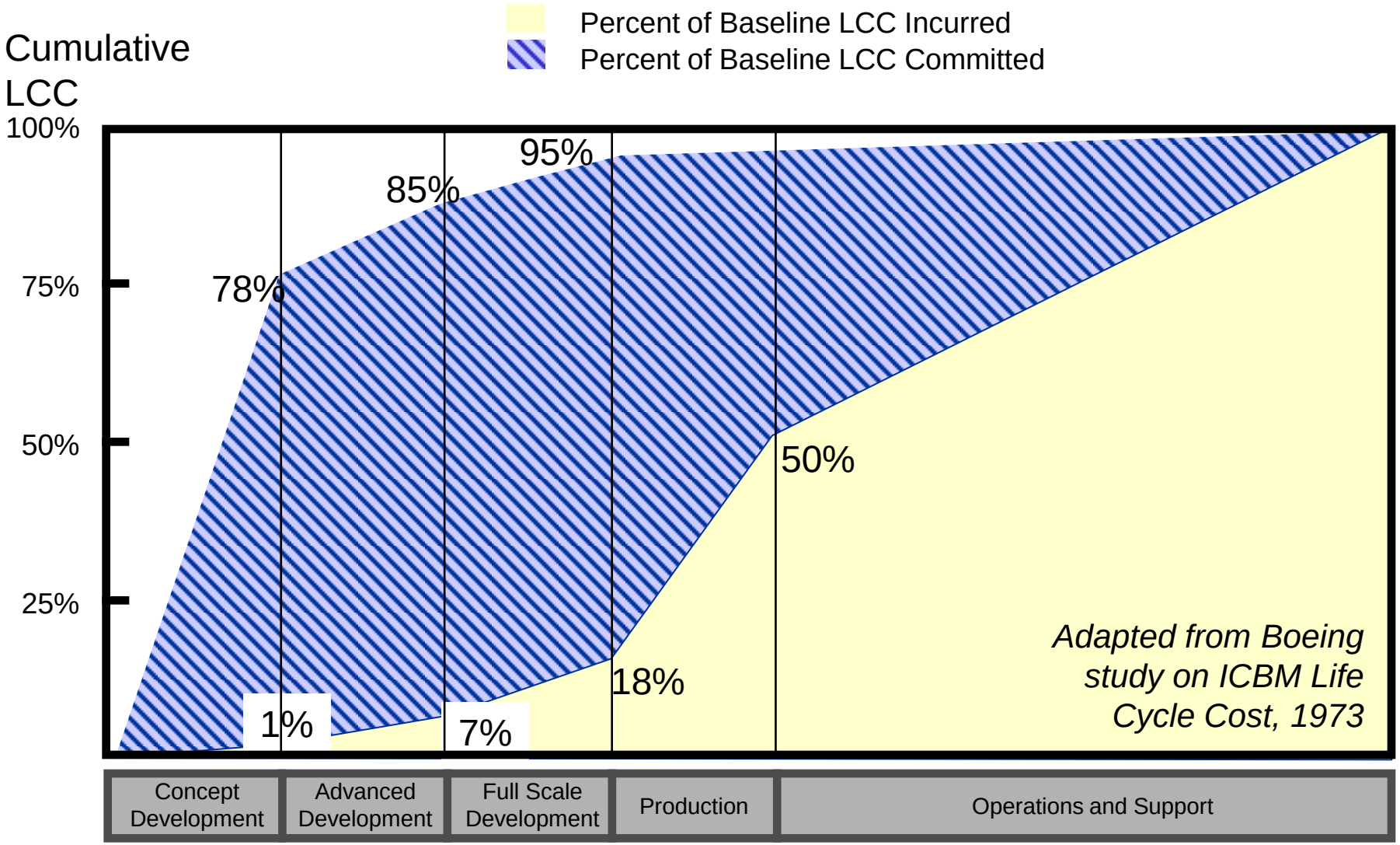
…it may be seen as the midwife of technological development.

Encyclopedia Britannica Online, “Systems Engineering”

Laboratory hook?
Focus on the Planning Stage. Proper use of the SE principles early can improve the transition of new technologies and thus result in improved systems solutions.

