

Risk Game

Impact of information quality on situation awareness and decision making

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Outline

CMRE Maritime Security programme overview

The Risk Game design

Some exploratory results

Conclusions and future works

Outline

CMRE Maritime Security programme overview

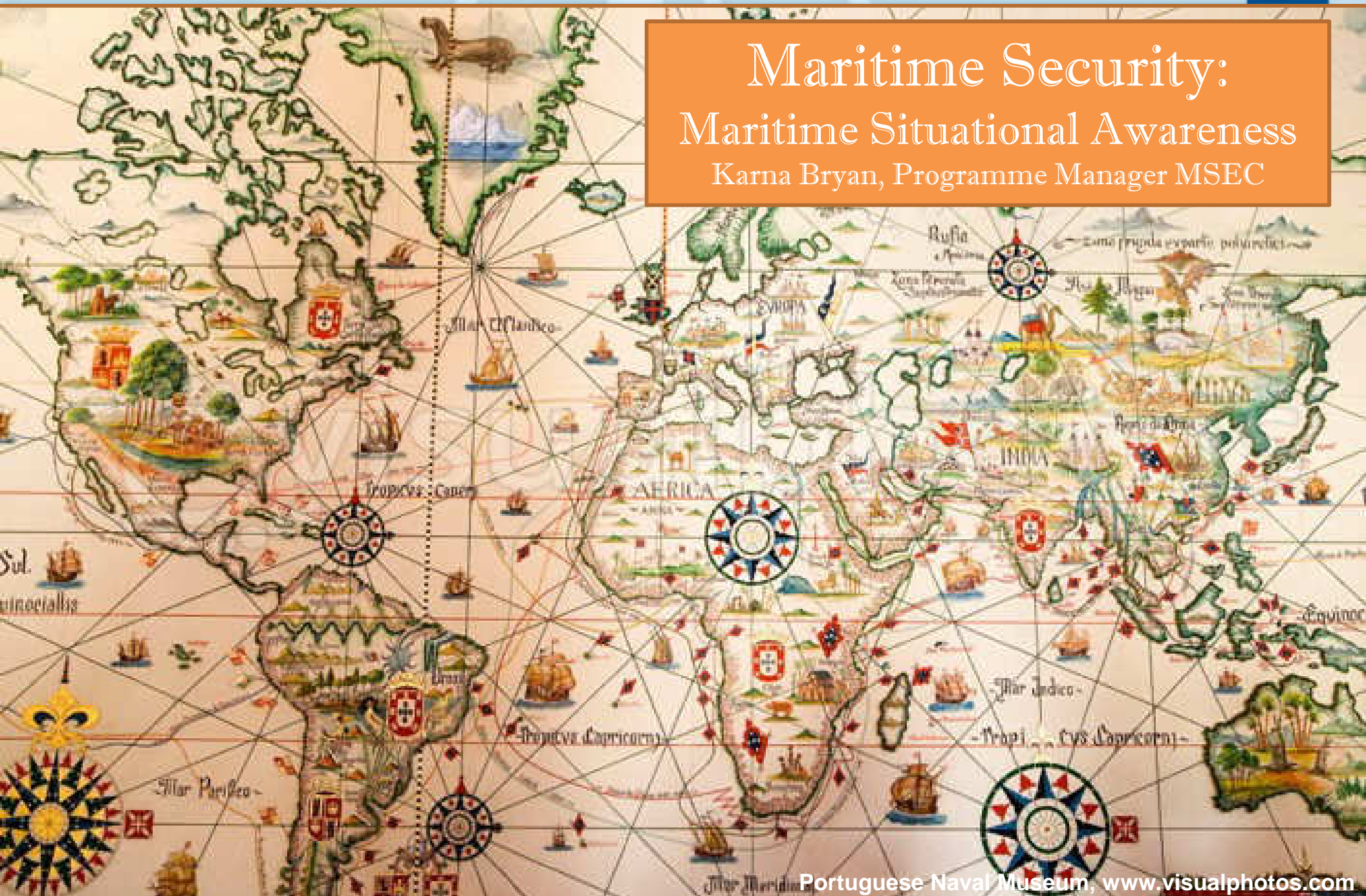
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Some exploratory results

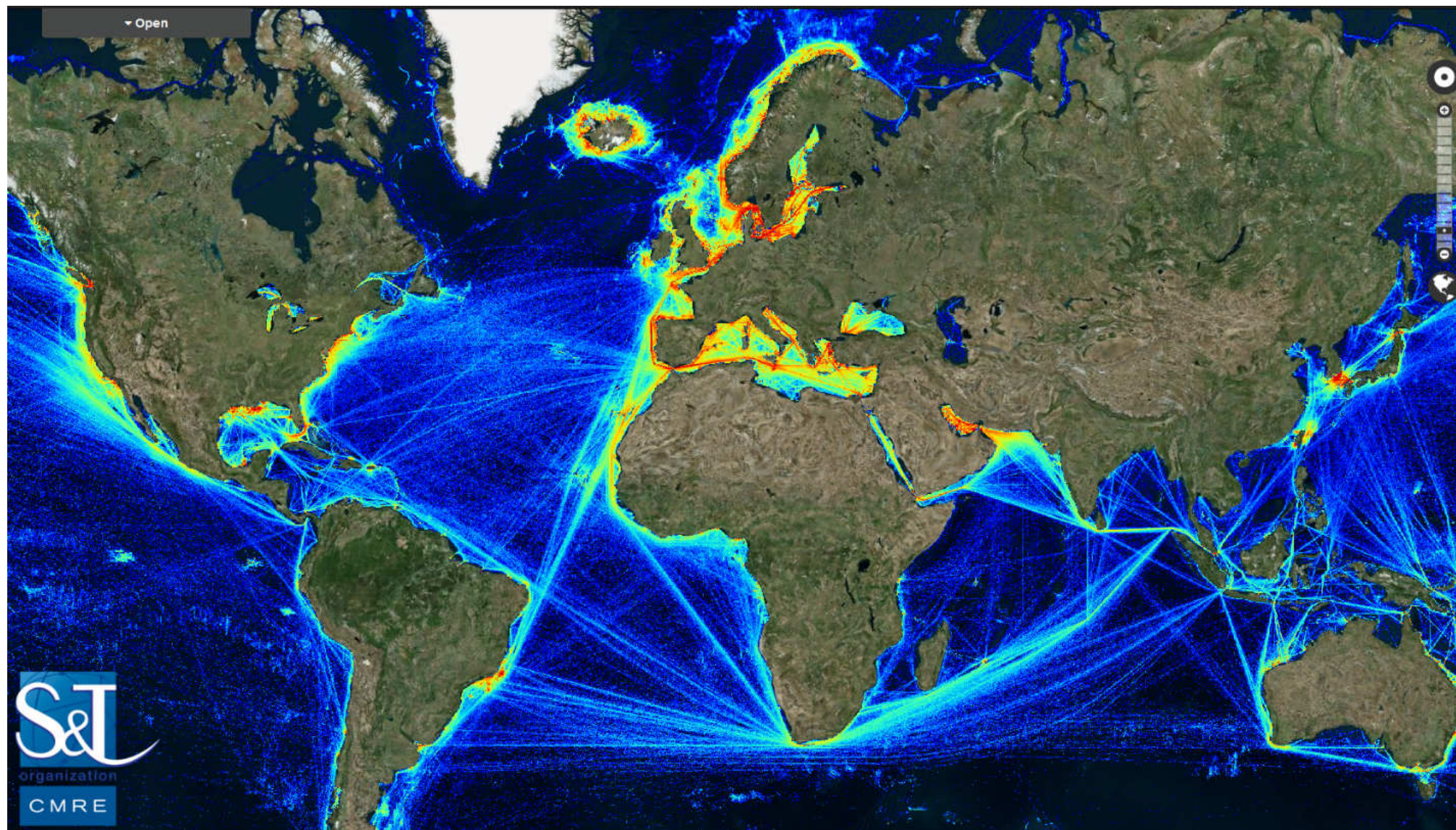
Conclusions and future works

Maritime Security: Maritime Situational Awareness

Karna Bryan, Programme Manager MSEC



Maritime Traffic Surveillance



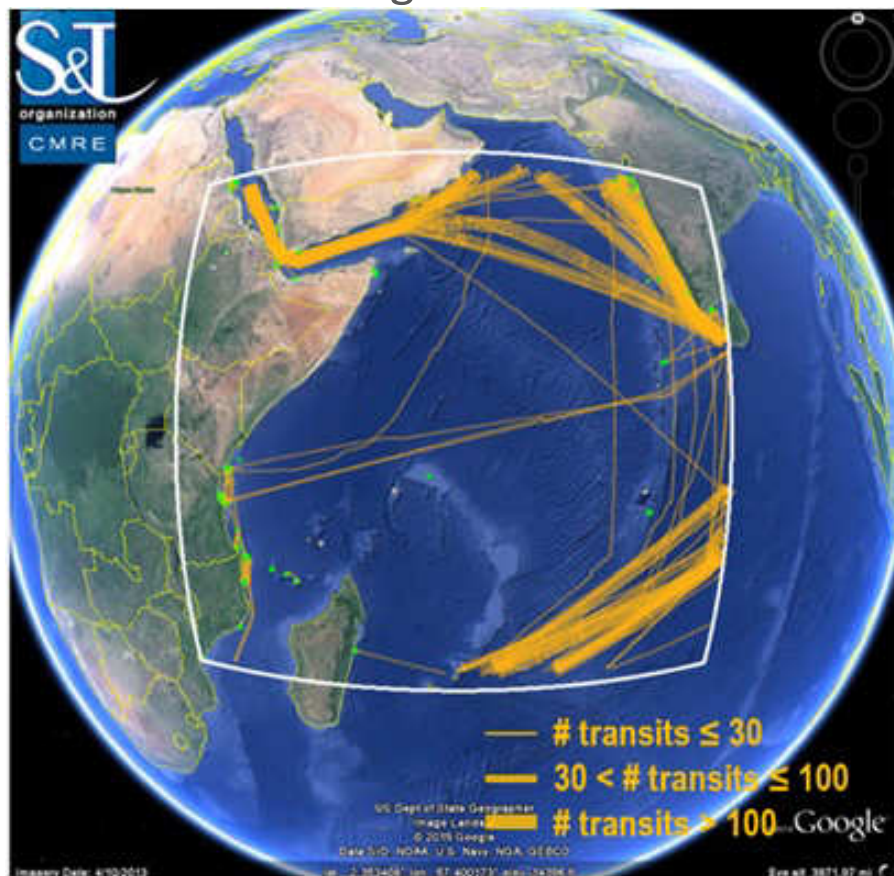
Naval Contributions to Maritime Security

- Increased role of navies in Maritime Security missions (NATO's Alliance Maritime Strategy, 2011)
- Maritime Interdiction Operations
Naval operations that aim to *interrupt, dissuade, or prevent* enemy or illicit activities at sea - before they do any harm
- Vessels in distress
- Illegal activities (e.g., smuggling, fishing)

