Demonstration & Evaluation of Moving-Maps to Improve Lane Navigation of Amphibious Vehicles

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Outline

- NRL MM Objectives
- Background
  - *AAV, LCU navigation procedures*
  - *NRL MM system*
  - *Previous NRL MM tests*
- FY03 MM Test Results
- Recommendations

NRL / MM (FY03)

- Demonstrate improved precise lane navigation of naval Amphibious Assault Vehicles (AAV) and Landing Craft Utility (LCU) using moving-map (MM) display.
- Measure navigation performance and assess crew workload: compare MM with “baseline” navigation methods.

Problems

- For both AAV and LCU, one crewmember navigates while another drives
- Communication hampered by remote location of these crew from one other
- Need tool to improve communications and facilitate shared situational awareness (SA) among crew → should improve crew's ability to precisely navigate assault lanes

LCU Crew

Craftmaster

Sits topside for 360° view of surrounding area

Communicate (via sound tube) course corrections with range and bearing

Communicate (via sound tube) course corrections with range and bearing

Helmsman

(drives the LCU)

Always below deck with limited outside view

Navigator

(access to paper charts, radar, and sometimes electronic chart)

AAV Crew

Crew Chief

↓

Communicate (via intercom) course corrections with range and bearing

↓

Driver

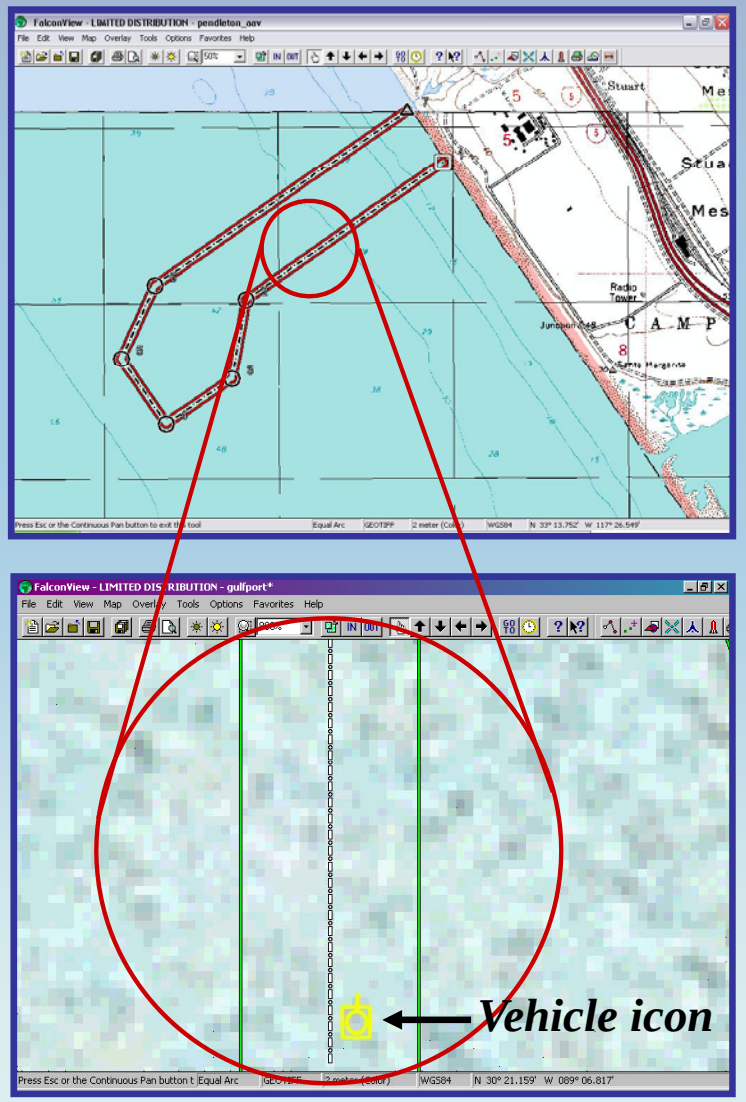
(relies solely on Crew Chief for direction)

Can go topside for 360° view of surrounding area

Always below deck with limited outside view

MM Software

- GOTS Navy Portable Flight Planning System (N-PFPS) software; FalconView module
  - *GPS / Moving-Map tools*
  - *Auto scrolling*
  - *Track – up display*
- Loads all military standard NIMA / NOAA charts & maps and supports GEOTIFF
- Supports direct operator input of Assault Lanes Battle Space Geometry



