FFI Forsvarets forskningsinstitutt

NCUBE-1 and 2
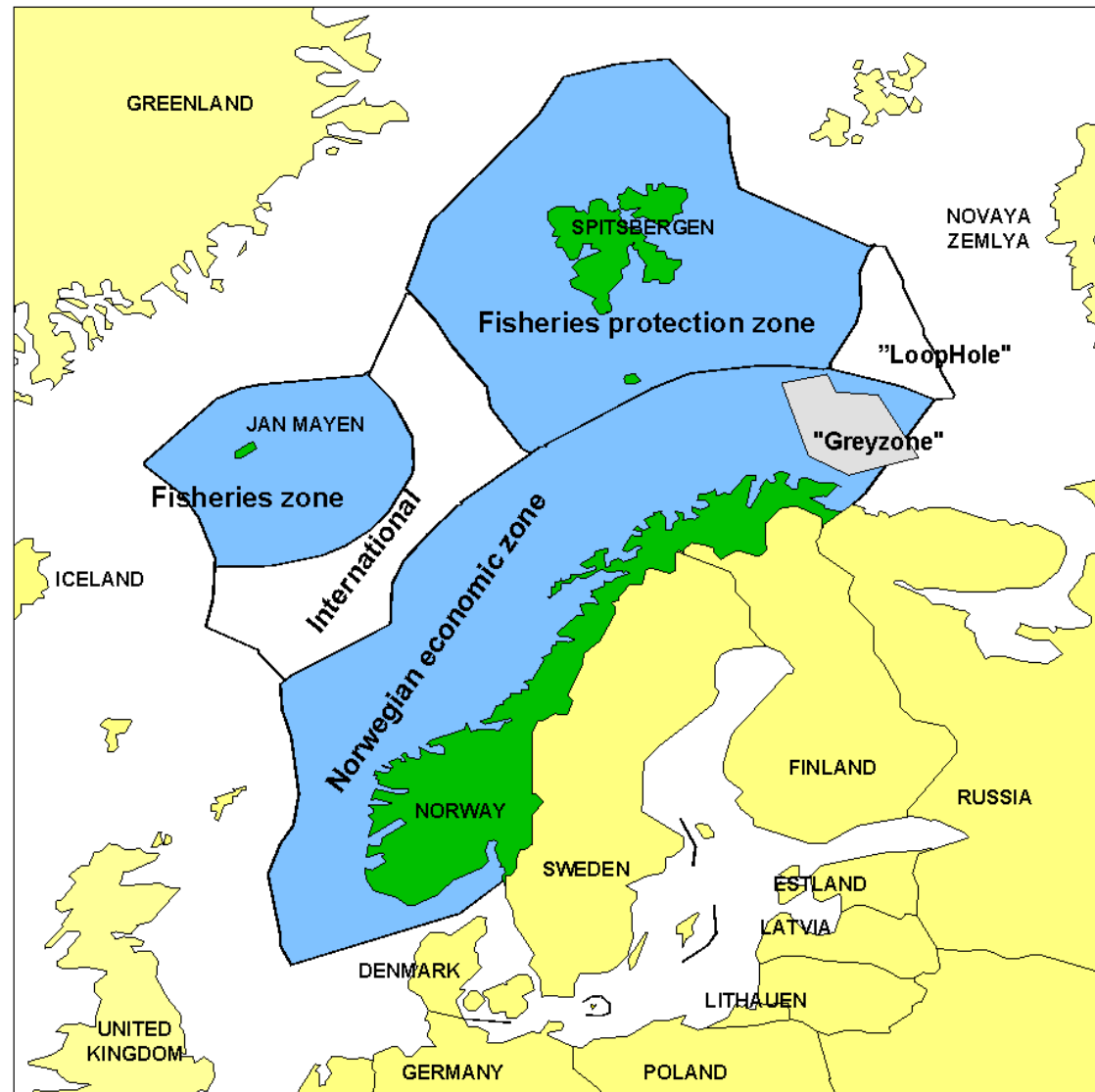# AIS Detection Probability

