

Using the Streamlined Systems Engineering (SE) Method for Science & Technology (S&T) to Identify Programs with High Potential to Meet Air Force Needs

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Air Force Research Laboratory (AFRL) Mission




*Leading the discovery, development, and integration
of affordable warfighting technologies for our air,
space, and cyberspace force.*




AFRL

Materials & Manufacturing Directorate (RX)








VISION

Aerospace materials and manufacturing leadership for the Air Force and the nation



MISSION

- Develop and deliver materials and manufacturing technologies for AF customers
- Advise AF acquisition, sustainment, and operational decision makers
- Create M&P technologies that are enabling for future capabilities



Motivation for Key S&T Program Identification



- **AFRL Commander's intent** -- “focus our AFRL S&T portfolio on high priority Air Force needs”
... in an era of constrained S&T budgets
- **Show S&T value** -- in developing and supplying mature technologies to customers both inside and outside of AFRL
- **Enable Process** -- by designation of Advanced Technology Demonstrations (ATDs) and High Visibility Programs (HVPs)
 - ATD/HVP designation shows AFRL leadership intent to closely monitor key S&T programs with high customer impact

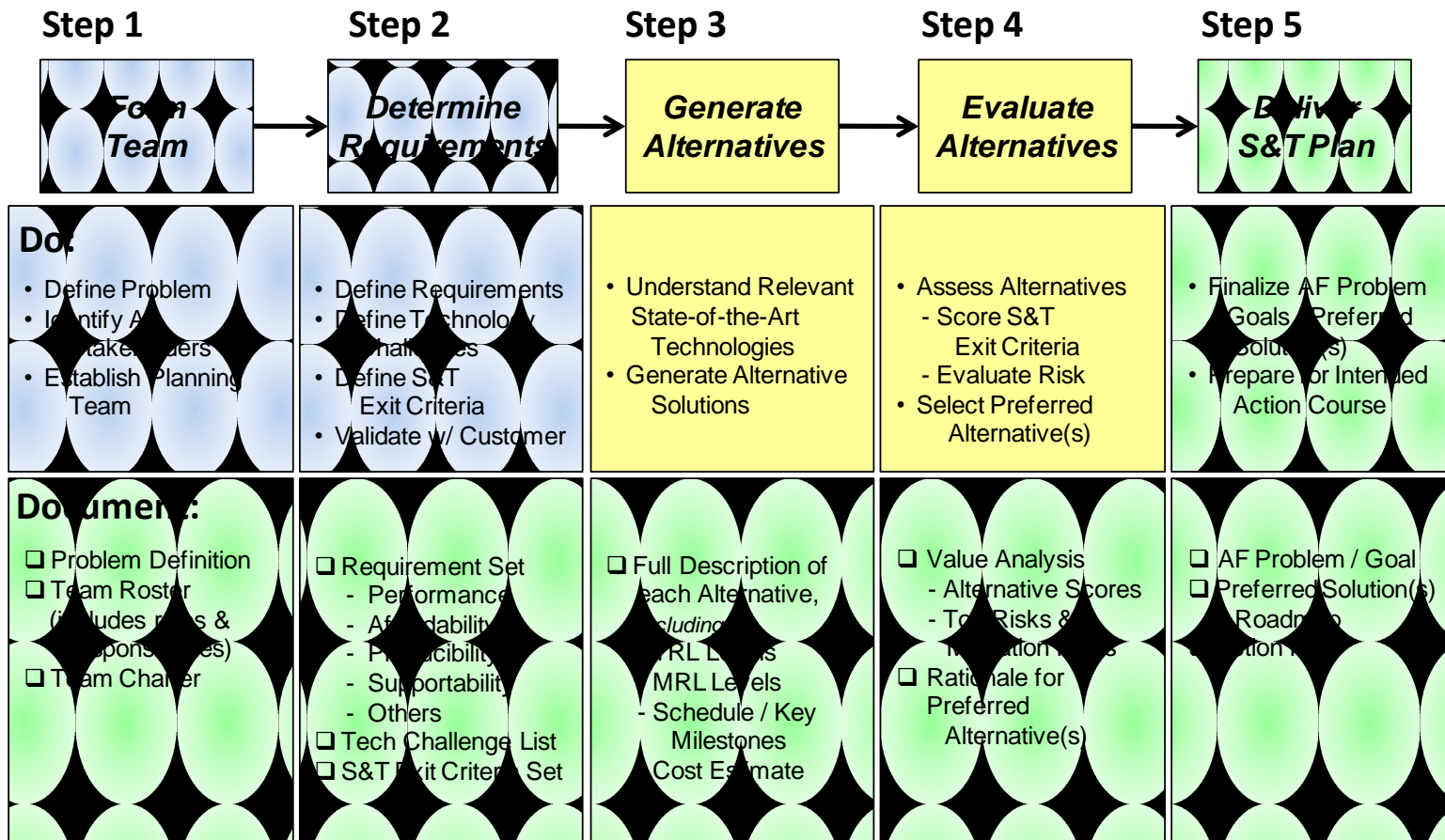


Solution Approach



Streamlined SE for S&T:

– Straight-forward method provides a relatively simple & traceable approach



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

AFRL/RX Version as of 15 March 2011



Step 1: Define Problem & Form Team



- **Problem Definition:**

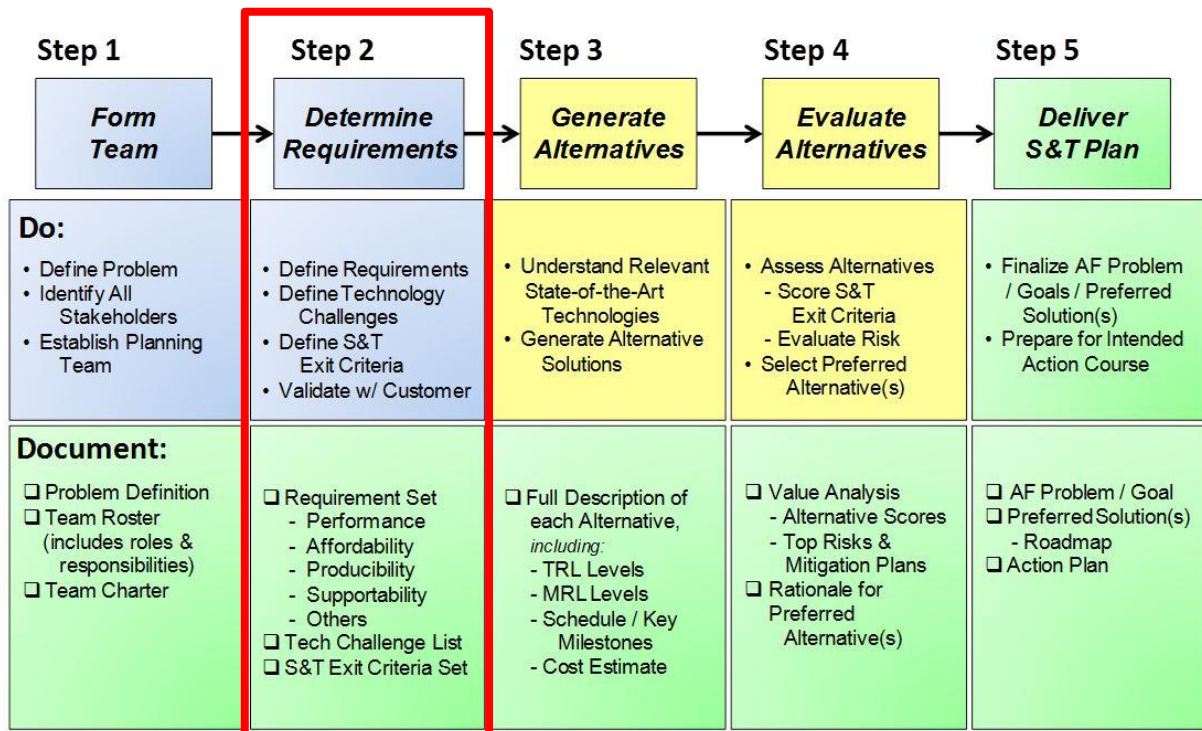
- Identify potential future RX ATDs & HVPs that satisfy **HIGH PRIORITY AF NEEDS**
 - Currently executing 3 ATDs & 2 HVPs ... all finish by end of FY16
- RX Director's tasking (11 Oct 2011): Identify potential future ATDs & HVPs **within a 60 day period**
 - Answer needed in time for next RX budget cycle (Feb 2012)

- **Team Formation:**

- Integrated Product Team (IPT) consisted of:
 - RX Chief Engineer
 - RX Core SE Planning Team (6 persons)
 - RX Technical Division representatives (6 persons)
- IPT Commitment: 3 face-to-face meetings with homework for each meeting



