



U.S. Army Research, Development and  
Engineering Command



***TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.***

Introduction of wireless and MEMs based devices into Fire Control  
Systems

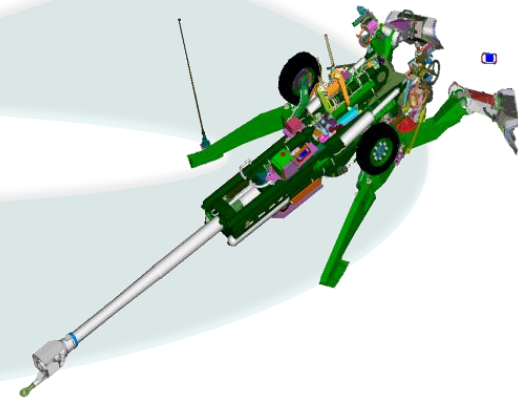
***Presented by***

***Ralph Tillinghast & Michael Wright***

***April 12, 2011***

## Outline

- **Current Technology State** (*Presented by: Ralph Tillinghast*)
  - Wireless & MEMs (Micro-electro-mechanical Systems)
  - Pointing and Navigation
  - Fire Control
- **Current Applications** (*Presented by: Michael Wright*)
  - 60 & 81mm Mortar Systems



- Current Wireless Protocols
  - Bluetooth
  - 802.11 (wireless A,B,G,N)
  - 802.15.4 (Zigbee)
- Army's Current Wireless System
  - Secnet 11 & 54, encrypted 802.11
  - Tactical modem through Army Radio (Taclink-ASIP)
- Other commercial entities currently developing new secure and affordable protocols.

# Current State (Pointing and Orientation)



DISTRIBUTION STATEMENT A

## Key Performance Parameters



Key Parameter	Near-Term External / Tripod Mount Threshold (T)	Long-Term Internal / Fully Integrated Objective (O)
<i>Azimuth Accuracy</i>	$\pm 4$ mils Probable Error (PE)	$\pm 1$ mil PE
<i>Vertical Angle Accuracy</i>	$\pm 4$ mils PE	$\pm 1$ mil PE
Orientation Range	Pitch: $\pm 500$ mils ( $\sim 30^\circ$ ) Bank: $\pm 270$ mils ( $\sim 15^\circ$ )	Pitch: $\pm 1511$ mils ( $\sim 85^\circ$ ) Bank: $\pm 500$ mils ( $\sim 30^\circ$ )
Slew Rate	$30^\circ$ per second	$1000^\circ$ per second
<i>Set up Time</i>	$< 180$ seconds	$< 1$ second
Operational Temperature	$-40^\circ\text{C} - +70^\circ\text{C}$	$-40^\circ\text{C} - +70^\circ\text{C}$
Shock	40g / 11 ms	2000 g / 1.5 ms (weapon fire)
Vibration	MILSTD 810/ min integrity	MILSTD 810/ min integrity
<i>Volume</i>	$\leq 50$ cu in	$\leq 0.25$ cu in
<i>Weight</i>	$\leq 4.0$ lbs ( $\leq 2.0$ lbs preferred)	$\leq 0.2$ lbs
<i>Power</i>	$\leq 10.0$ W ( $\leq 2.0$ W preferred)	$\leq 250$ mW
<i>Average Unit Production Cost (FY07 dollars)</i>	\$20K	TBD

**Slide from Presentation by Kate Jones, NSWC Dahlgren, 2009, Gun and Missile Conference, Azimuth & Vertical Angle Measurement (AVAM) Joint Working Group (JWG)**



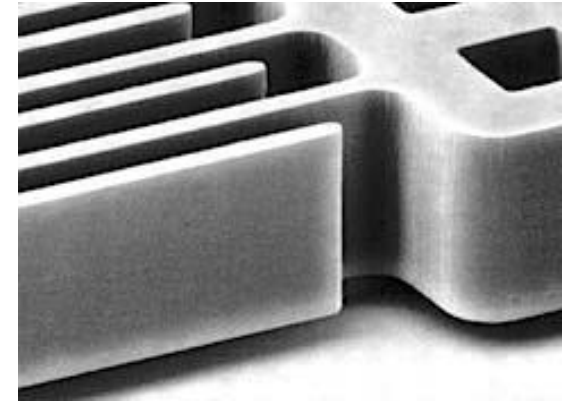
**TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.**

