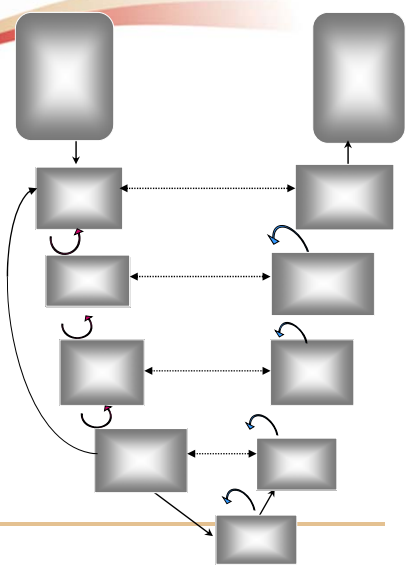
Defense Acquisition University

Technology Development Phase

Lesson 5



Defense Acquisition University

Terminal Learning Objectives

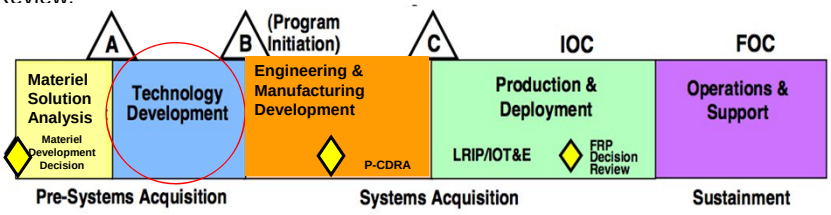
- Given a Technology Development (TD) scenario, interpret and flow-down the requirements from the Capabilities Design Document (CDD) into the System Specification, and supporting documentation, that allows selection and defense of a technology option that best meets User Needs while keeping in accordance with the DAG and DoD 5000 series documents.
- Given a TD competitive prototyping scenario, demonstrate an understanding of DoD technical risk management using technical reviews identified in the DAG.
- Given a scenario, illustrate the DoD SE Technical Management Processes in-use in the TD Phase scenario and relate them to your work environment.

Enabling Learning Objectives

- Recognize and summarize the poorly written requirement statements in the CDD and System Specification and indicate how you would correct them.
- Prioritize and list the DoD verification methods for requirement statements in the System Specification and defend why you selected that method.
- Summarize the DoD SE Technical Review(s) for this phase and describe how they should be used to reduce technical risk that is in accordance with the DAG.
- Demonstrate the roles of the DoD SE integrated product team (IPTs) in the test and evaluation planning and execution in the TD phase.
- Given a scenario, illustrate the eight SE Technical Processes in-use in the TD Phase and explain how they apply to your work environment.

Why Technology Development?

- Technology Development is a focused on maturing technology through CTE risk reduction and competitive prototyping, and initial end item design (through preliminary design).
- This phase develops and demonstrates prototype designs to reduce technical risk, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements.
- Based on refined requirements and demonstrated prototype designs, Integrated Systems Design of the end-item system can be initiated. When approved in the Technology Development Strategy, the Integrated Systems Design may be conducted prior to Milestone B, to include full functional analysis of the end-item system and establishment of the system allocated baseline following the Preliminary Design Review.



Identify the Issue:

Technology Maturity and/or Design Maturity

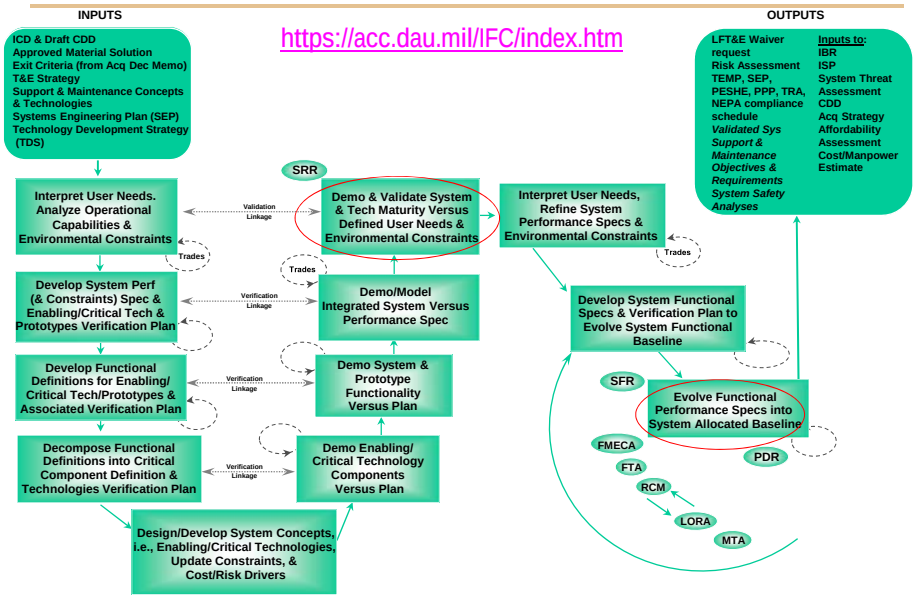
1. Hover Vehicle uses new compressor blades under development in S&T facility. Increases compressor life in a sand environment.
2. Wheeled Vehicle uses a diesel engine to power electric motors that turn drive wheels. Individual components have been proven in operational use but not together.
3. Tracked Vehicle uses the Abrams Tank drive train for proven performance and commonality.

(Refer to Lesson 01, Slides 10 – 19, and discuss which Cases (e.g.1-4) may apply above).

Technology Development Inputs

- **ICD & Draft CDD**
- **Approved Material Solution**
- **Exit Criteria (from Acq Dec Memo)**
- **T&E Strategy**
- **Support & Maintenance Concepts & Technologies**
- **Systems Engineering Plan (SEP)**
- **Technology Development Strategy (TDS)**

Technology Development Phase



Technology Development Outputs

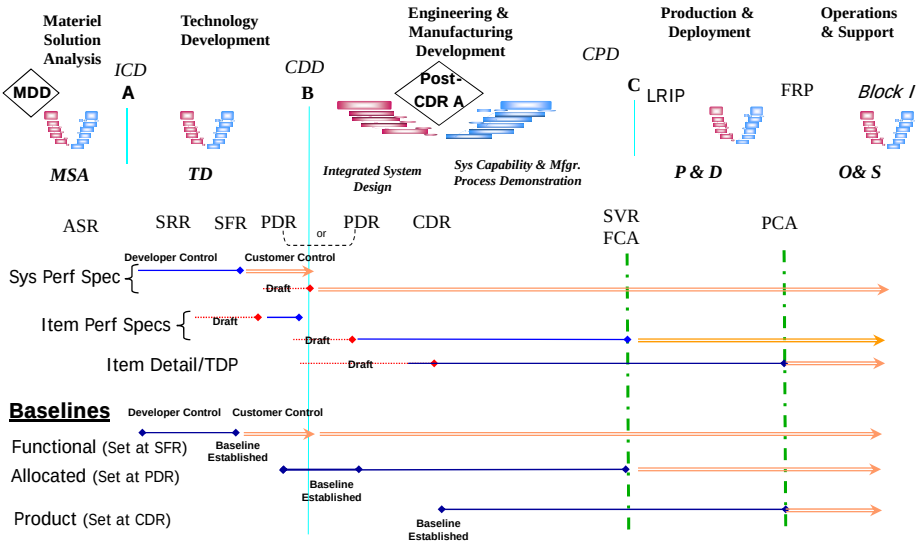
- LFT&E Waiver request
- Risk Assessment
- TEMP, SEP, PESHE, PPP, TRA,
- NEPA compliance schedule
- *Validated Sys Support & Maintenance Objectives & Requirements*
- *System Safety Analyses*

Inputs to:

- Integrated Baseline Review
- Information Support Plan
- System Threat Assessment
- Capabilities Development Document
- Acquisition Strategy
- Affordability Assessment
- Cost/Manpower Estimate

Supports MS B

Systems Engineering Baselines



Key Phase Document

Draft Capability Development Document

- **User Document (JCS)**
- **PMO Comments Invited**
- **Increment Specific**
- **Performance Attributes (KPPs and KSAs)**
- **Architectural Views Provided**
- **IOC / FOC Provided**

Capability Development Document Format (CJCSM 3170.01C)

1. Capability Discussion
2. Analysis Summary
3. Concept of Operations Summary
4. Threat Summary
5. Program Summary
6. System Capabilities Required for the Current Increment
   - Present each attribute in output-oriented, measurable and testable terms.
   - Provide tables summarizing specified KPPs and additional performance attributes in threshold - objective format, as depicted below

JOpsC key characteristics Key Performance Parameter Development Threshold

Development Objective

KPP 1 Value

Table X.X. Example Key Performance Parameter Table

Attribute Development Threshold / Development Objective

Attribute Value

Table X.X. Additional Attributes

Capability Development Document Format (CJCSM 3170.01C cont.)

