US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

Malcolm Baldrige National Quality Award 2007 Award Recipient

ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER PICATINNY ARSENAL, NJ

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

‘Active Stabilization’ of Firearms by Optical Target Tracking

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2016 Armament Systems Forum

Active Stabilization of Firearms by Optical Target Tracking

- Agenda
  - Project Background
  - Why Active Stabilization?
  - What is Active Stabilization?
  - Development Path
  - Project Development
    - Phase I
    - Phase II
    - Phase III
  - Summary
  - Final Thoughts

'AimLock' – Project Background

Schedule & Cost

	FY12	FY13	FY14	FY15
Solicitation of Concepts				
Contract Awards (5)				
Concept & Application Studies Formulated	2			
Design of Experiment				
Component Analysis/M&S Simulation Validation		3		
Component Proof-of-Concept Critical Function			3	
Component/Breadboard Validation in Lab Environment				4
Total 602623/H21 ($M)	**2.00**	**2.00**	**1.63**	**2.00**
ARL	**0.35**	**0.28**	**0.37**	**0.00**
TOTAL	**2.35**	**2.28**	**2.00**	**2.00**

$8.0M Total Program

Purpose:

- Identify and advance technologies leading to the ability to improve Small Unit Level effectiveness.
- Utilize new small arms technological concepts to improve range overmatch capability against like-sized threat elements.

Capability:

- Increase Probability of Hit (P_{Hit}) for rifles from 0-600m

Technology:

- Active Stabilization

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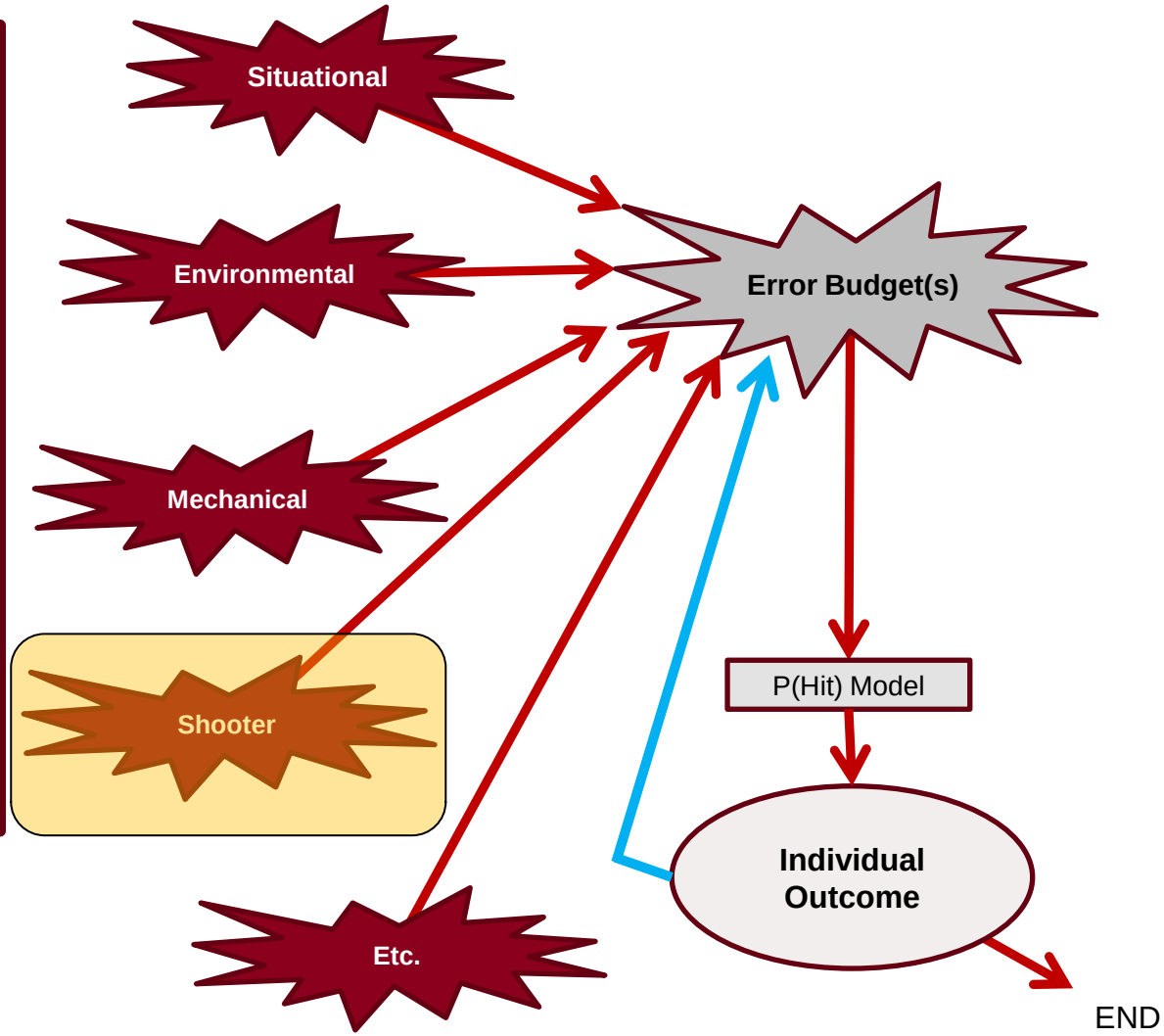
Why Active Stabilization?