# Current State (Pointing and Orientation)

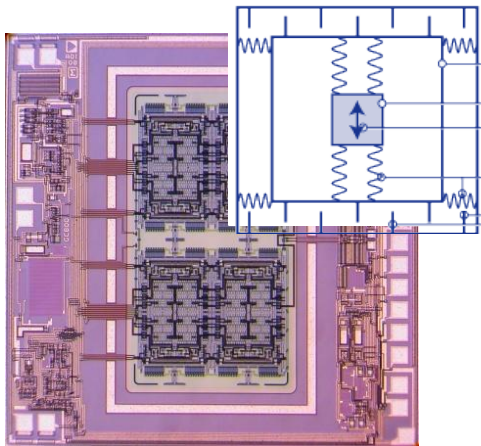


- GPS
- Laser Ring Gyro
- Fiber Optic Gyro
- Hemispherical Resonator Gyro
- Fluid Gyro
- MEMs Gyro
- Celestial System
- Optical Systems

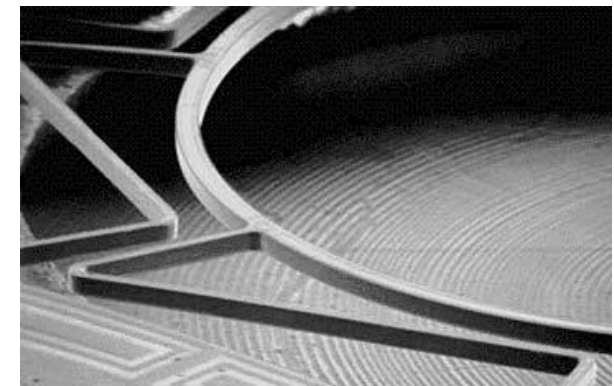
- Geophones
- Tuning Fork Gyro
- Vibrating-Wheel Gyro
- Wine Glass Resonator Gyro
- Foucault Pendulum Gyro



Draper Laboratory, 20 micron thick MEMs  
Accelerometer  
([www.sensorsmag.com](http://www.sensorsmag.com))



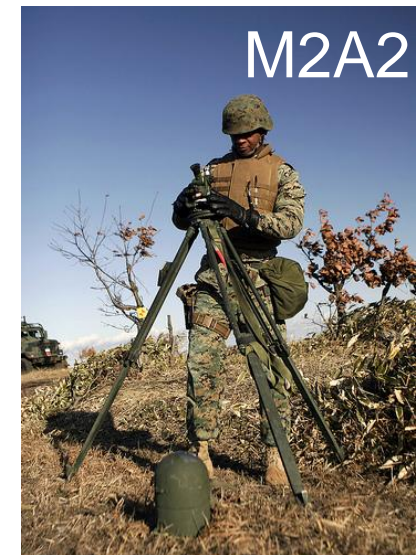
ADI's Quad differential gyro  
([www.analog.com](http://www.analog.com))



Resonating ring gyro, Silicon  
Sensing System  
([www.sensorsmag.com](http://www.sensorsmag.com))

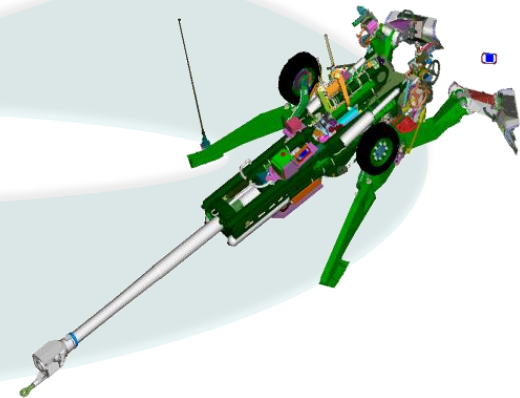


- M150/M151 120mm Mortar Fire Control
  - Laser Ring Gyro Based system (+/- 1 mil)
- Direct Lay Pointing (DLP)
  - 60mm Mortar (Charges 0 and 1)
  - Round Selection, Elevation and Time of Flight
- M2 Compass
  - Accuracy, +/- 10 mils
  - Handheld
- M2A2 Aiming Circle
  - Accuracy, +/- 2.0 mil
  - Large, Magnetic, Labor intensive



## Outline

- **Current and Future Technology State** (*Presented by: Ralph Tillinghast*)
  - Wireless & MEMs
  - Pointing and Navigation
  - Fire Control
- **Current Applications** (*Presented by: Michael Wright*)
  - 60 & 81mm Mortar Systems





