



SYSTEMS ENGINEERING AND INTEGRATION

**Systems Engineering Processes Applied
To Ground Vehicle Integration at US Army Tank
Automotive Research, Development, and
Engineering Center (TARDEC)**

Dr. Bruce Brendle and Andrew Yee

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Mission:

CGVDI provides the Department of Defense a single project management office that coordinates activities across RDECOM and DoD to conduct the complete spectrum of activities required for design, development, fabrication, integration and testing of ground systems (manned or unmanned) from engineering changes to full system prototypes in order to meet the needs of the warfighter.

Description

- Leverages RDECOM and DoD capabilities in a repeatable process to apply rigorous systems engineering to ground systems integration
- Provides customer partners a single entry point for cost, schedule, performance and risk management of system integration projects

Notable Recent Accomplishments

- MRAP Capability Insertion for Caiman, MaxxPro, RG-31 and RG-33 Systems
- Command and Control on the Move (Stryker and MRAP Integrations)
- Robotic Deployment System

Employs TARDEC organic Concepts, Analysis, System Simulation and Integration (CASSI), System Engineering (SE), and significant contributions from other RDECs and Organizations

CGVDI Projects (active):

- MRAP Capability Insertion
- C2OTM* – MRAP
- C2OTM* – Stryker
- LAV-R Upgrade
- RS-JPO
- PM-AMS

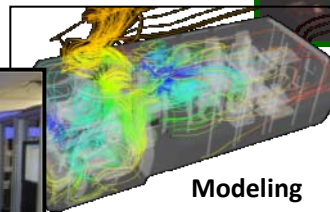
*Command & Control On The Move



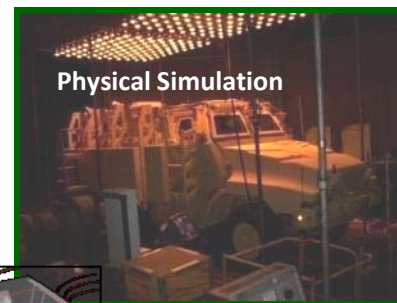
User Jury



C4 Integration Bench

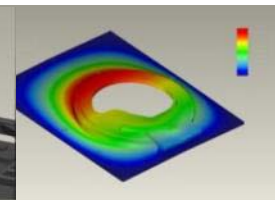
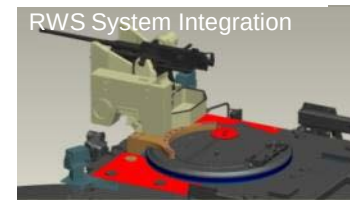


