



Concept Development of Artillery Precision Guided Munitions

DRDC Valcartier

April 2010



Defence Research and
Development Canada

Recherche et développement
pour la défense Canada

Canada

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 APR 2010		2. REPORT TYPE		3. DATES COVERED 00-00-2010 to 00-00-2010	
4. TITLE AND SUBTITLE Concept Development of Artillery Precision Guided Munitions			5a. CONTRACT NUMBER		
			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) Defence R&D Canada - Valcartier, 2459 Pie-XI Blvd North, Quebec (Quebec) G3J 1X5 Canada,			8. PERFORMING ORGANIZATION REPORT NUMBER ; DRDC-VALCARTIER-SL-2010-		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S) DRDC-VALCARTIER-SL-2010-		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 20	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



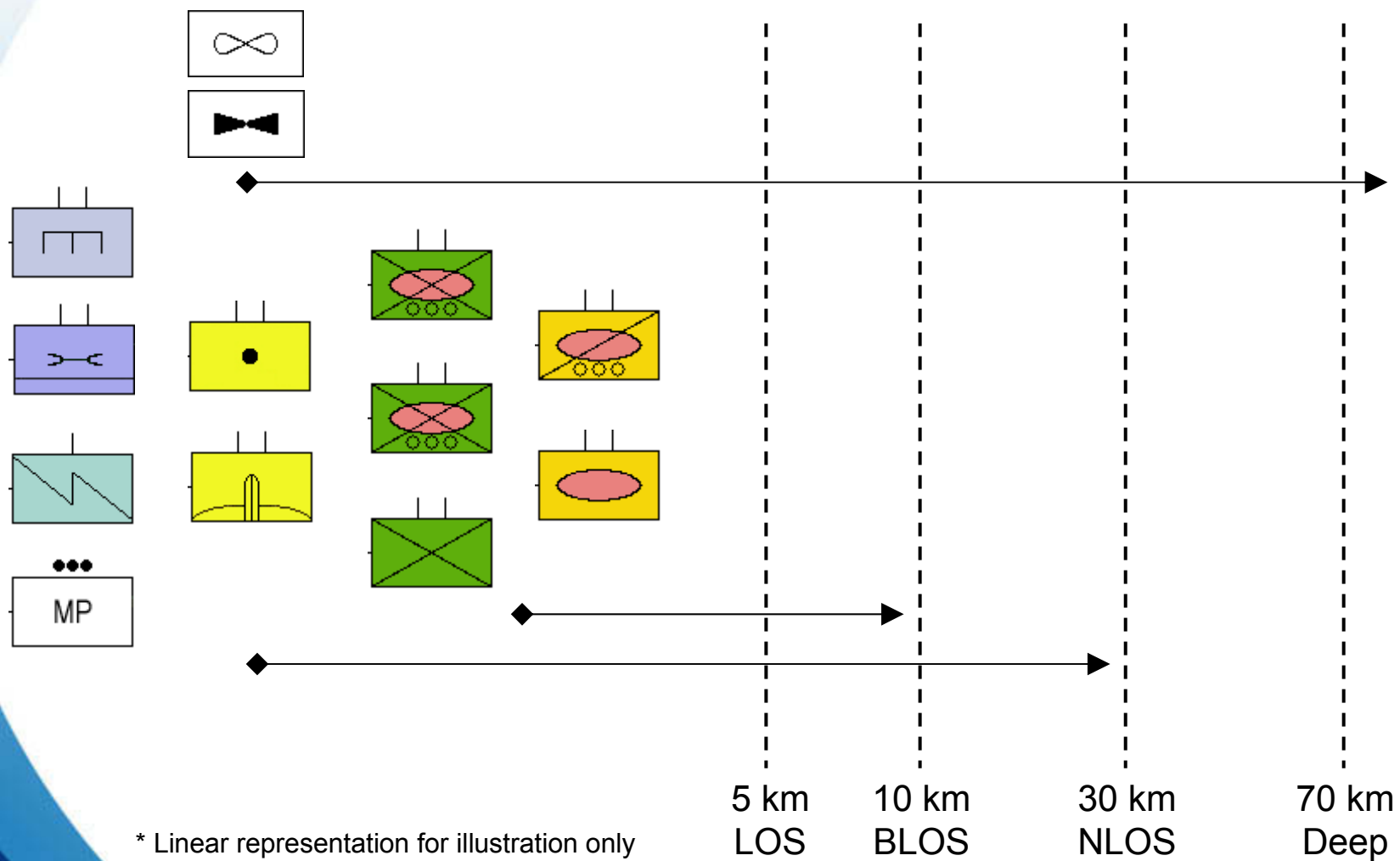
The 7 P's of Weapons Development

Purpose	Mission	SCIENTIST / ENGINEER	COMMANDER / SOLDIER
Payload	Effect on target		
Precision	Accuracy		
Propulsion	Range		
Protocol	Communication		
Packaging	Logistics		
Price	Cost to benefit		

The effectiveness of future CF weapons is dependent on meaningful dialogue and interaction between the end-user of the weapons and the S&T experts who are knowledgeable about weapon technology trends.



Aggregated Formation and Area of Influence





Convergence between Precision Guided Projectile and Rocket Weapons



Excalibur PGM

1.0 m length

155 mm diameter

48.2 kg AUW

15 kg HE warhead (est.)

