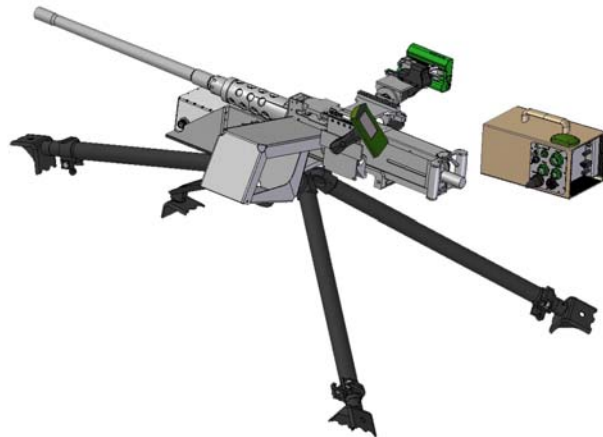
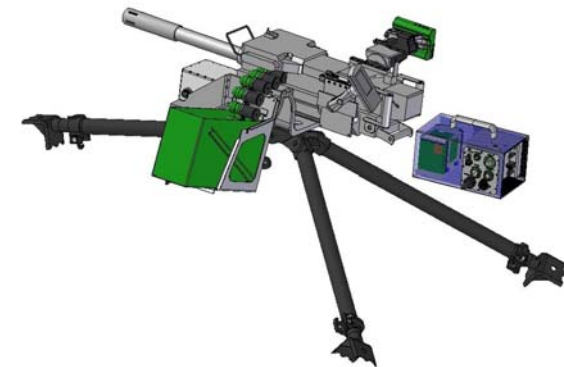




# Heavy Machinegun Fire Control as a Distributed Operations Enabler



9 May 2007



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# Background



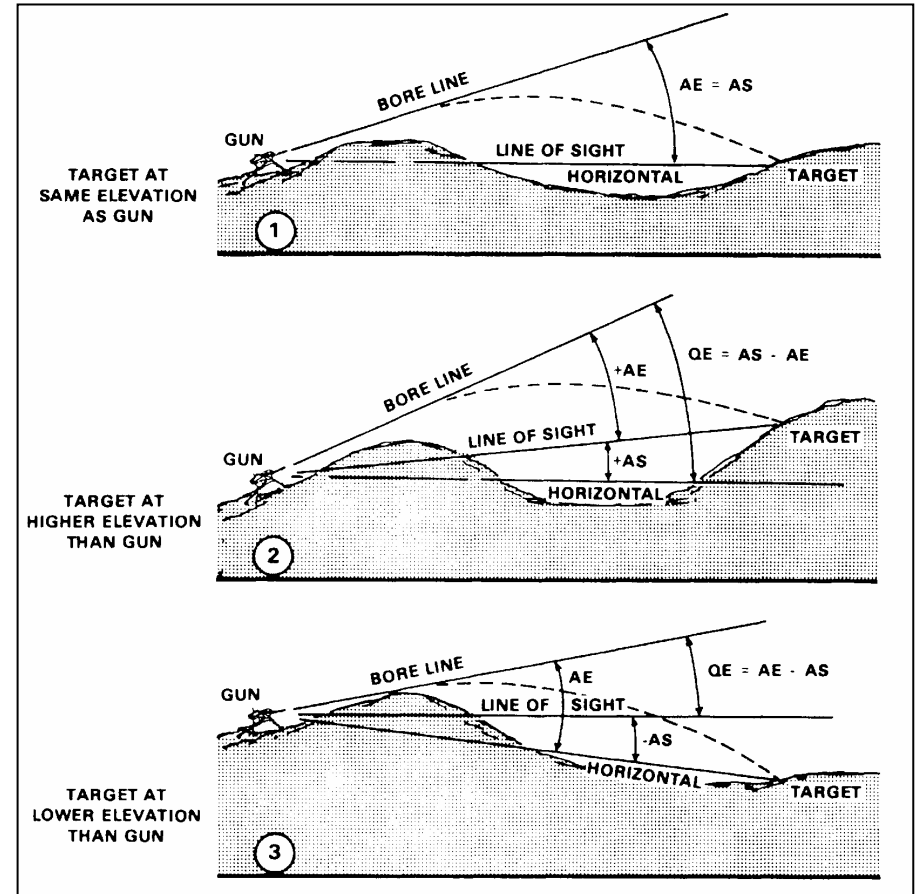
- **Request from ONR Code 30 Fires to address 40mm Indirect Fire feasibility as part of Improved Fire Control Systems FNC**
- **Proof of Concept demonstrator built and tested in late FY03**
  - **COTS components**
  - **In-house software**
  - **MCWL weapon/ammo/test support**



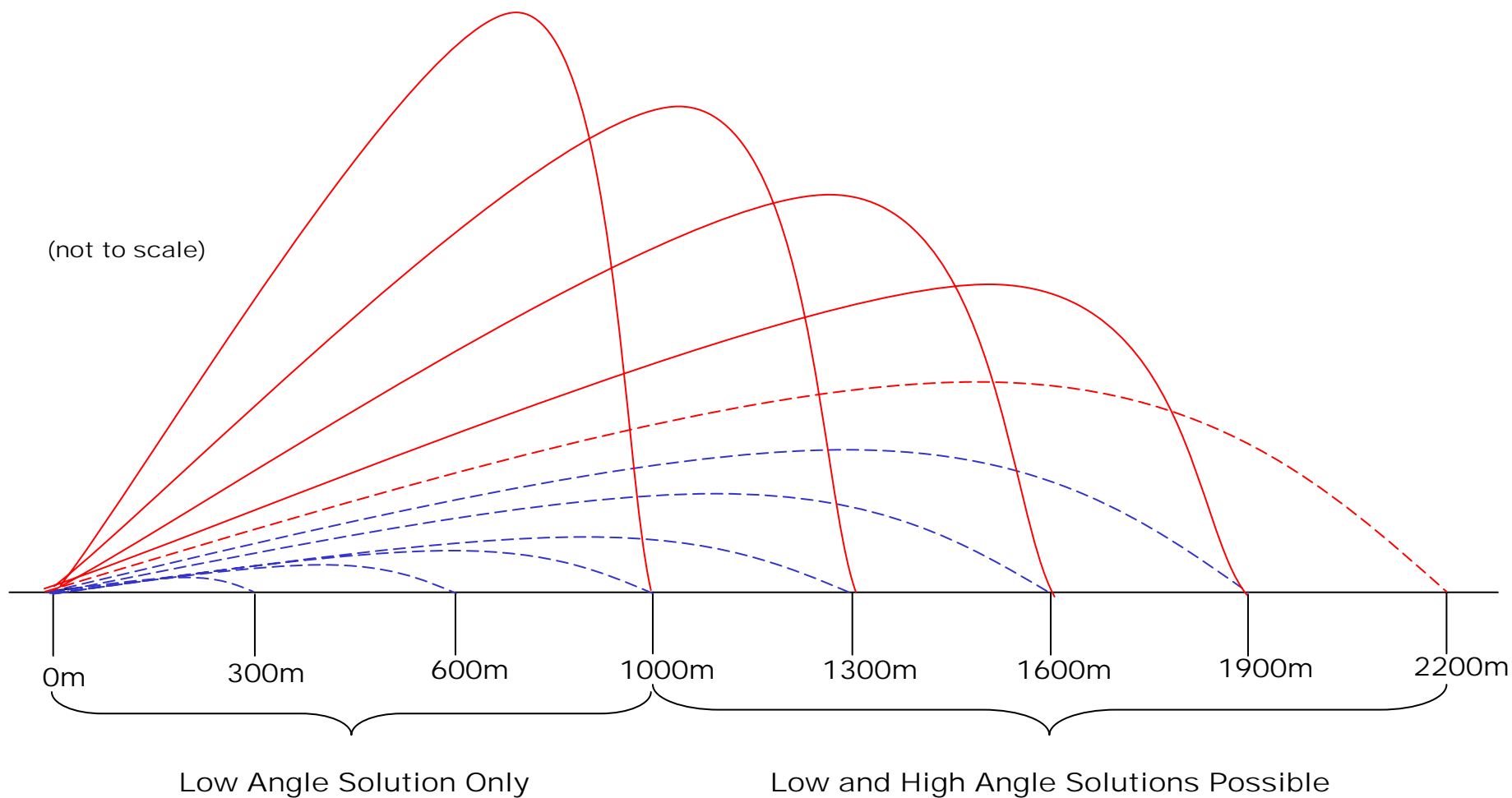
# Technical Approach



- Ballistic kernel calculates targeting solution using
  - Target & weapon geo-location
  - Inertial sensor for weapon attitude
  - MET data
- Provides aiming parameters to gunner when firing from defilade
- Lobbing trajectory allows substantial mask clearance at longer ranges
  - Hills
  - Trees
  - Buildings



# 40mm Range/Trajectory



# Proof of Concept Test



- **Demonstrated 40mm Indirect Fire Proof of Concept**
  - Used GD 40mm ALGL as test platform
  - Accurate to full range of weapon
  - Promising results exceeded user expectations
- **Improvements needed**
  - High-angle ballistic profile
  - Hardware integration
  - Software usability
  - Gunner interface



Hawthorne, NV, 2003







# Emerging Guidance



- **Marine Corps Improved Heavy Machinegun (IHMG) UNS**
  - Signed Nov 2003 by BGen Neller
  - Validated by DOTMLPF working group Feb 2004
  - Improved .50 cal and 40mm weapons
  - Common compatible mount w/ quick slewing capability
  - Direct and Indirect Fire Control with integral LRF
  - Common optics bench for current/emerging inventory sights
  
- **Addresses Expeditionary Maneuver Warfare Capability Gaps**
  - Enhance capabilities of infantry heavy weapons by incorporation of advanced fire control technologies.
  - Provide all-weather, fully integrated, and continuous lethal and non-lethal fires with extended range, volume, and accuracy.
  - Develop means to reduce time delay from target detection to identification and from target identification to engagement.
  - Provide extended, coordinated, and sequenced joint fires in support of maneuver elements.



