Higher-level Information Fusion for Situation Assessment

Part 1: General principles, recent developments, and challenges
Part 2: Application to MPA (CP-140)

Dr. Pierre Valin, Thrust Leader for Air Command, DRDC Valcartier
Outline

• PART 1: General principles, developments, challenges
  – Fusion levels: past, present and future
  – What is High-Level Information Fusion (HLIF)?
  – Situation Awareness & Threat Assessment
  – Decision Support Systems (DSS) and the OODA loop
  – Ontologies for Recognition & Identification (R&I)
  – Challenges, tradeoffs (kudos to Dale Lambert)
  – Issues with reliability and credibility

• PART 2: Maritime Patrol Aircraft (MPA), e.g. the CP-140
  – Description (pre- and post- AIMP)
  – 2 scenarios (MAAO and DFS), relevant to piracy operations
  – Typical performance of fusion, SAR, and FLIR

• Conclusions & Questions
Part 1: General principles, recent developments, and challenges
The JDL 1998 revised framework

A different view of the levels
The DFIG update

- DFIG members are: Frank White, Otto Kessler, Chris Bowman, James Llinas, Erik Blasch, Gerald Powell, Mike Hinman, Ed Waltz, Dale Walsh, John Salerno, Alan Steinberg, Dave Hall, Ron Mahler, Mitch Kokar, Joe Karalowski, Richard Antony
Need for Multi-Sensor Data Fusion

• We are drowning in information but starved for knowledge
  – This level of information is clearly impossible to be handled by present means (without some automation)
  – Uncontrolled and unorganized information is no longer a resource in an information society, instead it becomes the enemy

• MSDF has a “language” defined by the JDL:
  – Level 0 – Data Assessment
  – Level 1 – Object Assessment
  – Level 2 – Situation Assessment
  – Level 3 – Impact Assessment
  – Level 4 – Process Refinement
  – Level 5 – User Refinement
  – Level 6 – Mission Management

• At the heart of MSDF is the OODA loop: Observe, Orient, Decide, and Act (Col. John Boyd, 1986)
ID Info Fusion in level-1 MSDF

Diagram showing the flow of information and processes within a system. The diagram highlights the integration of information from various sources, including navigation, other information sources, sensors, and configuration monitoring. Key processes include data alignment, data association, track management, and kinematic data fusion. The diagram also indicates the interaction with track data store, tactical picture, and configuration requests.
Basic questions (1) from FUSION 2010 panel

• What is High-Level info Fusion (HLIF) as opposed to low-level information fusion?
  – Adopt the JDL “definition” that starts at situation assessment & includes everything else BUT
    • Level 0 (sub-object assessment often done in modern sensors, especially imaging sensors), and
    • Level 1 which involves tracking and ID (taxonomy/ontology dependent) at the platform level

• What are the tacit implications for HLIF?
  – HLIF techniques that can be employed are too numerous to guarantee a consistent picture for the user/commander – Need for standards
  – HLIF needs many networked platforms/sensors – by definition HLIF is distributed, and thus communications are very important
Basic questions (2) from FUSION 2010 panel

• What techniques and procedures are most applicable to HLIF?
  – Mixture of numeric and symbolic reasoning, such as expert systems, artificial intelligence

• What is needed in HLIF to support control (versus estimation)?
  – An efficient user interface that shows only relevant data (filtering, GIS, etc.), and that is defined according to the user’s role.
  – an underlying secure backbone (the “net”)
  – security: multi-layered, multi-caveat

• What is the impact of HLIF to decision support?
  – HLIF should provide alternatives, not make the decision for the commander.
  – In this respect, user inputs/decisions should enter at every fusion level.
DFIG HLIF functions

- **Level 2 – Situation Assessment**: estimation and prediction of relations among entities, to include force structure and force relations, communications, etc. (e.g. information processing), essential for recognition of piracy efforts.

