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Basic Commerce and Industries, Inc.
Innovative Support for Warfighting Readiness

Icons and Symbols - MIL-STD-2525 Symbology

Sailor-in-the-Simulation (SITS) Workshop
8 June 2005

Basic Commerce and Industries, Dahlgren, VA

In support of:
NSWCDD/PEO IWS

Outline

Background

- Symbology principles, MIL-STD-2525 history, other symbol sets

Previous Work

- Studies on symbology and situational awareness

Current Work

- PEO Integrated Warfare Systems (IWS) project on implementation of MIL-STD-2525 for Littoral Combat Ship (LCS)

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What is “Good” Symbology?

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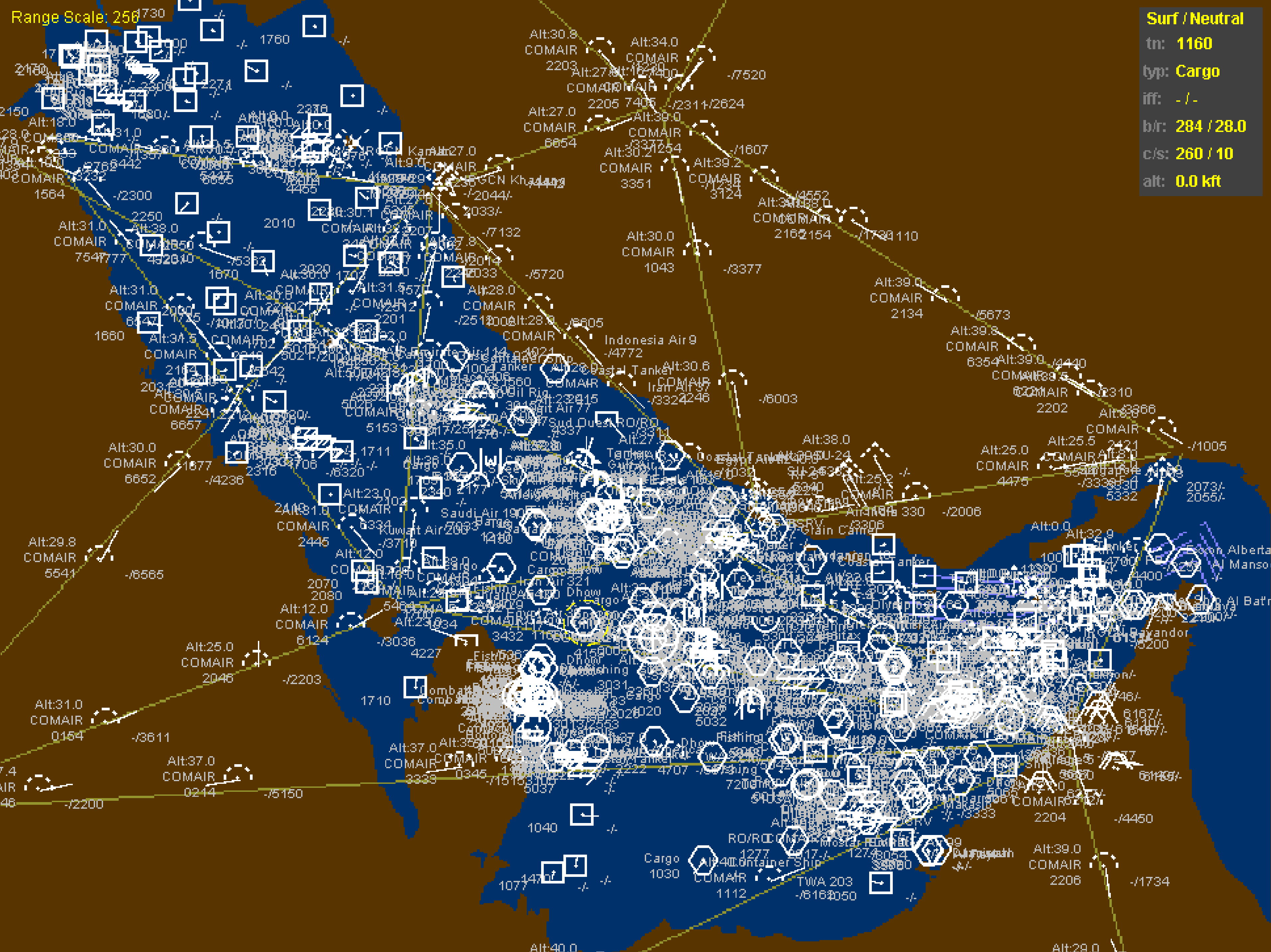
- Enable rapid learning
  - Use established conventions
  - Use easy-to-learn conventions
  - Compatible with previous symbology used
- Support user’s tasks, decisions, communications
  - Rapidly assess the situation
  - Support visual search and sorting
  - Reduce button actions
  - Allow for useful annotations
  - Allow tailoring or filtering to role or task
  - Commonality across systems
  - Provide the right information – platform vs function



Range Scale: 256
Surf / Neutral
tn: 1160
typ: Cargo
iff: - / -
b/r: 284 / 28.0
c/s: 260 / 10
alt: 0.0 kft
Alt:30.8
COMAIR
2203
Alt:34.0
COMAIR
Alt:27.0
COMAIR
6654
Alt:30.2
COMAIR
3351
Alt:39.2
COMAIR
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1043
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Alt:28.0
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Indonesia Air 9
Alt:38.0
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0214
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COMAIR
3335
Alt:39.0
COMAIR
2206
Cargo
1030
TWA 203
COMAIR
2204
Saudi Air 19
Kuwait Air 203
Alt:40.0
Alt:29.0

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History of MIL-STD-2525

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- Aug 1993: DISA tasked to take lead in standardizing warfighting symbology
- Sep 1994: MIL-STD-2525 published, drawn from:
  - NATO STANAG 2019 (APP 6), *Military Symbols for Land Based Systems*
  - US Army FM 101-5-1, *Operational Terms and Graphics*
  - NATO STANAG 4420, *Display Symbology and Colours for NATO Maritime Units*
- Dec 1996: MIL-STD-2525A published
- Jan 1999: MIL-STD-2525B published
- Mar 2005: Cut-off date for comments on 2525B Change 1
- Future symbol updates to be independent of new versions

MIL-STD-2525 Overview

- Compliance does *not* require use of all symbols
- Applicable to data transmission, but most useful for visual representation
  - Different displays or systems, same symbol
- Primary origin in “Force Domain” – application is difficult to “Engagement Domain”
- Intended to provide all useful information in monochrome display

Filled and Unfilled Symbols
Example: Friendly Cruiser

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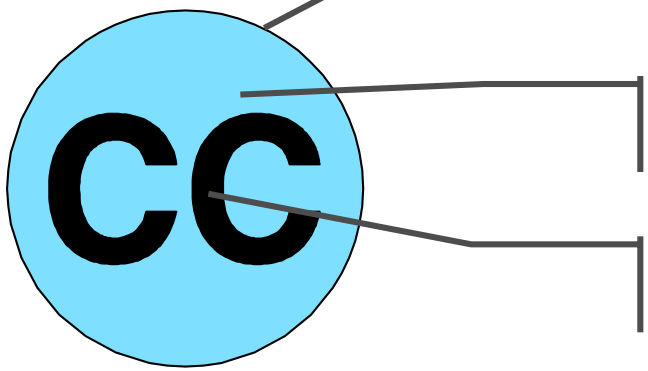
Filled Symbol

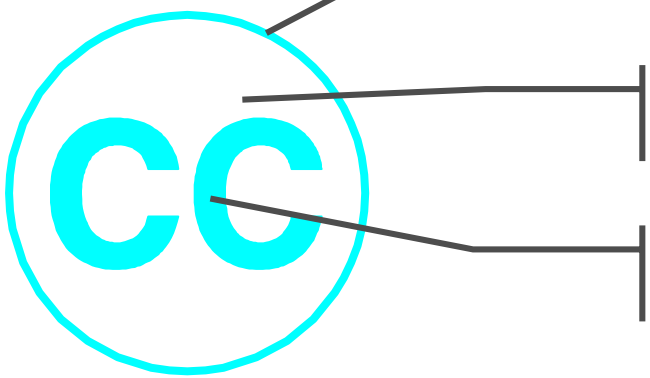


Frame: Shape Identifies both Affiliation and Category

Fill: Color Identifies Affiliation

Icon / Letter Code: Identifies Platform Type

Unfilled Symbol

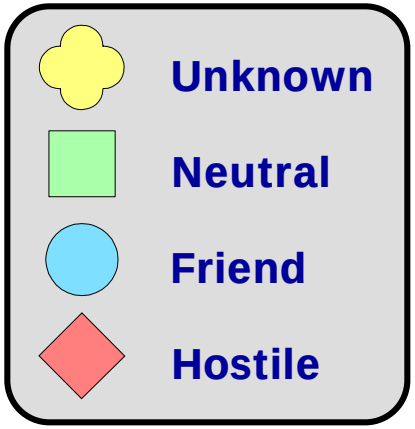


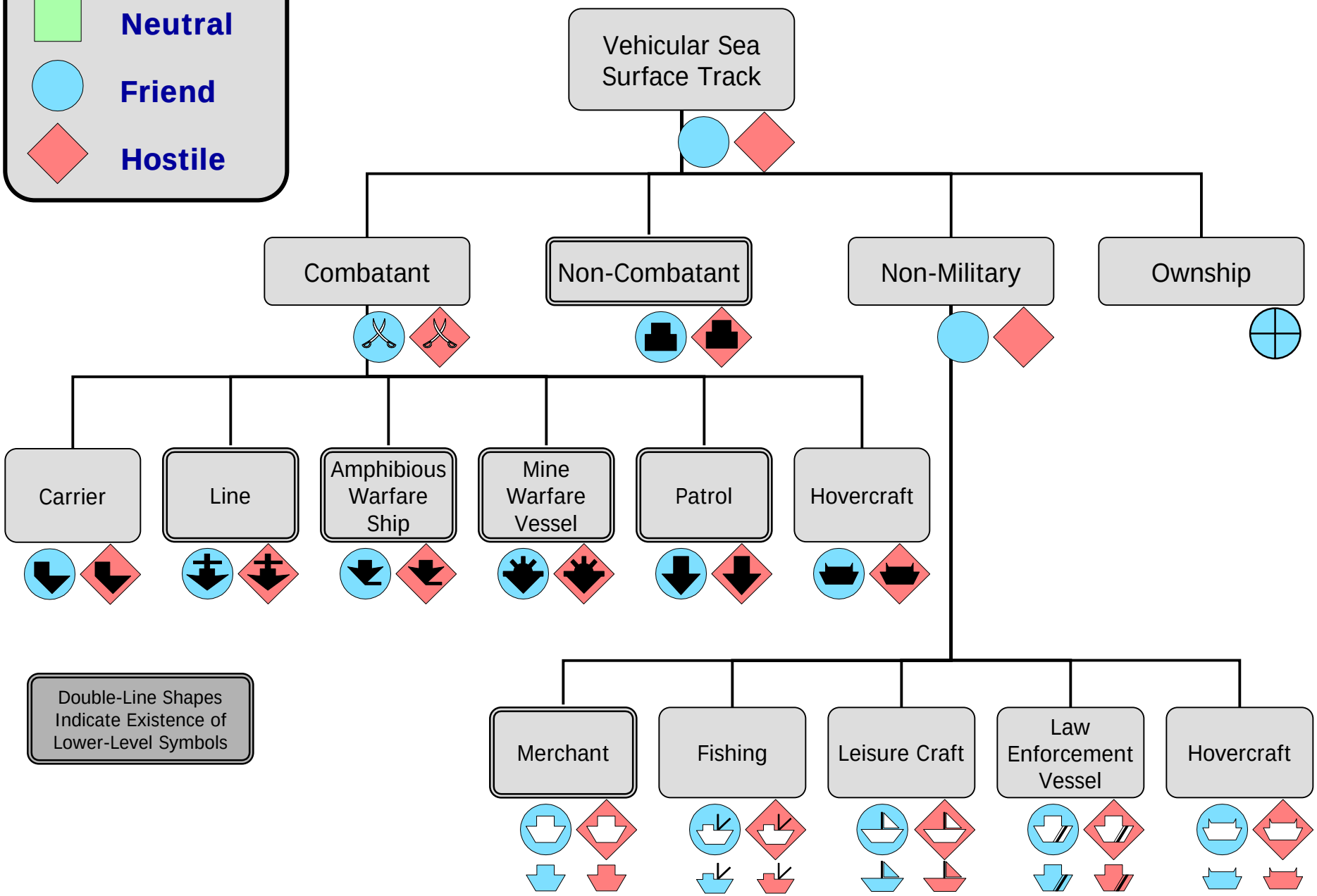
Frame: Colored Shape Identifies both Affiliation and Category