Look at all alternatives rather than pre-selected solutions
Interrogate advanced technologies (Low TRL; High Payoff)

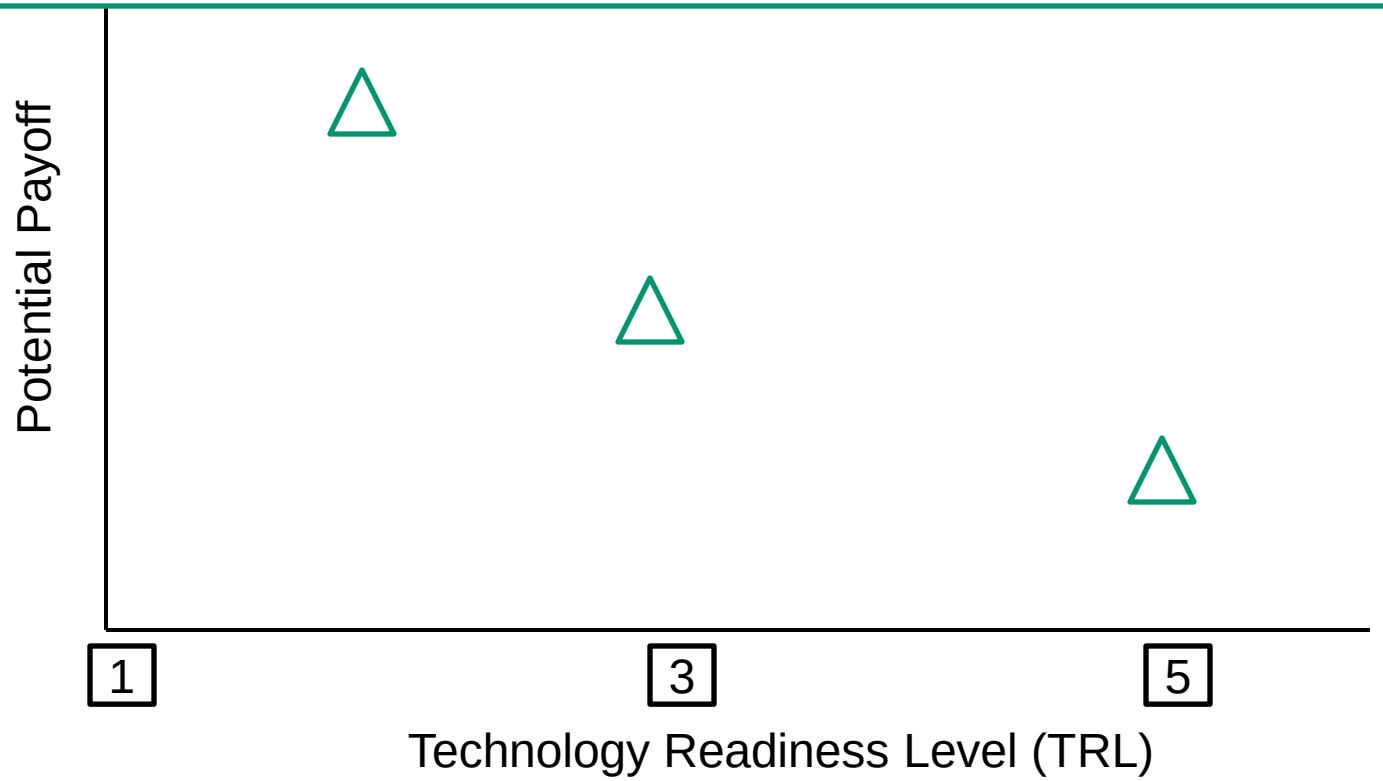
The Fundamental Benefit Applies to the Science and Technology Phase



Where Do We Best Apply the Talents of the Lab?

