GENERAL DYNAMICS
Ordnance and Tactical Systems–Canada

Development of an Extended Range, Large Caliber, Modular Payload Projectile

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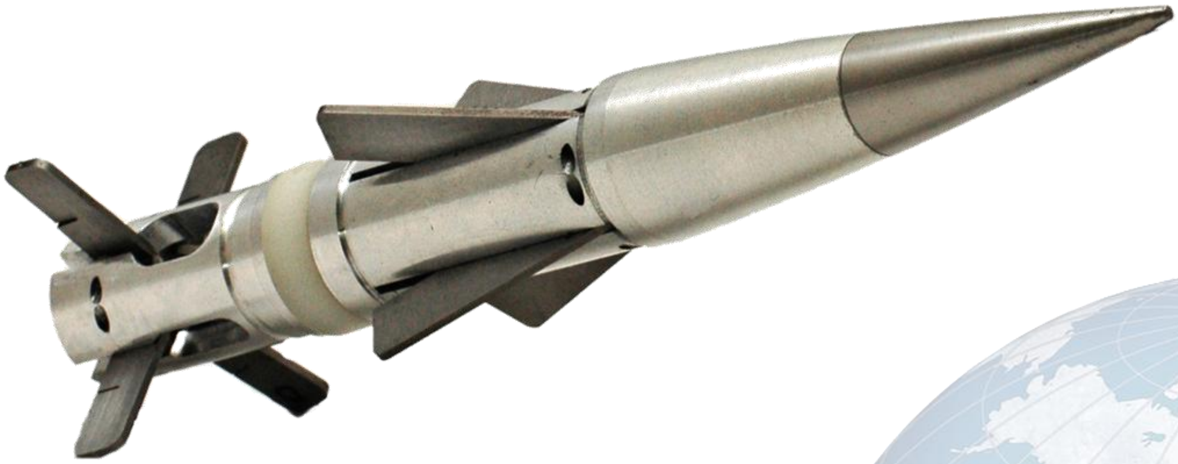
Speaker: Pierre-Antoine Rainville

Email: pierre-antoine.rainville@can.gd-ots.com

Phone : (450) 581-3080

11 830: Development of an Extended Range, Large Caliber, Modular Payload Projectile

- Summary
  - Today's Indirect Fire
  - Objectives
  - Development Methodology
  - Sub-scale Model (26 mm) Development
  - Full Size (155 mm) Development
  - Conclusions
  - Way Ahead



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- Today's Indirect Fire
  - Underwent a transformation from
    - The end of the Cold War with a lower demand for mass fire
    - The delivery of terminal effects against smaller footprint targets in urban area
  - Current indirect fire requirements
    - Increased range (better battlefield coverage)
    - Increased precision
    - Increased effectiveness against a variety of targets (From personnel in Urban terrain to fast moving vehicles
    - Better surveillance and target acquisition (ISTAR) and faster delivery

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- Objectives - Improve all of the following:
  - Range
    - Better projectile aerodynamics
      - Drag reduction
      - Higher Lift/Drag ratio for gliding
  - Precision
    - Active control necessary for a gliding projectile
    - Active control contributes to a decreased CEP
  - Modular Payload (follow up study)
    - Directional warhead
    - Observation system

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- Development Focus
  - Gun launched glider with a caliber of 155 mm
- Development Methodology
  - Literature search (do not reinvent the wheel)
  - Use Design of Experiment (DOE) in conjunction with simulations to optimize body geometry
  - Explore efficiency of wing configuration through simulations
    - Simulations compared to actual gun firings for sub-scale model (26 mm)
    - Simulations for full scale model (155 mm)
  - Test firings with sub-scale model
    - Verify performance for different flight conditions along the trajectory
    - Testing conducted in Indoor range using a 26 mm caliber gun