Modeling

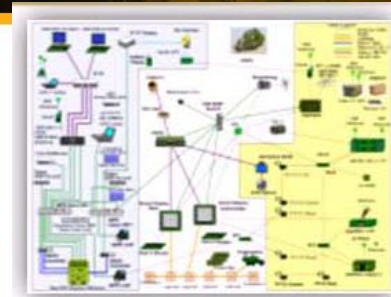


Physical Simulation

RWS System Integration



System Architecture

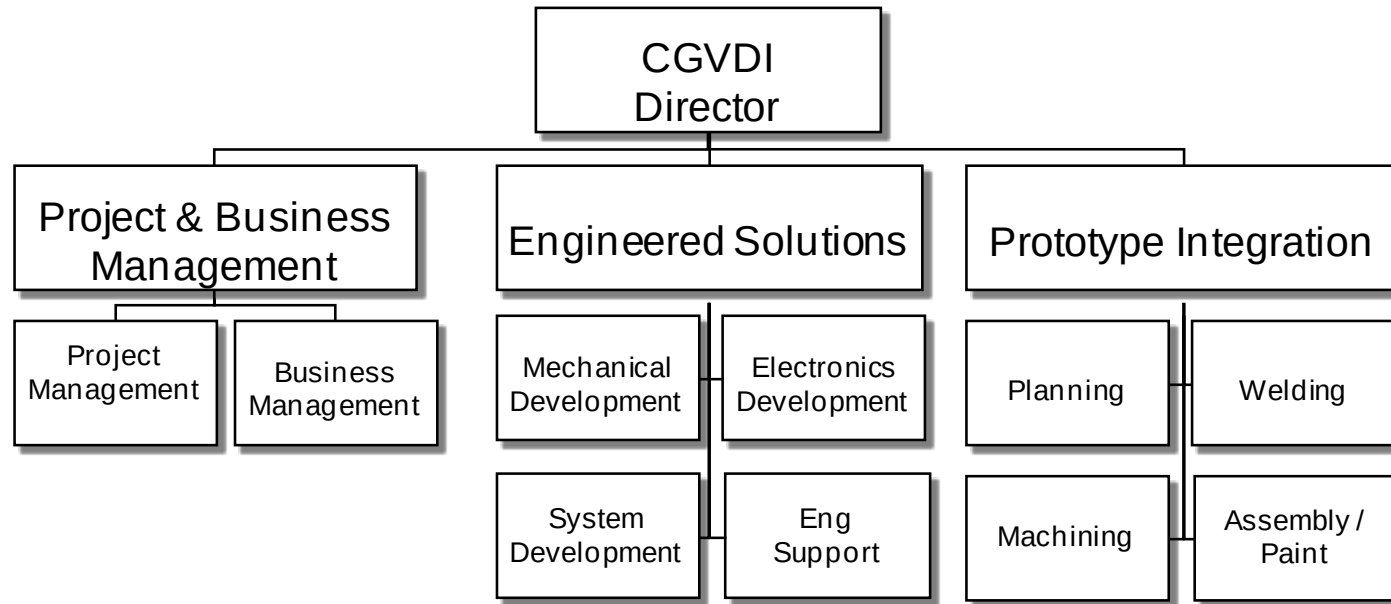


MRAP Capability Insertion

- Vanguard
 - CROWS II Remote Weapon Station
 - Boomerang
 - Double Shot
- LRAS3
- Check 6 Camera
- OGP Overhead Protection
- Overhead Wire Mitigation
- IBIS TEK Lights
- RPG Protection
- Power Upgrade (derived requirement)
- C4I Architecture (derived requirement)
- Thrown Object Protection System

Organizational Structure

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CGVDI combines TARDEC's Ground Vehicle Integration Center and Prototype Integration Facility to create an improved, integrated capability.



CGVDI Projects

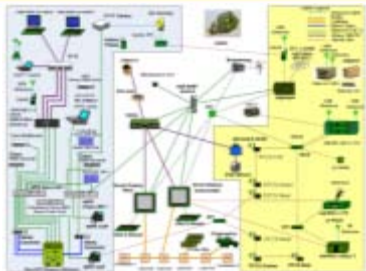
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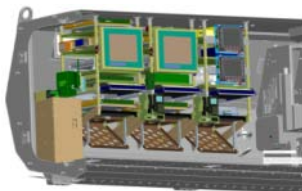
- Initial MRAP CI Scope: Capability Insertion System Integration for Caiman, MaxxPro, RG-31, and RG-33
 - System Development & Integration
 - Analyses
 - Installation Manuals
 - VAL/VER Kit
 - Spare Parts
 - Initial Production
 - Level III TDP
- New MRAP Scope
 - MaxxPro Dash CI
 - MATV CP 11-12
 - Caiman Ambulance
- Other Significant Efforts
 - Command & Control On The Move (C2OTM)
 - Caiman
 - Stryker
 - MATV
 - LAV-R Upgrade
 - Robotic Deployment System
 - MRAP Egress Assistance Trainer
 - Universal Combat Lock Tool

Sample Deliverables

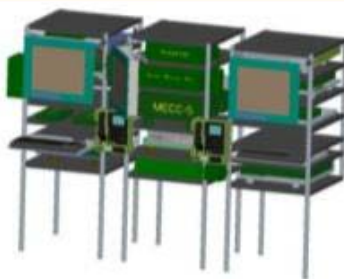
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Updated Architecture Requirement



Updated Architecture Requirement



Systems Integration Lab



Fully Integrated Test Asset



Fully Integrated Caiman First Unit Equipped Asset



8 Vehicle A Kits for Installation



2 Spare Kits



1 Validation Kit

Antenna Analysis
Power Analysis
Thermal Analysis
Blast Analysis
HFE Analysis
Safety Analysis