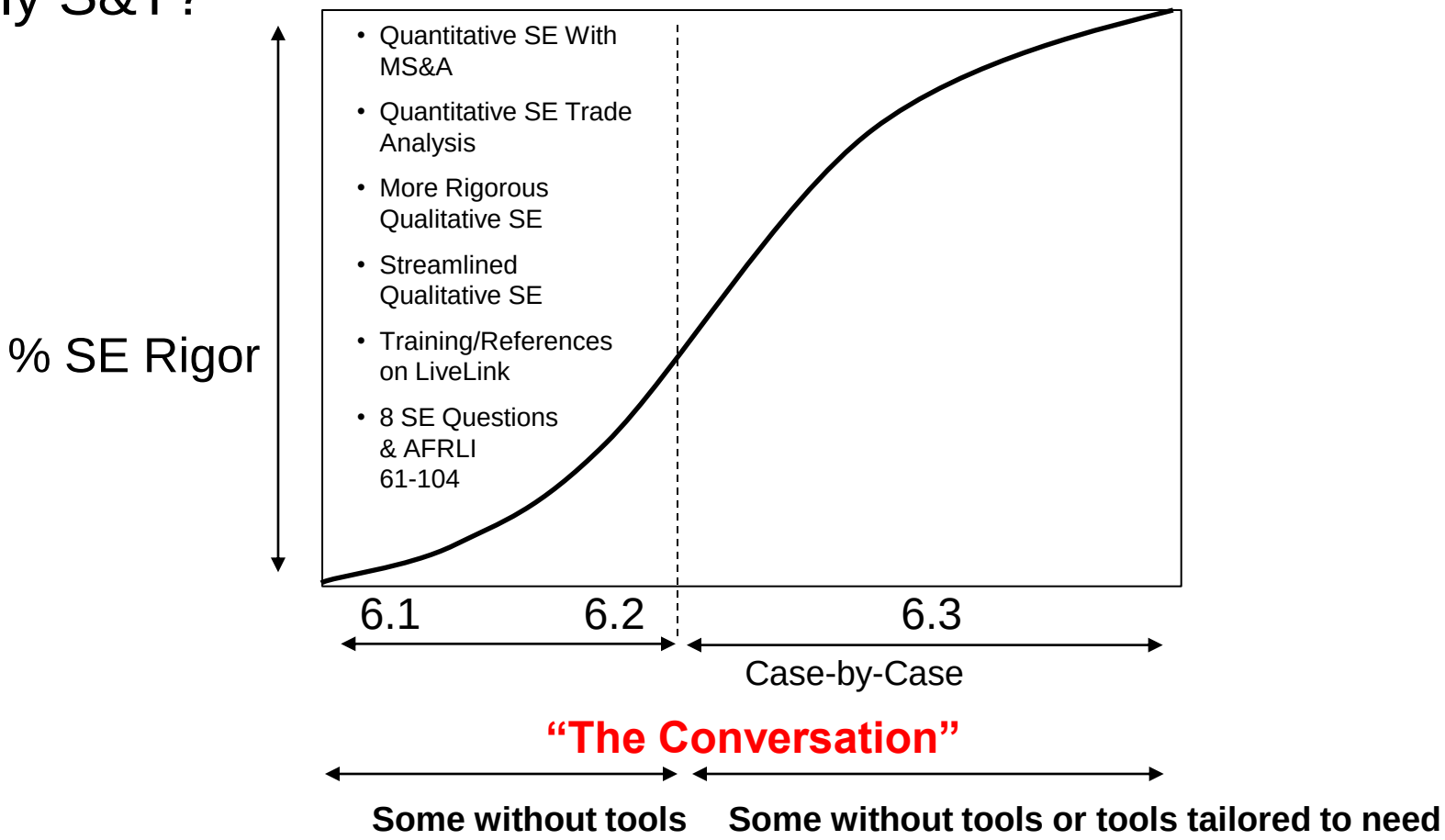
Seek to get the appropriate REQUIREMENTS linked up with the lab folks.

Look at all alternatives rather than pre-selected solutions
— Interrogate advanced technologies (Low TRL; High Payoff)



The S&T Response

How do we most effectively deploy Systems Engineering in Early S&T?



What is “The Conversation”?

- The right people organized to address a “technical” problem using some form of structured approach.
- In the earliest instantiations of S&T, the conversation could be simply between a project leader and an appropriate decision maker
- As the maturity of the problem space increases, the conversation needs to be more structured:
  - A multidisciplinary team approach is key
    - All necessary expertise represented in the team
    - Team members committed to team roles
    - A team charter or “contract” defined, including the “process”
    - Each step in the process must be documented
- In any event, the team and process must be consistent in pursuit of the best possible solution (“best value”?) to achieve the best result

- The heart of such an approach is captured in a concept involving:
  - A structured process to guide the conversation
    - We use a streamlined 5 Step process
  - A technique to get from requirements to best approach
    - We prefer a creative technique based on the concept of “desirements”

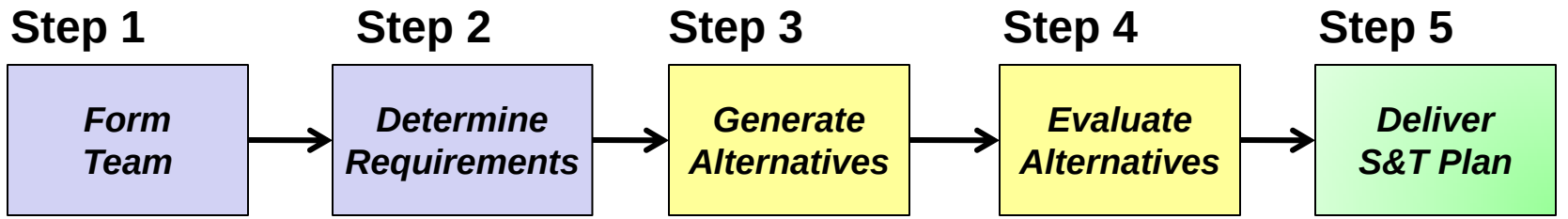
A Structured Process

Structured SE Process for S&T

- **Laboratory scientists and engineers are wary of systems engineering in S&T, claiming their creativity will be stifled.**

- **We emphasize Lab-Friendly processes that are flexible, quick, and efficient.**
  - **Two such processes we use are:**
    - **Streamlined Systems Engineering Process**
    - **SynGenics Corp SETFST Decision Support Process**