inertial and GPS guidance

canard flight control

35 km range

gun launched

Guided MLRS

3.94 m length

230 mm diameter

293 kg AUW

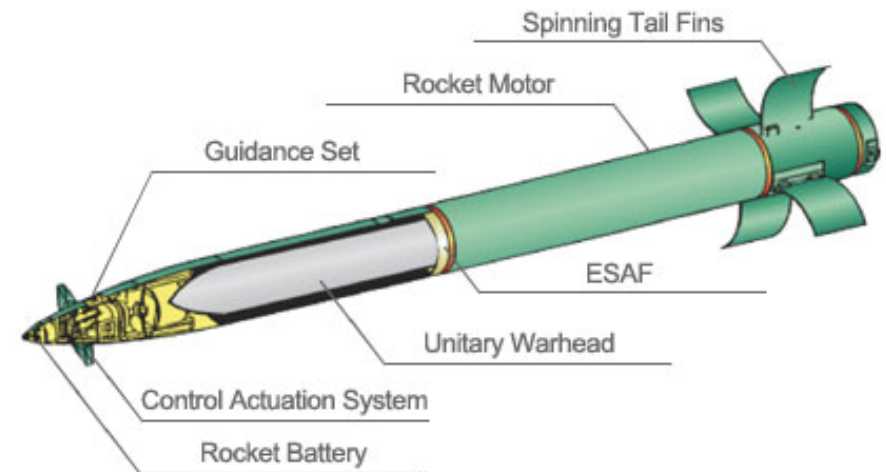
90 kg HE warhead

inertial and GPS guidance

canard flight control

70 km range

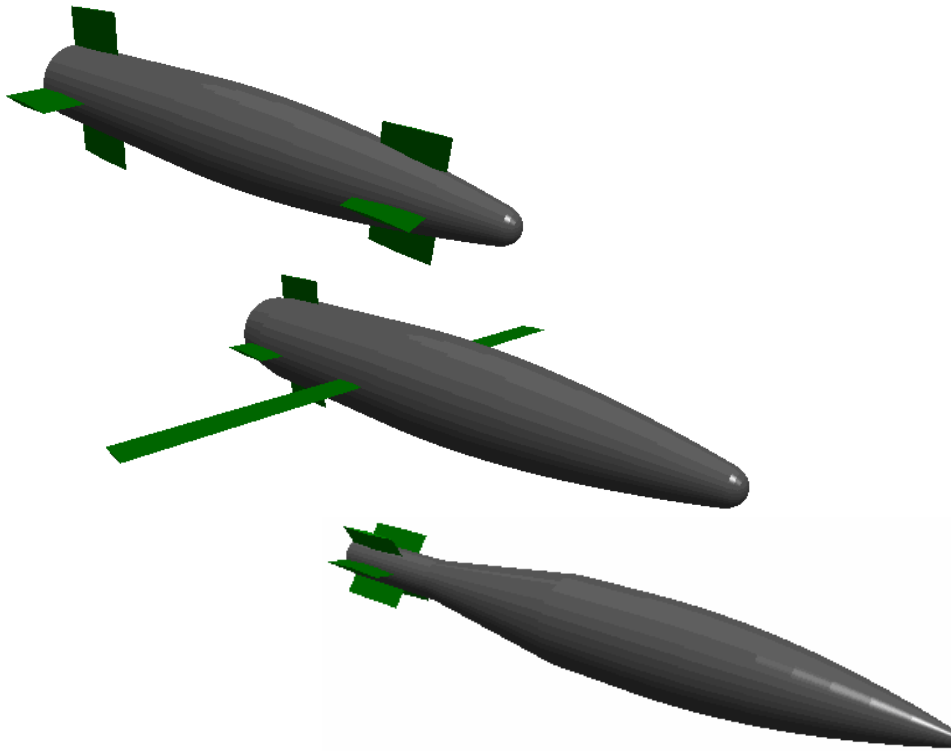
pod launched



Concepts for Artillery Precision Guided Munitions

Participants, resources & schedule:

- DRDC Valcartier, Honeywell, General Dynamics – Ordnance & Tactical Systems
- Project duration: April 2006 – March 2009
- Sponsor: Directorate Land Requirements



Objectives:

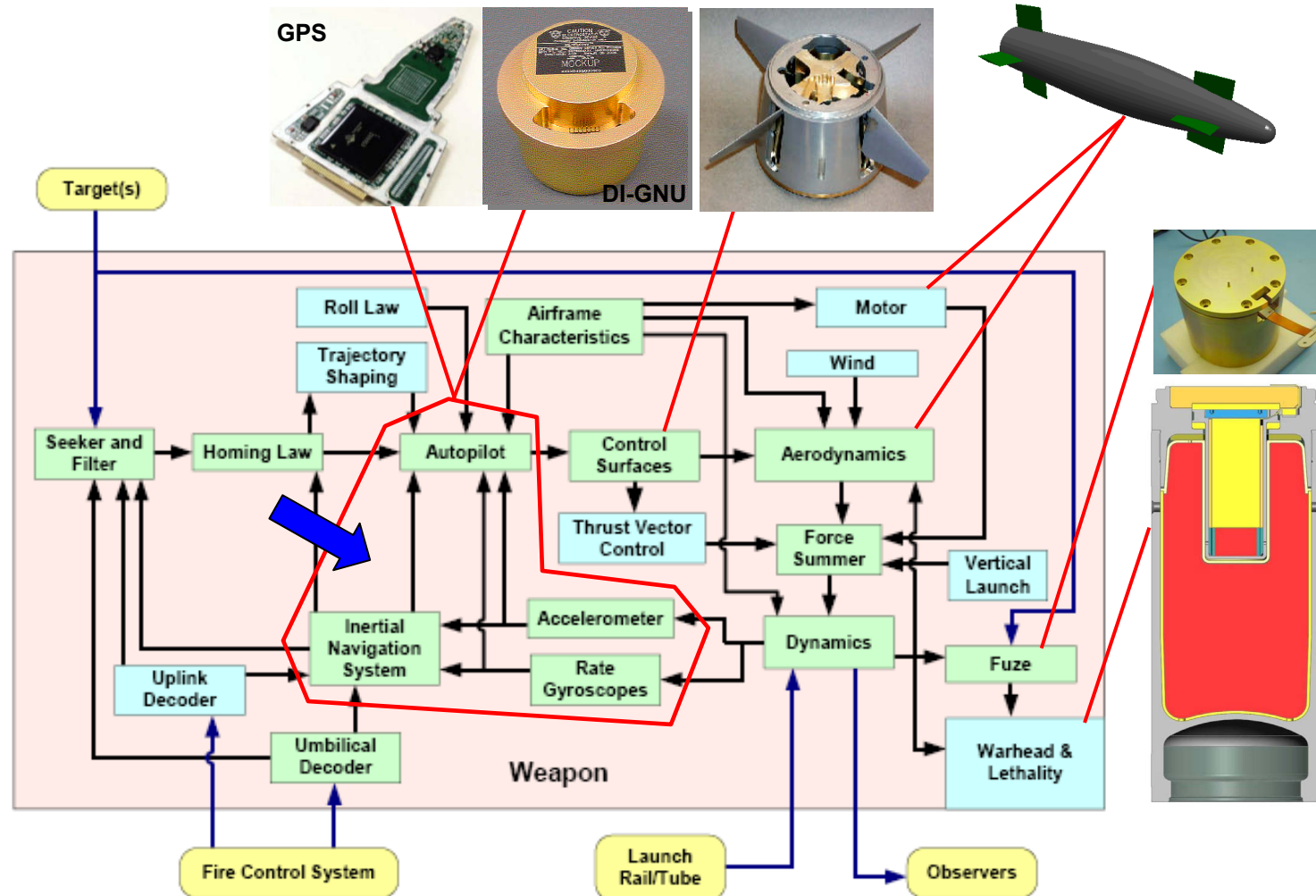
- Develop a modeling and experimentation environment that enable APGM concept evaluation and trade-off studies on sub-155mm munitions.
- Predict optimized APGM configuration and quantify inter-relationships between the components, sources of error and system performance.