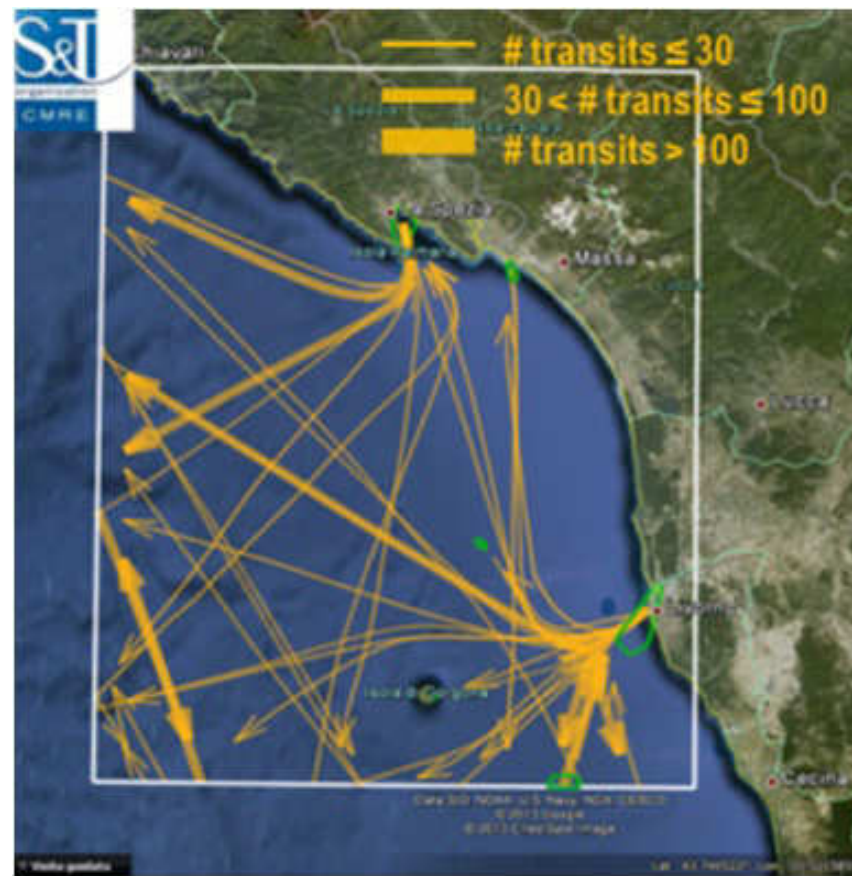


Traffic Route Extraction and Anomaly Detection (TREAD)

Large Scale



Local Scale



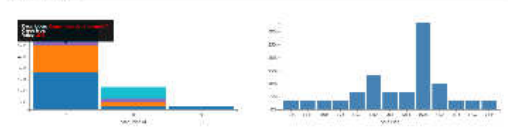
Pallotta G., Vespe M., Bryan K. (2013) "Vessel Pattern Knowledge Discovery from AIS Data: a Framework for Anomaly Detection and Route Prediction". *Entropy, Big Data Issue* 15(6), pp. 2218-2245. ISSN 1099-4300

Traffic Analysis/Summary Route Statistics

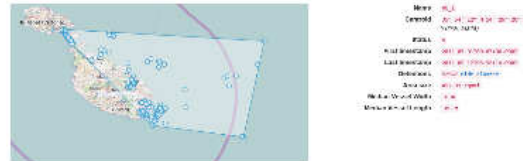
Route



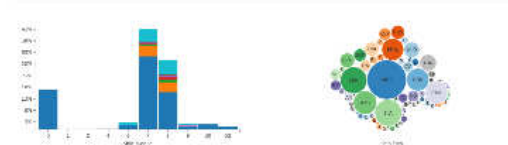
Dashboard



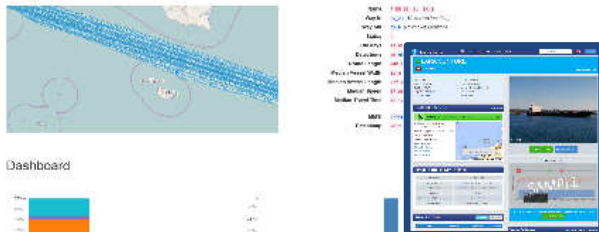
Area



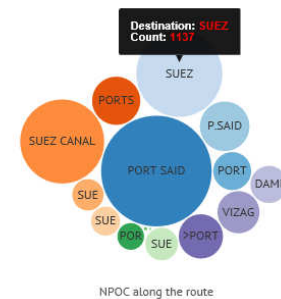
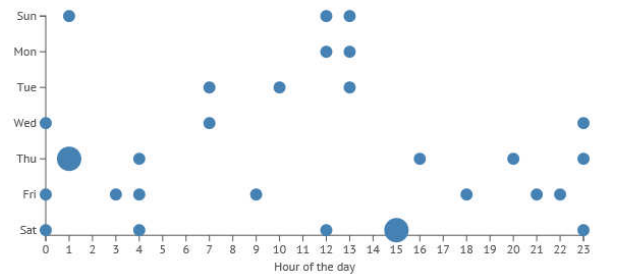
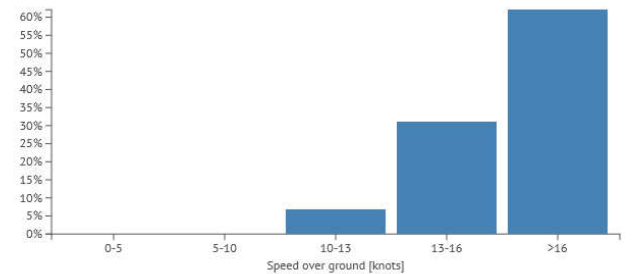
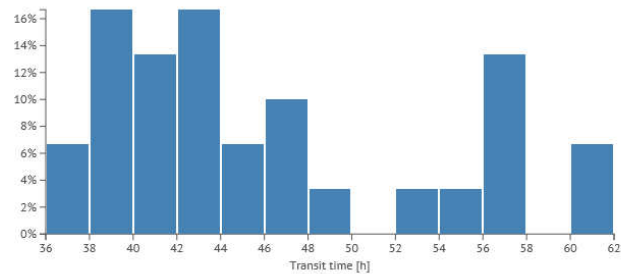
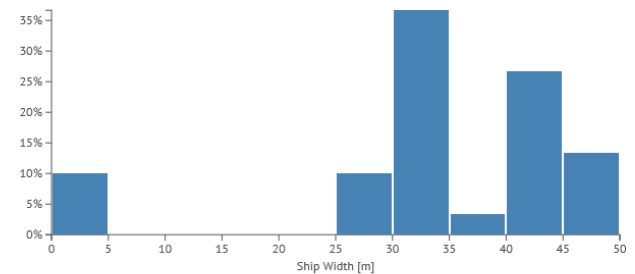
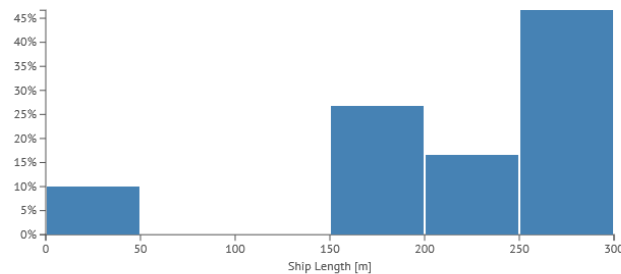
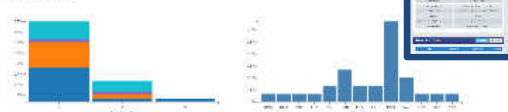
Dashboard



