U.S. Army Research, Development and Engineering Command

RDECOM

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

U.S. Army Electromagnetic Gun Project Backup Slides

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
08 SEP 2009	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
U.S. Army Electromagnetic Gun Project Backup Slides	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000**	8. PERFORMING ORGANIZATION REPORT NUMBER **20220RC**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) **TACOM/TARDEC**
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) **20220RC**

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

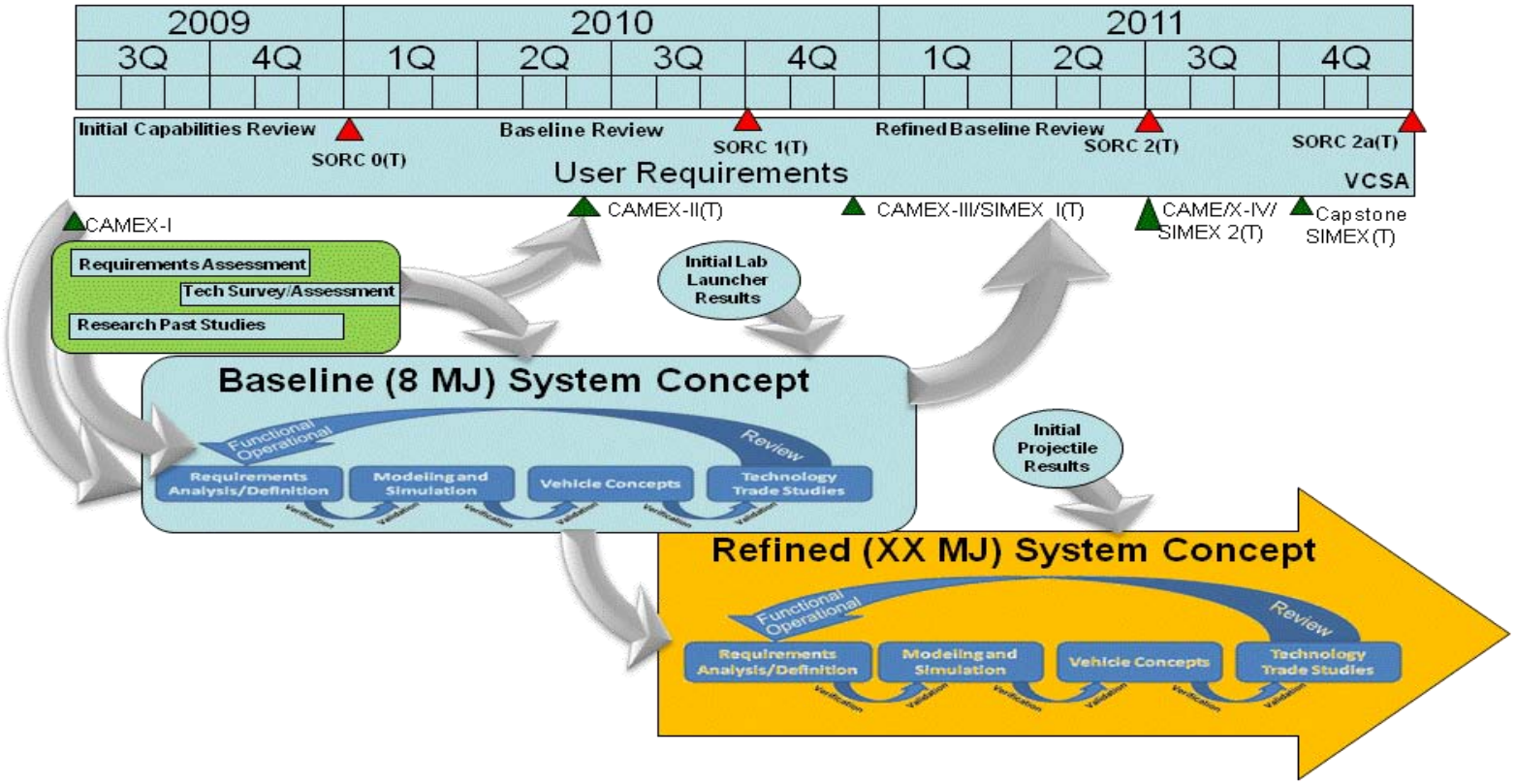
14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**16**	