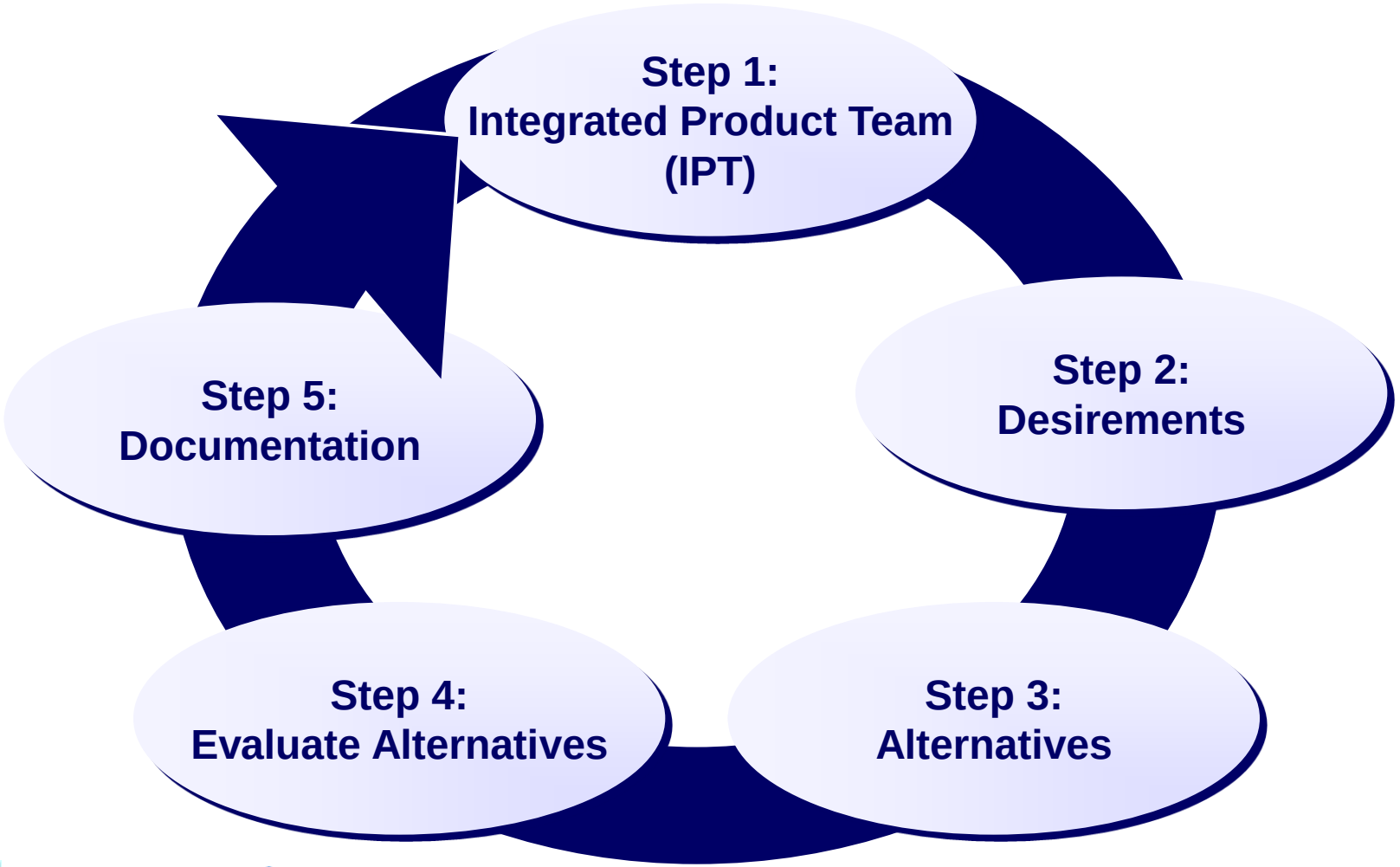
Streamlined Systems Engineering Process



Step 1	Step 2	Step 3	Step 4	Step 5
Do: • Define Problem • Identify all stakeholders • Establish Team	• Define requirements • Define tech challenges • Define S&T Exit Criteria (KPP sets) • Validate with customer	• Understand applicable state-of-the-art & near term technologies • Brainstorm different solution approaches	• Compare alternatives across Reqt's / S&T Exit Criteria •Solicit Customer approval for proposed solution	• Finalize AF Problem / Goal / Solution Objectives • Prepare for intended action course
Document: ❑ Problem Definition ❑ Team Directory (includes roles & responsibilities) ❑ Team Charter (Optional)	❑ Prioritized Requirement Set - Performance Set - Affordability - Producibility - Reliability - Supportability ❑ S&T Exit Criteria	❑ Alternative Definitions	❑Tech Readiness Assessment (TRA) ❑ Manufacturing Readiness Assessment (MRA) ❑ Risk Analysis ❑ Value Analysis ❑ Cost Estimate ❑ Schedule / Key Milestones	❑ AF Problem / Goal / Solution Objectives statement ❑ Program Roadmap ❑ Action Plan