7. Family of System and System of System Synchronization.
8. Information Technology and National Security Systems Supportability
9. Intelligence Supportability.
10. Electromagnetic Environmental Effects (E3) and Spectrum Supportability
11. Assets Required to Achieve Initial Operational Capability (IOC).
12. Schedule and IOC and Full Operational Capability (FOC) Definitions
13. Other DOTMLPF and Policy Considerations
14. Other System Attributes.
15. Program Affordability.
    - Mandatory Appendices (abbreviated due to space):
      - AV-1, OV-1, OV-2, OV-4, OV-5, OV-6C
      - SV-2, SV-4, SV-5, SV-6
      - TV-1 (Draft IT Standards Profile generated by the DOD IT Standards Registry (DISR) online)

Key Phase Document

Draft System Performance Specification

- **PMO Document (Contract Section C)**
- **Aligned with CM Baselines**
- **Oriented to WBS Product Breakdowns**
- **Increment Specific**
- **Contract Officer needed to Modify**

Performance Specification Format
(MIL-STD 961E)

- **Section 1- Scope: Consist of clear, concise abstract of coverage of specification. The scope shall not contain requirements.**
- **Section 2 - Applicable Documents: Shall list only those documents referenced in sections 3, 4, or 5 of specification.**
- **Section 3- Requirements: Defines the requirements that entity must meet to be acceptable. The following criteria shall apply:**
  - **Measurable / Achievable / Verifiable**
  - **Requirement cross-referenced to the verification method.**
  - **Requirements worded to be clear and unambiguous.**
  - **Requirements described in a manner to encourage competition.**
  - **Each paragraph should only address one requirement or topic.**

Performance Specification Format
(MIL-STD 961E)

- **Section 4- Verification: shall include all inspections to be performed to determine that the item to be offered for acceptance conforms to the requirements in section 3 of the specification**
- **Section 5- Packaging: the packaging requirements shall be as specified in the contract or order.**
- **Section 6- Notes: not contractually binding. No requirements shall be included in section 6.**

Verification Methods
(Section 4 of the System Specification)

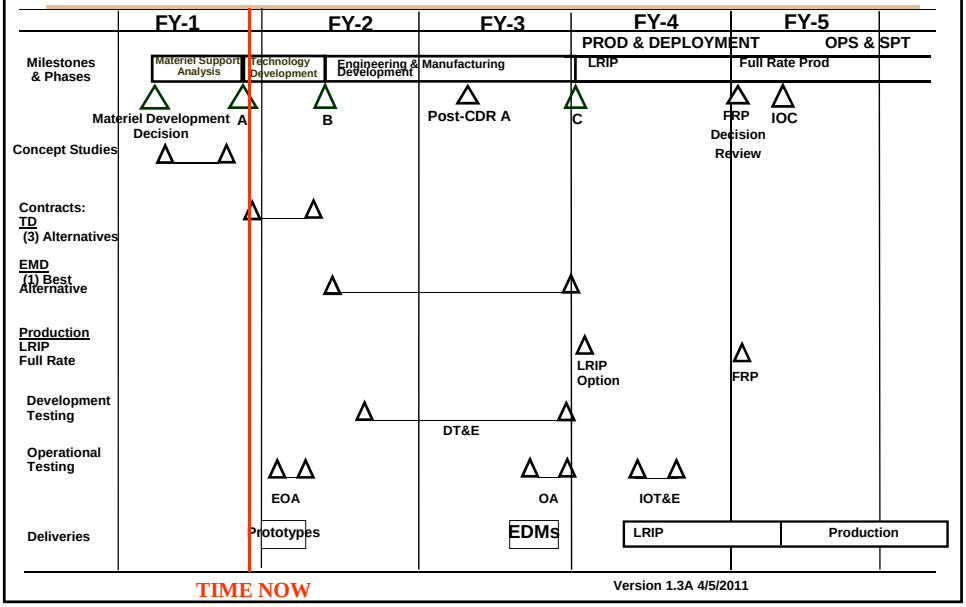
Demonstration: Performance of operations at system/sub-system level where visual observations are primary means of verification. Demonstration is used when quantitative assurance is not required for verification of requirements.