- **Level 3 – Impact Assessment**: estimation and prediction of effects on situations of planned or estimated actions by the participants; to include interactions between action plans of multiple players (e.g. assessing threat/intent actions to planned actions and mission requirements, performance eval.), essential for prediction of piracy efforts.

- **Level 4 – Process Refinement**: (an element of Resource Management) adaptive data acquisition and processing to support sensing objectives (e.g. fusion process control and information systems dissemination), for optimizing data collection of piracy efforts.

- **Level 5 – User Refinement**: adaptive determination of who queries information and who has access to information (e.g. information operations) and adaptive data retrieved and displayed to support cognitive decision making and actions (e.g. human computer interface).

- **Level 6 Mission Management**: adaptive determination of spatial-temporal control of assets (e.g. airspace operations) and route planning and goal determination to support team decision making and actions (e.g. theatre operations) considering social, economic, and political constraints.
Can a generic HLIF exist?

- Most approaches start from a description of the mission, therefore specific, not generic, e.g. mission goals such as piracy recognition and prediction are decomposed into sub-goals which eventually are asserted using Situation Evidence – see INFORM Lab presentation by A. Guitouni.

- HLIF must bridge the gap between numeric and symbolic.

- Salerno’s FUSION 2009 question for HLIF MOEs:
  - Is it possible to be have a set of MOEs that are completely Domain Independent? my answer: PROBABLY NO, so we need to come up with some for countering piracy.

- Even if the first branches of mind-maps are to some extent generic, the subsequent branches are specific to the context. Examples later for SA and TA.
An attempt at HLIF MOEs

HLIF Effectiveness = InfoGain * Quality * Robustness

where (FUSION 2010 paper)

InfoGain = value-added aggregation of elements of a situation (e.g. ability to link different regions of activity into a common temporal/spatial operational picture)

Quality = timeliness for actionable information, uncertainty reduction, and information confidence

Robustness = coping with real-world variation
A Model of Situation Awareness

Task/System Factors
- System Capability
  - Interface design
  - Stress and workload
  - Complexity, Automation

Individual Factors
- Perception of Elements in Current Situation
- Comprehension of Current Situation
- Projection of Future Status
- Decision
- Performance of actions
- Information Processing Mechanisms
  - Long Term Memory Stores
  - Automaticity

State of the environment

Feedback

Goals & Objectives
- Preconceptions (expectations)

This workshop is supported by: The NATO Science for Peace and Security Programme
An ontological view of Level 2 (SA)
(A-C Boury-Brisset, DRDC Valcartier, FUSION 2003)
An ontological view of Level 3 (TA)
(A-C Boury-Brisset, DRDC Valcartier, FUSION 2003)
Threat Analysis and Response Planning

Inherent Threat Assessment
- Inherent Threat Value Calculation
- Inherent Threat Ranking
  - Prioritized Threat List

Prioritized Risk List
- Actual Risk Ranking
- Actual Risk Value Calculation

Actual Risk Assessment

Reaction Time Analysis
- Quick Reaction Alerts

Critical Risk Analysis
- Critical Risk Alerts

Response Planning
- Prioritized Engagement List

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Decision Support Required?

- Communication and Collaboration
- Situation Awareness Support Including Assets Monitoring
- Planning and Decision Support
- Execution Management (coordination and control)
- Integration: Open System Architecture e.g. SOA
The Canadian view (DNDAF)
The OODA loop in the presence of enemies $MIPC = OODA$
Identification or recognition?

