Innovation ... Delivered.

5.56 mm Aluminum & .50 Caliber Steel Case Development

Presented to:

NDIA Joint Armaments Conference

Christian Miller

ATK Lake City Ammunition

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Develop New Lighter Weight Designs For The 5.56 mm & .50 Caliber Cartridge Case

GOALS

- Reduce Cartridge Case Weight

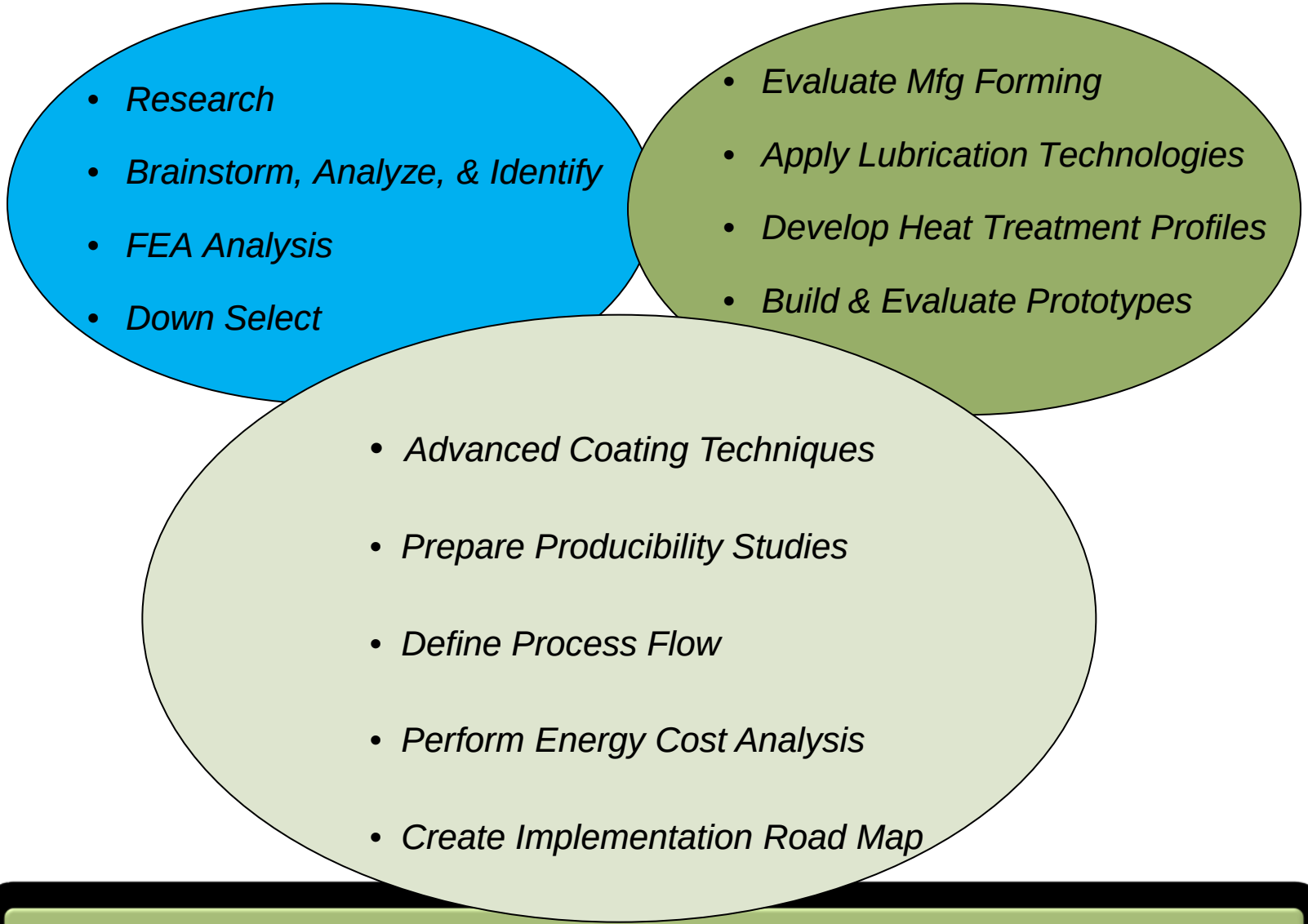
- Establish An Alternate Material For Cartridge Case Manufacturing
- Eliminate Sole Dependence on Brass Alloys