MM Tests & Demos

FY02

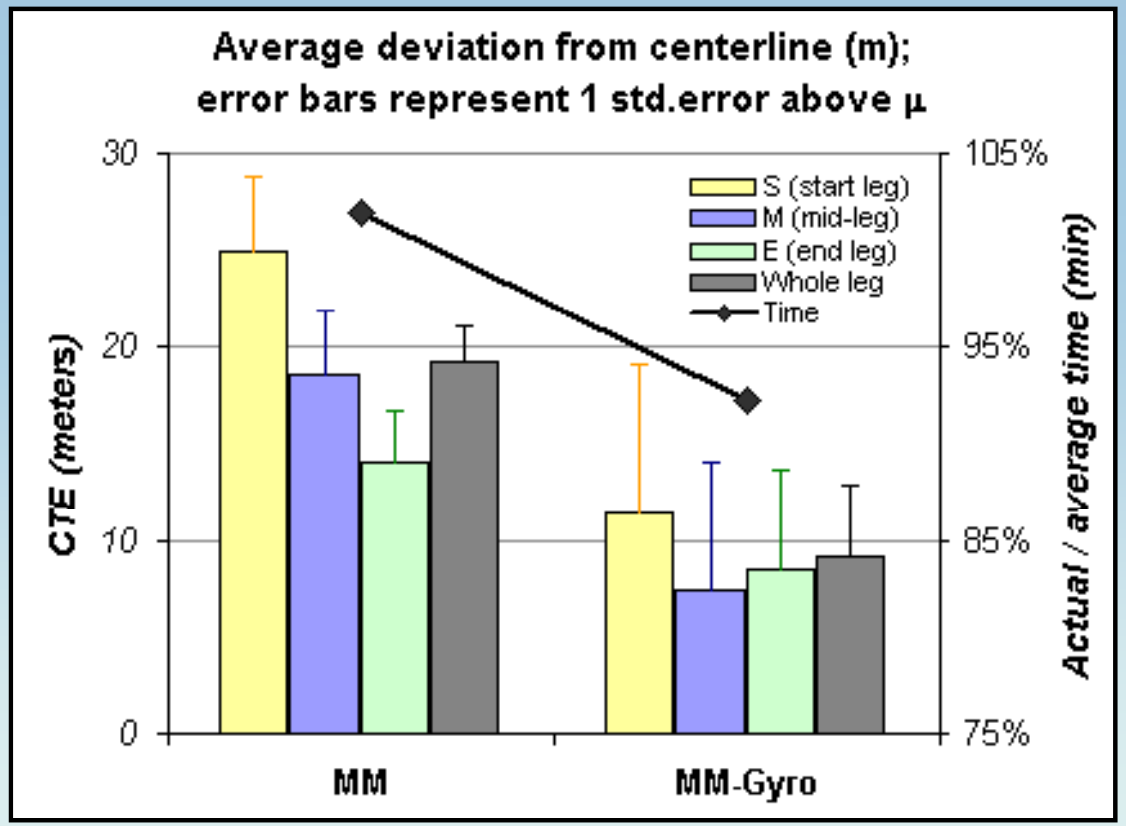
- **May '02:** AAV (Tests at 4th Assault Amphibian Battalion Reserve Unit, Gulfport, MS)
- **July '02:** AAV, LCU, LCAC (FBE-J, Camp Pendleton, CA)

FY03

- **Oct '02:** LCU (Testing gyrocompass input to MM; Little Creek, VA)
- **Nov '02:** AAV (Testing magnetic heading sensor input to MM, Camp Pendleton, CA)
- **Jan '03:** AAV, LCU (Transparent Hunter, San Diego and Camp Pendleton, CA)
- **June '03:** MM / ALNS field test, Panama City, FL