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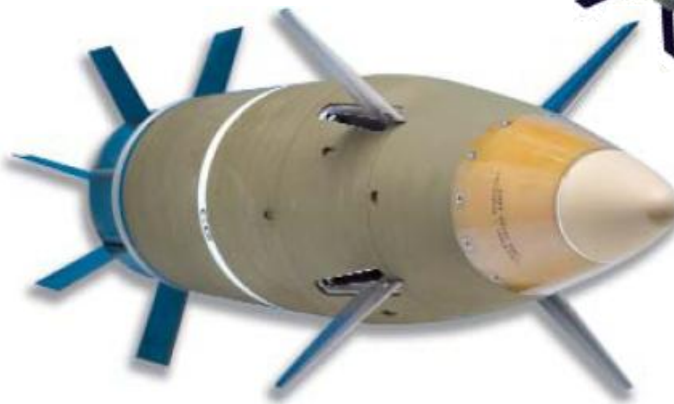
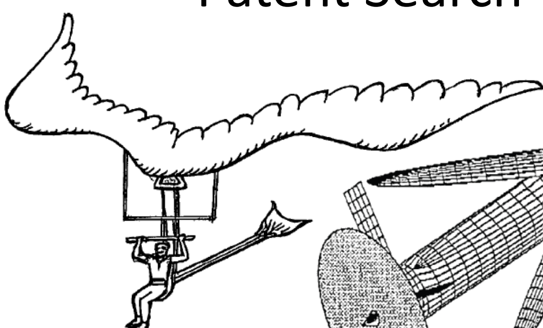
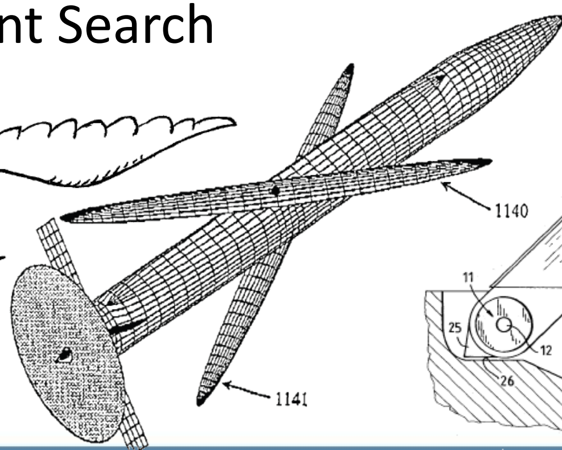
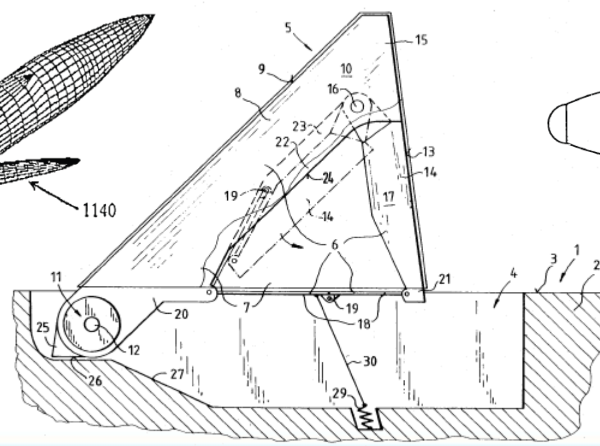
- Development Methodology
  - Literature Search

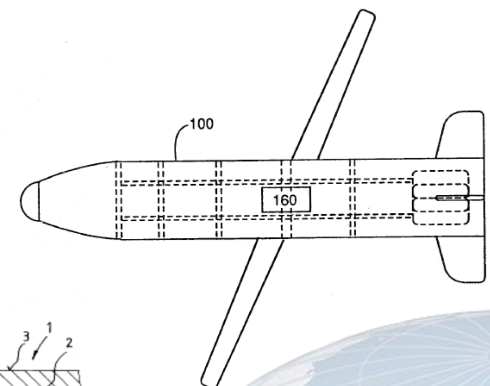


  - Patent Search









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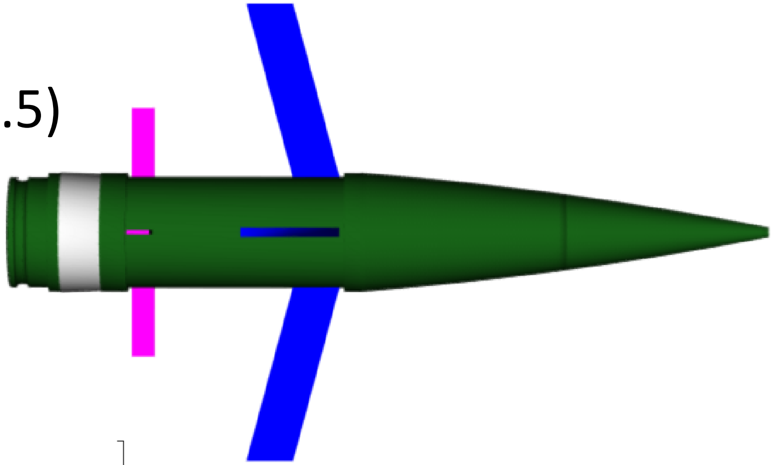
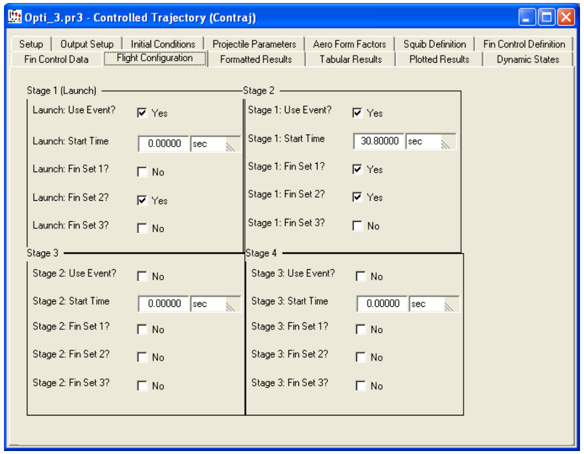
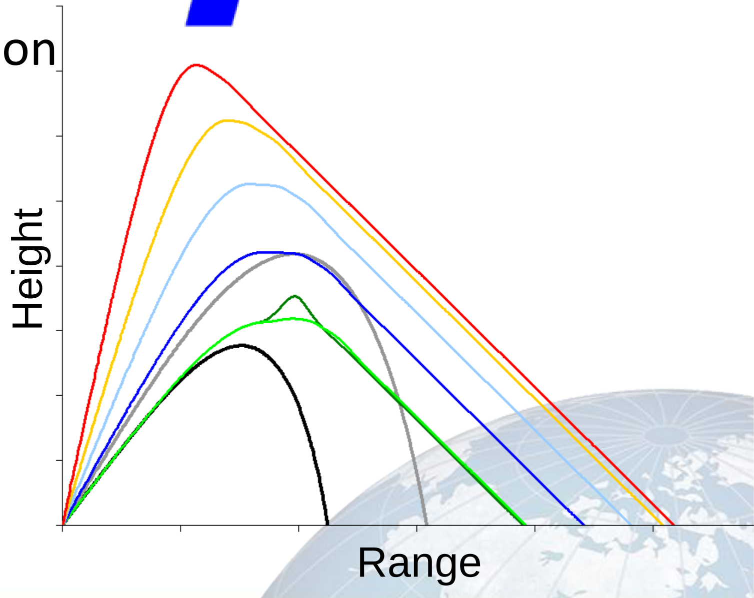
- Development Methodology
  - Simulation with PRODAS (Version 3.5)
    - Estimate aerodynamic coefficients from basic geometry



