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# Location probability distribution of a drifting object by Monte Carlo - simulation

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# ProSAR

**ProSAR is C4I decision support system for resource and operation management**

- **to provide the Maritime Rescue Coordinator, MRC with an intergrated presentation of the data from the different sources**

- **to carry out the heavy calculations needed in search planning and evaluation**

- **to provide the MRC with efficient planning tools to optimize the use of the resources**

- **to provide the MRC with data communication**

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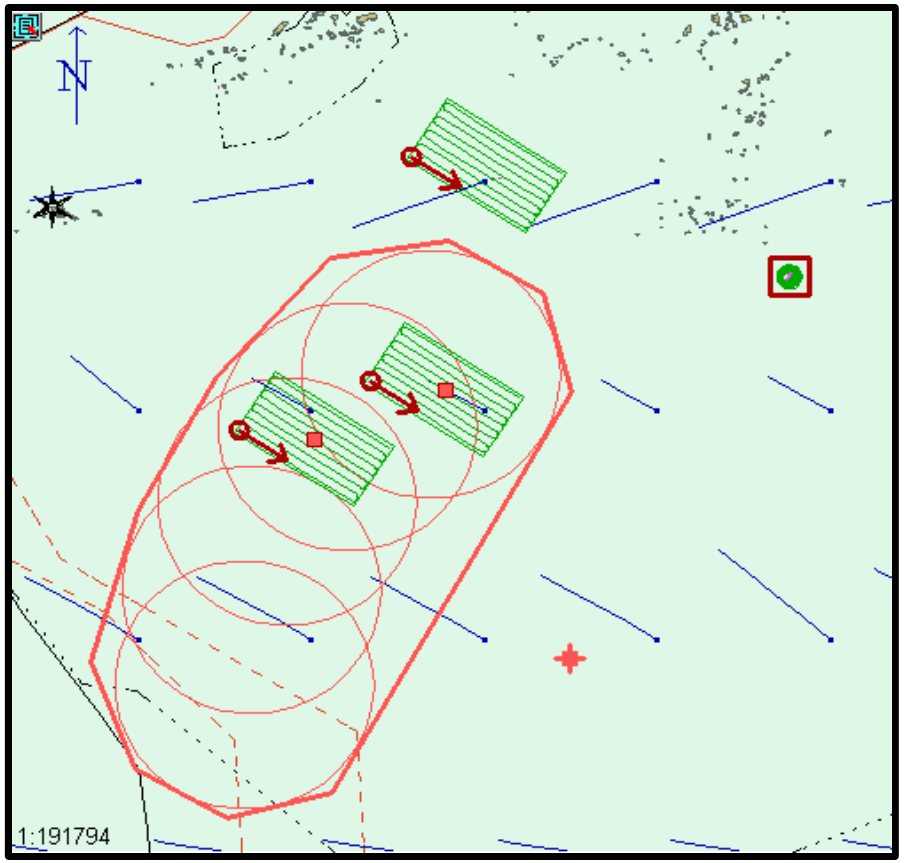
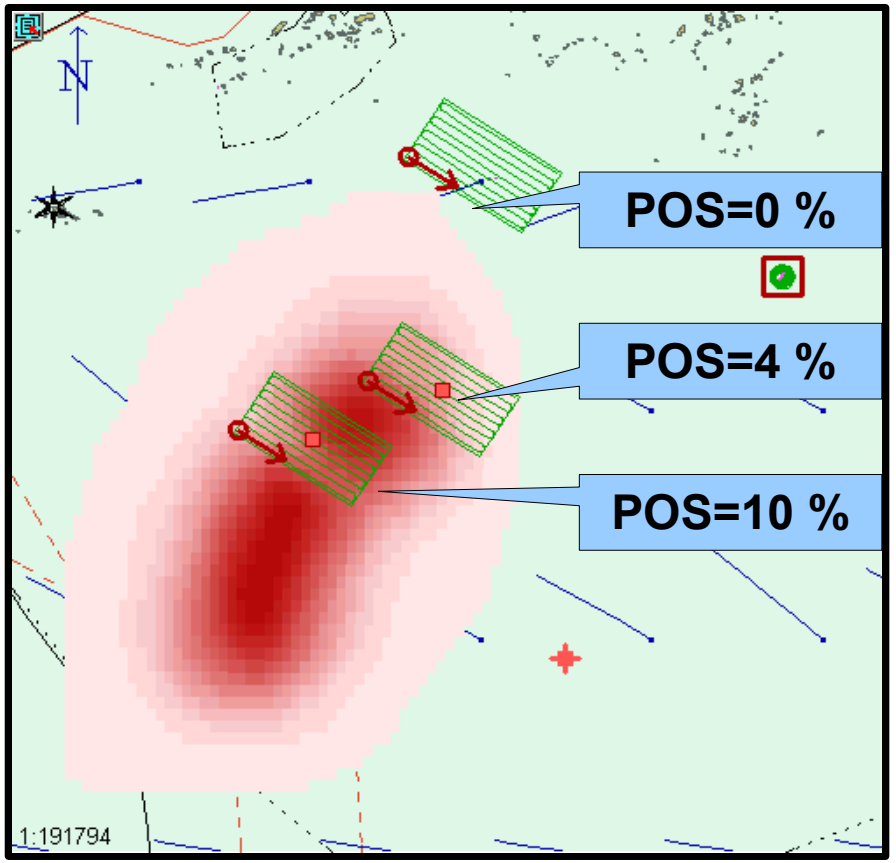
# OPTIMIZING THE USE OF THE RESOURCES

**In case of the search operation, optimizing = maximizing the POS (Probability of Success) of the search tasks**




**Search object's *location probability distribution* is needed for POS calculation**

***Location probability distribution* can be maintained by the particle based Monte Carlo simulation**

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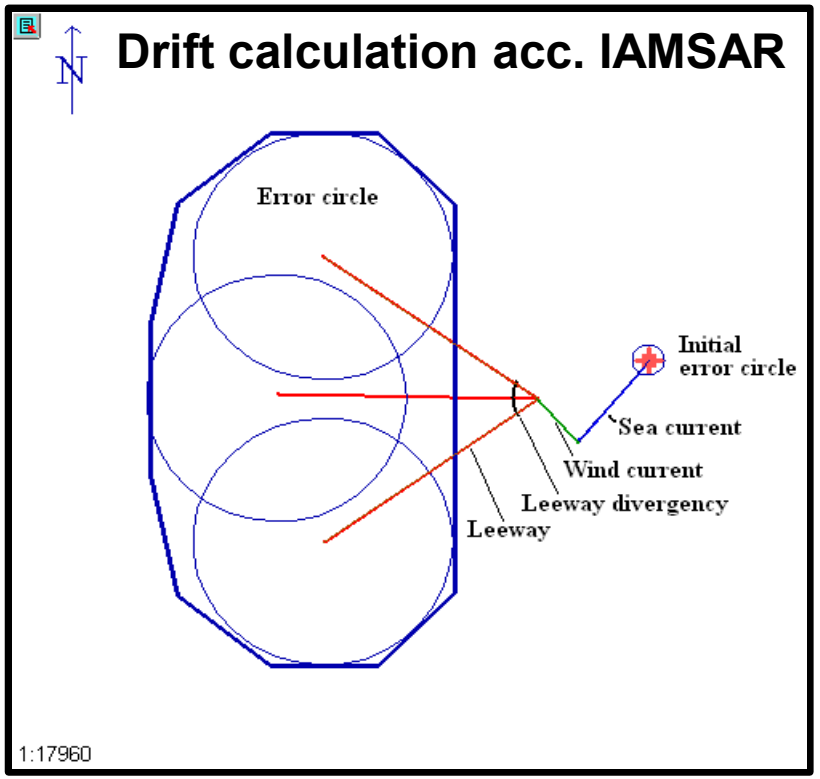
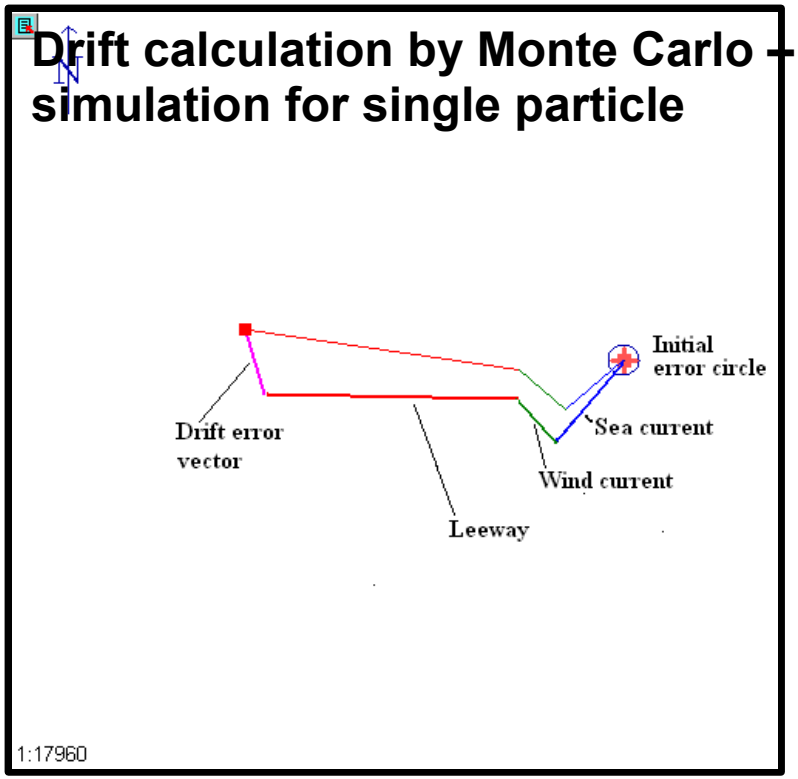
# DRIFT CALCULATION BY MONTE CARLO – SIMULATION

- The drift is calculated in a similar manner in the manual method and in Monte Carlo-simulation with vector components (sea current, wind current, leeway, tide)
- The trajectory of the drift object is calculated with 15 minutes time step




- Uncertainties of the environmental data (wind speed and direction, current speed and direction etc) are taken into account as drift error factor (normally =30%).
- The radius of the error circle is relative to the distance drifted.

- Uncertainties of the environmental data (wind speed and direction, current speed and direction etc) are defined as standard deviations
- The data is varied during the simulation producing the error vector component.

