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RDECOM

(U) 81mm Mortar Enhanced Warhead Cartridge Development Process

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(U) 81mm Mortar Enhanced Warhead Cartridge Development Process



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(U) BLUF



- (U) Responding to Combat & Materiel Developer's strategic planning & requirements
 - (U) ARDEC provided feasible material technologies for near, mid and long term goals
- (U) Understand the science to optimize lethality/effectiveness on a cartridge level, system solution
 - (U) Targets vulnerability, fragmentation pattern (projectile shape), warhead fragment size and velocity.
 - (U) Modeling and Simulation (M & S) tools were used to perform the down selection process.
- (U) For lethality technologies, ARDEC utilized a structured process to down select current ARDEC S & T warhead technologies.
 - (U) The Integrated Product Team consisted of the following divisions: Mortars; Warheads; Quality Control; Aerodynamics; Propulsion; Production, Organics, and other SMEs.
 - (U) Selection was based on performance, producibility, maintaining the industrial base, system compatibility, affordability, scalability, & spiral integration.
- (U) Cartridge solutions have been identified addressing near term goals:
 - (U) Leveraging Current and Past Technologies: Pre-Formed Fragments-Shrapnel (1784), Pre-scored Fragments - M26/M61 Grenades (Korean War), Natural Fragmentation Steel-Frankford Arsenal Report (1976), Combining technologies-Present

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(U) Common Definitions



- (U) Lethality is a measure of the ability of a weapon or munition to inflict harm / damage on a target. Often expressed in :
 - Lethal Area
 - Probability of Kill vs. Range (Pk vs. R)
 - Probability of Incapacitation P_i / Pk Matrix File
- (U) Effectiveness is a measure which couples munition lethality data with delivery errors to quantify performance. Often expressed in:
 - Fractional Damage (FD)
 - Expected Fractional Casualty (EFC)
 - Number of Rounds Required to Defeat a Target

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(U) In 1784, Henry Shrapnel invented the shrapnel shell for cannons. Shrapnel is a type of fragmentation named after the inventor, Major-General Henry Shrapnel. Shrapnel projectiles contained shot propelled by an explosive charge to scatter the shot as well as fragments of the shell casing.

(U) Shrapnel understood lethality/effectiveness was coupled to the ballistics of the projectile, height of burst and resulting fragmentation projection over an area

Foundation of Work

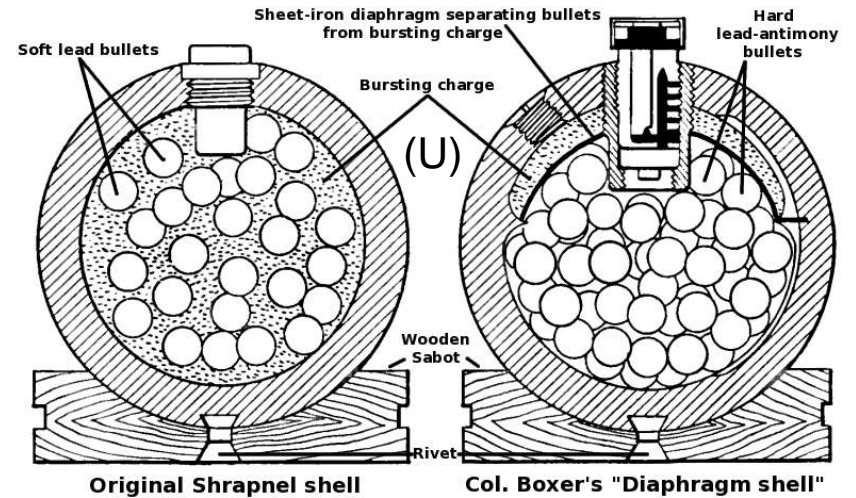


Fig. 2. Original Shell designed by Lieut. Henry Shrapnel and Col. Boxer's Improvement Machinery

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(U) Warhead Concepts Quality Functional Deployment (QFD) Scoring Criteria



(U) Eight scoring criteria was used to evaluate various warhead concepts in the mini QFD.