    - Trajectory simulation for a configuration with wings and active fins (CONTRAJ)





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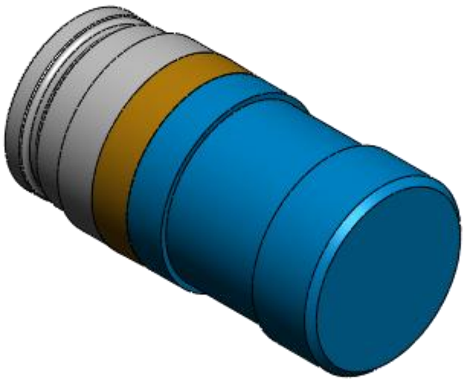
- Development Methodology
  - Scale model fired using a 26 mm smoothbore gun
    - 26mm smoothbore gun is a 25 mm Man Barrel without its rifling.
    - Firing in indoor range (40 m (~ 130 ft) long)
  - Interest of Sub-scale model firing
    - Demonstrate the feasibility with a gun launched projectile to fly with a trajectory modified by lift phenomena
    - Evaluate the capacity of deploying fins and wings after a gun launch



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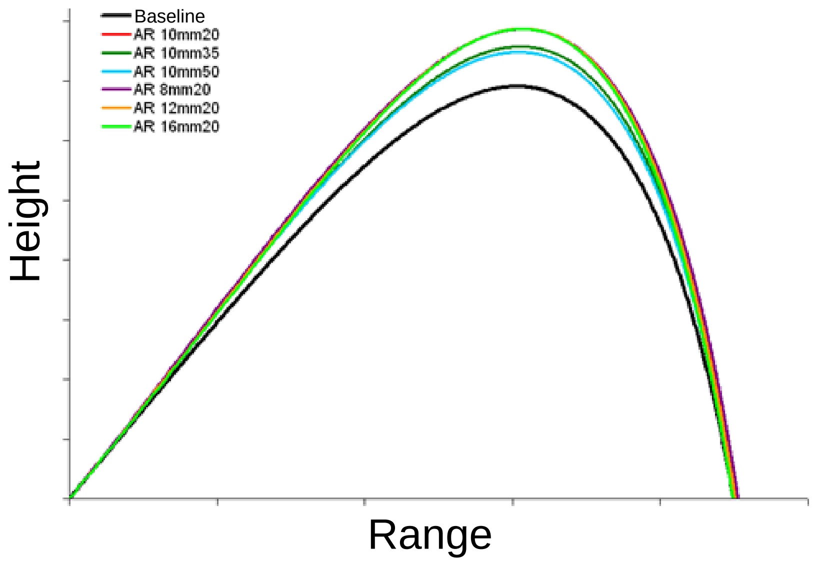
- Sub-Scale Model (26 mm) Development
  - Typical spin stabilized projectile
    (25 mm TP-T is the nearest to the 26 mm)
  - Body geometry with fin stabilization for 26 mm (use as baseline)
  - Range improvement (fixed wings)