• According to Chap. 6 of NATO MTP1, Vol. 1
  
  – **Identification** refers to the assignment of one of the six standard STANAG 1241 identities (sometimes called allegiances) to a track (Hostile, Suspect, Unknown, Neutral, Assumed Friend, Friend)
  
  – **Recognition** can range from a very rough scale (e.g. combatant/merchant) to a very fine one (e.g. name of contact/track), according to a hierarchical taxonomy such as MIL-STD-2525C (November 2008) or STANAG 4420
  
  – Often, in the academic literature, the meanings are reversed, e.g. an ID refers to a platform name, such as HALIFAX class frigate
  
  – To provide proper Recognition, and then STANAG 1241 Identification in level-1 fusion, one needs a Platform DataBase (PDB) containing attributes relevant for each platform. A situation can then be recognized from the interaction between platforms (HLIF).
Attributes in a PDB form 3 groups

1. **Kinematical**, providing limits for ID validation and typical values for fuzzified sensor declaration:
   - maximum: acceleration, altitude, speed (also minimum), etc.
   - typical: cruise velocity

2. **Geometrical**, for use with/within imaging sensor classifiers, providing Image Support Modules (ISM) similar to ESM role
   - actual size (length, width, height)
   - RCS values (top, side, front)

3. **Identification**, from intelligent sensors and/or operators
   - from Image Support Modules (ISM) for FLIR and SSAR
   - from ESM declaration of emitters on target platform
<table>
<thead>
<tr>
<th>ID #</th>
<th>NAME</th>
<th>FLATYPE</th>
<th>SUBTYPE</th>
<th>OFFENS</th>
<th>CONT</th>
<th>V MAX</th>
<th>LSM</th>
<th>HEI</th>
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<td>SURNILL</td>
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<td>STROOP</td>
<td>RUSS</td>
<td>32</td>
<td>124</td>
<td>5</td>
<td>14</td>
<td>62 59 66 45 71 103 101</td>
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<td>124</td>
<td>5</td>
<td>14</td>
<td>62 59 66 45 71 103 101</td>
<td></td>
</tr>
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</table>

**SAR IMAGERY**
Ontologies, e.g. MIL-STD-2525C (Nov. 2008)
PDBs obey a taxonomy, e.g. surface ships

Really Non-Navy: non-military in MIL-STD

- Combatant
  - Line: Carrier, Battleship, Cruiser, Destroyer, Frigate/Corv.
  - Amphibious Warfare
  - Mine Warfare
  - Patrol
  - Multi Purpose

- Non-Combatant
  - Underway Replenishment
    - Service & Support
    - Intelligence
    - Service & Support HBR

- Non-Naval
  - Merchant
    - Cargo, RoRo, Oiler/Tanker, Tug, Ferry, Passenger
  - Fishing
  - Leisure
  - Law Enforcement
  - Multi Purpose

STANAG 4420
Display Symbology and Colour for NATO Maritime Units

This workshop is supported by The NATO Science for Peace and Security Programme
Examples of line combatants

Knowledge Base generic rule #1:
line combatants => superstructures in the center
Examples of merchants

Knowledge Base generic rule #2:
merchants => superstructures at the end

NATO Science for Peace and Security Programme
PDBs obey a taxonomy, e.g. for air tracks

Americans use MIL-STD-2525C

Common Warfighting Symbology
Can one distinguish the platform?

They are all Fighters, i.e. a node in the PDB.
Ontology symbols

at war for exercises

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>HAND DRAWN</th>
<th>COMPUTER GENERATED</th>
<th>DARK</th>
<th>MEDIUM</th>
<th>LIGHT</th>
</tr>
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<tbody>
<tr>
<td>Hostile, Suspect, Joker, Faker</td>
<td>Red</td>
<td></td>
<td>RGB</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HSL (200, 0, 0)</td>
<td>RGB (255, 48, 49)</td>
<td>(0, 255, 100)</td>
<td>(0, 255, 152)</td>
<td>(0, 255, 192)</td>
</tr>
<tr>
<td>Friend, Assumed Friend</td>
<td>Blue</td>
<td></td>
<td>RGB</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HSL (0, 107, 140)</td>
<td>RGB (0, 168, 229)</td>
<td>(138, 255, 70)</td>
<td>(138, 255, 110)</td>
<td>(138, 255, 192)</td>
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<tr>
<td>Neutral</td>
<td>Green</td>
<td></td>
<td>RGB</td>
<td></td>
<td></td>
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<td></td>
<td>HSL (85, 255, 80)</td>
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<td>(85, 255, 80)</td>
<td>(85, 255, 113)</td>
<td>(85, 255, 213)</td>
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<td>Unknown, Pending</td>
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<td></td>
<td>RGB</td>
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<td></td>
<td>HSL (225, 255, 110)</td>
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<td>(225, 220, 0)</td>
<td>(255, 255, 0)</td>
<td>(255, 255, 128)</td>
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<td>Civilian (Optional Fill)</td>
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<td>RGB</td>
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<td>RGB (255, 161, 255)</td>
<td>(80, 0, 80)</td>
<td>(128, 0, 128)</td>
<td>(255, 161, 255)</td>
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</table>