Route

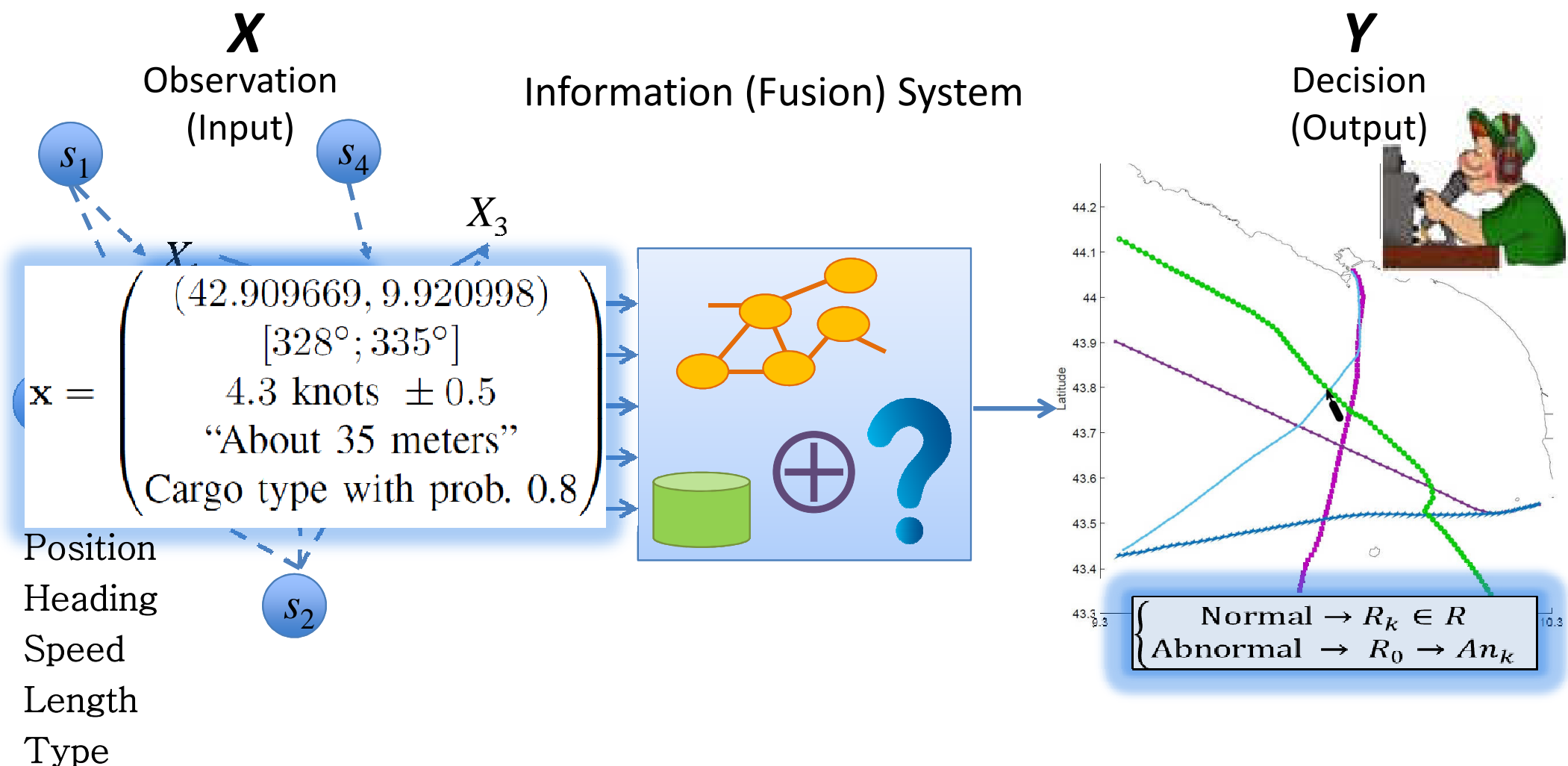


Dashboard



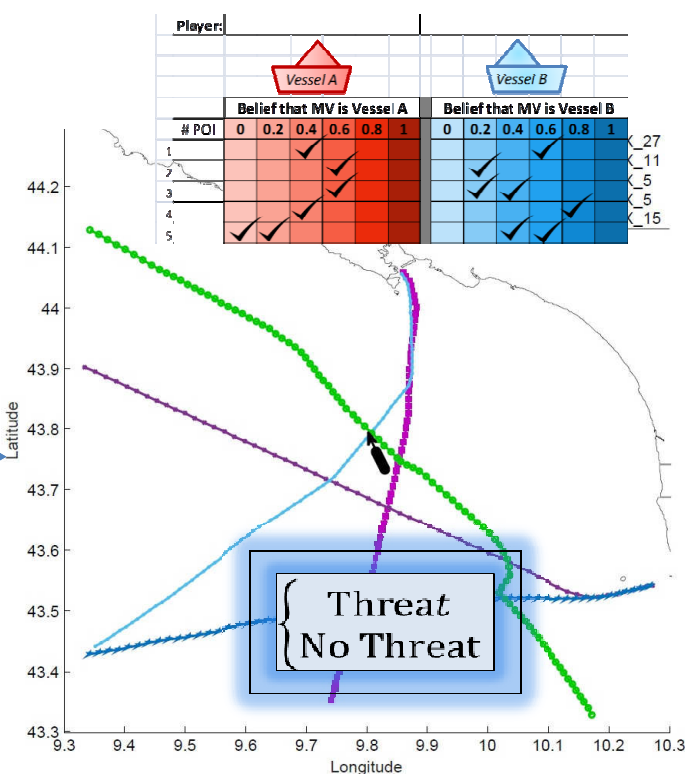
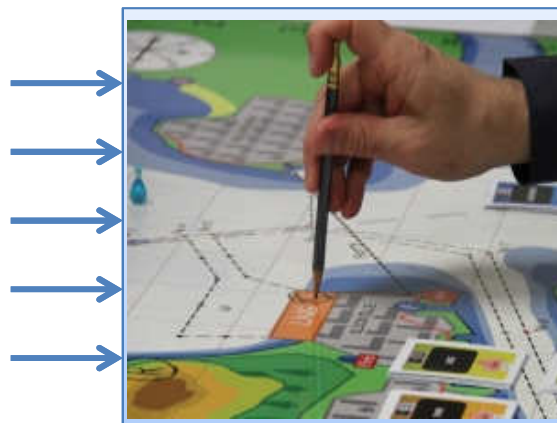
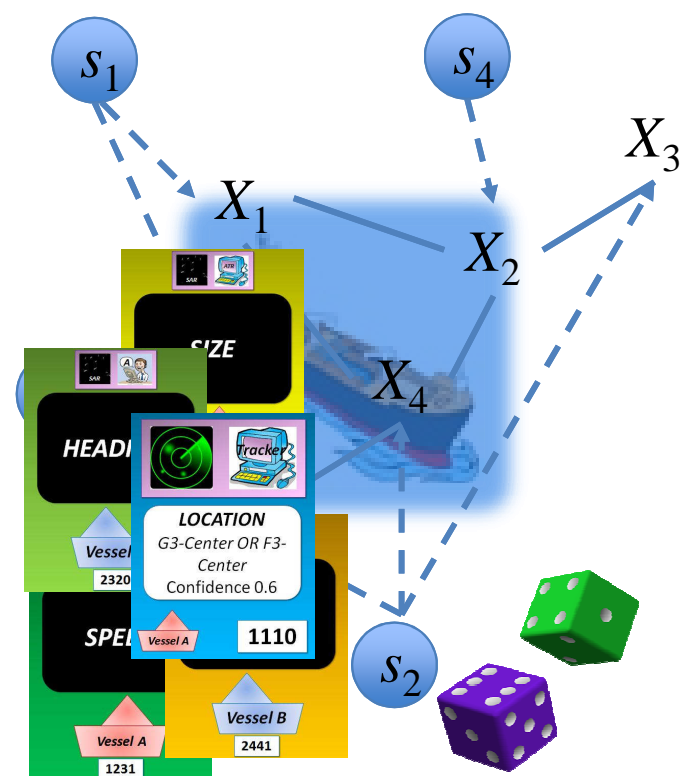
L. Cazzanti, G. Pallotta, "Mining Maritime Vessel Traffic: Promises, Challenges, Techniques," Proc. of the OCEANS'15 MTS/IEEE Conference, 2015

Maritime Anomaly Detection and situation awareness



RISK GAME

A methodology to elicit expert knowledge and know-how in making decision based on imperfect information



Outline

CMRE Maritime Security programme overview

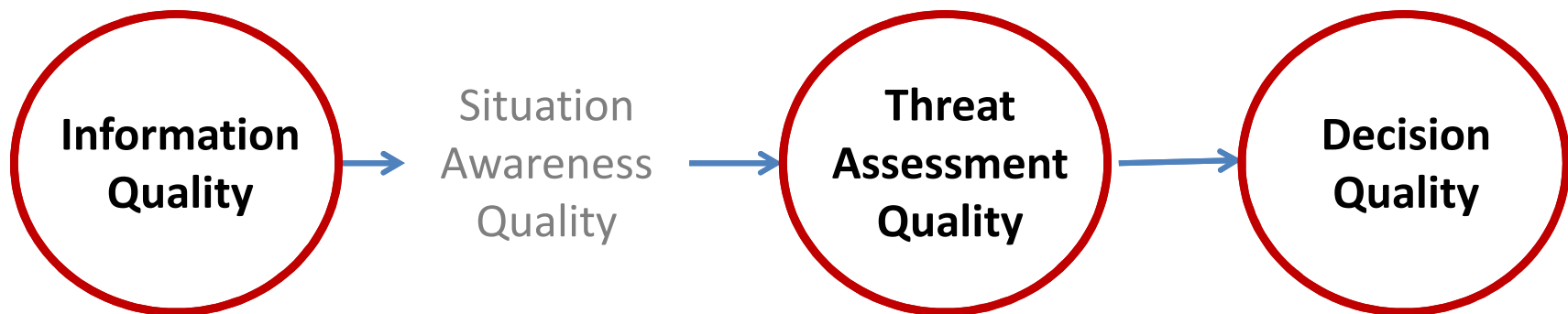
The Risk Game design

Some exploratory results

Conclusions and future works

Purpose of the game

- ❑ The Risk Game is a general methodology to elicit knowledge and know-how from Subject Matter Experts especially in their ability to
 - deal with information of different nature (from sensors to human witnesses),
 - consider the information quality (including source quality) and
 - reason about concurrent events.
- ❑ It is a technique aimed at capturing data expressing human reasoning features and information needs while performing a specific task of maritime situation assessment.

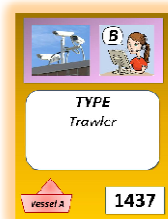




Playing the game



Queries

Scenario → Information → Player → Belief assessment → Decision

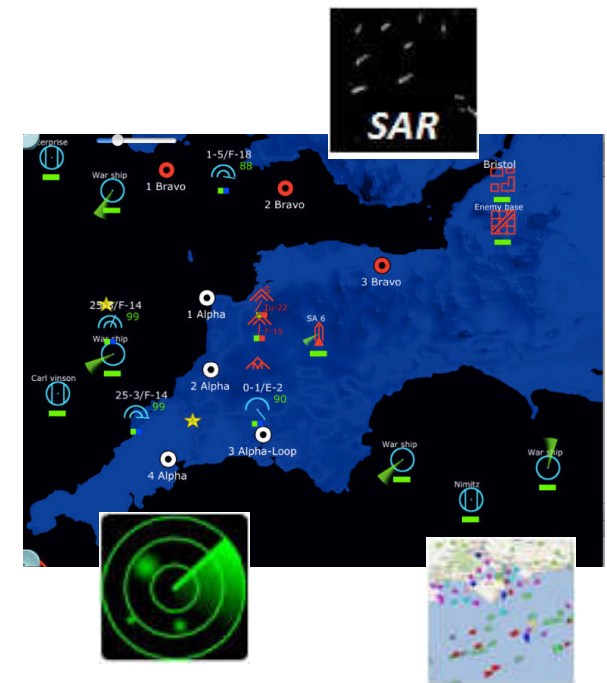


Player:		 Vessel A						 Vessel B					
		Belief that MV is Vessel A						Belief that MV is Vessel B					
#	U	U.2	U.4	U.6	U.8	1	U	U.2	U.4	U.6	U.8	1	
1													
2													
3													
4													
5													



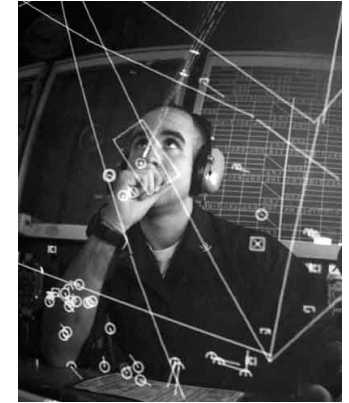
Decomposing the reasoning process

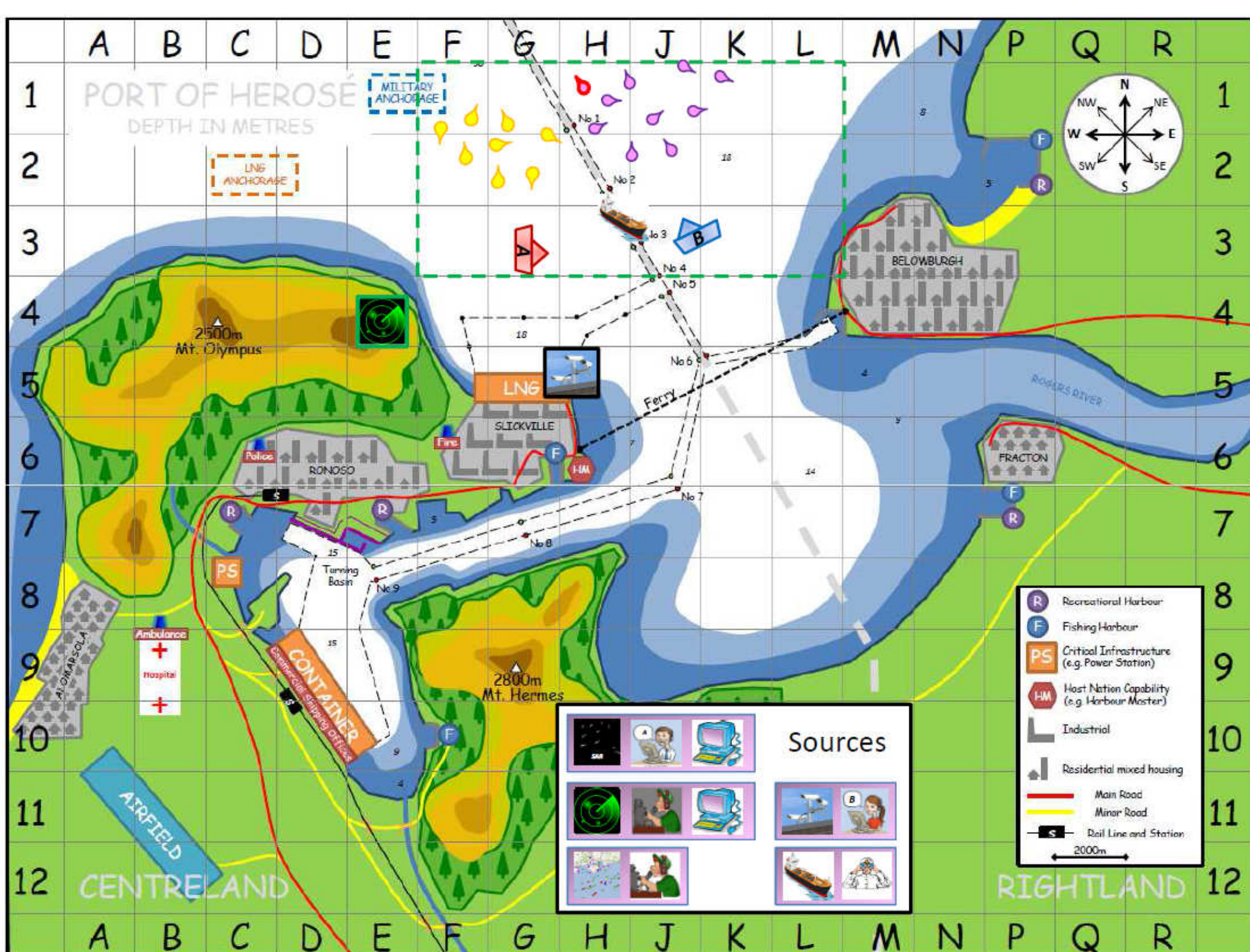
- ❑ The pieces of information provided all correspond to the situation at **time 1**.
- ❑ In practice, all the information is available at the same time, possibly on different screens, through radio links, etc.
- ❑ The idea of the game is to **decompose** the reasoning process which leads the player to the decision.
- ❑ The game lasts **20 minutes** which corresponds to **1 minutes** in practice, i.e., the time needed to analyze the tactical picture.