Heading Sensor Tests: LCU

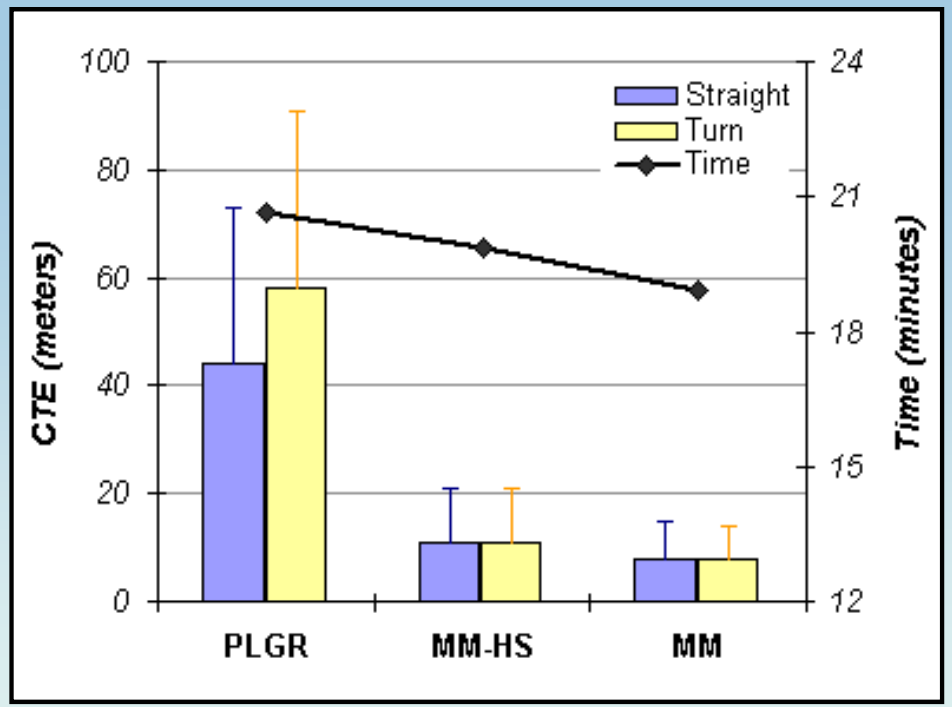
- **Hypothesis: independent heading sensor would provide direction when vehicle at rest, stabilize map, and assist driver at start of track or during slow turns.**



- **Magnetic heading sensor ineffective in LCUs (metal).**
- **Little Creek LCUs had onboard gyrocompass and analog-to-digital converter.**
- **NRL wrote software to merge digital gyro signal with GPS signal into NMEA string and input to FalconView.**
- **Significant improvement in lane nav performance with gyro (μ CTE = 9.1 m) vs. no gyro (19.2 m):** $t = 2.36$, $p < 0.02$.