Inspection/Examination: Visual inspection of equipment and evaluation of drawings and other pertinent design data and processes will be used to verify conformance with characteristics such as physical, material, part and product marking and workmanship.

Analysis: Use of recognized analytical techniques (including computer models) to interpret or explain behavior/performance of system element. Analysis of test data or review and analysis of design data will be used as appropriate to verify requirements.

Test: Provides data on functional features and equipment operation in an operational environment under fully controlled and traceable conditions. Data is subsequently used to evaluate quantitative characteristics. Evaluation includes comparison of demonstrated characteristics with requirements. Tests are conducted when acceptable level of confidence cannot be established by other methods, or if testing can be shown to be most cost-effective method.

Notional Bull Dog Program Structure Chart



Technology Development Exercise Overview

At Milestone (M/S) A, BG Beauregard issued an Acquisition Decision Memorandum (ADM) that set the exit criteria that must be achieved prior to entering into EMD. For the Bull Dog at M/S B, the exit criteria were:

a. Demonstrate Platform capability against the projected threat in the given environment.

b. Technical Maturity of the recommended UGV system must be assessed at TRL 6 or higher.

The two platform Materiel Solutions selected in the TD Phase will be prototyped and demonstrated in a relevant environment.

Your UGV IPT has been tasked with inputs for the upcoming M/S B decision.

Technology Development Exercise Assignment

Tasks: Select a briefer and divide the following exercise sections between your team members to complete.

1. Using the Student Briefing Templates on your Student CD in the Lesson 5 folder, use the CDD Requirements Matrix to identify the following:

   a. Is it a good CDD requirement (e.g. clear, measurable, etc.)?
   b. Do the requirements trace to TD specification?
   c. Is it a good specification requirement (e.g. clear, measurable, etc.)? Is there a performance criterion associated with requirement? What is it?
   d. What verification method would you use for the requirement?
   e. If the answer to a., b., or c. above is No/NA, what should you do?

Lesson 5, Question 1 Team 1

Team Assigned		CDD Requirements	Good CDD Reqmnt? Y/N	Traces to Spec? Y/N	Good Spec Reqmnt? Y/N	Verification Method	For No, Your Resolution?	Comments
1	1	(6.b.1.b.) Control. The UGV shall be capable of conducting operations by remote control using line-of-sight communications.						
1	3	(6.b.1.d.) Range. The UGV shall have a range of not less than 10 km (threshold), 30 km objective) [KPP].						
1	5	(6.b.1.f.) IFF Accuracy. The UGV shall be capable of identifying friendly targets with a single target accuracy of 0.90 (threshold), 0.99 (objective). [KPP]						
1	7	(6.b.1.h.) Transportability. The UGV shall be capable of being moved within theater by C-130 (t/o).						
1	9	(6.b.2.b.) Biological Detection. The UGV shall be capable of detecting and identifying each of the 14 biological agents listed in the classified annex to this CDD with an accuracy of .9 (t) and .98 (o).						

Lesson 5, Question 1
Team 2

Team Assigned		CDD Requirements	Good CDD Reqmnt? Y/N	Traces to Spec? Y/N	Good Spec Reqmnt? Y/N	Verification Method	For No, Your Resolution ?	Comments
2	2	(6.b.1.c.) Speed. Speed and ease of operation are closely intertwined. The system shall be capable of moving at a speed of 15 kph (threshold), 40 kph (objective).						
2	4	(6.b.1.e.) Terrain. The UGV shall be capable of operating across grass, dirt and loose sand and climb inclines up to 15 degrees (threshold), 30 degrees (objective).						
2	6	(6.b.1.g.) Automatic fire override. The UGV shall automatically override any firing command, stop and provide a message should the IFF system detect a friendly target.						
2	8	(6.b.2.a.) Chemical Detection. The UGV shall be capable of detecting the presence of contamination from chemical weapons with an accuracy of 0.8 (threshold) 0.95 (objective).						
2	10	(6.b.2.c.) Mine Detection. The system shall be capable of warning the operator of a buried mine so that the operator may take actions to avoid running over the mine. The UGV shall be capable of locating buried mines with a single-mine detection reliability of .95 (threshold), .99 (objective) [KPP].						