This workshop is supported by The NATO Science for Peace and Security Programme.
Ontology Engineering (TEWA)
Dale Lambert’s 5 grand challenges

• **Semantic Challenge:** What symbols should be used and how do those symbols acquire meaning?

• **Epistemic Challenge:** What information should we represent and how should it be represented and processed within the machine?

• **Paradigm Challenge:** How should the interdependency between the sensor fusion and information fusion paradigms be managed?

• **Interface Challenge:** How do we interface people to complex symbolic information stored within machines?

• **System Challenge:** How should we manage data fusion systems formed from combinations of people and machines?
Dale Lambert’s 8 tradeoffs

1. Automation levels, from fully manual to fully automatic, with all levels in between
2. Integration, including communication protocols, topology, roles, bandwidth, etc.
3. Fusion model, for machine-machine integration (MMI), human-machine integration (HMI) and human-human integration (HHI) aspects
4. SA by humans or machine, or both
5. Fusion C2 policy, centralized vs. decentralized
6. Representation, expressivity vs. calculability
7. Information processing, analytic vs. heuristic
8. Machine integration
Dale Lambert’s STDF model

STDF = State Transition Data Fusion

<table>
<thead>
<tr>
<th>Level</th>
<th>World</th>
<th>Human</th>
<th>Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 3:</td>
<td>Scenario</td>
<td>Human Projection</td>
<td>Machine Impact Assessment</td>
</tr>
<tr>
<td></td>
<td>scenario state $s(k)$</td>
<td>$\hat{s}(k+1</td>
<td>k+1)$</td>
</tr>
<tr>
<td>Level 2:</td>
<td>Situation</td>
<td>Human Comprehension</td>
<td>Machine Situation Assessment</td>
</tr>
<tr>
<td></td>
<td>state of affairs $\Sigma(k)$</td>
<td>$\hat{\Sigma}(k+1</td>
<td>k+1)$</td>
</tr>
<tr>
<td>Level 1:</td>
<td>Object</td>
<td>Human Perception</td>
<td>Machine Object Assessment</td>
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<tr>
<td></td>
<td>state vector $y(k)$</td>
<td>$\hat{y}(k+1</td>
<td>k+1)$</td>
</tr>
<tr>
<td>Level 0:</td>
<td>Observable</td>
<td>Human Sensation</td>
<td>Machine Observable Assessment</td>
</tr>
<tr>
<td></td>
<td>feature vector $d(k)$</td>
<td>$\hat{d}(k+1</td>
<td>k+1)$</td>
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**Issues in information evaluation: reliability — STANAG 2022**

**STANAG 2022 reliability codes**

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<tr>
<th>RELIABILITY</th>
<th>CODE</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completely reliable</td>
<td>A</td>
<td>It refers to a tried and trusted source which can be depended upon with confidence.</td>
</tr>
<tr>
<td>Usually reliable</td>
<td>B</td>
<td>It refers to a source which has been successfully used in the past but for which there is still some element of doubt in particular cases.</td>
</tr>
<tr>
<td>Fairly reliable</td>
<td>C</td>
<td>It refers to a source which has occasionally been used in the past and upon which some degree of confidence can be based.</td>
</tr>
<tr>
<td>Not usually reliable</td>
<td>D</td>
<td>It refers to a source which has been used in the past but has proved more often than not unreliable.</td>
</tr>
<tr>
<td>Unreliable</td>
<td>E</td>
<td>It refers to a source which has been used in the past and has proved unworthy of any confidence.</td>
</tr>
<tr>
<td>Reliability cannot be</td>
<td>F</td>
<td>It refers to a source which has not been used in the past.</td>
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## Issues in information evaluation: credibility – STANAG 2022

