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GUN & ELECTRIC WEAPON SYSTEMS DEPARTMENT (E)

An Analysis of the Visual Automated Scoring System Performance During Live Gunfire Events

Dr. Chris Weiland (E41) and Kevin Murray (E41)
NSWC Dahlgren

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Gunfire Support Missions

- Gunfire support missions – such as Naval gunnery, Army artillery/mortars – are an important mission for any modern military force
- Non-line of sight gunnery requires a sensor near the target to provide feedback on round miss distances and “walk in” the gunfire

USS *Benfold* (DDG-65) firing 5”/54 MK 45 gun during training exercises

USS *Iowa* (BB-61) firing its Mark 7 16-inch/50-caliber guns

Typical Target Engagement

1. Detect and track the target with a sensor
   - Radar
   - Electro-optic sight
   - Human forward observer
2. Identify the target – friend/foe/unknown
3. Target position is then fed into the fire control computer
   - Target position update rate depends on the sensor
   - Mathematically compute how weapon must be aimed
4. Weapon is fired at the target
5. Weapon effects observed with sensor
   - If the target is missed, the fire control solution is updated and weapon is fired again
   - Post-shot BDA…do I need to shoot again?

The FO's modern method: Target Location, Designation, and Hand-Off System (TLDHS)

The Sensor Plays an Important Role

- In all steps outlined previously, the sensor introduces error/variability
  - Identification of target
  - Target coordinates
  - Weapon effects observation
- Some error/variability is due to sensor limitations
  - Radar is limited to line of sight
  - With human FO's, it is difficult to provide real-time coordinates of moving target
  - With gun EO sight, geometry prevents accurate computation of miss distance

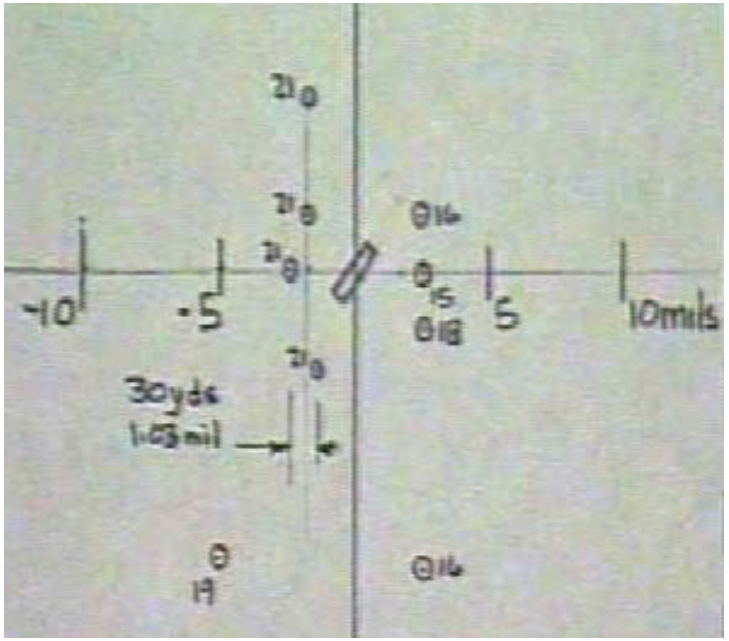
Using UAVs as an Additional Sensor for Enhanced Fire Control

- The concept of using a UAV as an organic sensor is being explored to overcome these limitations
  - Target detection and identification
  - Real-time target tracking and geolocation
  - Real-time gunfire shot correction orders
- NSWCDD uses the Insitu ScanEagle as its UAV
  - Endurance: 20+ hrs
  - Range (comms): 60+ miles
  - Payload: ~10 lbs

ScanEagle UAV at sea (above); on launcher below)

Using Unmanned Aerial Vehicles as a Sensor

- In 1980's, UAVs were used with battleships to provide gunfire correction orders