Based on S&T IPPD Process (Version 3 – 2002)

SynGenics Corp SETFST Decision Support Process



SynGenics © Corporation

From Requirements to Preferred Alternatives

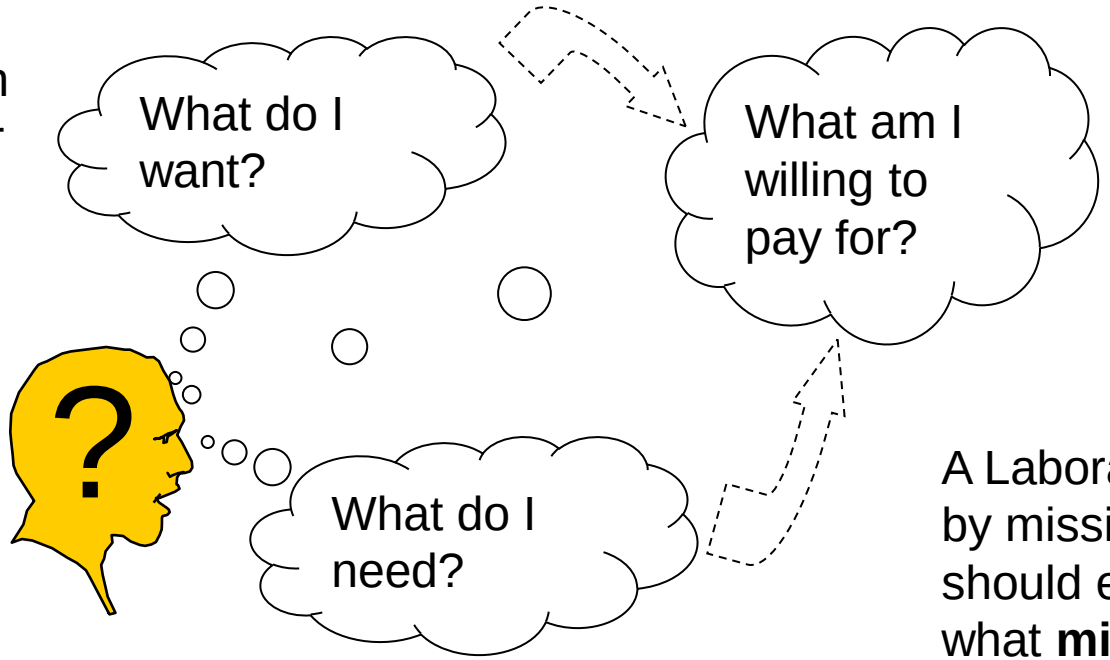
Technique: Requirements to Preferred Alternatives

- There are numerous ways to apply technical criteria to customer requirements and engage a team of subject matter experts to arrive at the “best” course of action
- Desirements are very well suited to S&T project planning

Why Desirements

Customer Requirements are usually at too high a level

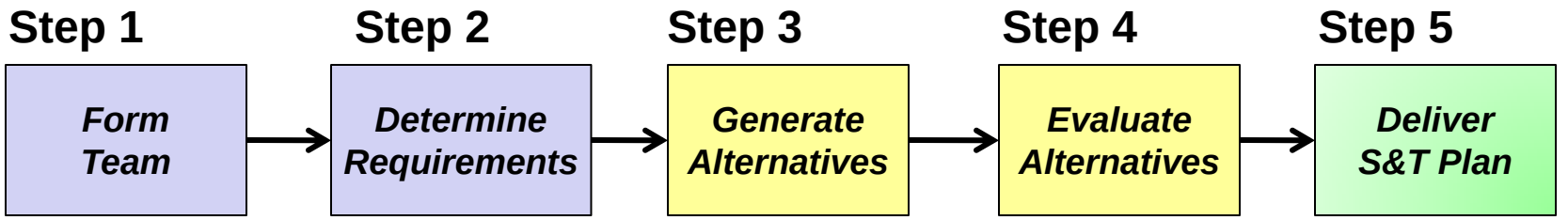
Measure of merit that characterizes the range between what the customer wants and needs.