Fill: Not Used

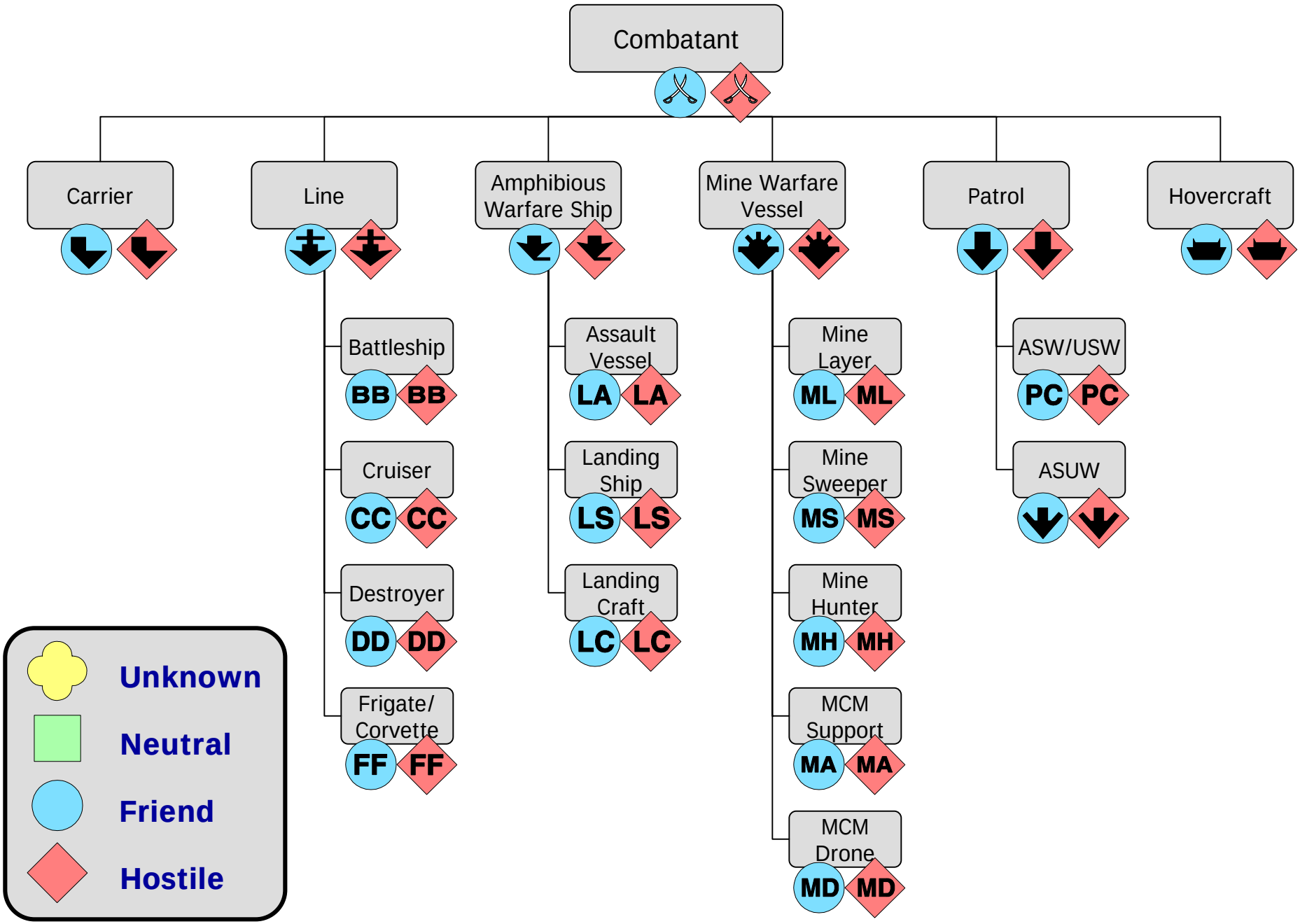
Icon / Letter Code: Identifies Platform Type

MIL-STD-2525B Sea Surface Tracks





MIL-STD-2525B Sea Surface Tracks - Combatants



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SSDS Mk 2 Mod 1 Symbology

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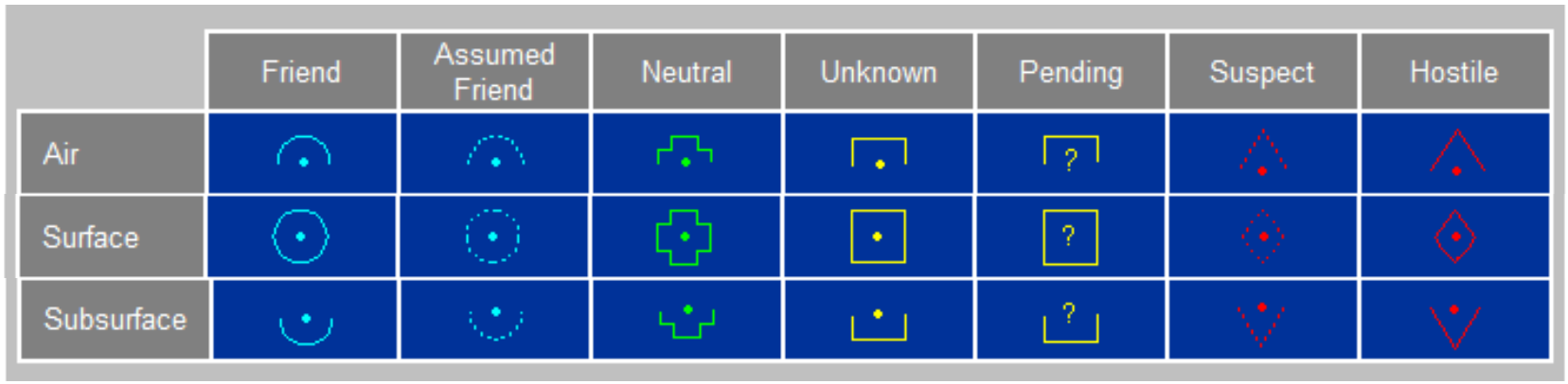
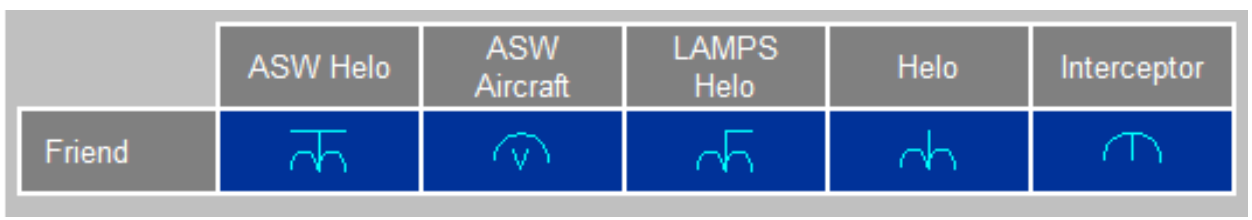
Categories



Platform Modifiers



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3-D Symbology: Area Air Defense Commander

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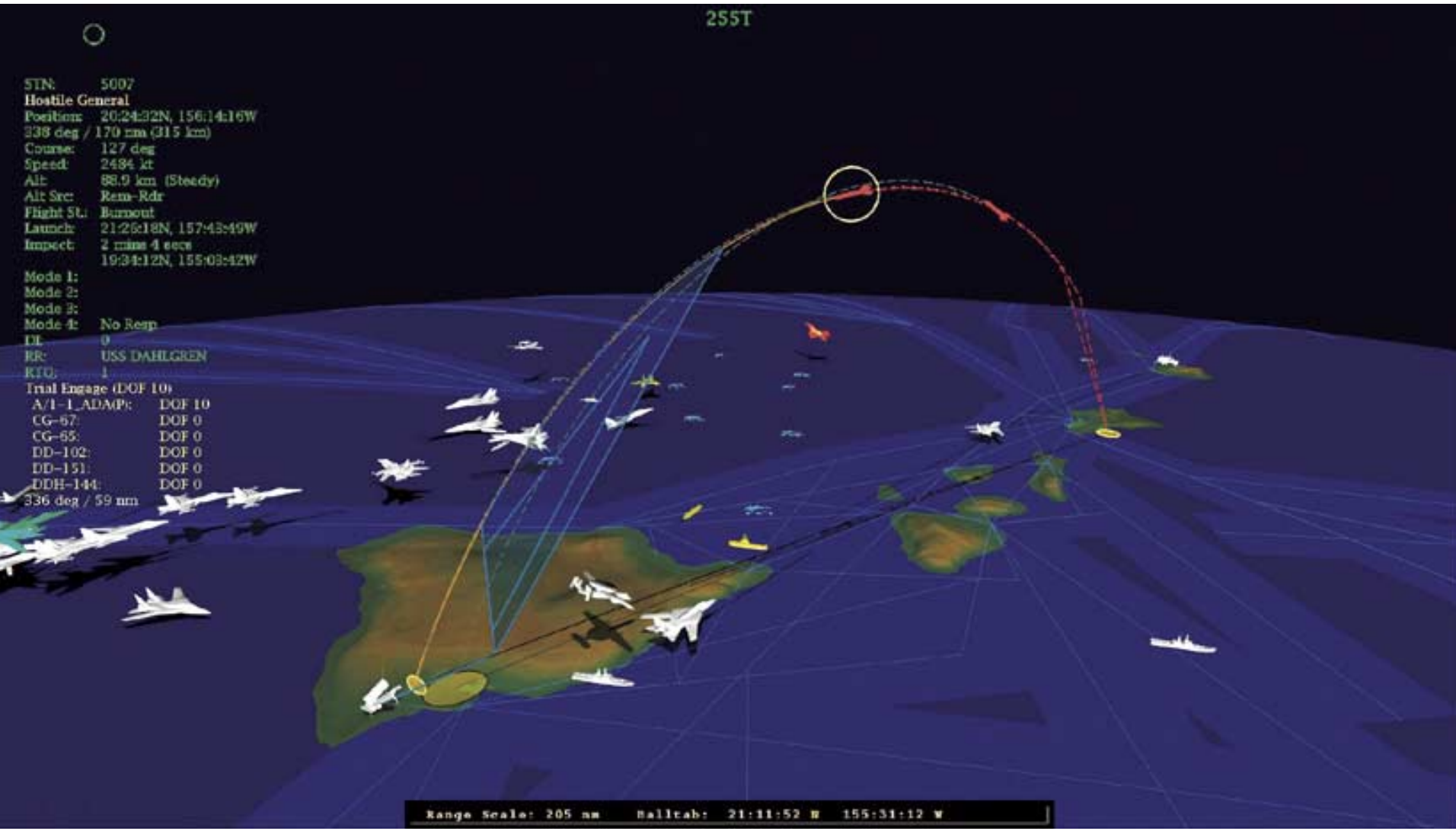
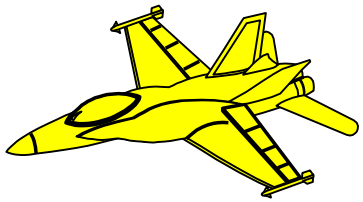
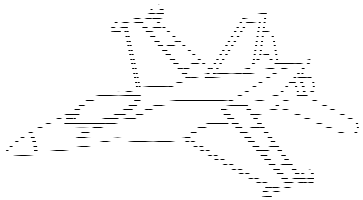