1. **(U) Cost/Producibility:** Complexity/mass United States of America production base and cost of warhead concept
2. **(U) Performance:** Meeting warhead objectives
3. **(U) Schedule (Gen 1):** Generation 1 concept meeting schedule
4. **(U) Schedule (Gen 2):** Generation 2 concept meeting schedule
5. **(U) Schedule (Gen 3):** Generation 3 concept meeting schedule
6. **(U) MRL:** Manufacturing Readiness Level maturity
7. **(U) TRL:** Technology Readiness Level maturity
8. **(U) Gun Launch Survivability:** Mortar warhead survivability during gun launch

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(U) Technology Evaluation Approach



- (U) Evaluated technologies based on cost, lethality/effectiveness, IM, TRL, MRL...(up front lethality analysis)
- (U) The mortar warhead technology mini QFD was broken down into categories. These categories were further broken down into specific warhead concepts.
- (U) The concepts were scored on a 1, 3, and 9 scale. After adding weighting factors for each scoring criteria, the top 13 concepts with the highest score were chosen from the mini QFD for further M&S evaluation.
- (U) Lethality and Effectiveness was evaluated using M&S tools (i.e. Cale/PAFrag, ALE3D, CTH...) and existing test data generated from other warhead applications to design, then assess mortar lethality and effectiveness.

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(U) Results



(U) Concepts		(U//FOUO) Scoring Criteria (Weighted)						
		Cost/ Producibility	Performance	Schedule (Gen 1)	MRL	TRL	Gun Launch Survivability	
		Con	Con	Con	Con	Con	Con	
		10	15	5	2	2	10	
38	3	9	3	9	9	9	306	
33	3	9	3	3	9	9	294	
35	3	9	3	3	9	9	294	
40	3	9	3	3	9	9	294	
41	3	9	3	3	9	9	294	
31	3	9	3	3	3	9	282	
5	3	9	3	3	1	9	278	
12	3	9	3	3	1	9	278	
13	3	9	3	3	1	9	278	
16	3	9	3	3	1	9	278	
6	9	3	3	3	9	9	264	
7	9	3	3	3	9	9	264	

(U) Category: Controlled Fragmentation 1 (6 Concepts)

(U) Category: Controlled Fragmentation 2 (1 Concept)

(U) Category: Controlled Fragmentation 3 (6 Concepts)

(U) The top 13 concepts results have been colored coded to show the technology category they belong to.

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(U) Modeling & Simulation Assumptions Summary



- (U) CEPs will match the current 81mm HE Cartridge (drives effectiveness).
- (U) Angles of fall at all ranges will match the current 81mm HE Cartridge AoFs.
- (U) The natural fragmentation steel selected will produce fragments of the same mass and shape distribution compared to the 81mm HE Cartridge while using IM explosives to accelerate fragments.
- (U) The natural fragmentation steel selected will accelerate in a similar manner as other steels (no degradation in velocity).
- (U) Blast over pressure during firing will not be affected by the new shape; no reduction in the allowable number of rounds per day (ANOR).
- (U) Obturation will be equivalent to the current 81mm HE Cartridge .
- (U) The designs can be implemented using current explosive processing, inspection, and x-rayed techniques and production methods.