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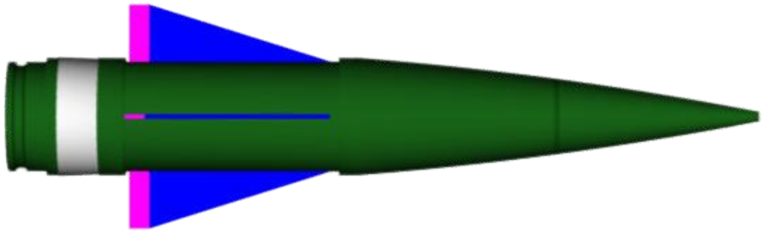
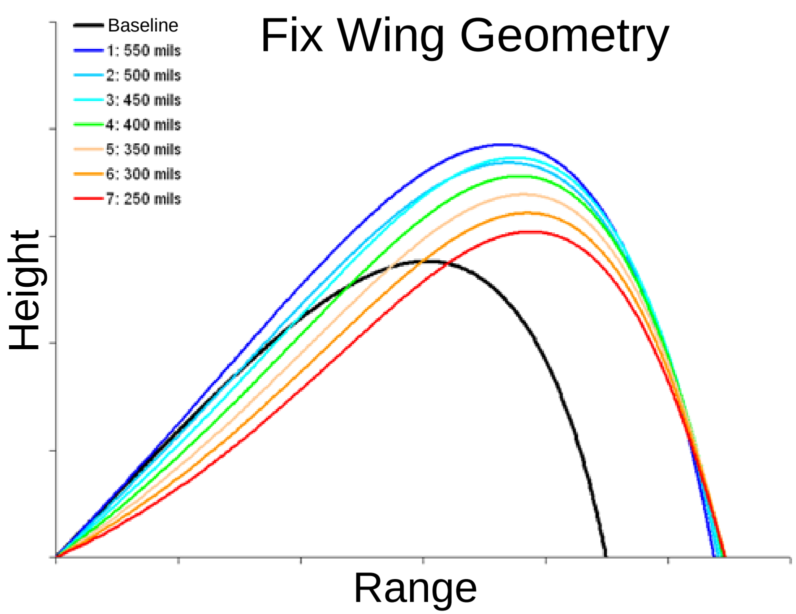
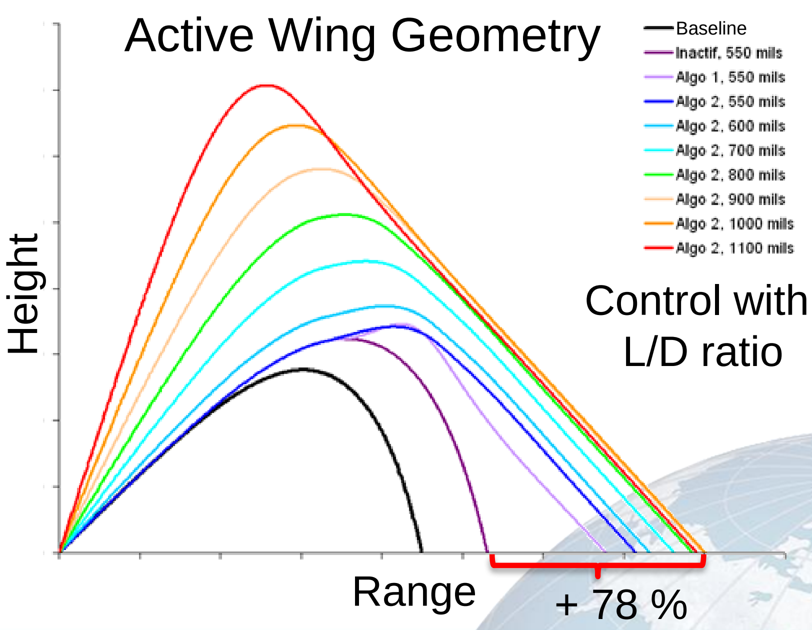
- Sub-Scale Model (26 mm) Development
  - "Better" model with larger wings (Delta)