Officer Of Watch

- ☐ The officer of watch (OOW) is in charge of mitigating the risk of a terrorist attack against the port of CL while preserving the daily activities of citizens from CL.
- ☐ The **player** plays the role of the **OOW**, monitoring the area with the aim of detecting any suspicious event.
- ☐ Several **sensing devices** together with the analysts teams are available to providing with information about the scene.
- ☐ Based on the information received, the player is asked
 1. to **assess his/her belief** about the location of the lost vessel
 2. to decide to **send or not a patrol aircraft** for further checking





Scenario – *Triggering event*

Time 0

- Two distinct groups of fishing vessels from RightLand and CentreLand are fishing in their respective area, some close to the border.

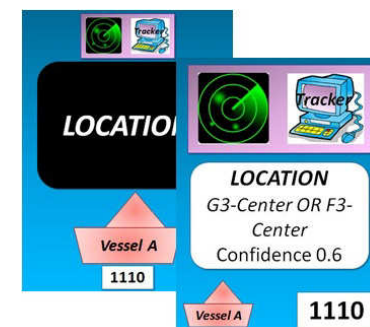
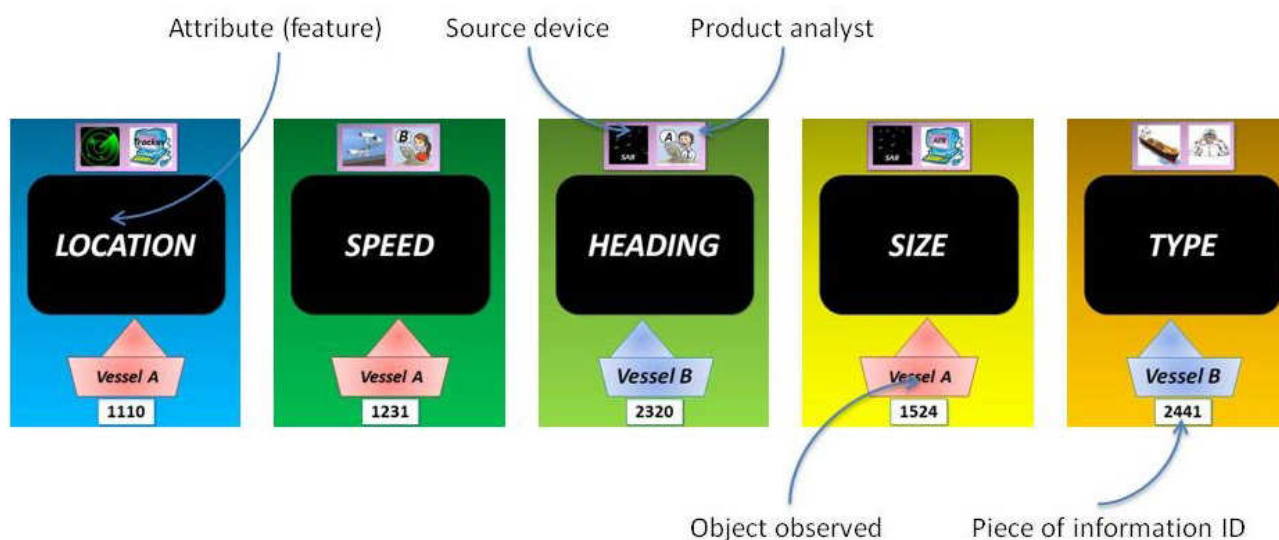


Time 1

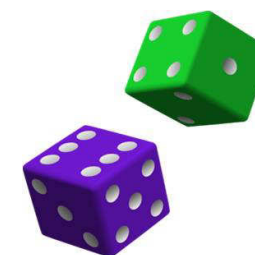
- The VTS operator reports that the trawler **CroakerBoat** stopped reporting its AIS information 1 hour ago.
- No answer to the radio call.
- Two prospect candidates to be the lost vessel CroakerBoat are detected as Vessel A in CentreLand area, Vessel in RightLand area.

Information cards

- Information is **abstracted away** by cards
- Only the **back** of the card is first presented to the player



- At each round, the player selects:
 - The **vessel**
 - The **attribute**
 - The **source**
- The **information quality** is determined by a dice roll



Information quality dimensions

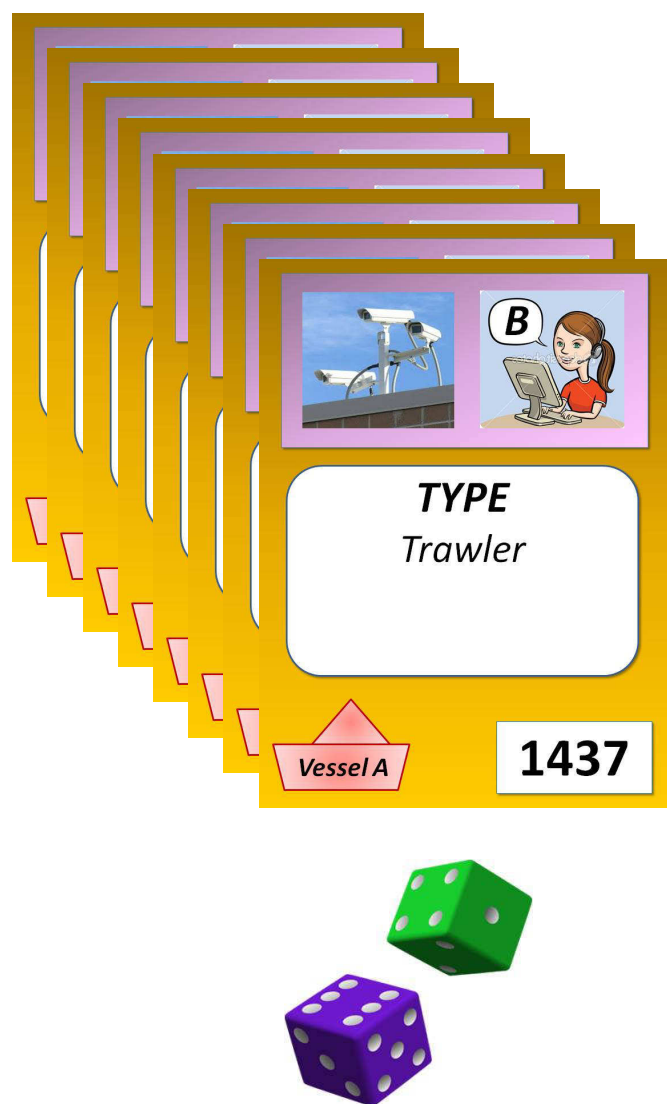
□ Information quality is made varying along the following dimensions:

1. **Correctness:** The information is conform to **truth**
2. **Precision:** The information focuses on a **single value** (in reference to a predefined domain)
3. **Certainty:** The information is provided with **maximum confidence** as assessed by the source itself

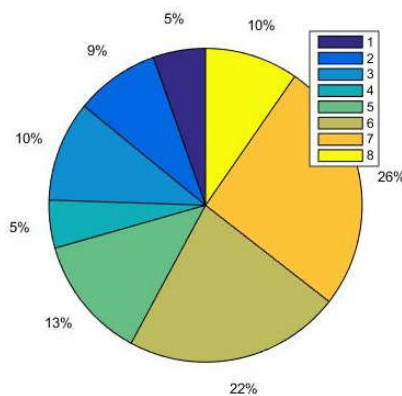
□ We considered binary quality values, thus 8 global quality levels

True	Precise	Certain
1	1	1
1	1	0
1	0	1
1	0	0
0	1	1
0	1	0
0	0	1
0	0	0

Information quality



- ☐ 8 versions of the same information
- ☐ Only one is available to the player
- ☐ The player rolls the dices to determine the quality obtained, i.e., one of the 8 cards
- ☐ The randomization is not uniform and represents roughly the sources limitations



True	Precise	Certain	Randomization	Q. rank
1	1	1	0.11	8
1	1	0	0.22	7
1	0	1	0.22	6
1	0	0	0.11	5
0	1	1	0.06	1
0	1	0	0.11	3
0	0	1	0.11	2
0	0	0	0.06	4

Uncertainty of hard and soft sources

Phrase	
Remote	0
Very unlikely	0.2
Unlikely	0.4
Even chance	0.5
Probably/Likely	0.6
Very likely	0.8
Almost certainly	1

- ❑ We follow the *Standardized lexicon used by the National Intelligence Council (US)*
- ❑ Only 2 levels of uncertainty are considered:
 - ❑ *Hard sources output a probability of either 0.6 or 1*
 - ❑ *Soft sources say the event is either probable/likely or almost certain*

Contextual information

CROAKERBOAT
MMSI - 316111000 IMO - 8800468



Location (t0) H2-right
Speed (t0) 4 knots
Heading (t0) NW
Size 30m X 6m
Type Trawler
Flag RightLand

CONTEXT



Time Spring 16:45
Traffic Heavy
Sea state 4
Fog 0

- Information about the lost vessel is provided
- As well as some other contextual information
- Harbor Protection Level is TWO

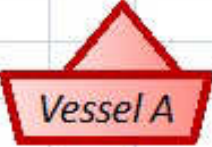

Harbour Protection Level	Force Protection Level	Security Alert State	ISPS Code
ONE	ONE	DELTA	THREE
TWO	TWO	DELTA	THREE
THREE	THREE	CHARLIE	TWO
FOUR	FOUR	BRAVO	TWO
FIVE	FIVE	ALFA	ONE

- Relationship between FPLs/NATO Security Alert States/ISPS Code

Record of belief state (SAW)

❑ After querying and discovering a piece of information, the player rates his/her belief state regarding the two events:

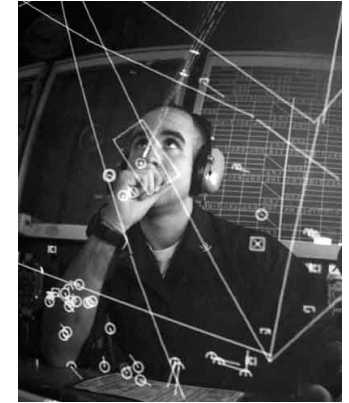
- *The lost vessel is A*
- *The lost vessel is B*

Player:															
															
		Belief that MV is Vessel A							Belief that MV is Vessel B						
	# POI	0	0.2	0.4	0.6	0.8	1		0	0.2	0.4	0.6	0.8	1	
1					✓						✓				
2	2120			✓								✓			
3	1157			✓							✓				
4	1224		✓								✓				
5	2135	✓	✓								✓	✓			

- ❑ The card ID is recorded (unique)
- ❑ The two belief values **do not need** to sum up to 1
- ❑ Assessing **just one** of the two events is allowed