Systems Engineering Approach

- *Outputs*
  - *Lethality study results integrated into Systems Engineering Assessment*
  - *2-n System Concepts (8MJ & XXMJ)*
  - *Technology Assessment & Investment Strategy*
  - *Operational Impact*



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

EM Gun Program Framework

Inputs:
Doctrine
Threat analysis
Battle Field Engagement

Long Term Strategy

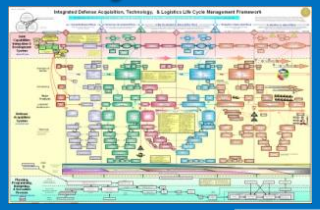
Outputs:
Integrated Electric weapon systems platforms

Capability

Application

Inputs:
User Requirements
Target Setting

Systems Engineering Analysis/Plan



Outputs:
8 MJ Muzzle Energy System Engineering Analysis
XX MJ Muzzle Energy System Engineering Analysis - Optimal
Verification/Validation Plan
Technology Assessments
Investment Strategy

Functional M&S

Operational M&S

Results

Results

Specs

Specs

Inputs:
Engineering Derived Requirements
Technology Maturation

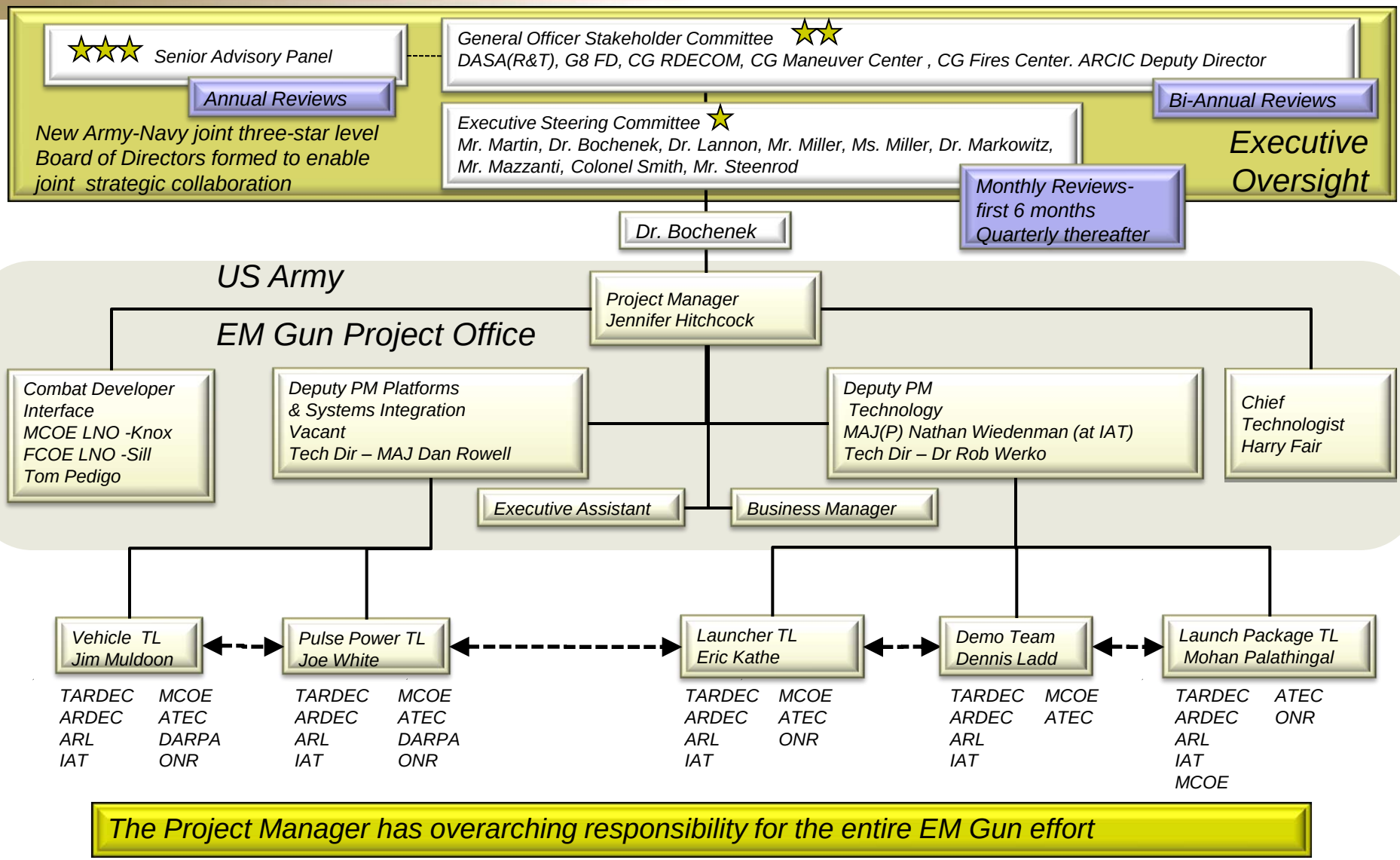
Technology Experiments

Outputs:
Lethality Study & Model Verification
Projectile/Launcher Interface
Weapon System Requirements

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

EMG Organizational Structure



The Project Manager has overarching responsibility for the entire EM Gun effort

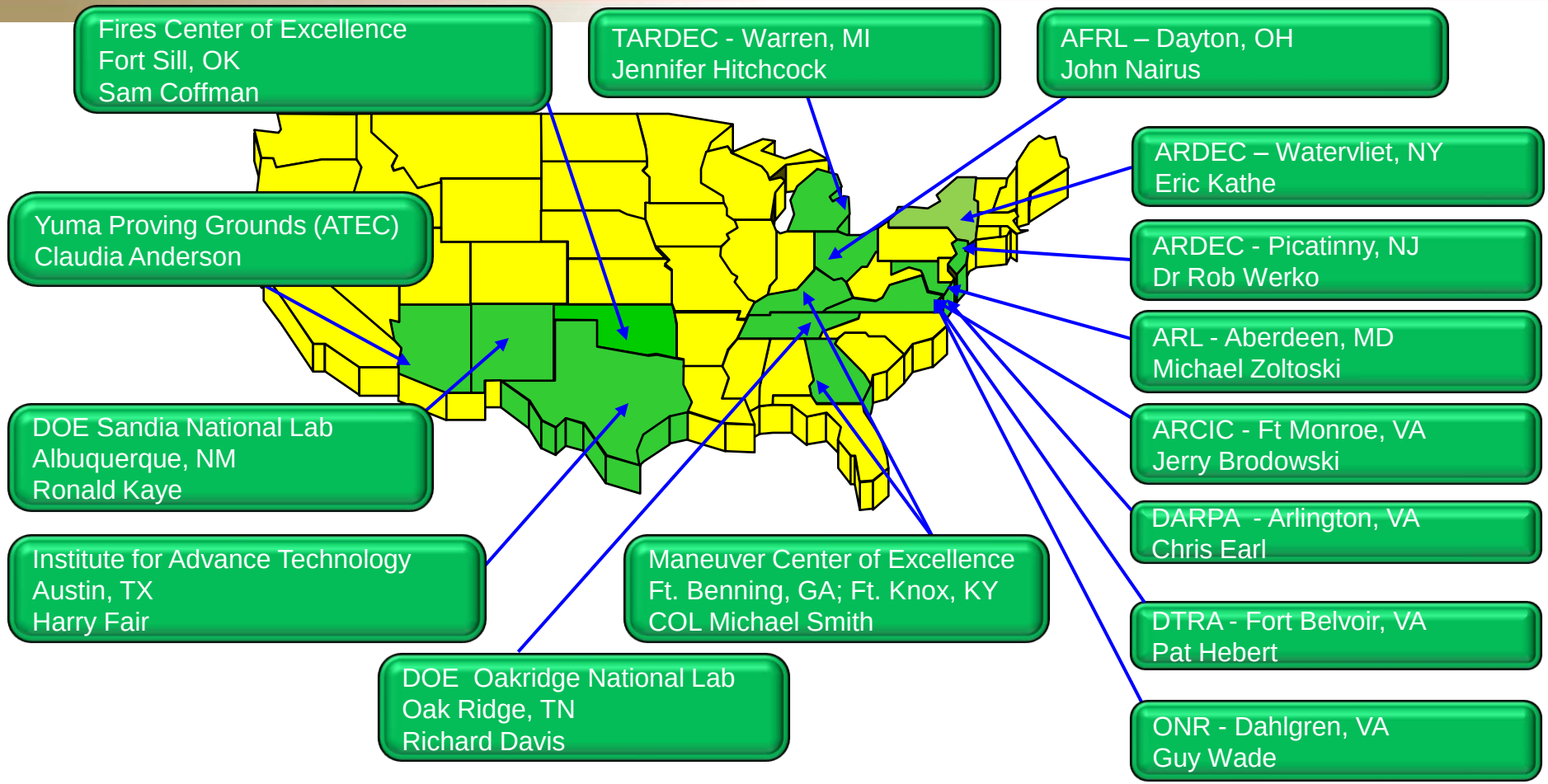
- - - - - - - - - *Collaboration Responsibility*