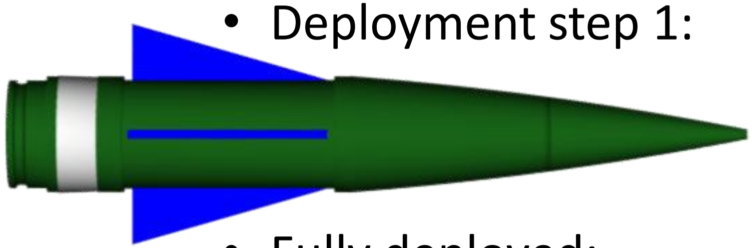


  - Importance of variable geometry during flight

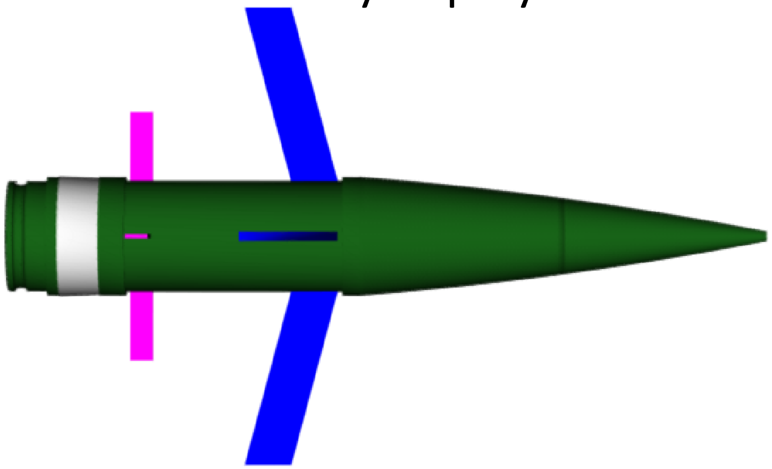




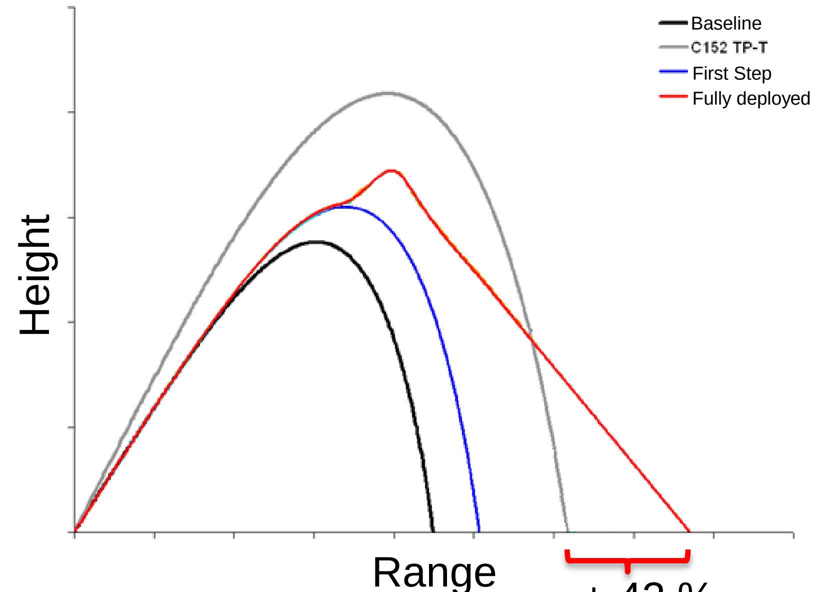
- Sub-Scale Model (26 mm) Development
  - Optimum geometry is an Aircraft like model
    - Deployment step 1:



    - Fully deployed:



  - Significant range improvement



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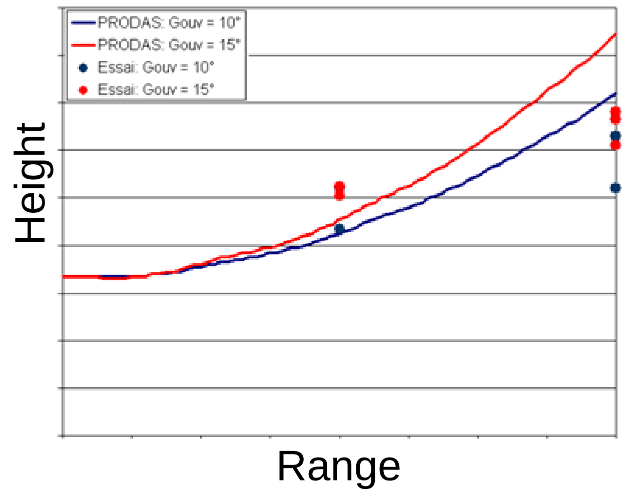
- Sub-Scale Model (26 mm) Development
  - Optimum sub-scale model geometry is too complex for gun firing
  - Two models built (Fast flight, Glider flight)
  - Results: (Smaller effect than expected)
    - Indoor range is short, use fins at 10° or 15°
    - The wings may have stalled…



Glider Geometry
(low initial velocity)

Stabilization Geometry
(high initial velocity)

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- Full Size (155 mm) Development
  - Initial geometry (155 mm M107)
    - Projectile length: 701 mm
    - Projectile mass: 43.9 kg
    - Muzzle velocity: 684.3 m/s
    - Maximum range: 18.1 km
  - Parameters used as constraints during development
    - Projectile length: 1000 mm
    - Projectile mass: 48 kg
    - Muzzle velocity: 684.3 m/s
      (as for M107 fired in M185 gun using Charge 8)

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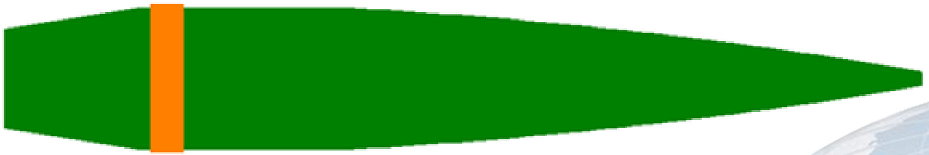
- Full Size (155 mm) Development
  - Optimization of the shell body using DOE
    - Parameter: Ogive length, Ogive radius, Meplat, Boom length, Boattail length and diameter.
    - Initial geometry