Decision

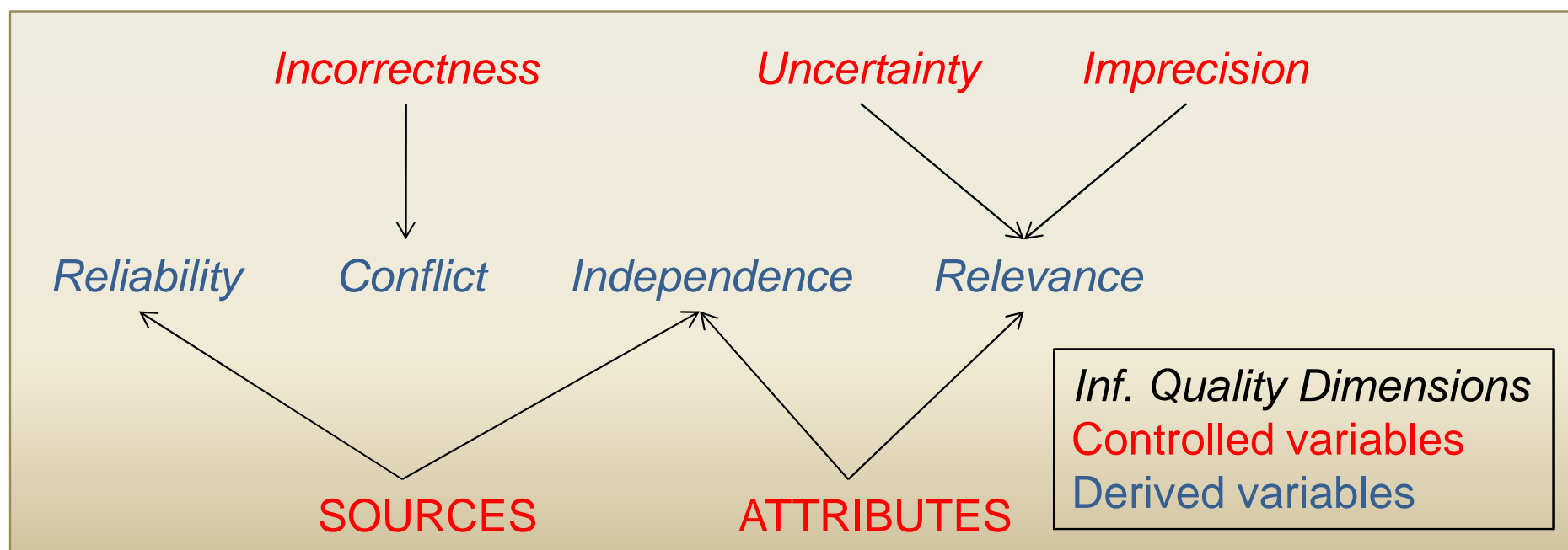
- ☐ At any time, the player can decide to:
 - *Send the aircraft*
 - *not send the aircraft*
- ☐ Sending the aircraft to check a particular vessel is costly (monetary, disturbance of local population), and he does not want to waste resources.
- ☐ Once the decision is taken, the game is over!



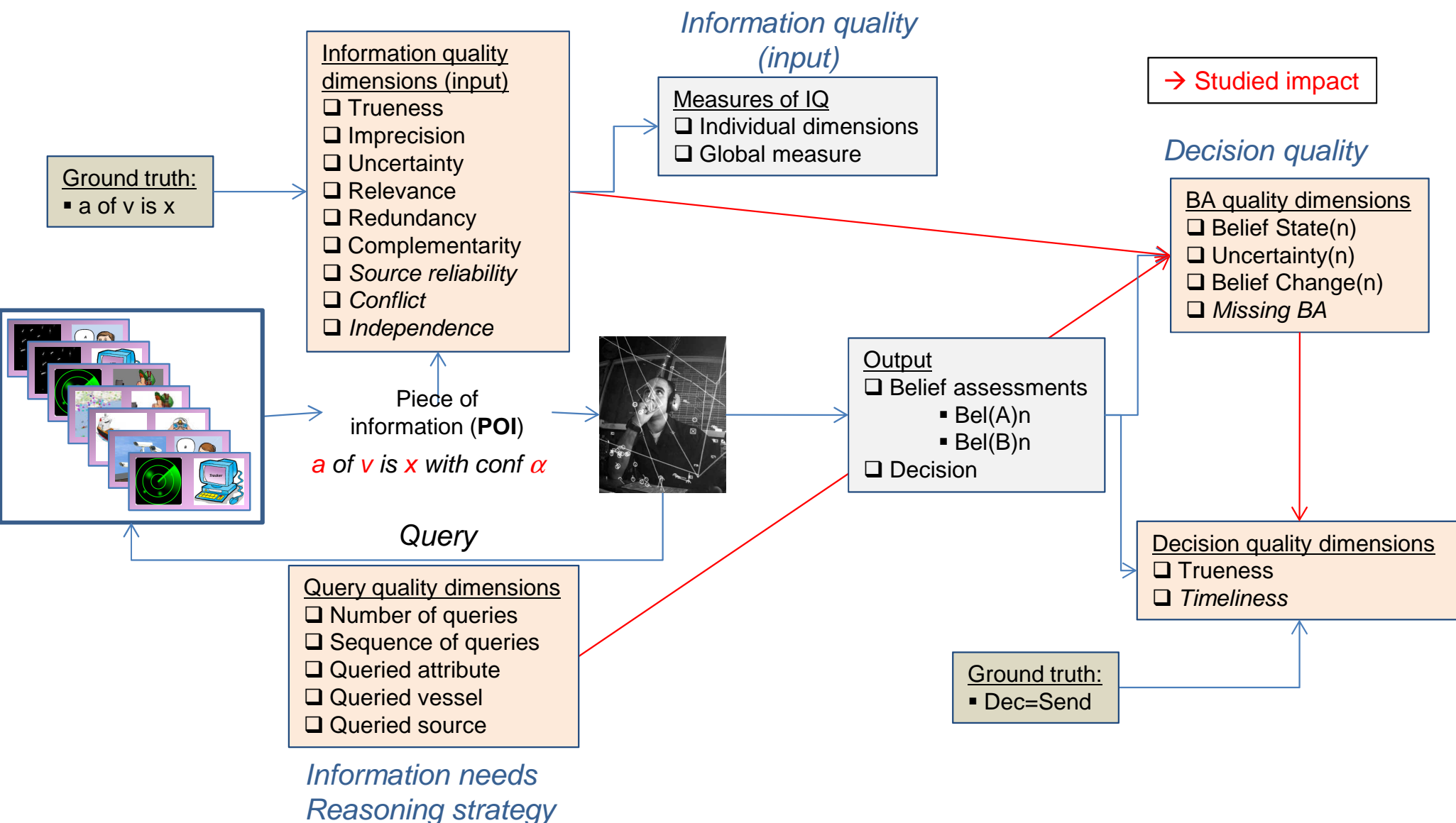
*Send or do not
send
?*



Variables of the game



Overview of the game design





Outline

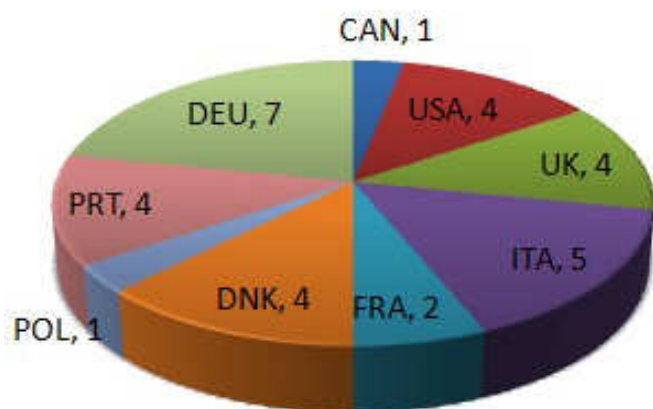
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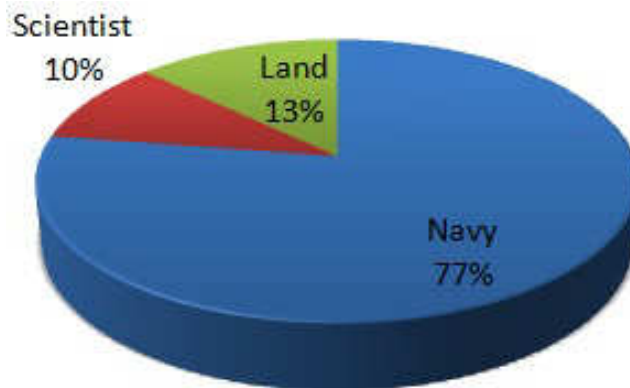
Conclusions and future works

Players' profile

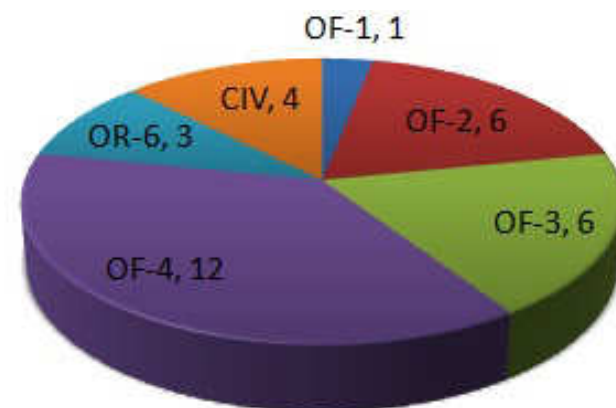


Nations

- ☐ 32 players
- ☐ 9 different NATO nations
- ☐ in majority from the maritime domain
- ☐ most of them having a NATO rank OF-2, OF-3 or OF-4