——————— *Reporting Authority*

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

EM Gun Partnerships & Key Stakeholders



Broad Participation

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

EMG Benefits

- Smaller, lighter, more efficient munitions
- Integration of EM Armor
- EM Gun provides better way to merge lethal and non-lethal capabilities
- Increased Maneuver:
  - Potentially lighter vehicles and combat loads
  - Improved Mobility
  - Improved Power Plants
  - Reduced Logistics
  - Stability Operations

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

EMG SE Decision Process

OPERATIONAL REQUIREMENTS

EMG Missions

Target X-Y-Z Defeat Method

Derived Reqts

SIMEX-CAMEX models

Combine best-of-the-best subsystem concepts to form 3-5 top-level EMG alternatives, then evaluate the "whole"

SYSTEMS ENGINEERING

Vehicle

EMG Solution Concept

Vehicle Concept - 1st Pass

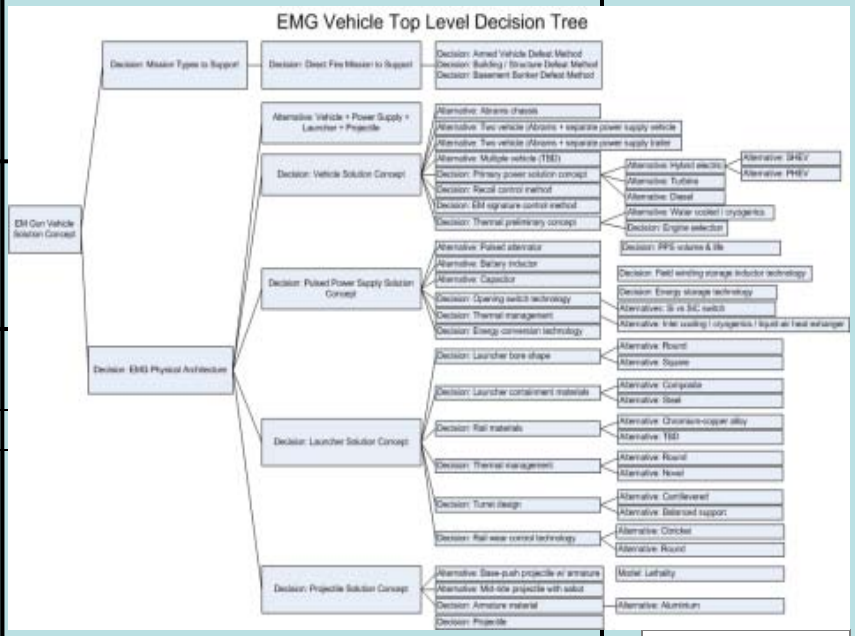
Derived Reqts

Primary Power Technology

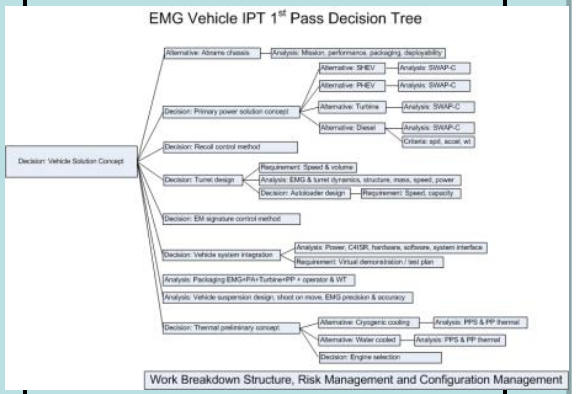
Vehicle Concept - 2nd Pass

Derived Reqts

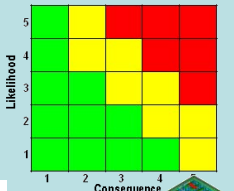
EMG Vehicle Top Level Decision Tree



EMG Vehicle IPT 1st Pass Decision Tree



Work Breakdown Structure, Risk Management and Configuration Management

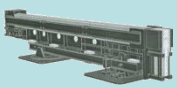


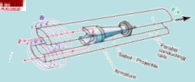
EM Gun Thermal Control

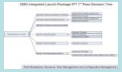
Power SWAP-C Management

Launcher

Launch Package







Vehicle M&S: break down to define specific models that inform specific decisions

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

EM Gun
"Elevator Speech"

- Electromagnetic Gun (EMG) technology has the potential to enable critical lethality overmatch against current and future threats by utilizing electromagnetic acceleration to potentially launch projectiles at hypervelocity speeds. By shifting from a reliance on propellants and explosives to achieve lethality to electrical power, we believe that electromagnetic gun technology could enable safer, more flexible combat systems. Operational platforms could carry greater numbers of (inert) kinetic energy projectiles whose range and lethality would be regulated by the launch energy applied.

- The technology developments related to the electromagnetic gun development, such as efficient power sources, advanced switches, thermal management and energy storage can be utilized by other military programs. Moreover, an integrated power and energy architecture could improve support for emergent survivability technologies, sensors and other systems of growing importance in full spectrum operations. Holistically, an electromagnetic gun platform, if designed carefully, may ultimately provide an additional source of power on the future battlefield to assist in meeting the ever growing power and energy demands.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Management & Collaboration Construct