Key outcomes:

- In-depth knowledge on guidance and autopilot software development for a state-of-the-art GPS/IMU device.
- Catalog of airframe and control surface concepts for a family of APGM concepts.
- Development of precision guided gun-launched projectile concepts with associated performance predictions.
- Directional warhead concepts.



Technology Options for sub-155mm Artillery Precision Guided Munitions

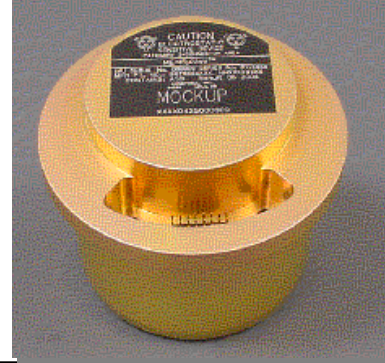




Honeywell Family of Gun-Hardened IMUs

BG1930G

- Size = 13.7 cu.in.
(2.75 in X 2.3 in)
- Gun Hard to 20,000 G
- Weight < 1 Lb
- Deeply Integrated
Guidance & Navigation
(DI-GNU)



HG1930



- Size: 4 in³ IMU
- Performance
 - G-hard to 20,000 g
 - < 20 deg/hr

DI-GNU is a tightly-coupled or ultra-tightly coupled INS and GPS system that runs all GNC functions on one microprocessor.

IGS-200 has its origins in the Common Guidance Program.