Step 2: Determine Requirements



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

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- For this study, requirements are framed in the context of the ATD & HVP definitions
- ATD & HVP definitions then used to define **S&T Exit Criteria**, which are then used to identify suitable S&T programs



ATD Definition

(Extracted Primarily from AFI 61-101)



- A **funded** S&T program that will **demonstrate** the maturity and potential of advanced technologies for enhanced operational capability or cost effectiveness
 - Typically ready to transition before the end of the FYDP (5 – 6 years)
 - Maturity Level: Usually at TRL 6 (TRL 5 for space) and MRL 4 – 5 at program completion
- Normally characterized by four parameters
 - **Large scale**, both in resources and complexity
 - Extensive **operator/user** involvement
 - Established **cost, schedule, and performance** metrics
 - A clearly **defined transition target/path**

Air Force ATDs are commissioned at MAJCOM Applied Technology Councils (ATCs) -- reviewed annually at the commissioning ATC and semi-annually at an AFRL Tech Directorate (TD) Program Baseline Review



HVP Definition

(Extracted primarily from AFRLI 61-108)



- An AFRL Program requiring the same level of management and reporting as an ATD, but **lacks a clearly defined transition target/path**
 - Nominated by AFRL TD Directors and approved by the AFRL Executive Director
- HVPs have the following characteristics:
 - S&T currently funded
 - Has an **established baseline** with focused objective(s), a defined budget and schedule, and **specific technology deliverables**
- HVPs may be commissioned as ATDs once a transition path is defined
- Note: HVP technology deliverables may be delivered to other AFRL TDs for integration at a higher system level

HVPs are reviewed semi-annually at TD Program Baseline Reviews



Step 2: Define S&T Exit Criteria



- Our “**Requirements**”, ie, the ATD/HVP definitions, must be properly applied to the RX S&T portfolio in order to identify potential ATDs & HVPs
 - Target programs typically in late Applied Research (6.2) and Advanced Tech Development (6.3) Program Elements
- IPT-derived **S&T Exit Criteria** based on these “Requirements” should act as **program discriminators** that identify a suitable subset of the RX S&T program portfolio as potential out-year ATDs & HVPs



Step 2: Define S&T Exit Criteria for Potential HVPs



Seven IPT-derived S&T Exit Criteria – many less stringent than for ATDs

Parameter	Weight	Threshold	Objective	Other Comments
Clearly Defined Deliverables	1	Contains specific deliverables generally tied to customer requirements; integration efforts required	Contains specific deliverables derived using SE approach clearly tied to customer requirements; integration efforts required	
Potential Customers	1	Potential Customers identified, but not actively involved in focusing tech development	Potential Customers identified and actively involved in focusing tech development	Customers can include external organizations and internal AFRL TDs
Program Scale (Resources)	1	Req'd S&T Funding ≥ \$0.5M/yr (unburdened)	Req'd S&T Funding ≥ \$1M/yr (unburdened)	Multiple deliverables meeting single need OK
Final TRL/MRL Level	1	TRL 6/MRL 4 for transition; TRL 4-5/MRL 4 for delivery to internal AFRL customers	TRL 7/MRL 5 for transition; TRL 6/MRL 5 for delivery to internal AFRL customers	TRL 5 for space
Program Completion Date	1	Before end of current FY+6	Before end of current FY+6	
Requirements Pull	1	Helps satisfy high priority need in 1 SCF or feeds another TD's documented roadmap	Helps satisfy high priority need in multiple SCFs or feeds another TD's documented roadmap	Strong ROIs strengthen business case
Adequate S&T Funding	1	Funding programmed to accomplish most program objectives	Funding programmed to fully accomplish program objectives	

Note: TRL = Technology Readiness Level; MRL = Manufacturing Readiness Level; ROI = Return on Investment
 SCF = Air Force Service Core Function (eg, Air Superiority, Global Precision Attack, Command & Control, etc)