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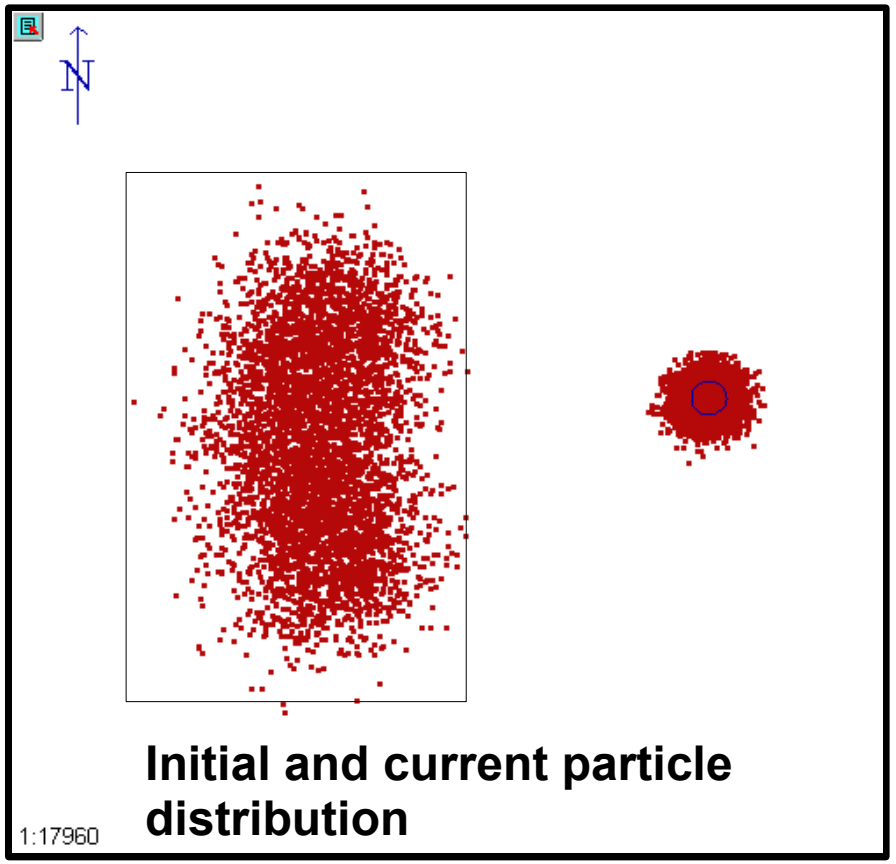
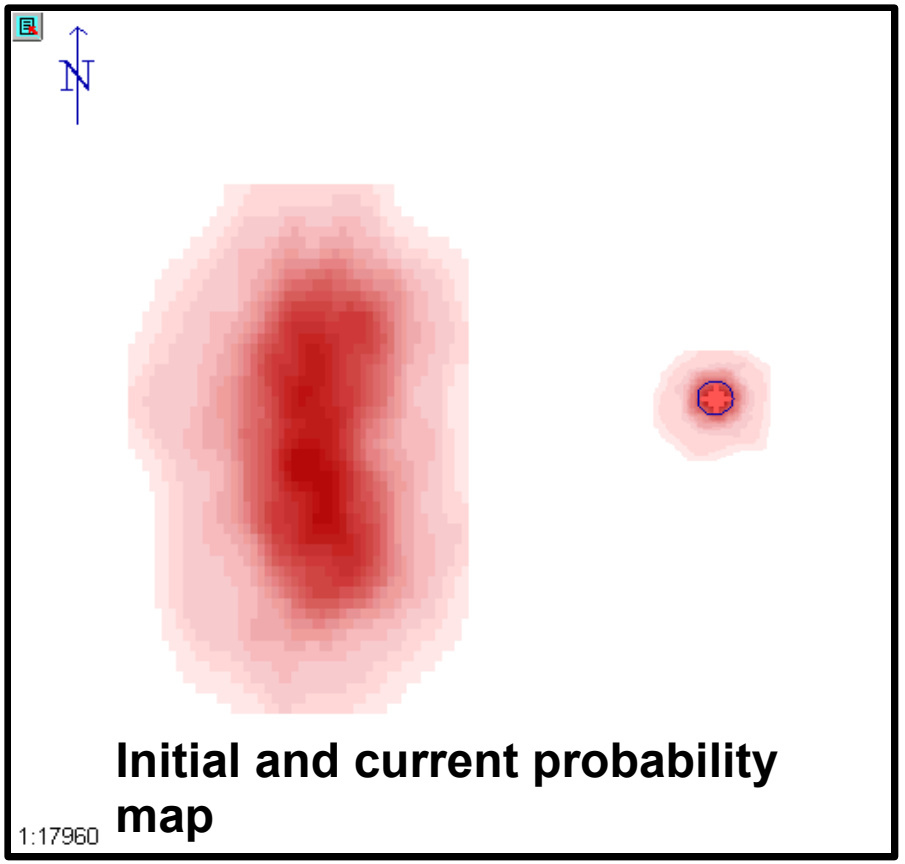
# LOCATION DISTRIBUTION BY MONTE CARLO – SIMULATION




Initial and current particle distribution




Initial and current probability map

- 5000 or more independent particles, are needed for the position probability distribution
- For the probability map a regular grid is created around all the particles, with desired grid density (default 50 x 50 cells).
- POC (Probability of Containment) in each cell is (number of particles within the cell)/( tot.number of particles)
- Probability map is presented as color coded POC- distribution

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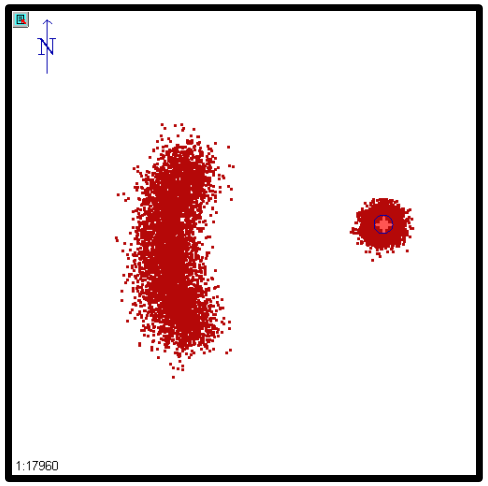
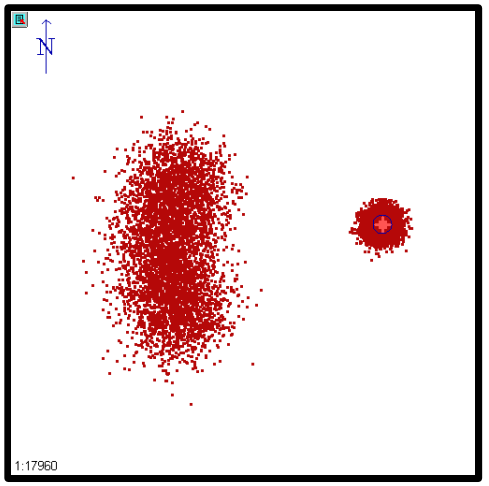
# PARTICLE PROPAGATION MODEL:

Propagation model defines how the particles reacts on the changes in drifting forces. The random velocity components in the turbulent velocity field (two independent velocity components u and v)



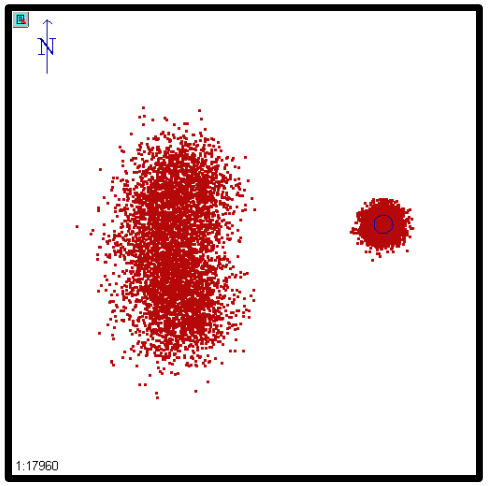

## Random walk

The random walk velocity:
for each time step
u(t) = б Wu *n[0,1]
v(t) = б Wv *n[0,1]
б Wu* б Wu = velocity variance (u).
б Wv* б Wv = velocity variance (v).
n[0,1] = normally distributed random variable with zero mean and variance=1.




## Random flight

The random flight velocity:
for each time step
u(t) = A* u(t-dt) +
б Fu *sqrt( 1-A*A ) *n[0,1]
A = exp( -dt/T ).
dt = the time step.
T = the turbulent time scale.
б Fu* б Fu = random flight velocity variance.




## Ballistic model

The ballistic velocity error:
Constant velocity error
u(t) = u(t-dt)= ... = u(0)
= б Bu *n[0,1]
б Bu* б Bu = velocity variance.

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## SCENARIO

A consistent set of fact and assumptions describing what may have happened to survivors. It usually consists of a sequence of actual and assumed events starting sometime prior to the distress incident and continuing to the present time. The most likely scenario(s) is used as a basis for planning searches (IAMSAR 4.6.1)

## POSSIBILITY AREA

The smallest area containing all possible survivor or search object locations. For a scenario, the possibility area is the smallest area containing all possible survivor or search object locations which are consistence with the facts and assumptions used to form the scenario (IAMSAR 4.6.1)

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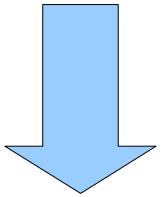
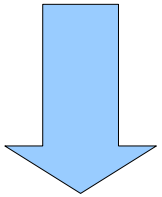
**SCENARIO AND FULL SCALE SITUATION PICTURE**



**INITIAL POSSIBILITY AREA**
**INITIAL POSITION PROBABILITY DISTRIBUTION**



- Movement estimation
- Maritime drift
- Searches conducted

**CURRENT POSSIBILITY AREA**
**CURRENT POSITION PROBABILITY DISTRIBUTION**

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# ASSUMPTIONS AND UNCERTAINTIES vs. POSSIBILITY AREA

- **Distress incident position**
- **Distress incident time**

Affect on initial possibility area

- **Characteristics of the search object**
  **-leeway characteristics**
- **Environmental data**
  **-winds,water currents,waves, temperatures, visibility**

Affect on current possibility area

**THE BIGGER THE UNCERTAINTIES ARE, THE LARGER IS THE POSSIBILITY AREA**

**THE MOST COST EFFECTIVE SEARCH IS DONE BY AIMING FOR THE MORE ACCURATE DATA**

# INITIAL POSSIBILITY AREA

**The smallest area containing all possible survivors or search object locations at the time of the distress incident.**

**ProSAR supports the following *elementary datum types* to define the initial possibility area**

- **Point datum**
- **Line datum**
- **Area datum**
- **Route datum**
- **Back Track datum**