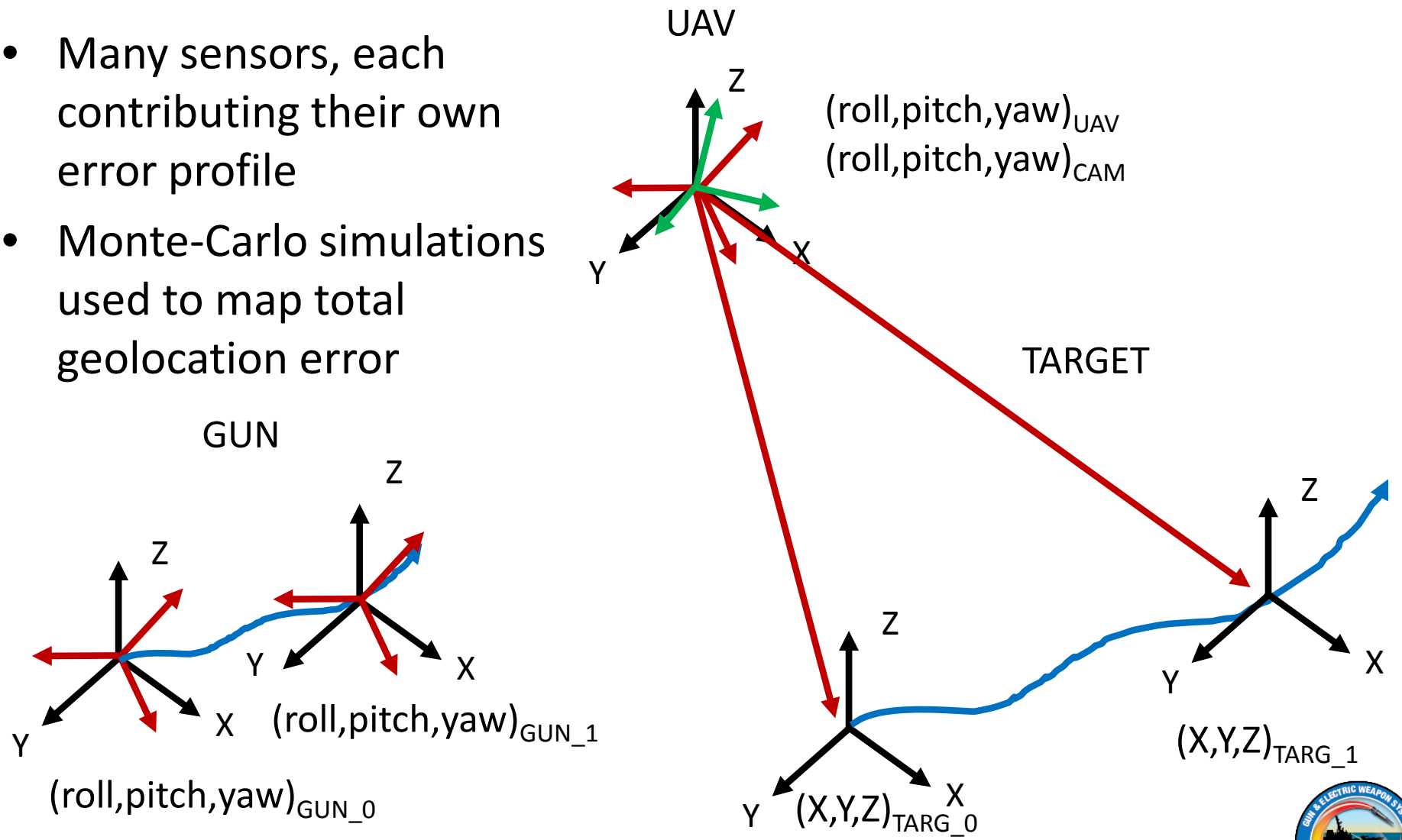
Manual scoring of gunfire relative to target, USS *Iowa* (BB-61), 1986

Crewmen recover a RQ-2 Pioneer UAV from the deck of the USS *Iowa* (BB-61), 1986

- These UAVs lacked the sensor payload to quantitatively score gunfire in real-time