Step 2: Define S&T Exit Criteria for Potential ATDs



Seven S&T Exit Criteria for ATDs – many more stringent than for HVPs

Parameter	Weight	Threshold	Objective	Other Comments
Clearly Defined Deliverables	1	Contains specific deliverables generally tied to customer requirements; integration efforts required	Contains specific deliverables derived using SE approach clearly tied to customer requirements; integration efforts required	
Potential Customers/ Transition Path	1	Specific customer(s) and transition path(s) identified, but transition funding not yet identified	Specific customer(s) and transition path(s)/funding fully identified	
Program Scale (Resources & Complexity)	1	Req'd S&T Funding ≥ \$0.5M/yr (unburdened)	Req'd S&T Funding ≥ \$1M/yr (unburdened)	Multiple deliverables meeting single need OK
Final TRL/MRL Level	1	At least TRL 6/MRL 4	TRL 7/MRL 6	TRL 5 for space
Program Completion Date	1	Before end of current FY+6	Before end of current FY+6	
Requirements Pull	1	Helps satisfy high priority need in 1 SCF or S&T Strategy document	Helps satisfy high priority need in multiple SCFs or S&T Strategy document	Strong ROIs strengthen business case
Adequate S&T Resources Available	1	Funding/manpower programmed to accomplish most program objectives	Funding/manpower programmed to fully accomplish program objectives	

Note: TRL = Technology Readiness Level; MRL = Manufacturing Readiness Level; ROI = Return on Investment
 SCF = Air Force Service Core Function (eg, Air Superiority, Global Precision Attack, Command & Control, etc)



Step 2: Define S&T Exit Criteria



- A scoring scale was created for each of the seven S&T exit criteria as a tool for the Step 4 Evaluation of Alternatives
- **Deliverable** example is shown in the table below:

<i>S&T Exit Criteria</i>	Scoring Criteria (HVP and ATD SAME) (<i>Scoring Basis 1 to 10, 10 is best</i>)
<p>Clearly Defined <u>DELIVERABLE(S)</u></p> <p><i>...when you complete the execution phase of this program, what is "It" that you will be delivering to a customer?</i></p>	<p>9-10: There is a high probability a comprehensive test or demonstration will be developed and executed tied to customer requirements or needs.</p> <p>7-8: There is a reasonable probability that a test or demonstration will be developed and executed tied to customer requirements or needs.</p> <p>5-6: There is a reasonable probability that a test or demonstration will be developed and executed tied to customer requirements or needs, but there are significant deficiencies or uncertainties in the understanding of customer requirements or needs.</p> <p>3-4: A test or demonstration, based on customer driven requirements has been identified, but there is low confidence the program as structured will reach its goals.</p> <p>1-2: A complete test or demonstration plan has not been identified even though expectations among interested parties are clear. There's a low probability this can or will be executed based on the program's proposal.</p> <p>0: There are notional thoughts only of what would constitute a test or demonstration but no confidence it can be executed.</p>