# HMG Indirect Fire History

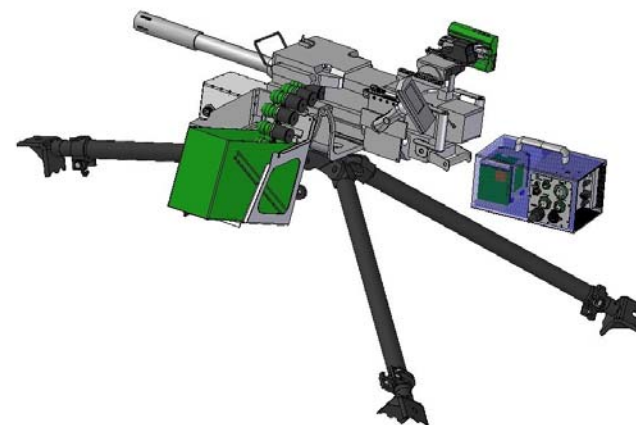
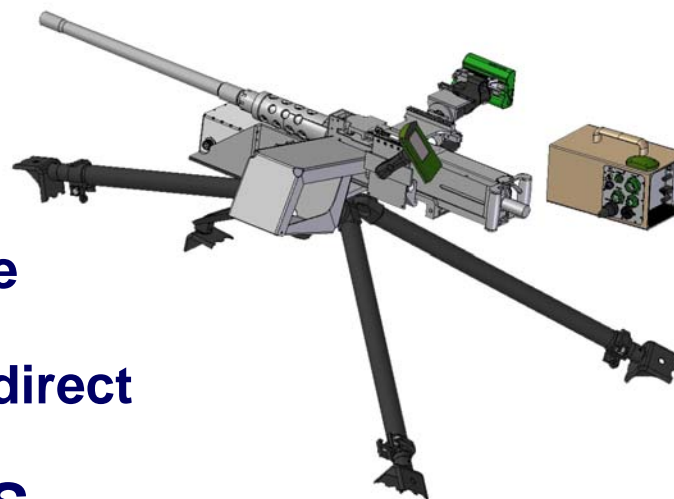


- **Used effectively in WWI & WWII - “rain of slugs”**
- **Occasional use in Korea**
- **Foliage of Vietnam reduced opportunities**
- **New mounts did not facilitate high angles**
- **Instruction/Training lacking**
  - Time and Ammunition intensive
  - .50 cal Indirect Fire is a lost art - no longer taught
  - 40mm Indirect Fire only taught at MC Advanced Machinegun leaders course
    - 45 minutes to set up a mission
    - Lucky to hit within a football field on first shot
- **Lack of doctrine for accurate, coordinated, and timely employment**
- **Loss of expertise due to lack of use**





- **Major transformation for Heavy Machineguns**
  - Extends practical useable range of weapons
  - Enables timely execution of accurate indirect fire
  - Increase in first round accuracy for direct fire
- **Radical enhancement of CONOPS**
  - Ideal for current conflicts & MOUT engagements
  - Situational awareness for heavy machinegun teams
  - Networked Fire Control allows
    - Direct sensor-to-shooter link
    - Call for fire support on targets of opportunity
    - Collaborative attack capability







# Project Sponsors



- Office of Naval Research (ONR)
  - Expeditionary Maneuver Warfare Department
    - Fires Thrust Area



- Marine Corps Warfighting Lab (MCWL)
  - Technology Division
    - Ground Combat Element Branch





# Team Responsibilities



- **Technology Transition Agreement between ONR, MCWL, & MCSC signed June 2004**
  - **NSWC Crane (ONR Design Agent)**
    - Fire control development
    - Communications / networked fires interoperability
    - Overall system integrator
    - Coordinate technology demonstration
  - **MCWL**
    - Advanced Common Mount (ACM) development
    - Evaluation of MK19 replacement candidates
    - Weapon, ammo, and range support for tests and demos
    - Operational demonstrations
    - Funded fire control completion and system verification test in FY06



# Indirect Fire Employment



Forward Observer (FO)



