

Methods and System Design of the FOI Information Fusion Demonstrator – IFD03

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Outline

- Introduction
- Information Fusion Methods
 - Force Aggregation
 - Tracking
 - Sensor Resource Management
- System Description
- Conclusion

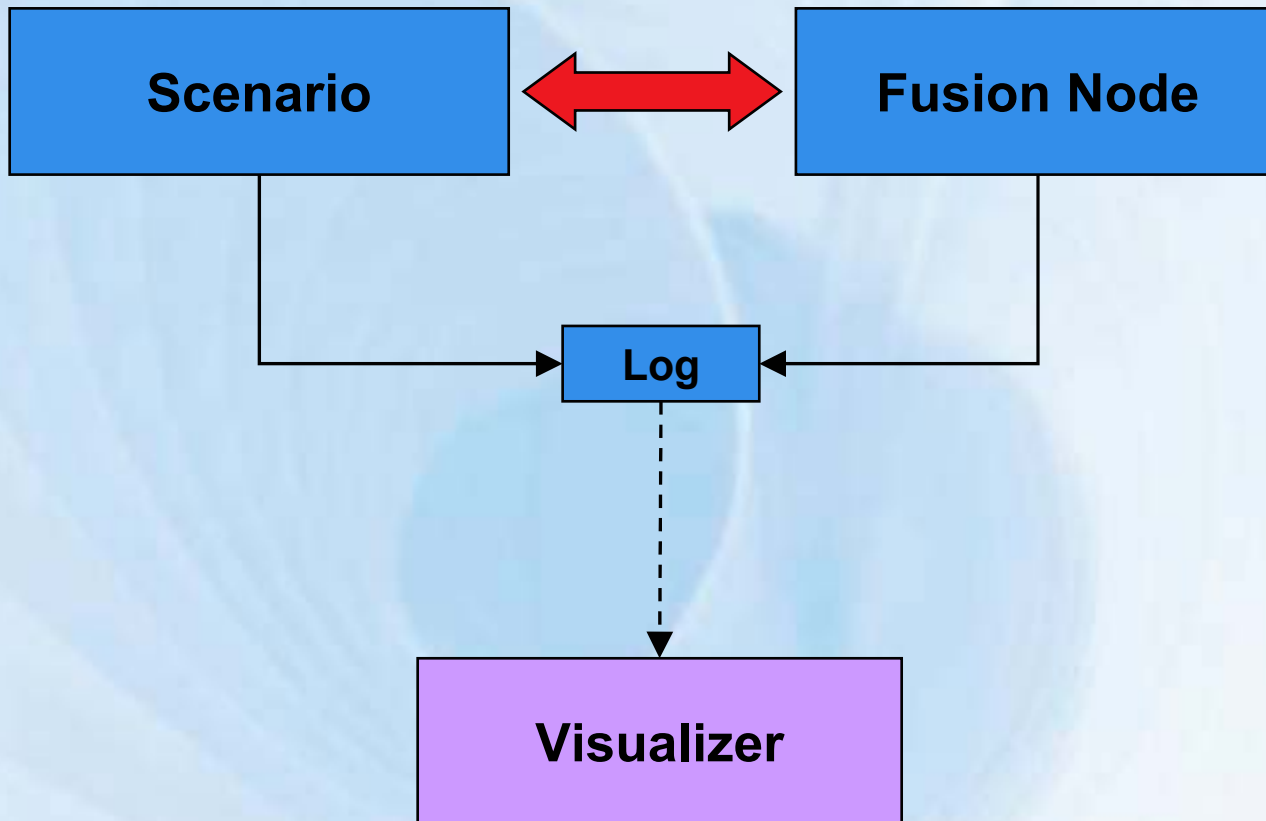
Introduction

■ What is the IFD03?

- A *concept* demonstrator for information fusion methodology in a future Network Based Defence C4ISR system
- Focus on analysing intelligence reports at the division level in a ground warfare scenario

■ Reasons for building the IFD03

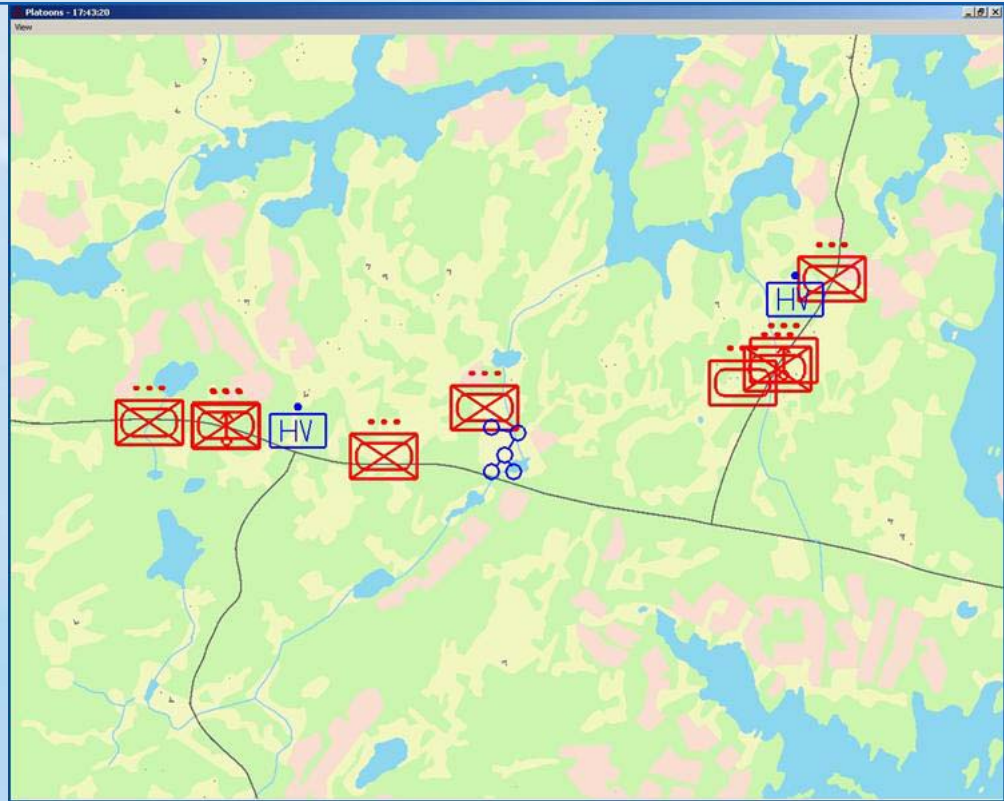
- Explore how fusion methods can be combined in a single system
- Show information fusion in a concrete fashion to our customers