OBJECTIVES

- Utilizing Modern Aluminum & Steel Alloy Options
- Existing & New Production Forming Processes
- Enhanced Lubrication Formulations
- Optimize Tooling Designs
- Customized Heat Treatment Profiles
- Advanced Coating Technologies

Lighter Ammunition For Today's Warfighter

Development Overview



Systems Engineering Approach

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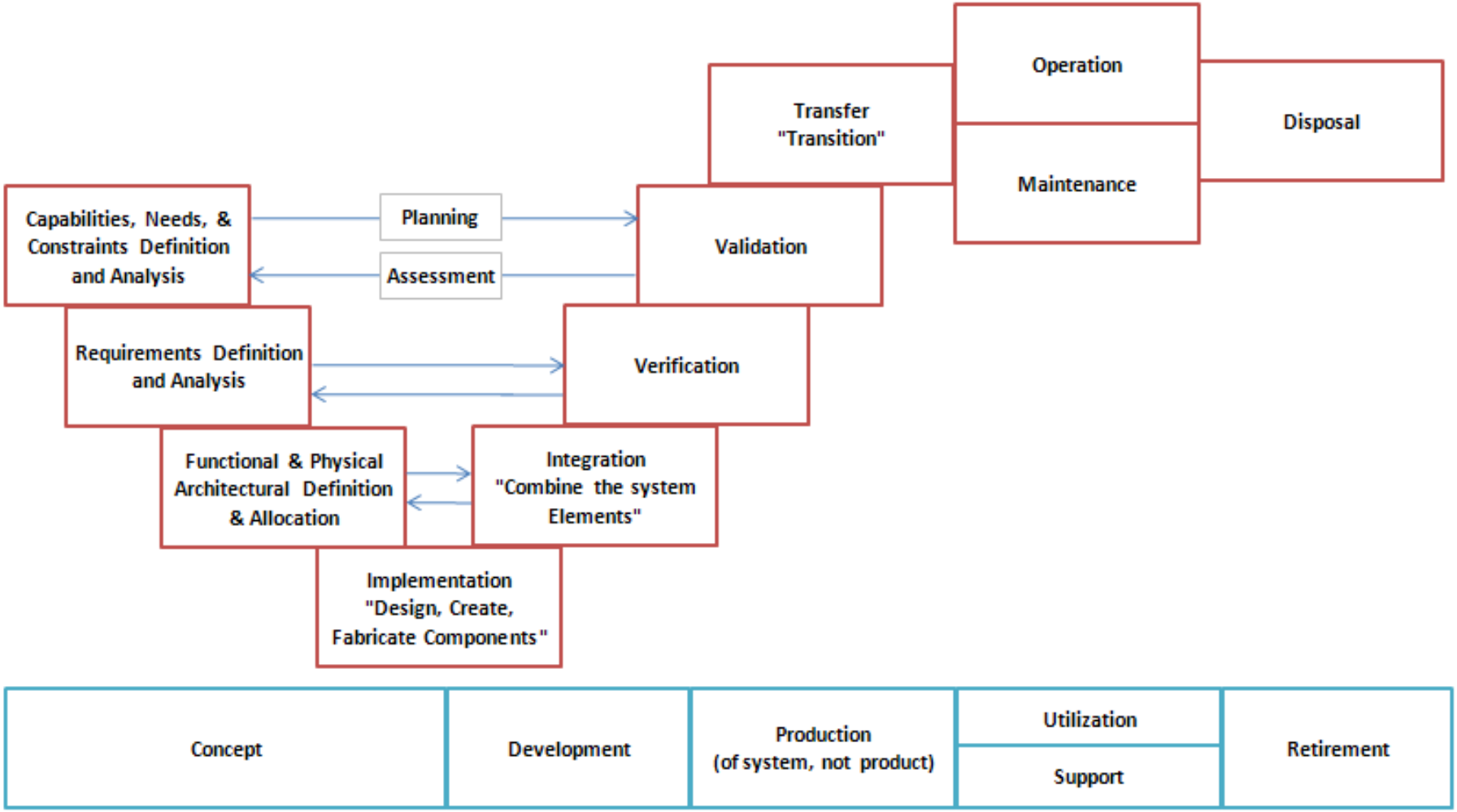