FO Determines Target's  
Location and Adjust Fires

FO relays  
Targeting  
information



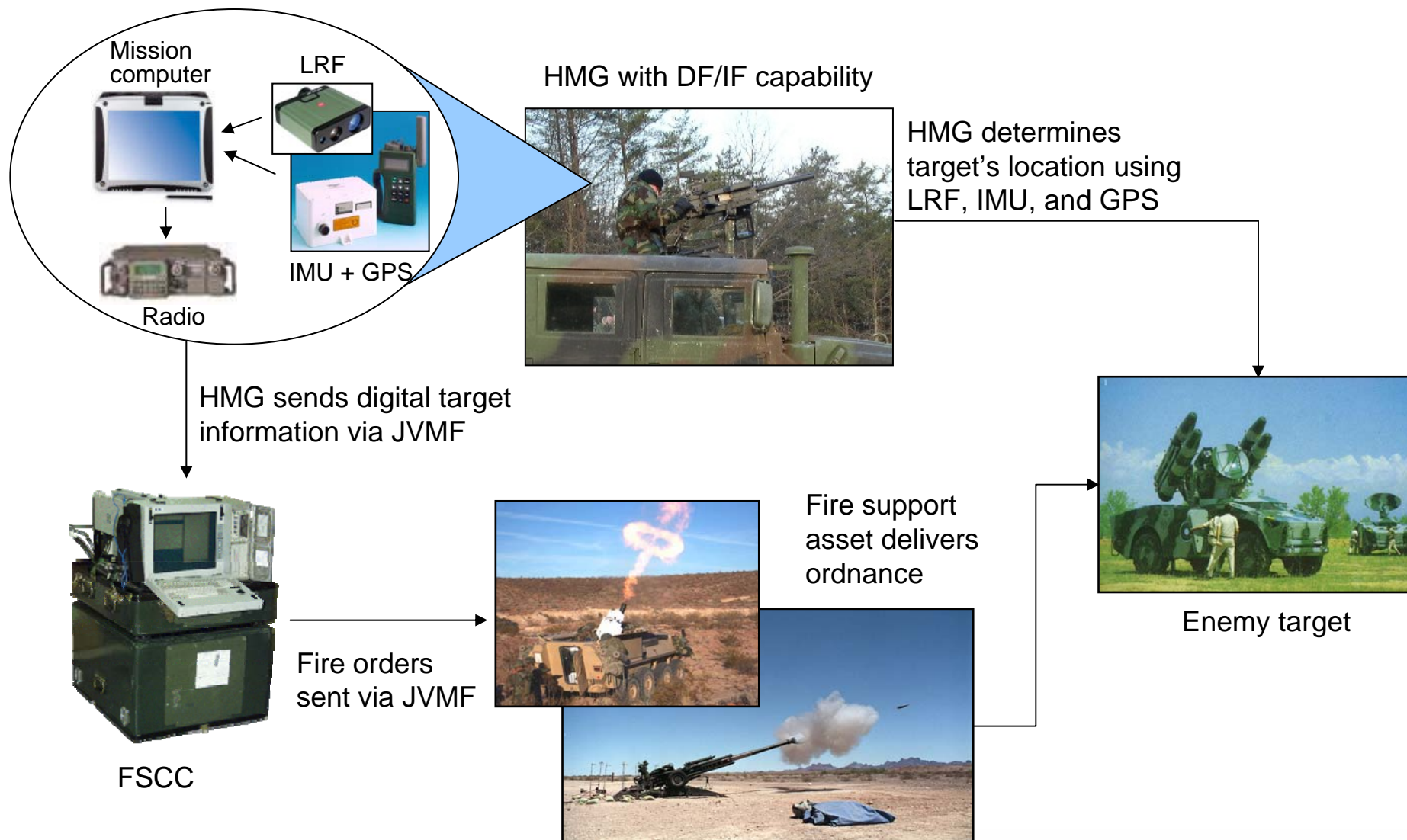
FSCC

Fire orders  
sent via JVMF

HMG with DF/IF capability

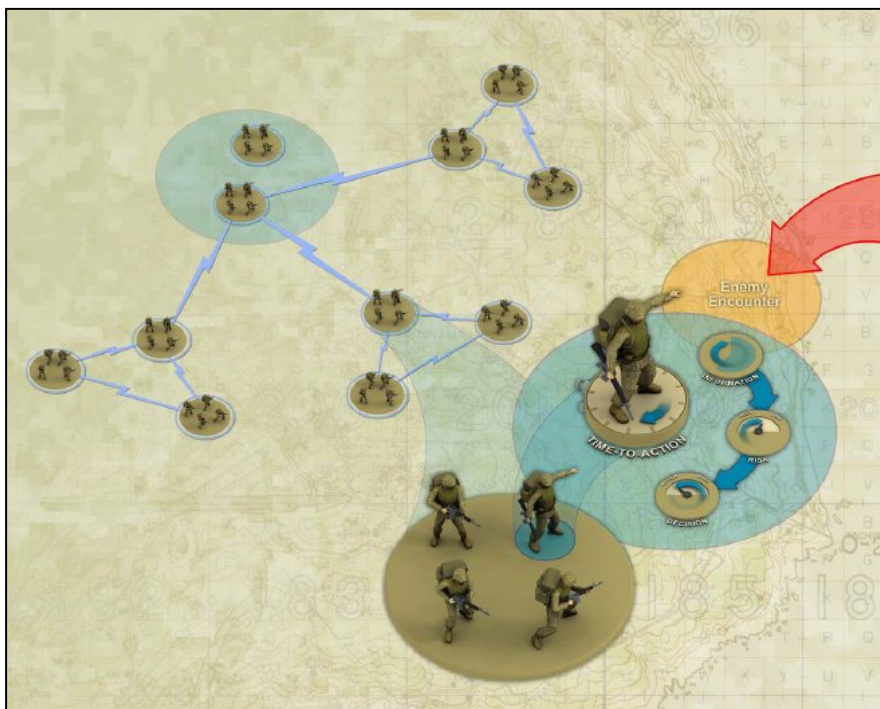


# Direct Fire / Sensor Employment





# Distributed Operations Enabler



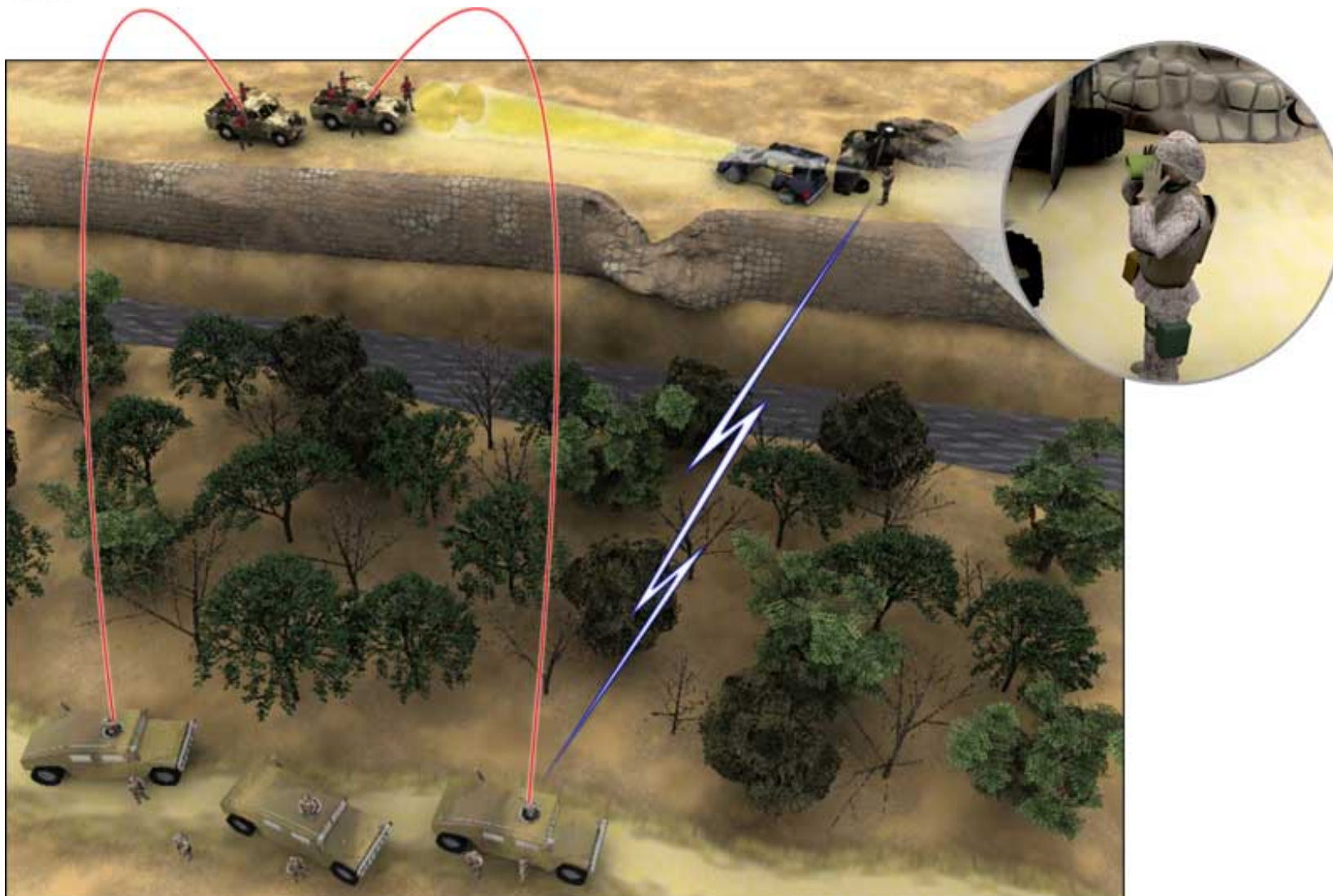
A Concept for Distributed Operations. 25 April 2005. Department of the Navy, HEADQUARTERS U.S. MARINE CORPS, Washington, DC.

- Provide the ability to distribute or re-aggregate depending on the threat.
- Provide the ability to quickly and accurately engage targets using a distributed processing architecture.
- Provide collaborative and coordinated engagement of targets.
- Provide teams that are multifunctional (sensor, shooter, and/or comms relay).
- Provide multiple teams a coordinated, interdependent approach to intelligence gathering, situational awareness, and target identification/location.