Step 2: Define S&T Exit Criteria

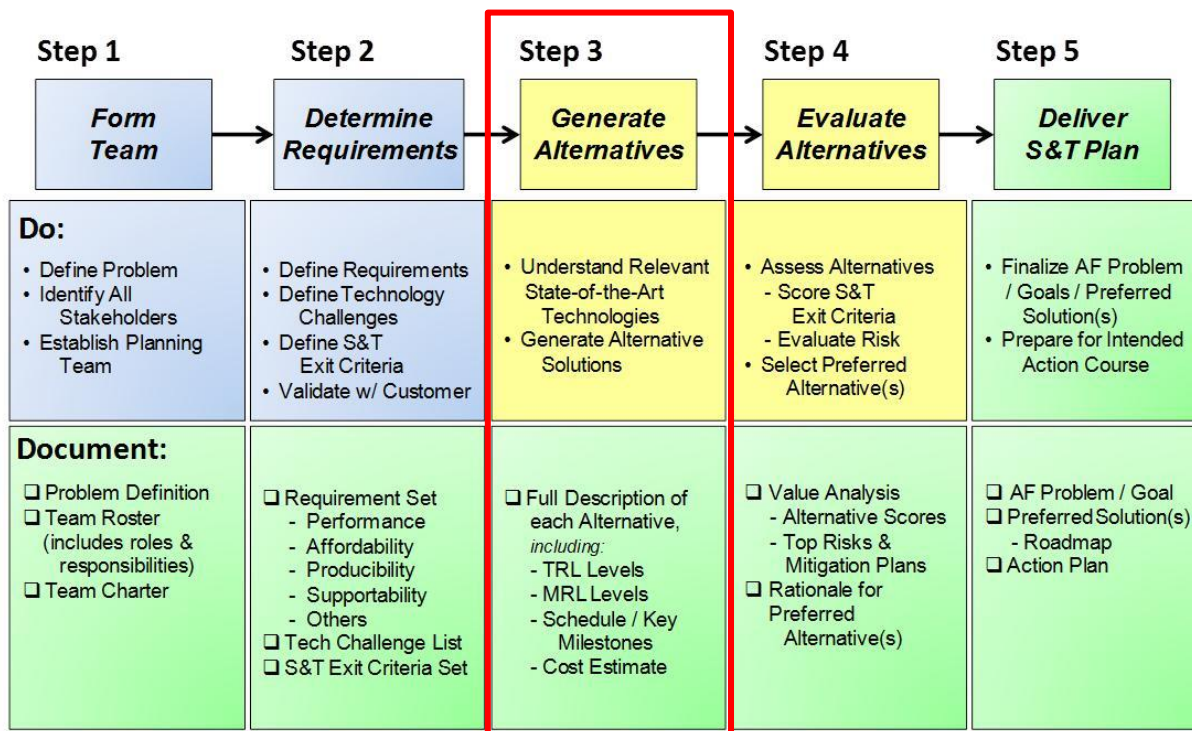


- **Customer scoring scale example shown below:**

<i>S&T Exit Criteria</i>	<i>Scoring Criteria (Scoring Basis 1 to 10, 10 is best)</i>
<p><u>Customer</u> (HVP)</p> <p><i>Who will receive the technology deliverable? Who will be interested in acquiring, and continuing technology development? Who is the end user, and how actively are they participating in S&T development?</i></p>	<p>10: Internal and external customers identified to include targeted SPO(s) and MAJCOM users who are funding or will fund a phase of the program.</p> <p>8-9: Key customer(s) identified / actively involved, participate in requirements development, reviews; provide funding and management commitment; 6.3 customer buy-in secured. An official POC exists.</p> <p>6-7: A customer or prospect has expressed interest by committing to participate, but has not participated in an active way. (higher score for more than one customer)</p> <p>3-5: No customer or prospect is directly involved, but probable potential end users have been identified (higher score for more than one potential customer)</p> <p>1-2: No customer or prospect is directly involved, potential end users have been identified (higher score for more than one potential customer), low probability they will be interested.</p> <p>0: No potential customer or prospect is directly involved; end users not identified.</p>
<p><u>Customer</u> (ATD)</p> <p><i>How committed are the above customer's? An ATD must have an external (non-AFRL) transition customer. Category differences reflect the degree of commitment by the transition organization and end user</i></p>	<p>10. CAT 1 ATD: Major Command (MAJCOM)/Agency supports and has programmed required funding for transition within the FYDP; OR, Qualified external customers identified to include targeted SPO(s) and MAJCOM users who are funding or will fund a phase of the program. Well defined transition path and funding in place (programmed).</p> <p>8-9: CAT 2A ATD: MAJCOM/Agency supports and is committed to identify transition funding in next programming cycle. OR, Key customer(s) identified and actively involved, by participating in requirements development, reviews or providing funding and management commitment; 6.3 customer buy-in secured. An official POC exists. Customer and transition path identified with high potential for funding.</p> <p>6-7: Cat 2B ATD: MAJCOM/Agency supports but is not currently able to budget for transition, OR, A customer or prospect has expressed interest by committing to participate, but has not participated in an active way. (higher score for more than one customer) Transition path identified, customers interested by funding not identified.</p> <p>0: Potential customers may have been identified, but no transition path identified to date.</p>



Step 3: Generate Alternatives



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

AFRL/RX Version as of 15 March 2011

- For this study, the **initial set of alternatives** consisted of 80+ AFRL/RX S&T candidate programs/roadmaps used in the FY12 RX budget process