Information Fusion Methods

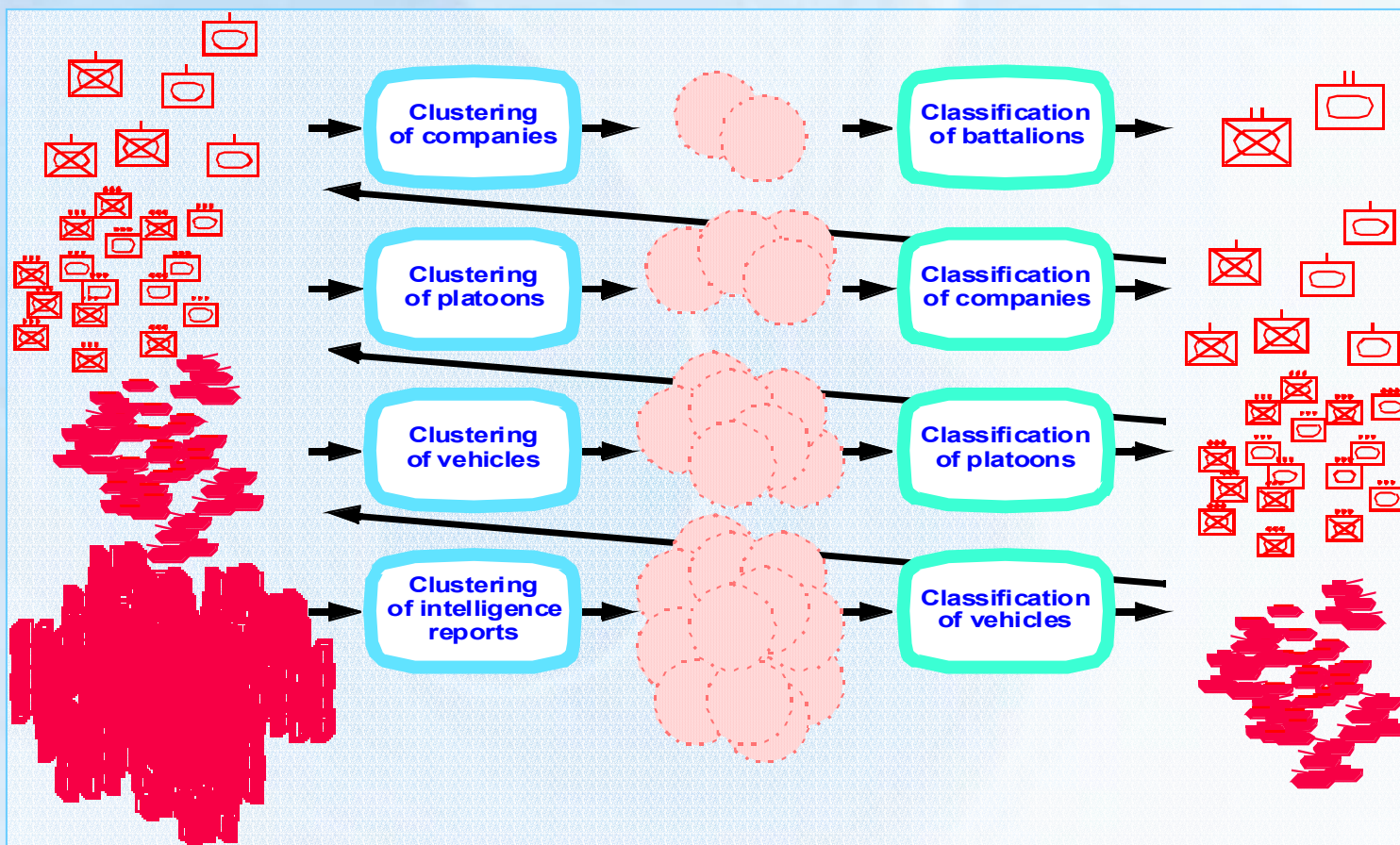
- **Force Aggregation**
 - Clustering
 - Classification
- **Ground Vehicle Tracking**
 - PHD Particle Filter
- **Sensor Resource Management**
 - Random Set Simulations