REPORTING REQUIREMENT	PRODUCT	DESCRIPTION	FREQUENCY	TARGET	REMARKS
Weekly Significant Activity Report (EMG WSAR)	Word Document	SITREP addressing all relevant working actions across the program	Weekly	PM/DPM	Each Leader, User and Chief Technologist provide this weekly to PM/DPM – consolidated and sent to entire team
Entire Leadership Team Meetings	Excel Document Tasker due outs	Issues addressed and decisions made to move program forward	Weekly – teleconference Bi-weekly in person or VTC	PM/DPM, other EMG program leads	
IPT Leader meeting	Excel Document Tasker due outs	Daily sync ups to ensure issues are worked for all tasks	Daily – until further notice	Product Directors/Team Leaders/DPM	
VCSA Updates	Briefing	Standard briefing chart deck with topic of the month	Monthly	VCSA	
Senior Advisory Panel Updates	Briefing / Information Exchange	Periodic exchange of updates and guidance focused on program progress, key issues, and guidance	Annual	New Army-Navy joint three-star level Board of Directors, Dir ARCIC	
General Officer Stakeholder Committee	Briefing / Information Exchange	Periodic exchange of updates and guidance focused on program progress, key issues, and guidance	Semi-annual	Dr. Killion, CG RDECOM, CG Maneuver Center , CG Air Defense Artillery, CG Field Artillery School, DD ARCIC	
Executive Steering Committee	Briefing / Information Exchange	Periodic exchange of updates and guidance focused on program progress, key issues, and guidance	Quarterly	Mr. Martin, Dr. Bochenek, Dr. Lannon, Mr. Miller, Ms. Miller, Dr. Markowitz, Mr Mazzanti, Mr. Steenrod	

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

US ARMY RDECOM

PM Team Roles & Responsibilities

Executive Steering Committee	**Provides governance and direction on the initiatives undertaken by the Product Directors and approved by Program Manager. Evaluates high dollar and critical path technology investments. Provides oversight to eliminate unnecessary redundancies that could result during the development of key technology areas. Provides guidance to the EM Gun Project Office, by ensuring, in particular, that the technical efforts are in line with the plans and schedules set out in the EM Gun Technology Development Strategy. Has the authority to provide additional policy, advice, and objectives on the development efforts in all technical areas of the EM Gun Development Strategy.**
Project Manager	**Has overarching responsibility for cost, schedule and performance of entire EM Gun effort. Works at senior Army level to define, integrate & implement strategic direction for family of Army Electromagnetic Gun weapon products. Leads, defines & integrates efforts of technical experts from DARPA, ARL, TARDEC, ARDEC, IAT, as well as industry partners. Generates, proposes and defends EM Gun weapon concepts, program budgets and long term development roadmaps underpinned by robust technology forecasts of emerging technologies built through interactions with various research and development organizations.**
Deputy PM for Systems Integration	**Translates customer needs into system requirements, creates high-level system architecture, identifies alternatives for major components, conducts trade studies/modeling and simulation to select best technical approach, generates and maintain system specifications, generates and maintain subsystem specifications, integrates and tests components and subsystems. Conducts system verification effort to ensure system meets specification and validates the product meets customer requirements. Implements new problem solving / decision making methodologies and techniques while working with senior Army management to define, establish and direct organizational focus on highly complex decisions related to EM Gun technology products. Implements accepted system engineering analysis practices into the program.**
Deputy PM for Technology	**Technology Risk Manager with responsibility for coordinating and assessing all technologies within four IPT's and working with Academia and International partners to mitigate technology risks**
Chief Technologist	**Applies his/her extensive knowledge of such areas as power systems, physics, material science, and system engineering to discover and utilize new materials and material forms that can lead to integrated system solutions to future Warfighter needs. Serve as internationally recognized technical expert in electromagnetic launch technology. Serves as lead technical advisor to project office and associated IPTs.**
Combat Developer Interface **(Knox LNO/Sill LNO)**	**Actively engages end-user representatives across all agencies to elicit feedback regarding needs, desires, expectations, and constraints. Transmits warfighter operational requirements, priorities, thresholds and goals to the PM office. Integrates end user into early trade studies in an effort to find best value.**
Product Director (TARDEC) for Vehicle IPT and Pulsed Power IPT	**Responsible for cost, schedule, performance, and risk management in the development of vehicle, prime power, and thermal management subsystems of the EM Gun weapon system. Will establish and lead an Integrated Product Team (IPT) consisting of key Government and contractor representatives from appropriate functional disciplines. Responsible for cost, schedule, performance, and risk management in the development of pulsed power subsystem of the EM Gun weapon system. Will establish and lead an Integrated Product Team (IPT) consisting of key Government and contractor representatives from appropriate functional disciplines.**
Product Director for (ARDEC) Launcher IPT and Launch Package IPT	**Responsible for cost, schedule, performance, and risk management in the development of launcher and launch package subsystems of the EM Gun weapon system. Will establish and lead an Integrated Product Team (IPT) consisting of key Government and contractor representatives from appropriate functional disciplines.**