# Distributed Ops Application





# HMG Fire Control on CCM



Weapon  
Attitude  
Sensor

PLGR or  
integrated  
SAASM

Computing  
Platform



Optical  
Quadrant  
Deck

Gunner's  
Display

Common-Compatible Mount w/ std T&E





# HMG Fire Control on ACM

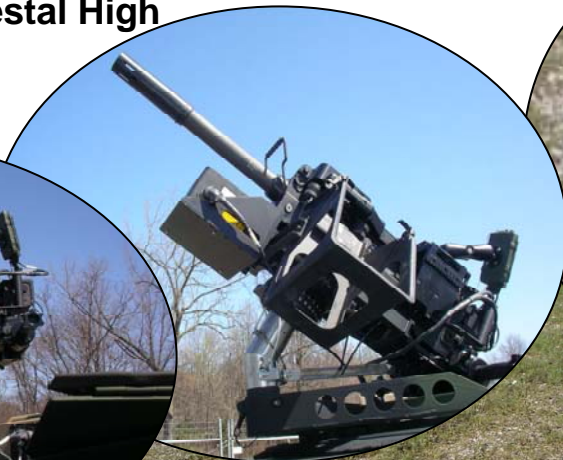


**Vehicle Mount**

**Dual Range  
Pedestal Low**



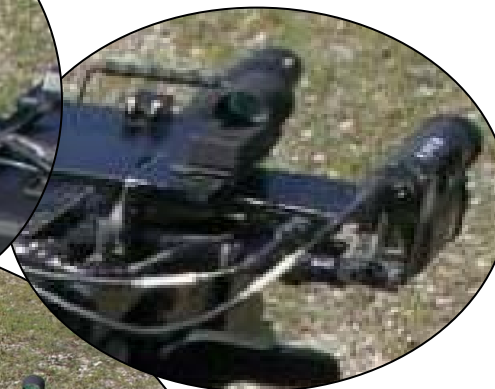
**Dual Range  
Pedestal High**



**Gunners Display**



**Optical  
Quadrant Deck**



**Team Leaders  
Display**



**Computing  
Platform**



Advanced Common Mount with  
Integrated T&E and Trigger Mechanism





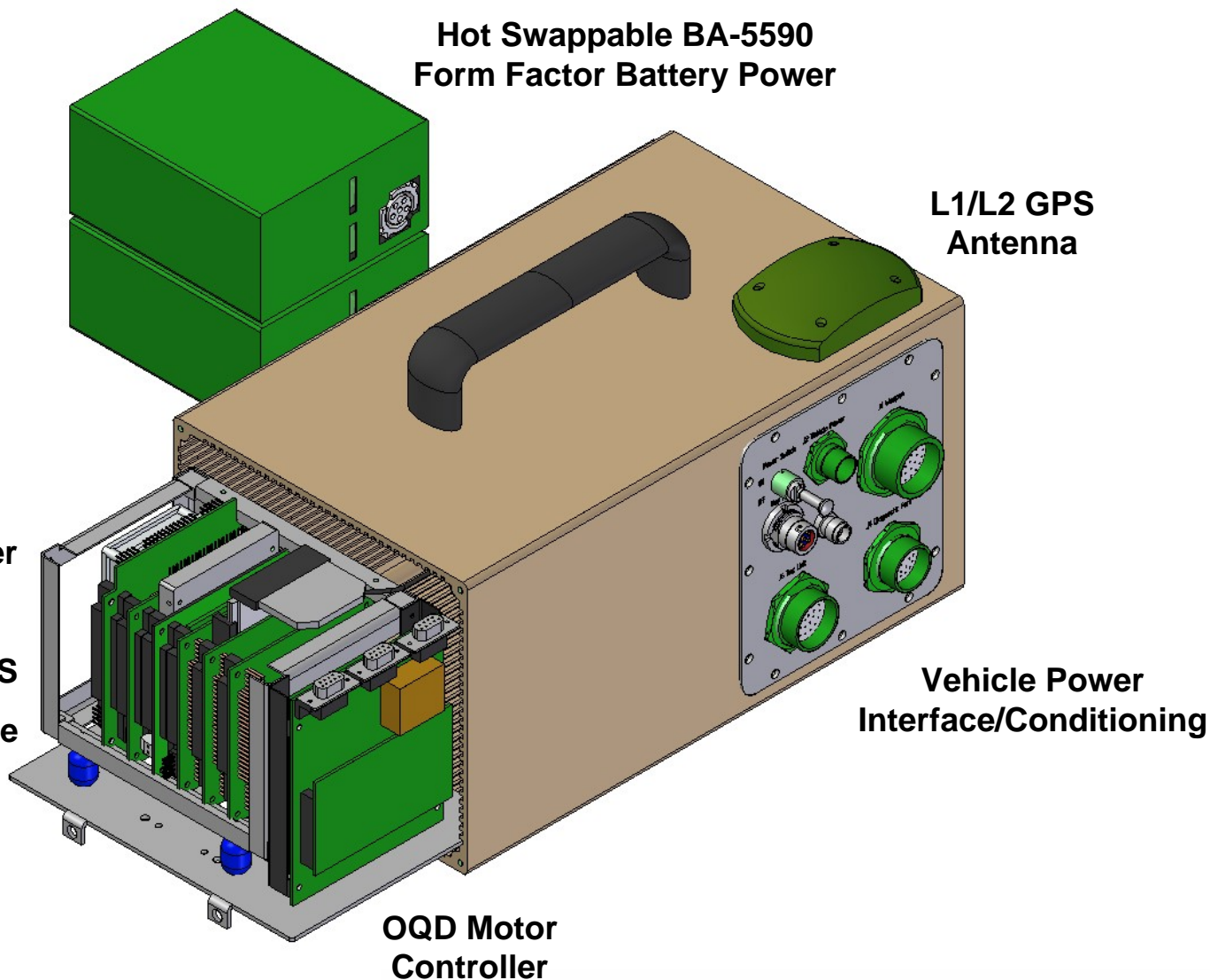


# Computing Platform

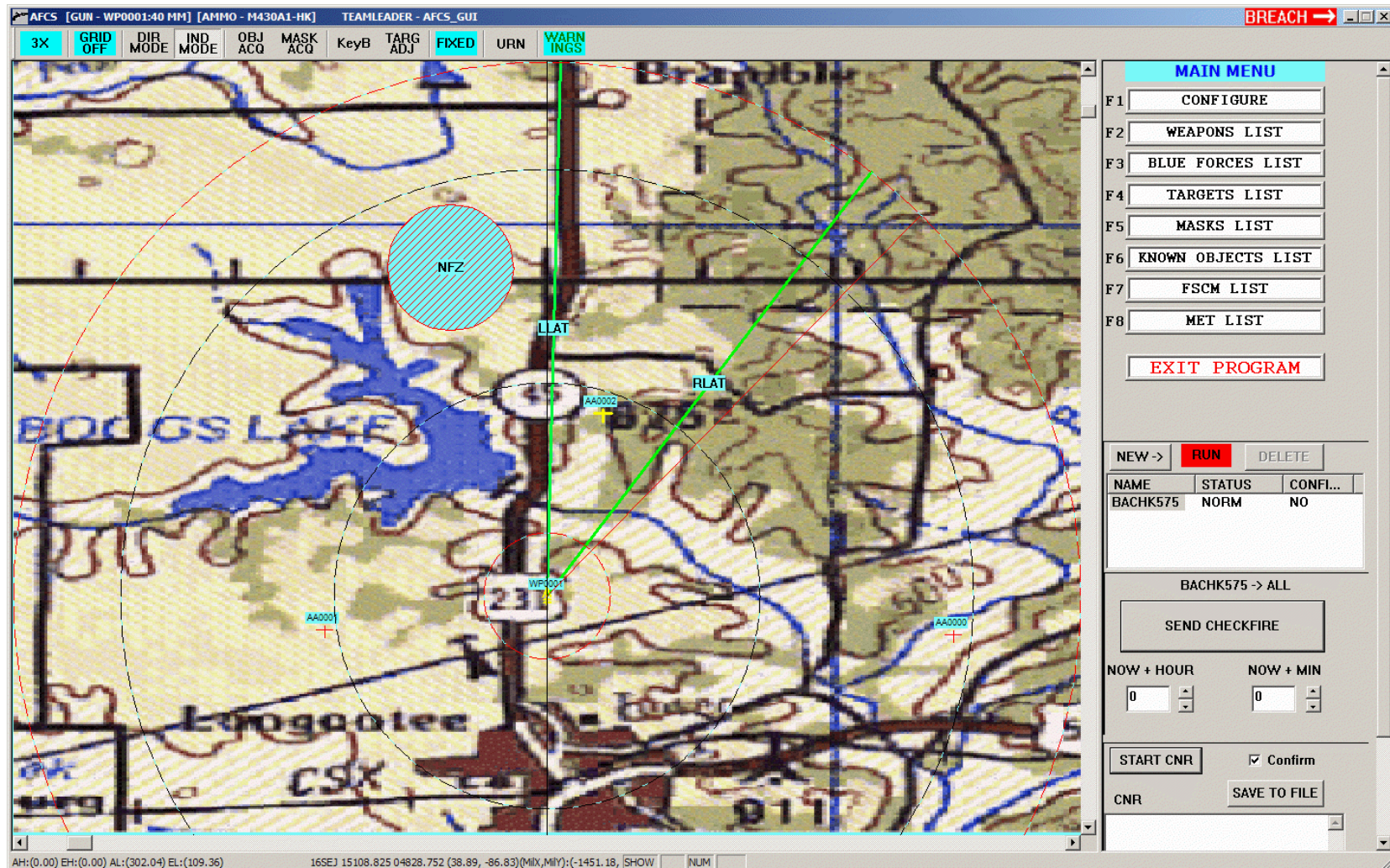


## Shock Mounted PC-104 Stack

- Single Board Computer
- Solid State Hard Drive
- SAASM Compliant GPS
- Tactical Radio Interface
- 8-port Serial Card