Source: March/April 2001 Surface Warfare Magazine

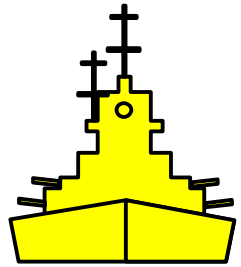
Area Air Defense Commander (AADC) Symbology



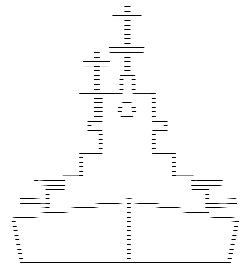
Air Unknown



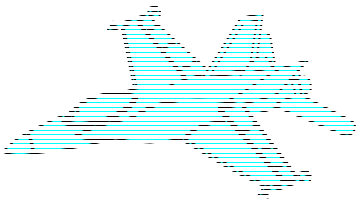
Air Friendly



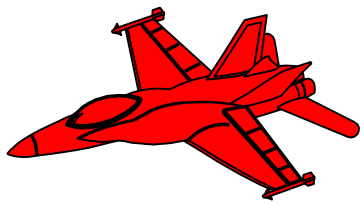
Surface Unknown



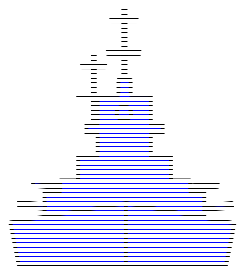
Surface Friendly



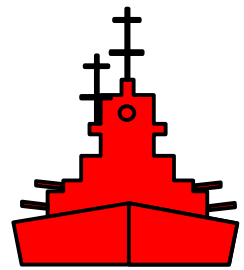
Air Unknown Assumed Friendly



Air Hostile

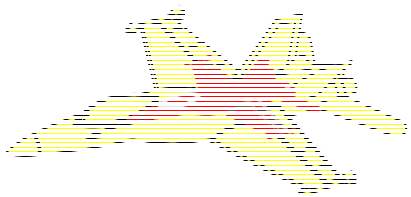


Surface Planned Position

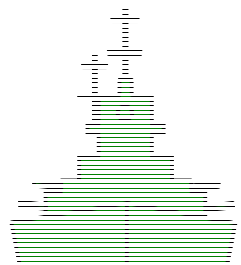


Surface Hostile

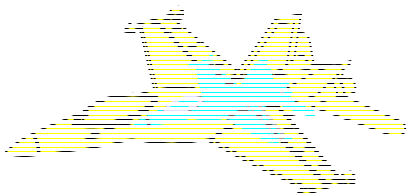
Air Unknown Evaluated



Air Unknown Evaluate - Not in an Airway



Surface Unknown Assumed Friendly



Air Unknown Evaluate - In an Airway

***Note**: SUSPECT symbols are Red with embedded yellow symbol*

Outline

Background

- Symbology principles, MIL-STD-2525 history

Previous Work

- Studies on symbology and situational awareness

Current Work

- PEO Integrated Warfare Systems (IWS) project on implementation of MIL-STD-2525 for Littoral Combat Ship (LCS)

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Previous Research
Symbol Sets and 3D Displays

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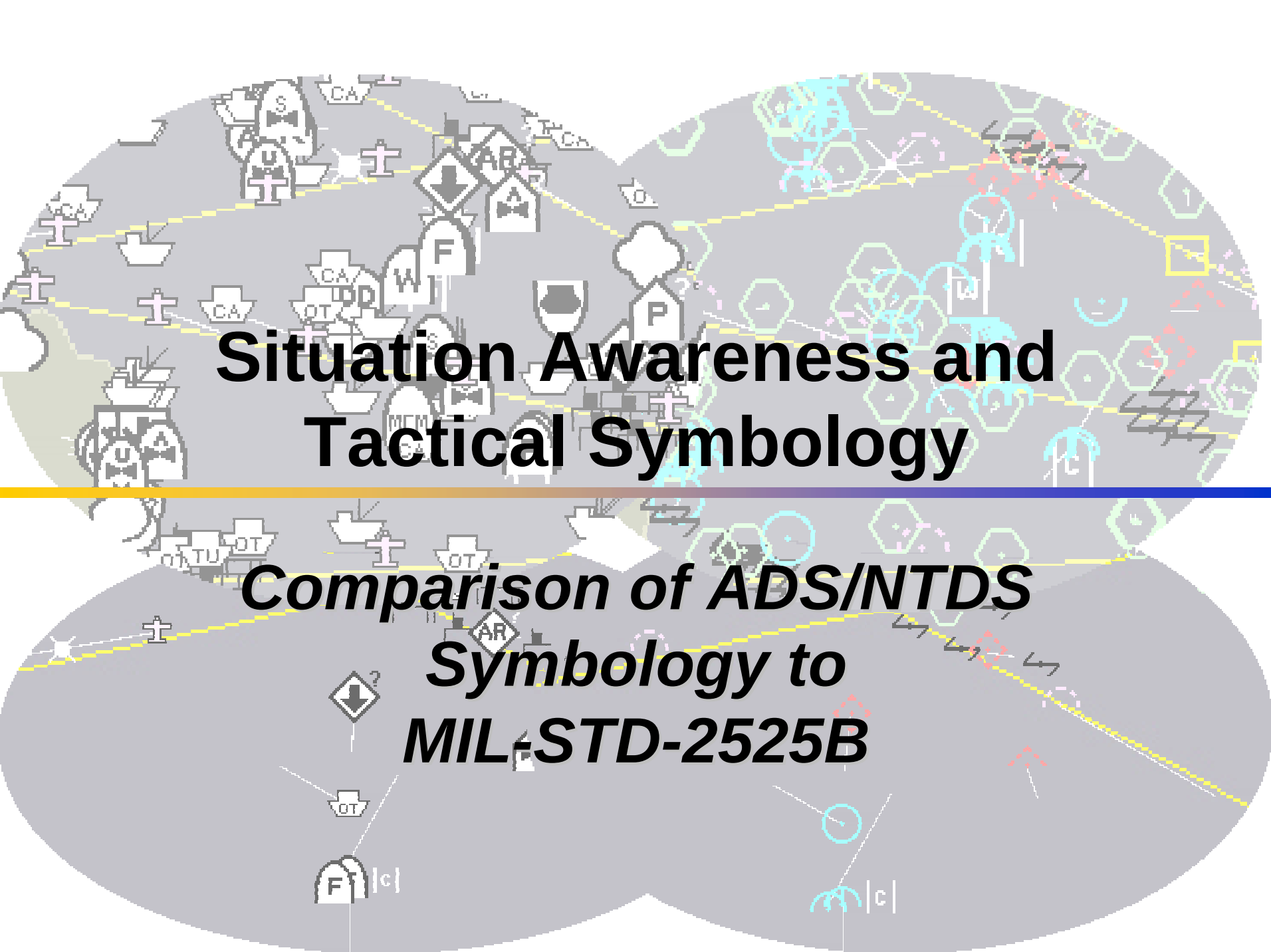
- Symbol Sets
  - Multiple studies comparing operator performance
- 3D Displays
  - Advantages of 3D based on task to be performed
  - Perspective View Technology (ONR/SSC Project)
    - Orient (3D) and Operate (2D)
    - 2525B symbols more easily identified than realistic icons
    - Symbicons – abstract, not realistic, icons
    - Perspective displays prevent accurate size or distance estimates in a single dimension

ONR Situational Awareness Study

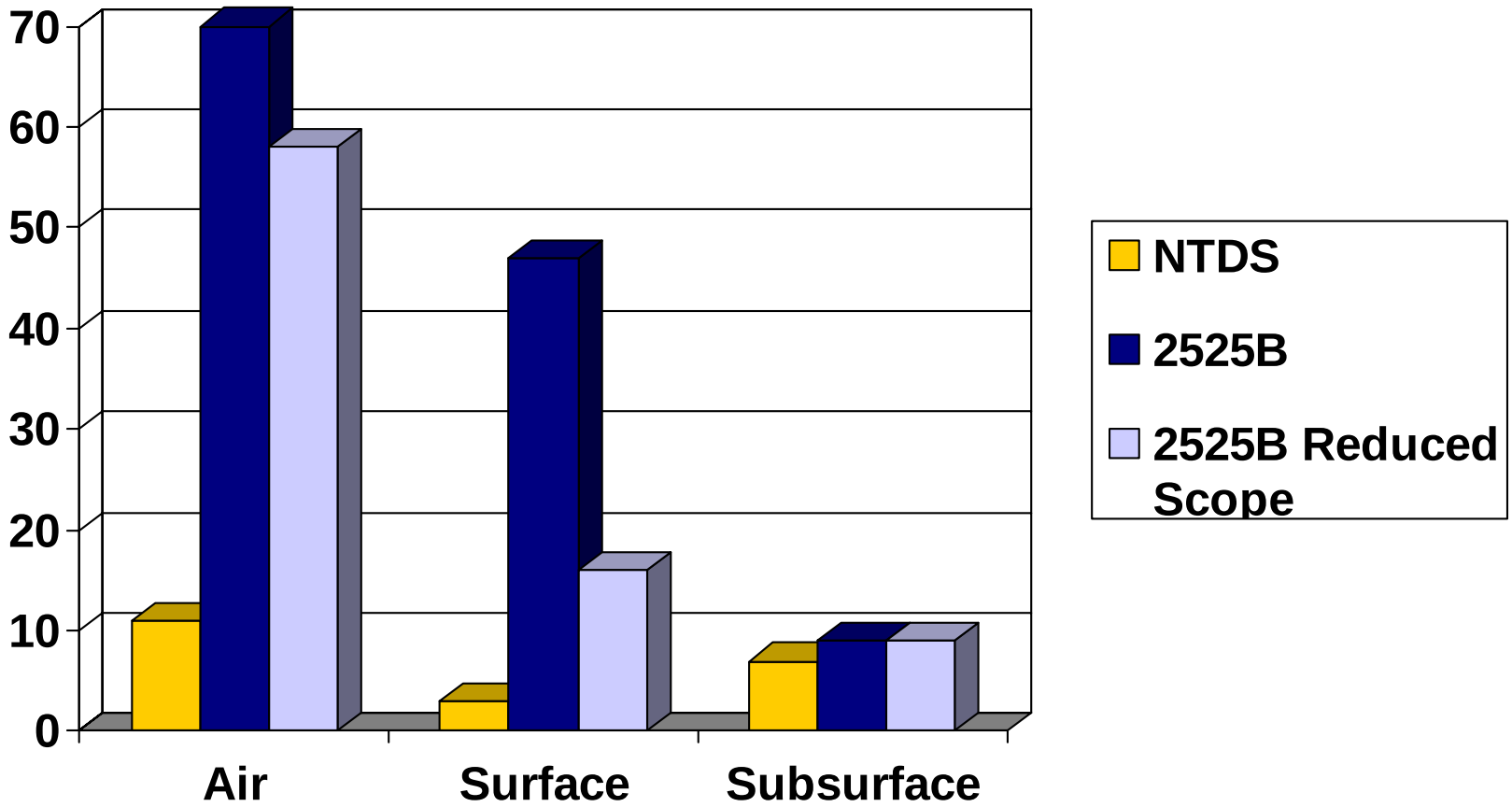
- Supporting the goal of “instant situational awareness” for DD 21
- Three components:
  - Automated support of watch turnover
  - Cognitive agents for operator support
  - Symbology comparison
    - Mapping of MIL-STD-2525 symbols to available Aegis options
    - Subjective operator feedback
    - Objective performance comparison



Situation Awareness and Tactical Symbology

Comparison of ADS/NTDS Symbology to MIL-STD-2525B

Symbol Set Sizes
Vehicular Tracks



Note: Symbol counts are across ID/affiliation.
MIL-STD-2525B includes ≈475 Land Unit and Equipment Symbols.