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Terms of Reference

- ILP – integrated launch package; includes projectile and armature/sabot
- Base push – launch technique whereby the projectile is pushed by an armature carrying the applied current
- Mid-ride – launch technique whereby the projectile is held in a traditional sabot arrangement; the sabot and round act as the armature to carry the applied current
- Containment – outer portion of EM gun responsible for maintaining structural integrity under launch loads; optimal arrangement dependent upon launch technique and core configuration
- Core – inner portion of EM gun responsible for carrying applied current and conveying it to the ILP; consists primarily of rails and insulating material
- Rails – part of EM gun core that carries current to ILP; subject to intense mechanical, electromagnetic, and thermal loading
- Capacitor bank – pulse power source which stores energy in the form of charge on parallel plates; occupies largest physical space, but most mature of current options
- Battery-inductor – pulse power source which stores energy in magnetic field of inductor; under development at IAT
- Pulsed alternator – pulse power source which stores energy in the spinning of a flywheel; this mechanical energy is converted to an electrical pulse through coils
- L’ – inductance gradient of the launcher; higher is better
- Armature – current-carrying element that moves along rails; current flowing through rails induces magnetic field which results in propelling force on armature and ILP

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

SE Terms of Reference

- Analysis Of Alternatives is essentially a tradeoff, leading to a selected system architecture baseline as the final output. The objective is to select the best from among a set of System Architecture candidates, which have been constructed in a manner that assures (with reasonable certainty) that one of the candidates is acceptably close to the true optimum.
- Baseline is a design or work product that can be used as a logical basis for comparison. A baseline may also be established as the basis for subsequent select activities.
- Capability development document (CDD) provides operational performance attributes, including supportability, including key performance parameters (KPP) and other parameters that guide the development, demonstration, and testing of the current increment. It also outlines the overall strategy for developing full capability.
- Capability Gap Analysis determines the gap between requirements that are met and not met; a deficiency assessment.
- Concept of Operation describes the way the system works from the operator's perspective. The ConOps includes the User Description which summarizes the needs, goals,and characteristics of the system's user community, including operators, maintainors, and support personnel.
- Configuration management is the application of sound business practices to establish and maintain consistency of a product's attributes with its requirements and product configuration information
- Decision Analysis provides the basis for evaluating and selecting alternatives to achieve a balanced, supportable, robust, and cost effective system design. These analyses include trade studies, models and simulation, supportability analysis, level of repair analysis, post fielding support analysis, repair versus discard, and cost analysis

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

SE Terms of Reference

- Decompose: to break down into component parts. For example, ABCD decomposes to AB and CD. AB then decomposes to A and B, and CD decomposes to C and D.
- Derived: derived requirements trace back to a driving requirement(s). The derived requirement is identified during the development process. The driving requirement is not satisfied unless the derived requirement is. Interfaces with other systems are an example of derived requirements. Some authors use derive to mean decompose.
- Dynamic Object Oriented Requirement System (DOORS) is a tool for managing requirements and provides traceability back to user-defined capabilities as documented through the Joint Capabilities Integration and Development System
- Eliciting Requirements: the task of communicating with customers and users to determine what their requirements are
- Functional Decomposition is the process of resolving a functional relationship into its constituent parts for the purpose of gaining insight into their functional requirements.
- Functional Requirements define what the system must do. They are the criteria imposed on the missions, features, capabilities, functions of the system and its interface within the operational environment
- Initial Capability Document (ICD) describes the capabilities (and operational performance criteria) required to successfully execute missions; the shortfalls in existing weapon systems to deliver those capabilities and the associated operational risks; and the possible solution space for the capability shortfalls