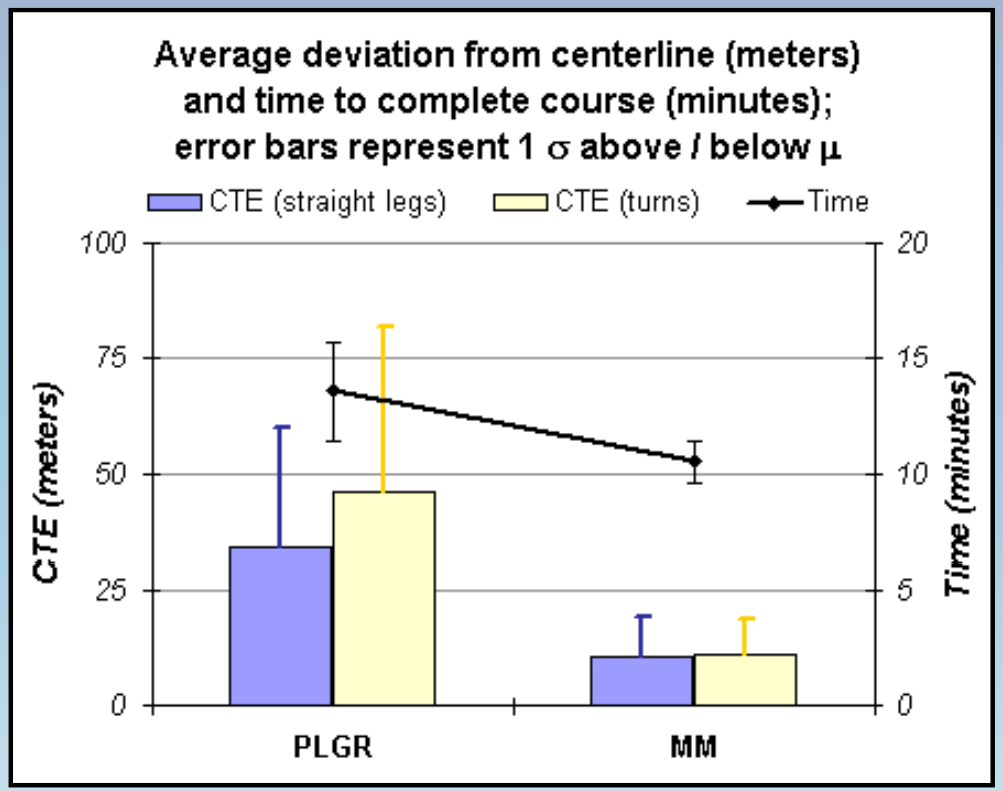
Heading Sensor Tests: AAV

- Magnetic heading sensor worked OK on AAV.
- NRL wrote software to merge heading sensor signal with GPS signal into single NMEA string and input to FalconView.



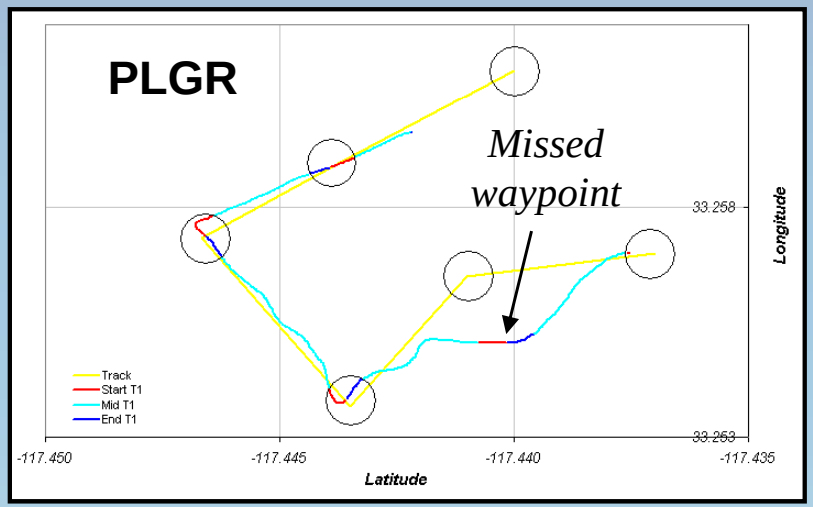
- Unexpected time lag introduced during signal merge; unable to fix during this field test.
- No AAV lane navigation improvement seen between MM with heading sensor vs. without (likely due to lag issue).

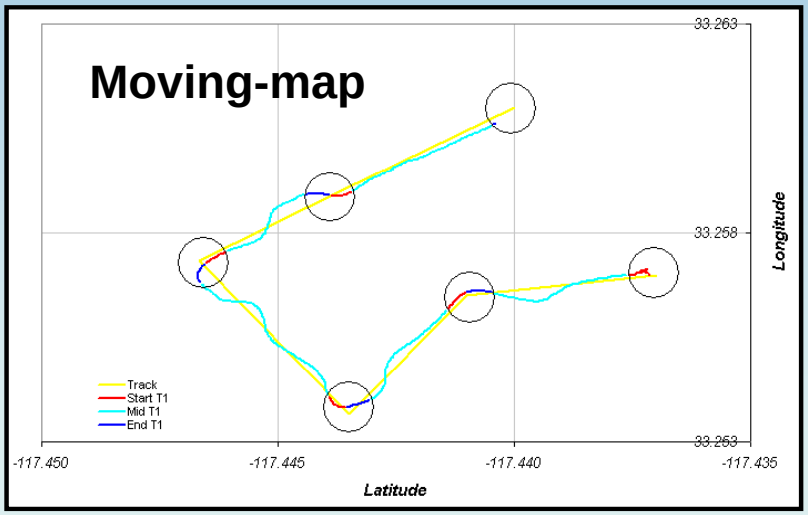
Summary of AAV performance results from MM tests during TH03