Sources: ADS COM OPP 5.3/3A; MIL-STD-2525B

ADS/NTDS to MIL-STD-2525B Symbol Mapping

Symbol Group	*ADS/NTDS Platform Statements*	*ADS/ NTDS Symbols*	*MIL-STD-2525B Symbols*	*ADS/ NTDS Symbols w/o Match*
Air Platform Symbols	30	10	23	3
Surface Platform Symbols	20	2	18	0
Subsurface Platform Symbols	27	6	5	3
Land Platform Symbols	16	2	7	0

Sources: ADS COM OPP 5.3/3A; 6P3 SRS CPRS; MIL-STD-2525B

ADS/NTDS to MIL-STD-2525B Symbol Mapping

Symbol Group	*ADS/NTDS Platform Statements*	*ADS/ NTDS Symbols*	*MIL-STD-2525B Symbols*	*ADS/ NTDS Symbols w/o Match*
Space Category Symbols	1	1	0	1
Miscellaneous Track Symbols	3	3	1	2
Special Symbols	4	4	1	3
Special & Miscellaneous Category Symbols	89	82	52	30

Sources: ADS COM OPP 5.3/3A; 6P3 SRS CPRS; MIL-STD-2525B

Mapping Results – ADS Platform Statements

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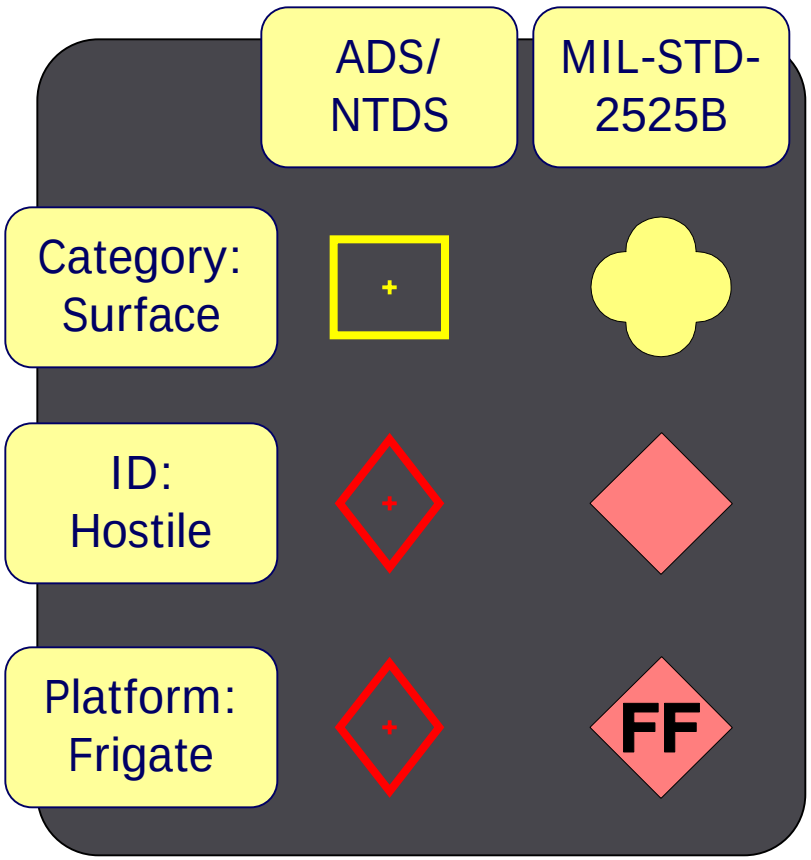
More platform statements have unique symbols in 2525B than in ADS/NTDS

Track Category	*ADS/NTDS Platform Statements*	*ADS/NTDS*		*MIL-STD-2525B*	
		Unique Symbol Pairings	*Percent Coverage*	*Unique Symbol Pairings*	*Percent Coverage*
Air Vehicular Tracks	31	7	23%	22	71%
Surface Vehicular Tracks	21	2	10%	15	71%
Subsurface Vehicular Tracks	27	3	11%	5	19%

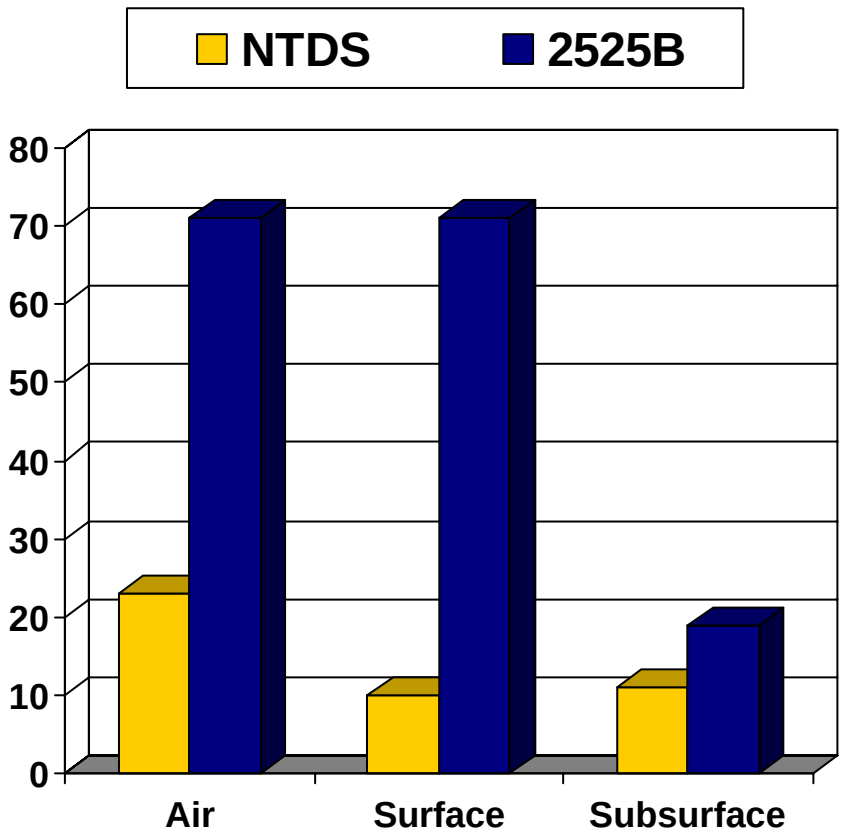
Sources: ADS COM OPP 5.3/3A; 6P3 SRS CPRS; MIL-STD-2525B

Results – ADS Platform Statements



More information inherent in the symbol

Percent Unique Platform-Symbol Matches

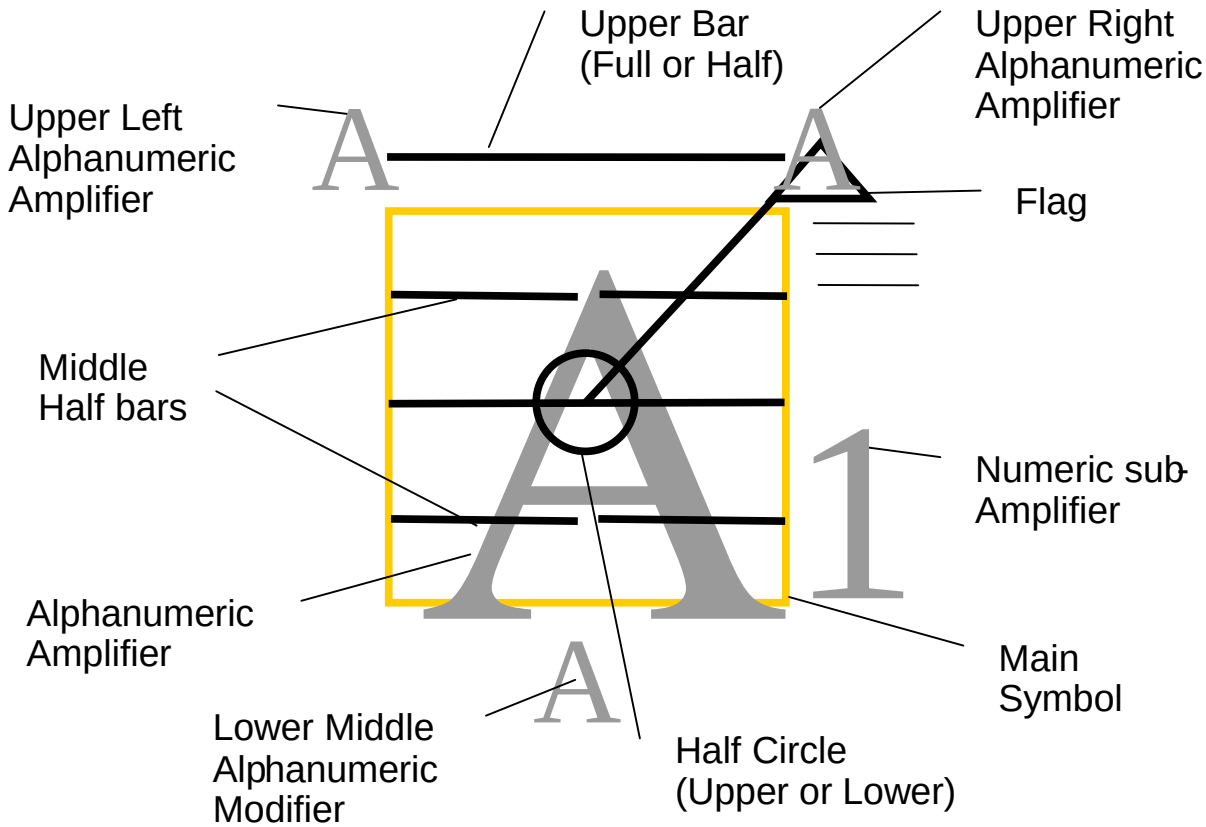


Sources: ADS COM OPP 5.3/3A; 6P3 SRS CPRS; MIL-STD-2525B

Mapping Results – Unique ADS/NTDS Symbols

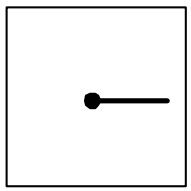
- Nearly all vehicular track symbols have comparable symbols in 2525B, except…
  - Radar processing symbols (“Flying rocks,” Tentative Track)
  - Boom/Drogue Tankers, Missile Carrier
  - LAMPS Mk 3
  - POSSUB, PROBSUB, CERTSUB
  - Missile Submarine
- Many Special Point symbols have no match in MIL-STD-2525B
  - Most common symbols have counterparts

Aegis Symbol Modifiers

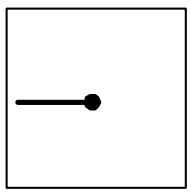


Engagement Symbology

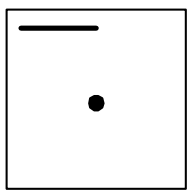
Engagement Modifiers



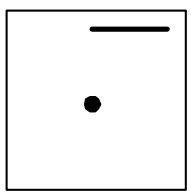
Assignment or cover order has been ordered



Engagement in progress or ordered



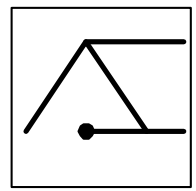
Missile in flight / Target under missile attack