    - Second geometry

    - Final geometry



    - Maximum range is now 22 km with the optimized geometry

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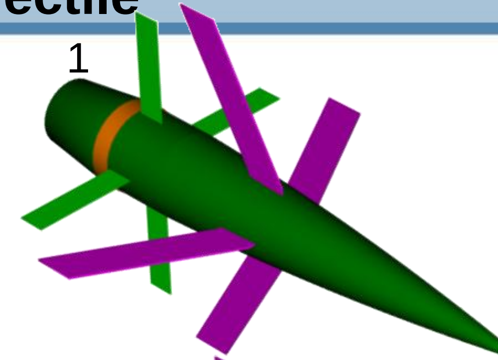
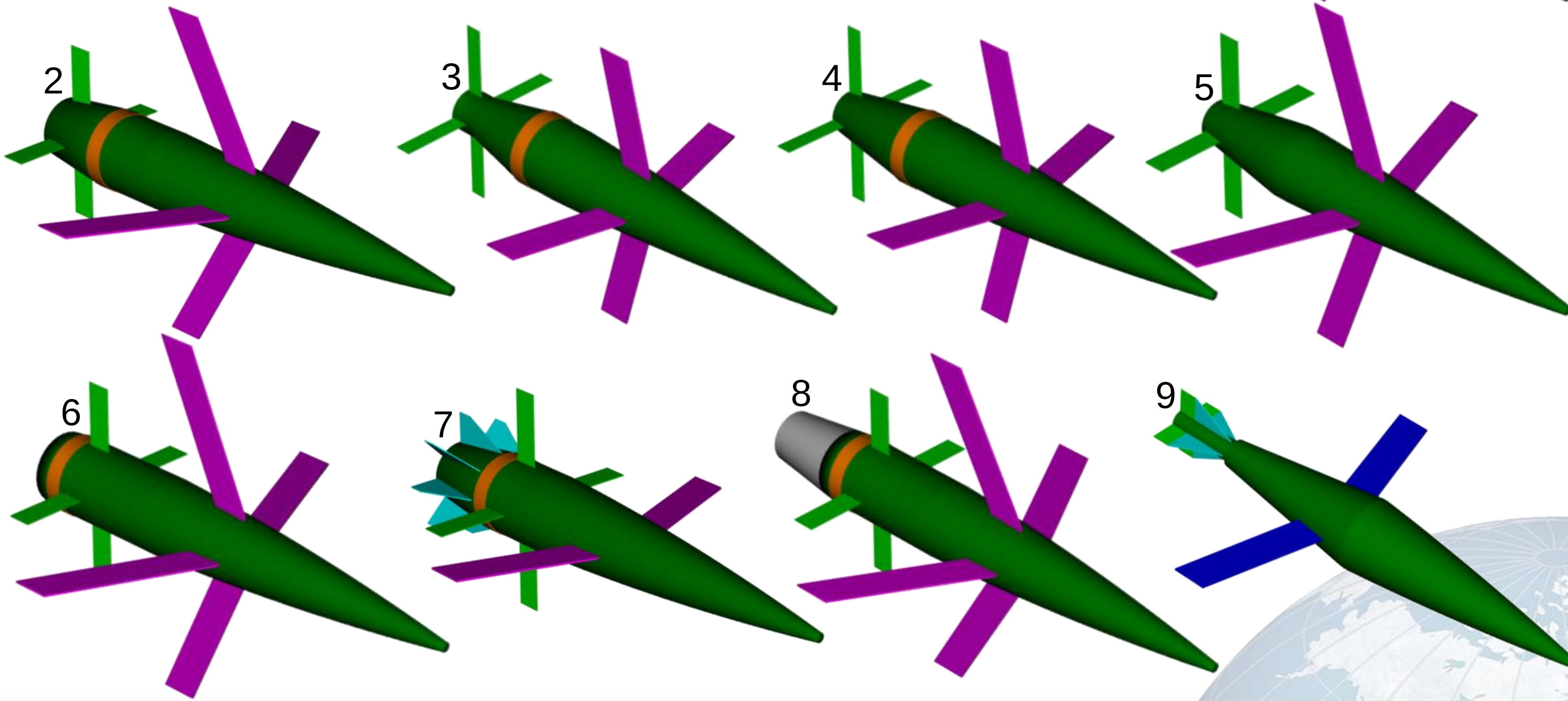
- Full Size (155 mm) Development
  - Explore design space for an optimal wing configuration