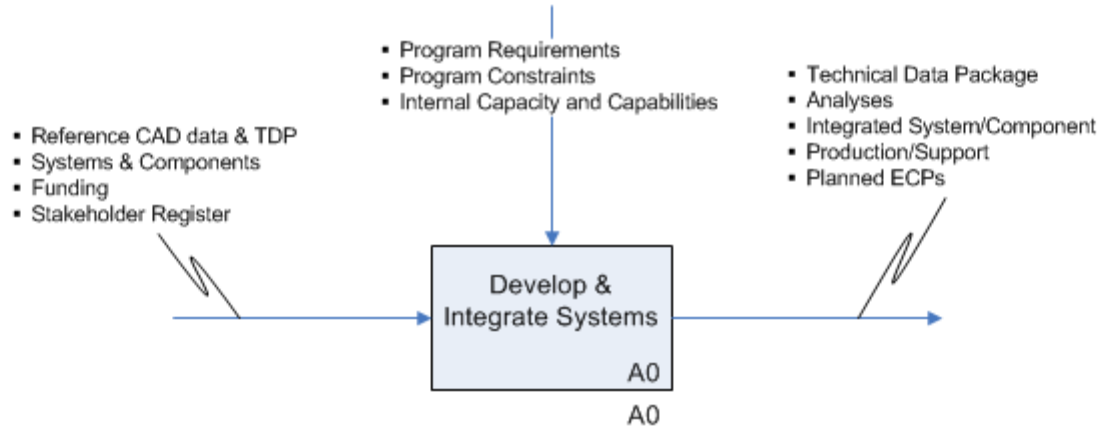
Level II
Drawings

FSR
Level
Install-
Manuals

Level III
Drawing
Package

System Development & Integration Process

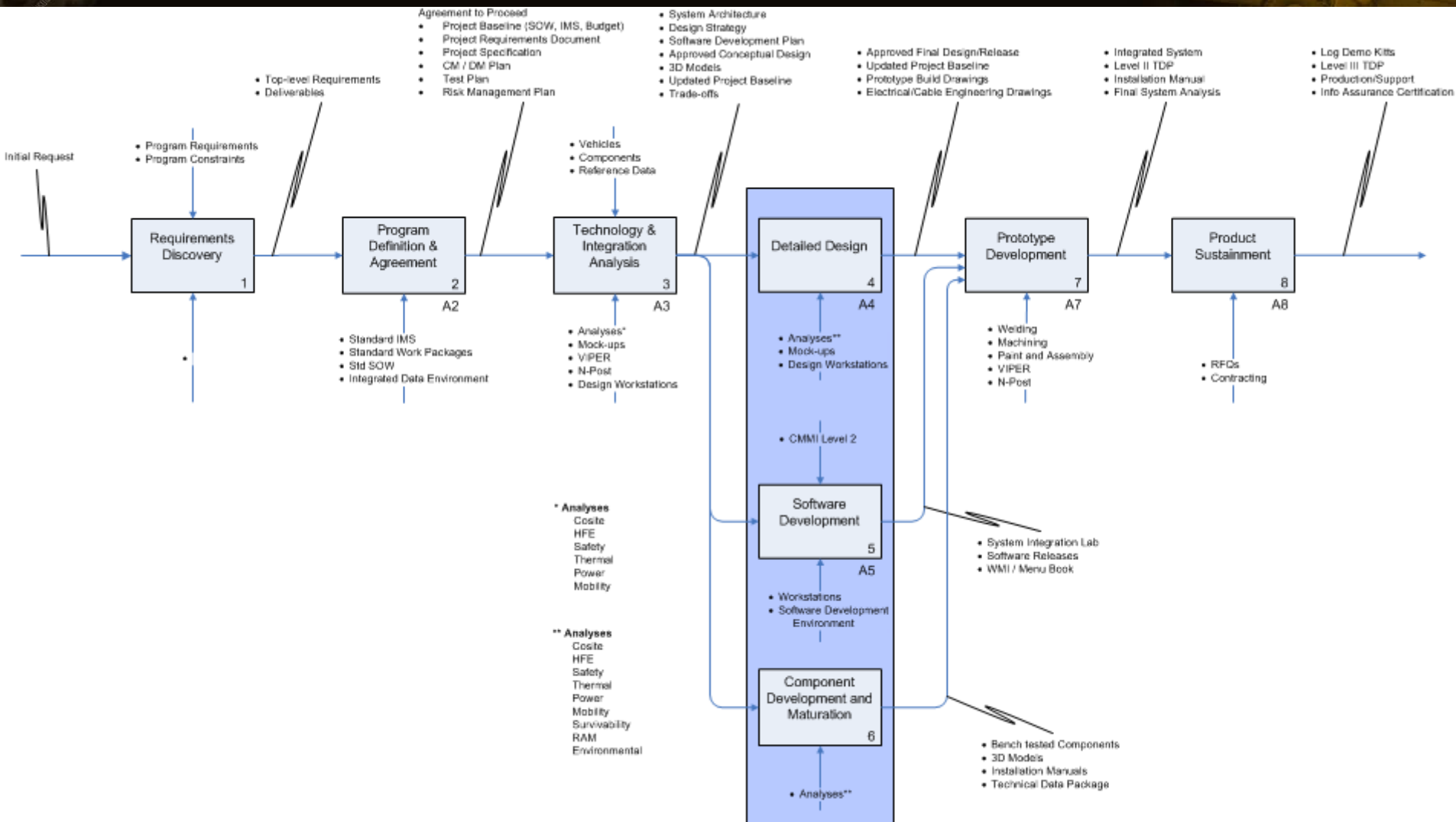
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Purpose: To ensure rigorous system engineering principles are applied in a repeatable fashion to all TARDEC System Development & Integration projects

