Field works for the improvement of drift forecast models for SAR operations

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Drift Forecast Models

Operational Drift forecast Models:

Prediction of trajectories of objects lost at sea

Used by Rescue Coordination Centres for Search & Rescue (SAR) operation and oil spills mitigation

Various models developed in different countries
Drift Forecast Models

Based on stochastic approaches:

Definition of a search area from computation of probable trajectories
Uncertainty level for various parameters:

- start time and location,
- objects main dimensions (draught…)

Take into account:

Environmental forcing components (surface currents, wind…) obtained from forecast models and/or in-situ measurement,

Drift speed computation models based on objects hydrodynamics and aerodynamics properties (USCG database, 63 objects)
Drift Forecast Models

Success:
find the object in as little time as possible
using as little resources as possible

Model Accuracy depends on:
Quality of environmental forecast
Level of uncertainties on object’s drift properties
Drift properties of objects can be described by mean of their leeway coefficients, according to leeway definition as stated by Allen & Plourde (1999):

“Leeway is the motion of the object induced by wind (measured at 10 m reference height) and waves relative to ambient current (measured between 0.3 m and 1.0 m depth).”

leeway rate : percentage of wind speed  
leeway angle : angle between the downwind direction and the direction of drift of the object
Leeway

Leeway is generally decomposed into a downwind (DWL) and a crosswind (CWL) component.

DWL and CWL are obtained by linear regression between the wind speed and the downwind and crosswind components of the leeway speed so that leeway can be described by a set of nine coefficients.

(Breivik & Allen, 2008)

\[
L_d = a_d W_{10} + b_d + \varepsilon_d \\
L_c+ = a_c+ W_{10} + b_c+ + \varepsilon_c+ \\
L_c- = a_c- W_{10} + b_c- + \varepsilon_c-
\]

with $W_{10}$ wind speed at 10 m

Assessment of leeway coefficients is based on a direct method requiring measurements acquired during field tests.
Sea Trials

Sea trials consist in simultaneously recording environmental parameters and object’s location while let adrift from several hours to several days

Ground speed (AIS)

Environmental parameters:

Local Wind (anemometer)
Local current (currentmeter attached to object)
Global current (drifters, HF Radars)
Waves (directional buoys)
Sea Trials

SAR-Drift Project

2 campaigns organised in 2008

NORWAY

Site: Fedje (60°46’ N, 4°38’ E)
Duration: 5 days (April 2008)

Objects: Container 1:3 scaled model,
         Oil drum,
         Mine

Measurements:

         currents (HF Radars, currentmeters),
         wind,
         waves (buoy)
Sea Trials

SAR-Drift Project

2 campaigns organised in 2008

FRANCE

Site: Iroise Sea (48°15’ N, 5°10’W)
Duration: 2 days (22-23 September 2008)

Objects: 20’ Container

Measurements:

- currents (HF Radars, currentmeters),
- wind,
- waves (buoy)
Sea Trials

Oil Drum

1:3 Scaled Container

20' container
Iroise Sea Trials

20 ‘ Container

- 420 kg ballast on floor
- 5.8 m³ floats under ceiling
- Appertures on floor

Trial Duration : 24 hours
Total drifting distance : 16.8 Naut. miles
Mean speed : 0.7 kts
Environmental data

Currentmeter data:
Mean Local Drift speed:
19.6 cm/s (0.38 kts)

Anemometer data:
Mean wind speed (7 hours):
North-easterly
10 m/s (19.5 kts),
gusts 28 kts
Leeway data

Trajectory and Leeway Speed

Drift Speed & Leeway Speed

Drift Speed (Speed over Ground):
Mean: 36.48 cm/s (0.7 kts)
Std: 16 cm/s
Large variability

Relative Speed:
Mean: 19.45 cm/s (0.38 knts)
Std: 1.6 cm/s
Steady

Leeway Direction

Leeway direction is restricted to the south to west quadrant as a result of the action of the northeasterly wind and wind-sea.

Total drift directions spread all over the south to north sector because of the influence of the tidal currents.
Leeway Coefficients

Leeway coefficients: components of the leeway speed evaluated in the wind referential.

\[ CWL = L_{speed} \cdot \sin(\theta) \]
\[ DWL = L_{speed} \cdot \cos(\theta) \]
\[ \theta = \theta_{drift} - \theta_{wind} \]

<table>
<thead>
<tr>
<th>Leeway Speed</th>
<th>DWL</th>
<th>CWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope (%)</td>
<td>Off-set (m/s)</td>
<td>Slope (%)</td>
</tr>
<tr>
<td>1.167</td>
<td>0.065</td>
<td>0.916</td>
</tr>
</tbody>
</table>

Leeway coefficients as functions of wind speed in m/s
Leeway Coefficients

Progressive Vector Diagram
(Trajectory in the wind referential)

Container:
steady direction at 34.2°
to the downwind direction
No jibing

Oil Drum: jibing
Frequency of Jibing influenced to some extent by waves
Drift Forecast Model

SAR-Drift forecast tool

Stochastic approach based on MonteCarlo method:

Each drift simulation is run for a large number of containers, each with slightly different characteristics depending on uncertainties on various parameters (such as initial time and location, draught...).

Predicted trajectory is then obtained by evaluating at each time step the location corresponding to the highest probability of presence of the container (highest density).

Drift computation by Static method (Pavec, 2008): drag forces and drift speed are evaluated at each time step considering the object at equilibrium.

Other methods exist such as the Leeway method (Breivik, 2004)
Drift Forecast Model

Quality of environmental forecast data

FORECAST

HF Radar
Drift Forecast Model

Sensitivity of the model: Influence of Draught

70%  80%  90%

Container's actual draught
Conclusion

Field tests:

- Leeway coefficients obtained from direct measurement
- Combined action of wind and waves
- Assumption: linear regression

Forecast model:

- Show good ability to forecast drift for several hours
- Need for high quality current and wind forecast
- Need for accurate information on object’s drift properties
- Need for advanced trajectories computation methods

More field tests:

- Norway - Fedje: September 10-14 (KV Alesund)
  Sunfish, 12' Norwegian pram, mine
- Norway - Bodø: September 23-27 (KV Harstad)
  20' container, 12' Norwegian pram