Structured Toward Success

Project Phases

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- **Pre-Phase 1**
  - Establish
  - Identify
  - Provide

Complete

- **Phase 1**
  - Research
  - Analyze
  - Select

Complete

Al Case In-Process

- **Phase 2**
  - Identify
  - Specify
  - Design
  - Create

Steel Case In-Process

- **Phase 3**
  - Investigate
  - Analyze
  - Reduce
  - Improve
  - Recommend

Finalize

- **Phase 4**
  - Integrate
  - Verify
  - Validate
  - Transition

Implement

Development Progress

Technical Challenges

Aluminum & Steel Alloy Selections

- Stiffness,Toughness, Overall Strength Across Temperature Exposure, Rate of Strengthening, Yield Strength, Machinability

  - Research – Analyze –Test - Down Select To Optimize Formability, Performance, And Cost Efficient Manufacturability

Corrosion Coatings

- Steel Alloys Require Additional Processing To Prevent Corrosion
  - Identify Coatings Capable Of
    - Eliminating Corrosion Potentials - Impact/Handling Protection- Inhibit Burn Through

Alloy Selection And Corrosion Coatings

Technical Challenges

Production Cycle Time

- Number Of Forming Operations To Achieve Final Draw And Overall Heat Treatment Requirements
  - Develop The Draw Forming Process To Minimize Overall Steps
  - Customize Heat Treatment Profiles To Reduce Extended Cycling

Process Tooling

- Tooling Design, Base Material, And Coatings
  - Evaluate Present Tooling Configuration For Interchangeability
  - Optimize Tooling Base Material And Coatings

Production Cycle Time And Tooling

Steel Alloy Selection – Frankford Arsenal

Historical Evaluations

- Past Efforts Focused On Six (6) Specific Low-Medium Carbon Alloy Types In Two Conditions.
    - *Casualties Observed – Split Neck, Split Body, Rupture, Rim Shear, & Leaky Primer*
- Extended Development Efforts Focused On Varying The Alloy Chemistries And Observing The Structural Effects Realized Through Multiple Heat Treatment Profiles.

Conclusions

- Identified Three Top Steel Alloy Candidates And Recommended Structural Conditions For Each.

Constraints

- Recommendations Were Made Based Upon Using One Specific No. Of Draw Forming Steps.

Earlier Efforts Established Good Baseline

Aluminum Alloy Selection – (Frankford Arsenal-ATK)

Historical Evaluations

- Past Efforts Considered all Al Alloys, Narrowing to Three (3) Specific Grades.
    - *Burn Through Experienced Throughout All Efforts*
- Early Studies (1950-1956) Isolated & Identified One (1) Specific Alloy Grade Recommended for Further Evaluation. These Recommendations Were Picked Up Again in (1965 – 1970), Then On Again in (1970-1976).
- In 2004, the Original (3) Alloy Grades Identified in Earlier Efforts Were Re-Evaluated & A Different Alloy Candidate Was Chosen To Pursue For Further Development.

Conclusions

- Of The (3) Alloys Identified Throughout Early History, (2) of the Three (3) have been Chosen Over Time for Development. Burn Through has Challenged the Best Alloy Selections that have Faired Well Throughout the Rigors of Forming.

Historical Efforts Established Alloy Performance

Steel Corrosion Coatings – Frankford Arsenal

Historical Evaluations

- Three (3) Proprietary Chemically Activated Base Finishes Were Tested In Addition to Three (3) Electro-Plating Options.
    - *Functional Characteristics Evaluated– Corrosion Resistance (Std Salt Spray), Abuse Resistance (Typical Handling Evaluations), Stretches (Condition After Firing), Chamber Build-Up (Gun Chamber Accumulation), Stoppages (Failure of the Gun To Operate)*
- Follow-up Developments ,Tested Combination Finishes And Coatings In Attempts To Achieve Maximum Protection And Wear Resistance.

