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ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER PICATINNY ARSENAL, NJ

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Paladin Secure Trajectory Enhancement (PaSTE)

2015 NDIA

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Agenda

- Framing the Issue
- M109 155MM SPH Indirect Fire Artillery System Background (evolution)
- Projectile Tracking System (PTS) Radar Detection and Tracking History
- PaSTE Concept
- Historical Example
- Potential Scenario
- Expected Limitations
- Future Growth Potential
- Conclusions

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Framing the Issue
Stating the Obvious

"Modern weapon systems have extremely long ranges. It is possible for a shooter to fire through friendly forces without realizing, or through enemy forces onto friendly forces. The main causes of this problem are: a lack of awareness of the location of friendly forces, often compounded by poor command and control (C2) systems; poor battlespace de-confliction procedures, in other words, unsafe planning relating to the positioning of units (this is a particular problem when trying to ensure that artillery does not fire through aircraft operating areas); and human factors issues, particularly stress and fatigue."

(Fratricide in Battle)

https://books.google.com/books?id=_3ycln4nauIC&pg=PA95&lpg=PA95&dq=deconfliction+of+artillery+fires&source=bl&ots=nXB_pl_9EB&sig=KlSV1Yf3ZIwiPi-vHQgmeXLEaM8&hl=en&sa=X&ei=WnsZVZDcG8XAggTps4TgDw&ved=0CDkQ6AEwBjgK#v=onepage&q=artillery&f=false

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Framing the Issue
Coordination and Control Measures

- Commanders tailor their use of control measures to conform to the higher commander's intent, their mission, and the amount of authority delegated to subordinates.

- The purpose of a Purple Kill Box (PKB) is to facilitate the attack of surface targets with subsurface/surface-to-surface, and air-to surface munitions. The PKB allows joint fires in the kill box to create synergistic effects with maximum potential for engaging targets. Surface-to-surface direct fires are not restricted by the establishment of a PKB.