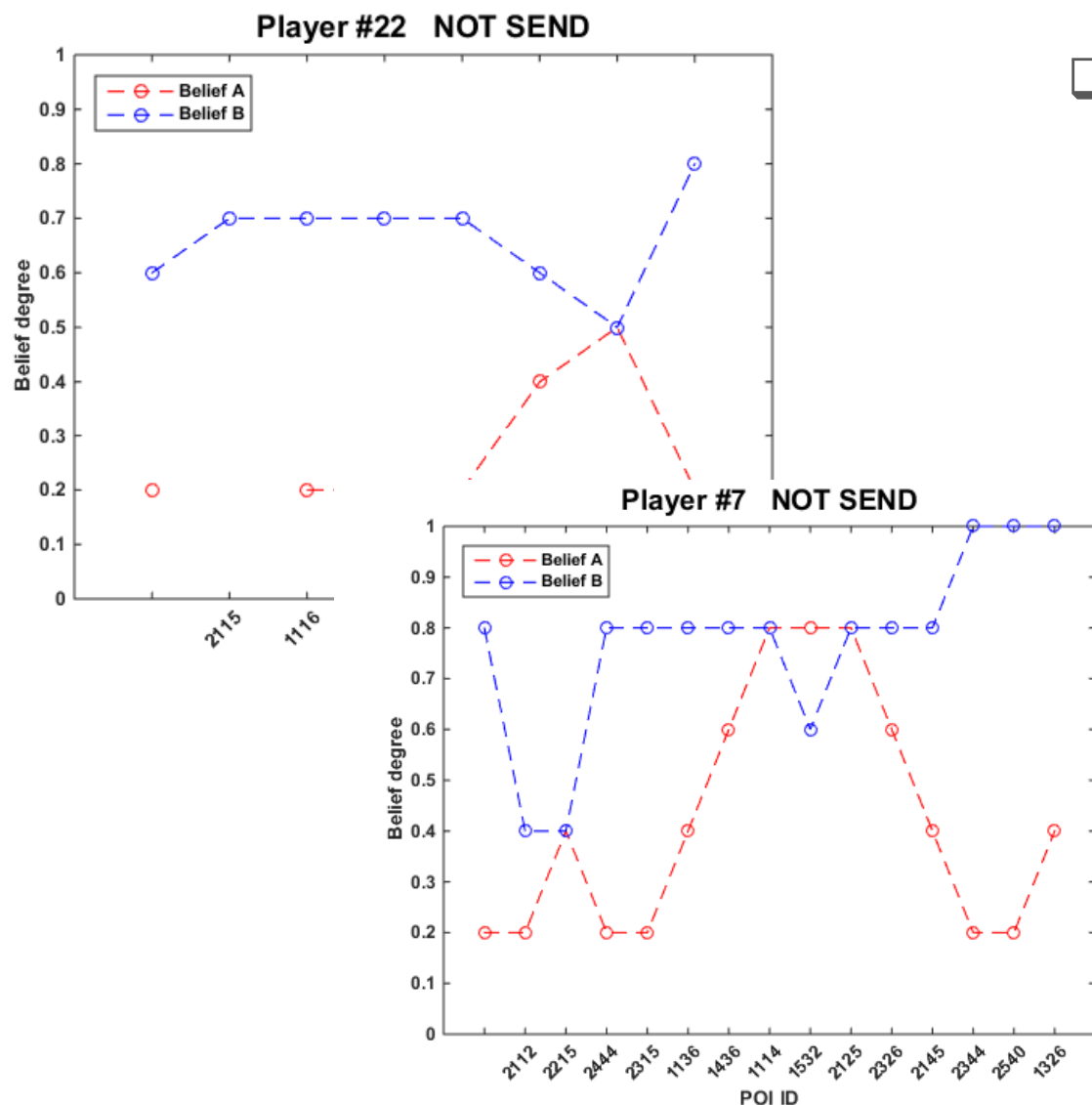


Domain



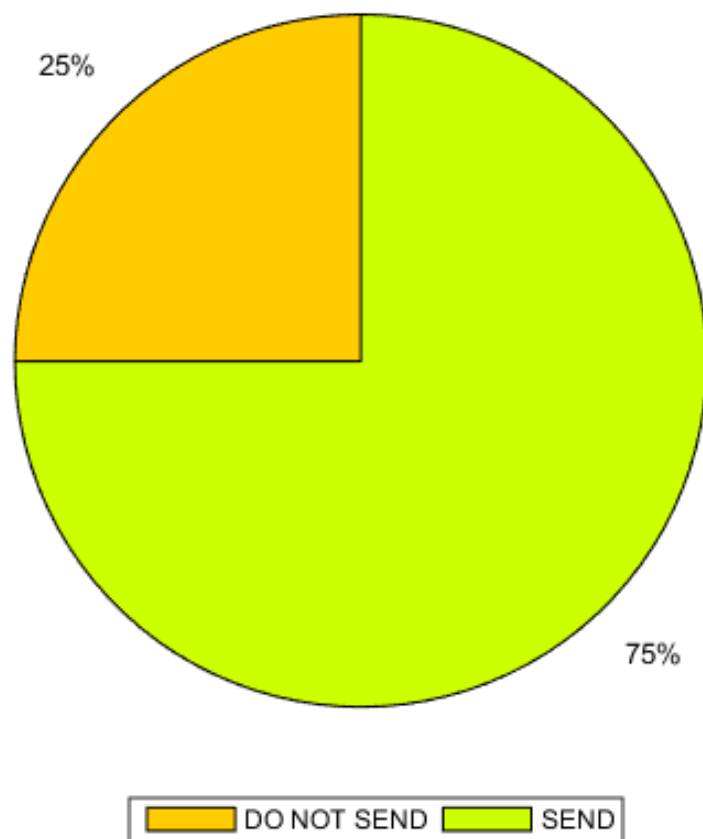
NATO rank

Dataset collected



- We collected the data from the set of players about:
 - The evolution of **belief state** regarding the two events
 - The **final decision**
 - The **ID** of the piece of information picked-up (vessel, source and attribute)
 - The **quality** of information obtained
 - Possible **missing** assessments

Final decision



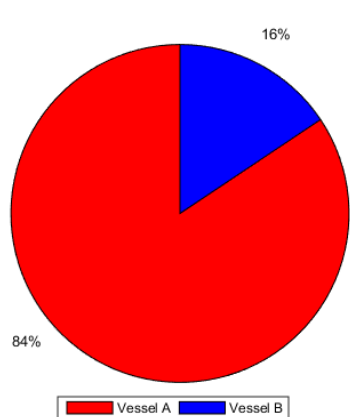
- ❑ Most of the players took the decision to send the patrol (“good decision”)
- ❑ Explained by the asymmetry of the two vessels’ risk levels



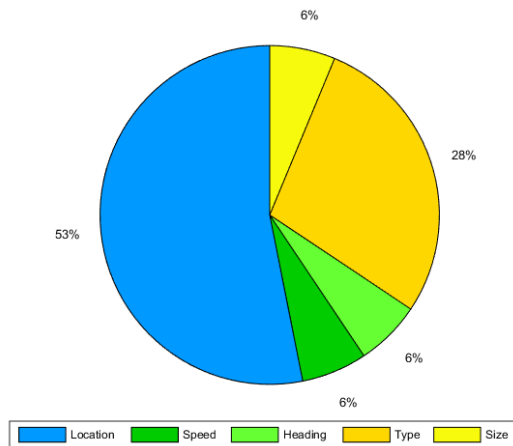
Information needs

□ The player had 4 degrees of freedom to query the information:

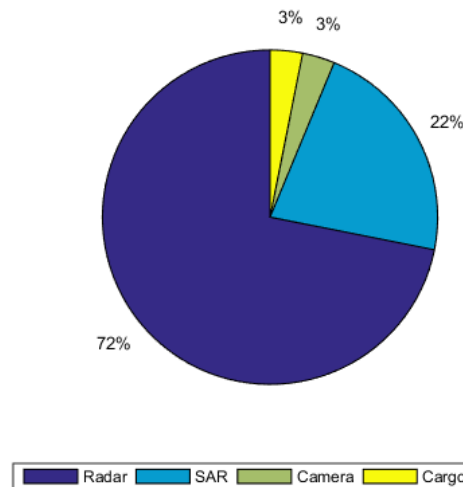
- The vessel (A or B),
- the attribute (LOCATION, HEADING, SPEED, TYPE and SIZE),
- the source (Radar, SAR, Camera and Cargo), and
- the number of queries



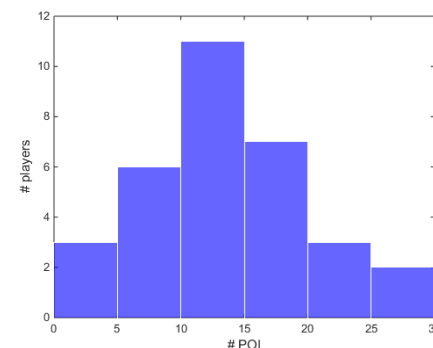
Vessel A was the most queried



LOCATION was the most queried attribute

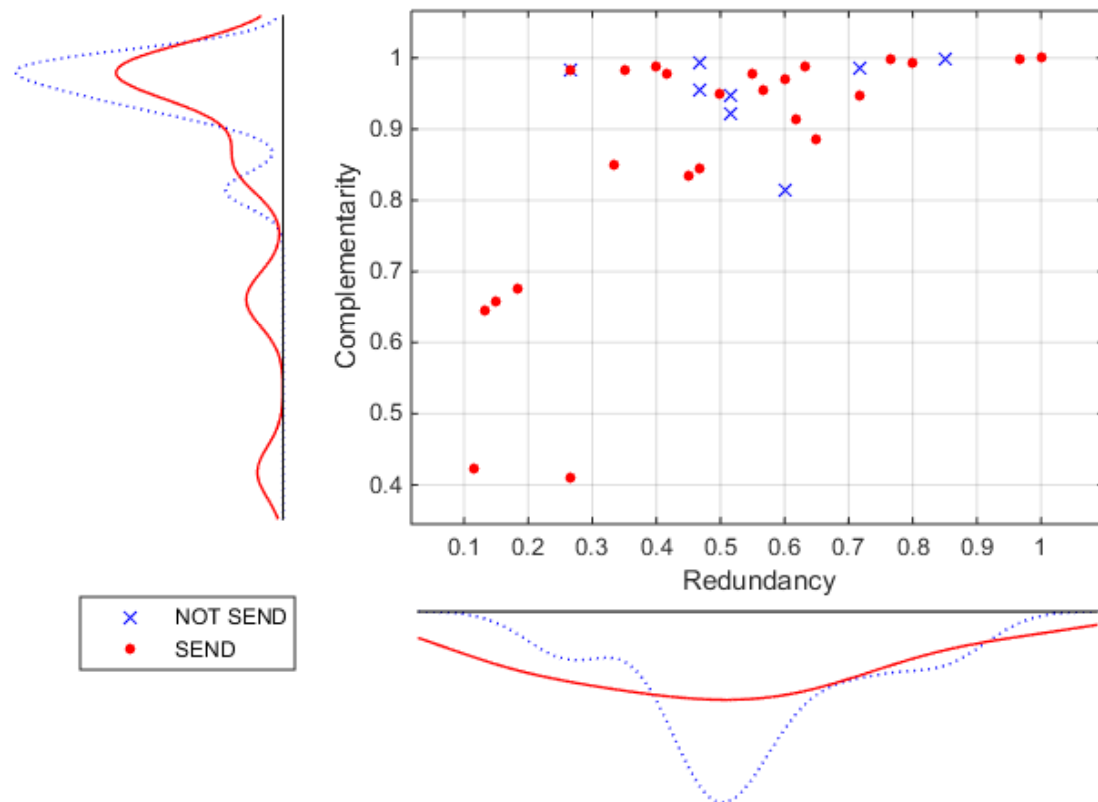


RADAR was the most queried source



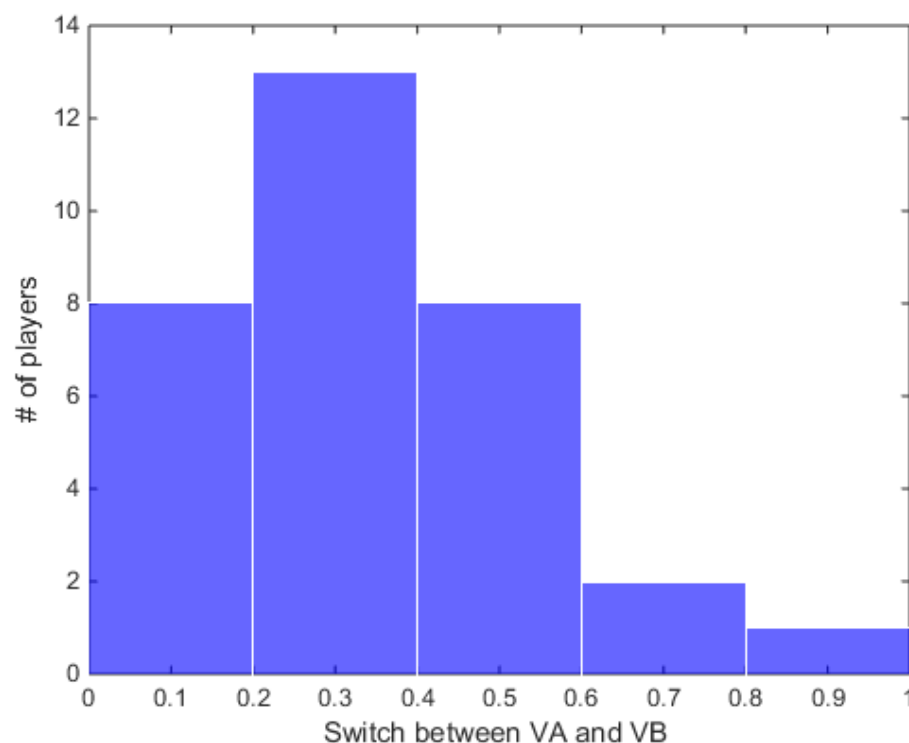
On average, **12 queries** (out of 26)

Reasoning strategy - *Redundancy vs complementarity*



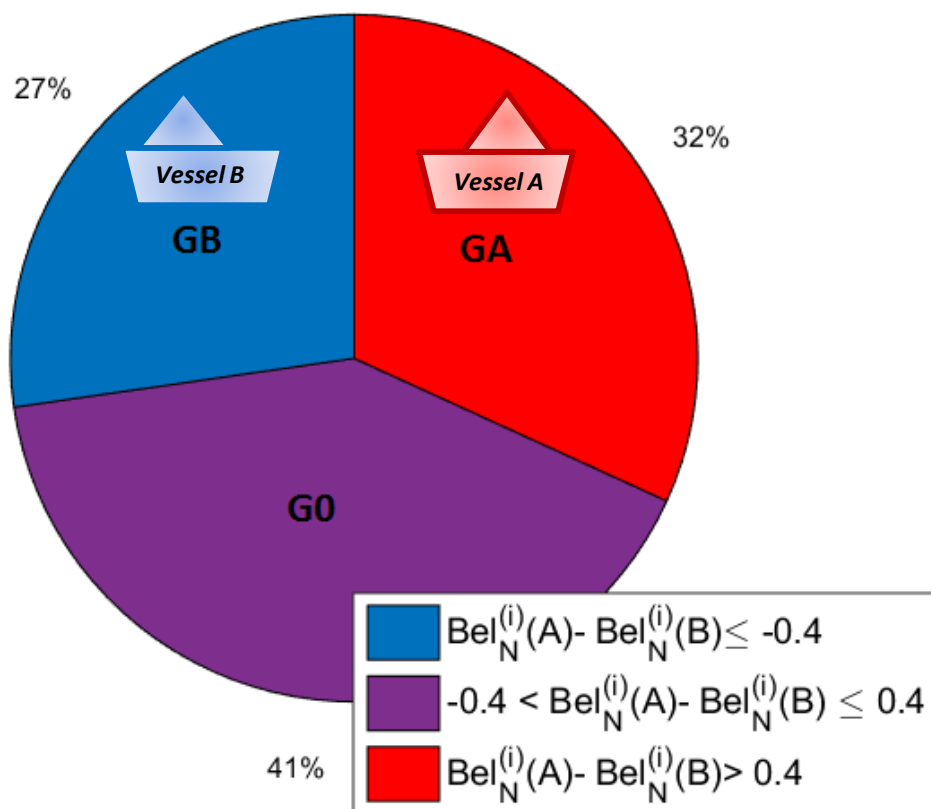
Most of the players adopted a strategy based on a high level of complementarity (i.e.(0:8;1)) and a medium level of redundancy, giving priority to multi-attribute investigation.