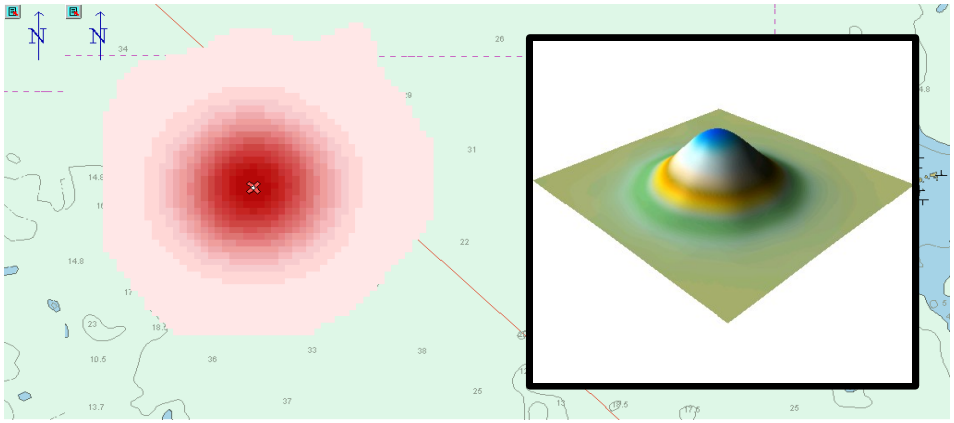
**The initial possibility area can also be defined as a *combination of the elementary datums***

# INITIAL POSSIBILITY AREA:

## ELEMENTARY DATUM TYPES

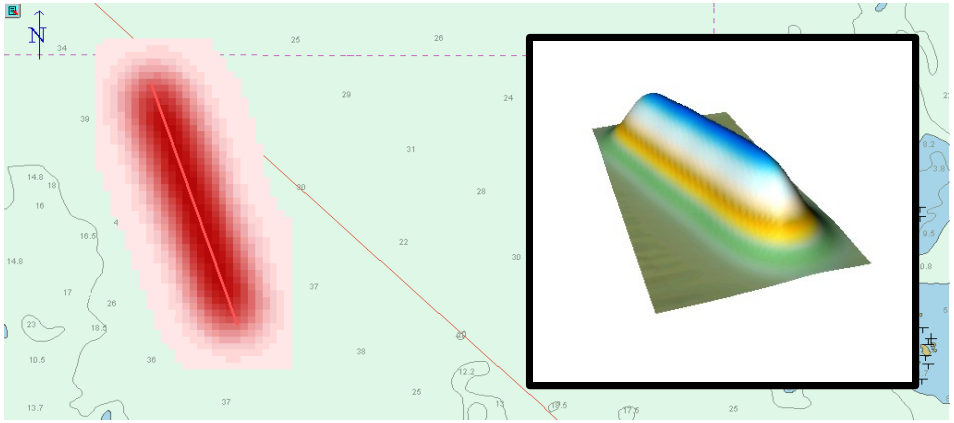
### POINT DATUM

- Position (Phi,Lambda)
- Position accuracy
- Normal circular position probability distribution



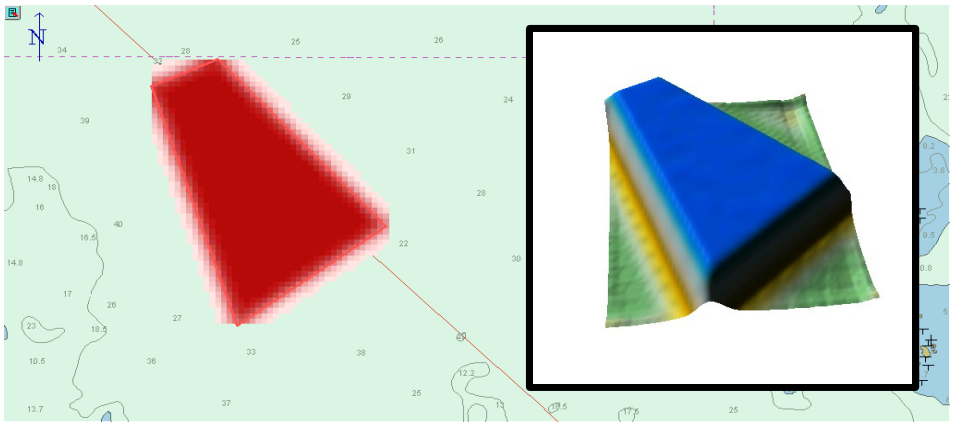
### LINE DATUM

- Polyline 2...n geographical points in sequence
- Position accuracy
- Normal position probability distribution on line cross section



### AREA DATUM

- Uniform position probability distribution within the area
- Area border as 3...n geographical points in sequence

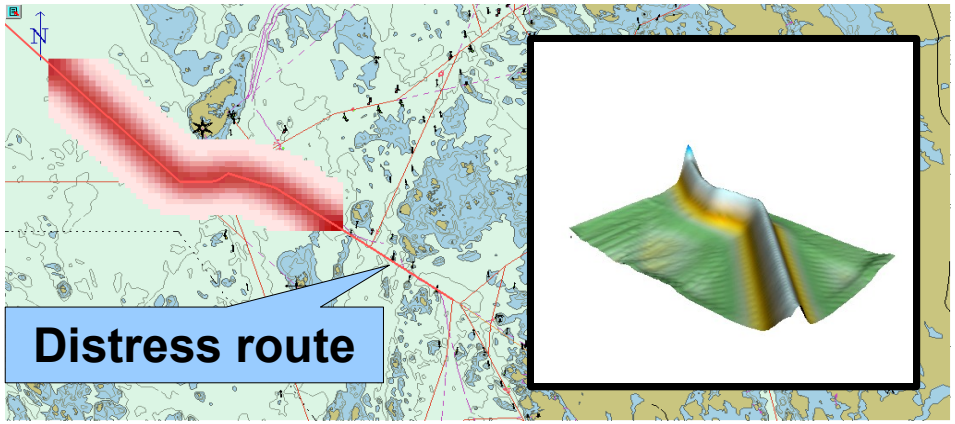


# INITIAL POSSIBILITY AREA:

## ELEMENTARY DATUM TYPES

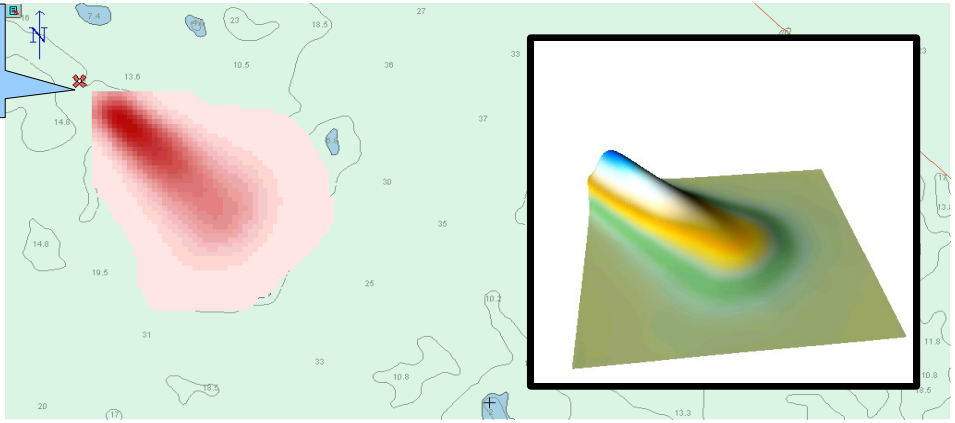
### ROUTE DATUM

- 2...n waypoints in sequence each point associated with the time.
- Position accuracy
- Normal position probability distribution on line cross section
- Route defined by the user or as known track history of the selected vessel or aircraft




In case distress incident time period the route datum is a part of the route.
In case of exact distress incident time the route datum is a point

### BACKTRACK DATUM




Reverse drift calculation for a known object e.g. capsized boat or debris to establish the inital possibility area and position probability distribution of the search object

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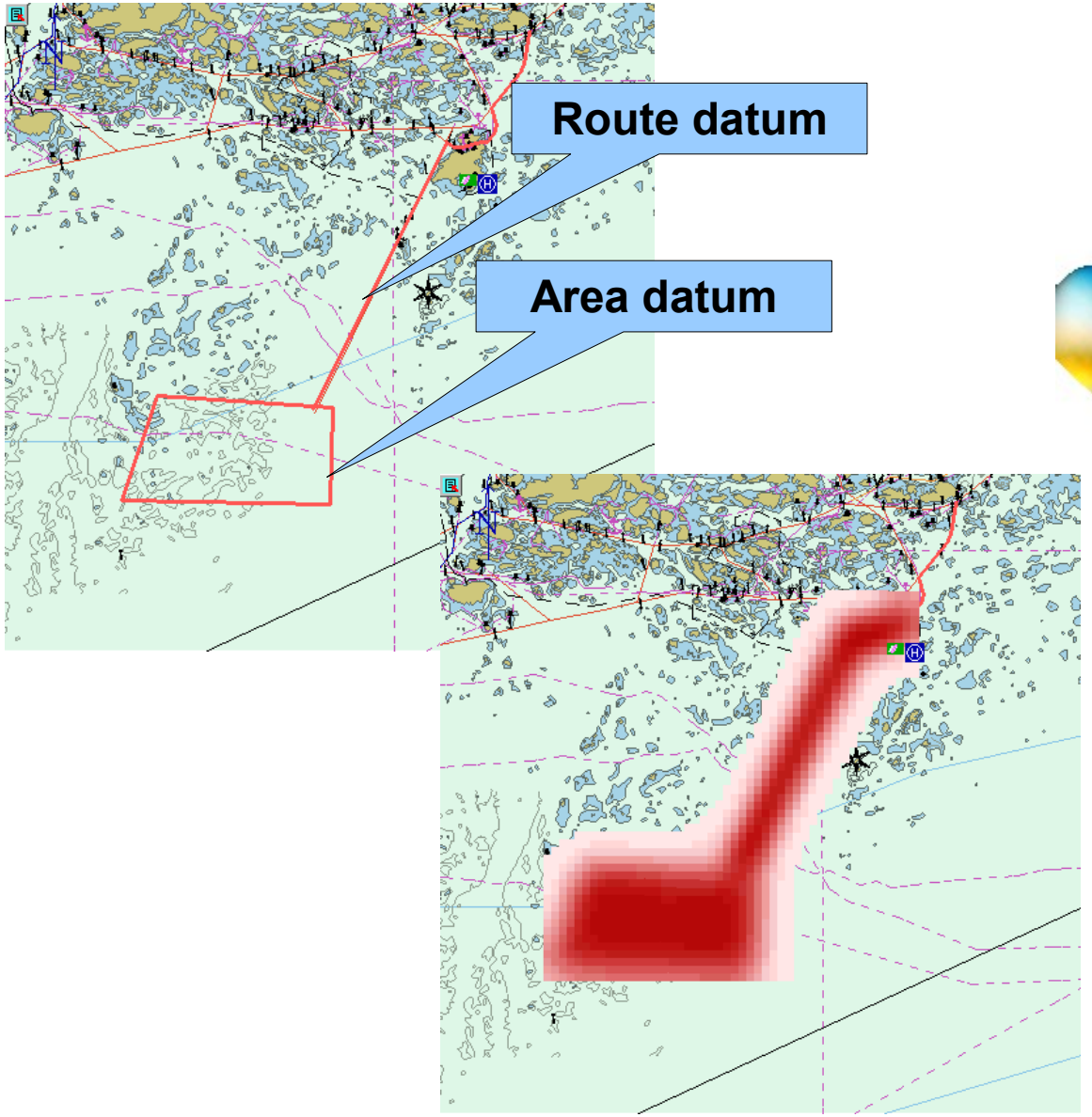
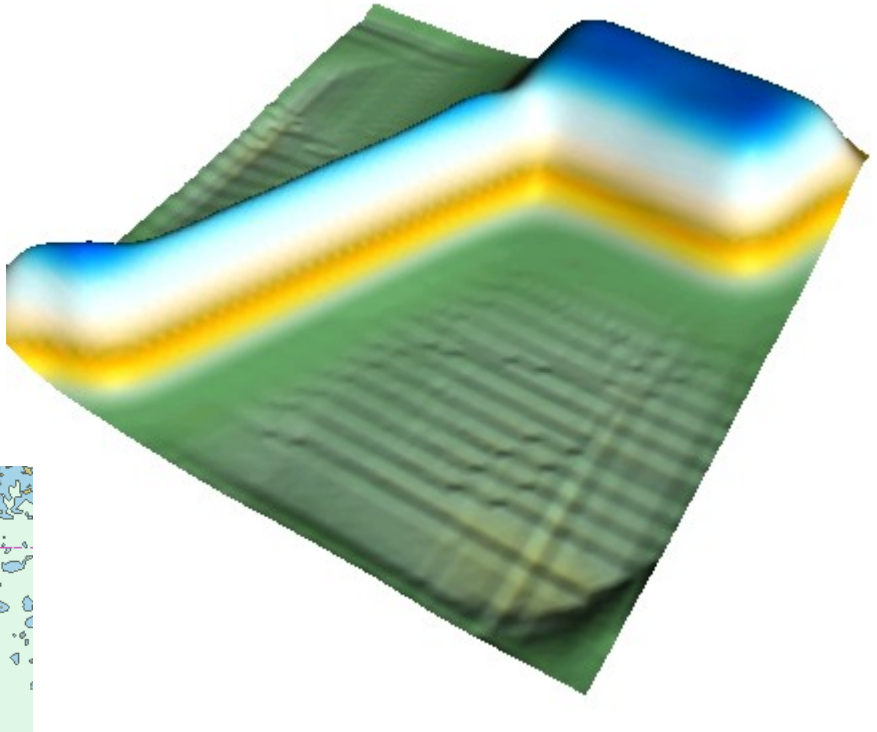
# INITIAL POSSIBILITY AREA:

## COMBINATION OF ELEMENTARY DATUMS



Any number of different elementary datums (point,line, area, route and backtrack) can be combined to form the initial possibility area

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# INITIAL POSSIBILITY AREA:

## WEIGHTING THE INITIAL POSITION PROBABILITY DISTRIBUTION

- Automatic, time based weighting when distress incident has been defined as time period

- User defined proportional weights for the elementary datums

- User defined hazard areas with desired risk levels

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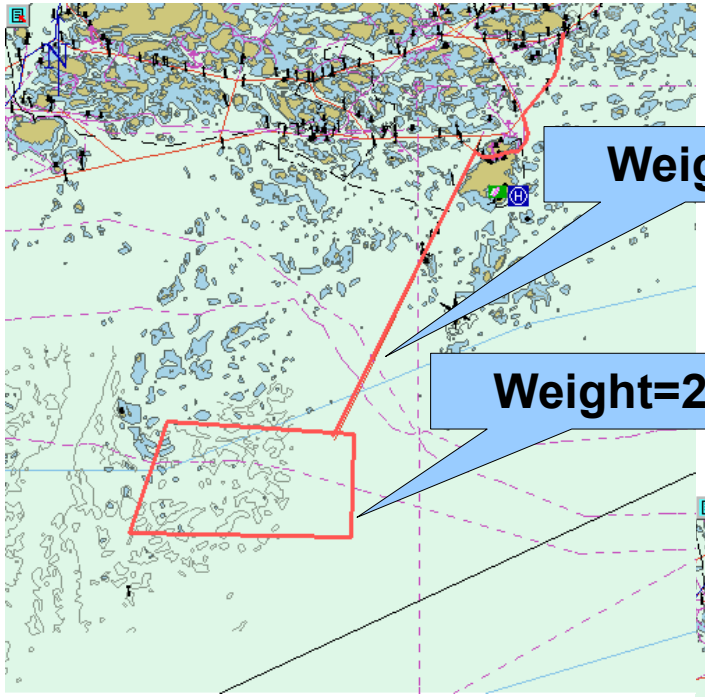
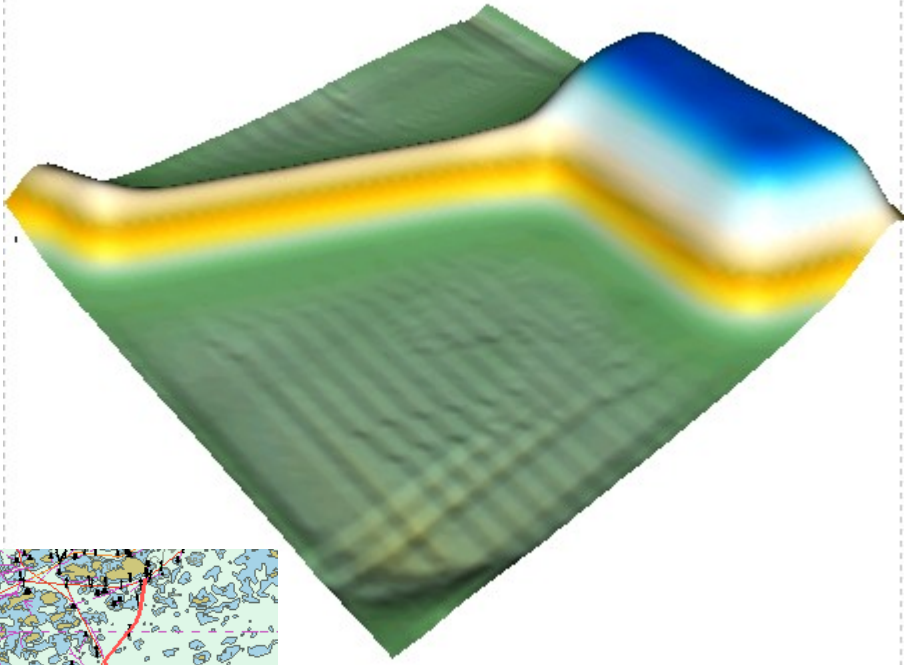
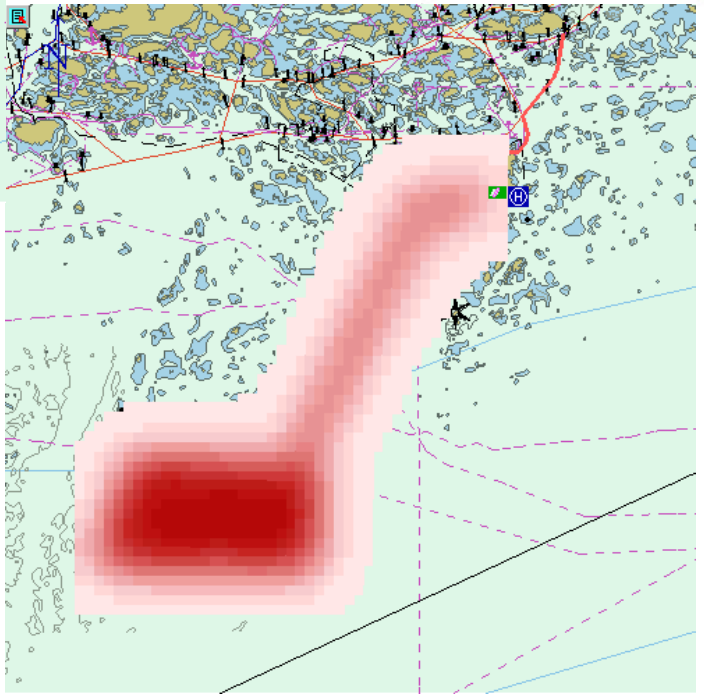
# INITIAL POSSIBILITY AREA:

## USER DEFINED PROPORTIONAL WEIGHTS FOR THE ELEMENTARY DATUMS





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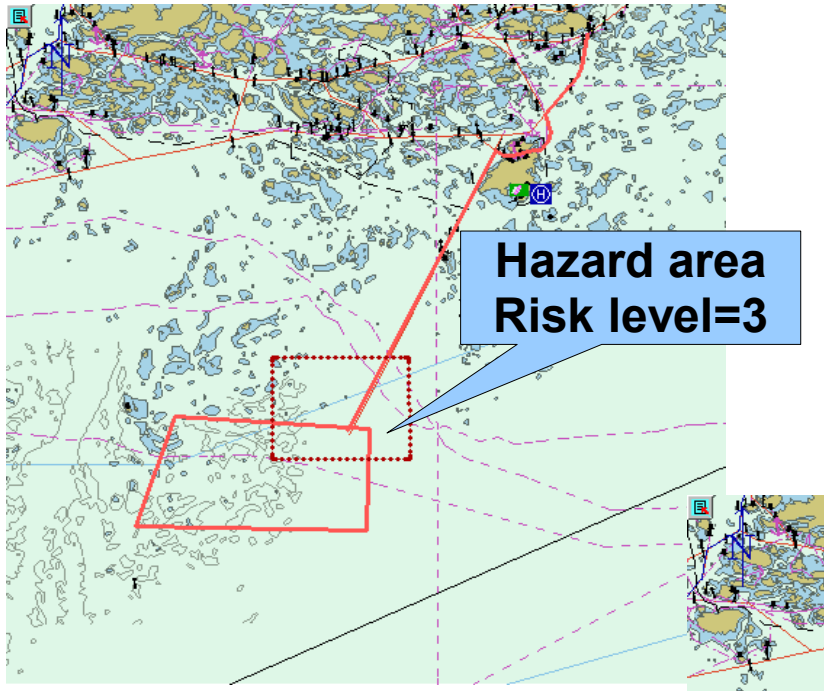
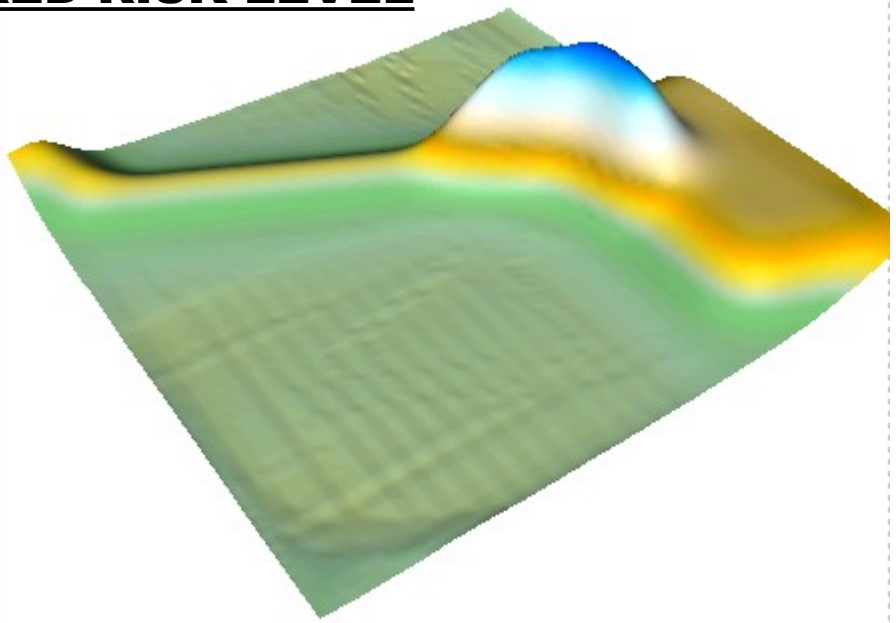
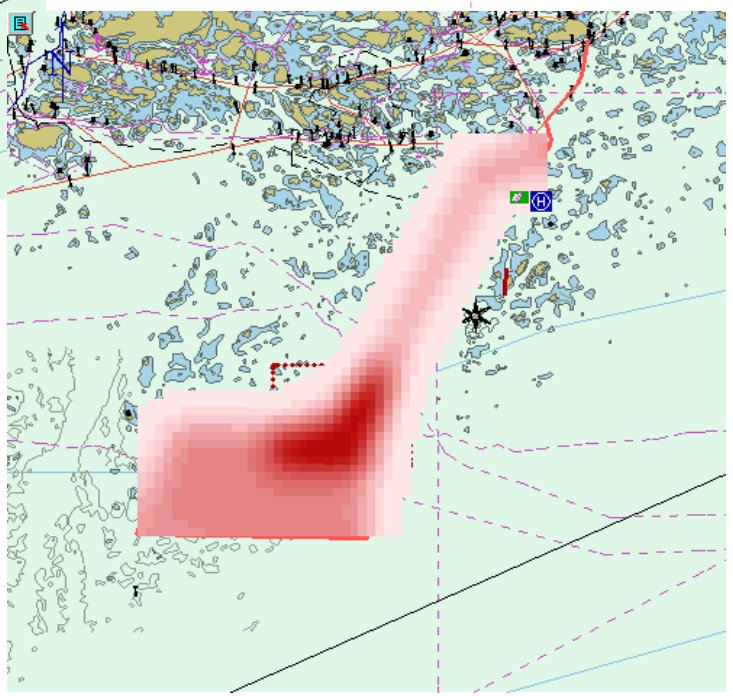
# INITIAL POSSIBILITY AREA:

## USER DEFINED HAZARD AREAS WITH DESIRED RISK LEVEL





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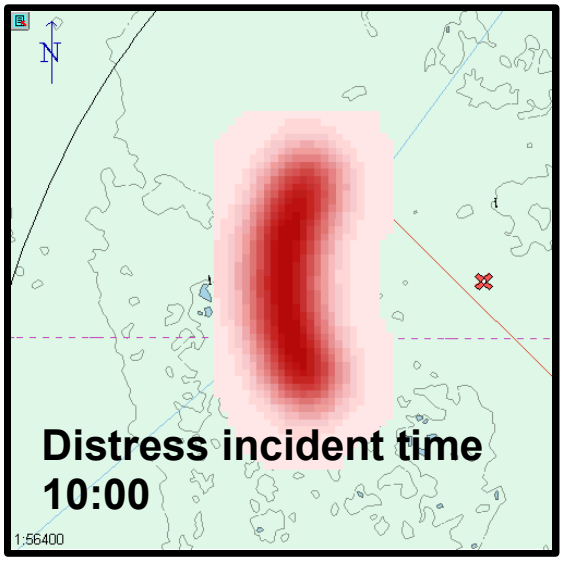
# DISTRESS INCIDENT TIME:

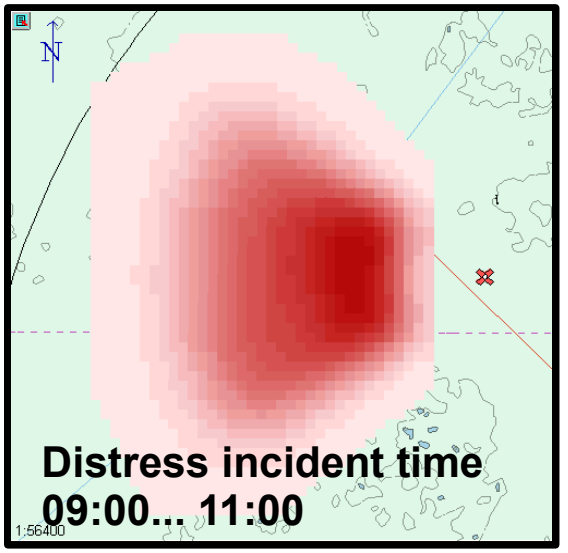
## EXACT DISTRESS INCIDENT TIME

- The distress time is known with a high accuracy




## UNCERTAIN DISTRESS INCIDENT TIME

- Distress incident time is not known accurately
- Time is estimated as a time period
- The probability of the distress time is evenly distributed within the time period
- The uncertainty in the distress incident time increases the possibility area in case of a mobile search object (actively or passively moving seach object)

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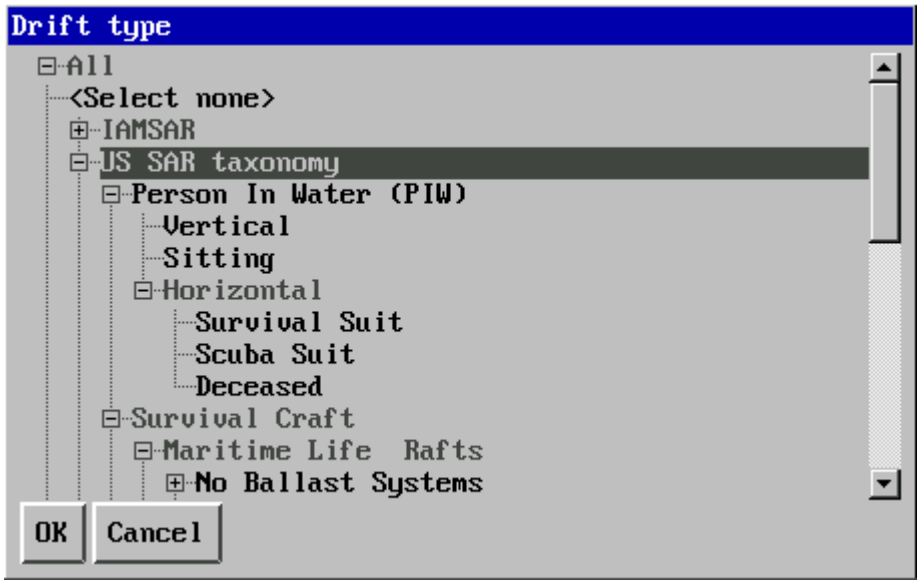
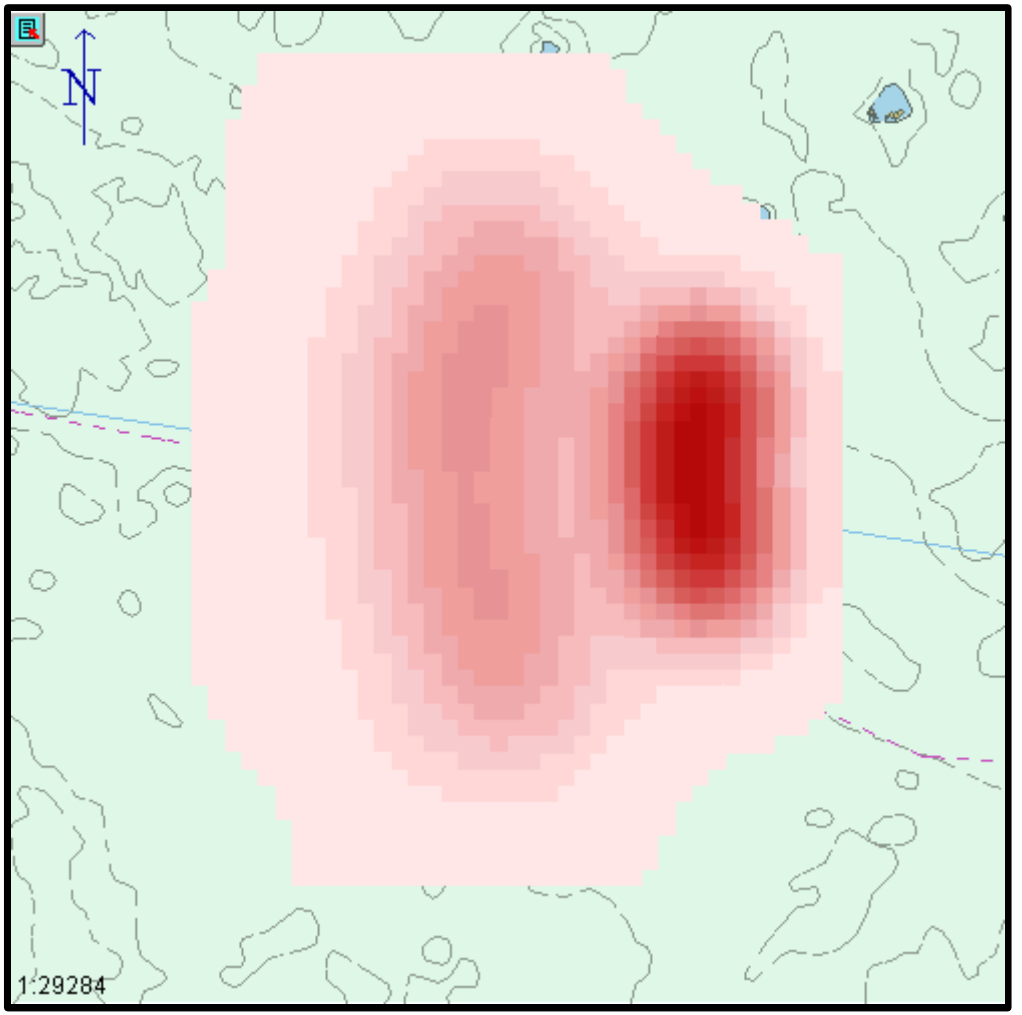
# DRIFT OBJECT TYPE :