Force Aggregation



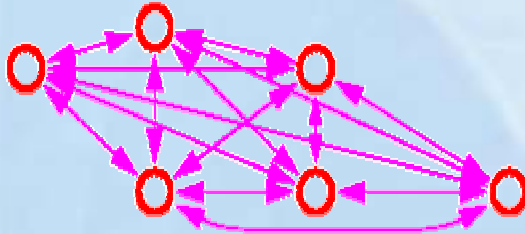
- **PROBLEM:** Determine positions and organizational structures of enemy units
- **SOLUTION:** Dempster-Shafer Clustering and Classification

Aggregation = Clustering + Classification



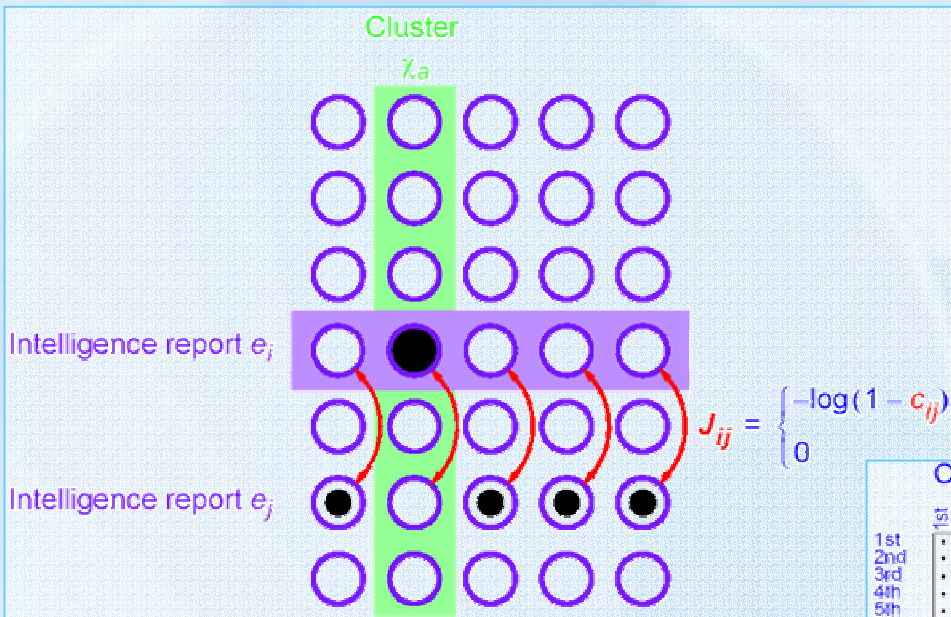
Clustering

- Evaluate all pairs of intelligence reports



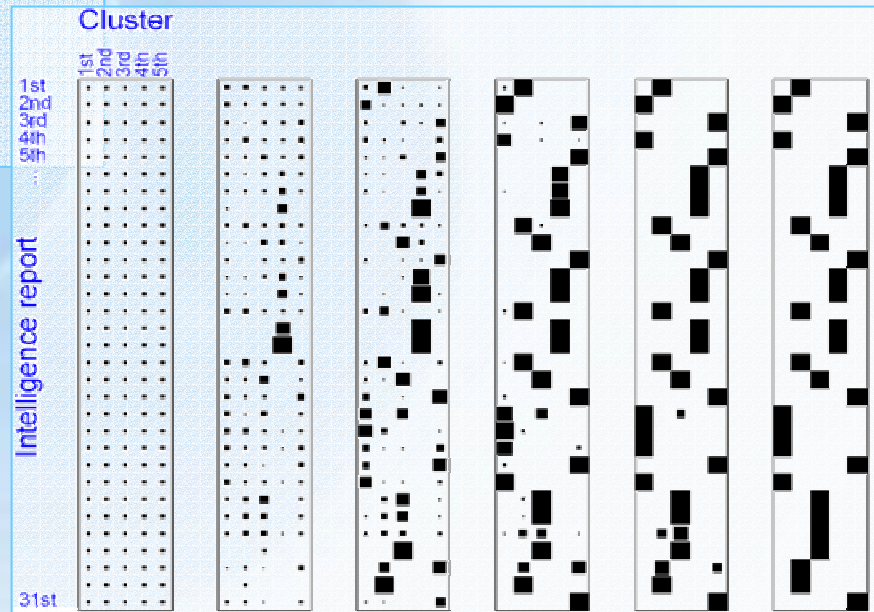
- Find whatever is against that two reports are referring to the same object
 - Wrong type of vehicle? (Dempster-Shafer conflict)
 - Is distance too long?
 - Wrong direction?
- this yields a potential conflict between each pair of intelligence reports