Bjørn T Narheim

btn@ffi.no

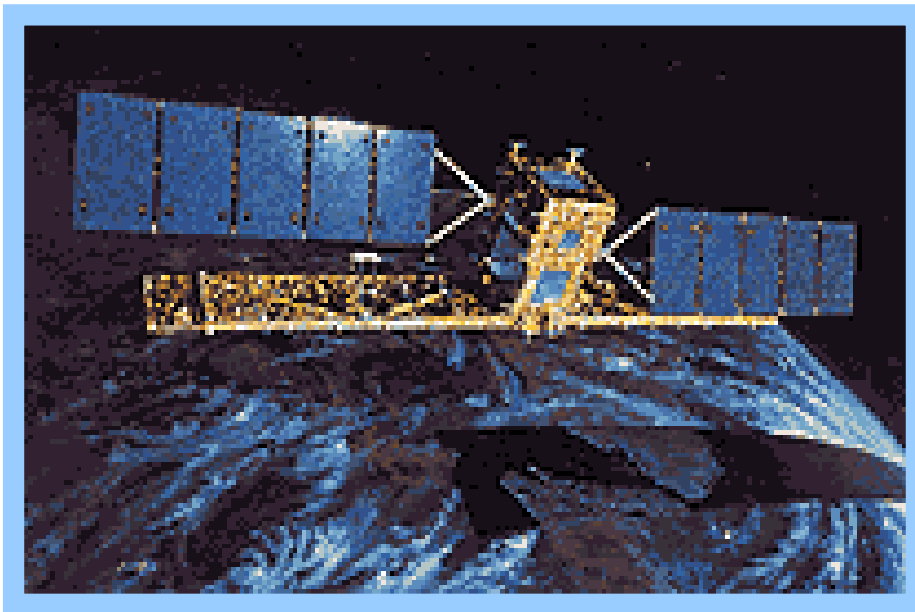**Norwegian Defence Research Establishment**
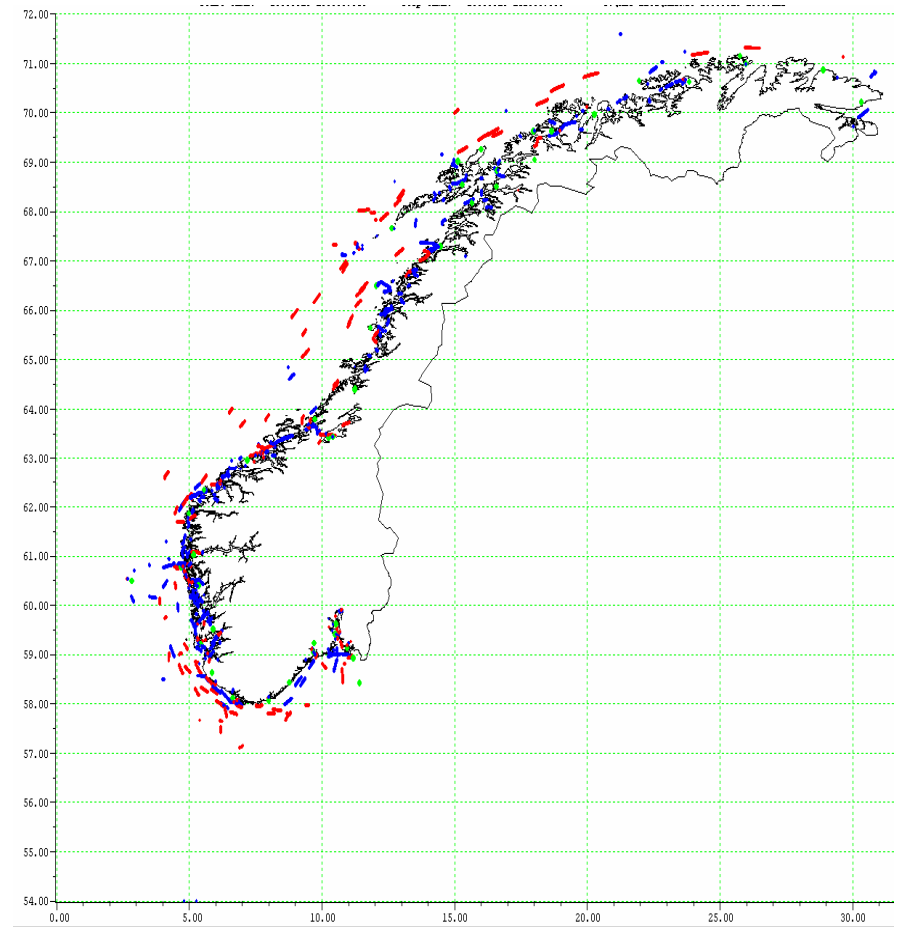
www.ffi.no