Conclusions

- This Was The Most Difficult Challenge And Has Remained Relatively Un-Solved.

Constraints

- Limited Coating Technologies Available, Hindered By Contact And Respiratory Poisoning Hazards Present With Coating And Finishing Options Utilized.

Limited By Technological Advances

Aluminum Coatings – Frankford Arsenal

Historical Evaluations

- Anodizing was among the coating systems considered but others were also reviewed: These Included Chromate Conversion Coatings, Paint, Aluminum Nitride Coatings, Electroless Nickel, Electroless Nickel-Boron Coating ,etc.
- Follow-up Developments ,Tested Combination Finishes And Coatings In Attempts To Achieve Maximum Protection And Wear Resistance.
    - Some Combinations Yielded Less Than Favorable Results

Conclusions

- At a Minimum it was Recommended to Have an Anodic Coating Applied.
- This Was The Most Difficult Challenge And Has Remained Relatively Un-Solved.

Limited By Technological Advances

Steel Production Cycle Times – Frankford Arsenal

Historical Evaluations

- The Number Of Overall Draw Steps Initially Established To Achieve Final Form Was Five (5); One (1) To Blank And Four (4) To Final Draw Configuration. Heat Treatment Cycles Employed Were Conducted Using A Gas Fired Furnace.
    - *Observations– More Draw Steps Required to Final Form Than Brass Case Manufacturing. Varied Heat Treatment Cycles To Achieve Several Different Structures*
- Efforts Focused On Reducing The Draw Steps To Final Draw Configuration As Well As Hopes To Establish An Optimal Heat Treated Case Structure.

Conclusions

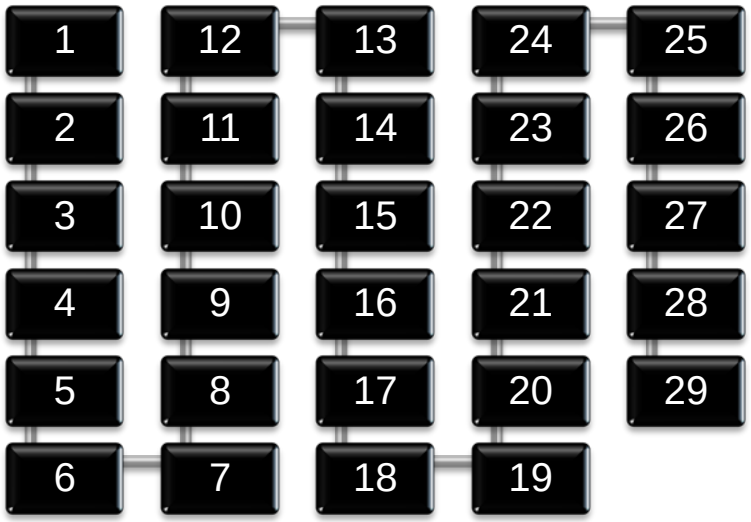
- Reduced Overall Draw Steps To Achieve Final Form From Five (5) to Four (4)…..One Being The Blank Step, Yielding Final Form In Three (3) Steps. Recommended One Specific Heat Treatment Structure To Achieve For Conducting Draw Operations.

Draw Reduction Improvement/Heat Treat Not Optimized

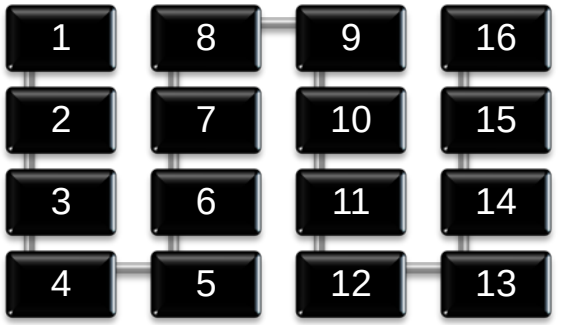
Aluminum Production Cycle Times - Historical

- May Require Up To 25 Hours Of Heat Treatment
- Many Process Steps
- Batching Not Desirable In A Continuous Flow Production Environment