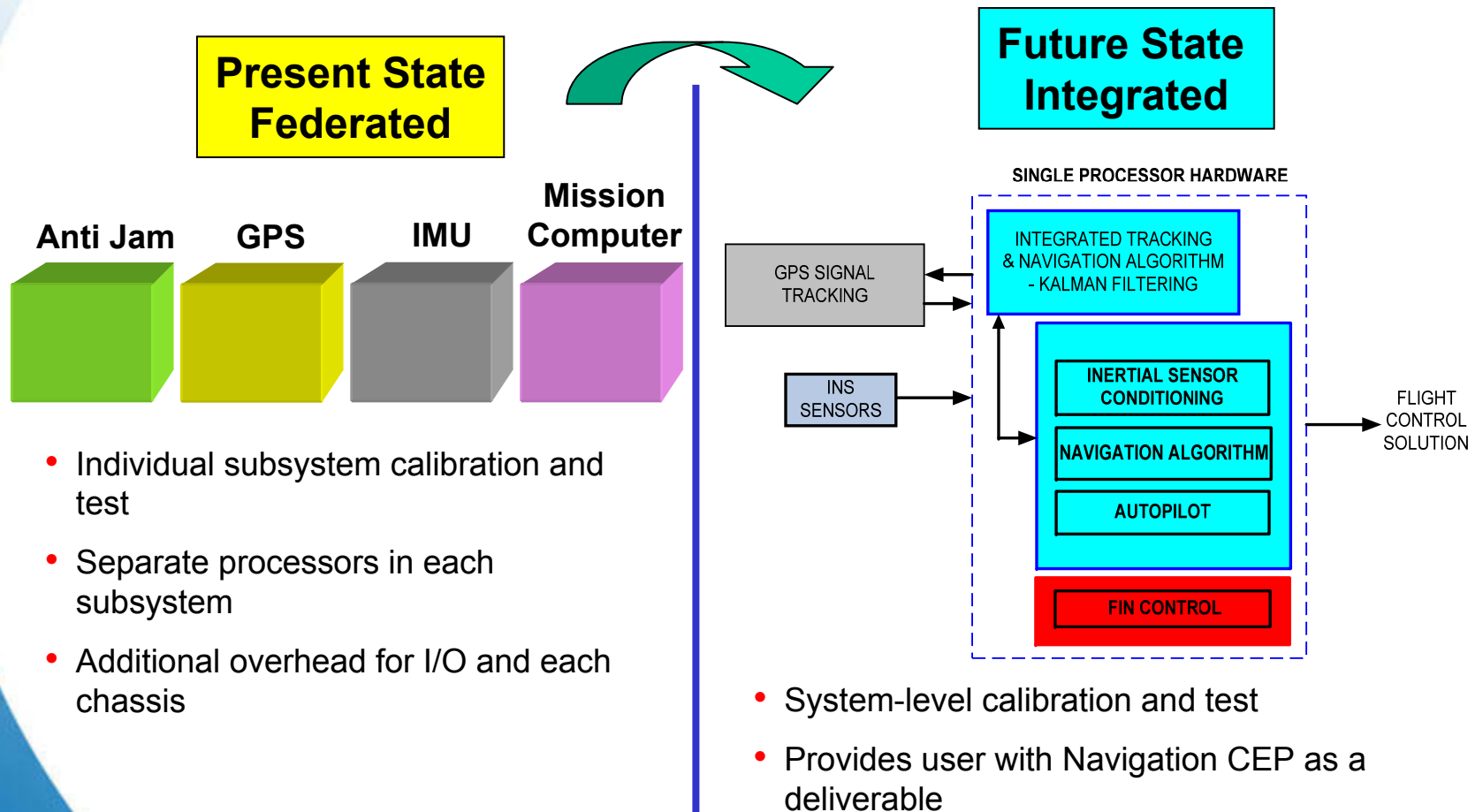
HG1940



- Size: 2 in³ IMU
- Performance
 - G-hard to 20,000 g
 - <1 deg/hr



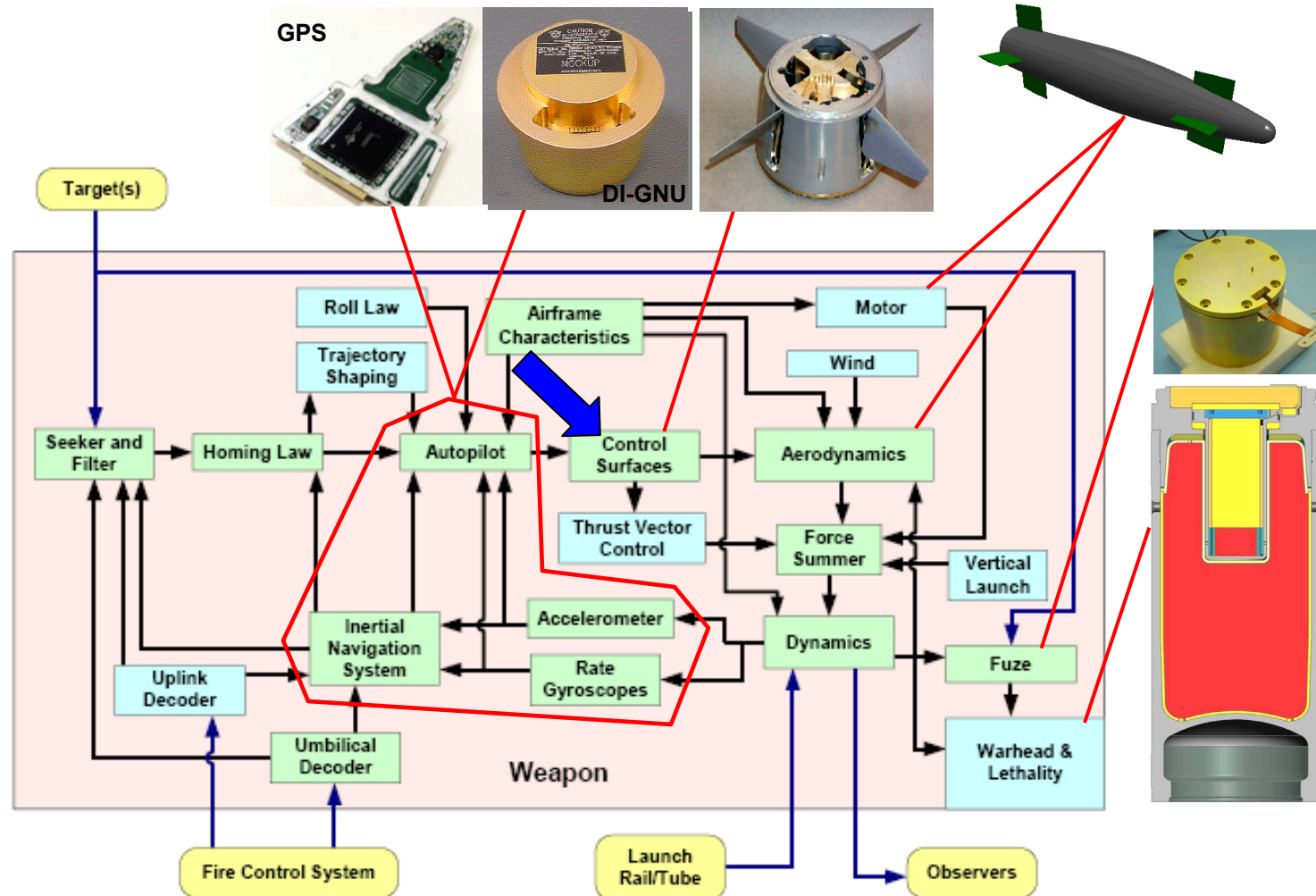
Implications of DI-GNU Structure



Honeywell

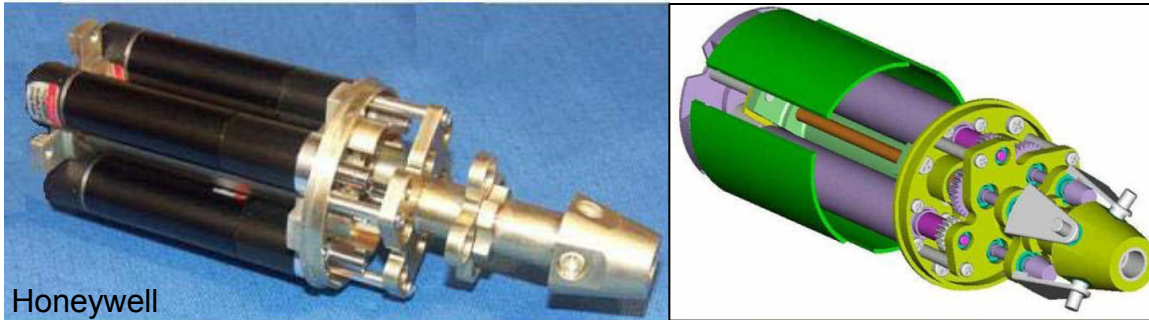


Technology Options for sub-155mm Artillery Precision Guided Munitions



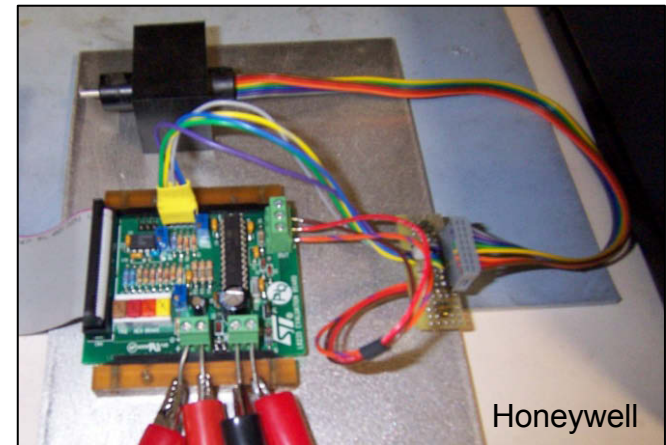
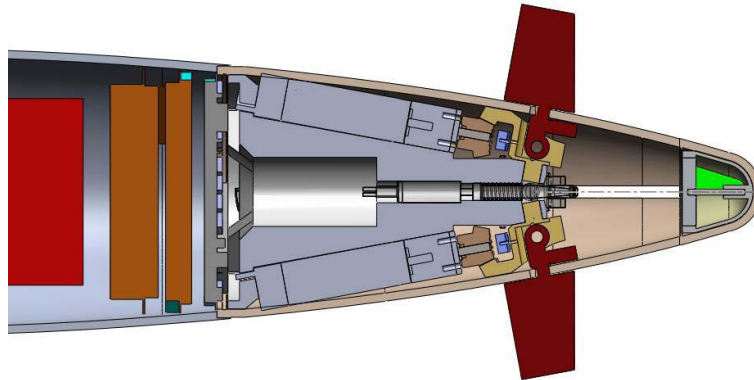