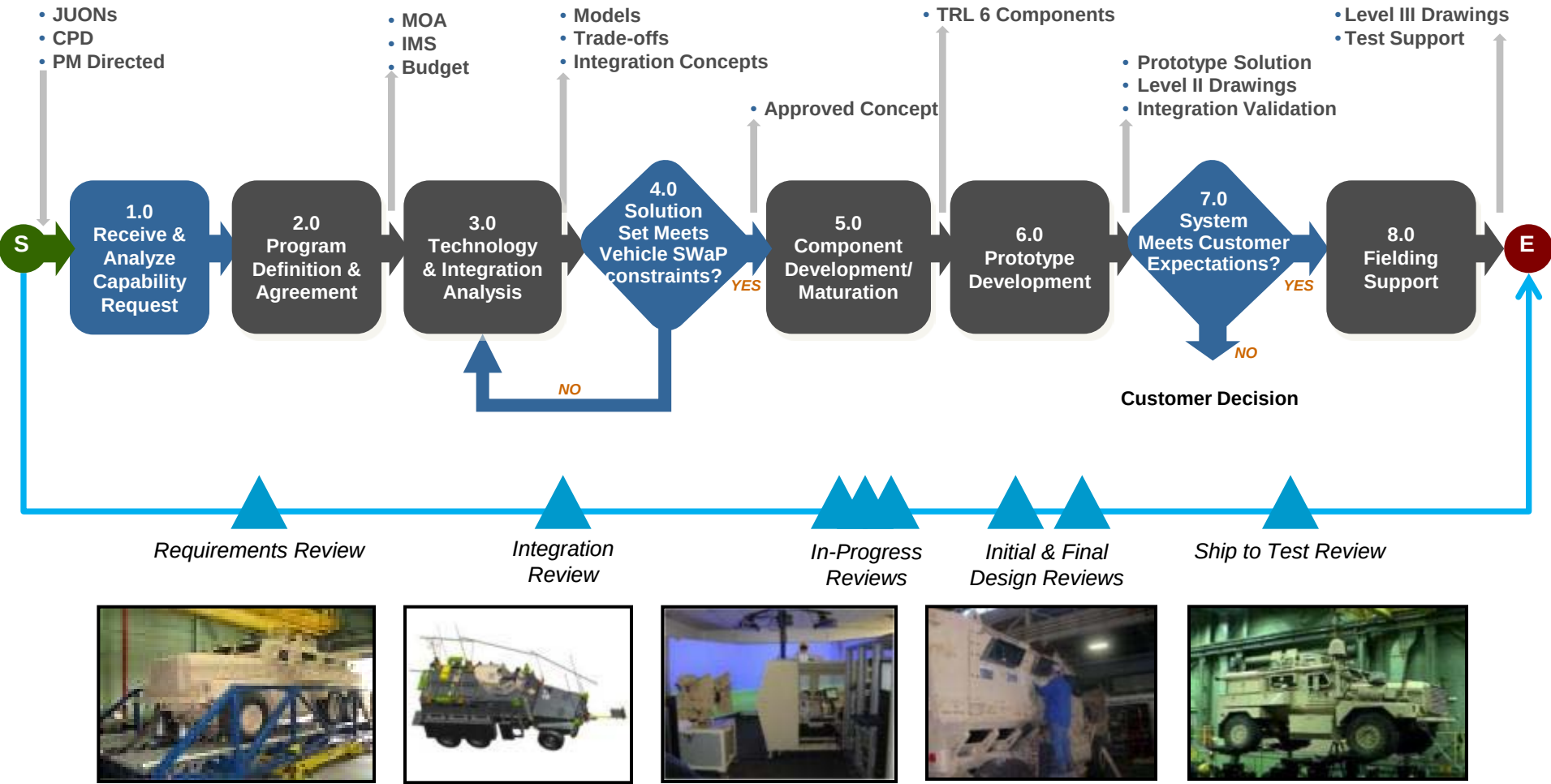
System Development & Integration Process

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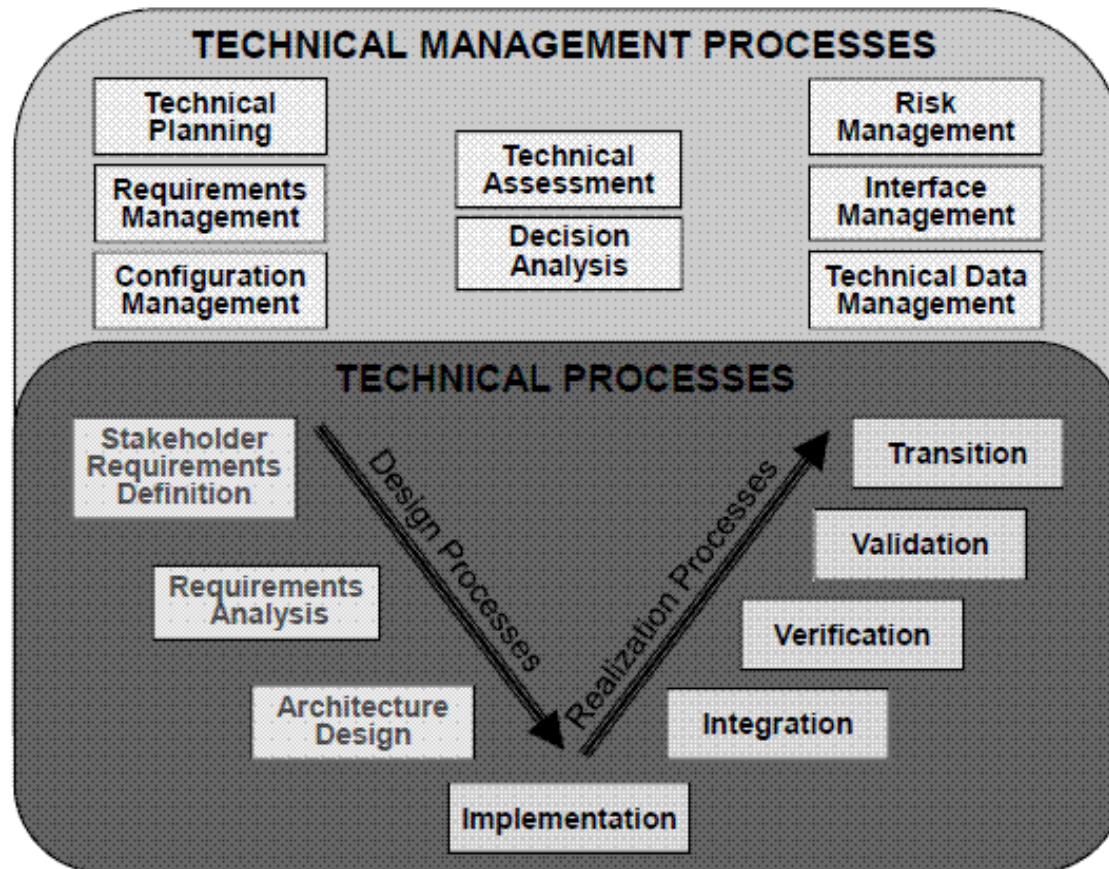