Drift object leeway definitions according to

- IAMSAR taxonomy
- US CG taxonomy
- User defined drift object definition




Drift object type uncertainty. Several drift object types for a single search object

# MOBILITY OF THE SEARCH OBJECT

**The mobility of the search object after the distress incident**

**Fixed**

- **The search object is not moving after the distress incident**

**Mobile**

- **Parachute drift, aircraft glide, dead reckoned movement**
- **Moving actively by own means (walking, swimming, driving a vehicle)**
- **Moving passively due to the environmental forces (maritime drift)**

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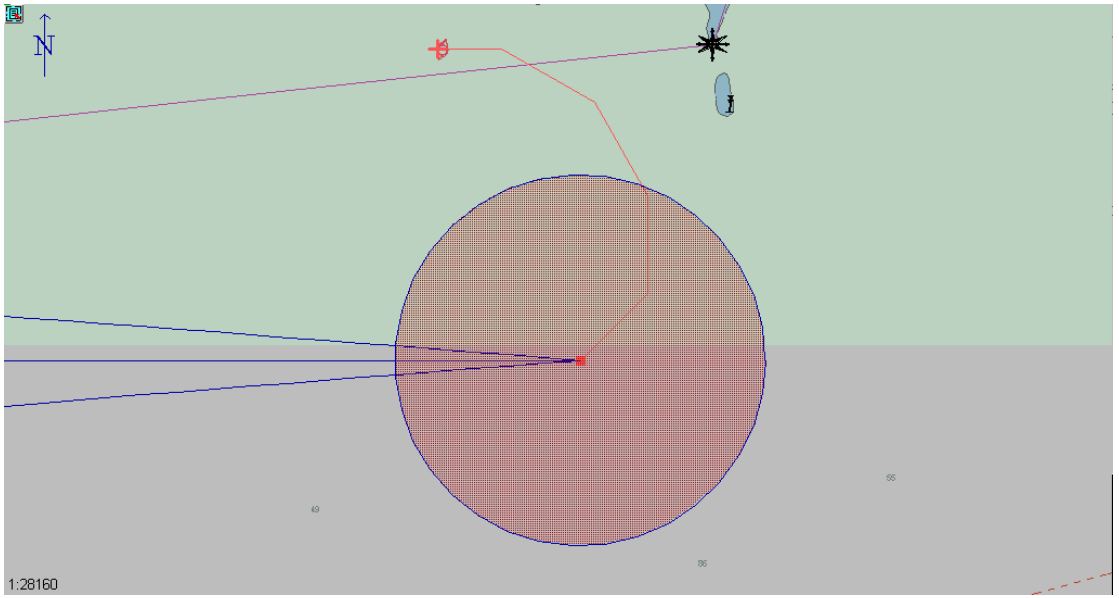
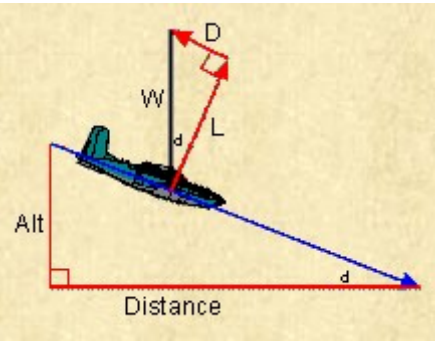
# MOBILITY OF THE SEARCH OBJECT

## PARACHUTE DRIFT, AIRCRAFT GLIDE, DEAD RECKONED MOVEMENT

**These movement are taken as an offset to the initial possibility area.**




**For parachute drift and aircraft glide the high winds has to be defined**

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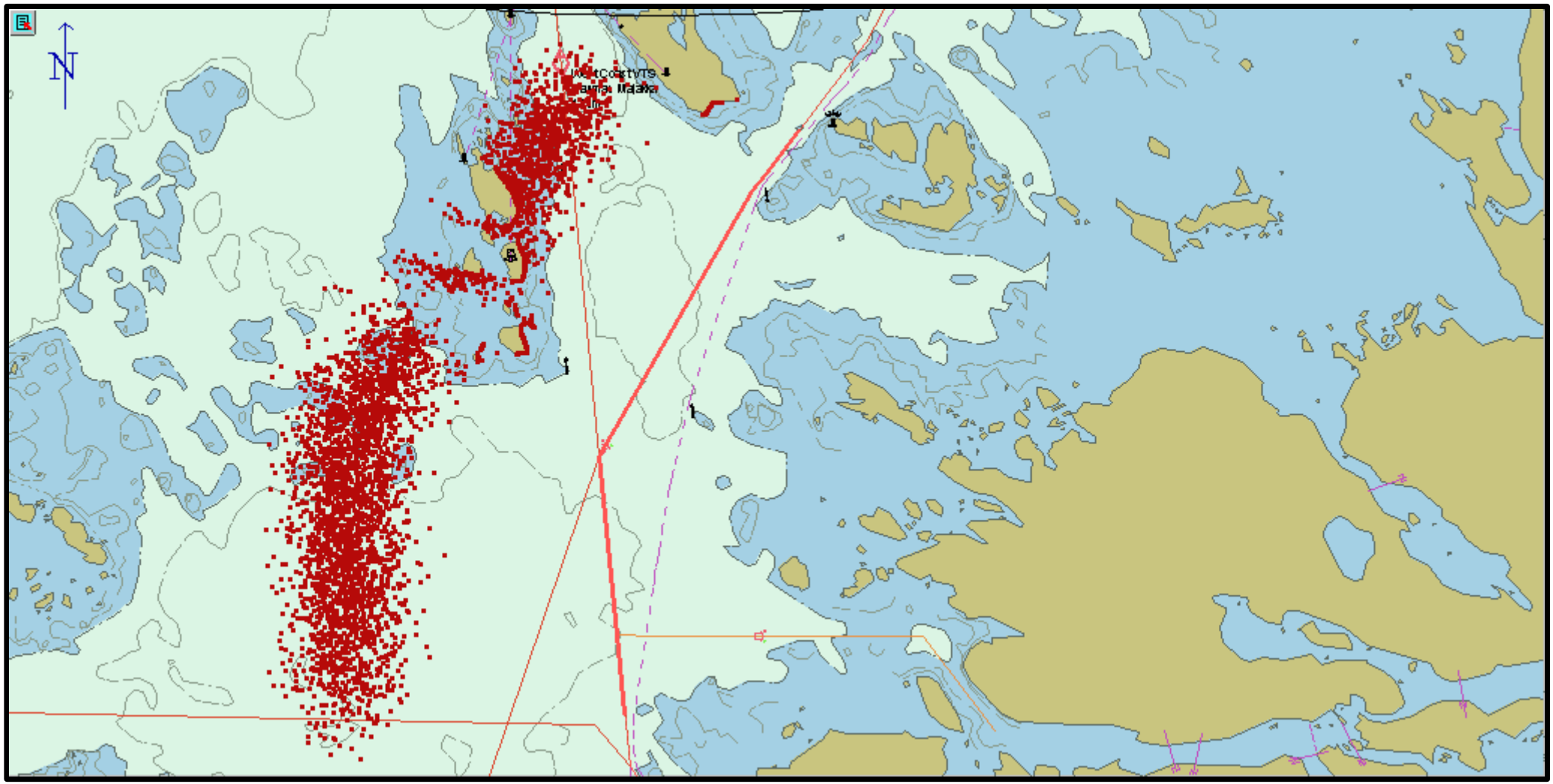
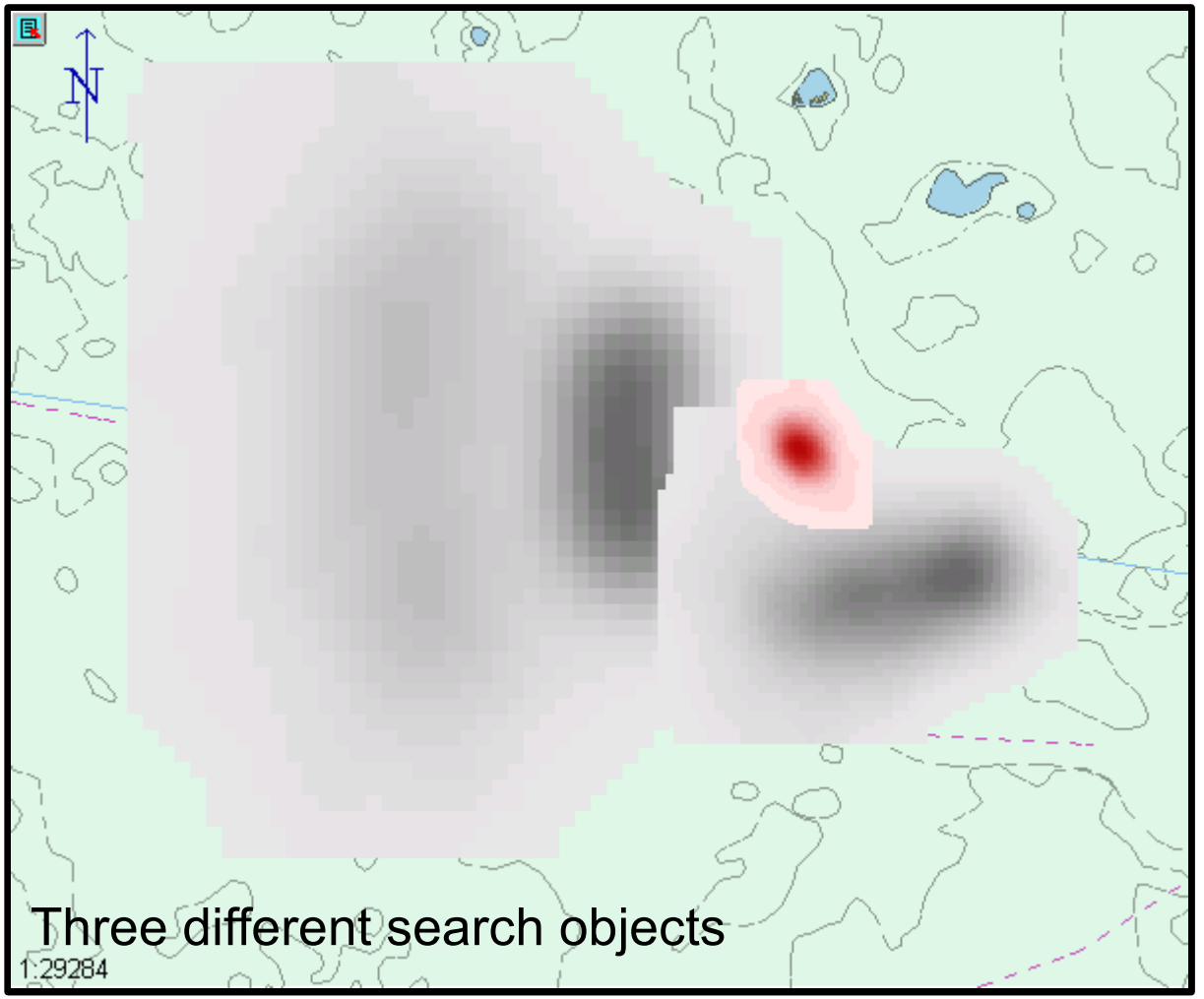
# LOCATION PROBABILITY DISTRIBUTION IN THE ARCHIPELAGO