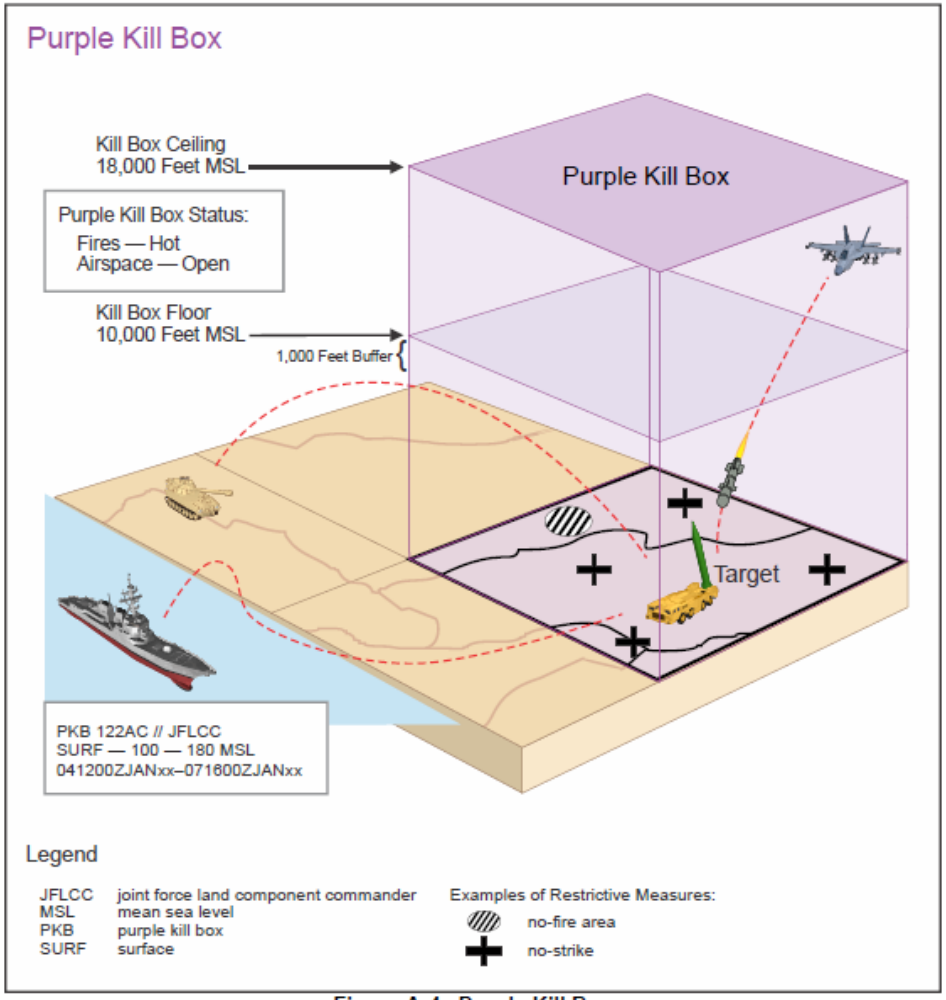

Figure A-4. Purple Kill Box

See FM 3-09, Field Artillery and Fire Support, *and Army Tactical Publication (ATP) 3-09.34/MCRP 3-25H/NTTP 3-09.2.1/AFTTP 3-2.59,* Multi-Service Tactics, Techniques, and Procedures for Kill Box Planning and Employment, *for further information.*

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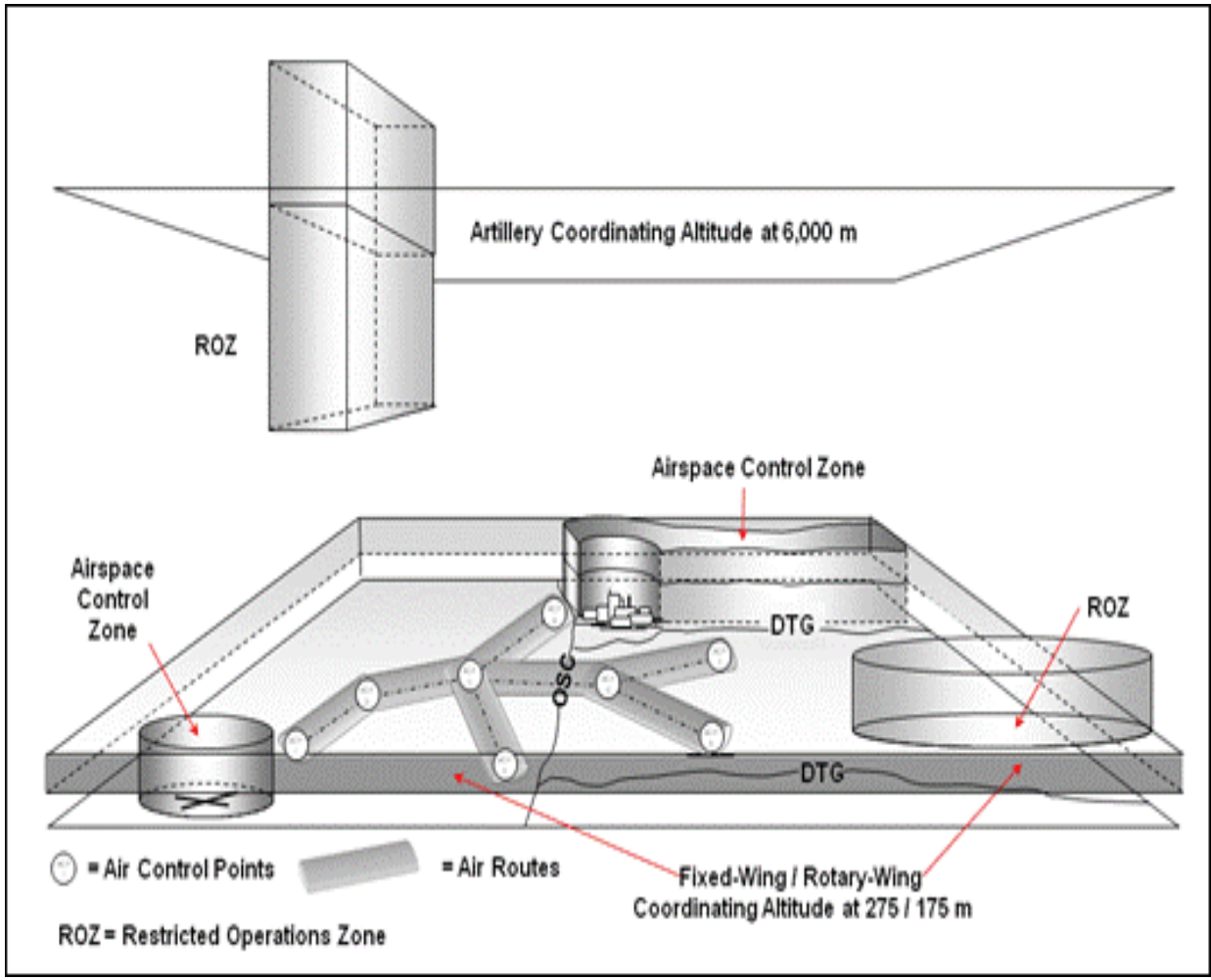
Framing the Issue
Procedural Control

- Procedural control relies on previously coordinated and disseminated order or procedures to control the operation and flow of air traffic.