### STANAG 2022 credibility codes

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<thead>
<tr>
<th>CREDIBILITY</th>
<th>CODE</th>
<th>EXPLANATION</th>
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<tbody>
<tr>
<td>Confirmed by other sources</td>
<td>1</td>
<td>If it can be stated with certainty that the reported information originates from another source than the already existing information on the same subject.</td>
</tr>
<tr>
<td>Probably true</td>
<td>2</td>
<td>If the independence of the source of any item of information cannot be guaranteed, but if, from the quantity and quality of previous reports, its likelihood is nevertheless regarded as sufficiently established,</td>
</tr>
<tr>
<td>Possibly true</td>
<td>3</td>
<td>If, despite there being insufficient confirmation to establish any higher degree of likelihood, a freshly reported item of information does not conflict with the previously reported behaviour pattern of the target,</td>
</tr>
<tr>
<td>Doubtful</td>
<td>4</td>
<td>An item of information which tends to conflict with the previously reported or established behaviour pattern of an intelligence target.</td>
</tr>
<tr>
<td>Improbable</td>
<td>5</td>
<td>An item of information which positively contradicts previously reported information or conflicts with the established behaviour pattern of an intelligence target in a marked degree.</td>
</tr>
<tr>
<td>Cannot be judged</td>
<td>6</td>
<td>If its truth cannot be judged.</td>
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Issues in information evaluation: reliability of codes – MIL STD 6040

**MIL-STD-6040 reliability of information codes**

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<th>CODE</th>
<th>EXPLANATION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly and consistently reliable</td>
<td>A</td>
<td>Refers to information that can be depended upon with much confidence.</td>
<td>0.95</td>
</tr>
<tr>
<td>Very reliable</td>
<td>B</td>
<td>Refers to information upon which some degree of confidence can be placed.</td>
<td>0.85</td>
</tr>
<tr>
<td>Fairly reliable</td>
<td>C</td>
<td>Refers to information for which there is some element of doubt.</td>
<td>0.75</td>
</tr>
<tr>
<td>Not usually reliable</td>
<td>D</td>
<td>Refers to information for which there is more doubt than confidence.</td>
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</tr>
<tr>
<td>Unreliable</td>
<td>E</td>
<td>Refers to information that has proven to be unworthy of any confidence.</td>
<td>0.1</td>
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<tr>
<td>Reliability cannot be judged</td>
<td>F</td>
<td>Refers to information that has not yet been evaluated for reliability</td>
<td>0.6</td>
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</table>

**MIL-STD-6040 reliability of source codes**

| RELIABILITY OF SOURCE                       | CODE | EXPLANATION                                                                 | |
|--------------------------------------------|------|------------------------------------------------------------------------------|
| ROS percentage 100%                        | 100  | A tried and trusted source which can be depended upon with confidence.       | |
| ROS percentage 80%                         | 80   | A source which has been successful in the past but for which there is still some element of doubt in a particular case. | |
| ROS percentage 60%                         | 60   | A source which has occasionally been used in the past and upon which some degree of confidence can be based. | |
| ROS percentage 40%                         | 40   | A source which has been used in the past but has proved more often than not unreliable. | |
| ROS percentage 20%                         | 20   | A source which has been used in the past and has proved unworthy of any confidence. | |
| ROS percentage 0%                          | 0    | A source which has not been used in the past. | |
Part 2: Application to MPA, such as the Canadian Aurora or CP-140
Aurora = P-3 (Orion) with S-3 (Viking) sensors
AIMP = Aurora Incremental Modernization Program

SSAR upgrade
FLIR +
IFF +
ESM +
Link-11 (soon 16)
Aurora capabilities

• Canada’s only strategic maritime surveillance aircraft, the CP-140 Aurora is capable of flying more than 9000 km - or 5000 nautical miles - without refuelling

• Its 17-hour endurance make the aircraft ideal for an evolving variety of operations, including long-term observation of piracy efforts.