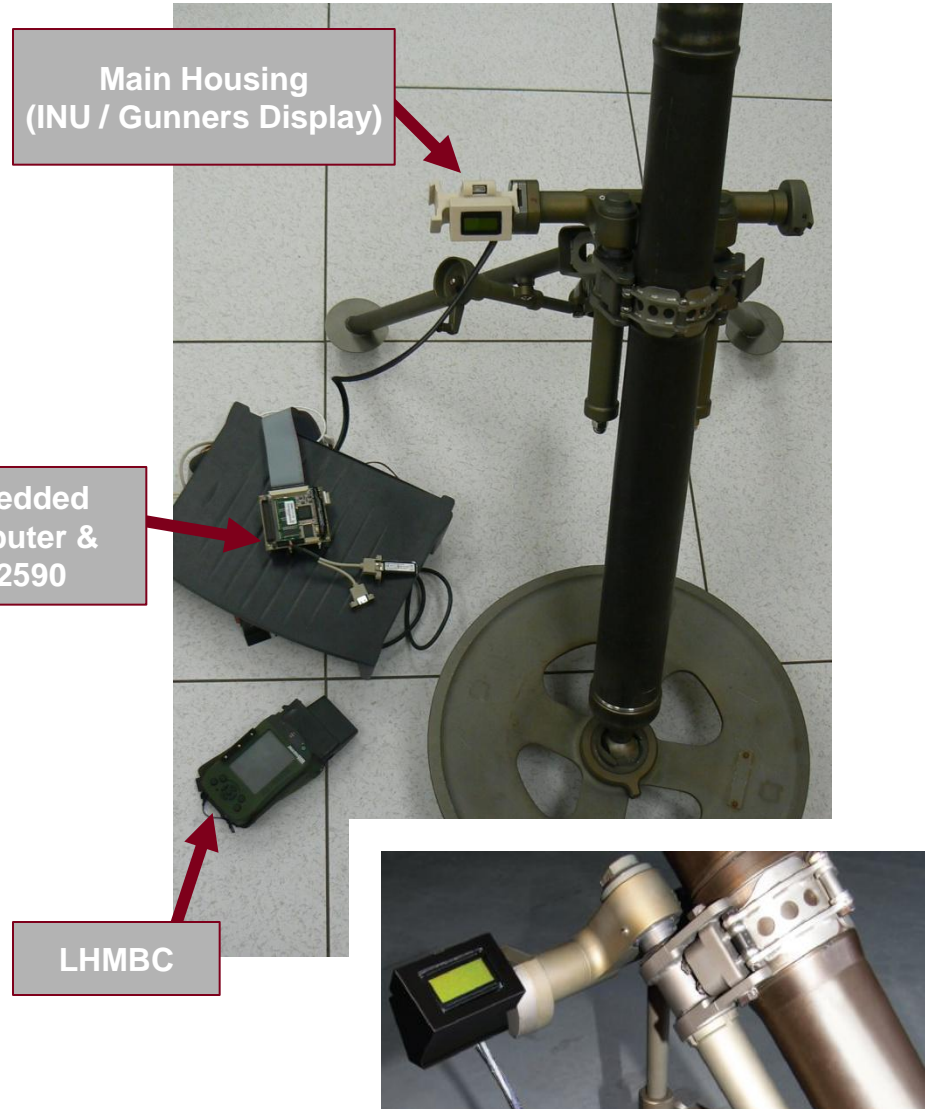
# Current Applications (60 & 81mm Mortar Systems)



- M95/M151 far too heavy and power hungry for dismounted mortar operations
- Direct Lay Pointing (DLP) is only elevation on 60mm
- Trade off between accuracy and number of rounds
- The need to be smaller, lighter, faster rules out currently fielded technology
  - Laser ring north finding
  - Directly cabled solutions
- Needs to seamlessly fit within current mortar usage and tactics

WULF provides weapon pointing data from the LHMBC wirelessly to gunner. The Gunners display unit indicates the required gun shift information.

- Embedded Computer
- 3-4 mil Accuracy
- Target Battery Life: 24+ hours
- Report Delta Deflection and Elevation
- Adaptable to different wireless standards
- 60, 81 and 120mm compatible



- Magnetic compass north finding easily effected by inference and incorrect declination.
- MEM's gyro north finding not accurate enough for 81mm mortars.
- Optical tracking can not handle large shifts in azimuth
- Laser and Fiber Optic Gyros too heavy, expensive, and inefficient.
- Combination of technologies required to accurately detect and hold north reference through magnetic interference and firing events.

# Current Applications, Communication (60 & 81mm)



- Army radio (ASIP) not practical to have at every gun
- Guns operated relatively close to digital fire direction center (M32).
- Minimal amount of data needs to be transmitted
- 802.11 ADHOC supports auto forwarding between nodes on same net
  - Bluetooth deemed impractical for this application.
- Security handled through software encryption, message limitation (does not transmit position information), and range limitation.

## Contact Info:

Ralph Tillinghast

Collaboration Innovation Lab

Lab Director

Fire Control Systems & Technology

US Army ARDEC, RDAR-WSF-M

973.724.2095

ralph.tillinghast@us.army.mil

Michael Wright

Wireless Universal Lightweight Fire-Control

ARDEC Project Officer

Fire Control Systems & Technology

US Army ARDEC, RDAR-WSF-M

973.724.8614

michael.wright26@us.army.mil

***Please visit the ARDEC Booth in the Exhibit Hall***