Control Actuation Systems



Honeywell

Miniaturized Electro-mechanical Body Flaps

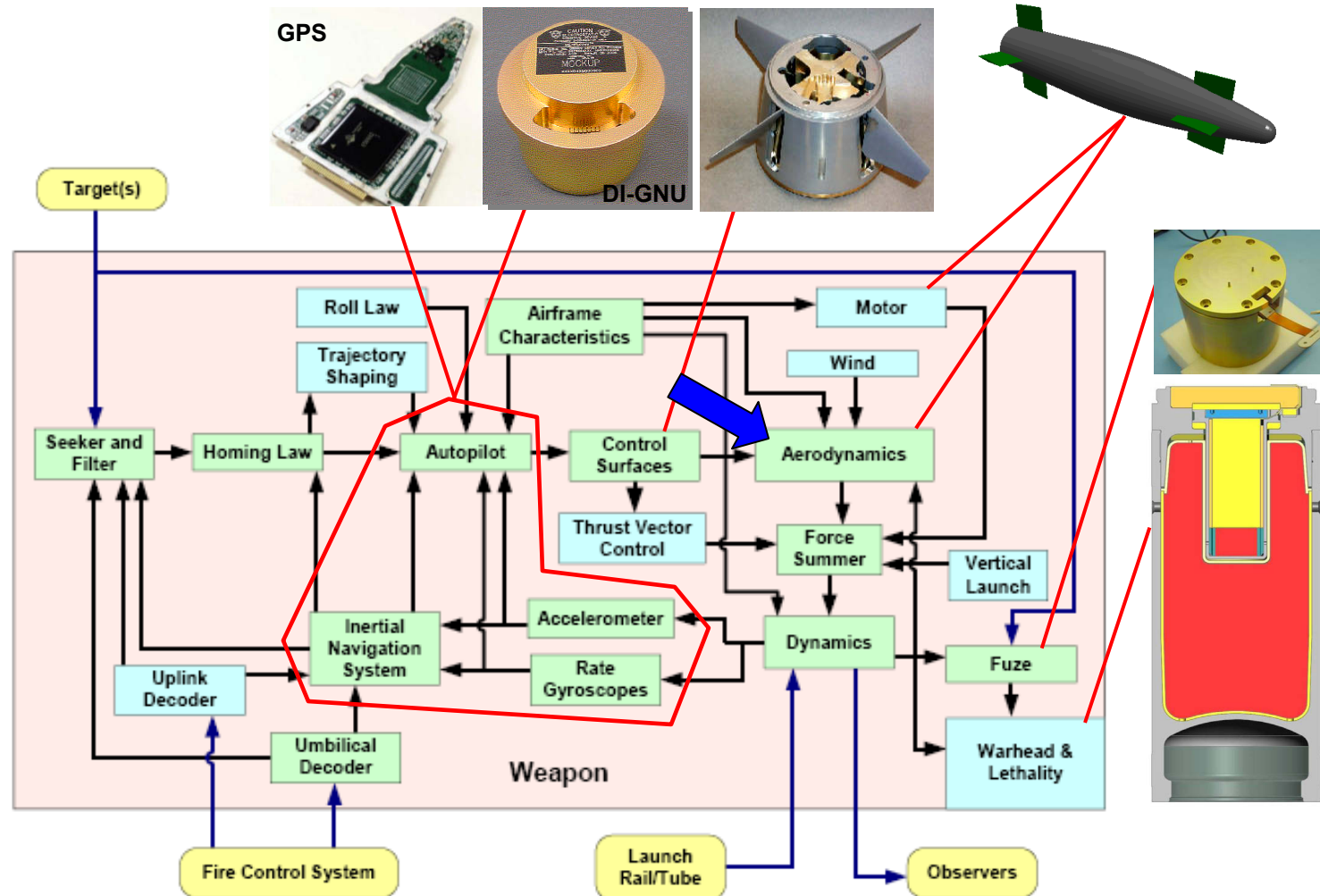


Honeywell

Miniaturized Electro-mechanical Canards

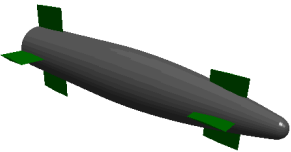
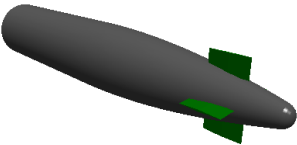
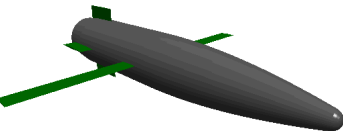
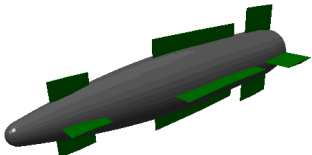
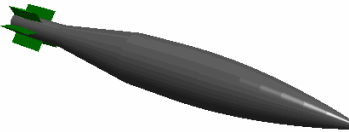