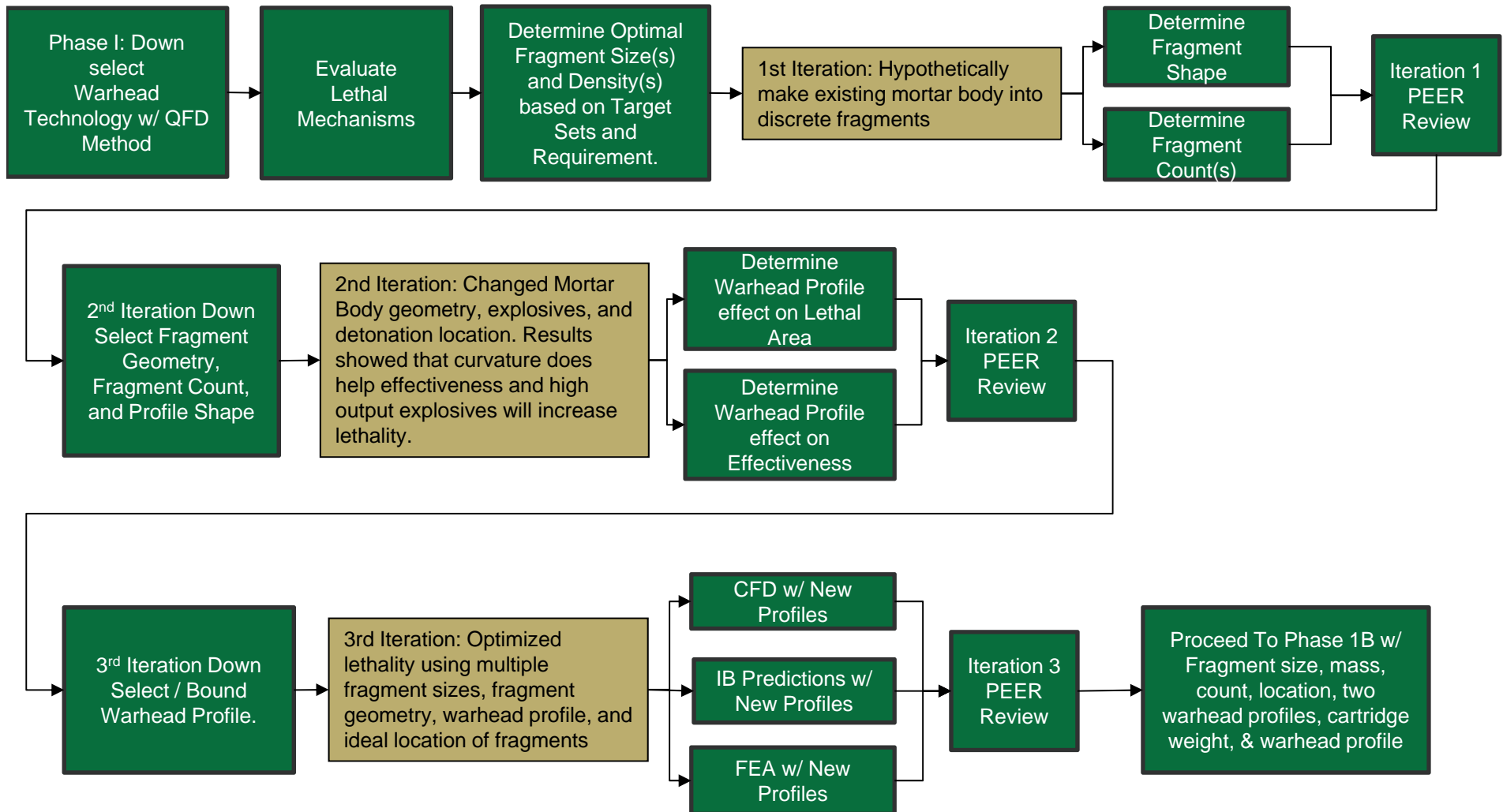
TEST DATA WILL VERIFY ASSUMPTIONS

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(U) 81mm M&S Optimization Process