System Integration Process

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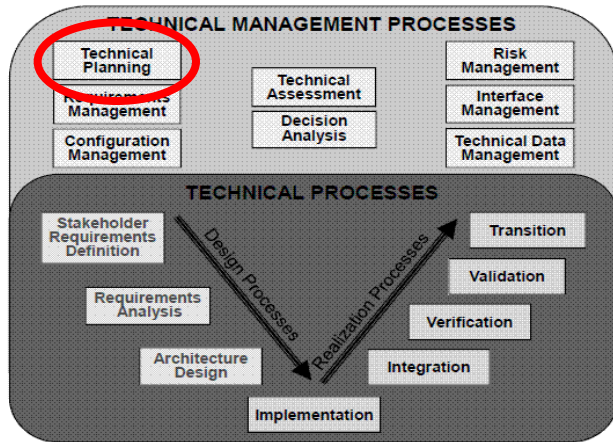


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DEPARTMENT OF DEFENSE SYSTEMS ENGINEERING PROCESS MODEL 2009

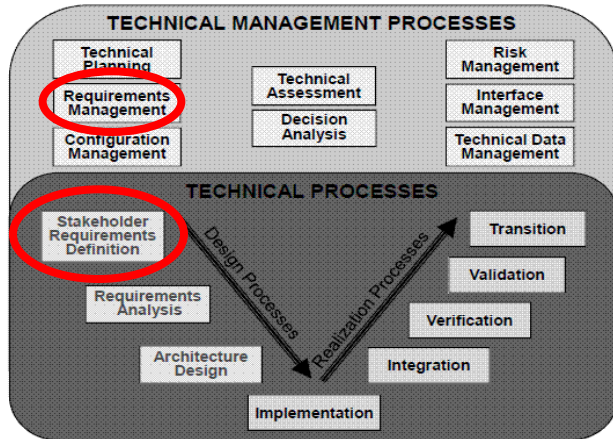
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TECHNICAL PLANNING

- Infused SE Processes Throughout the CGVDI System Development & Integration Process.
- Developed and Documented a Systems Engineering Plan (SEP) to Layout Operating Process.
 - ❑ Form the Basis for Developing Standard Operating Procedures (SOPs).
- Foundation for Planning “What” SE Processes to Implement and “How” to Implement.