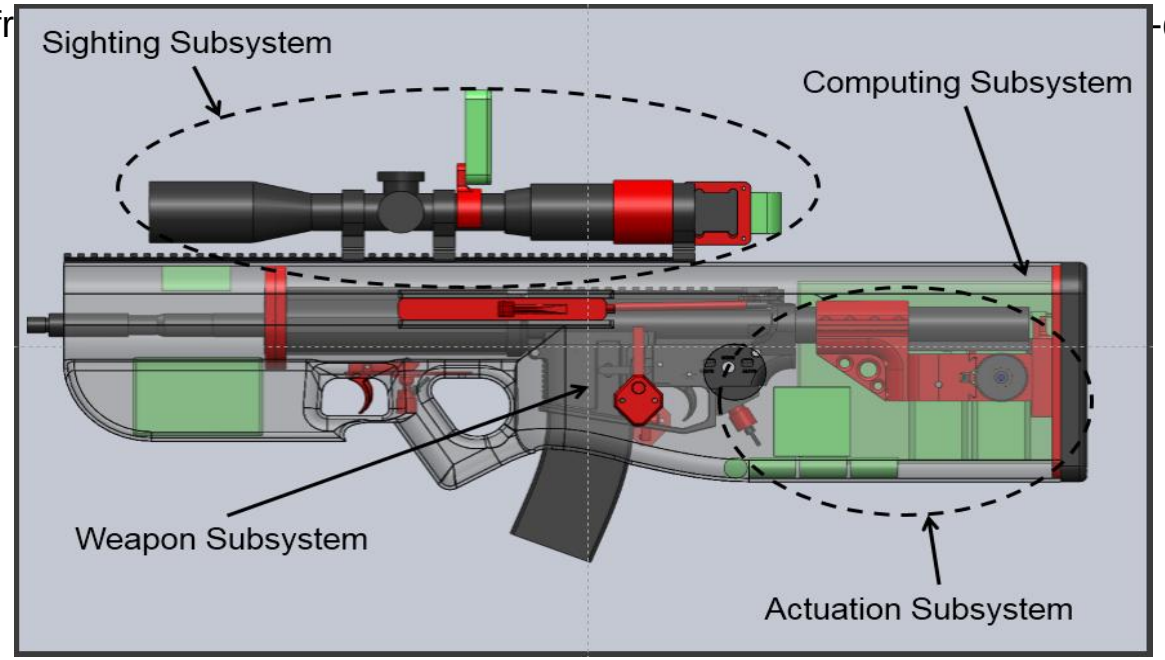
P(Hit)

- Mathematical function which conveys the likelihood of an impact within a designated area under specified conditions
- Dependent upon a number of other considerations and assumptions. These are conveyed via an **error budget**. This budget identifies and quantifies the impact of various **situational, environmental, mechanical, and psychological factors** that ultimately determine and ground the P(Hit) function with the specified firing event.



What is Active Stabilization?

- **What is Active Stabilization**
  - **Barrel and receiver are articulated independently from the shooter-interface components of the system**
    - Grips, stocks, and optics, each of which are mounted to a “carriage” that envelops the moving parts of the weapon system.
    - Separation of the projectile-launching components of the weapon system from the user-interface components is controlled via target tracking software and embedded mobile processing hardware that optically monitor target position relative to point of aim.
    - Electromechanical actuators are activated to rapidly redirect the LOS of the barrel and receiver, separately fr -direction relative to the target.



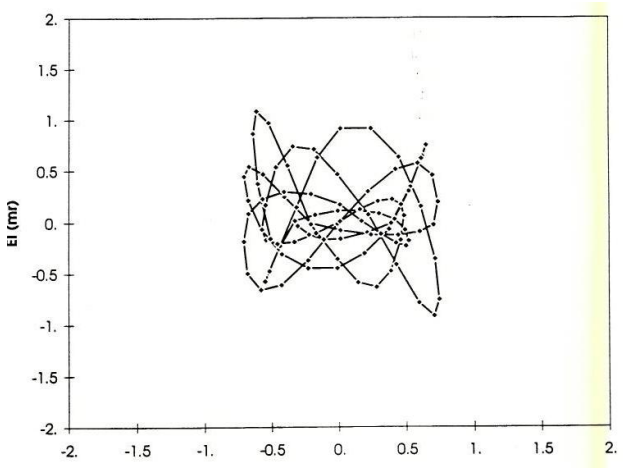
Development Path

Requirement:

- Development of a technology to mitigate the 1.5 Hz “Shooter Wobble” associated with the firing of a weapon from an un-supported position.