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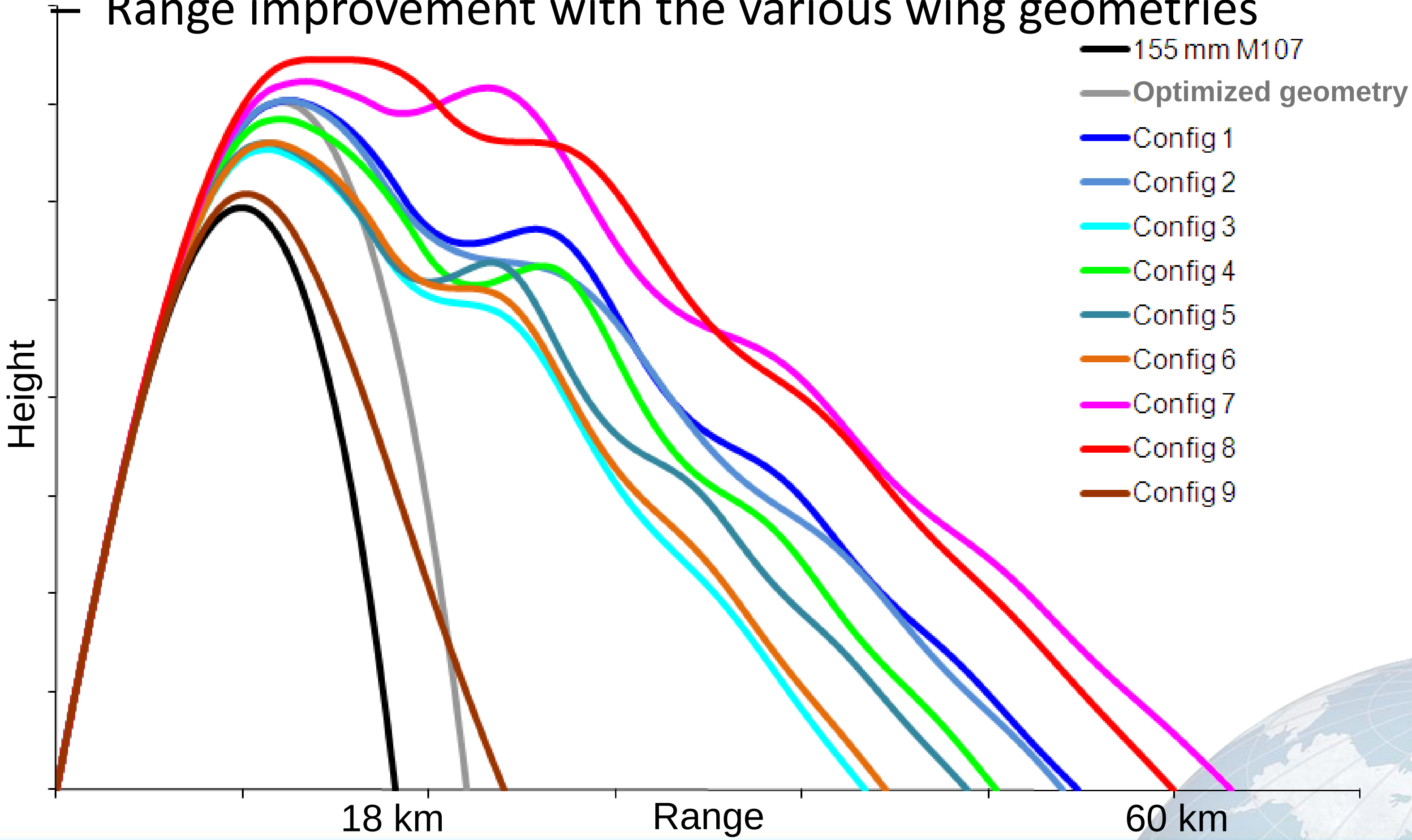
- Full Size (155 mm) Development
  - Range improvement with the various wing geometries



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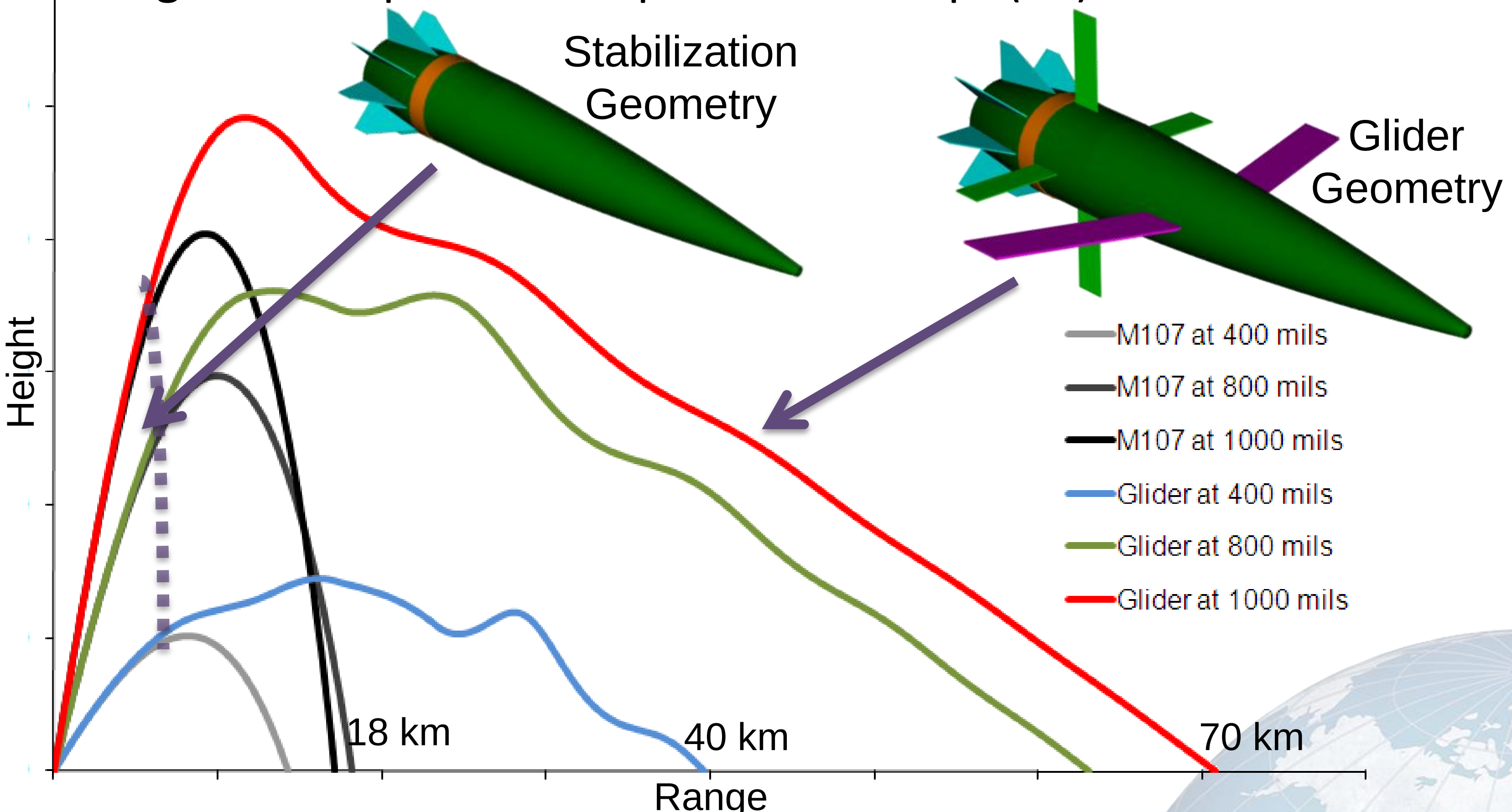
- Full Size (155 mm) Development
  - Flight envelope for the optimum concept (#7)