Reasoning strategy – *Switch between vessels*



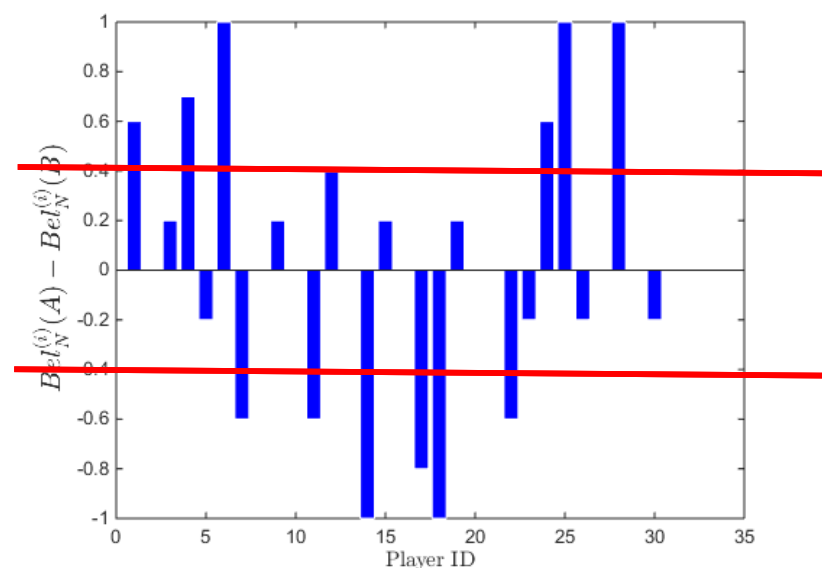
- ❑ Ratio of switches in the queries between Vessels A and B, either from A to B or from B to A, relatively to the maximum number of possible switches
- ❑ A null ratio means that the player queried a single vessel
- ❑ A low ratio means that the player mostly queried one vessel and then the other one
- ❑ A high ratio means that the player systematically queried one vessel and right after the other one, demonstrating thus a reasoning strategy by comparison

Final belief

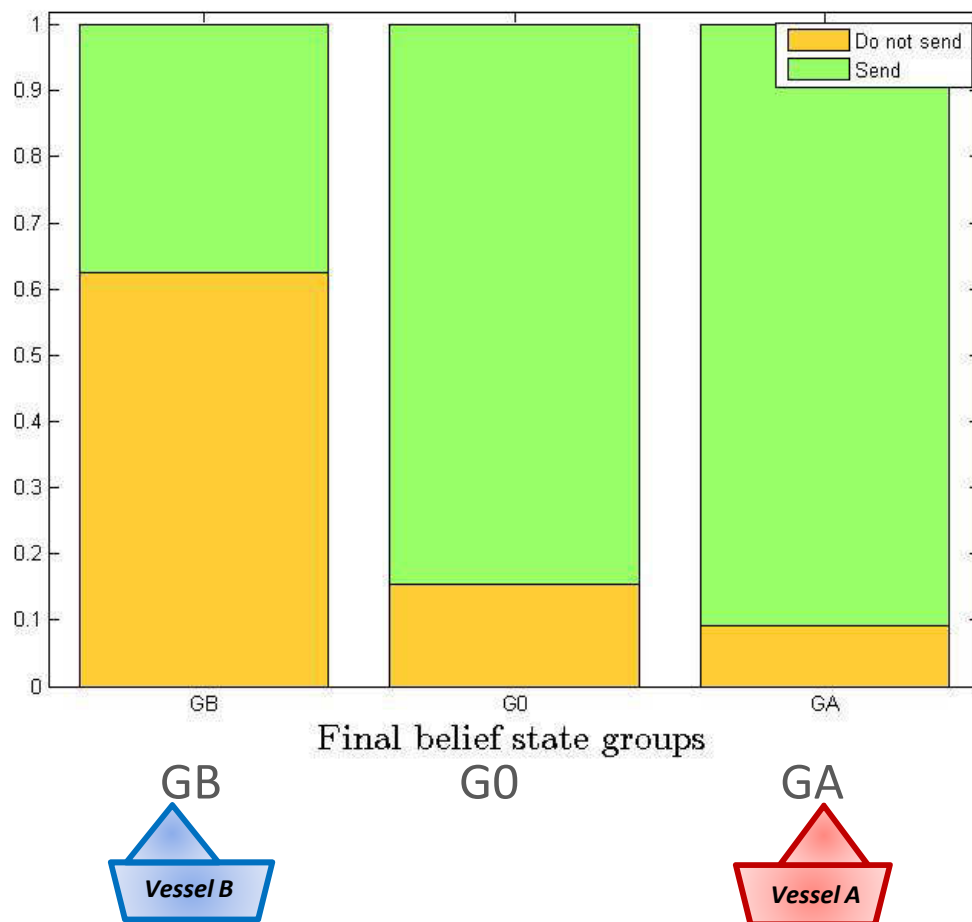


□ We build 3 groups of players based on their final belief:

- GA: Greater belief toward A
- GB: Greater belief toward B
- G0: Uncertain

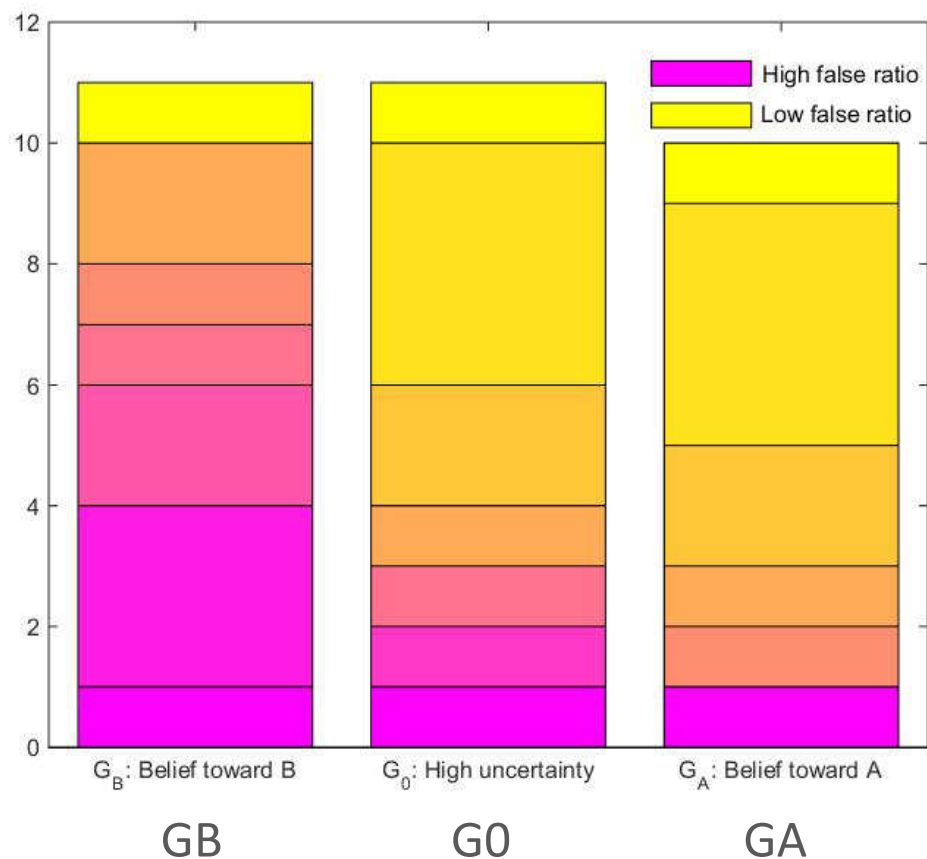


Final belief vs decision



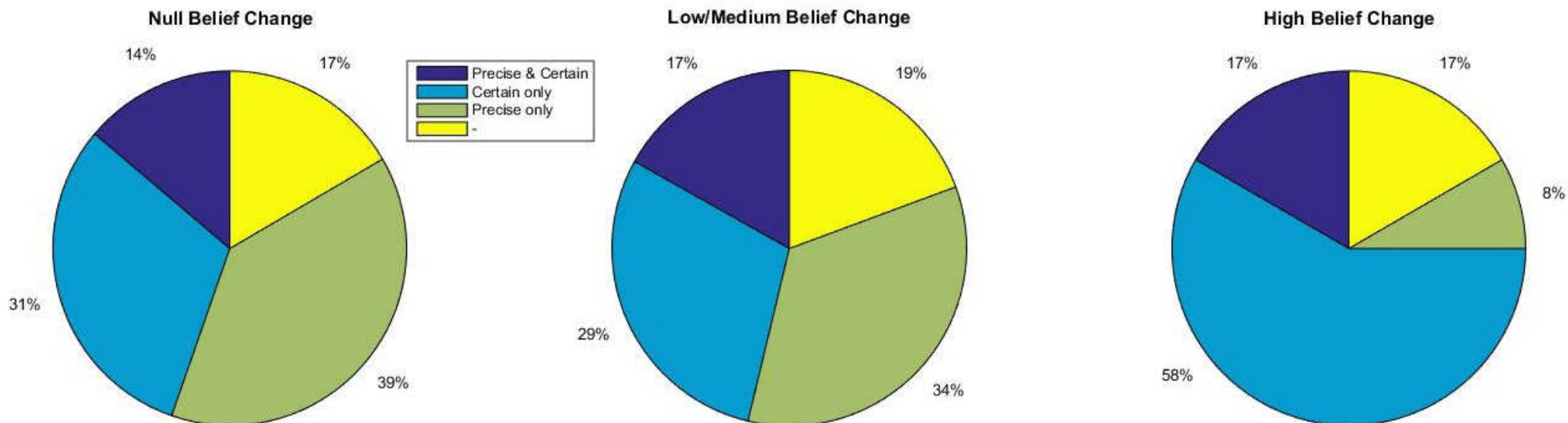
- A few percentage of player who lean toward A actually **did not send** the patrol (*thinking they still have time*)
- Players with high uncertainty before decision with a large majority decided to **send the patrol**
- Some players who strongly believed that the lost vessel was still in its area (event B) actually decided to **send the patrol** (*due to the risky context*)