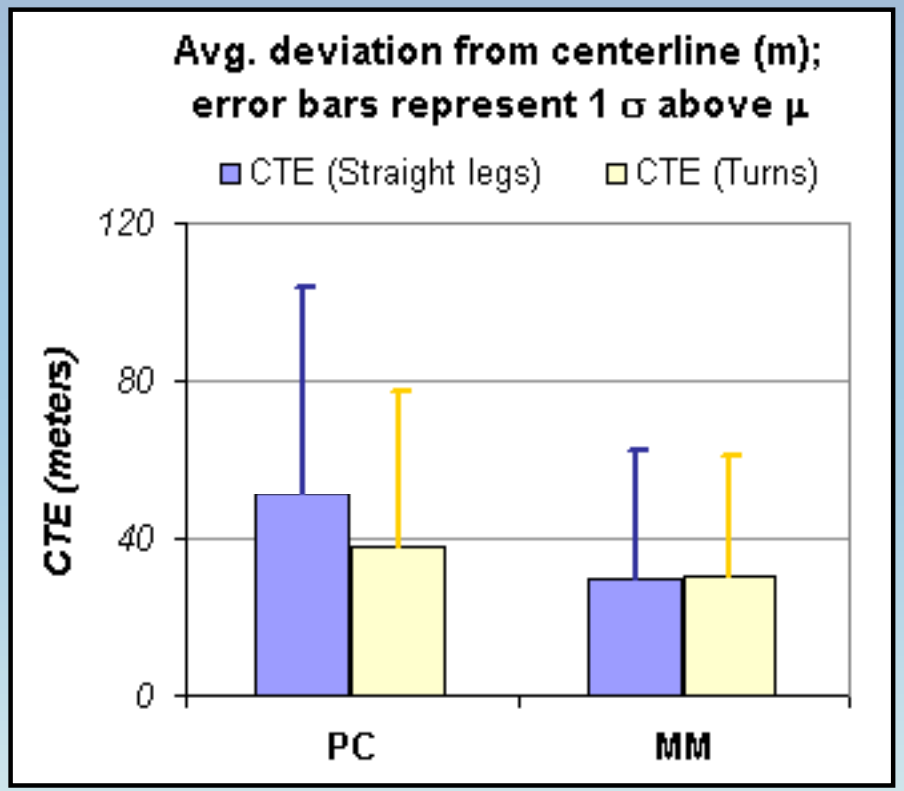
- MM significantly reduced required lane width, on average, compared with PLGR on straight legs ($t = 5.24$, $p < 0.0001$) and during turns ($t = 4.61$, $p = 0.0003$).
- MM significantly reduced time required to complete the course, compared with PLGR ($t = 3.02$, $p < 0.005$).

Sample runs:



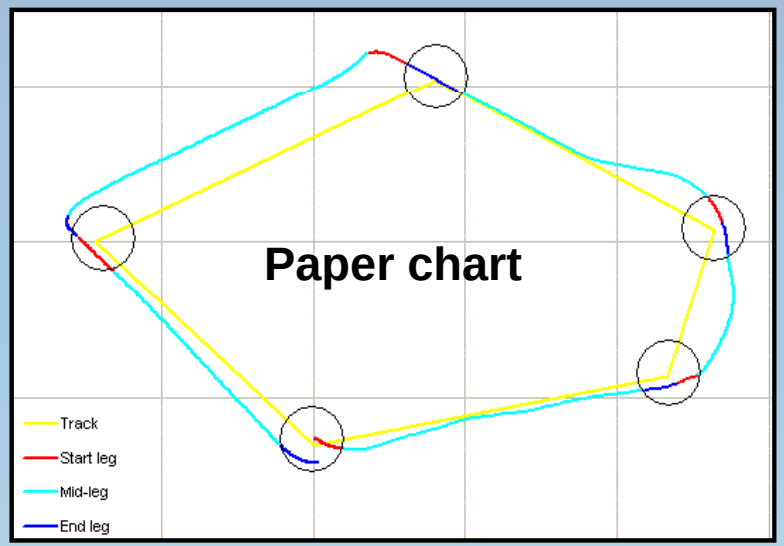


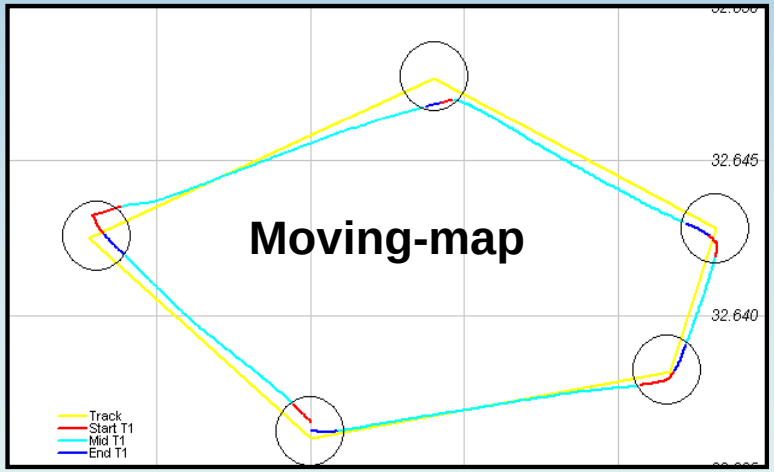
Summary of LCU performance results from MM tests during TH03



- MM reduced required lane width, on average, compared with paper chart, although T-test could not confirm significance (not enough paper chart runs).

Sample runs:

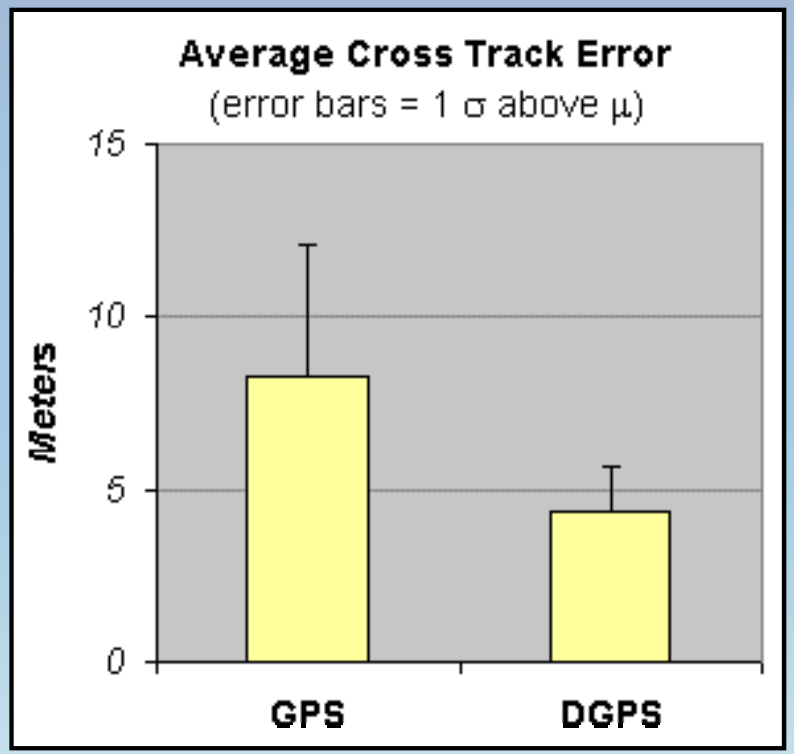




ALNS / MM Results

- ALNS and MM interfaced seamlessly: MM system successfully input ALNS-corrected GPS signals (in NMEA-0813 compliant format) in real-time and displayed boat position in track-up over a digital nautical chart of the operational area.
- Abundance of boat traffic during field tests precluded reasonable navigation performance comparisons among the three MM configurations (i.e., ALNS, GPS, DGPS).
- Most important metric was precision of ALNS positions compared with DGPS.