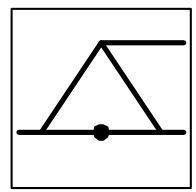
Local engagement indicator

Local Weapon Engagement

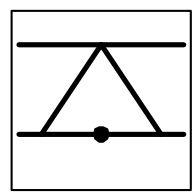
Assign / Cover



Engage



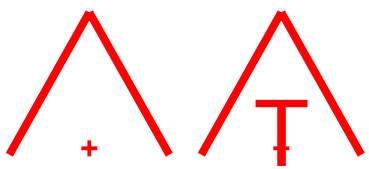
Missile in Flight

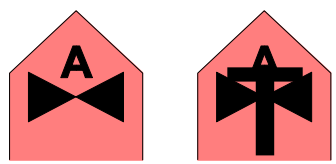


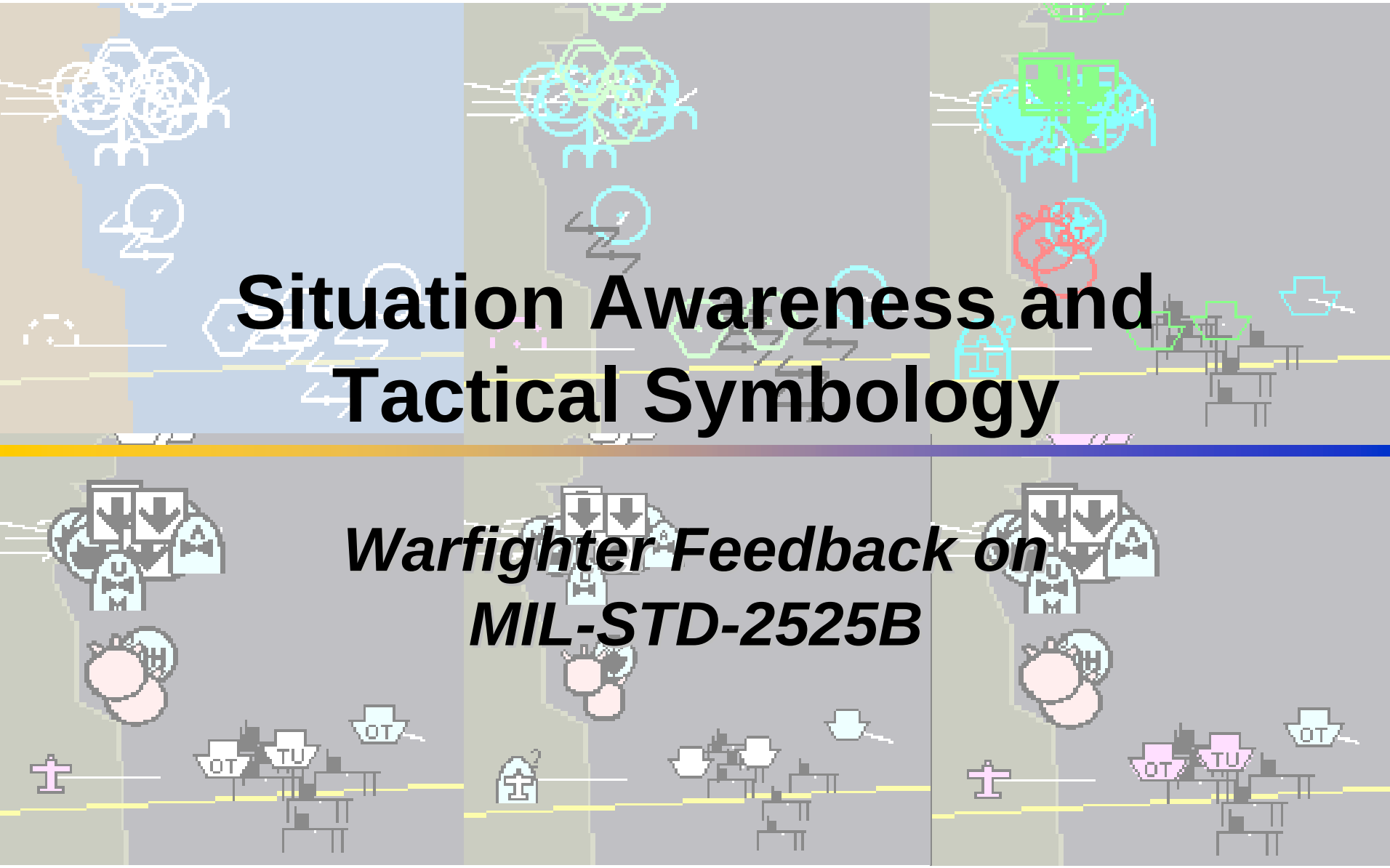
Source: SSDS Mk 2 Mod 1/2 HMI SRS

Mapping Results – Symbol Modifiers

- Few relevant modifiers in MIL-STD-2525B
- Critical modifiers omitted in 2525B
  - TacSig, Non-Real Time, Training tracks
  - Engagement modifiers
- With internal icons in 2525B symbols, modifiers are more difficult to implement







Situation Awareness and Tactical Symbology

Warfighter Feedback on MIL-STD-2525B

Warfighter Feedback – Symbology Options

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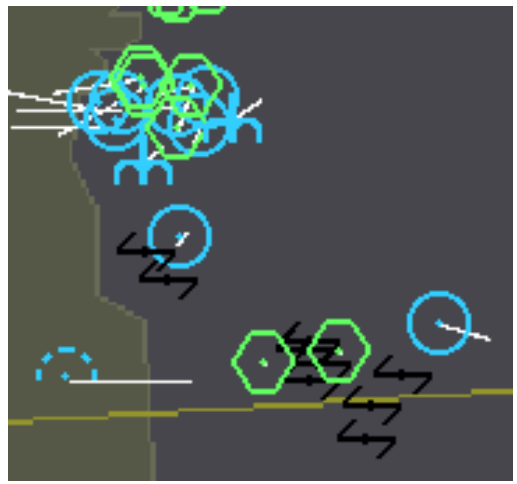
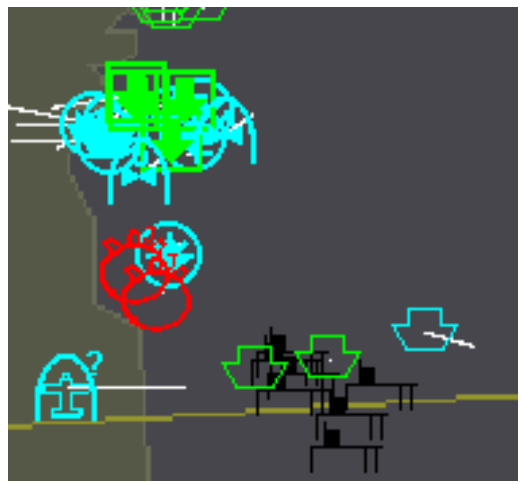
MIL-STD-2525 vs. NTDS symbols

- MIL-STD-2525 preferred over NTDS symbols due to additional information



Filled vs. Unfilled symbols

- Filled symbols preferred to allow readability for overlapping symbols



Warfighter Feedback – Symbology Modifications

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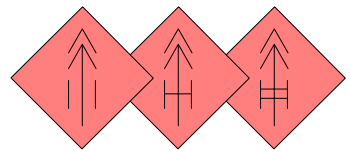
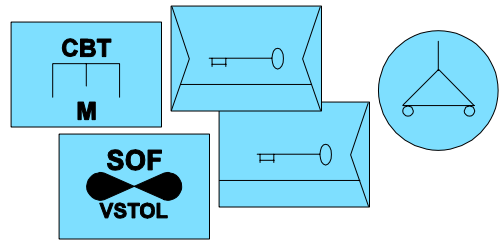
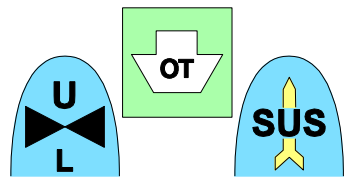




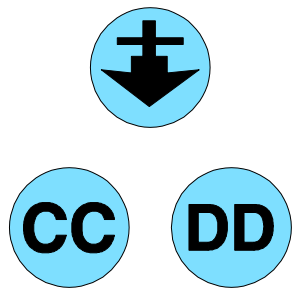


Symbol Size

- Smaller symbols preferred
- *2525B symbols used by most Naval operators still identifiable at smaller size*

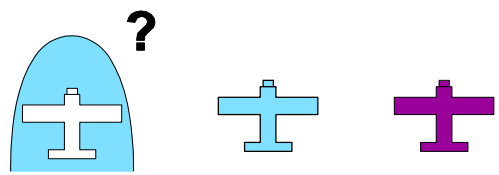
Scope

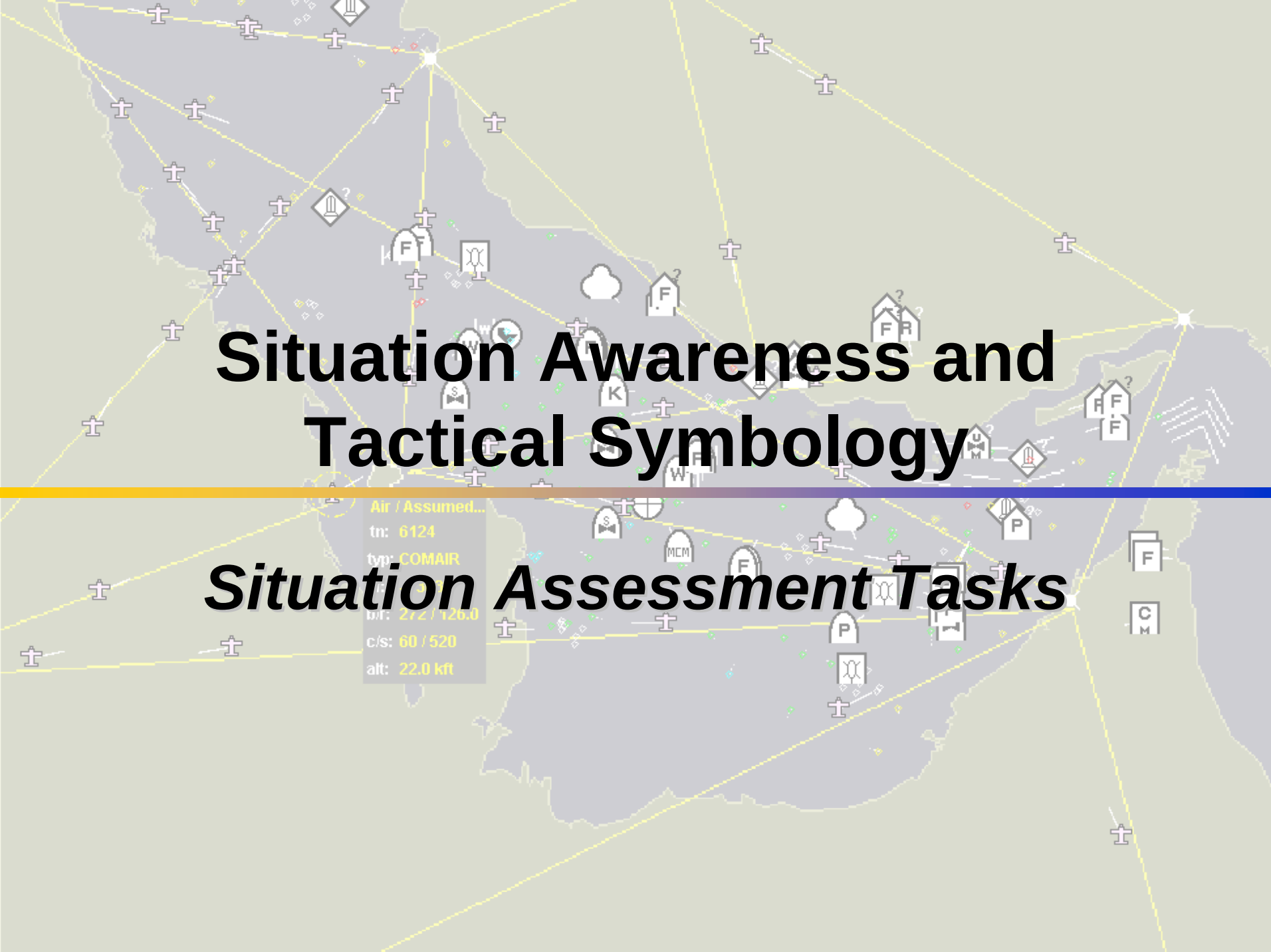
- Full version preferred
- *Letter codes easier to understand and recognize than icons*