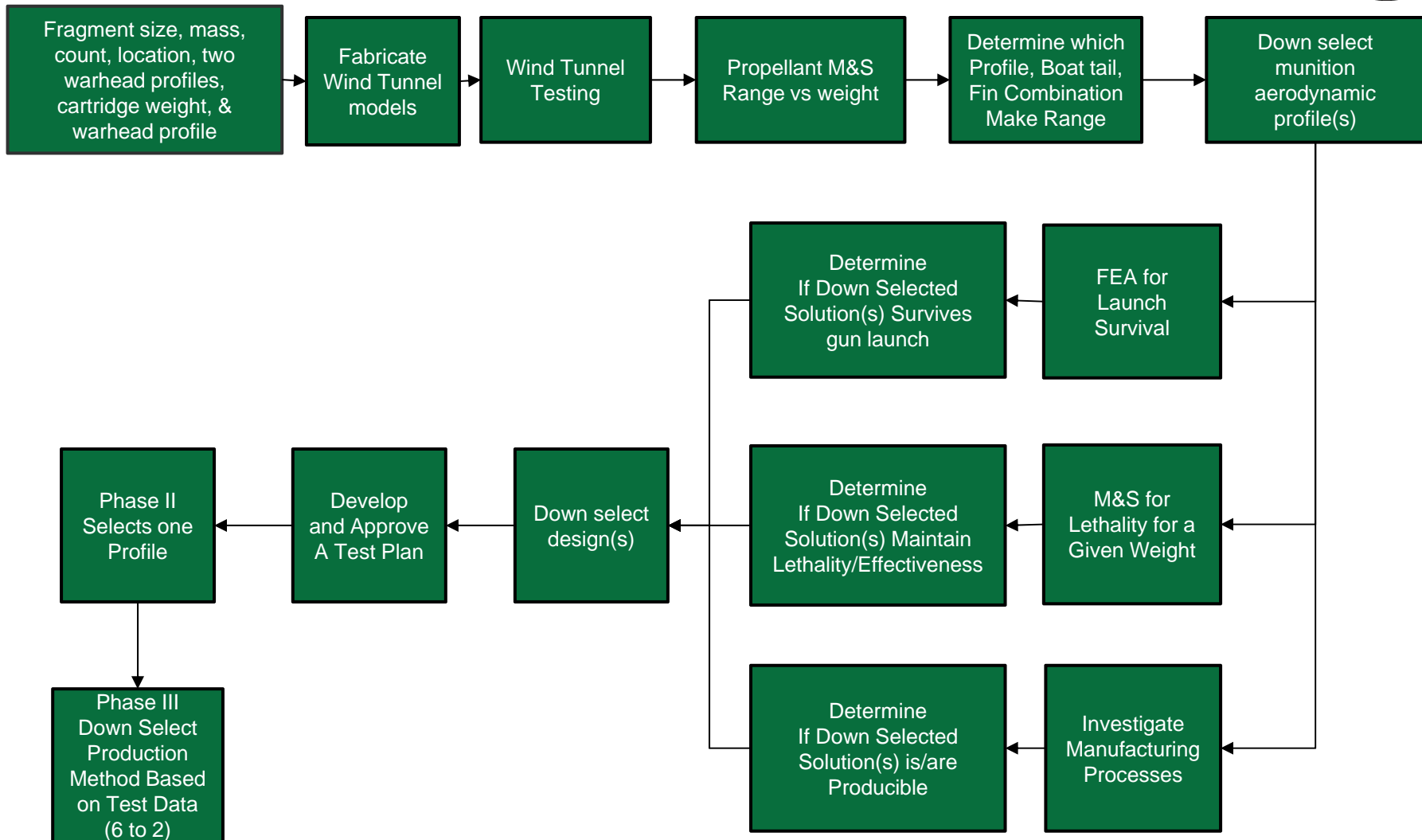


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(U) 81mm M&S Optimization Process Cont'd.