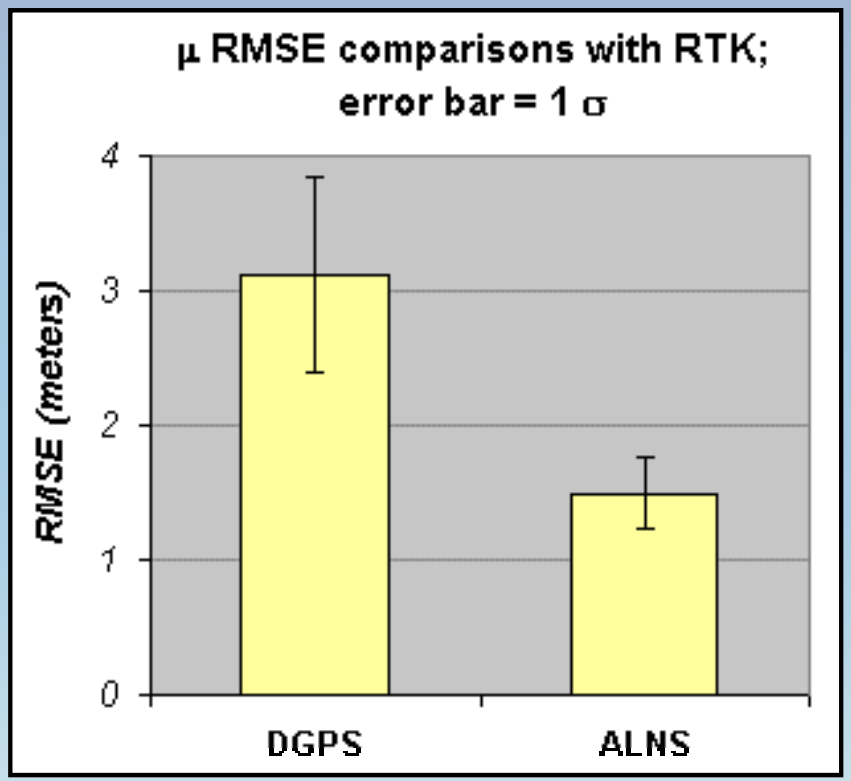
Importance of Precise Positioning



Difference in performance (CTE) between navigating with MM/GPS vs. MM/DGPS is significant:
$t_{14df} = 2.91$, $p=0.01$

- **Result of NRL MM tests on AAVs (May'02, Gulfport): improved positioning precision (i.e., from GPS to DGPS) corresponded with improved driver's ability to follow the centerline of a preset lane.**
- **However, DGPS is not available globally.**
- **Proposed: ALNS can provide MM with DGPS precision on a global scale.**

ALNS/MM (CONTINUED)



ALNS surpassed DGPS precision on these tests, on average, compared with RTK:

$t_{14df} = 7.54$, $p < 0.0001$

- 9 runs with MM / ALNS
- 8 runs with MM / non-corrected GPS
- NRL logged DGPS position on 2nd MM system for comparison
- CSS logged boat position using real-time kinematic (RTK) system for common ground-truth on all runs
- RMSE betw. ALNS & RTK: 1.49 m
- RMSE betw. DGPS & RTK: 3.12 m
- ALNS / MM shows tremendous potential for improving SA and providing a globally available navigation aid with precision equivalent to DGPS

Crew Feedback

- MM most useful for:
  - *Staying on track*
  - *Anticipating turns*
  - *Aiming for waypoint*
  - *Traversing track quickly*
  - *Avoiding minefields rather than clearing mines*
- Driver learned primary MM functions easily
- Crew recommendations for improvement:
  - *Reduce size of screen and move to less intrusive location; in high seas, need to keep outside view (not focus on map).*
  - *Thermal imaging / moving map should be able to switch back / forth or display as picture within picture.*

Other Suggestions

- Operator interface should be minimal.
- Declutter display; make it simple.
- Need a way to plan or mission re-plan on the fly (i.e., a way to dump new waypoints to the map quickly).
- Allow MM to input coordinates from PLGR.
- Can't rely on commercial GPS; need militarized GPS (ALNS?)
- Thermal imaging viewer: actual view out in front; may want to consider a "highway display" but would need a predictor capability to help anticipate next turn.
- Audible cues tied into head phones.
- Dim display for nighttime use (to minimize night blindness and chance for enemy NVGs to see you).
- Consider touch screen (but must withstand petroleum/grease).
- Make all hardware more waterproof!!

Summary

- NRL demonstrated that a moving-map system significantly improves lane navigation performance in AAV & LCU, compared with baseline nav. methods.
- NRL used GTRI FalconView as demo system: GOTS software with free licensing, operates on COTS Windows PC.
- NRL has software developers' tool kit (STK) for FalconView; can add new functionality to follow recommendations, if required.
- Next step: *Install moving-map (or ECDIS) on AAV, LCU?*

NRL MM POCs

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