COMAIR

- Preferred purple, no-frame COMAIR symbol
- *Size and color make it less obtrusive*





Situation Awareness and Tactical Symbology

Situation Assessment Tasks

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Situation Assessment Testing

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Three symbol types tested:

- Colorized NTDS
- Adaptation of MIL-STD-2525B (filled)
  - Smaller size, purple frame-off COMAIR
- Realistic 3D icons

Four test tasks used

- Each task addressed a different symbology issue
- Color coding and track filtering was identical across symbol sets
- NTDS and 2525B shown using same software

Background and Constraints

Tactical Scenario:

- Static situation, 296 tracks & special points
- Tracks filtered out based on task requirements
- No display manipulation allowed, 2D or 3D

2D display:

- Custom display, changeable symbol sets

3D display:

- PC-based, small symbol library (<20 symbols)
- Only fixed location CRO available in 3D displays

Participants:

- 45 total: 25 Active Duty, 10 Navy experienced, 10 non-Navy

Symbol Sets and Color Codes

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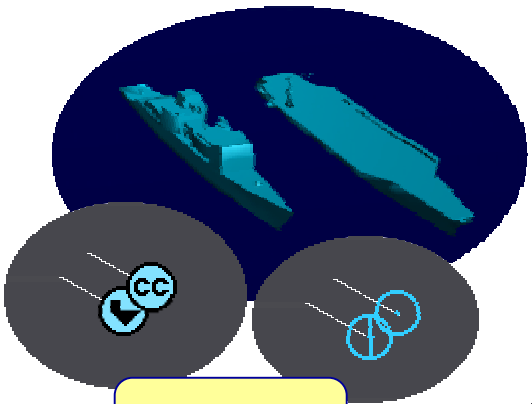
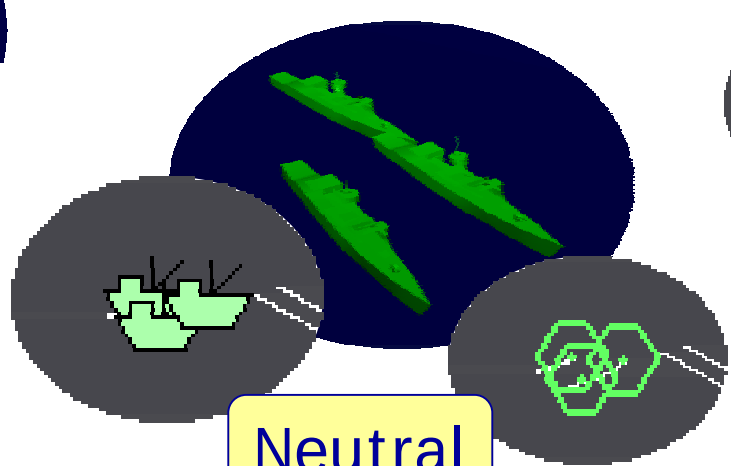
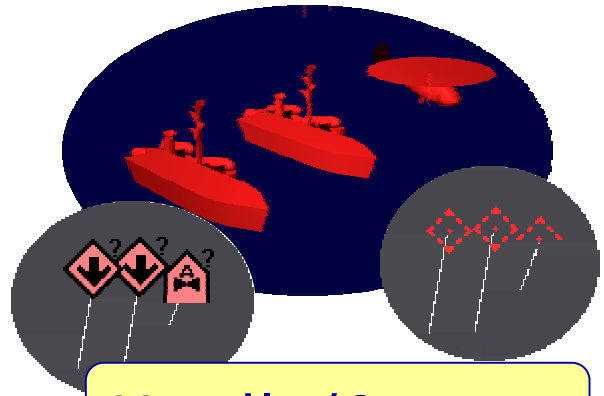