Technology Options for sub-155mm Artillery Precision Guided Munitions



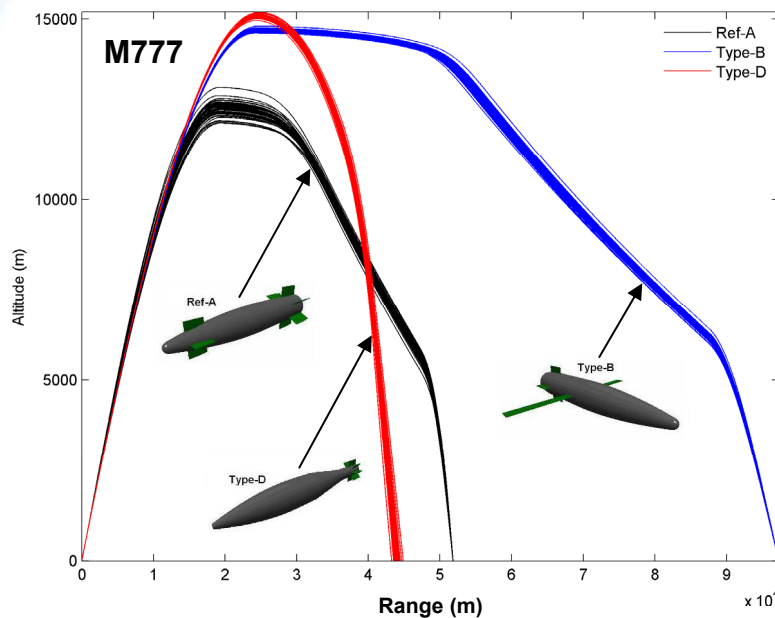


Candidate Configurations

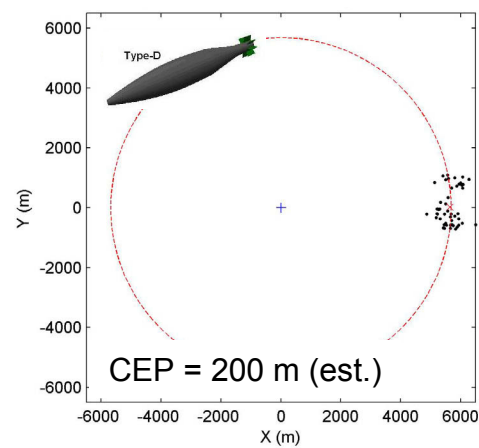
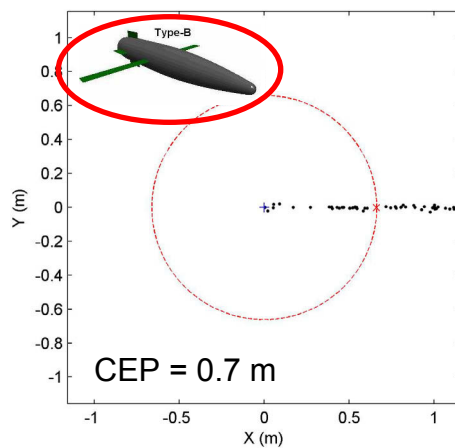
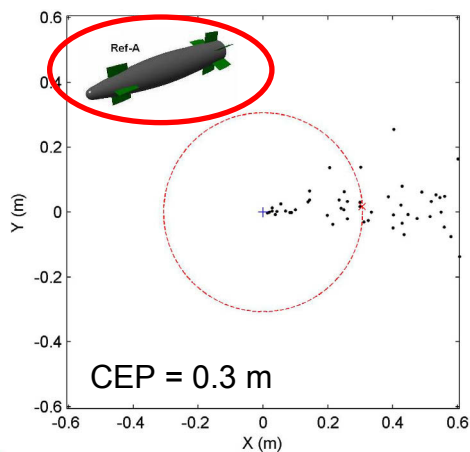
Ref A: Pseudo-Excalibur	
Ref B: Pseudo-Course Correction	
Type A: Low Drag	
Type B: Subsonic Glider	
Type C: Highly Manoeuvrable	
Type D: Robust	



Performance Study

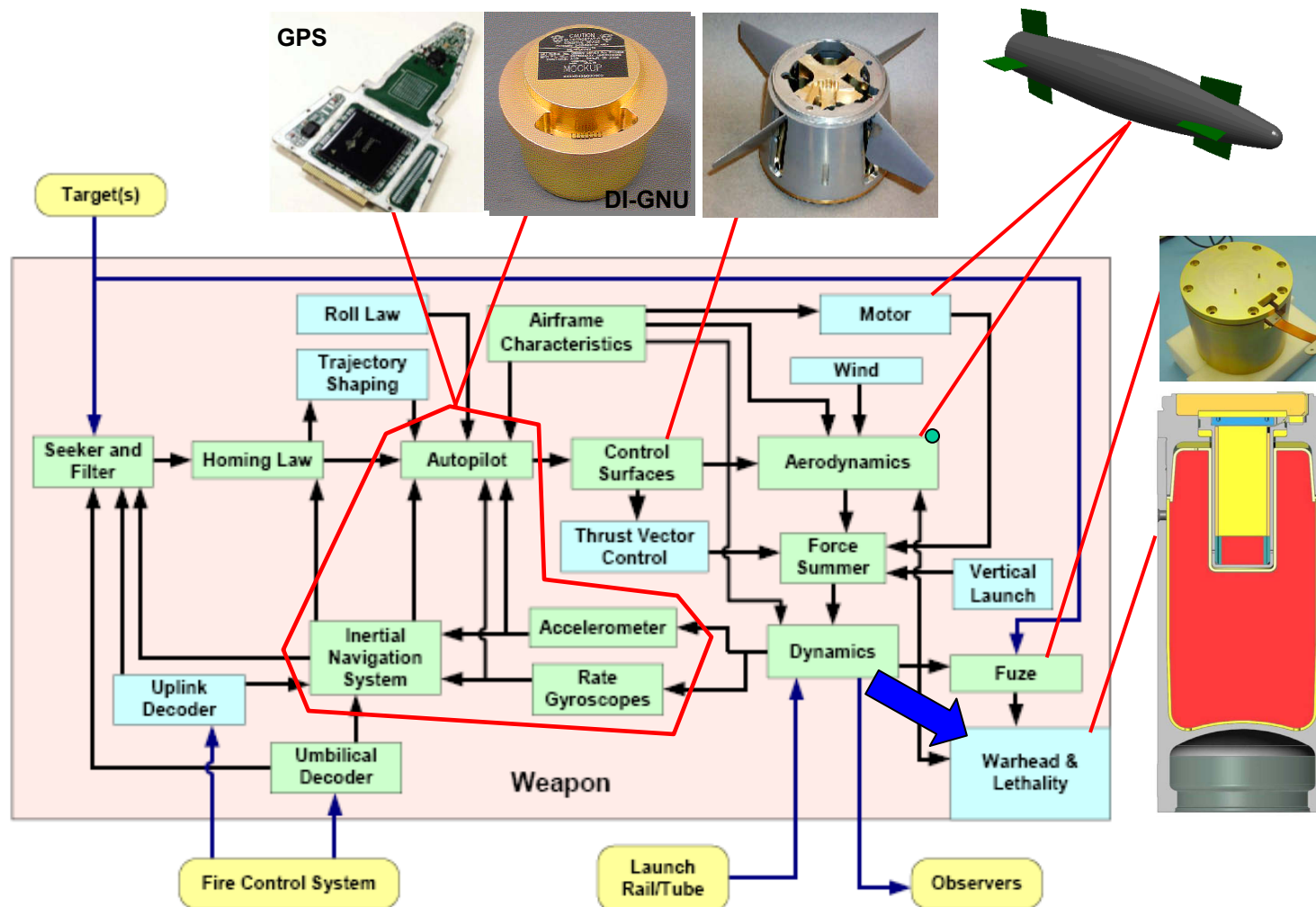


Muzzle velocity deviation = 2 m/s
Gun elevation deviation = 0.5 mils
Gun azimuth deviation = 0.5 mils
Wind speed variation = 2.8 m/s