-These procedures, coupled with OPFOR emphasis that combined arms forces must be generally familiar with each other's tactics and equipment, help alleviate problems that arise in coordination during combat.



Airspace procedural control measures (example)

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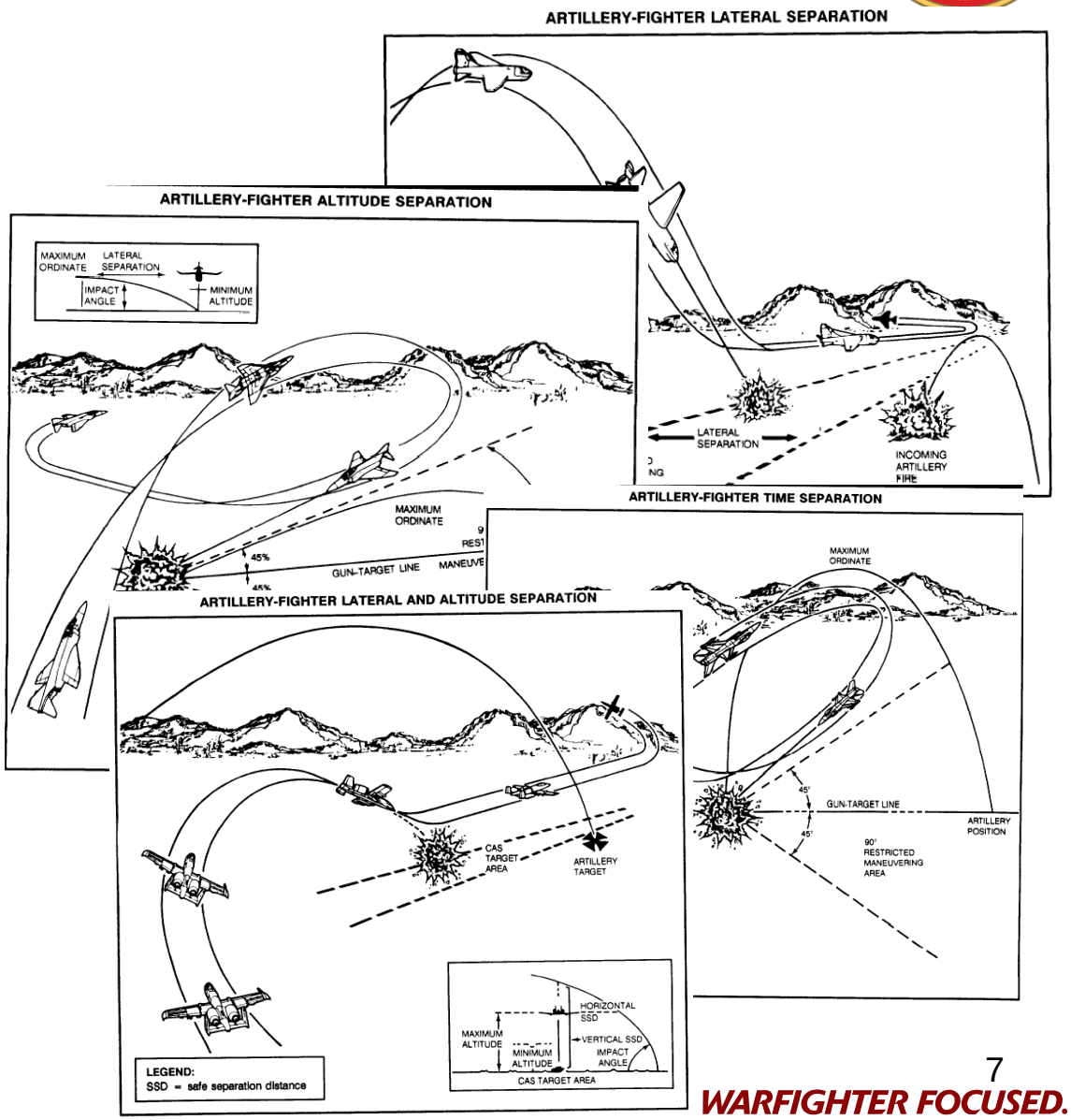
Framing the Issue
Fire Support Coordinating Measures

9-64 Fires pose a potential hazard to friendly maneuver forces and aircraft activities. (See chapter 10 for more information on air and artillery coordination measures.) To reduce potential conflicts between indirect fires and maneuver forces or aircraft, information pertaining to firing positions, targeted areas, and fire support plans is distributed to commanders and their staffs.