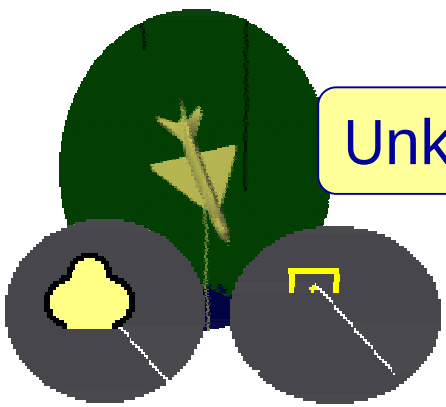
Friend



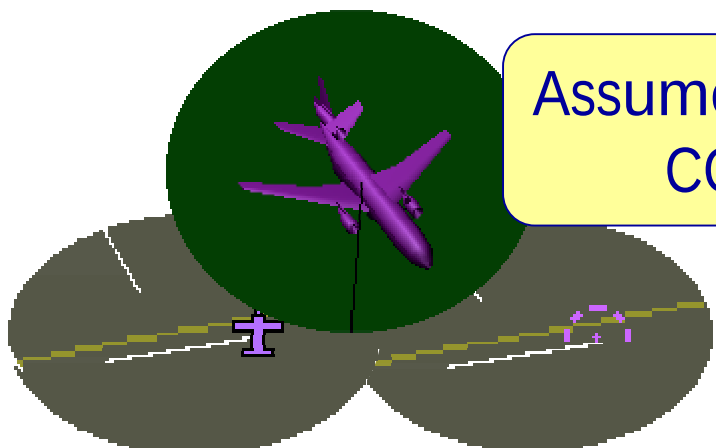
Neutral



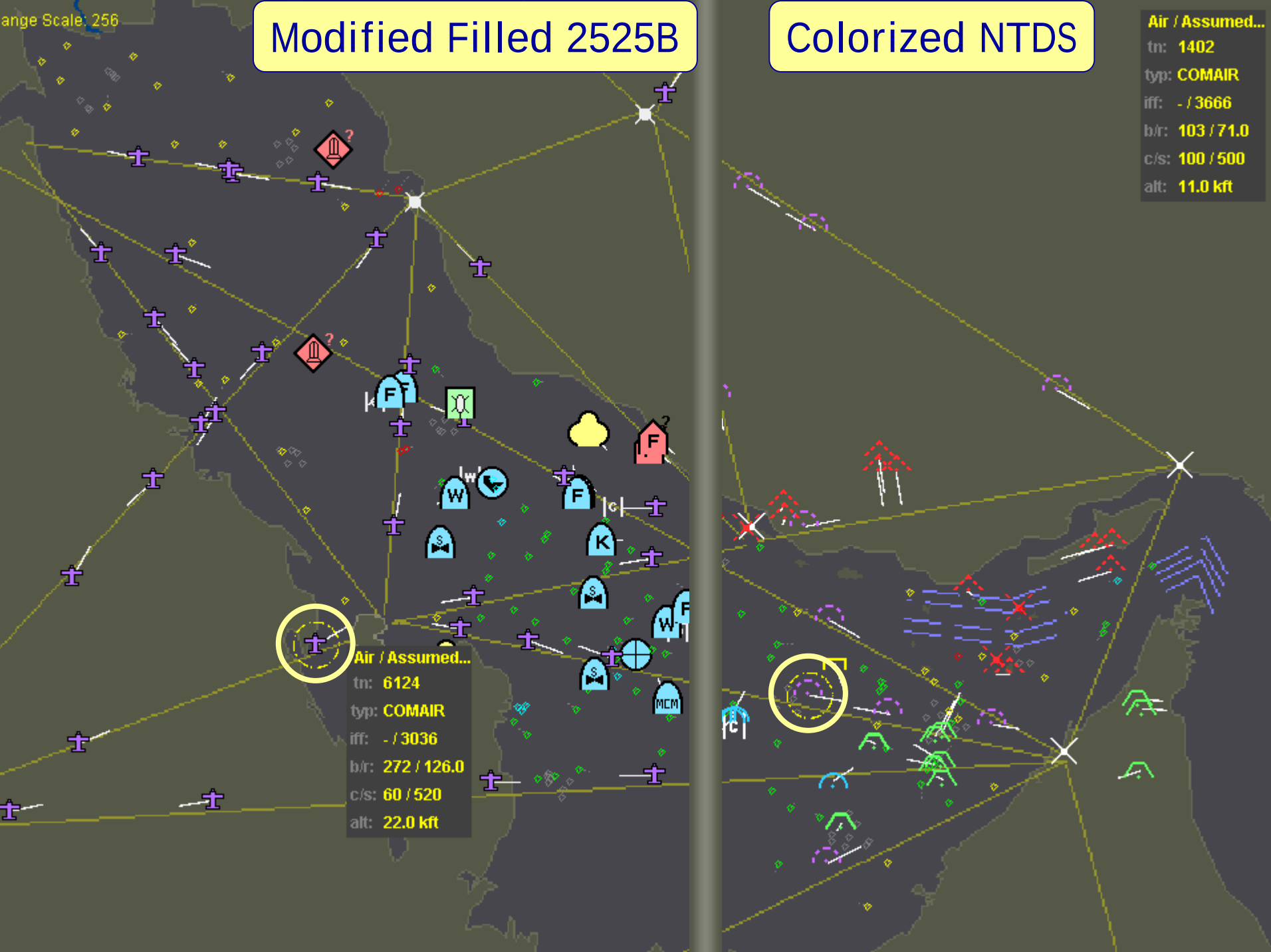
Hostile/Suspect

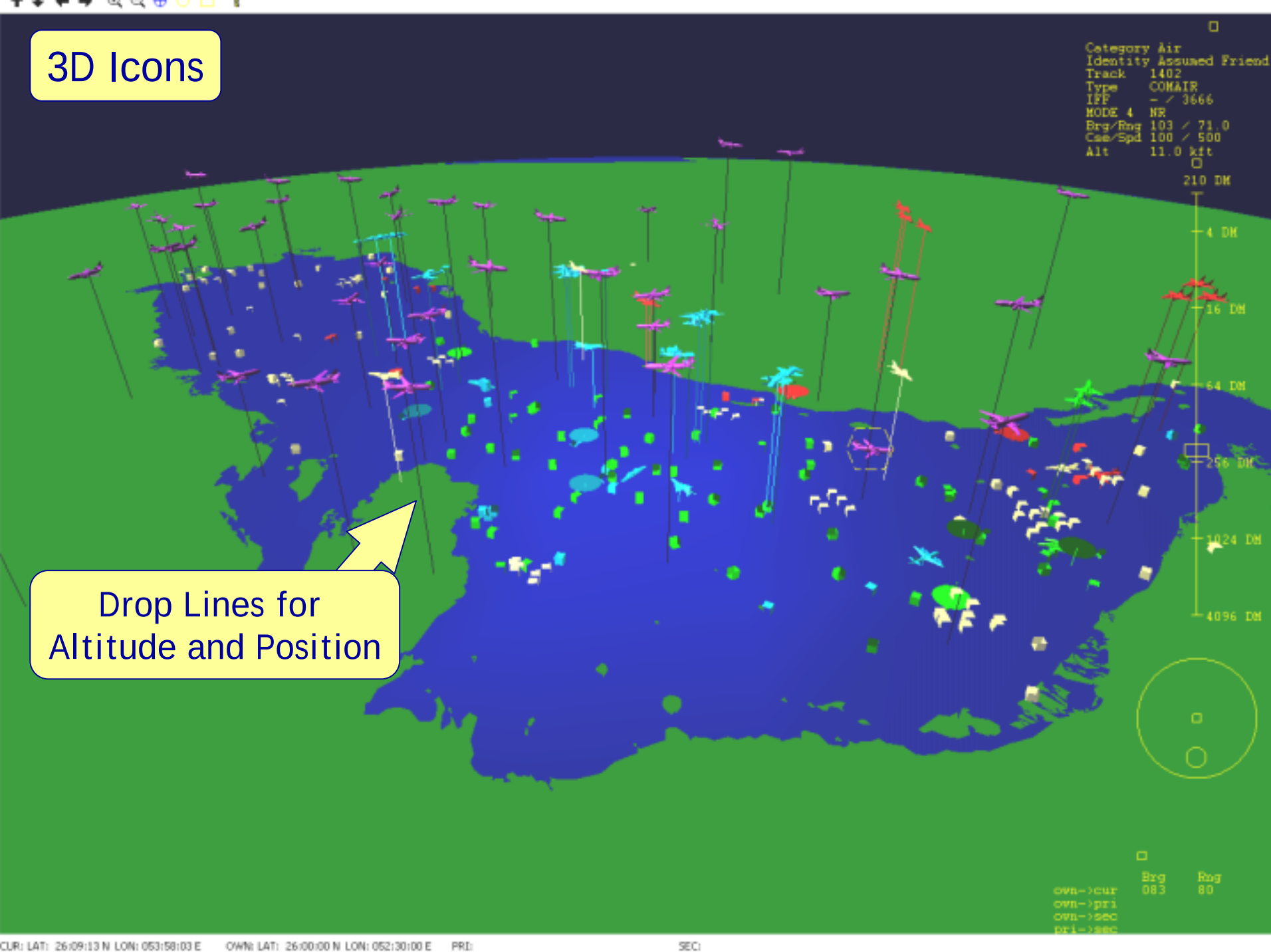


Unknown



Assumed Friend/ COMAIR


ange Scale: 256
Modified Filled 2525B
Colorized NTDS
Air / Assumed...
tn: 6124
typ: COMAIR
iff: - / 3036
b/r: 272 / 126.0
c/s: 60 / 520
alt: 22.0 kft
Air / Assumed...
tn: 1402
typ: COMAIR
iff: - / 3666
b/r: 103 / 71.0
c/s: 100 / 500
alt: 11.0 kft


3D Icons
Drop Lines for
Altitude and Position
Category Air
Identity Assumed Friend
Track 1402
Type COMAIR
IFF - / 3666
MODE 4 NR
Brg/Rng 103 / 71.0
Cse/Spd 100 / 500
Alt 11.0 kft
210 DM
4 DM
16 DM
64 DM
256 DM
1024 DM
4096 DM
Brg Rng
ovn->cur 083 80
ovn->pri
ovn->sec
pri->sec
CUR: LAT: 26:09:13 N LON: 053:58:03 E
OWN: LAT: 26:00:00 N LON: 052:30:00 E
PRI:
SEC:

Situation Assessment Test Tasks

Search for specific **air** tracks

- IFF check of friendly aircraft
- *Expect NTDS = 2525B = 3D*

Search for specific **surface** tracks

- Locate neutral tankers
- *Expect 2525B > NTDS = 3D*

Altitude check air tracks

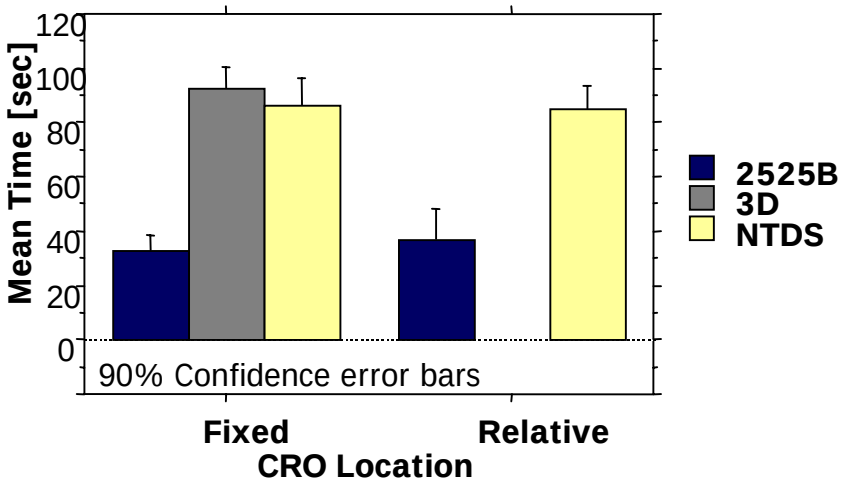
- Locate COMAIR under specific altitude
- *Expect 3D > NTDS = 2525B*

Recognize specific air tracks

- Count number of threat fighter aircraft
- *Expect 2525B > 3D > NTDS*

Search Task Results

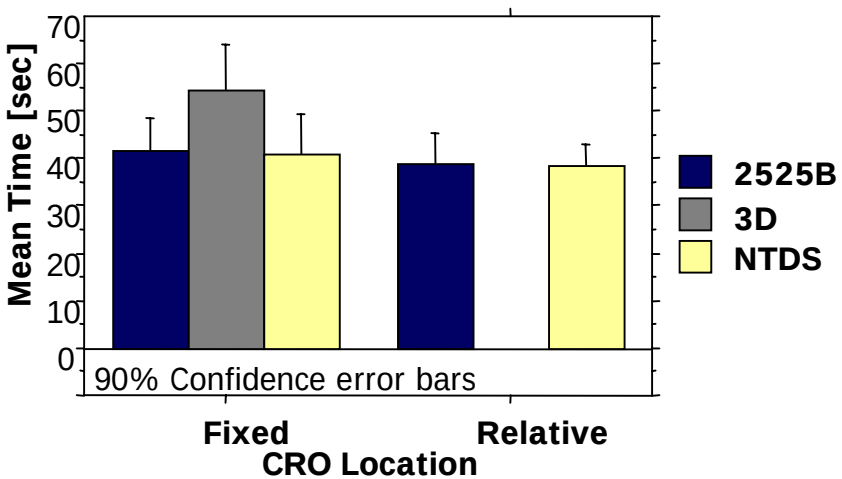
Surface Tracks



2525B faster than NTDS or 3D Icons: 60% less time required

- Required information included within MIL-STD-2525B symbols

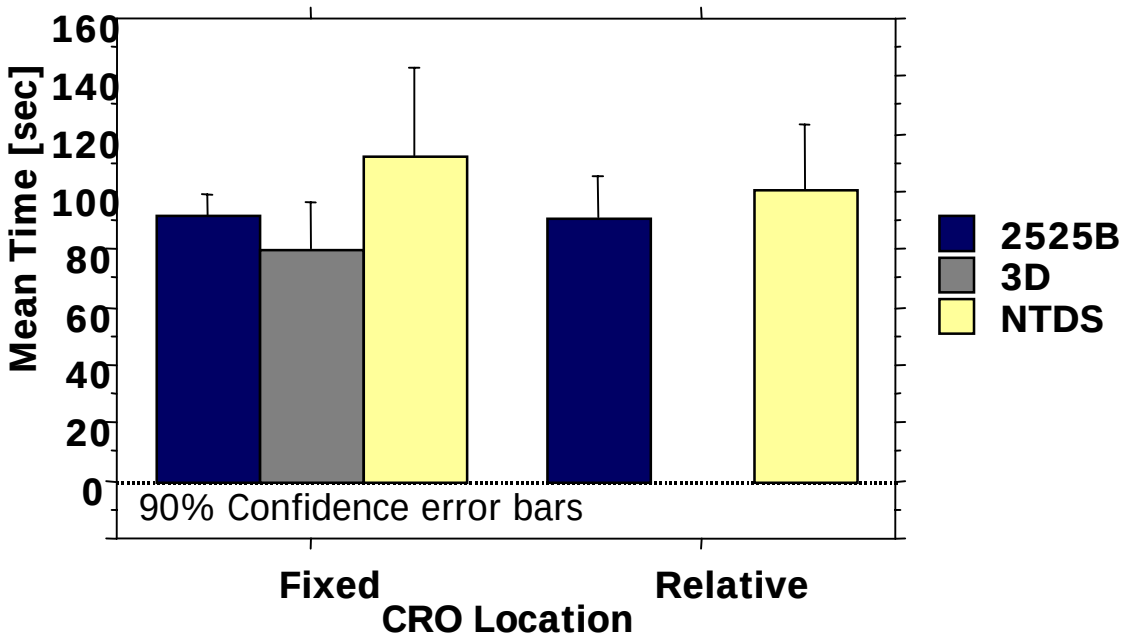
Air Tracks



3D Display slower than 2D sets: 36% increase

- More difficult to pick out tracks in 3D display
- Higher symbol complexity, larger symbol size, and drop lines used in 3D

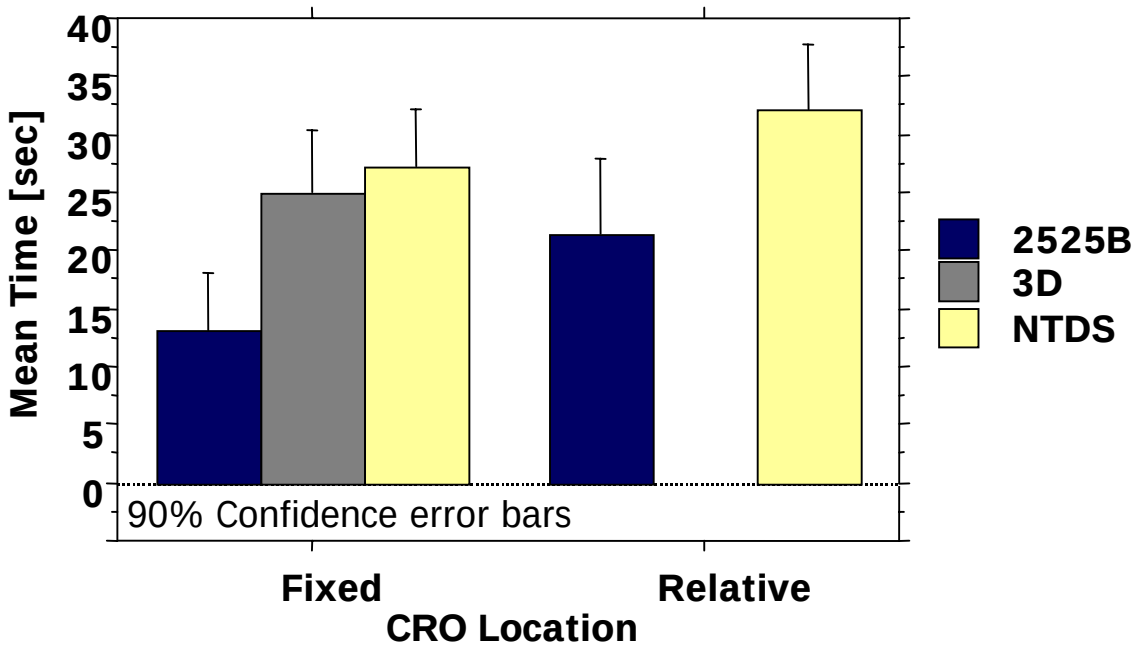
Altitude Task Results



3D marginally faster than 2525B and NTDS, but not significantly

- Drop lines underneath 3D icons allowed altitude estimation without pre-hooking track, but:
  - High track load prevented drop lines from being visible, and
  - Air tracks already shown to be harder to hook in 3D