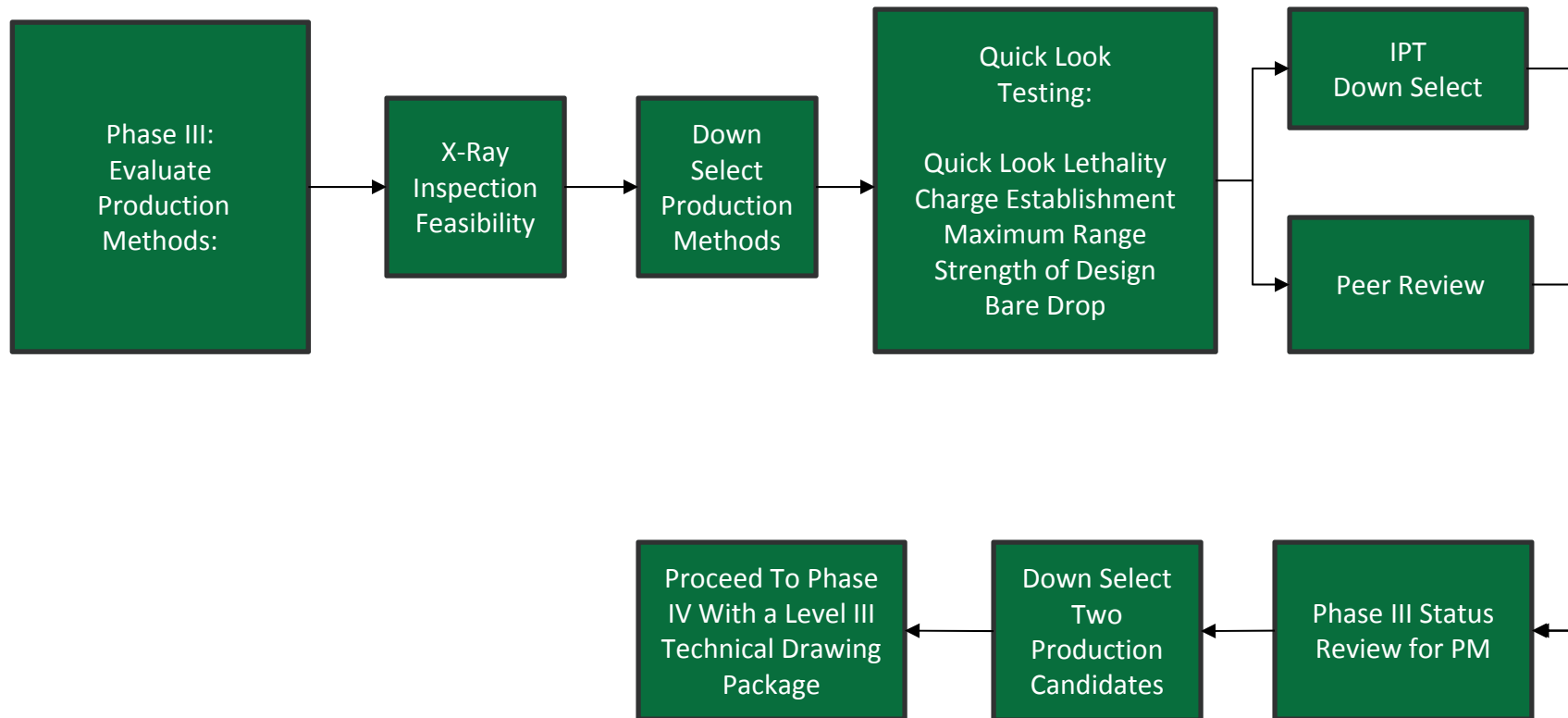


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(U) 81mm Cartridge Phase III