TC 7-100.2 Opposing Force Tactics, 9 Dec 2011 Training Circular No. 7-100.2



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Framing the Issue
AFATDS

"***AFATDS displays can deconflict planned fires from ACMs. If conflict is present between planned artillery trajectory and ACM, AFATDS is unable to determine if manned and unmanned 'airspace usage elements' are operating within ACMs. This necessitates communication between AFATDS and TAIS operators via email net. Work in progress to automate this process.***"

(Integration, Control and Deconfliction of Joint Fires Study, May 2003)

ACM – Airspace Coordination Measure
TAIS – Tactical Airspace Integration System
AFATDS - Advanced Field Artillery Tactical Data System

Integration, Control and Deconfliction of Joint Fires Study May 2003, NDIA
http://www.ndia.org/Divisions/Divisions/StrikeLandAttackAndAirDefense/Documents/Content/ContentGroups/Divisions1/Strike,_Land_Attack_and_Air_Defense/PDFs15/JFS_Vol1.pdf

Framing the Issue
Big Sky/Little Bullet

"The analysis shows that though the risk of conflict is small in the 'big sky – little bullet' condition, for large sorties some losses can be expected"

Conflict Analysis
Aircraft vs. Artillery Rounds

The industry team addressed the question of "how significant is the deconfliction problem" by performing a parametric study of the probability of conflict (Pcon) vs. acceptable miss distance (Dm) by having aircraft transiting an area into which artillery rounds are being fired. Since real-time call for fire missions poses a risk of conflict with manned aircraft in the target area, the primary parameter to assess was Pcon under a series of different Dm values between 50 m and 500 m. A monte-carlo computer simulation was developed by the team to quantitatively address this problem.

The study assumed a high density condition of a full artillery barrage. The worst case scenario showed Pcon less than 0.008 per 4 aircraft strike package at Dm less than 50 m. A typical Pcon was less than 10^{-5}. The analysis shows that though the risk of conflict is small in the "big sky -- little bullet" condition, for large sorties some losses can be expected.

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Framing the Issue
Big Sky/Little Bullet

"Conflict exists less than 1% per sortie at 50 m or less miss distance; thus worst case for 100 sorties is 1 conflict"

"Chance for conflict still a risk though probability low"

http://www.ndia.org/Divisions/Divisions/StrikeLandAttackAndAirDefense/Documents/Content/ContentGroups/Divisions1/Strike,_Land_Attack_and_Air_Defense/PDFs15/concept_of_ops.pdf

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Conflict Analysis
Aircraft vs. Artillery Rounds

- Joint Fires Study conducted quantitative analysis to test thesis of "big sky -- little bullet"
- Approach
  - Assess probability of conflict vs. acceptable miss distance between transiting aircraft and maximum density tube artillery barrage
  - Use monte-carlo runs
  - Treat artillery target locations and aircraft headings as random
  - Assume [redacted]-m lethal radius for 155-mm artillery round
- Parameters
  - 432 artillery rounds/min in target area ([redacted] 155-mm tubes @[redacted] rds/min max sustained fire rate)
  - Barrage over 40-km wide by 15-km deep area
  - One 4-aircraft strike package enters target area at 600 kts every 3 minutes
  - Time frame: 15-minute barrage
- Results
  - Conflict exists less than 1% per sortie at [redacted] m or less miss distance; thus worst case for 100 sorties is 1 conflict
  - Chance for conflict still a risk though probability low

10

Framing the Issue
In Summary

"The management of airspace continues to be one of the U.S. military's most daunting tasks. Clearing Fires above the coordinating altitude (CA) and integrating a high volume of artillery fire within close proximity to aircraft is a significant challenge for airspace managers during combined arms maneuver (CAM) operations."

(Fires 3/1/2013, "Fires Integration and Airspace Management")

http://www.readperiodicals.com/201303/2961670421.html#ixzz3Vt55Du9p

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Historical Example
Blackhawk into Hot LZ

- Blackhawk was approaching for a landing
- TOC informed the Blackhawk pilot that the LZ was hot and to wait until green
- Pilot approached LZ while still hot
- After wave off pilot turned into artillery line of fire

https://www.youtube.com/watch?v=A6Zj2wdX0tc

"The TOC told that pilot the LZ was hot and to circle the river to our south and wait until the LZ was green. Pilot showed up to throw complaints, but was told she had better get back on that bird and leave. Situational awareness!!"