A Laboratory, by mission, should explore what **might** be possible

SynGenics Corporation ©

Streamlined Systems Engineering Process



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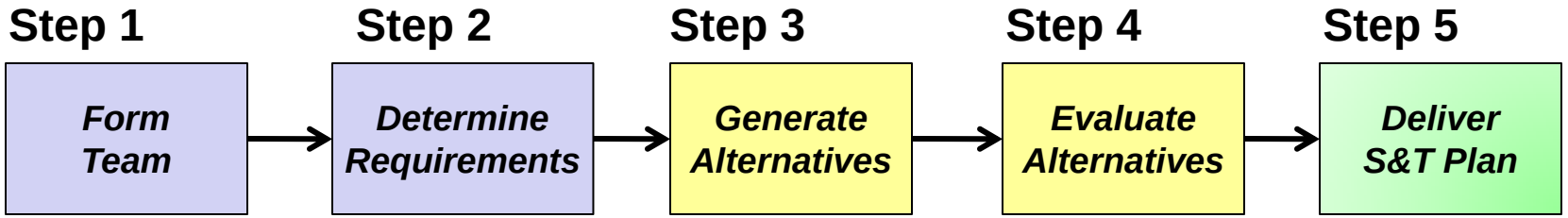
Process and Product Flow

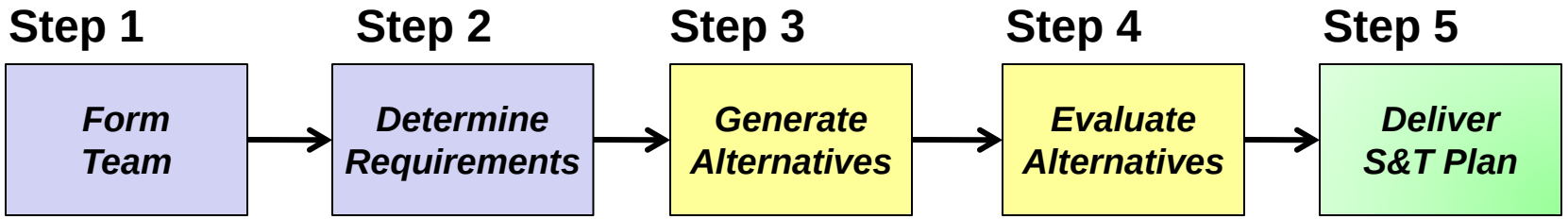
Process Flow:



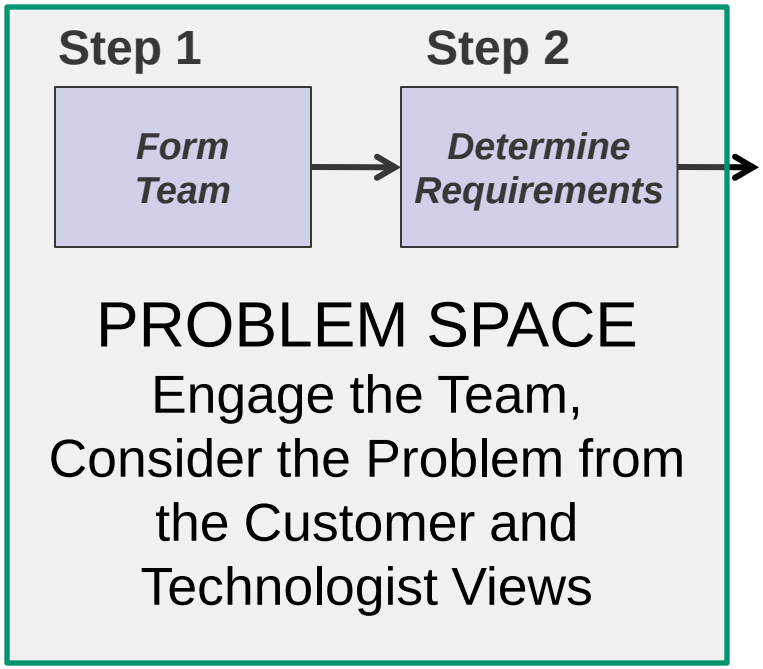
Product Flow:

Desirements -> Alternatives -> Value Analysis -> Preferred Alternatives

Establish Desirements

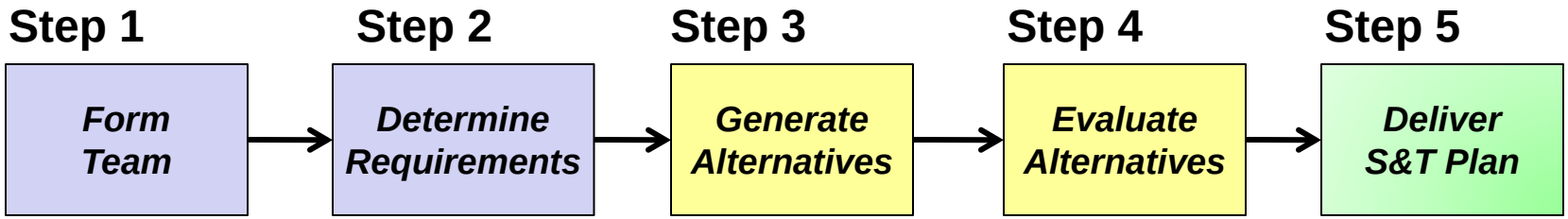


- Requirements come from the Customer
- Desirements are negotiated by the team
- Iterative Process



Desirement		
ID	Name	Description
1.		
2.		
3.		
4.		