The Challenge

Large Ocean Area under Norwegian Jurisdiction (blue)
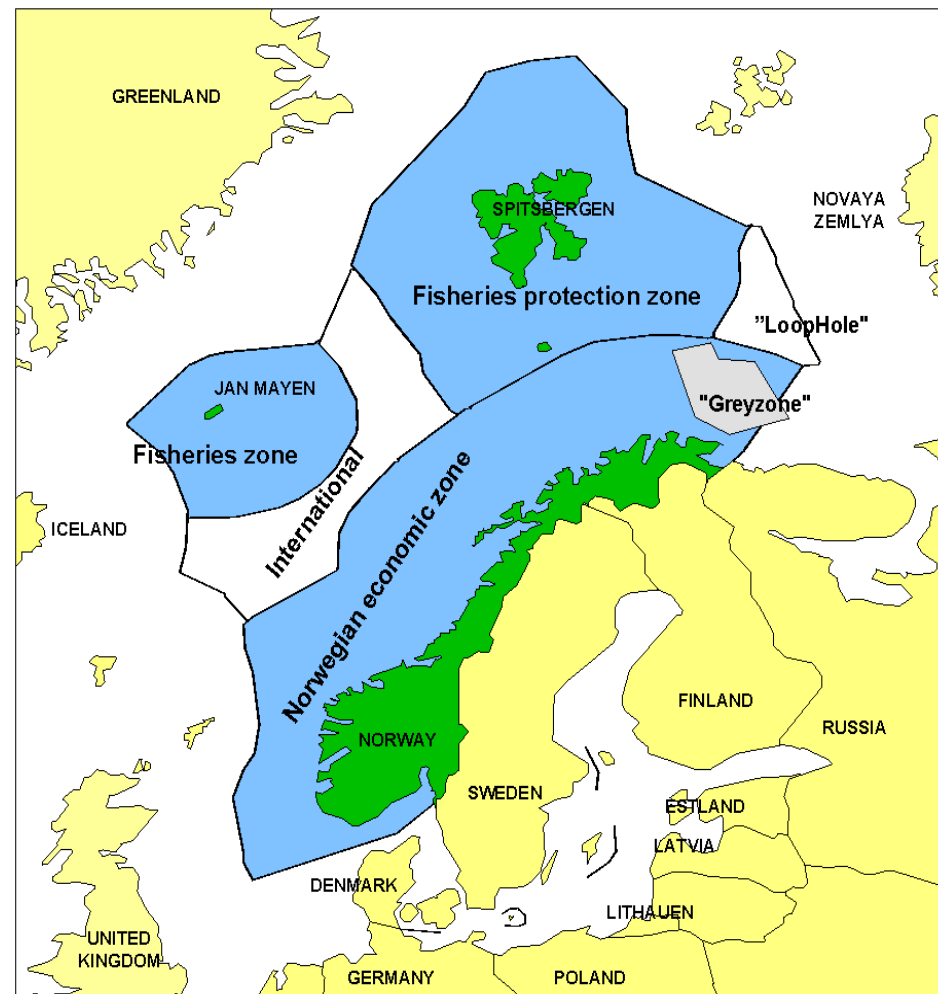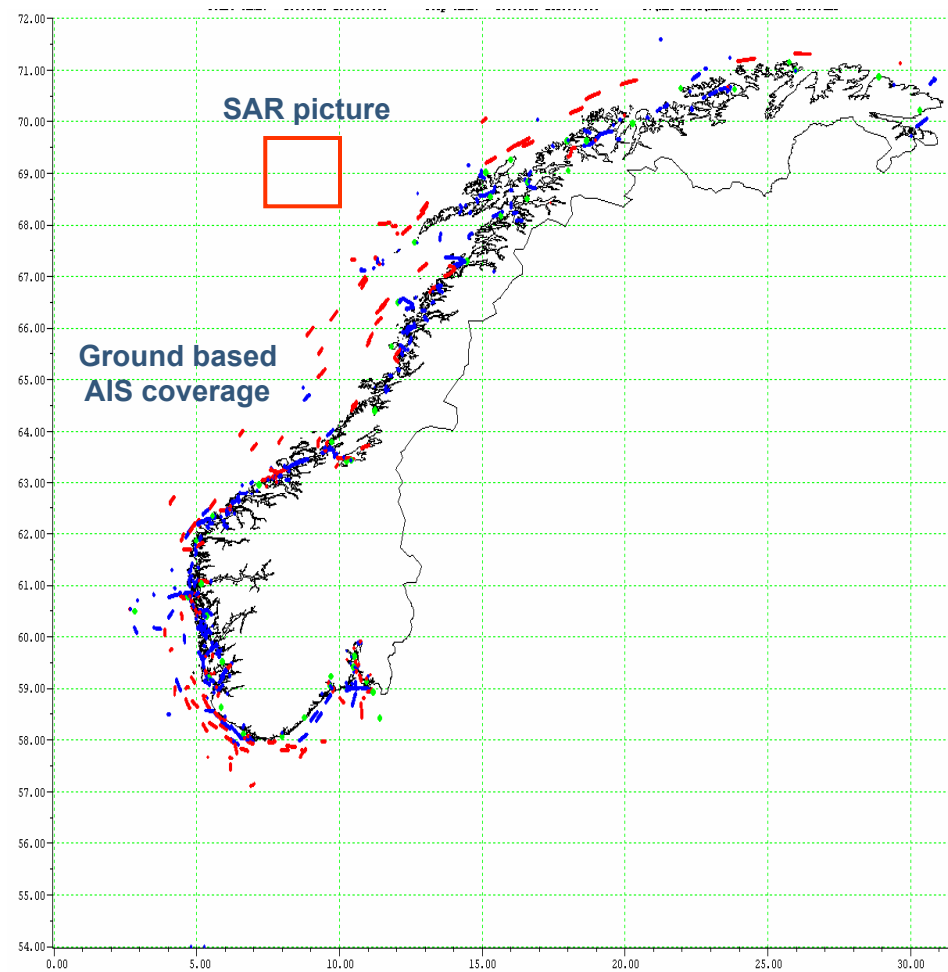
The Modern Tools