Lesson 5, Question 1
Team 3

Team Assigned		CDD Requirements	Good CDD Reqmnt? Y/N	Traces to Spec? Y/N	Good Spec Reqmnt? Y/N	Verification Method	For No, Your Resolution?	Comments
3	11	(6.b.2.d.) Terrain. The UGV shall be capable of maneuvering over small obstacles and around large obstacles while conducting this mission.						
3	13	(14.a.) Infrastructure Support. Vehicles must be supportable by current and projected combat support and service support assets. Forces must be transportable in an operational configuration in strategic and tactical air transportation aircraft. Systems must also be capable of transport on unrestricted highway, rail, maritime prepositioned ships, amphibious ships, amphibious landing craft, and other marine transport worldwide.						
3	15	(14.c.) Training. A complete training support package, including appropriate training methods, devices and simulators must be available concurrent with system fielding for both the institutional training base and units in the field.						
3	17	(14.e.1.) Compatibility and interoperability with existing and planned C3I systems are the key to the success. The UGV must fully comply with all Global Information Grid (GIG) policies and be fully compatible with its architecture.						

Lesson 5, Question 1
Team 4

Team Assigned		CDD Requirements	Good CDD Reqmnt? Y/N	Traces to Spec? Y/N	Good Spec Reqmnt? Y/N	Verification Method	For No, Your Resolution ?	Comments
4	12	(6.b.3.b.) Reconnaissance Operations. As a secondary mission, the UGV shall be capable of detecting the presence of chemical and biological contamination. The most likely scenario for use of chemical and biological weapons would be in operations other than war such as a terrorist attack. Therefore, the UGV shall be capable of both rapid and precise maneuver in restricted spaces to move over and around obstacles during this mission.						
4	14	(14.b.) Manpower and Personnel. A primary goal is to reduce the number of personnel involved in hazardous operations (e.g., RSTA and mine detection), and thus to cut casualties. Maintenance of UGV shall require no skills not already in existence within the Army, Marine Corps, or Air Force personnel structures.						
4	16	(14.d.) Environmental. Must comply with all U.S. environmental regulations and with all international environmental protocols and treaties to which the U.S. is a signatory.						

Lesson 5, Question 1
Team 5

Team Assigned		CDD Requirements	Good CDD Reqmnt? Y/N	Traces to Spec? Y/N	Good Spec Reqmnt? Y/N	Verification Method	For No, Your Resolution?	Comments
5	19	(14.e.3.a.) UGV must be capable of conducting operations in all applicable operational environments, including hot, basic, and cold climates. Environmental conditions include BC, electronic, and electromagnetic environments and toxic industrial chemicals.						
5	21	(14.e.5.) Supportability. The UGV shall be supported over its life cycle by replacing individual parts as they wear out. The system is expected to be in service for a period of 15 years and shall be designed for a minimum service life of 15 years.						
5	23	(14.e.7.) Readiness/Operational Availability Measures. Fully mission capable (FMC) and mission capable (MC) rates will be the measures employed to assess system readiness/operational availability. FMC is the percentage of time during which the system is capable of performing all assigned missions; MC is the percentage of time during which the system is capable of performing at least one of its assigned missions. Actual FMC and MC ratesare evolving requirements and will be the subject of the next CDD review.						