Benefits / Attributes of Desirements



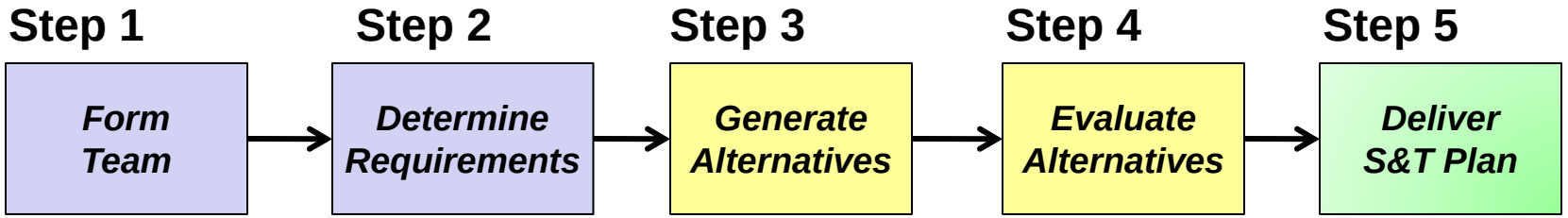
- Team refines the Desirements by adding quantitative measures, distilling into S&T Exit Criteria

Desirements									
ID	Name	Units	Preferred Objective	Acceptable Threshold	Unacceptable Limit (Low / High)	Priority or Weight	Desirement Description	Assumption, How Measured or other clarification	Rationale behind the values
	Type:	Performance							
P1									
P2									
P3									
	Type:	Cost							
C1									
	Type:	Schedule							
S1									

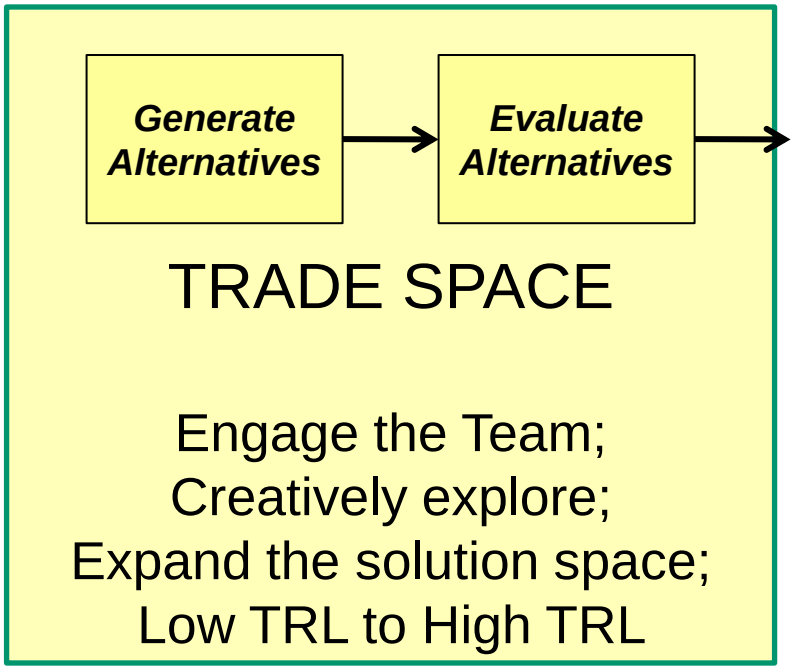
Formulating & Clarifying Desirements

- **Typical Types of Desirements:**
  - **Performance (e.g. resolution, power, weight, footprint),**
  - **Cost (e.g. acquisition costs, deployment costs, and development costs)**
  - **Schedule (e.g. initial operating capability and technical feasibility demonstration)**
  - **Human Factors (e.g. skill level required for use, manpower to operate),**
  - **Logistics / supportability**
  - **Operational Environment (e.g. emissions, compatibility with infrastructure)**
  - **System Reliability**
  - **System Producibility**

Step 3: Define Alternatives

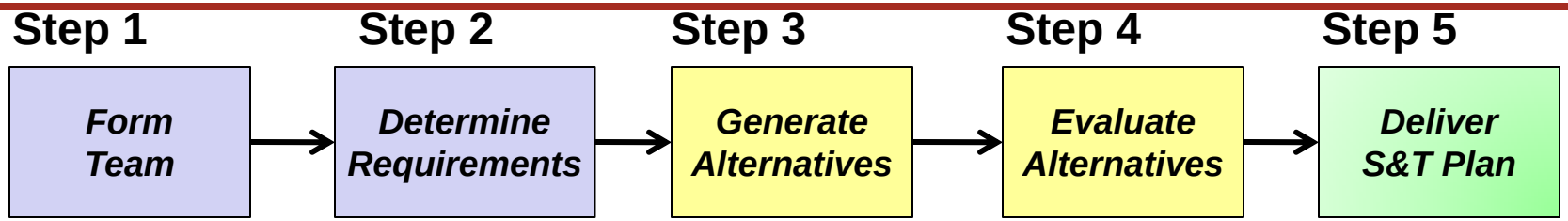


- Team collaborates on candidate solutions that **might** satisfy the desirements



Alternative		
ID	Name	Description
A.		
B.		
C.		
D.		