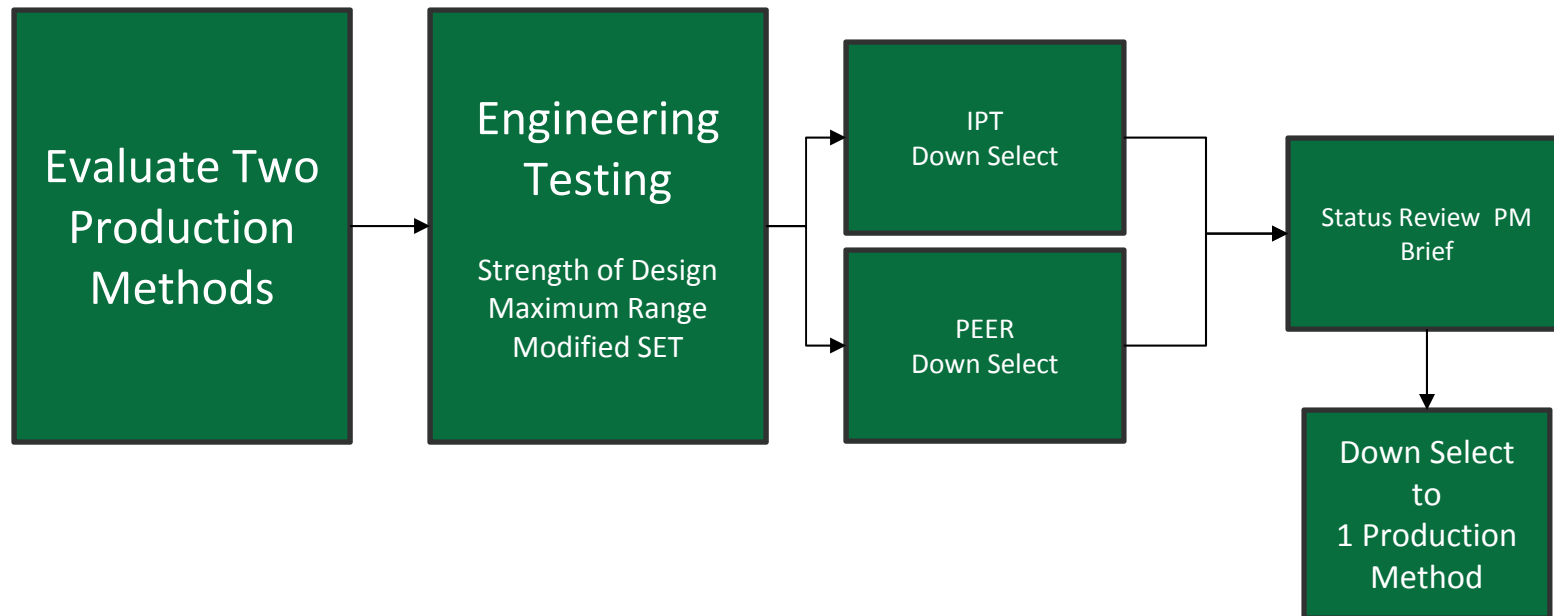


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(U) 81mm Cartridge Phase IV

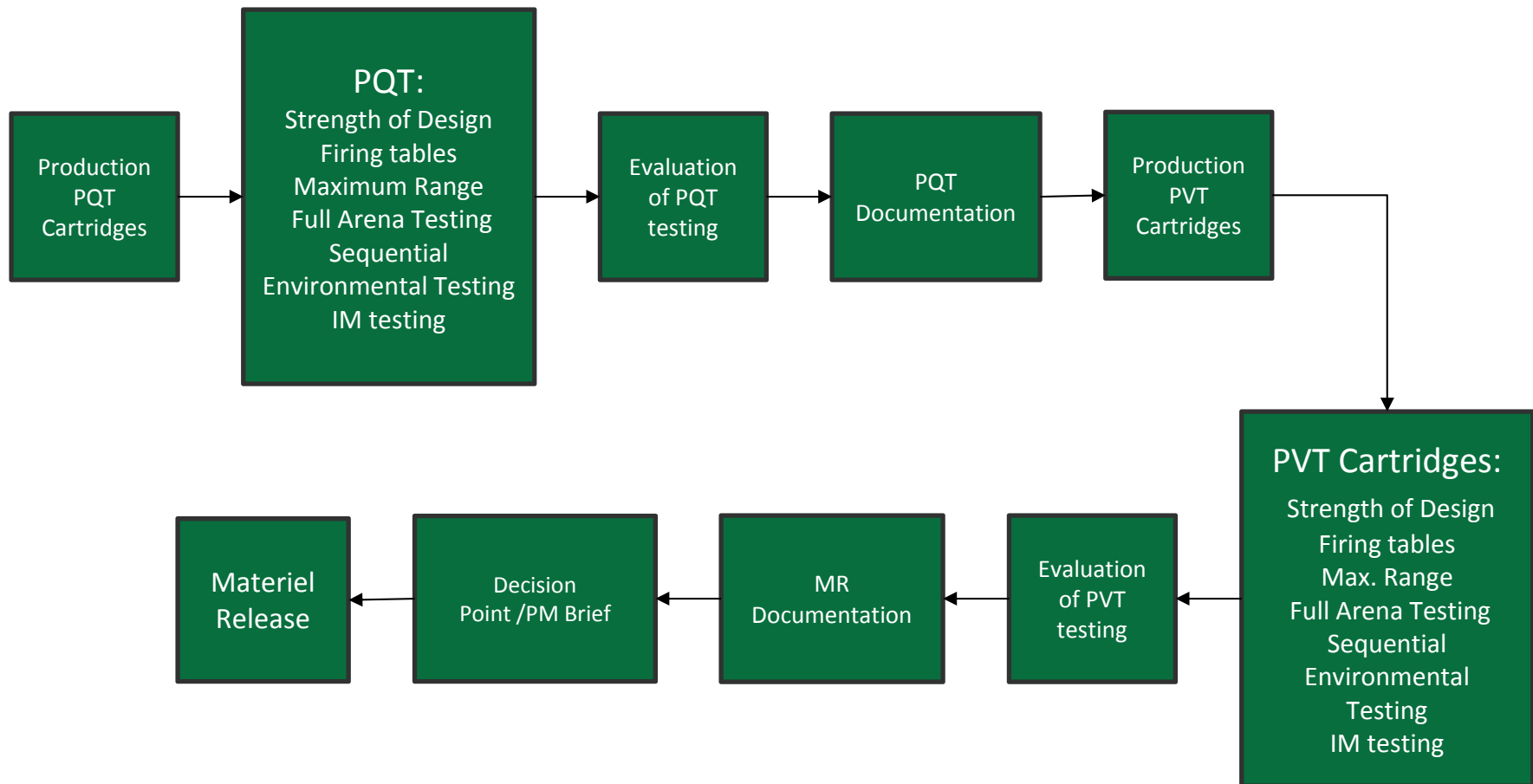


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(U) 81mm Phase V – Production Qualification Testing



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(U) Summary



- (U) Under this effort, the IPT identified several materiel solutions for an affordable 81mm Enhanced Fragmentation Cartridge
- (U) Government / commercial M & S codes were used to model and optimize the cartridge for critical munition traits.
 - (U) M & S analysis will be verified through testing.
- (U) USG Technical Data Package will be developed under this effort.
- (U) The effort leveraged U.S. technology, U.S. manufacturing and strived to maintain the U.S. production base while allowing for spiral integration of emerging technologies.
- (U) Lessons learned, methodology, and technology can be leveraged into other munition programs.
- (U) Leveraging other initiatives, efforts, and programs.

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