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M109 155mm Indirect Fire Artillery System Evolution

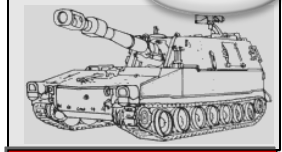
M109

1963

Initial Capability

M109A1

1973



Improved Lethality

M109A2 / A3

1978

Improved Maintainability
Safety

M109A4 / A5

1992

Improved Survivability
Lethality

Currently Fielded

M109A6 Paladin

1993 2004

Digital Architecture

M109A7

FUE: 2017

Crusader

1995-2002

NLOS-C

2003-2009

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PTS Detection and Tracking History

- Projectile Tracking System (PTS)
- Developed for Crusader/NLOS-C to improve accuracy
- Also utilized by other programs to provide target tracking of UAV's, aircraft, munitions, etc
- Very good at tracking, not as great at detection
- Can also be used to provide limited target identification (such as from rotor speed)

- Already a planned part of ARMY and Naval programs
- Utilized at Black Dart and as part of the Army's EAPS program

PaSTE Concept

- Paladin Secure Trajectory Enhancement (PaSTE)
- Software only modification to allow near future howitzers to identify trajectory obstruction before firing
- Utilize onboard PTS radars to detect airborne friendly forces
- Modify software to alert crew to potential intercept
- Engagement profile out to ~30 km, ~120 sec TOF
- Low cost, low risk supplement to current methods, not a replacement

Potential Scenario
Helicopter Hover Fire

- **10-188. *Hover Fire.* The OPFOR employs hover fire in the attack if the capabilities of the aircraft allow. APs are chosen so that surrounding terrain provides cover and concealment for attack helicopters. They should also afford good, unrestricted fields of fire as the OPFOR attempts to engage the enemy at the maximum effective range of its weapons. These APs are near the ground forces, within the range of friendly air defense assets, and within range of friendly artillery.**

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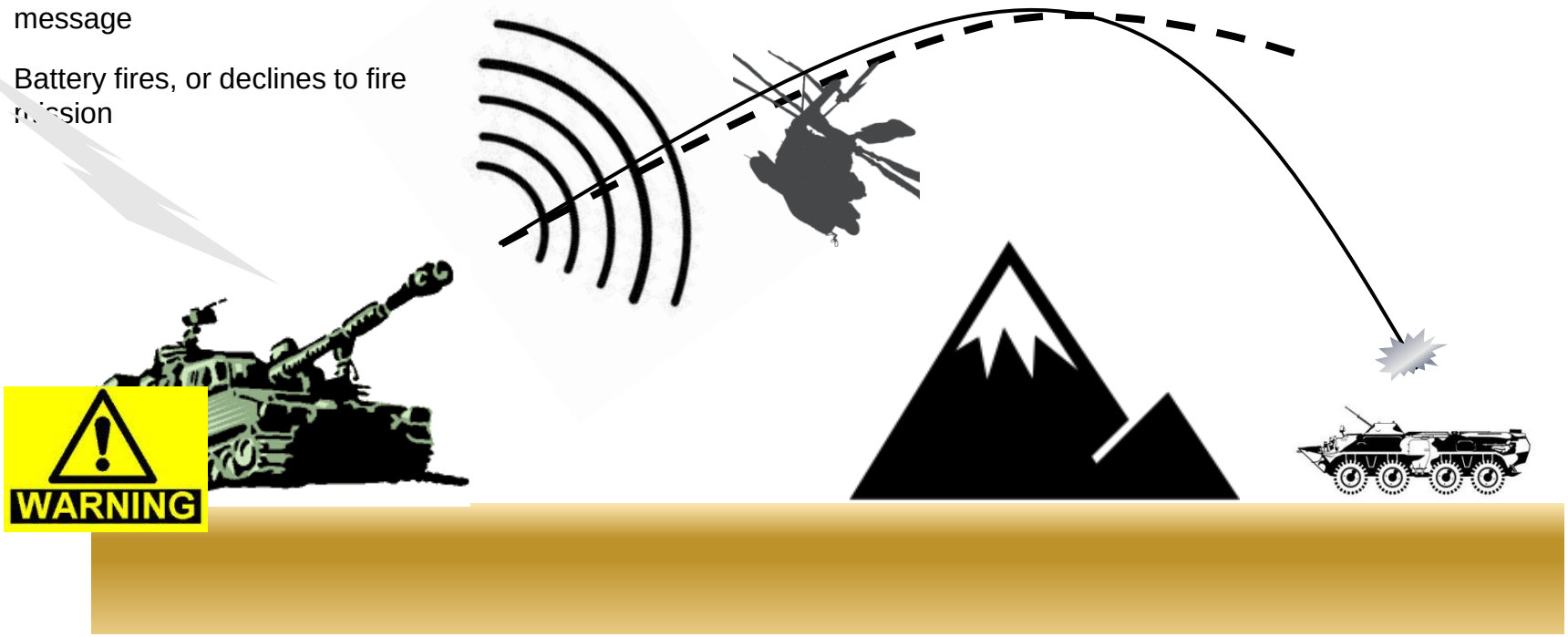
Potential Scenarios
Helicopter Hover Fire