<u>Aluminum Case</u>
Multiple Process Steps
Lengthy Heat Treatment Time



<u>Brass Case</u>
Fewer Process Steps
Highly Automated1200 Parts Per Minute



Cycle Time A Constraint To High Rate

Historical Evaluations

- Evaluations Were Conducted On All Tooling Used In Brass Case Production While Processing Steel Cases Through To Final Taper.
    - *Observations – Established Tool Mortality Chart Comparison To Document Overall Tooling Performance*

Conclusions

- The Comparison Data Was Used To Illustrate Tooling Life Expectancy With The Present Designs And Tooling Materials Employed At That Time. The Data Was Used To Justify Tooling Material Changes For Several Tools As Well As Several Configuration Differences For Each Operation.

Establish Tooling Baseline And Improve

Steel Alloy Selection – ATK Present Day

Present Evaluations

- Initially Identified Four (4) Specific Low Carbon Alloy Steel Types.
  - *Actions Taken – Developed Samples, Analyzed, Evaluated Using FEA Modeling Techniques, Compared Characteristic Profiles To Expectations, Down Selected, Produced Samples For Testing, And Introduced Into Production For Manufacturing Evaluations.*
- Ongoing Development Efforts Are Focused On Customizing The Heat Treatment Profiles To Optimize The Initial And Intermediate Structural Condition Of The Case.

Conclusions

- Down Selected To Two (2) Steel Alloys
- Testing And Evaluation Under Way To Establish Feasibility And Manufacturability Using Existing And New Mfg Processes.
- Validating Heat Treatment Profiles For Optimized Structural Condition

Lessons Learned Established Initial Direction

Aluminum Alloy Selection – ATK Present Day

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Alloy A
- Commercially Available
- Has a Balance Of Strength, Toughness And Resistance To Corrosion
- Has a Low Quench Sensitivity

Alloy B
- Commercially Available
- Moderate Strength
- Good Strength After Temperature Exposure

Alloy C
- Not Commercially Available
- Moderate Strength and Good Formability
- Good Retention of Strength after Temperature Exposure

ALCOA DEFENSE

Three (3) Aluminum Alloys Under Evaluation

Steel Production Cycle Times– ATK Present Day

Present Evaluations

- Efforts Are Directed At Reducing The Number Of Forming Steps To Achieve Final Form Configuration In Two (2) Steps As Compared To The Previously Established Three (3) Step Draw Operations Utilized.
    - *Actions Taken – Produced Samples For Testing And Introduced Into Production For Manufacturing Evaluations.*

Conclusions

- Initial Testing Yielded Successful Case Samples Through Final Draw Form In Two Draw Operations
- Evaluating Final Draw Formed Cases Using The New & Existing Mfg. Back End Processes

Goal

- Continue Mfg Testing to Support The Heat Treatment Profile Optimization Evaluations And Document Interactions Throughout Production Processes.

Continue Cycle Time Evaluations To Improve

Process Tooling – ATK Present Day

Present Evaluations

- Continuous Tooling Improvements Implemented Throughout The Years In Production Have Yielded Very Good Tooling Configurations Through All Forming Operations.
    - *Observations – Present Tooling Used In Brass Production Are Providing Fairly Good Overall Tooling Performance During Our Testing & Evaluations Using Steel Alloys.*