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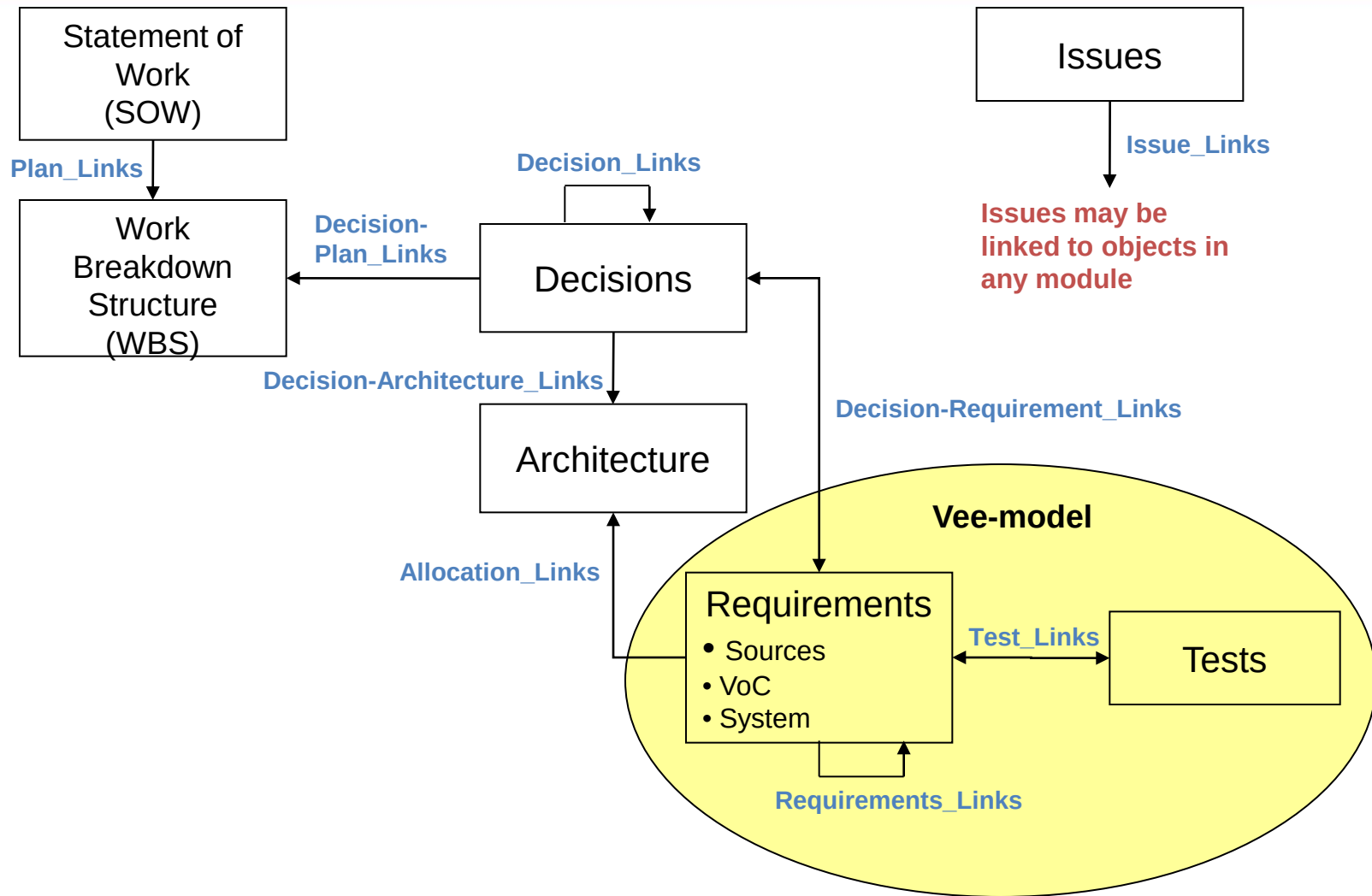


STAKEHOLDER REQUIREMENTS DEFINITION

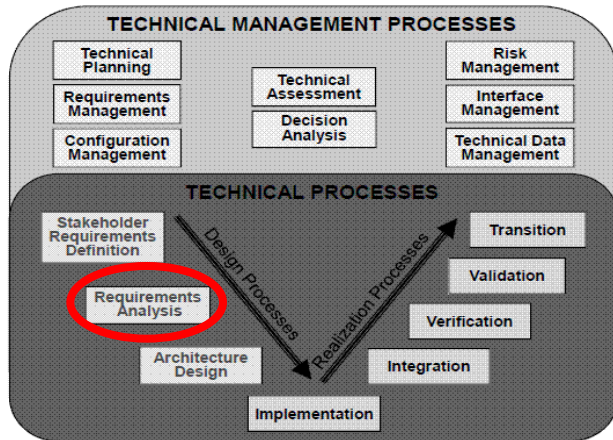
- Requirements Management Process Implemented to:
 - ✓ Capture Project Requirements
 - ✓ Organize Project Requirements
 - ✓ Analyze Project Requirements
 - ✓ Trace Project Requirements
- Requirements Gathering From Sources Such As:
 - Project Statement of Work
 - Customer Input/Documents
 - System Requirements
 - Derived Requirements
 - Lessons Learned

REQUIREMENTS INFORMATION MODEL

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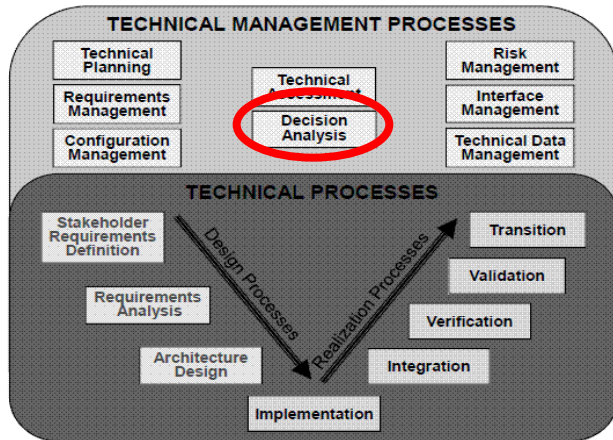
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REQUIREMENTS ANALYSIS