- Target is identified at 15 km
- Fire Mission is sent from AFATDS to Artillery platform
- Artillery platform calculates solution
- Friendly helicopter engages same or close vicinity target
- Artillery radar identifies something near the solution trajectory
- Artillery platform commander's display presents a WARNING message
- Battery fires, or declines to fire mission

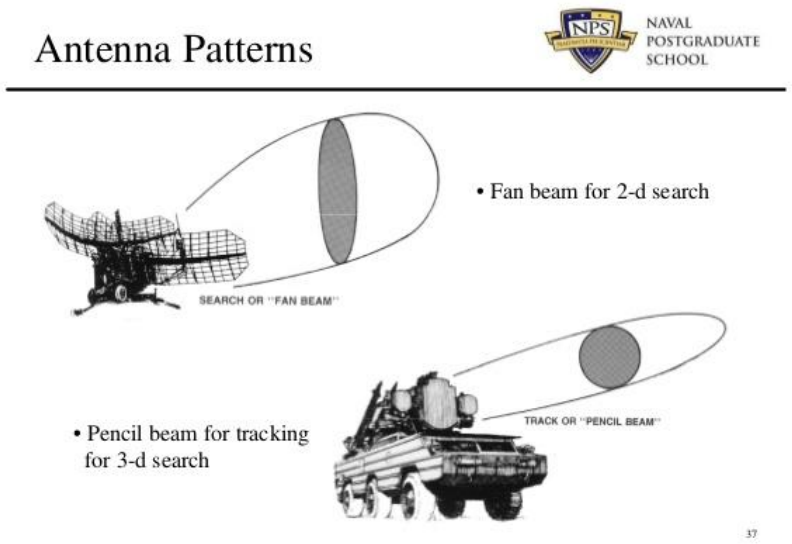


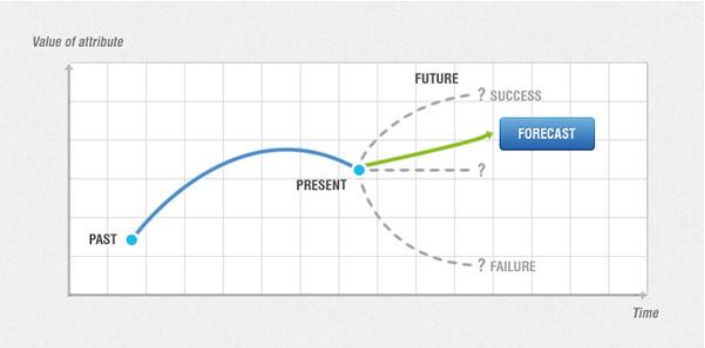
Expected Limitations

- Due to PTS scan envelope, only slow movers very close to or within the trajectory of fire would be detected
- Expected friendly involvement: Helicopters, UAS's
- Limited effectiveness against missiles, jets, etc.
- PTS is better at tracking than detecting, actual effectiveness in this role still under investigation

Future Growth Potential

- **Initial concept would be a software only change utilizing already planned hardware**
- **Utilize wider scan radar system to allow for more extensive detection (but also increase visibility to enemy systems)**
- **Implement flight path prediction algorithms to better identify and avoid potential intercept**





Conclusions

- The management of airspace remains a complex and challenging problem
- The potential exists for ground to air friendly fire when simultaneously utilizing artillery and air assets
- Software modifications to near future artillery systems can serve as an inexpensive supplement to existing friendly fire avoidance systems
- Further discussion with users and stakeholders to better balance “big sky, little bullet” and the proposed solution is required

Questions

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