Conclusions

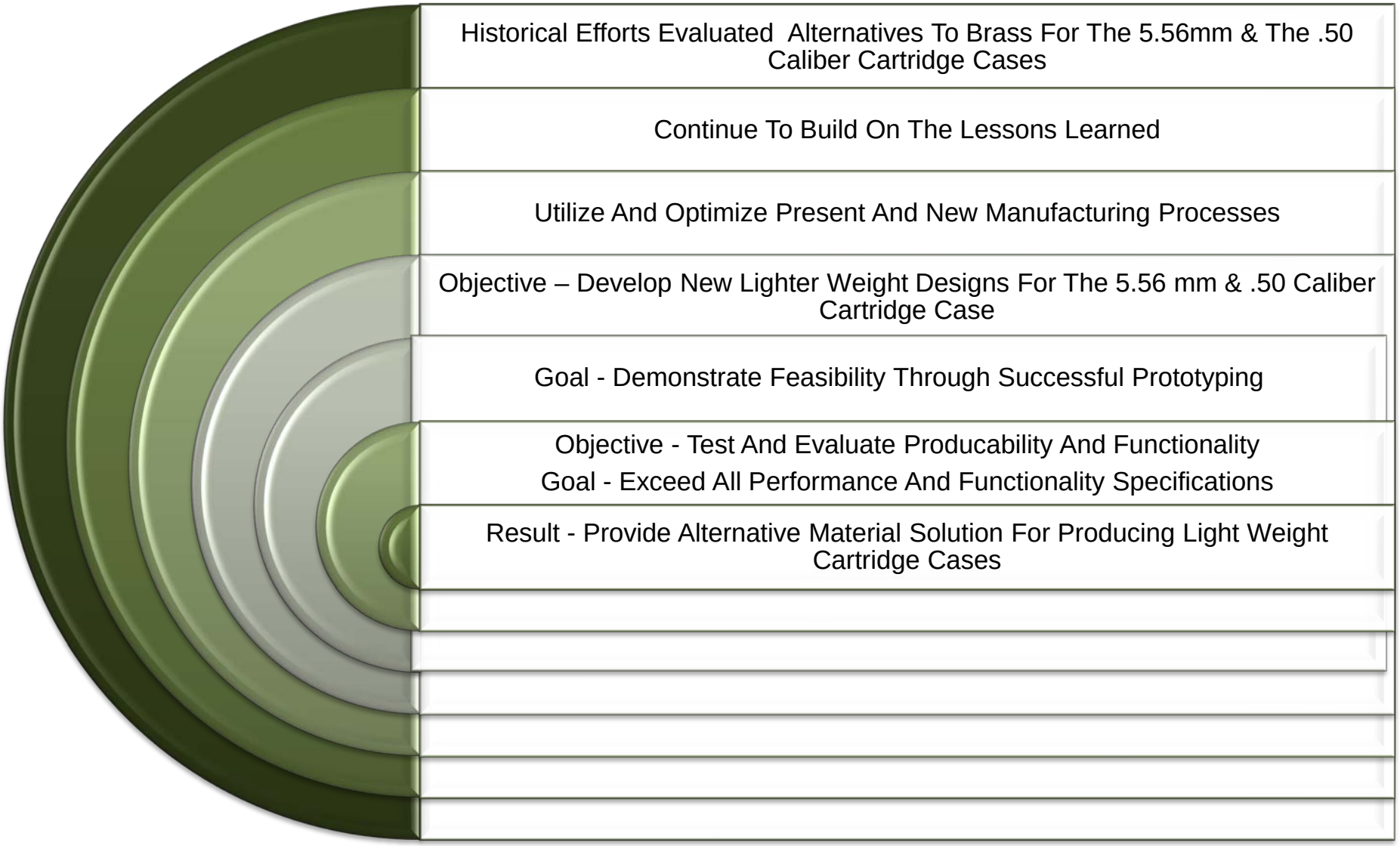
- Continue To Evaluate And Identify Wear Areas As Observed
- Specify Improved Coatings And / Or Base Materials To Further Enhance Durability And Toughness

Goal

- Use Same Tooling Configuration as Used For Brass For Aluminum & Steel Alloys
    - Change Only Tooling Profiles To Establish Light Weight Case Characteristics

Continue Tooling Improvements

Summary


Historical Efforts Evaluated Alternatives To Brass For The 5.56mm & The .50 Caliber Cartridge Cases
Continue To Build On The Lessons Learned
Utilize And Optimize Present And New Manufacturing Processes
Objective – Develop New Lighter Weight Designs For The 5.56 mm & .50 Caliber Cartridge Case
Goal - Demonstrate Feasibility Through Successful Prototyping
Objective - Test And Evaluate Producability And Functionality
Goal - Exceed All Performance And Functionality Specifications
Result - Provide Alternative Material Solution For Producing Light Weight Cartridge Cases

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Contact Information:

Christian Miller
Technology Project Manager
Christian.Miller@ATK.com

ATK Armament Systems
Small Caliber Systems
P.O. Box 1000
Independence, Mo. 64051-1000
816-796-7101