- Requirements Decomposition – Ensures Requirements are:
 - ✓ Singular
 - ✓ Concise
 - ✓ Unambiguous
 - ✓ Verifiable
- Requirements Traceability– Provides Confidence in Project Completion (Gap Analysis) :
 - ✓ All Requirements Are Allocated to Architecture/Solution
 - ✓ All Requirements Are Linked to Verification Method

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DECISION ANALYSIS

- Alternative Solutions Selection
 - Define Criteria
 - Assign Weighting Factors
 - Assign Relative Category Importance (Cost, Schedule, Performance)

DECISION ANALYSIS TOOL

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Vehicle Winch Alternative Selection Matrix

Category Weight

Defined Criteria

Criteria Scoring Value Guidance

Criteria Relative Importance Ranking

Criteria Score

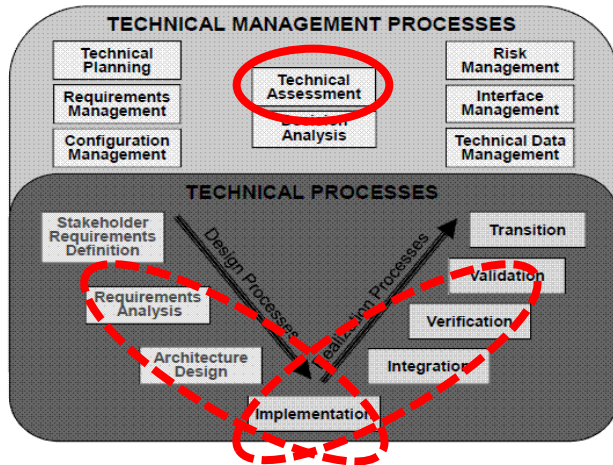
Criteria Weighted Score

Total Option Score – Highest Value Chosen

Criteria	Scoring Quantifiers	Weighting Factor (Priority Within Category 1-Low to 10-High)	Normalized Weighting Factor	Option 1 Raw Score	Option 1 Criteria Value	Option 1 Weighted Score	Option 2 Raw Score	Option 2 Criteria Value	Option 2 Weighted Score	Option 3 Raw Score	Option 3 Criteria Value	Option 3 Weighted Score
Performance		30%										
		8	0.0369231	9		0.3323077	3		0.1107692	3		0.110769
Criteria 1	3 = > criteria value 6 = <= criteria value < 9 9 = < criteria value	6	0.0276923	9		0.2492308	9		0.0830769	6		0.166154
		6	0.0276923	6		0.1661538	6		0.1661538	6		0.166154
		6	0.0276923	9		0.2492308	9		0.2492308	9		0.249231
		1	0.0046154	3		0.0138462	3		0.0138462	3		0.013846
		5	0.0230769	3		0.0692308	6		0.1384615	3		0.069231
		5	0.0230769	3		0.0692308	3		0.0692308	3		0.069231
		10	0.0461538	9		0.4153846	6		0.2769231	6		0.276923
		10	0.0461538	9		0.4153846	3		0.1384615	3		0.138462
Criteria n		8	0.0369231	3		0.1107692	3		0.1107692	3		0.110769
Subtotal		65										
Weighted Subtotal						2.0907692			1.3569231			1.370769
Schedule		50%										
Criteria 1		10	0.1470588	6		0.8823529	9		1.3235294	9		1.323529
		4	0.0588235	9		0.5294118	9		0.5294118	9		0.529412
		10	0.1470588	3		0.4411765	3		0.4411765	3		0.441176
		10	0.1470588	3		0.4411765	3		0.4411765	3		0.441176
Criteria n												
Subtotal		34										
Weighted Subtotal						2.2941176			2.7352941			2.735294
Cost		20%										
Criteria 1		10	0.0377358	6		0.2264151	6		0.2264151	6		0.226415
		8	0.0301887	9		0.2716981	6		0.1811321	9		0.271698
		7	0.0264151	9		0.2377358	6		0.1584906	6		0.158491
		1	0.0037736	6		0.0226415	3		0.0113208	3		0.011321
		2	0.0075472	0		0	0		0	0		0
		9	0.0339623	4		0.1358491	1		0.0339623	3		0.101887
Criteria n		8	0.0301887	3		0.090566	3		0.090566	3		0.090566
		8	0.0301887	3		0.090566	3		0.090566	3		0.090566
Subtotal		53										
Weighted Subtotal						1.0754717			0.7924528			0.950943
Grand Total		100%				5.4603556			4.88467			5.057007

Total Option Score – Highest Value Chosen

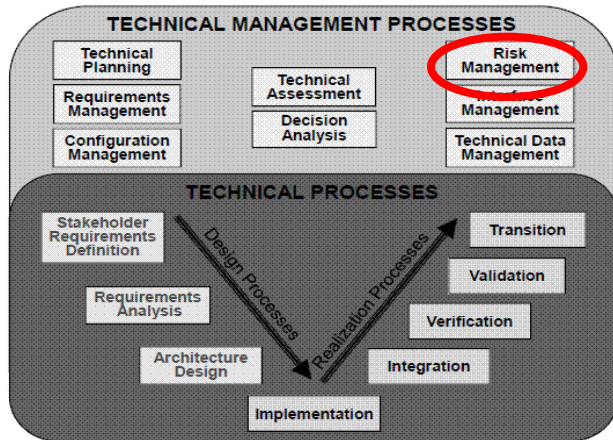
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TECHNICAL ASSESSMENT