Clustering - Potts Spin neural network

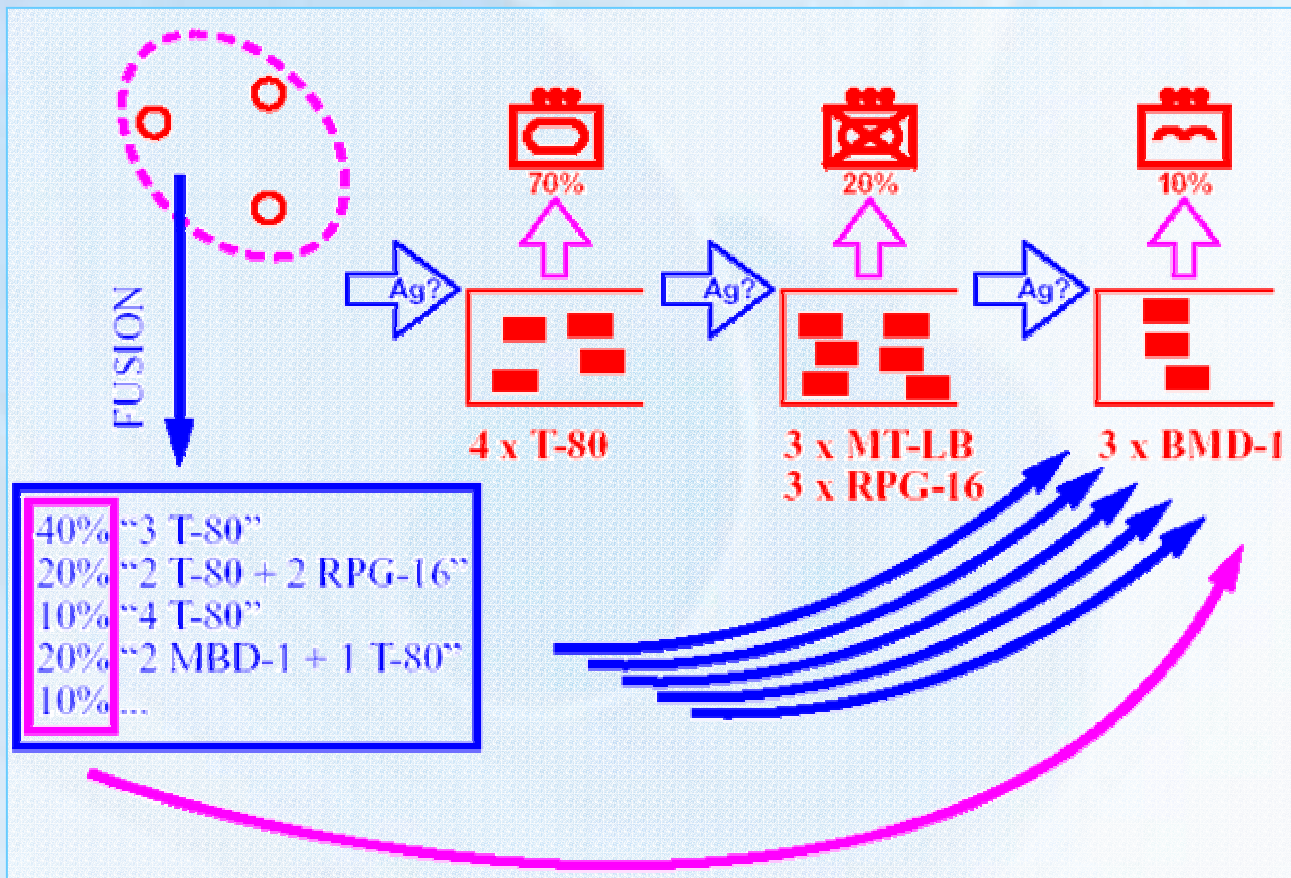


Cluster example:

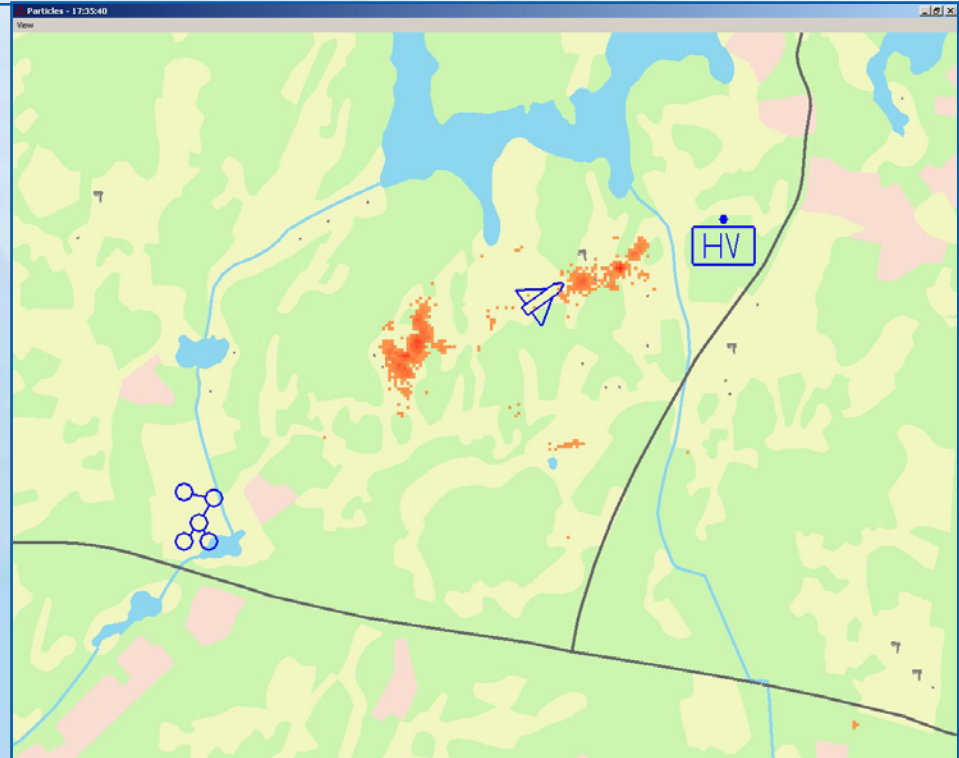
31 intelligence reports are clustered into 5 clusters



Classification



Ground Vehicle Tracking



- **PROBLEM:** Tracking of a large number of vehicles in terrain from incomplete observations.
- **SOLUTION:** PHD Particle Filtering (PHD = Probability Hypothesis Density)