Impact of false information on belief



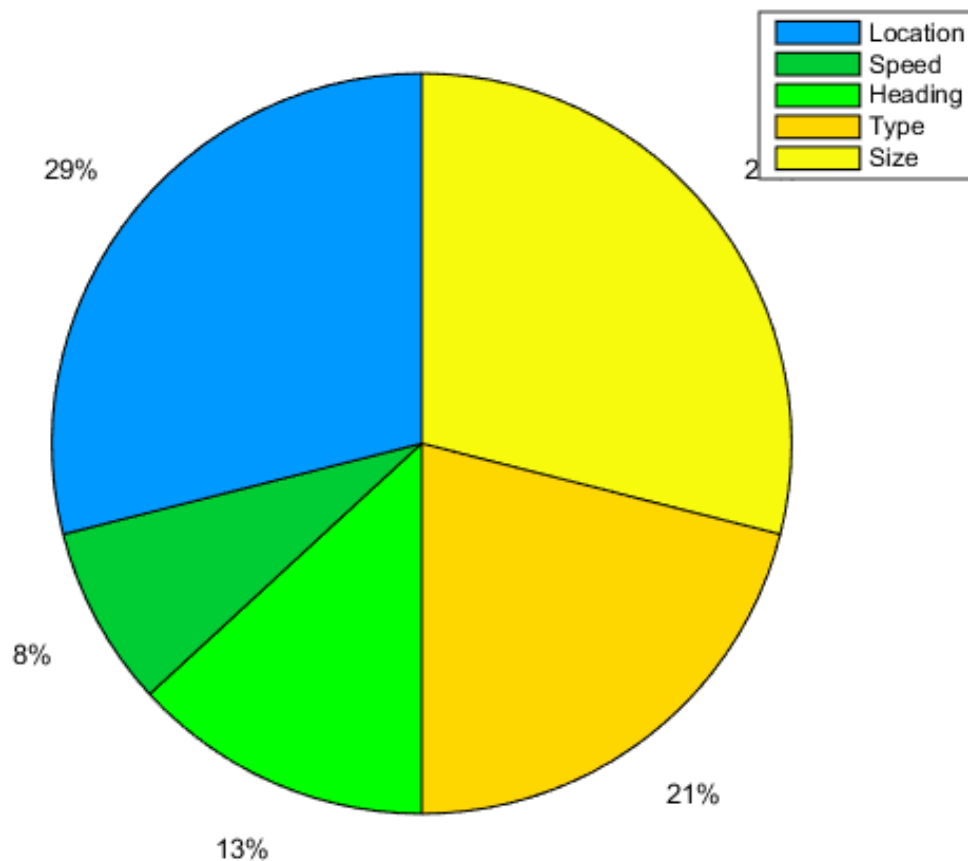
- ❑ The players who leaned toward event B indeed received a **higher ratio of false information** than the ones who were highly uncertain, and than the ones who leaned toward event A.
- ❑ This result may indicate that a high ratio of false information generates an **increased confusion** in the decision maker mind, up to “misassessing” the situation.

Impact of information content on belief change



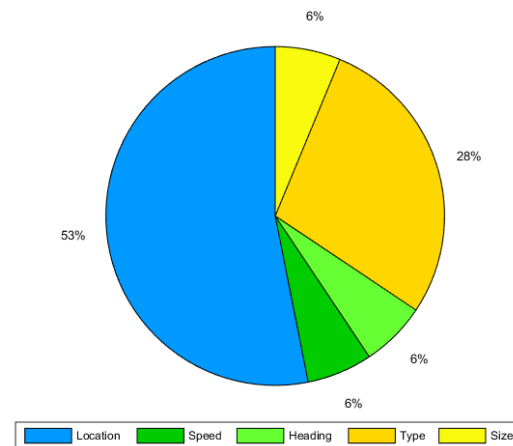
- ☐ The set of information which made the players switching from a belief toward A to a belief toward B (or reversely) contains a very high proportion of certain pieces of information
- ☐ Further investigation is required to confirm (or not) that an information expressed with high certainty had a high impact on the players' belief change

Impact of attributes on belief change



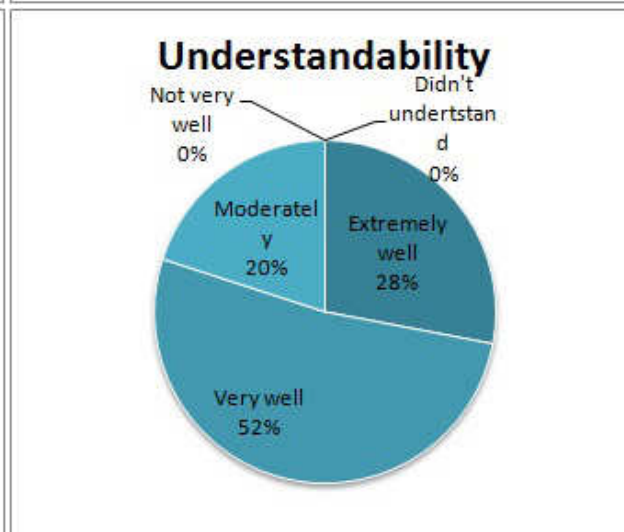
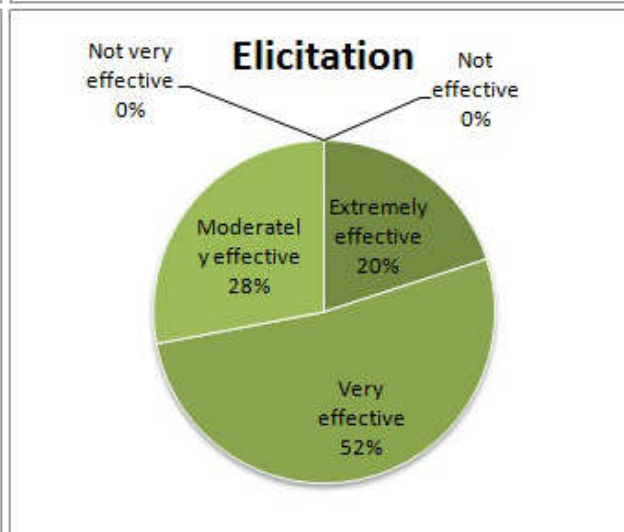
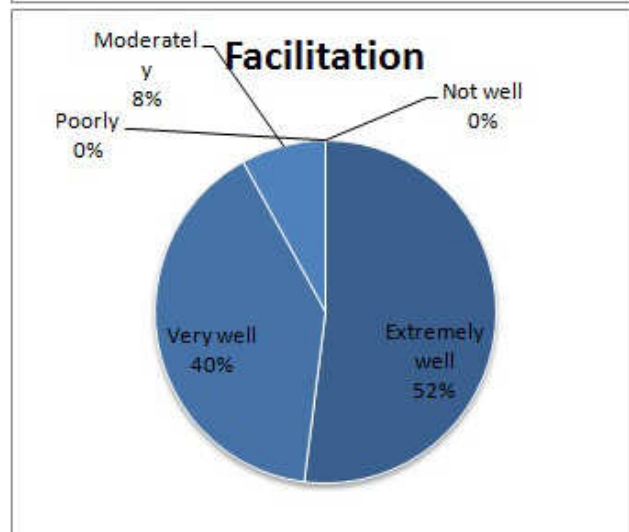
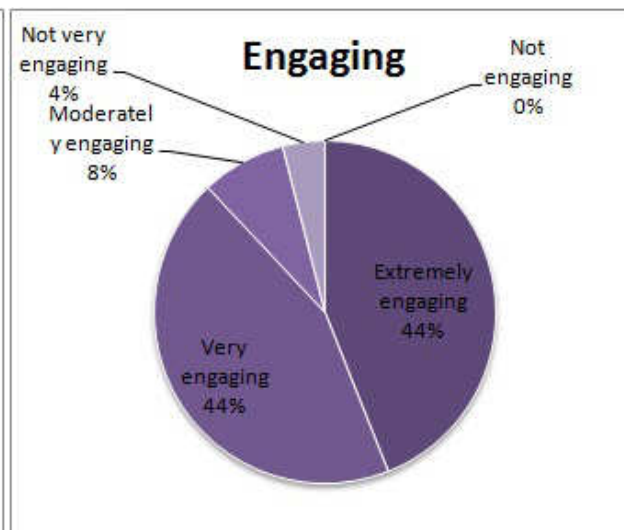
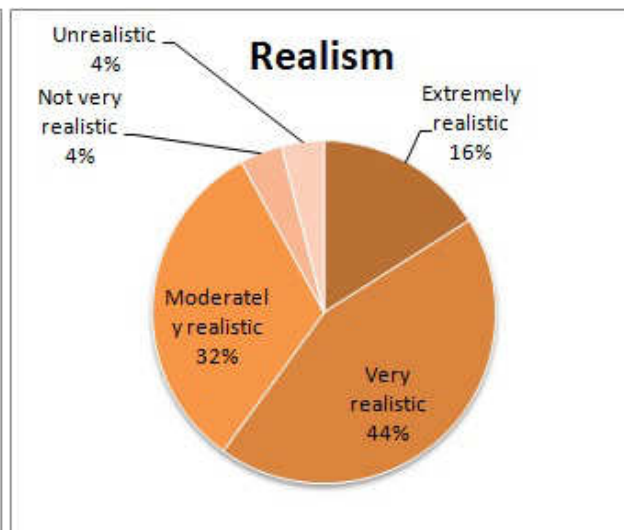
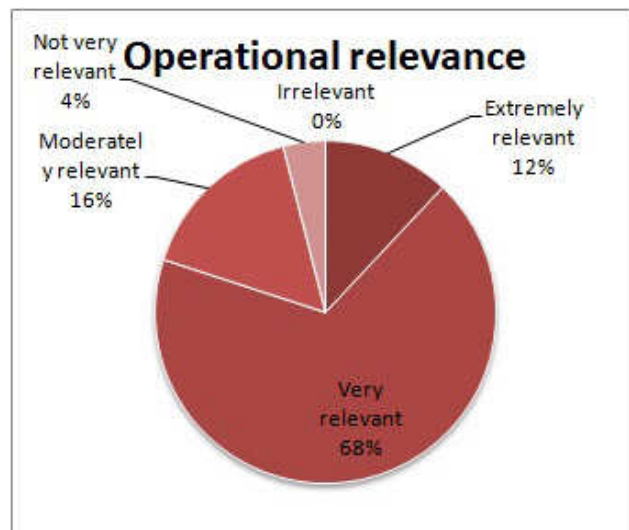
Which was the attribute which made the players changing their mind from one event to another (either A to B or B to A):

- Size
- Location (!?)
- Type



Most queried attribute

Players' feedback after the game



Outline

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Conclusions and future works

Conclusions

- ❑ Validation of the elicitation method which includes the structure for data gathering
- ❑ Established a formal link between information quality, belief assessment and decision making and gathering of the supporting data
- ❑ The analysis of data highlights for instance that
 - the players' perceived information relevance may differ from the effective relevance,
 - a high amount of false information increases the uncertainty of the player before decision and may lead to wrong decisions,
 - Information expressed with high certainty by the sources has a high impact in belief change,
 - the context (here the global security level) impacts the decision taken.
- ❑ A (generally) enthusiastic feedback from the operational community that will support further developments

Future work

- ☐ Game design
 - Randomisation of the scenario
 - Modify the type of decision
 - Modify the context
- ☐ Formal analysis of players' profile
 - Comparison with automated reasoning methods
- ☐ Measuring information quality
 - covering the different quality dimensions
 - discriminating between them to avoid double counting
- ☐ A step toward the automation of MSA
 - support human reasoning process
 - contribute to the development of automated algorithms for an improved synergy with the human operator



A.-L. Joussetme, G. Pallotta, J. Locke, *A Risk Game to study the impact of information quality on human treat assessment and decision making*, CMRE report, CMRE-FR-2015-009, 2015.