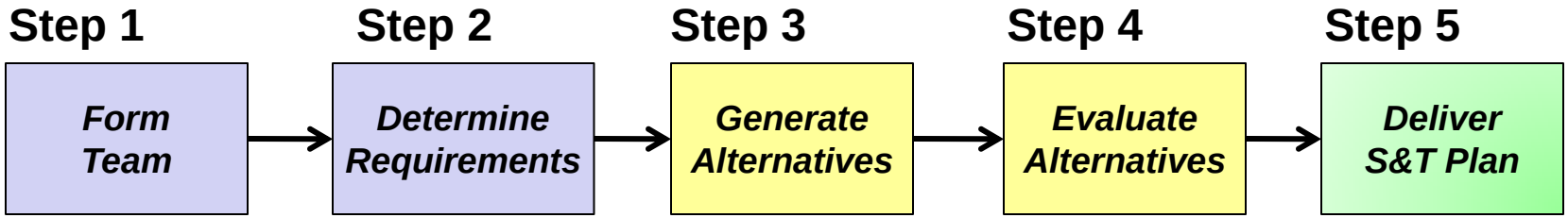
Detailed Alternative Descriptions



- Team refines the Alternatives by adding quantitative expected performance (Expected Value, Range and Risk) towards all desirements.

Alternate A Performance Against All Desirements									
ID	Name	Units	Obj	Threshold	Unacceptable Limit (s) (High / Low)	Priority or Weight	Assessment of Alternatives		Comments
							Exp Val	Std Dev	
	TYPE:	Performance							
P1.									
P2.									
P3.									
	TYPE:	Cost							
C1.									
	TYPE:	Schedule							
S1.									

Step 4: Value Analysis of Alternatives



- Team scores the Alternatives against the Desirements, using repeatable / traceable process; Example, SynGenics Corp SETFST Process
- Process should allow variation of values and “What If” analyses
- Process should allow tailorable rigor and complexity
- Process should allow for Sanity testing
  - did the numbers input produce a bad output

Alternate A Expectation Against All Desirements											
ID	Name	Units	Obj	Threshold	Unacceptable Limit (s) (High / Low)	Priority or Weight	Assessment of Alternative		**Desirability Score**		Comments
							Exp Val	Std Dev	**Desire**	**Risk**	
TYPE:		Performance									
P1.											
P2.											
P3.											

Step 4: Determining the Preferred Alternative

- **Previous Step provided the absolute score of each Alternative against each Desirement**
- **Process uses absolute scores to calculate desirability and risk of each Alternative**
- **To determine the Path Forward, the Team needs to compare Alternatives, relative to each other and decide on the S&T Plan**
- **Need to produce a Composite Scorecard ranking all alternatives**

The Composite Scorecard

- **SETFST produces a composite scorecard, visually presenting the aggregate desirability and risk of each alternative**
- **Desirability and risk scores range from 0 to 1**
  - **Score of 0 means the alternative failed one or more criteria.**
- **Team needs to confirm the scores; Does the data make sense?**
- **Based on Value Analysis, Team needs to decide on the S&T Plan**

Type / Alternative	Performance		Cost		Schedule		**Overall Affordability**	
	Desire	Risk	Desire	Risk	Desire	Risk	**Desire**	**Risk**
D	.791	.511	.800	.159	1.000	0.000	**.918**	**.6169**
B	.583	.292	.463	.308	1.000	0.000	**.760**	**.6244**
C	.758	.418	.255	.067	.271	.025	**.698**	**.516**
A	.932	.045	0.00	.511	.311	.023	**0.000**	**.585**

Summary

- Systems engineering is a powerful tool at every level of the acquisition process
- Early application of the SE principles is where the highest potential benefit accrues
- We are moving SE into the culture of our laboratories and tailoring…
- Early planning is the key to best program solutions, even in early S&T
- The "Conversation" is our shorthand for applying technical expertise and creativity to push the boundaries of research at all levels

- We have seen numerous cases where even a high performance laboratory team discovers new insights and directions when they apply the SE discipline.
- There is great benefit to be derived from taking the time to look at technical, and even non-technical, options in a disciplined manner