Goal:

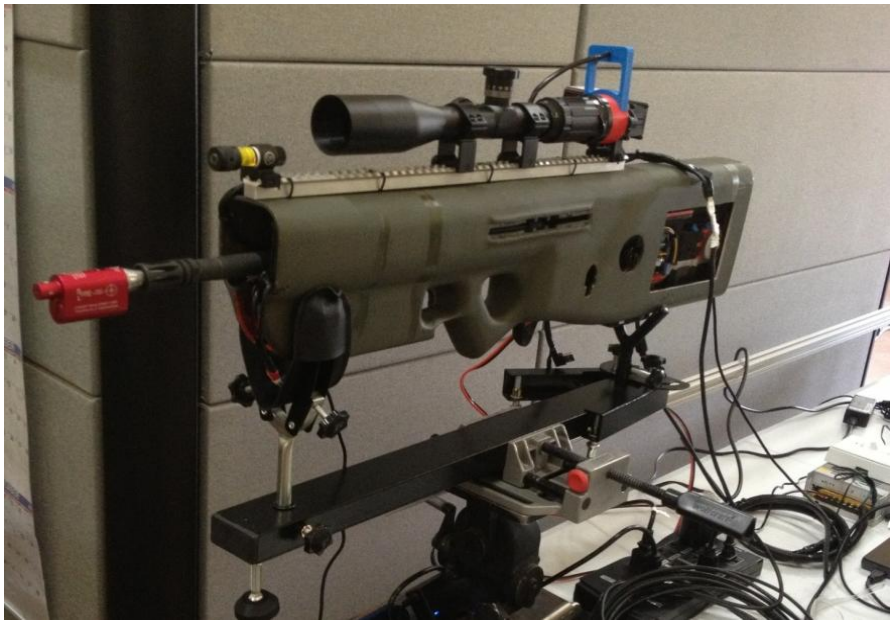
- Reduce unsupported dispersion of small arms fire attributed to shooter wobble in order to increase Probability of hit (P_{hit})
  - Threshold: Reduce baseline dispersion by 10%
  - Objective: Reduce baselines dispersion by 25%



Active Stabilization – Phase I

Phase I

- Static Detection
- Integrate optical target detection and tracking
- Integrate active electro-mechanical stabilization
- Demonstrated TRL 3 Proof of Concept on an M4 type weapon platform



Active Stabilization – Phase II

Phase II

- Conduct Live Fire Test
- Trade-Study
  - –Optics, Computing, Actuators
- Live Fire Test Results
  - **–Improved (P_{hit}) for both skilled and unskilled shooters with decreased engagement time in both stationary and moving targets**

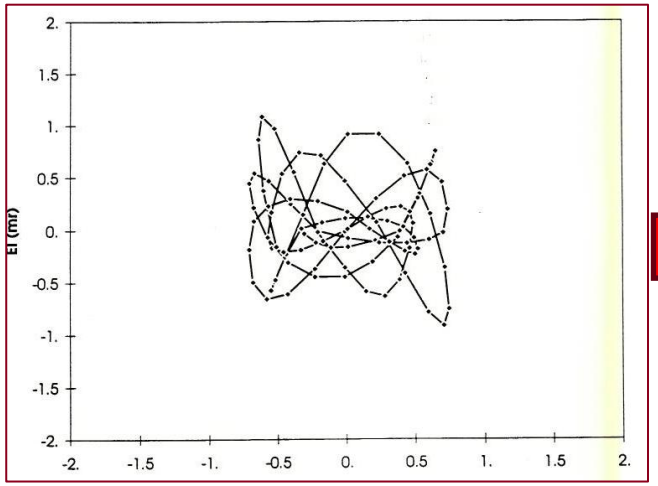
Test Stats						
Iteration	Shooter	Position	Stabilization	Target	Firing Sequence	Environmental
1	Skilled	Standing	Off	Stationary	8 groups/10 shots	Temp: 72-76° F Winds: 2.5-12 mph
2	Unskilled	Standing	Off	Stationary	8 groups/10 shots	Temp: 78° F Winds: 4-11 mph
3	Skilled	Standing	On	Stationary	8 groups/10 shots	Temp: 77° F Winds: 2-8 mph
4	Unskilled	Standing	On	Stationary	8 groups/10 shots	Temp: 76-77° F Winds: 4.5-8 mph
5a	Skilled(RMSL)	Prone	Off	Stationary	8 groups/10 shots	Temp: 64.8-65° F Winds: 0-1.5 mph
5b	Skilled	Prone	Off	Stationary	4 groups/10 shots	Temp: 71-76° F Winds: 0 mph
6	Skilled	Prone	On	Stationary	10 groups/10 shots	Temp: 71-77° F Winds: 0-10 mph
7	Skilled	Standing	Off	Moving	1 groups/10 shots 5 groups/5 shots	Temp: 63-69° F Winds: 2-10 mph
8	Unskilled	Standing	Off	Moving	4 groups/5 shots	
9	Skilled	Standing	On	Moving	4 groups/5 shots	
10	Unskilled	Standing	On	Moving	4 groups/5 shots	
Baseline Comparison (AR Platform not in Stabilization Shell)						
1B	Skilled	Prone	--	Stationary	1 group/10 shots	Temp: 73° F Winds: 5-6 mph
2B	Unskilled	Standing	--	Stationary	1 group/10 shots	
3B	Skilled	Standing	--	Stationary	1 group/10 shots	
4B	Skilled	Standing	--	Stationary	1 group/10 shots	
Active Stabilization Test Results Dates: 6/12/14 - 6/19/14 Location: Private Test Range in Conifer, CO Elevation: 8800 ft. All Units: INCHES						