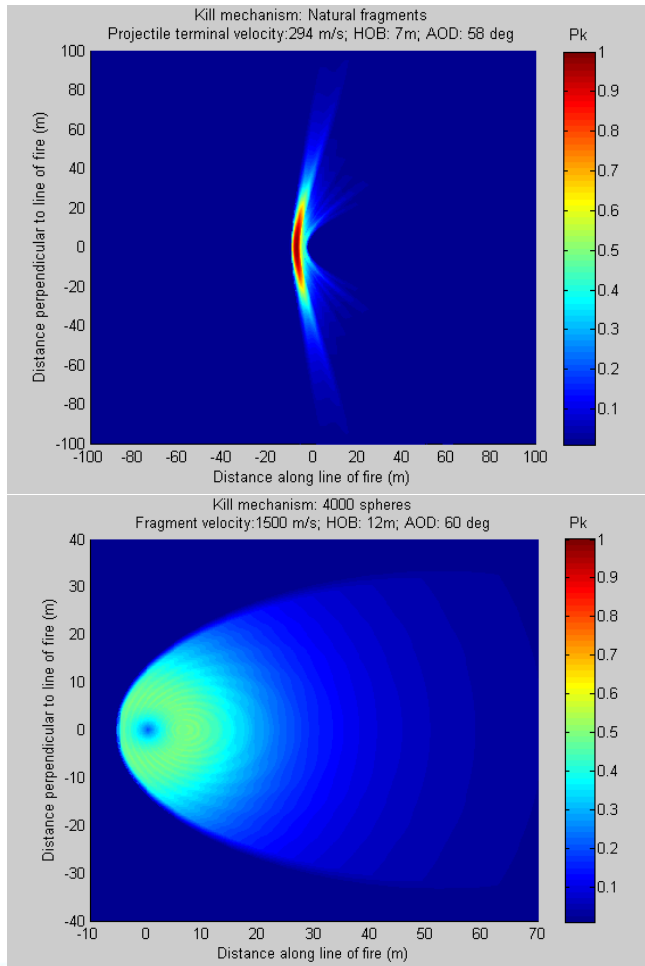


Technology Options for sub-155mm Artillery Precision Guided Munitions





Directional Warhead Concept



Current
M1



Directional
pre-formed fragments
steel spheres

Directional

Study Parameters

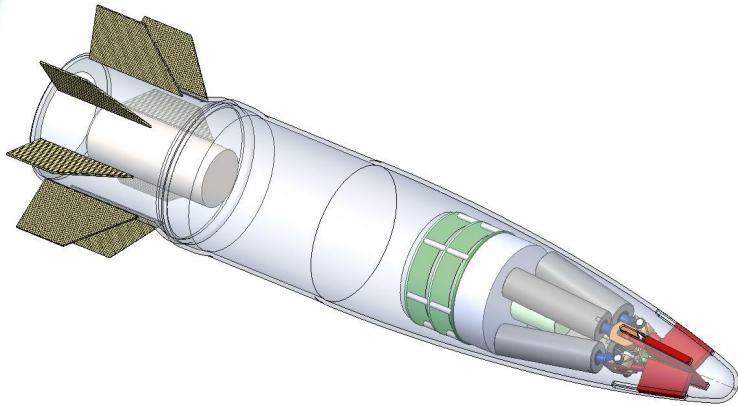
- Height of burst: 8m to 12m
- Number of fragments: 2000, 4000, 6000
- Fragment velocity: 900 and 1500 m/s
- Angle of descent: 60 and 90 deg
- Terminal velocity: 0.4 and 0.8 Mach

Results

- Large number of fragments, > 4000
- High velocity
- Angle of descent, 60 to 80 deg
- HOB can be varied to tailor effect



Sub-155mm Artillery PGM Concepts



105mm PGM

1.0 m length

105 mm diameter

18.5 kg AUW

6 kg HE warhead (est.)

inertial and GPS guidance

canard flight control

35+ km range

gun launched

105mm+ Glider PGM

1.0 m length

105mm+sabot diameter

20 kg AUW

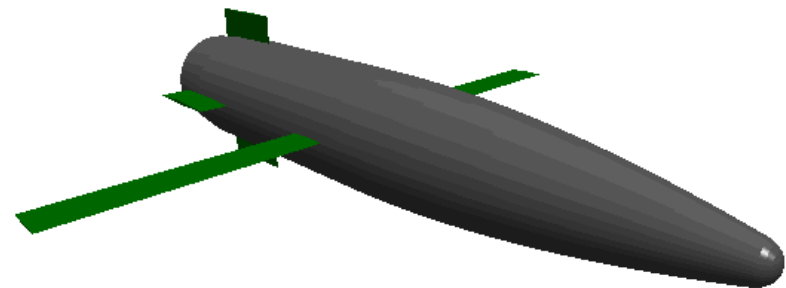
6 kg HE warhead (est.)