PHD Particle Filtering – Approach

- **We track the first moment of joint distribution, i.e., PHD**
 - Integral of PHD over an area is expected # targets – compare with PDF with integral 1
 - Avoids combinatorial explosion – good for large number of vehicles
- **Here – particle filter implementation**
 - No need for analytical motion and observation models
 - Suitable for non-linear problems

PHD Particle Filtering – Illustration

- A PHD is represented by $N \times 500$ particles
- N is expected number of targets

Posterior at $t-1$

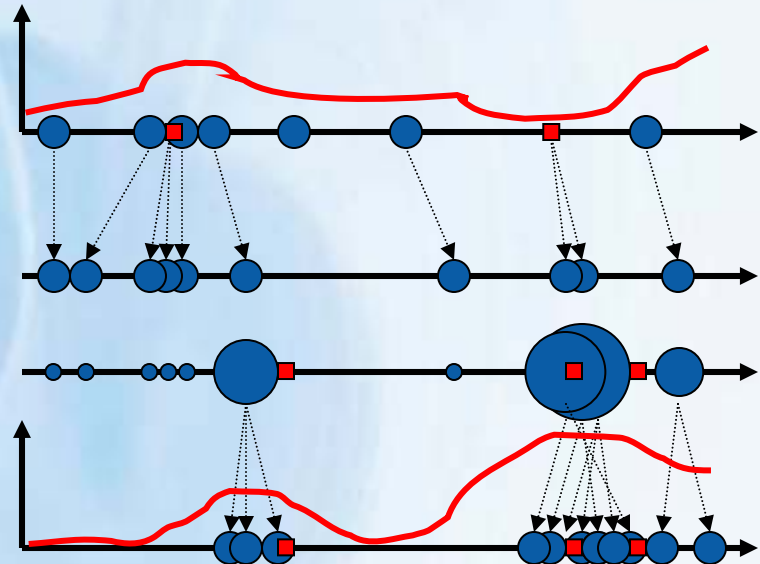
Propagate

Prior at t

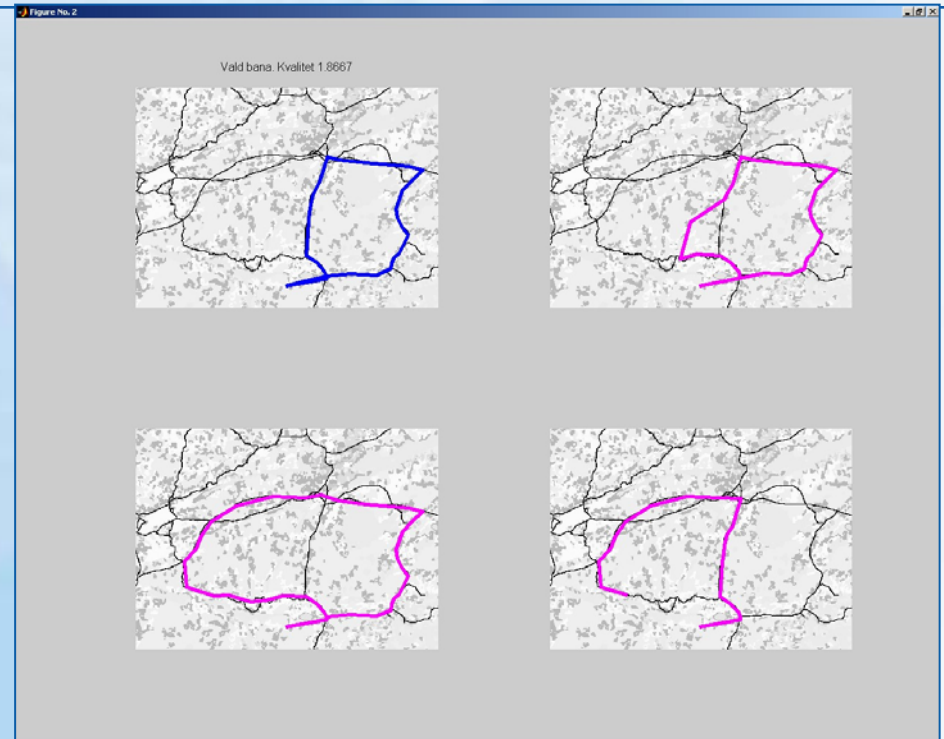
Multiply with SUM of likelihoods

Resample

Posterior at t

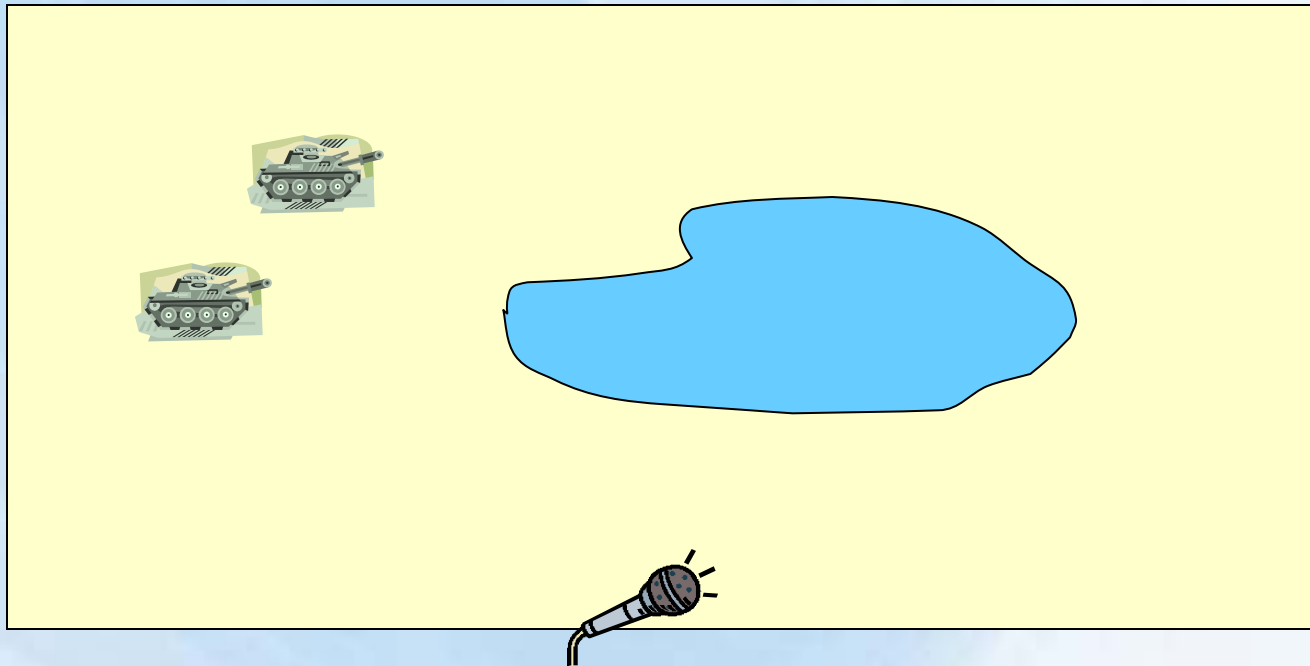


Sensor Resource Management

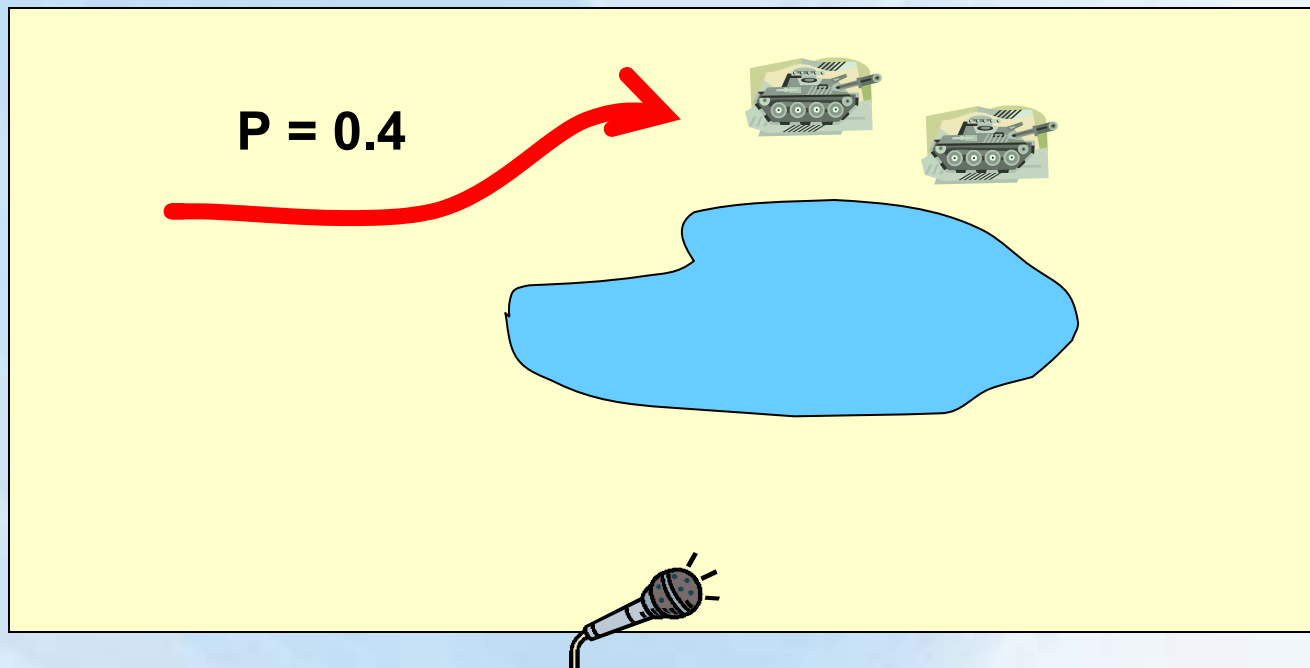


- **PROBLEM:** Given positions and possible strategies for the enemy, find an optimal sensor control policy
- **SOLUTION:** Evaluate sensor allocations by simulating different futures