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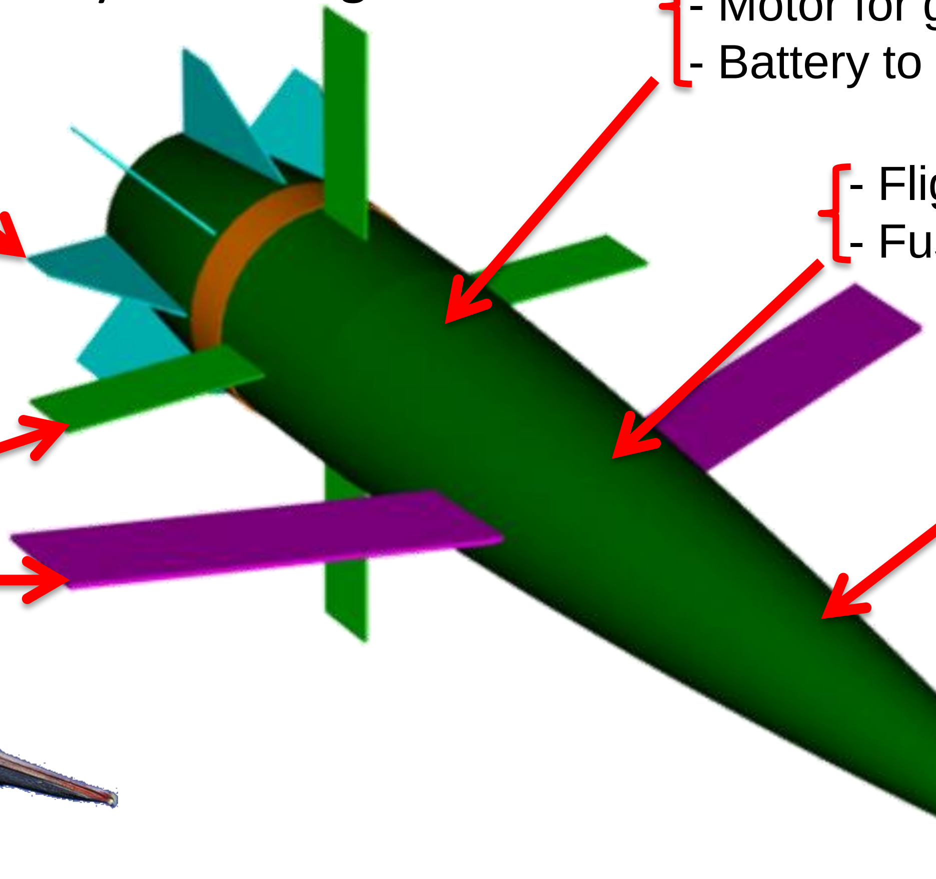
- Full Size (155 mm) Development
  - Possible system integration



- Conclusions
  - Starting with an M107 projectile fired from a 39 caliber barrel and optimizing only the projectile geometry using DOE and PRODAS results in a significant range improvement
  - Several wing configurations were studied with PRODAS.
    - Better performance from two groups of wings
    - Active fins used for trajectory control should be located as far away as possible from the main wings
    - Fins used for stabilization should minimize the drag during supersonic flight
  - Results from scale model with simulation do not match very well
    - Angle of fins between 10 and 15 for testing to increase lift forces.
    - For range improvement, the fin angles should be between 2 and 5 .
    - Aerodynamic coefficients not well predicted through simulation.

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- Future Work Required (Simulation and Experimental Validation)
  - Optimize projectile mass and length
    - Optimization done with internal ballistic constraints
  - Optimize the aerodynamics of the projectile
    - Optimize body shape with resulting effect of wings and fins
    - Optimize wings and fins geometries
    - Improve aerodynamic coefficients prediction
  - Develop system integration concepts
    - Select or develop an adapted warhead
    - Develop mechanism for wing deployment and fin control
  - Develop a guidance system for the projectile
    - Trajectory shaping to optimize the gliding performance
    - Attain the target accurately (Small CEP)

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- Questions