Lesson 5, Question 1
Team 6

Team Assigned		CDD Requirements	Good CDD Reqmnt? Y/N	Traces to Spec? Y/N	Good Spec Reqmnt? Y/N	Verification Method	For No, Your Resolution?	Comment
6	18	(14.e.2.) The system must utilize a distributed network control-communication architecture which allows for flexible integration and operation of multiple remote sensor systems and control stations. This architecture must provide flexibility in future integration with evolving military digital radio networks (i.e. Army's Tactical Internet and DARPA's Warfighter Internet).						
6	20	(14.e.4.) Transportation. The UGV shall be capable of transportation to the theater of operation in standard shipping containers. These containers shall be selected from the existing government inventory. Once in theater, UGV shall be capable of rapid deployment to forward operating areas.						
6	22	(14.e.6.) Maintenance and Operations. The UGV will have three categories of maintenance: organization, intermediate and depot level. The system shall not require the use of highly educated or trained personnel for its operation or for organizational maintenance.						
6	24	(14.e.8.) Combat Support Requirements. The UGV shall be capable of battlefield damage repair in the field using currently available tools and repair techniques.						

Vehicle Risks

(Select the top risks for your two vehicles)

2. What are the risks associated with each of your platforms taken into the TD phase? Use the Competitive Prototyping Test Report and your experiences and/or background to identify potential risks.

Tracked Vehicle:

Wheeled Vehicle:

Hover Vehicle:

Platform Design Comparisons
(Pick the best platform)

3. a. Identify at least four key platform performance requirements that you can use under the "Performance Column" to compare the alternatives. Then considering the risks from the previous slides, rank order the platforms to allow you to select the best one to take forward into the EMD acquisition phase.

   b. Provide your assumptions and associated rationale supporting your selections.

   c. Use a weighting factor of 60% for Performance / 30% for Cost / 10% for Schedule (which may be equal for all platforms at this time).

Platform Design Comparisons

Describe how you came up with your final Bull Dog selection.

- Explain why you selected these performance requirements as critical to the mission(s). Change/expand chart as needed:

TD Phase Comparisons(1=High/3=Low)

Selection Criteria	Weight Factor	Platform #1	Platform #2
PERFORMANCE: KPPs	.60		
TOTAL COST:	.30		
SCHEDULE:	.10		
Total score			

Technical Reviews

4. Technical Reviews:

a. Given these phase reviews, what is their purpose? (ref: DAG 4.3.2.4.)

- System Requirements Review (SRR)
- Systems Functional Review (SFR)
- Preliminary Design Review (PDR)
- Technology Readiness Assessment (TRA)
- Integrated Baseline Review (IBR)

Technical Reviews

b. What entrance/exit criteria would you propose for these Bull Dog reviews?

	Entrance Criteria	Exit Criteria
SRR		
SFR		
PDR		
TRA		
IBR		

Systems Engineering Plan

5. Explain what information in this phase could be used to update the following SEP areas for the M/S B review?
   - Requirements:
   - Technical Staffing:
   - Technical Baselines:
   - Technical Reviews:
   - Technical integration with business functions:

Technical Processes

6. Relate the following Technical Process steps to the SE efforts in this phase.
   - Stakeholder Requirements Definition
     - What requirements would make good KPPs?
   - Requirements Analysis Process
     - What functions must the vehicle perform to successfully do the Laser Directed Attack Scenario?
   - Architectural Design Process
     - Which of the above functions relate to the vehicle design vice the sensor/weapon design?
   - Implementation
     - Using the Laser Directed Attack Scenario, which functions will be most likely performed by GFE (sensors/weapons) given to the developer to integrate on their platforms?
   - Integration
     - Would you expect software to be integrated into the prototypes during this phase? Why?

Technical Processes

- Verification
  - Would you expect any verification to be completed in this phase?
- Validation
  - Would you expect any validation be completed in this phase? By whom?
- Transition
  - What data is needed to support the next Milestone Review?

Technical Management Processes

7. Briefer: Relate the following Technical Management Processes to what you do at work.
   - Decision Analysis
   - Technical Planning
   - Technical Assessment
   - Requirements Management
   - Risk Management
   - Configuration Management
   - Data Management
   - Interface Management

Lesson References and Tools

- Wall Chart:
  https://ilc.dau.mil/
- Milestone Document Identification Tool:
  https://dap.dau.mil/mdid
- DAU Glossary:
  https://dap.dau.mil/glossary
- Technical Review Checklists:
  http://www.acq.osd.mil/se
- SETR Processes (Navy):
  https://nserc.navy.mil