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

SE Terms of Reference

- Integration is the process of incorporating the lower-level system elements into a higher-level system element in the physical architecture
- Interface Management Process ensures interface definition and compliance among the elements that compose the system, as well as with other systems with which the system or system elements must interoperate.
- Key Performance Parameters (KPP) is capability or characteristic so significant that failure to meet the threshold can be cause for the materiel concept or system selection to be reevaluated or the program to be reassessed or terminated. KPPs are extracted from the ORD and included in the APB.
- Measure of Effectiveness reflects the overall customer/user satisfaction (e.g. performance, safety, reliability, availability, maintainability, and workload requirements).
- Non-functional requirements define constraints on the functional requirements such as how well the system must function or when it shall function. It also address the system attributes, environmental, maintenance, robustness, usability, interface, supportability requirements, required performance characteristics such as response time, throughput and data volumes.
- Operational Analysis is performed to assess the operational system performance, constraints and to develop operational strategy.
- Operational Requirements: e.g., system monitoring, training, system support, software/system, maintenance, physical security and safety, user interface, human-computer interfaces, configuration control, facilities, operating/maintenance documentation
- Performance Requirements: – e.g., efficiency, growth, flexibility, integrity, interoperability, maintainability, portability, usability, reliability, workloads, throughput, data quality, accuracy, capacity, growth

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

SE Terms of Reference

- Preferred System Concept (PSC) is the optimum system architecture selected from among other similar systems based on satisfying system requirements.
- Quick Deployment Function (QFD) is a structured approach to define customer needs or requirements and translate them into specific plans to produce products to meet those needs.
- Requirement Decomposition Process converts customer needs into engineering requirements.
- Requirement Development Process takes all inputs from relevant stakeholders and translates the inputs into technical requirements
- Requirement Traceability is concerned with documenting the life of a requirement. High level requirements (user and system) generally trace downward to lower level more detailed requirements. Likewise, low level detailed requirements must trace to high level system and user requirements.
- Requirements Definition: an assessment of the needs a system is to fulfill, including why the system is needed; what features will service or satisfy the need; and how the system is to be constructed.
- Risk Management is the overarching process that encompasses identification, analysis, mitigation planning, mitigation plan implementation, and tracking
- System Boundary Diagram clearly identify system elements and all of their physical or functional interfaces under design control of the project team. It is used to develop interface requirements based on their expected interactions.
- System Functional Requirement: these requirements specify a condition or capability that must be met or possessed by a system or its component(s). System functional requirements include functional and non-functional requirements. System functional requirements are developed to directly or indirectly satisfy user requirements.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

SE Terms of Reference

- Test Readiness Review is a multi-disciplined technical review to ensure that the subsystem or system under review is ready to proceed into formal test. It verifies the traceability of planned tests to program requirements and user needs.
- Trade Studies are conducted among operational capabilities, functional, and performance requirements, design alternatives and their related manufacturing, testing, and support processes; program schedule; and Lifecycle cost. Trade studies are used for the resolution of requirement conflicts.
- User Requirements are system level or top level requirements established by the users or customers to do their jobs.
- Validation Process answers the question of "Did you build the right thing". As such, it tests the performance of systems within their intended operational environment, with anticipated operators and users. In the early stages of the system life cycle, validation may involve prototypes, simulations, or mock-ups of the system and a model or simulation of the system's intended operational environment.
- Verification Process confirms that the system element meets the design-to or build-to specifications. It answers the question "Did you build it right?" As such, it tests the system elements against their defined requirements ("build-to" specifications).
- Voice Of The Customer is the term to describe the stated and unstated customer needs or requirements.
- Work Breakdown Structure is a tool used to define and group a project discrete work elements (or task) in a way that helps organize and define the total work scope of the project. It also provides the necessary framework for detailed cost estimating and control along with providing guidance for schedule development and control.

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.