Active Stabilization – Phase III

Phase III

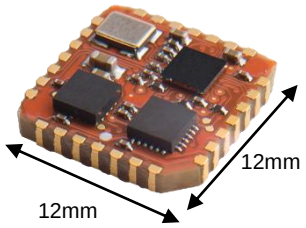
- Live Fire Test (More dynamic environment)
  - **Scenario 1: Static Unsupported Baseline (100m)**
  - **Scenario 2: Static Fire – Static Target (Range: 200-500m)**
  - **Scenario 3: Moving Platform from Ground Vehicle – Static Target**
  - **Scenario 4: Moving Platform from Aerial Vehicle – Static Fire**
- Integrate Improved Controls, Drives, and Servo motors
- Integrate IMU and sensors, rangefinder, barometric sensors, ballistics engines, wind sensors

Active Stabilization - Phase III (IMU Integration)



Inertial Measurement Units (IMUs)

- Self-contained system that measures linear and angular motion usually with a triad of gyroscopes and triad of accelerometers.



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Active Stabilization – Phase III

Phase III (Results)

- **Implementation**
  - Integration of Modular Enhancements (to include Inertial Measurement Unit (IMU), Environmental Sensors, Higher Resolution Imaging Sensors, Ballistics Algorithms)
  - Integrate hardware into Active Stabilization Weapon System Prototype
    - Precision Weapon, Semi-Automatic (M110 type SASS (commercial Variant)
    - .338 Lapua (Alexander Arms)
  - Perform a ground-based live fire test series to verify all modular enhancements that have been integrated onto Serial #002.
- **Emerging Results/Analysis**
  - **Scenario 1,2,3**: Data Collection from bullet impacts indicated errors remained in accounting for **all digital latencies;** e.g., bullet impacts were grouped further off target than appropriate if firing platform velocity and bullet flight time were the only contributors.
  - **Scenario 4:** Extreme MOA spread may indicate **digital latencies** in the correction algorithm

FY16 and beyond

1. Continue Technology Development (Component Level)
   - Applicable to all small arms to include individual, mounted, dismounted and crew-served. Ability to remove most shooter and environmental error causes and be universal in improvement of P(Hit).

2. Focus on Platform Area (Light/Medium/Heavy Machine Gun)
   - Applique/Hybrid Development
   - Deck/Vehicle Mounted Applications

3. Individual Weapon Development (Future Integral Target Engagement System – FITES)
   - Govt/Contractor Teaming Effort

4. Army Expeditionary Warrior Experiment (AEWE) -Tier I Selection (FY17)

Summary

Payoff

- **Increased in Probability of Hit P(Hit)**
- **Significantly reduce target acquisition time by offering shooters an effective 'snap-to-target' capability**

- Directly Coupling Fire Control Information with the mechanical movement of the weapon.
- Shooter maintains trigger pull capability
- Minimizes almost all shooter errors
- Decreased training time to same level of skill
  - Less costs and more time to teach advanced TTPs
- Improved $P_{(hit)}$ on stationary targets for both skilled and unskilled shooters with decreased engagement times
- Increased effectiveness of system in standing unsupported position to almost match prone supported system results.
  - NOTE: Shooter in loop standing nearly matched system accuracy in bench rest on multiple occasions.
- Can be optimized within purpose built weapon system for form/function/SWAP

Acknowledgements

Contract Partner

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- Littleton, CO 80127
- www.rmsl.net

Government Team

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