- Technical Reviews Based On Formal Reviews Defined in Defense Acquisition Guidebook.
 - Less Formal Implementation (Formal Reviews Reserved for Major Defense Acquisition Programs)
- Reviews Include:
 - ✓ Project Requirements Review
 - ✓ Project Functional Review
 - ✓ Integration Review
 - ✓ Initial Design Review
 - ✓ Final Design Review
 - ✓ Risk Management Reviews
 - ✓ Stakeholder Integrated System Review
 - ✓ Functional Verification Audit
- Entry/Exit Criteria Used To Determine Outcome (Pass, Fail, Pass with Follow-Up).

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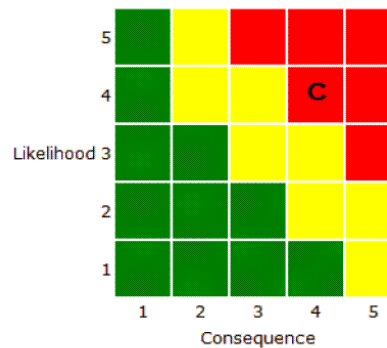


RISK MANAGEMENT

- Project Risks Continuously Evaluated In Areas Such As:
 - Performance
 - Cost
 - Schedule
- Risks Managed Using Risk Management Tool called “Risk Recon” Developed by Program Executive Office (PEO) Ground Combat Systems (GCS).

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RISK MANAGEMENT TOOL



Home Reports New Users Help Users: Project: No Project Loaded...

Classified data must not be stored in this risk management tool

Home Page

General Project Information

Project: [Click 'Open Project' to load a project or click 'New Project' to create a new project](#)

Organization: TBD

PMO: TBD

Product: TBD

Program: TBD

[Open Project](#)

Risks Assigned to this Project

Risk Review Board

Risk Management Team

Classified data must not be stored in this risk management tool

Home Page

General Project Information

Project: test three

Organization: HBCT Test Org

PMO: HBCT Test PMO

Product: HBCT Training

Program: HBCT Training

[Open Project](#) [Edit Project](#)

Risks Assigned to this Project

	Status Report	Info Sheet	Detailed Analysis	ID	Risk/Name	Status	Lead	Opened Date	Consequence	Likelihood
Edit	View	View	View	701	To - Test V4.5	In Planning		3/24/2010	(4) Critical	(2) Low Likelihood
Edit	View	View	View	827	Car ran out of gas	Closed		1/8/2010	(2) Marginal	(8) Near Certainty
Edit	View	View	View	658	Class work not on time	Baseline		1/13/2010	(3) Moderate	(8) Moderate
Edit	View	View	View	822	Data Loss	Examined		4/2/2010	(4) Critical	(3) Moderate
Edit	View	View	View	628	Faulty Brakes	Closed		1/8/2010	(2) Marginal	(3) Moderate
Edit	View	View	View	001	Global Warming due to fossil fuels	In Planning		2/17/2010	(4) Critical	(8) Moderate
Edit	View	View	View	825	Hitting a deer	Baseline		1/8/2010	(4) Critical	(4) Highly Likely
Edit	View	View	View	587	Loss of power in a thunderstorm	In Planning		10/27/2009	(4) Critical	(4) Highly Likely
Edit	View	View	View	748	Operating system rollout data moved up	Baseline		3/17/2010	(4) Critical	(8) Moderate
Edit	View	View	View	617	Parking lot accidents	In Planning		1/8/2010	(3) Moderate	(2) Low Likelihood
Edit	View	View	View	557	Risk 01	In Planning		12/14/2009	(3) Moderate	(3) Moderate
Edit	View	View	View	567	Risk 02	In Planning		12/17/2009	(3) Moderate	(3) Moderate
Edit	View	View	View	593	Risk 04	In Planning		12/17/2009	(3) Moderate	(3) Moderate
Edit	View	View	View	002	Risk 05	In Planning		12/24/2009	(4) Critical	(8) Moderate
Edit	View	View	View	787	Risk 08	Examined		3/23/2010	(3) Moderate	(3) Moderate
Edit	View	View	View	652	GIL delay	In Planning		1/21/2010	(4) Critical	(4) Highly Likely
Edit	View	View	View	620	Vehicle Theft	Watch List		1/7/2010	(3) Moderate	(8) Moderate

[Create New Risk](#)



SUMMARY

SYSTEMS ENGINEERING AND INTEGRATION



- The Systems Engineering Revitalization In the Department Of Defense is Gaining Momentum At TARDEC Through the Systems Engineering Group's Effort.
- The Center For Ground Vehicle Development And Integration's System Development And Integration Process Has Become An Excellent Implementation Of The Systems Engineering Process Model.