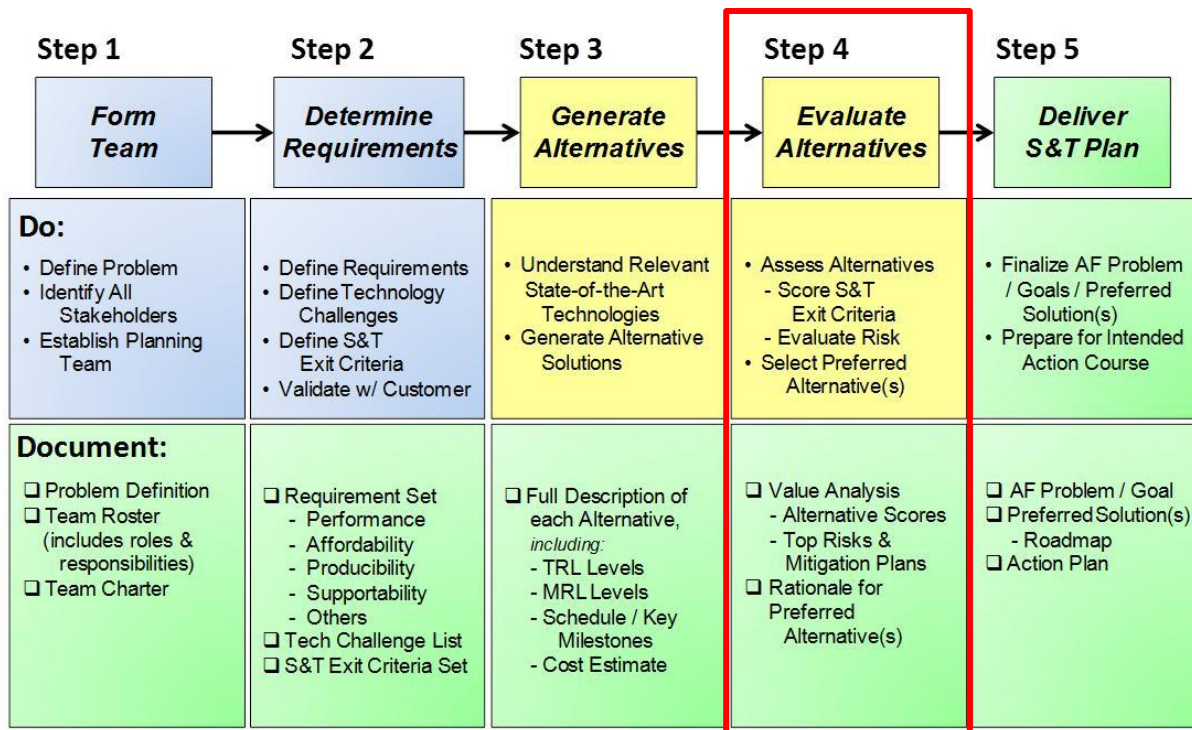
Step 3: Generate Alternatives



- **80+ FY12 RX budget Quads/Roadmaps** used as initial alternative set
 - Information available ranged from a quad chart only for lower TRL S&T efforts to full product roadmaps for more mature programs
- **RX SE Core Team** performed an initial sorting of alternatives using the draft S&T Exit Criteria set
 - Initial review resulted in 27 remaining RX alternatives for full IPT consideration as potential ATDs/HVPs
 - All possessed some form of product roadmap



Step 4: Evaluate Alternatives



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

AFRL/RX Version as of 15 March 2011

- **Step 4: 27 Alternatives evaluated in detail as potential future RX ATDs & HVPs**



Step 4: Evaluation of Alternatives



Methodology:

- **Alternative scoring sheets/spreadsheet approach used for traceability**
 - Scoring sheets included **quantitative scores** and **rationale** for each score
- **Process consisted of three IPT meetings within 60 day time period**
 - **Meeting #1:**
 - **IPT kickoff, review of process, & vetting of S&T Exit Criteria**
 - ✓ Homework – Quickly review 80+ candidates to validate focus on 27 Alternatives
 - **Meeting #2:**
 - **S&T Exit Criteria scoring scales discussed & finalized**
 - **Threshold S&T Exit Criteria applied to 27 Alternatives -- resulted in down-select to 21 Alternatives & info gap identification**
 - ✓ Homework - Detailed independent scoring of Alternatives by Division Reps and Core SE Team
 - **Meeting #3:**
 - **Scores and rationale of final 21 Alternatives finalized by full IPT**
 - **General Alternative suitability as either a potential ATD or HVP determined**