**Radar Satellites
(non-cooperative tool)**

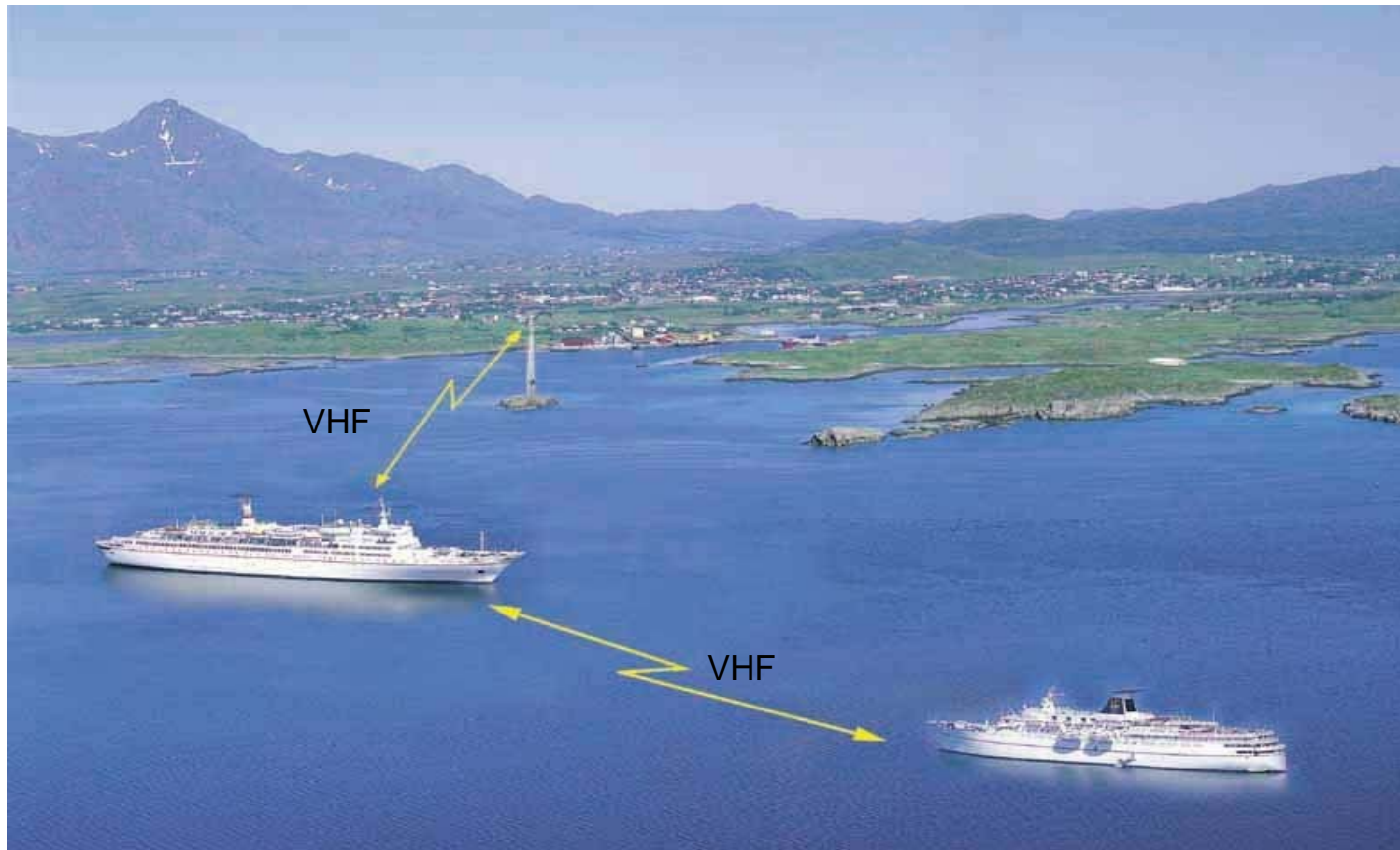**Ground-based AIS Networks
(cooperative tool)**

The Current Status

SAR picture

Ground based
AIS coverage

GREENLAND

NOVAYA
ZEMLYA

SPITSBERGEN

Fisheries protection zone

"LoopHole"

JAN MAYEN

"Greyzone"

Fisheries zone

ICELAND

International

Norwegian economic zone

NORWAY

FINLAND

RUSSIA

SWEDEN

ESTLAND

LATVIA

DENMARK

LITHAUEN

UNITED
KINGDOM

GERMANY

POLAND

Typical SAR and AIS coverage

The challenge remains !