Enemy positions now

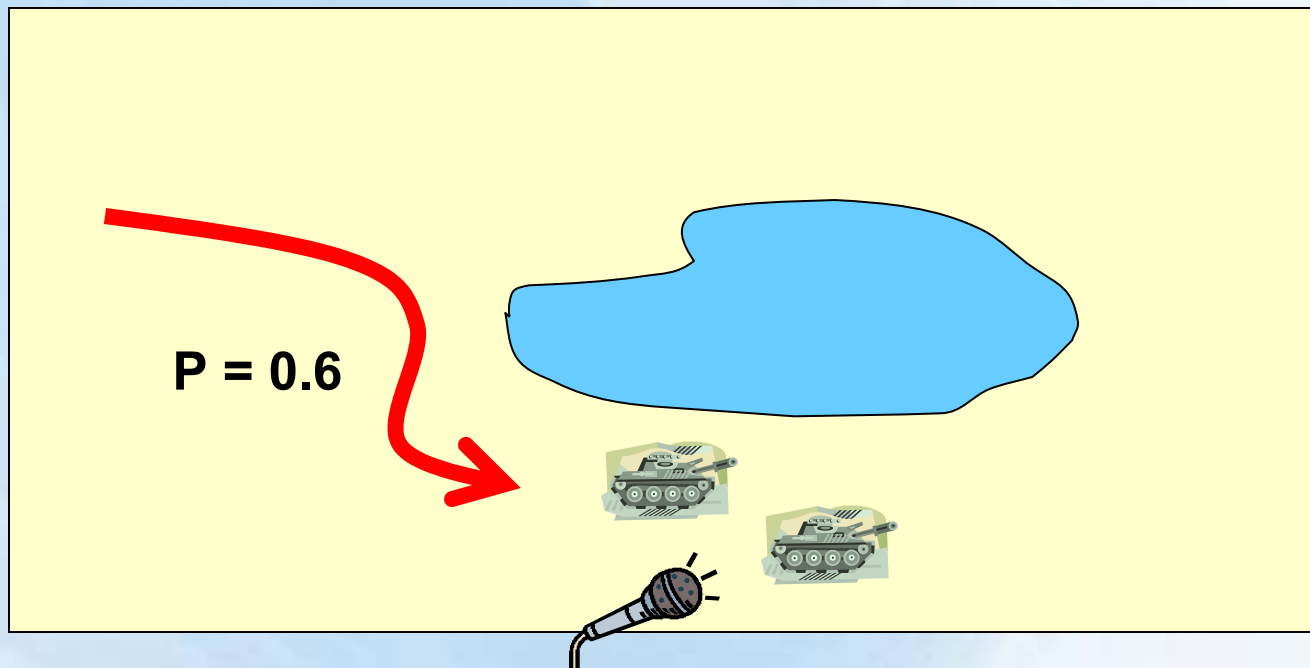


One possible future path



Sensor doesn't hear tanks!

Another possible future path

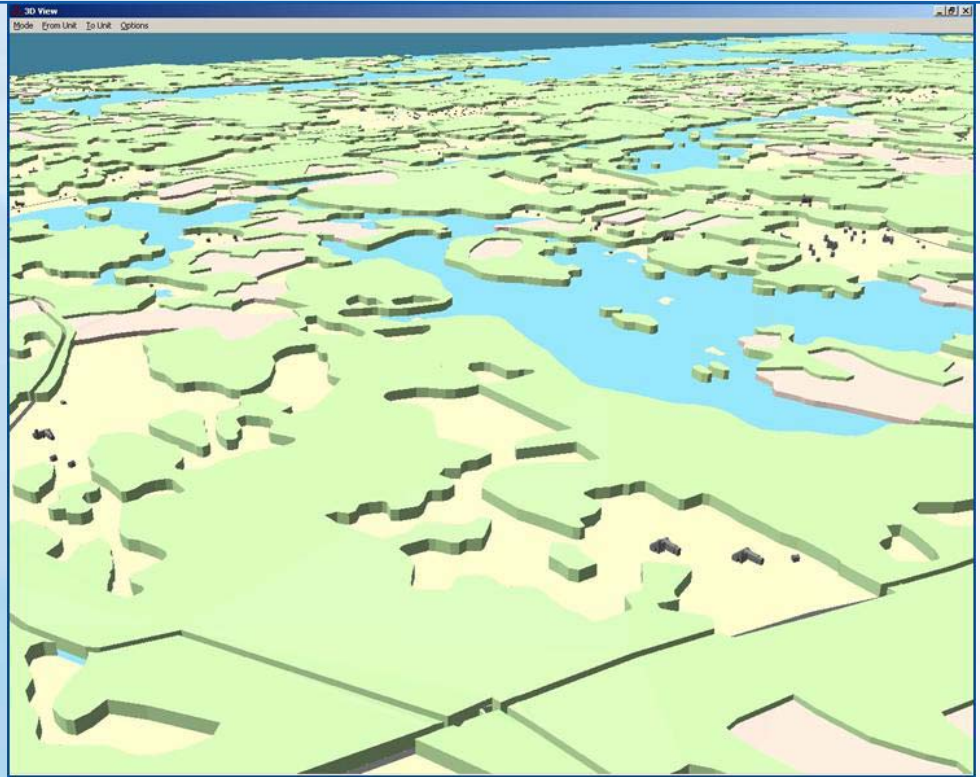


Tanks are observed!