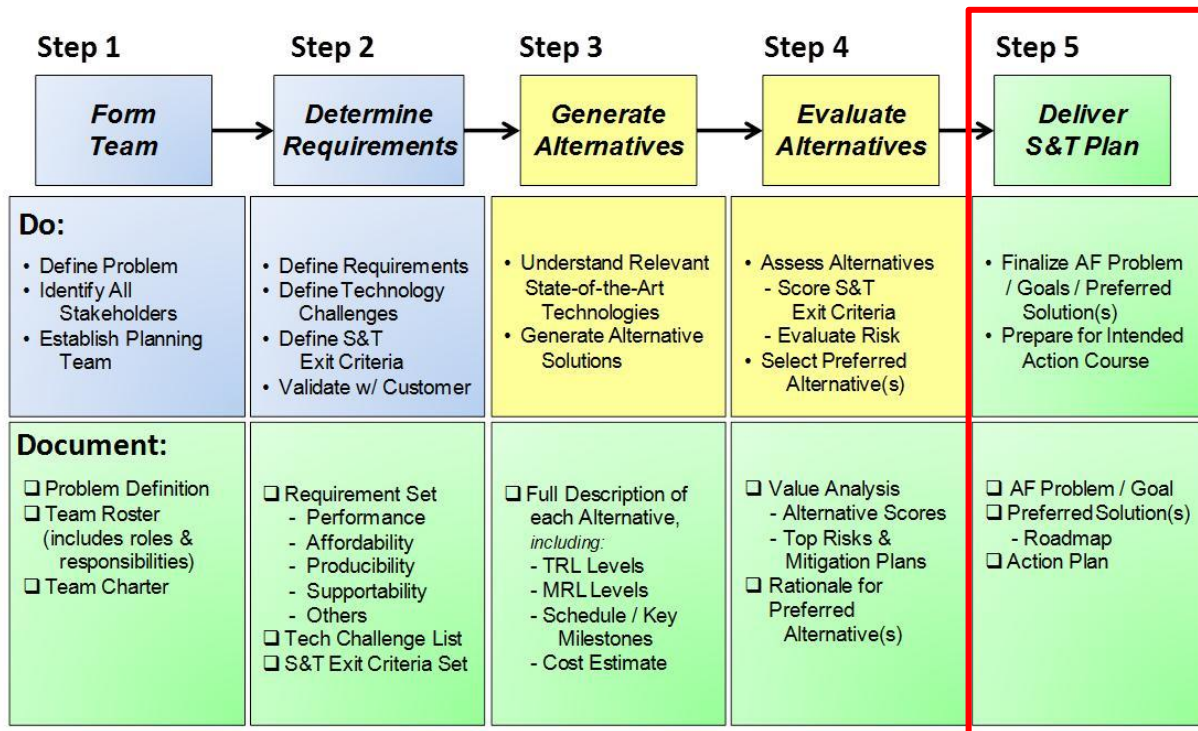
Results of Evaluation of Alternatives



- Two of final 21 Alternatives failed at least one S&T exit criterion, thus excluding them from further consideration
- 19 Alternatives scored between 44 – 64 points (70 pts possible)
- **Scoring rationale** and **engineering judgment** were used by the IPT to determine suitability of final Alternatives as ATDs or HVPs
 - Numerous Alternatives scored high in some criteria, but much lower in others
- **Final Result:** Remaining alternatives sorted into the following categories:
 - **Potential Near-term ATD (CY12) - 0**
 - **Potential Near-Term HVP (CY12) - 1 (63 pts)**
 - **Potential Mid-term HVP/ATD (CY13 & out) – 6 (58 pts average)**
 - **Continue to track as AFRL/RX Product Roadmap – 12 (51 pts average)**



Step 5: Deliver Results



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

AFRL/RX Version as of 15 March 2011

- Step 4 results were presented to the AFRL/RX Director for validation during late Jan 2012



Step 5: Deliver Results



- During Jan 2012 Outbrief, the RX Director:
 - **Strongly validated the study process and results**, requesting annual repeat of process in preparation for RX Buy Plan
 - **Approved one new AFRL/RX space-focused HVP**, which has high potential to become an AFSPC ATD
 - **Requested continued close tracking of the six programs** suitable for potential mid-term (FY13 & out) ATDs/HVPs
- Due to leadership visibility of this process and strong customer pull, two of the remaining 12 Alternatives subsequently included as part of AFSPC & AFMC ATDs



Summary



- Using the ***RX Streamlined SE Method for S&T***, potential high impact S&T programs were quickly identified -- results validated by Senior Leadership
- **This SE process can be tailored for use in any S&T organization**
 - Typically, S&T program alternatives competing for resources are developed in line organizations organized around technical disciplines
 - In this SE process, an IPT is formed which includes experts from each of the line organizations that develop these alternatives, tending to negate the effects of individual technology biases
 - This SE process puts **quantitative, documented, and traceable decision factors** on the record, while leaving room for solid engineering judgment
 - Process results become “Team” results that are owned by the IPT as a whole – not “them vs. us”
- **“AFRL/RX Streamlined S&T Planning Guide for Applying Tailored SE” GUIDE and Companion WORKBOOK** can be found at:
 - DTIC Technical Report AFRL-RX-WP-TR-2011-4176
 - URL: <http://www.dtic.mil/dtic/tr/fulltext/u2/a546068.pdf>



Questions?