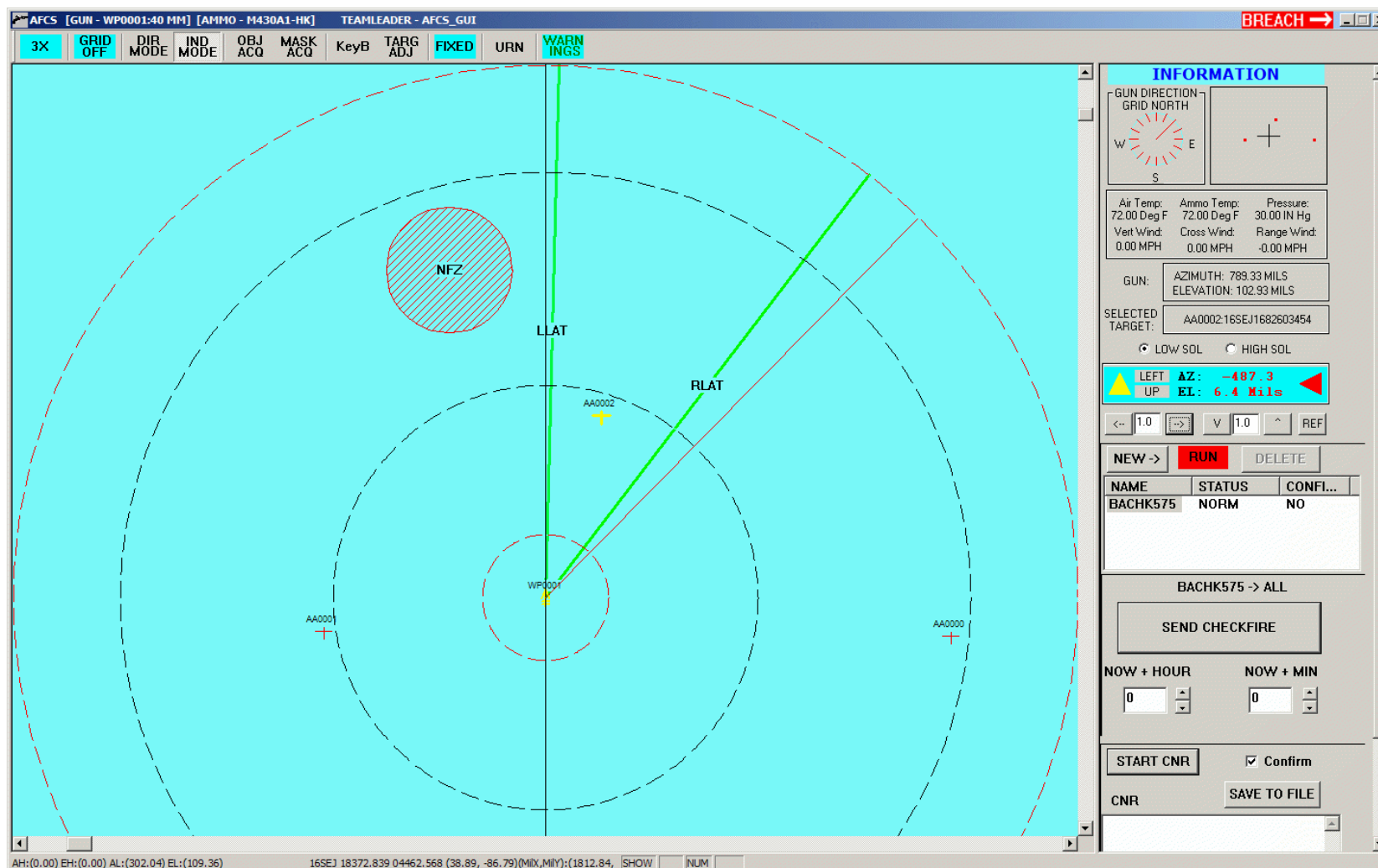








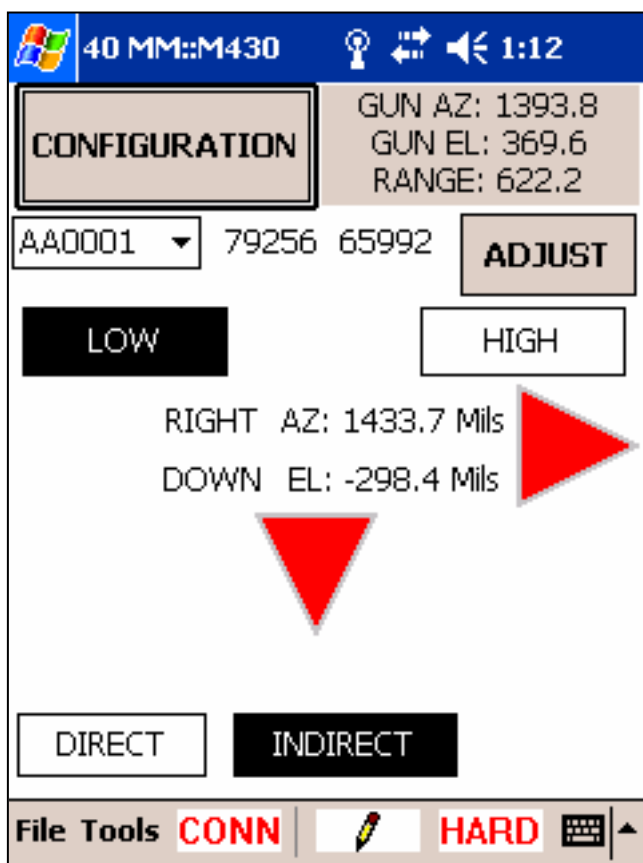
# Squad Leaders Display - Fixed







## Weapon Aiming Cues



40 MM::M430 1:12

**CONFIGURATION**

GUN AZ: 1393.8  
GUN EL: 369.6  
RANGE: 622.2

AA0001 79256 65992 **ADJUST**

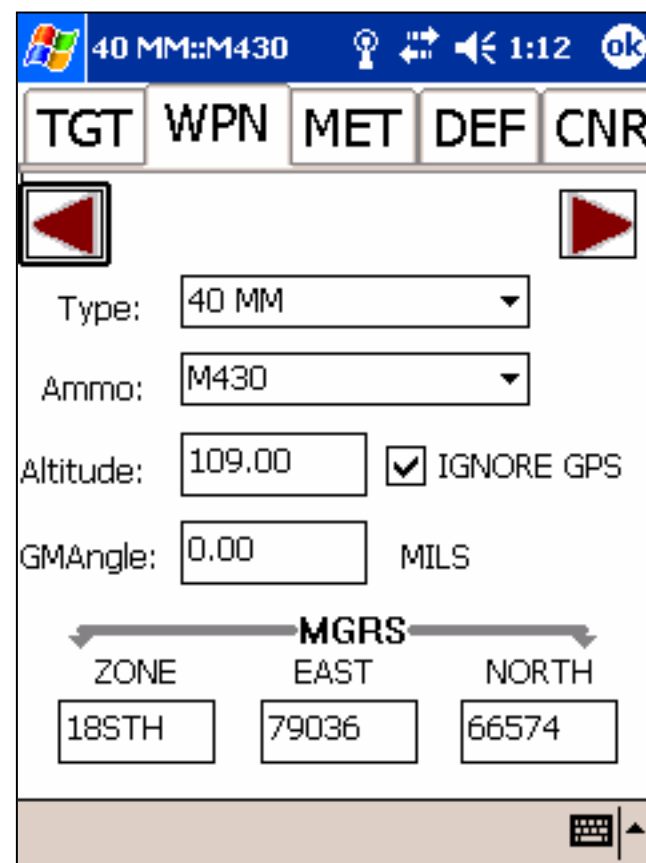
**LOW** **HIGH**

RIGHT AZ: 1433.7 Mils  
DOWN EL: -298.4 Mils

**DIRECT** **INDIRECT**

File Tools **CONN** **HARD**

## System Data Interface



40 MM::M430 1:12 ok

**TGT WPN MET DEF CNR**

Type: 40 MM  
Ammo: M430  
Altitude: 109.00 ☒ IGNORE GPS  
GMAngle: 0.00 MILS

**MGRS**

ZONE EAST NORTH  
18STH 79036 66574





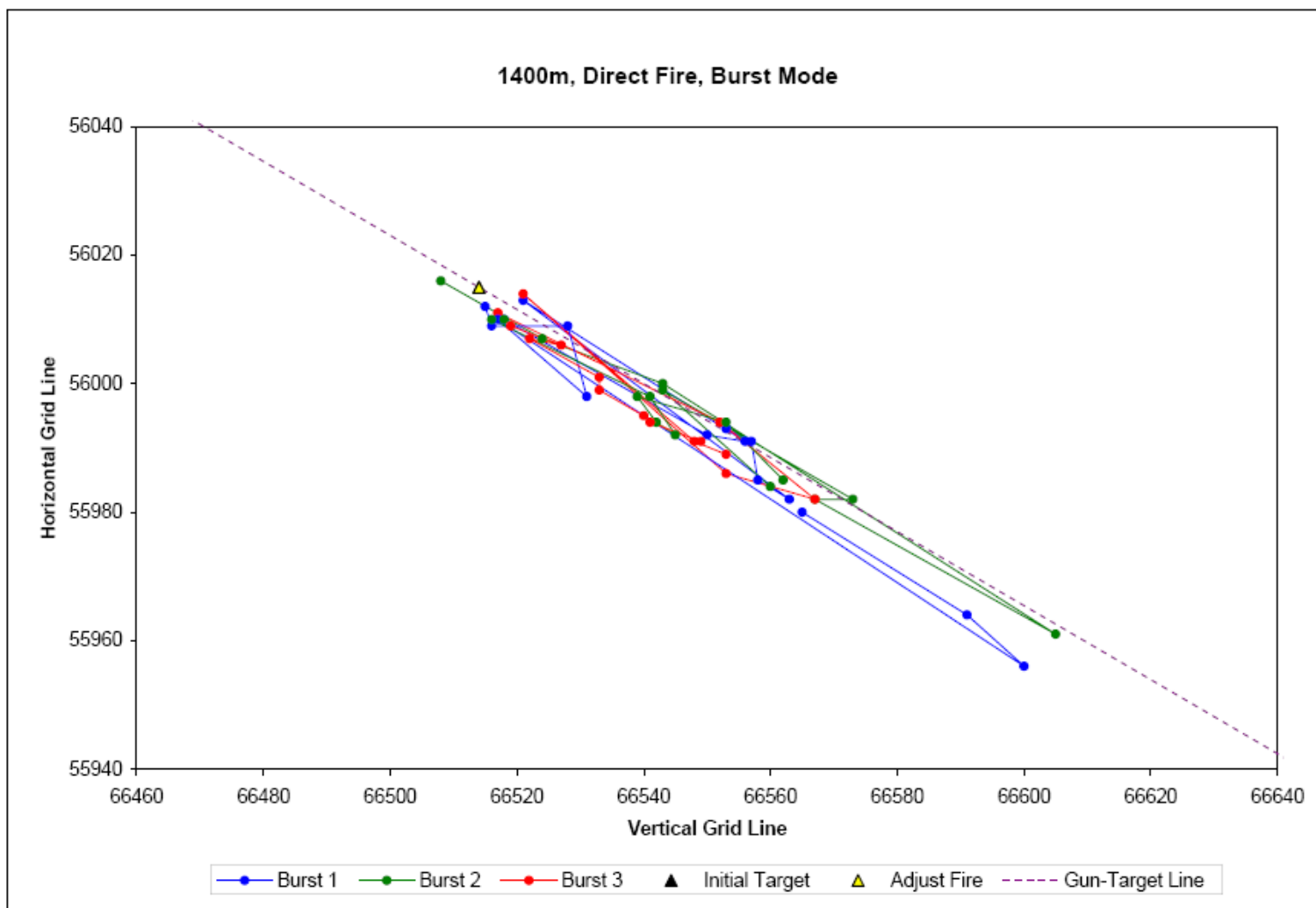
## Test conducted by MCPD Fallbrook at Hawthorne, NV in Sept 2006

– Test system performance against TTA exit criteria.

- 40mm HK GMG and M2HB .50cal
- Direct Fire and Indirect Fire engagements
- Low and High QE 40mm
- Average Radial Error for accuracy
- CEP for burst fire precision