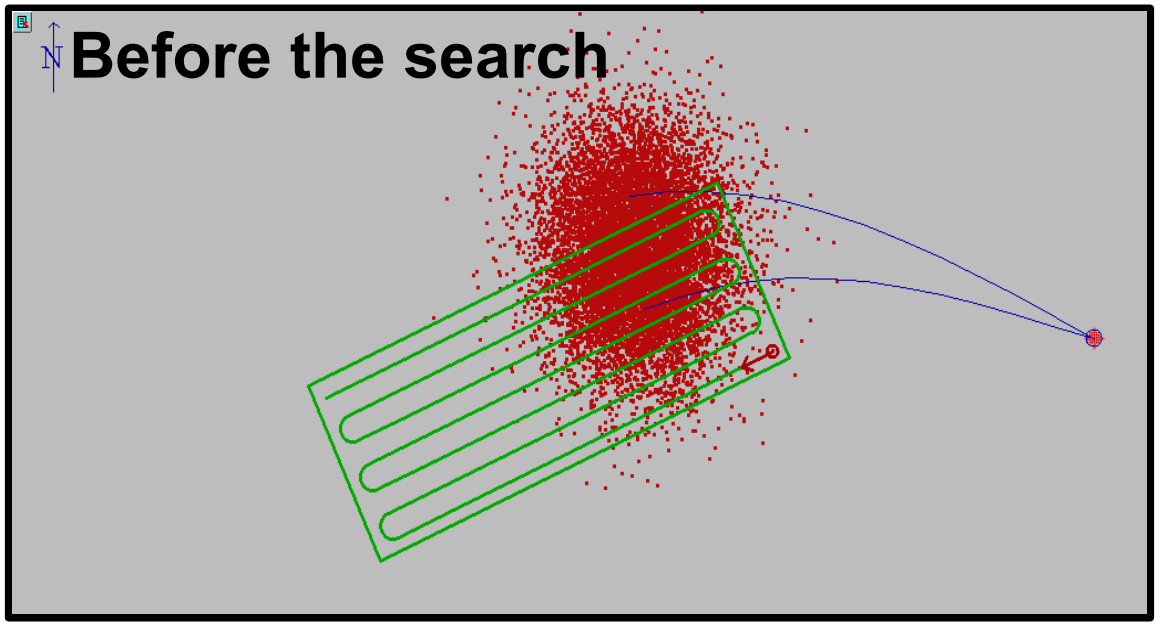


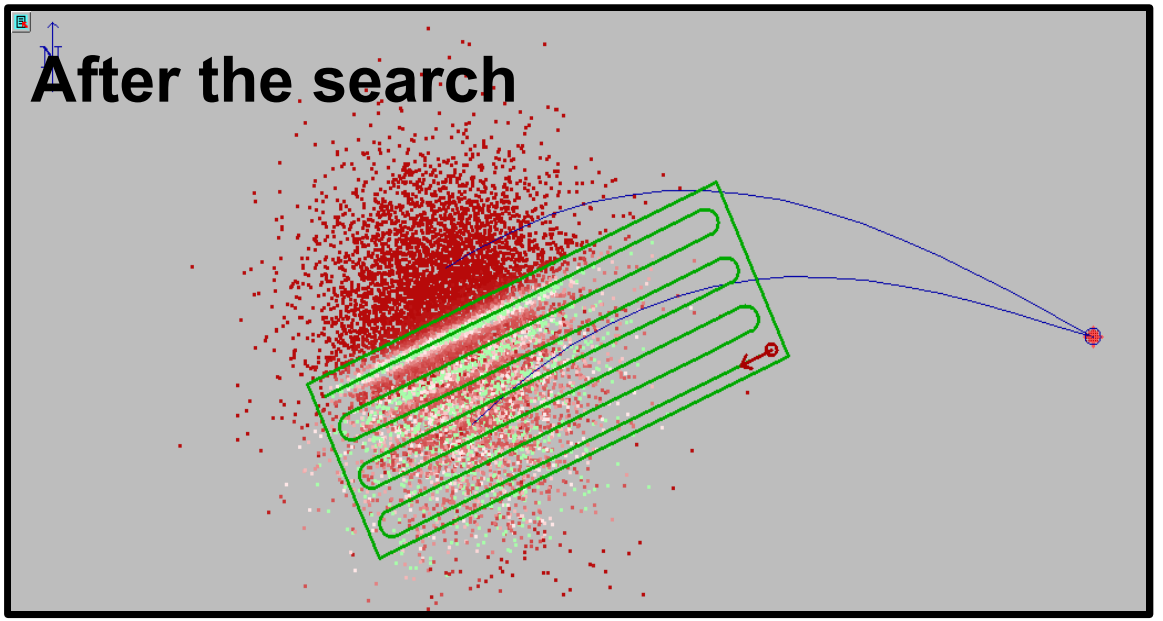
# MULTIPLE SEARCH OBJECTS




**The search operation can contain several simultaneous search objects**

# 'PREVIOUS SEARCH - EFFECTS' ON POSITION PROBABILITY DISTRIBUTION




Scatter dots are color coded according to the current POE (particle's Probability Of Existence)

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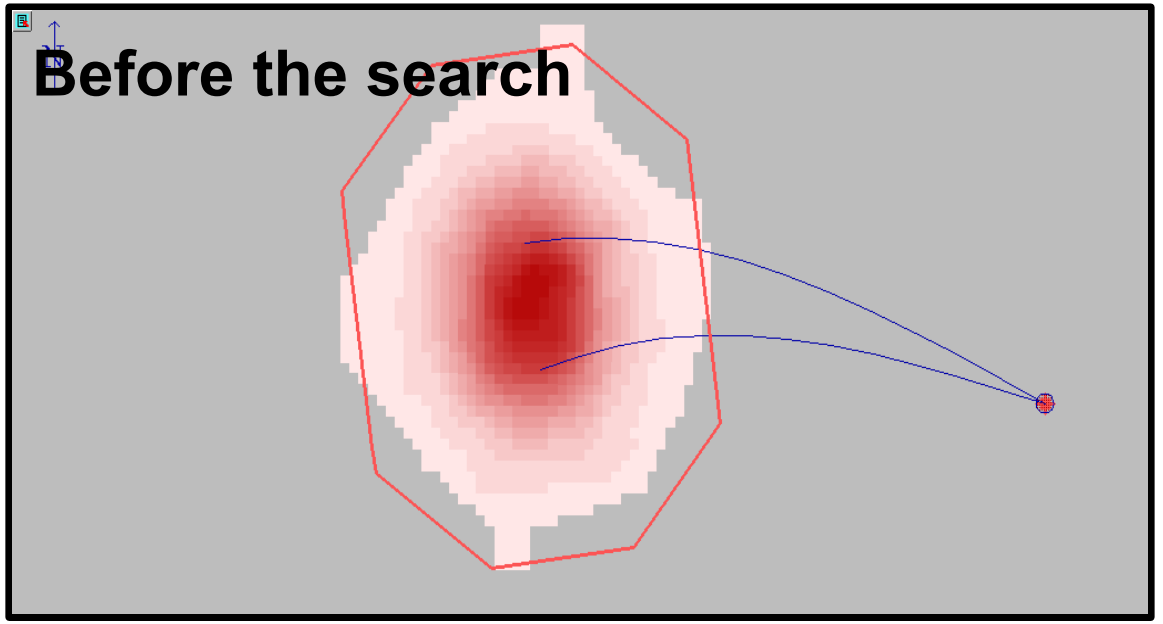
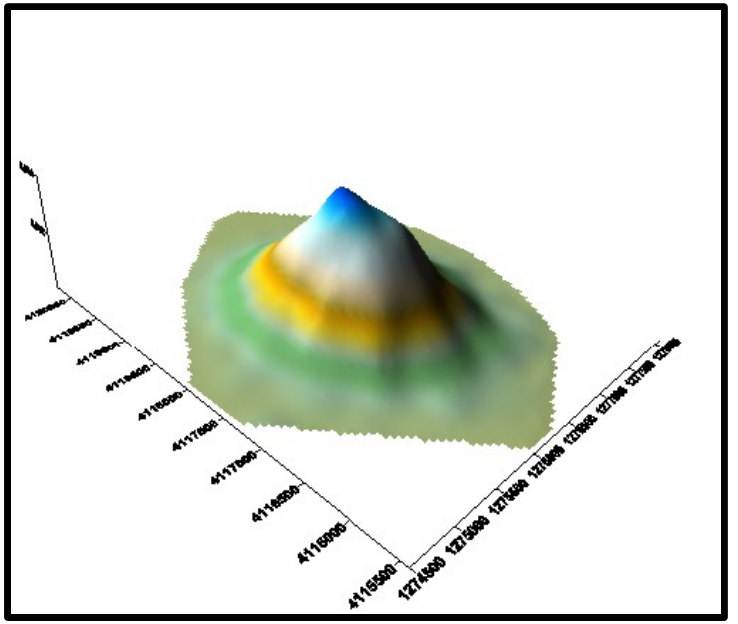
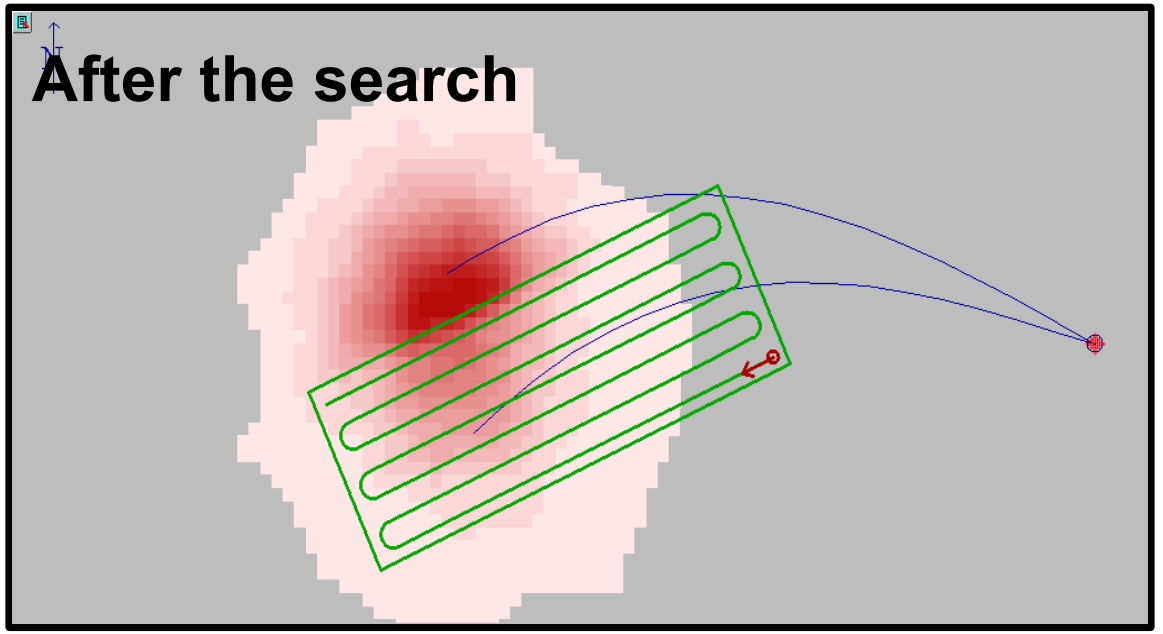
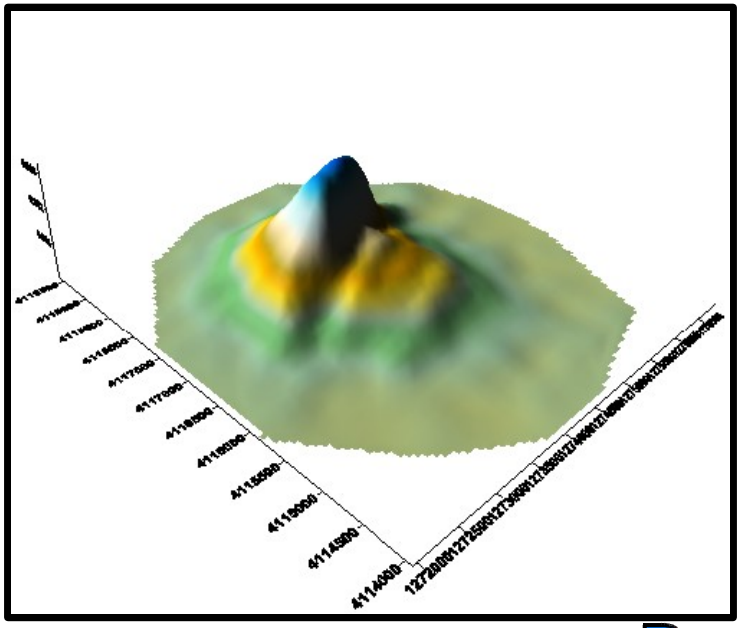
# PROBABILITY MAP AND 3D-DISTRIBUTION