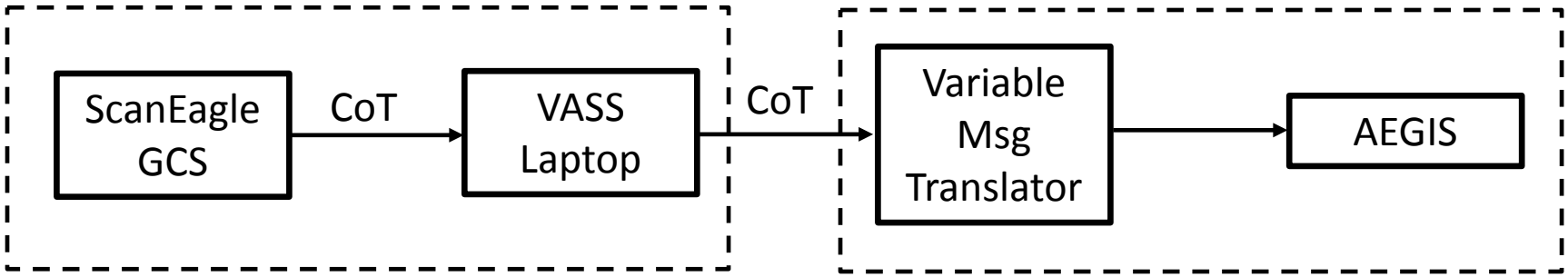
Geolocation of Ground Targets

- Many sensors, each contributing their own error profile
- Monte-Carlo simulations used to map total geolocation error



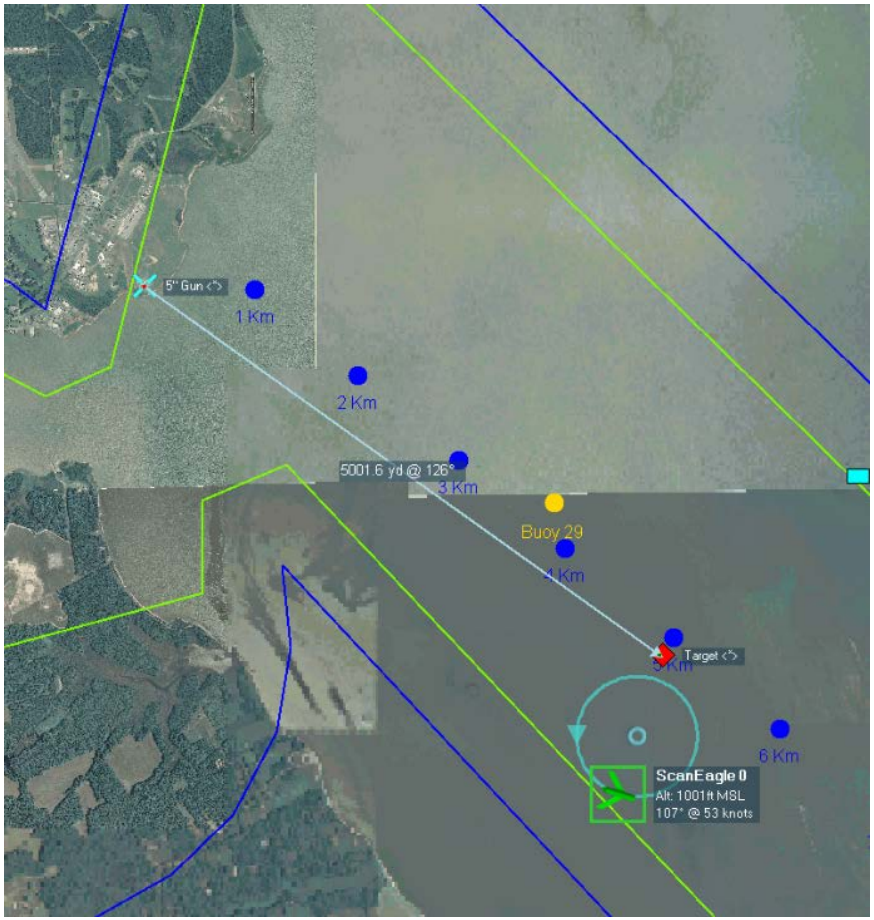
VASS Experimentation

- The concept of integrating VASS and a UAV into fire control was demonstrated at NSWC Dahlgren's Potomac River Test Range
- Purpose was to demonstrate the utility of UAV as organic AEGIS sensor in engaging surface targets with 5-inch gunfire
- Variable Message Translator (VMT) written to convert VASS CoT messages for AEGIS connection