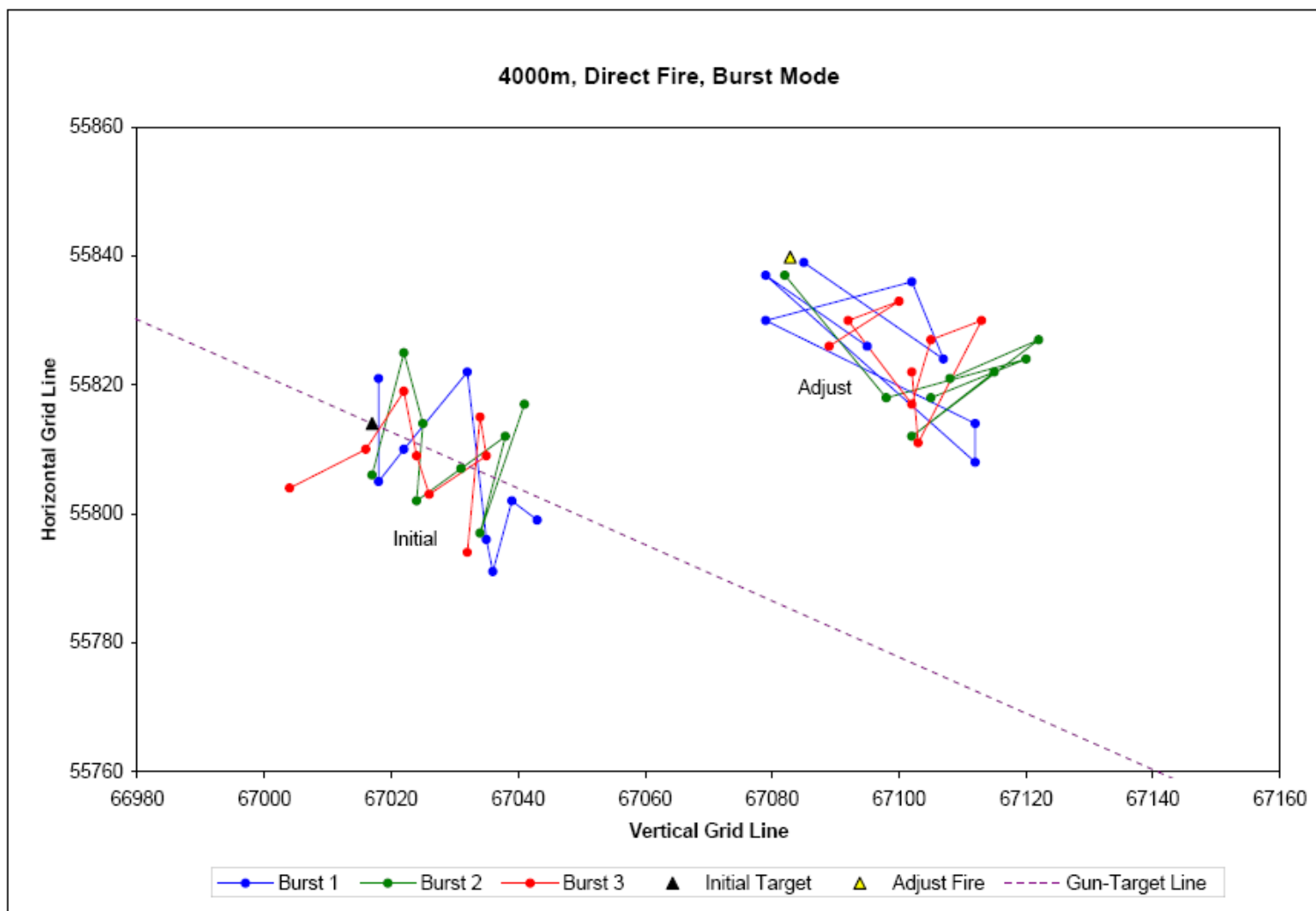


# .50 cal Direct Fire @ 1400m

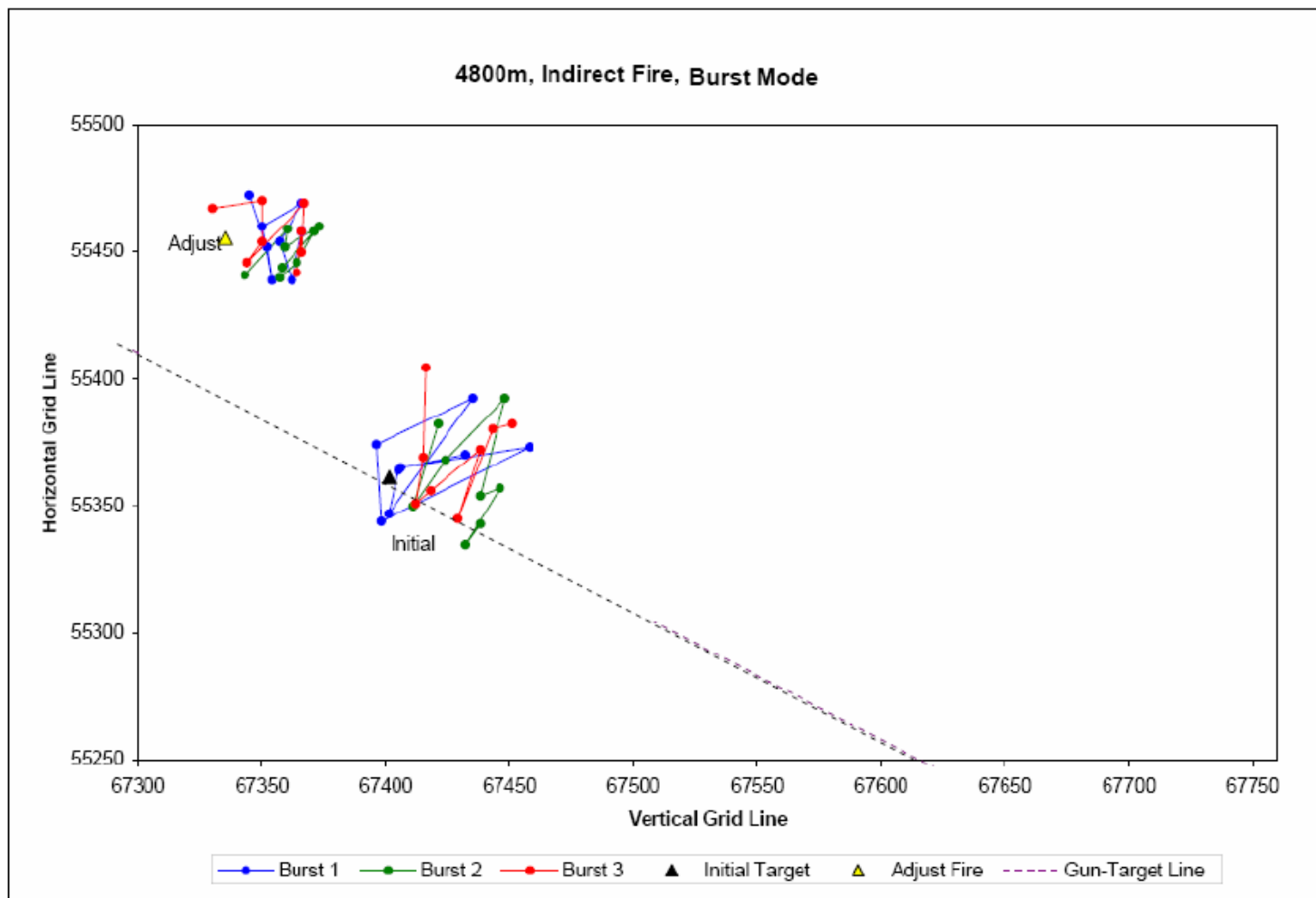




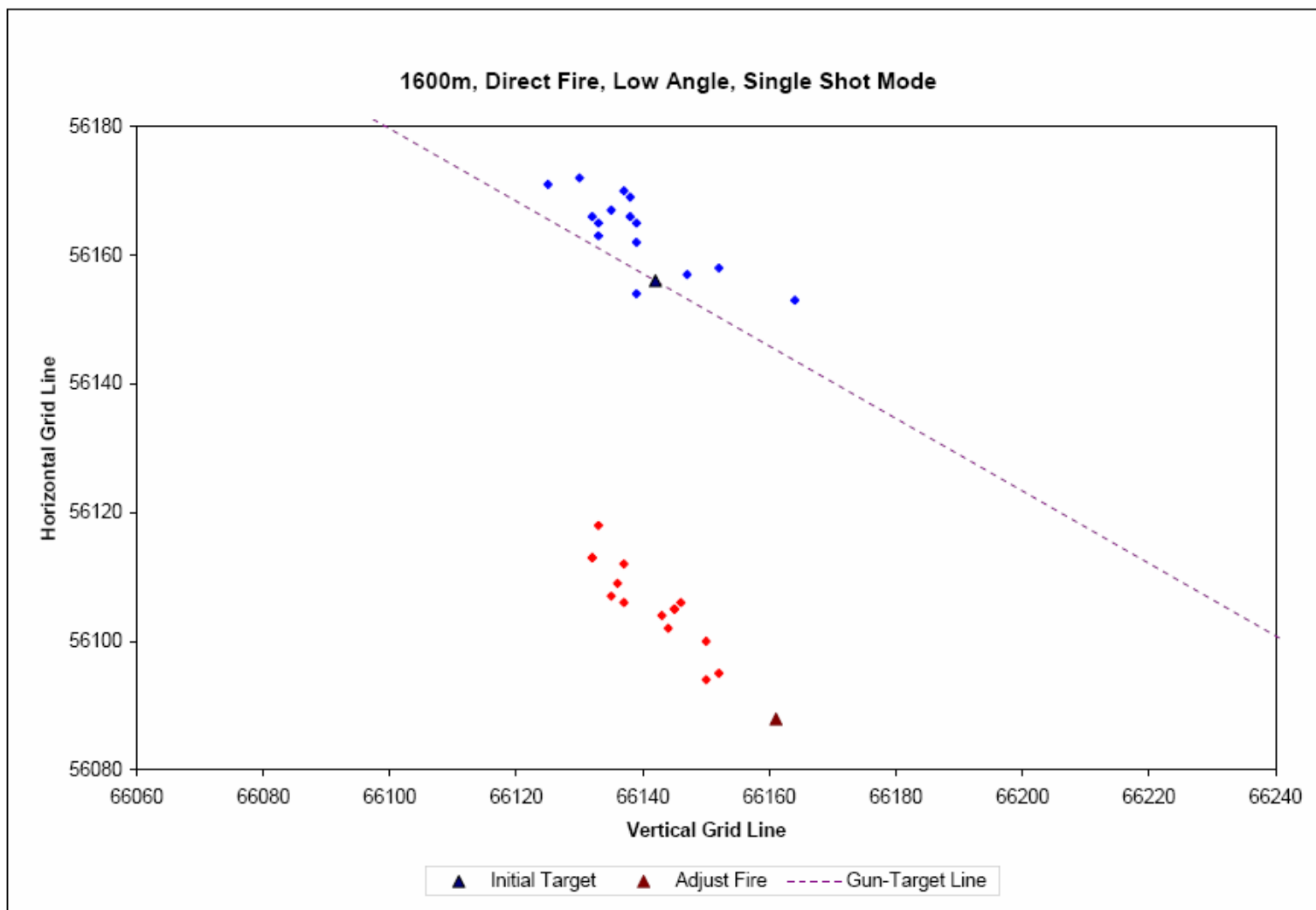
# .50 cal Direct Fire @ 4000m



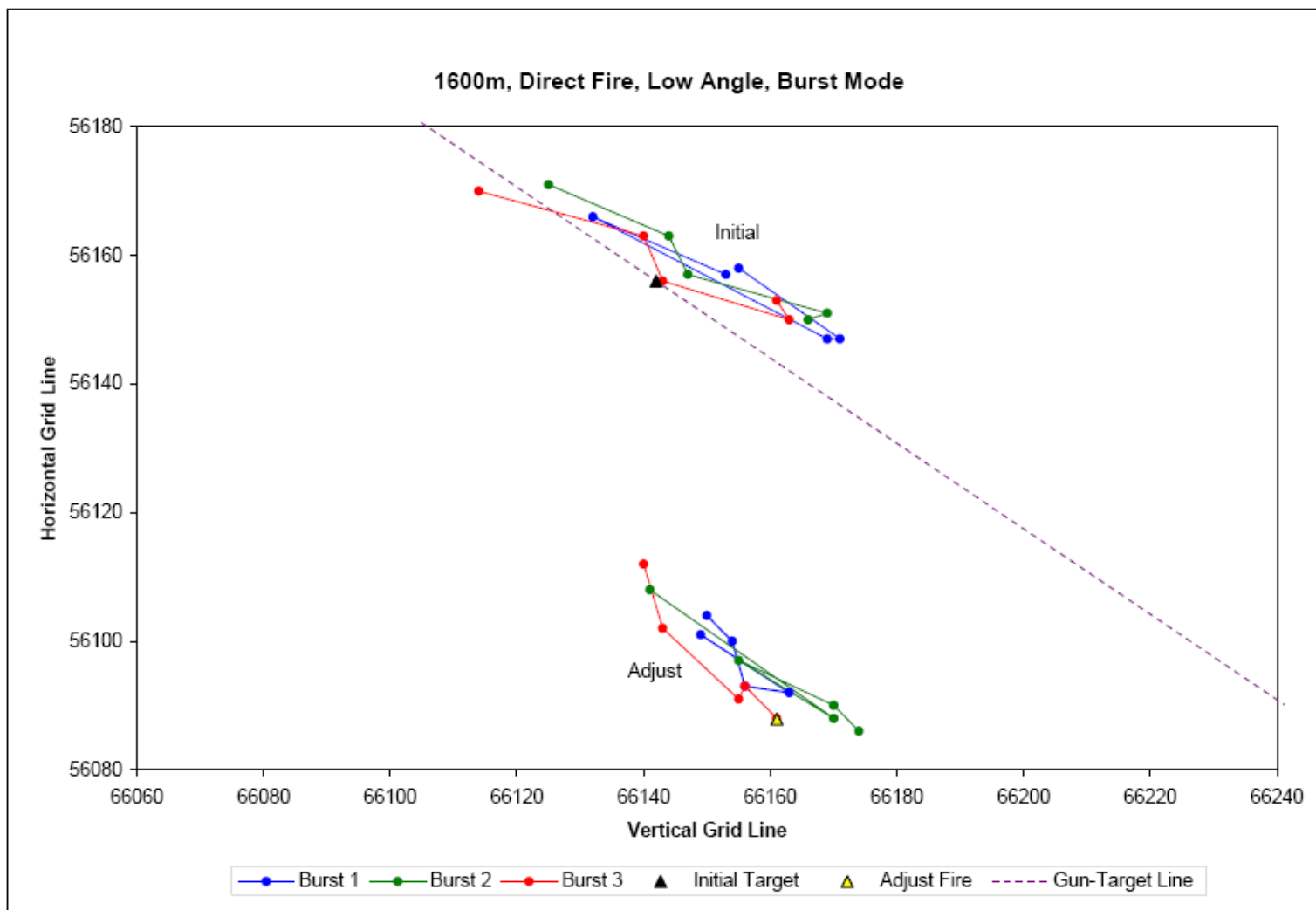
# .50 cal Indirect Fire @ 4800m



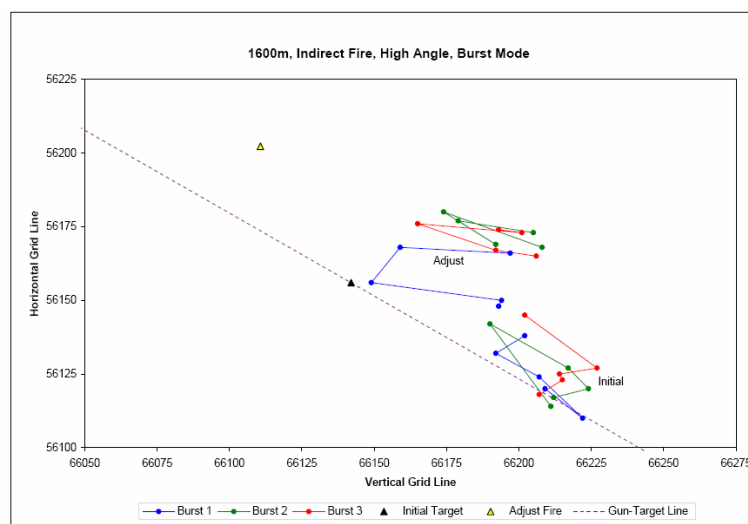
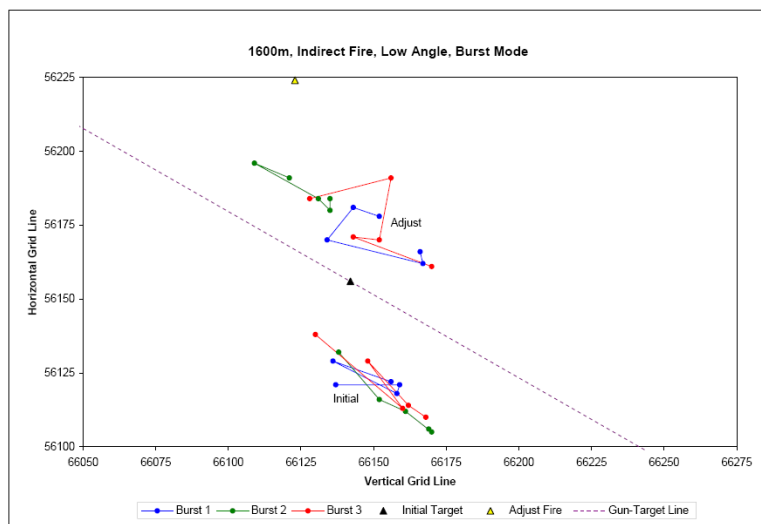
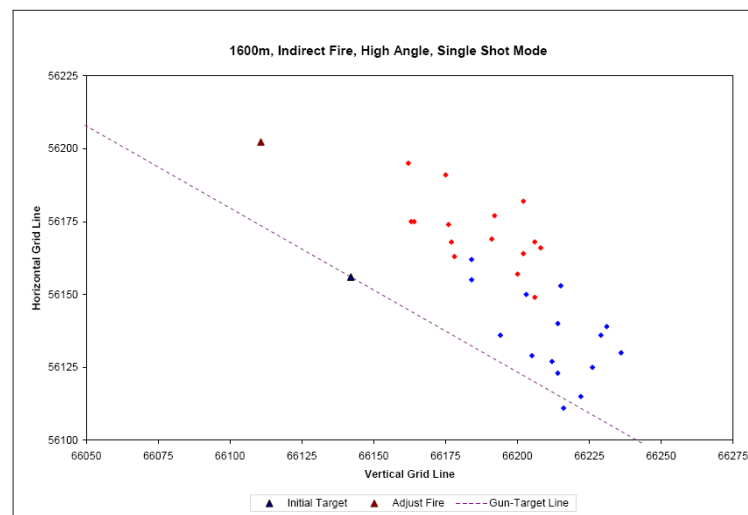
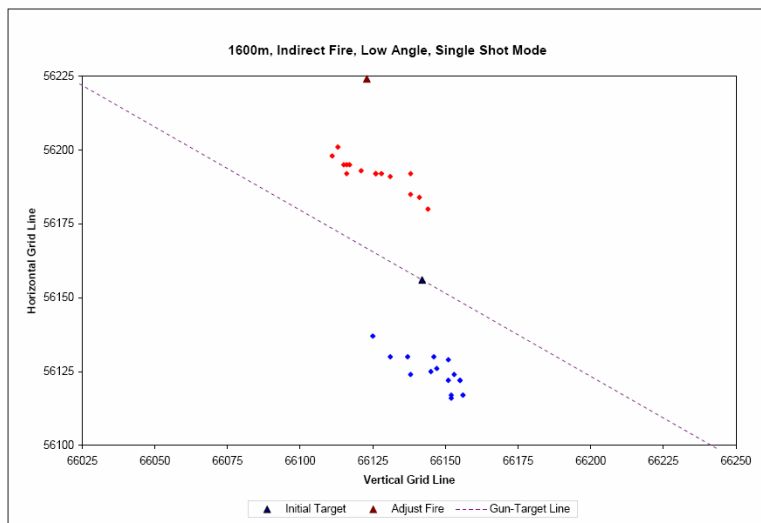
# 40mm Direct Fire @ 1600m



# 40mm Direct Fire @ 1600m



# 40mm Indirect Fire @ 1600m







# HMG TTA Exit Criteria



| Attribute/Parameter                           | Current                                     | Threshold   | Objective  |
|---|---|---|--|
| System Weight                                 | 150 lbs – foot mobile with 3 Marines        | Shall not increase number of personnel needed to transport weapon                                       | Shall not add more than 10 pounds total to weapon system                                 |
| Indirect Fire Engagement Time - ground        | Greater than 15 minutes                     | Less than 7 minutes   | Less than 2 minutes  |
| Indirect Fire Engagement Time - vehicle       | No Capability                               | Less than 7 minutes   | Less than 2 minutes  |