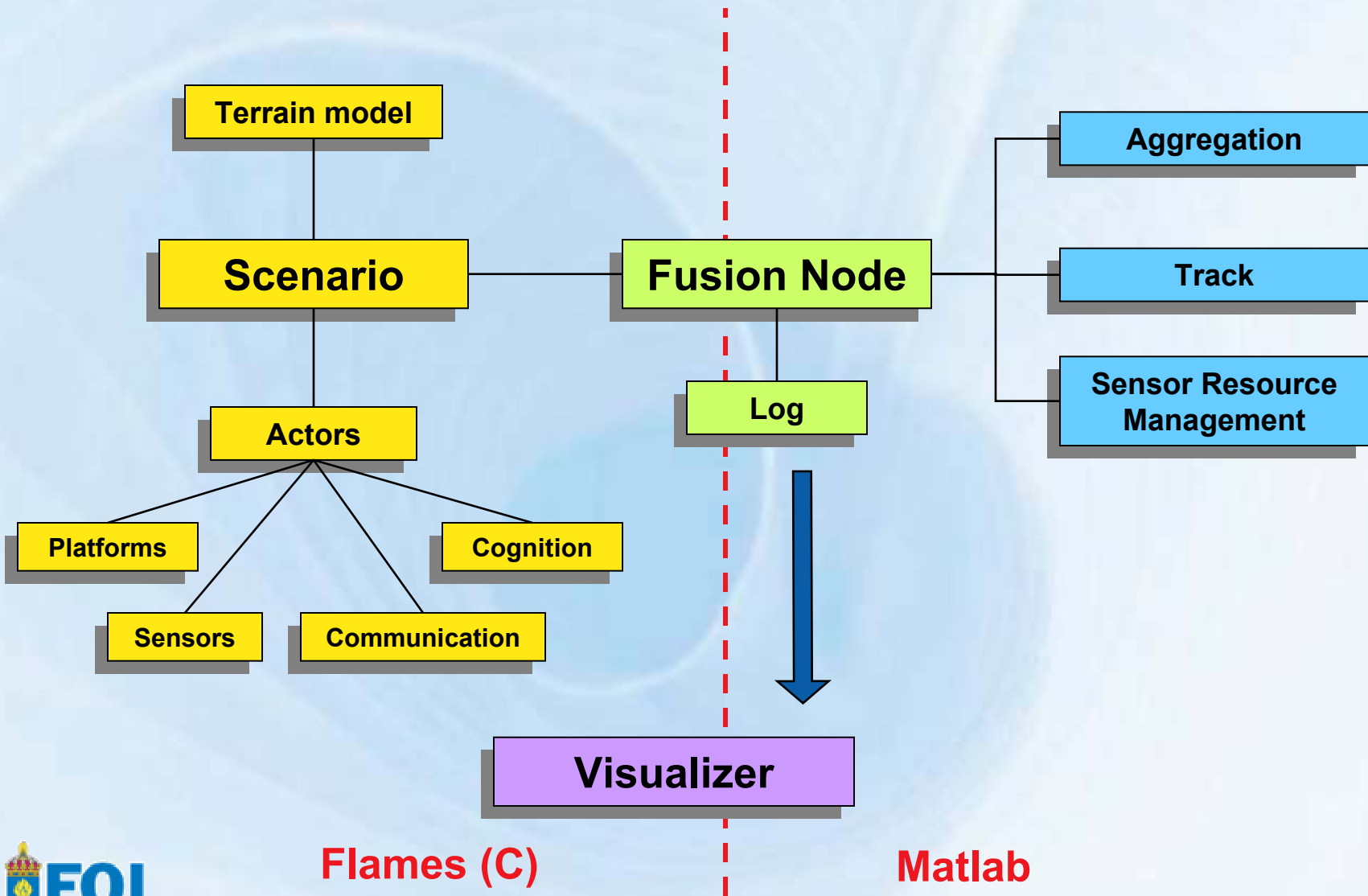
Sensor Resource Management

- Compare pre-determined sensor allocations
- Best sensor allocation is determined by averaging over many possible future paths

System Description



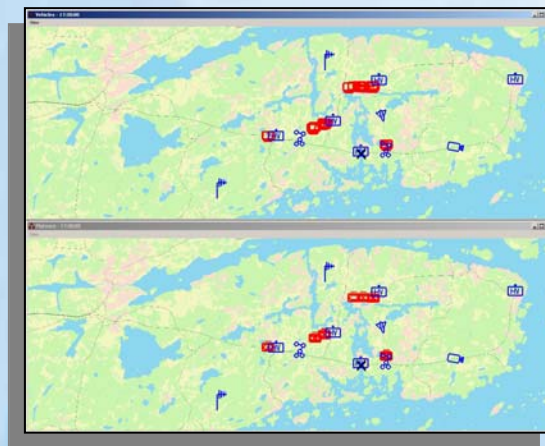
- Simulation Framework (Flames)
- Terrain model generator (Terra Vista)
- Analysis methods implemented in Matlab



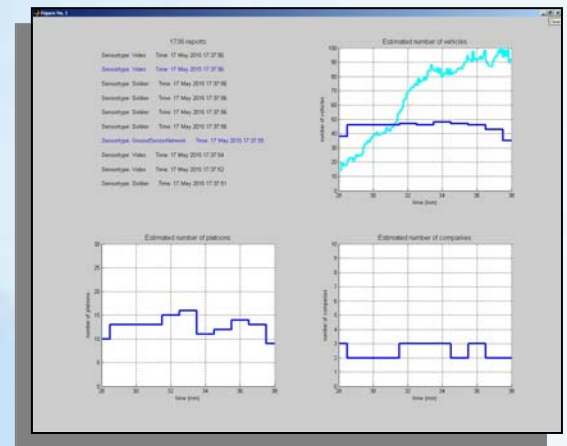
Visualizer



**Intelligence/
Ground truth**



**Aggregation/
Track**



**Parameters/
Sensor Management**

Conclusion

- We have developed a concept demonstrator for information fusion methodology
- Focus on intelligence processing at the division level
- A demonstration of IFD03 in December 2003 for the Swedish Armed Forces was a great success

Questions?

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