Track Recognition Task Results



MIL-STD-2525B significantly *faster* than NTDS or 3D Icons: Up to 40% reduction

- 2525B symbols include platform/function information
- 3D Icons show airframe, *implying* function
- Given exact platform to function mapping, performance with 3D would improve

Situation Assessment Test Summary

Search for specific **air** tracks

- *Expected NTDS = 2525B = 3D*
- 3D slower than NTDS or 2525B

Search for specific **surface** tracks

- *Expected 2525B >> NTDS = 3D*
- 2525B faster than NTDS or 3D

Altitude check air tracks

- *Expected 3D > NTDS = 2525B*
- No significant differences for any symbol sets

Recognize specific air tracks

- *Expected 2525B > 3D > NTDS*
- 2525B faster, 3D and NTDS equivalent

Situation Assessment Testing – Conclusions

- High track loads may reduce benefits of 3D displays for specific tasks
  - Drop lines hard to pick out with many tracks
- No difference between 2D and 3D displays in hooking surface tracks
- Harder to hook air tracks in 3D displays than in 2D
- Amplifying info in 2525B symbols significantly reduces response time
  - 3D potentially better than NTDS, but not better than 2525B
- Despite strong operator preference, no performance benefit with Relative CRO

Outline

Background

- Symbology principles, MIL-STD-2525 history

Previous Work

- Studies on symbology and situational awareness

Current Work

- PEO Integrated Warfare Systems (IWS) project on implementation of MIL-STD-2525 for Littoral Combat Ship (LCS)

PEO IWS
MIL-STD-2525 Effort

- Goal is to impact systems for Littoral Combat Ship (LCS)
- Funding cut, but may be restored
- Three components:
  - Conduct evaluations of implementation options and necessary modifications
  - Develop “Implementation Guide”
  - Develop sample symbol filtering capability

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Planned Evaluations

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- Selection of symbol fill colors
- Selection of default symbol sizes
- Impact of alternative Neutral frame shape on filled symbol discriminability
- Selection of new symbols
- Selection of new symbol modifiers
- Definition of engagement modifiers
- Design of HCI for symbol filtering

Study Summary

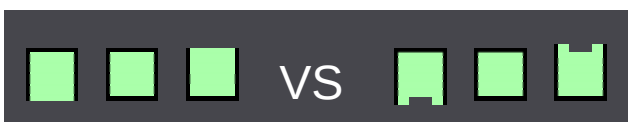
Preliminary Study: Results

- **COLOR:** Saturated “pure” colors have faster search times than standard “pastel” colors

- **ID:** Hostiles & Friendlies have faster search times and less errors than Neutrals & Unknowns

- **SIZE:** Size of symbol from small (16x16 pixels) to large (32x32) had no impact on performance
  - Operators preferred medium (24x24) and large (32x32) icons

- **TYPE:** Neutral symbols were difficult to discern type (air, surface, subsurface)
  - Alternate Neutral symbol with a “notched” fill greatly improved search times



Current Study

- **NEW 2525B SYMBOLS:**
  - Fill in current gaps between AEGIS B/L 7 and MIL-STD-2525B
  - Create new symbols (i.e., LCS, USV, & Ballistic Missiles)
- **NOTCHED FRAME FILL:** Determine if performance benefits transcend Neutral tracks
- **SPEED LEADERS:** Test speed estimation and icon legibility with speed leaders in front or in back of symbols
- **SUSPECT & ASSUMED FRIEND MODIFIERS:** “?” modifier is standard but may be occluded in high density TACSITs
  - Dotted symbol frame options are being tested in addition to “?” modifier
- **COMAIR TRACKS:** Determine alternate way to represent commercial air (COMAIR) tracks
  - Test the use of purple fill to denote COMAIR

Planned Content of Implementation Guide

- Recommended symbol set (subset of MIL-STD-2525)
- Recommended symbol sizes and colors
- Default filtering options
- Navy-specific additions
  - Additional symbols
  - Additional symbol modifiers
  - Engagement modifiers

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Recommended Changes to MIL-STD-2525

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(1) Change Civil Air symbols to “Frame Optional” (**High Priority**)

- Civil Sea Surface symbols currently Frame Optional
- COMAIR tracks often ID’d as “Assumed Friend,” requiring external modifier
- Removal of frame allows symbols to be less obtrusive

(2) Add Non-Real Time symbol modifier (**High**)

- Visual distinction for NRT tracks is needed
- Aegis internal alphanumeric modifier can’t be carried over to MIL-STD-2525

Recommended Changes to MIL-STD-2525

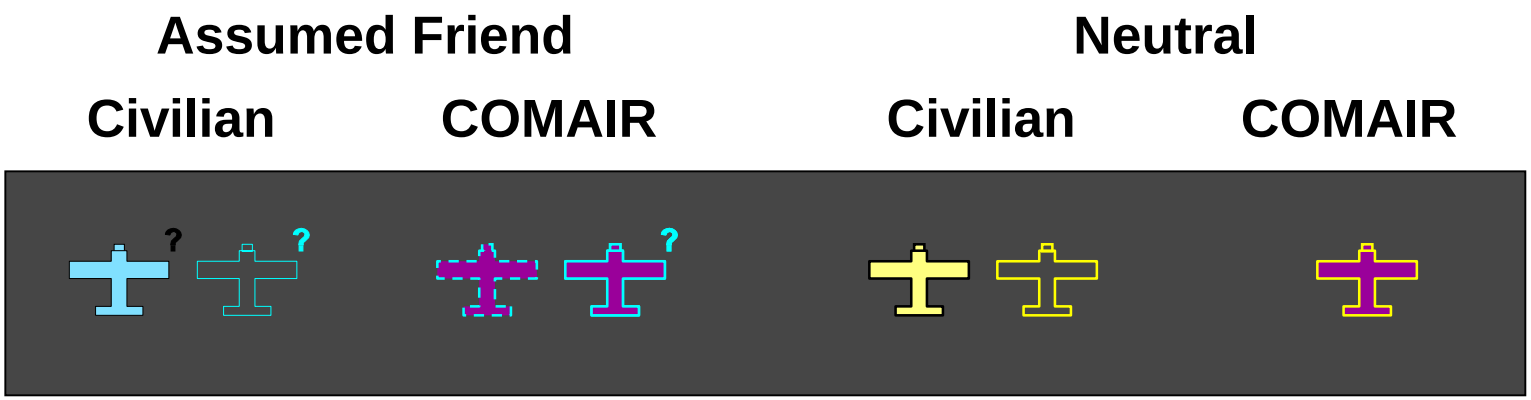
(3) Permit use of dashed outline for Assumed Friend and Suspect (**High**)

- "Planned" or "Anticipated" positions have little to no utility for Surface Navy
- Users have strong association for dashed symbols and this use
- Dashed outline appears to be more easily identified than question mark external to the frame

Recommended Changes to MIL-STD-2525

(4) Permit use of purple fill for commercial tracks (**High**)

- COMAIR tracks may be various Affiliations, but treated similarly
- Could lose representation of Affiliation if shown “Frame Off”
- Could reconcile with Icon Outline in Affiliation color, filled with “commercial” color



Recommended Changes to MIL-STD-2525

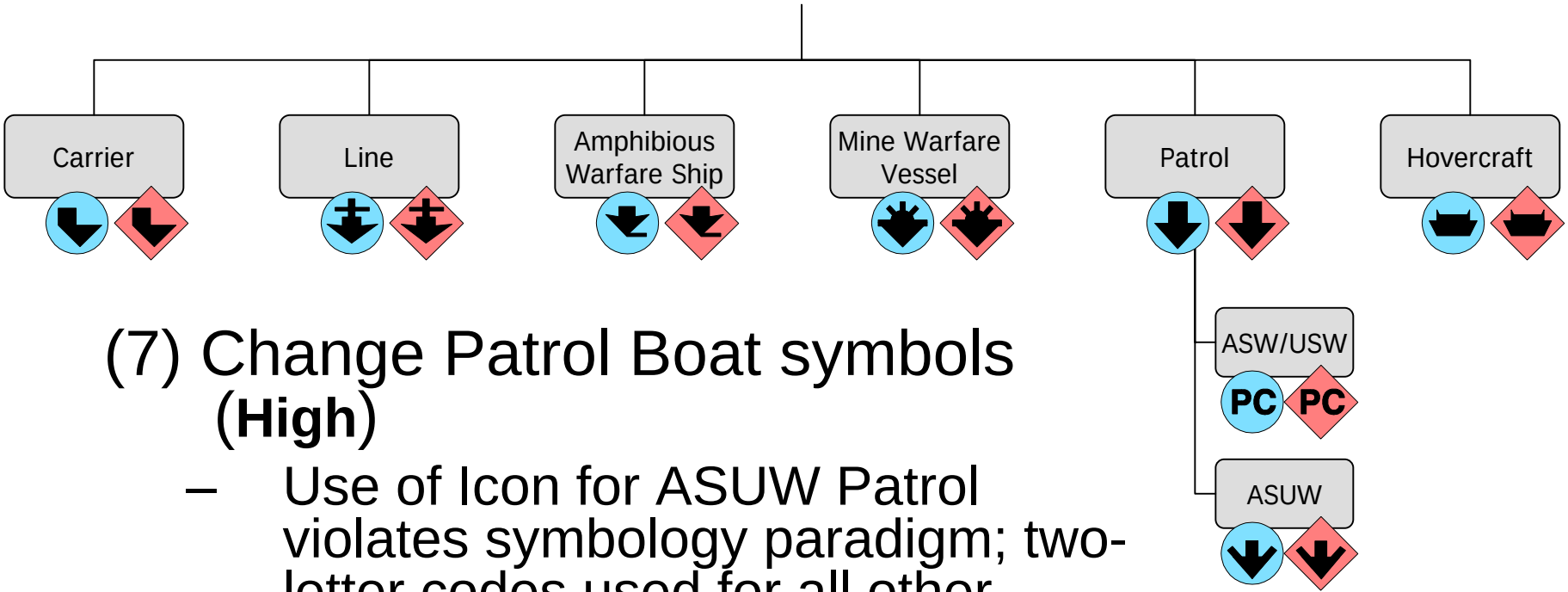
(5) Add symbology for Littoral Combat Ship (**High**)

- New symbol needed for new class of ship
- Symbol should allow for reconfigurability of ship, much like UAV symbols
- But designation of the ship class is still TBD (Defense News, 13 Dec 04)

(6) Add symbology for Unmanned Surface Vehicles (USVs) (**High**)

- Current symbols include UAVs and UUVs, but no USVs
- USVs with different functions are critical part of LCS concept

Recommended Changes to MIL-STD-2525



(7) Change Patrol Boat symbols (**High**)

- Use of Icon for ASUW Patrol violates symbology paradigm; two-letter codes used for all other detailed symbols
- "PC" more appropriate for ASUW than ASW/USW
- Opportunity for consistency with Aircraft codes (N = ASUW, S = ASW)

Recommended Changes to MIL-STD-2525

(8) Add SPACE track for TBM/ICBM (**High**)

- "Generic" Space Track would have to be used now

(9) Add new symbols (**Medium Priority**)

- Electronic Counter Measure (ECM) and Surface Decoys
  - Use same basic symbol as Air and Subsurface decoys
- Command Ship

Recommended Changes to MIL-STD-2525

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(10) Add Submarine Modifiers (**Medium Priority**)

- No modifiers available for certainty of classification (POSSUB, PROBSUB, CERTSUB)
- No modifiers available for submerged/surfaced submarines

(11) Add symbology for missile submarines (**Medium Priority**)

- Current symbols only account for type of propulsion
- Current Navy symbology provides visual distinction
- Fielding of SSGN may need to be addressed