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Back-up Charts





USAF Major Commands and Service Core Functions



AFMC



ACC



AMC



AFSPC



AETC



AFSOC



AFGSC

Agile
Combat
Support

Air
Superiority

Global
Precision
Attack

Rapid
Global
Mobility

Space
Superiority

Building
Partnerships

Special
Ops

Nuclear
Deterrence
Ops

Global
Integrated
ISR

Command
and
Control

Cyber
Space
Superiority

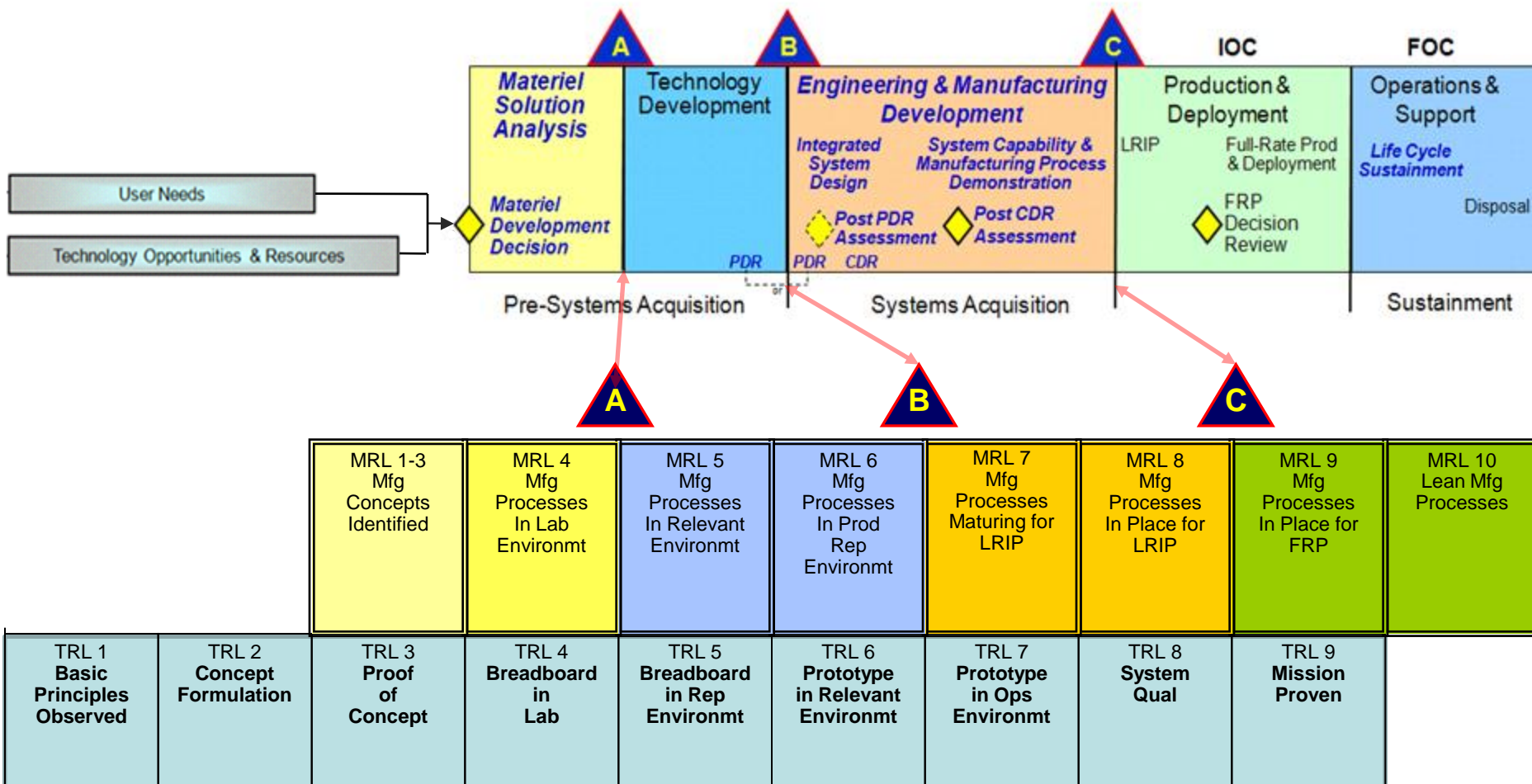
Personnel
Recovery



MRL/TRL Relationships



Relationship to System Acquisition Milestones (DoDI 5000.02)



Relationship to Technology Readiness Levels

Approved for Public Release