• With its air-droppable survival pods, the CP-140 can also perform search and rescue duties.
Pre-AIMP sensor suite

- Objects of interest = Ships (Friend or Foe), very relevant for piracy operations
- Dissimilar Non-Imaging Sensors for low-level fusion
  - 2-D AN/APS-506 radar providing tracks, in 3 modes
  - Electronic Support Measures (ESM) AN/ALR-502 providing passive ID information through detection of emitters cross-correlated with a realistic a priori Platform DataBase (PDB)
  - Interrogation Friend or Foe (IFF) AN-APX-502 providing allegiance (if in proper working condition)
  - Link-11, mainly for ID information
- Complementary Imaging Sensors for fusion
  - Spotlight Synthetic Aperture Radar (SSAR) planned upgrade to AN/APS-506 radar --> designed & implemented cued classifier
  - Forward-Looking Infra-Red (FLIR) OR-5008/AA passive sensor --> designed & implemented different classifiers & fused them
Attributes in a PDB form 3 groups

1. **Kinematical**, providing limits for ID validation and typical values for fuzzified sensor declaration:
   - maximum: acceleration, altitude, speed (also minimum), etc.
   - typical: cruise velocity

2. **Geometrical**, for use with within imaging sensor classifiers, providing Image Support Modules (ISM) similar to ESM role:
   - actual size (length, width, height)
   - RCS values (top, side, front)

3. **Identification**, from intelligent sensors and/or operators:
   - from Image Support Modules (ISM) for FLIR and SSAR
   - from ESM declaration of emitters on target platform
SAR ISM: hierarchical imagery classifier

STEP 1

Image segmentation
Using ship orientation

STEP 2

9-bin decomposition
Ship length

STEP 3

NN supervised by KB rules for ship category
(Line, Merchant, Unrecognized)

If Line

Bayes classifier for Line ship type (e.g. Frigate)

STEP 4

Ship class modules dispatcher
According to Length, Category, Orientation

NN module for Frigate classes

NN module for Destroyer classes

NN module for Merchants

Fusion Through DS Evidential Reasoning

This workshop is supported by: The NATO Science for Peace and Security Programme
Ship Length is a discriminator for line combatants

... but not for merchants!
Scenario studied: MAAO

MAAO = Maritime Air Area Operations

Fleet of 3 enemy line ships imaged by the SSAR

All 3 ships have some common emitters and are imaged by the SSAR

Some emitters do not correspond to PDB (countermeasures)

Path of Aurora
Scenario studied : DFS

DFS = Direct Fleet Support

- SACRAMENTO support ship
- COONTZ destroyer
- SPRUANCE destroyer
- NIMITZ aircraft carrier
- VIRGINIA cruiser

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Typical results for SAR classifier

**Udaloy destroyer**
- \( L = 140; \ [133, 179] \)
- Line = 86 %
- Merch. = 5 %
- Unrec. = 9 %
- Frigate = 8 %
- Destroyer = 48 %
- Cruiser = 29 %
- Battleship = 0 %
- Aircraft Car. = 1 %

**Kara cruiser**
- Frigate = 0 %
- Destroyer = 10 %
- Cruiser = 67 %
- Battleship = 0 %
- Aircraft Car. = 4 %

**Mirka frigate**
- \( L = 71; \ [66, 102] \)
- Line = 86 %
- Merch. = 5 %
- Unrec. = 9 %
- Frigate = 86 %
- Destroyer = 0 %
- Cruiser = 67 %
- Battleship = 0 %
- Aircraft Car. = 4 %