inertial and GPS guidance

canard or tail flight control

95+ km range

gun launched



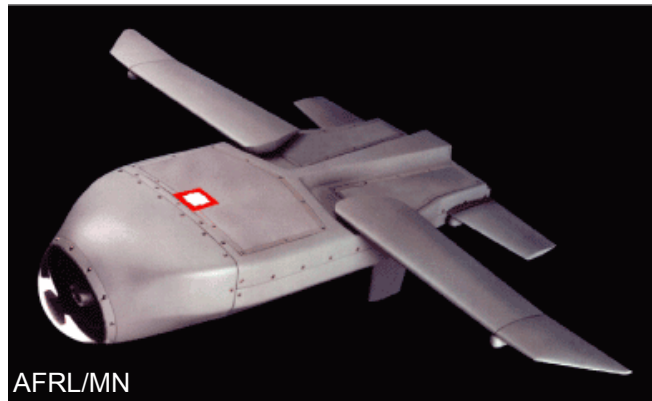


Winged Munitions



LM-Diehl

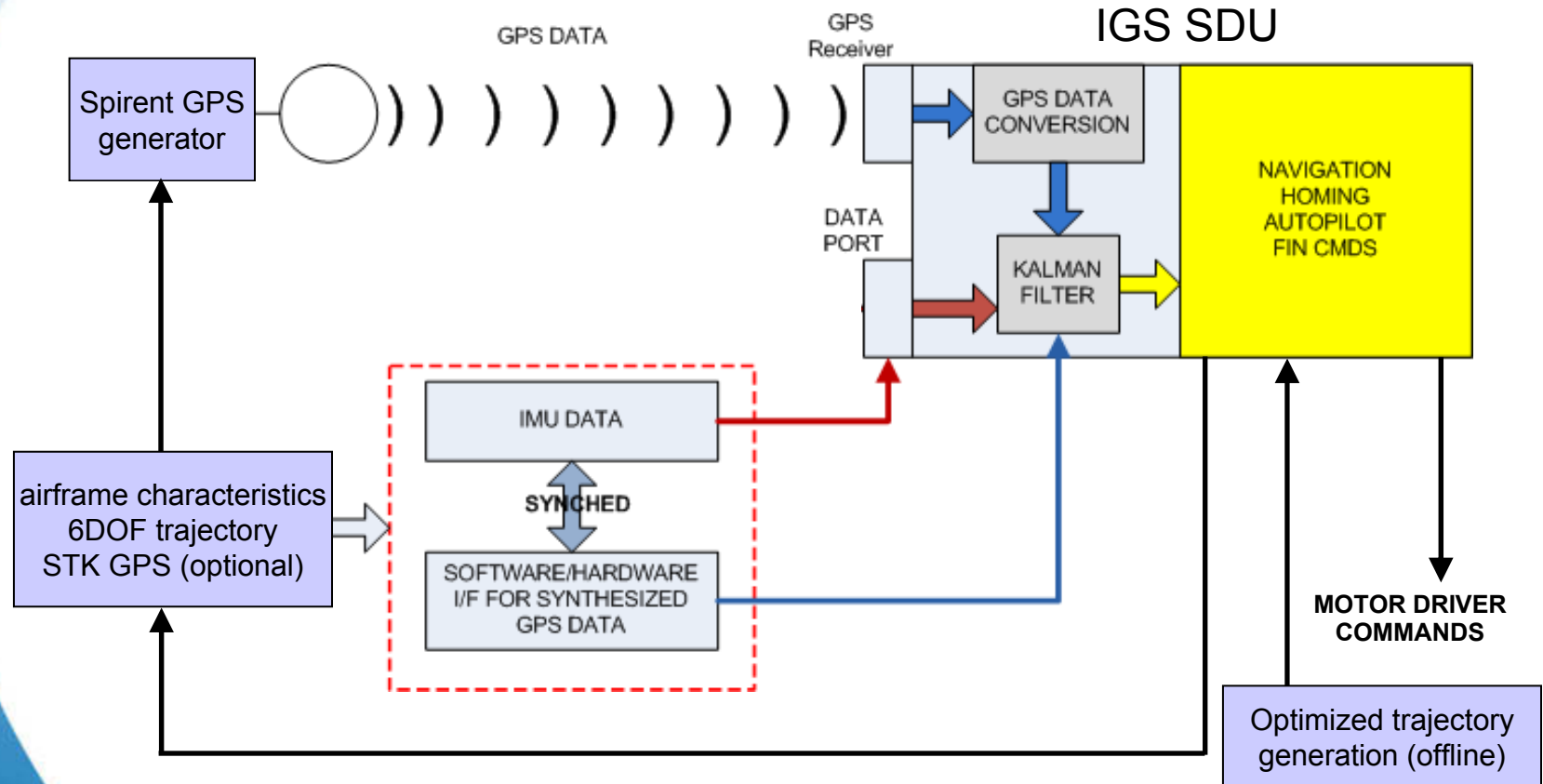
LM-Diehl M395
120mm mortar with IR seeker and
wing flight control actuation system



PLOCAAS
LADAR seeker, multi-mode
warhead and turbo jet engine

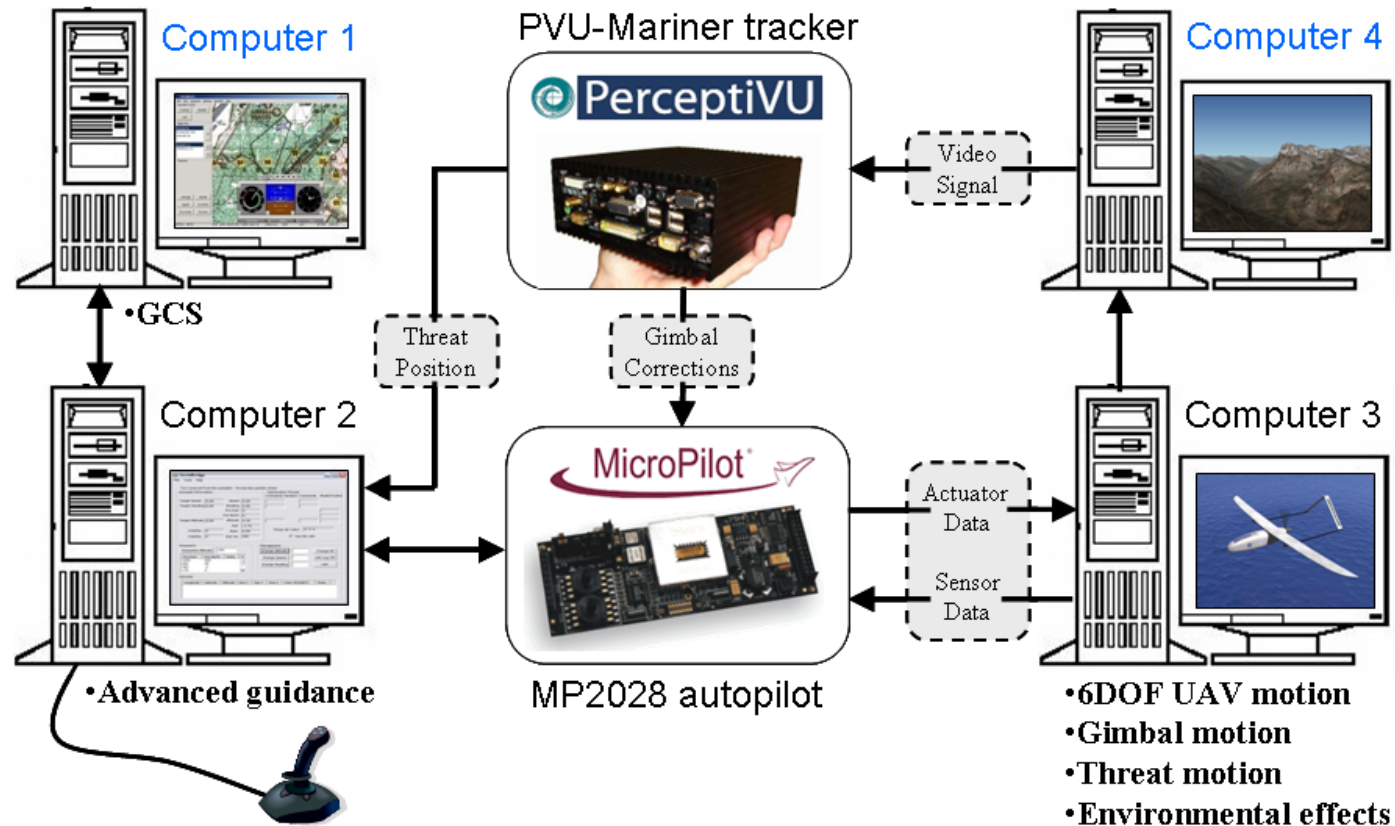


HIL IGS Layout





Target Pursuit for Marine Force Protection



Hardware-in-the-Loop facility to pursue target-of-interest using a UAV with a gimbaled camera.



Summary

- The objective of the APGM research program is to understand and develop sub-155 mm calibre PGM concepts that will demonstrate their operational capabilities to the CF Army for future acquisition programs.
- Precision guided munitions are becoming more prevalent as the number of battle successes increase and their costs diminish.
- The effectiveness of future CF weapons is dependent on dialogue and interaction between the end-user of the weapons and the S&T experts who are knowledgeable about weapon technology trends.
- DRDC has examined a number of APGM configurations and is pursuing two promising concepts that provide desired precision, range and terminal effects.