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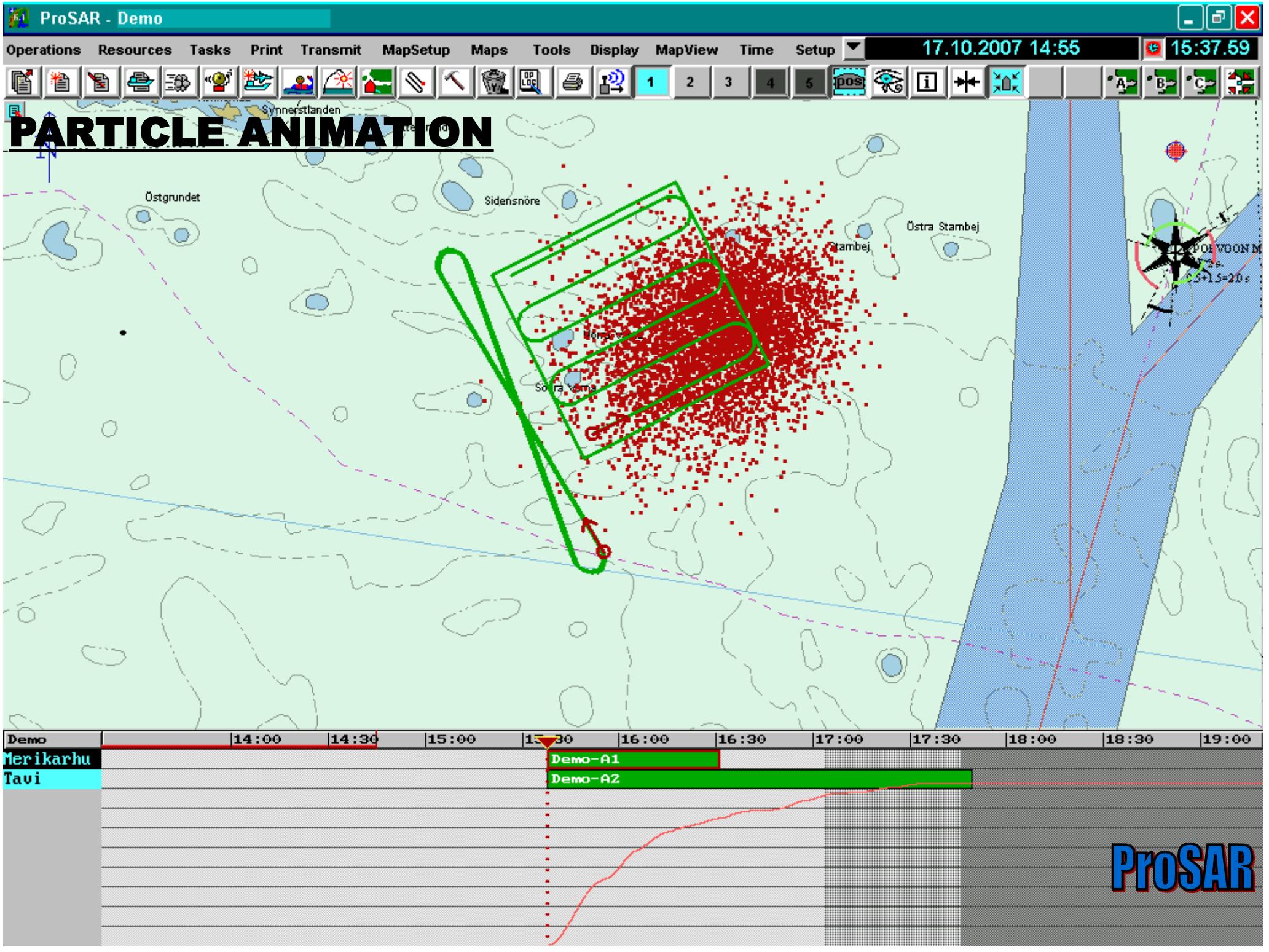
ProSAR - Demo
Operations
Resources
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PARTICLE ANIMATION
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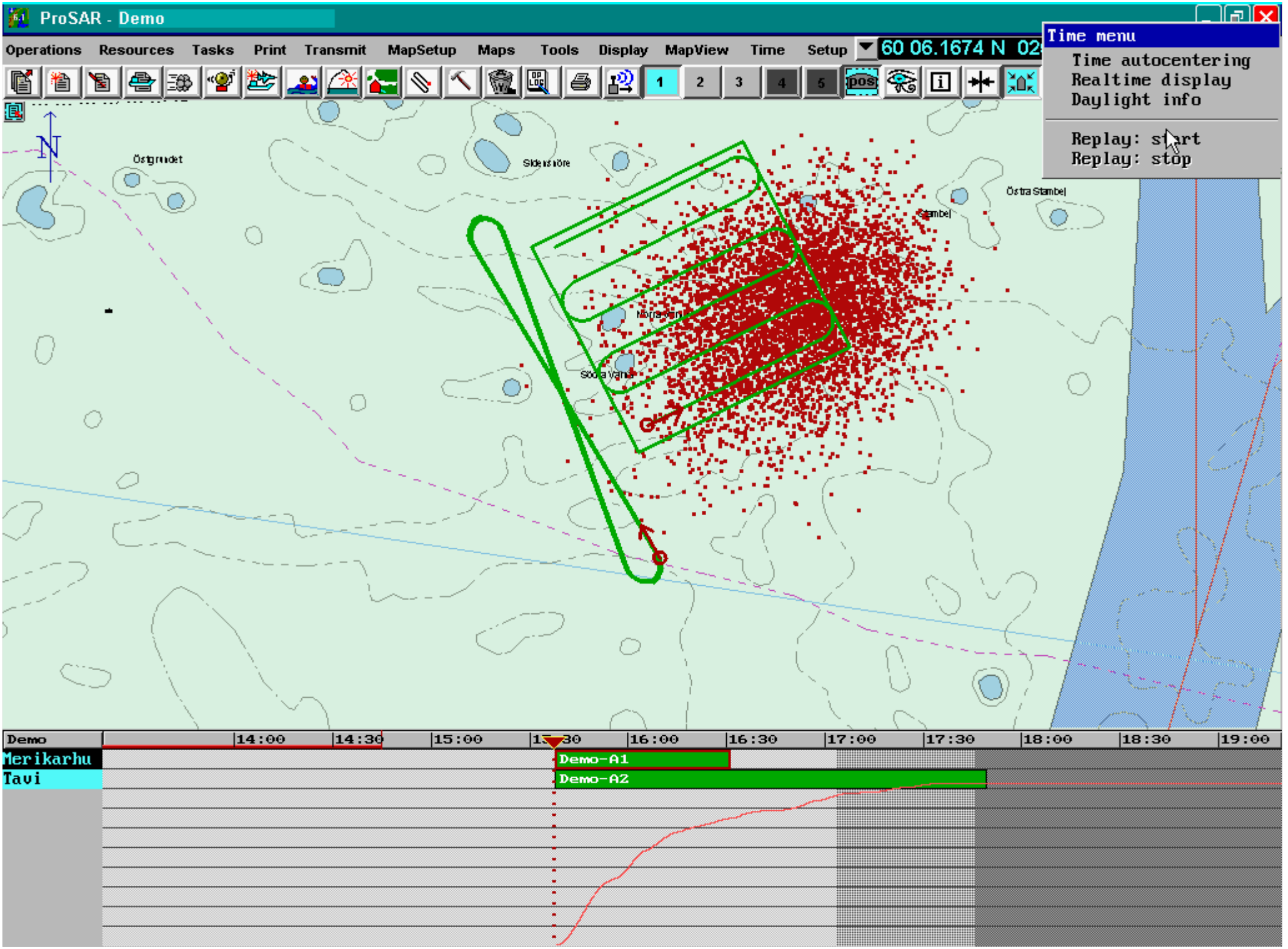
Sidensnöre
Östra Stambej
Demo
Merikarhu
Tavi
Demo-A1
Demo-A2
ProSAR


ProSAR - Demo
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Merikarhu
Tavi
Demo-A1
Demo-A2

# The End

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