WARNING: small ship
Typical results for FLIR classifier and Neural Net fuser

Training / Test sizes vary between 1,000 and 1,500

<table>
<thead>
<tr>
<th>Training size</th>
<th>Testing size</th>
<th>Bayes, DS</th>
<th>Bayes, K-NN</th>
<th>Bayes, K-NN, DS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>1500</td>
<td>0.814</td>
<td>0.950</td>
<td>0.951</td>
</tr>
<tr>
<td>Best single classifier</td>
<td>0.773</td>
<td>0.950</td>
<td>0.950</td>
<td></td>
</tr>
</tbody>
</table>

DS = Dempster-Shafer  
K-NN = K Nearest Neighbours
Fusion of imaging & non-imaging sensors by DS reasoning

- Must process **incomplete information** ⇒ ignorance
- Must handle **conflicts** between contact/track ⇒ DS
- Must be a **real-time** method ⇒ Truncation is required
- Operator wants **best ID** ⇒ give preference to singleton
- Operator wants **next best** ⇒ doublet, triplet, etc.
- Must be **tested** operationally ⇒ complex scenarios
- Ordinary DS must explode ⇒ large complex PDB
- Must resist CM ⇒ contact report conflicts with PDB
- Must resist false associations ⇒ ESM to wrong track

CONFLICTING, UNCERTAIN and INCOMPLETE information are ideally suited to Dempster-Shafer (DS) evidential reasoning, while TRUNCATION (TDS) ensures low CPU usage
Typical results of fusion

- Udaloy II in presence of countermeasures

1 = wrong Kara doublet due to false emitter

2 = Udaloy triplet

3 = Udaloy doublet containing the Udaloy II

Emitters correlated to Platform DataBase (PDB)

SAR data #69 #63
Conclusions for CP-140 sensor suite

- Large a priori database constructed
- SSAR ISM classifier implemented
- DS scheme usually robust under
  - Countermeasures (MAAO)
  - Miss-associations (DFS)
  - Wrong ISM reports (DFS)
- ... unless 2 or more of these problems happen at the same time ...
- One could do MHT or MFA to remove miss-associations, but there will be sensor upgrades in the Aurora Incremental Modernization Project (AIMP)
What will AIMP change?

- **Block II: EGI (Embedded GPS and INS)**
  - Positional accuracy of aircraft vastly improved, can provide accuracy needed for SAR imaging
- **Block III: Data Management System (DMS) and new sensors**
  - Modern DMS can allow passive fusion module
  - Wescam MX-20 (EO added to an improved IR)
  - New ESM with “extreme bearing accuracy” will remove ESM-to-track association errors
  - New Telephonic APS-143 imaging radar
- **Block IV: upgrades to sensors not studied previously in fusion:**
  - Acoustic, Magnetic Anomaly Detection (MAD) : irrelevant (only for submarine detection)
- **Substantial gains in sensor resolutions will provide new capabilities to fusion, new challenges too**
New sensors

WESCAM MX-20

APS-143B(V)3

This workshop is supported by: The NATO Science for Peace and Security Programme
MSDF on-board the Aurora

- Selected publications of interest related to platform MSDF
Networked MSDF

- Selected publications of interest related to networked MSDF
  - Bossé, E., Valin, P. Definition of Data/Information Fusion in the Context of the C4ISR plan, TN 2008-538
  - Valin, P., Multi-Platform Information Fusion & Management (UAV, CPF, CP-140) - Final Report, DRDC Valcartier TM 2010-392.
Refined networked MSDF

- **Selected publications of interest related to refined networked MSDF**
  - Valin, P., Bossé, E., Blanchette, M., A Functional Description of the STANAG 4162 NATO Identification System (NIS), DRDC Valcartier TR 2011-XYZ.
QUESTIONS?

CP140

More info at http://www.casr.ca/101-af-cp140-aurora.htm

NATO

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