| 40mm Indirect Fire Accuracy - first shot      | Radial error greater than 200m              | Average <b>radial error &lt; 50m</b>  | Average radial error < 15m   |
| 40mm Indirect Fire Accuracy - first adjust    | Unknown                                     | Average <b>radial error &lt; 15m</b>  | Average radial error < 5m  |
| 40mm Fire Precision - automatic fire          | Unknown                                     | Achieve <b>CEP &lt; 50 m</b>  | Achieve CEP < 15 m   |
| .50 cal Indirect Fire Accuracy - first burst  | No Capability                               | Achieve <b>beaten zone impact within 100m</b> of target   | Achieve beaten zone impact within 50m of target  |
| .50 cal Indirect Fire Accuracy - first adjust | No Capability                               | Achieve <b>beaten zone impact within 50m</b> of target  | Achieve beaten zone impact on target   |
| .50 cal Direct Fire accuracy on first burst   | Unknown                                     | Achieve <b>beaten zone impact</b> on target at 75% of weapon's maximum effective range ( <b>1400m</b> ) | Achieve beaten zone impact on target at 110% of weapon's maximum effective range (2000m) |
| Integrated Fire Control                       | No automated fire control for indirect fire | Provide onboard fire control using HMG-unique BK  | Provide onboard fire control using integrated NABK                                       |
| Networked Fires Connectivity                  | Voice only.                                 | External connectivity to higher echelons via JVMEF encoded messages                                     | Same as threshold.   |





# Results Summary

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- **Achievable effects on target on initial engagement**
- **Consistent effects on target after first adjustment**
- **Low angle accuracy is better than High angle, but allows for less mask clearance**





# Potential Enhancements



- **Improved inertial sensor**
  - Smaller/lighter
  - Improved accuracy
  - Greater shock tolerance
- **Ammunition improvements**
  - More consistent muzzle velocity
  - Less variance from propellant temp
- **Wind compensation**
  - Improved collection of wind data
  - Better incorporation of wind data into BK





# Questions?



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