VASS Experimentation

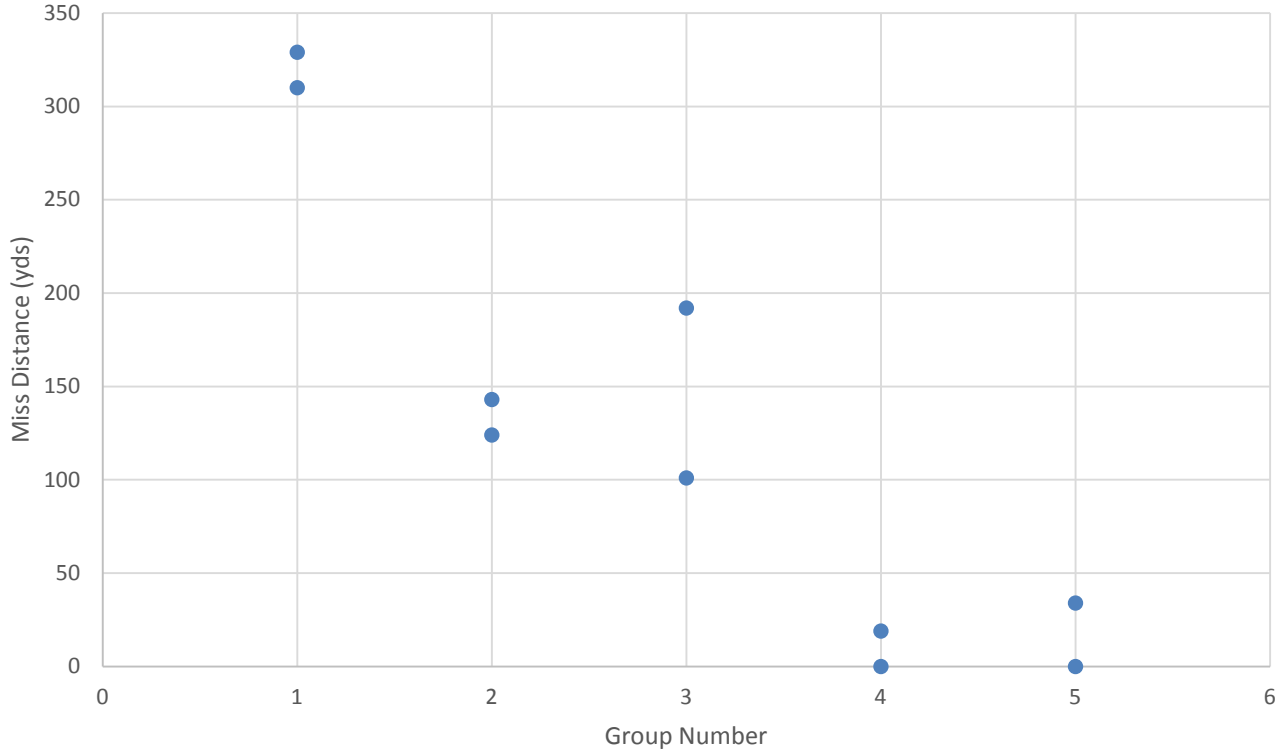
- Two static pontoon targets at 5kyds from gun
- UAV patrols designated space
- UAV encounters surface target and identifies it as hostile and begins track
- 5-inch gun fires two rounds at target; VASS calculates gunfire miss distance (artificially miss first round by 200 yds)
- VASS provides shot corrections to MK160 fire control computer; process is repeated until gunfire converged onto target



VASS Experimentation

VASS Experimentation

- Rounds fired in two-shot groups
- Gunfire rapidly converged onto target
- Gunfire adjustment orders provided by marking splash with computer mouse



FUTURE WORK

Adaptive Fire Control

- Direct communication between VASS and the fire control computer allows optimization of gunfire engagements
- Round impact point is *automatically computed in VASS*, resulting in a gun adjustment order that is sent to the fire control computer
  - Object recognition models to compute splash position tested post-test with good results

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VASS as a Gunfire Training Tool

- Naval Gunfire Support training uses the IMPASS hydroacoustic buoy system
  - A system of buoys that must be deployed into the ocean
  - Computes the splash location and sends this information to the Virtual At-Sea Training system: a simulation environment for NGFS training
- One UAV and VASS can feed these splash positions directly into VAST for training – without the need for buoys
- ***A ship can train gunfire crews anywhere in the world, at any time, with one UAV and VASS***