The AIS Concept

The Question

AIS-Sat

VHF

VHF

VHF

VHF
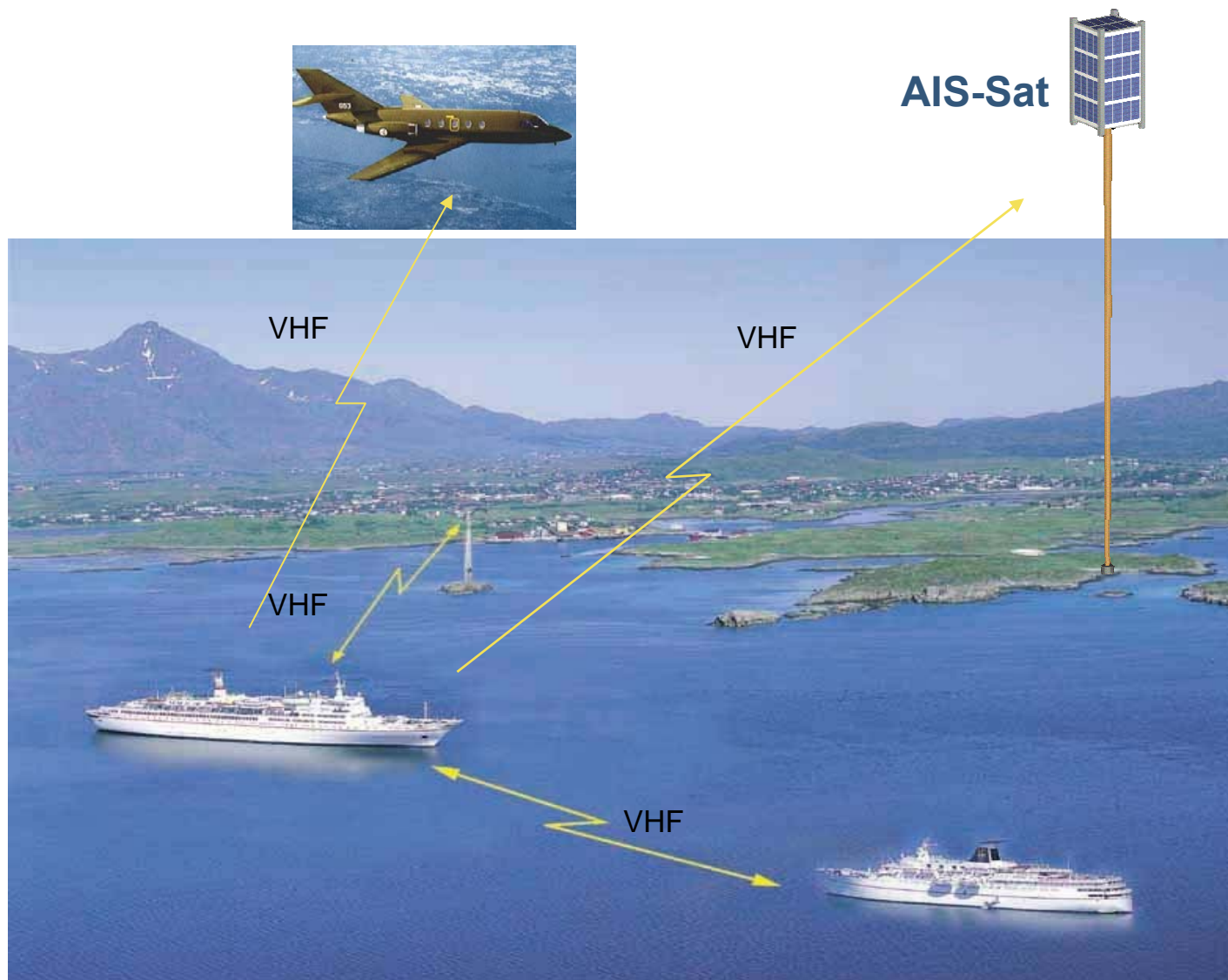
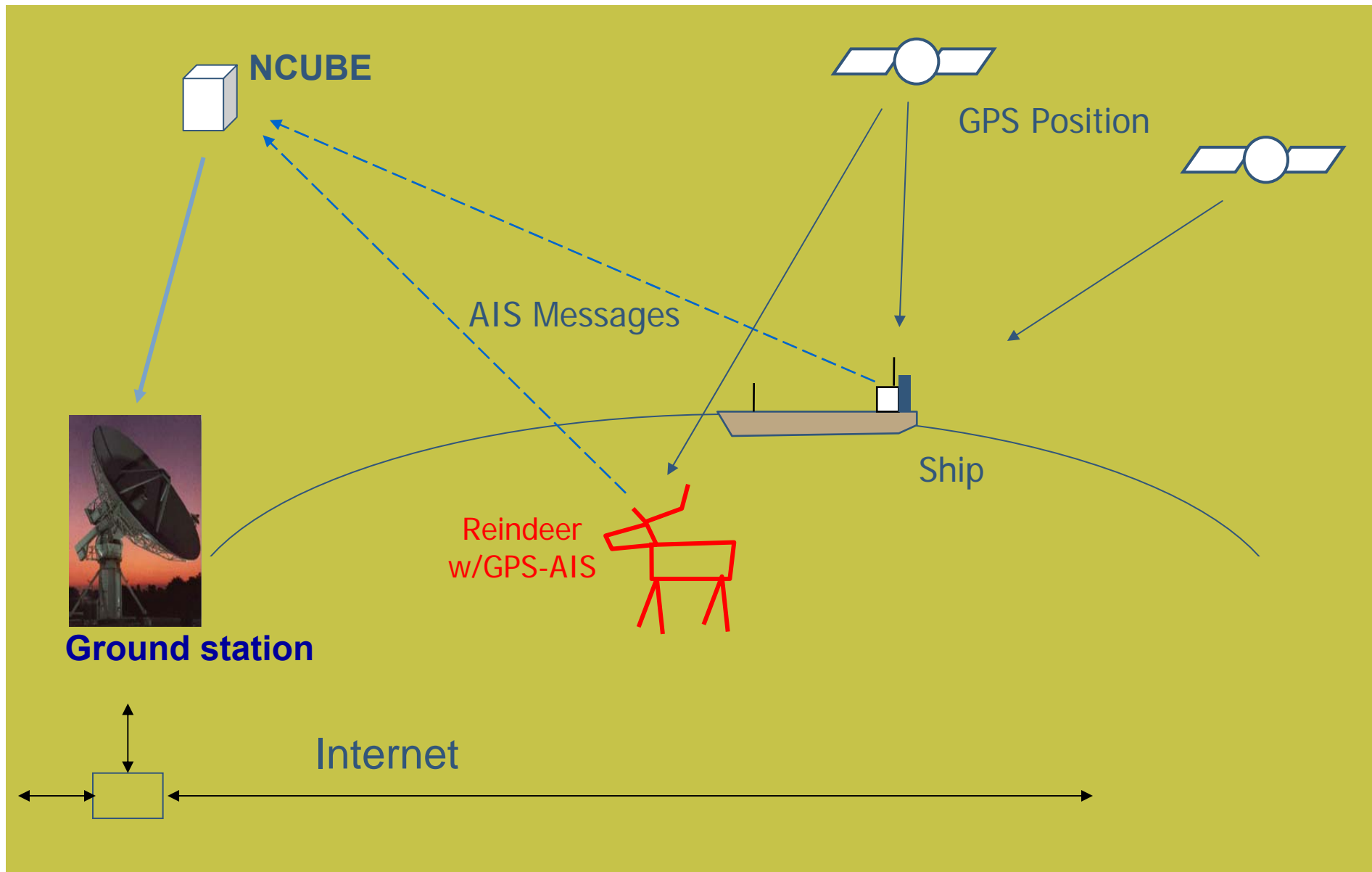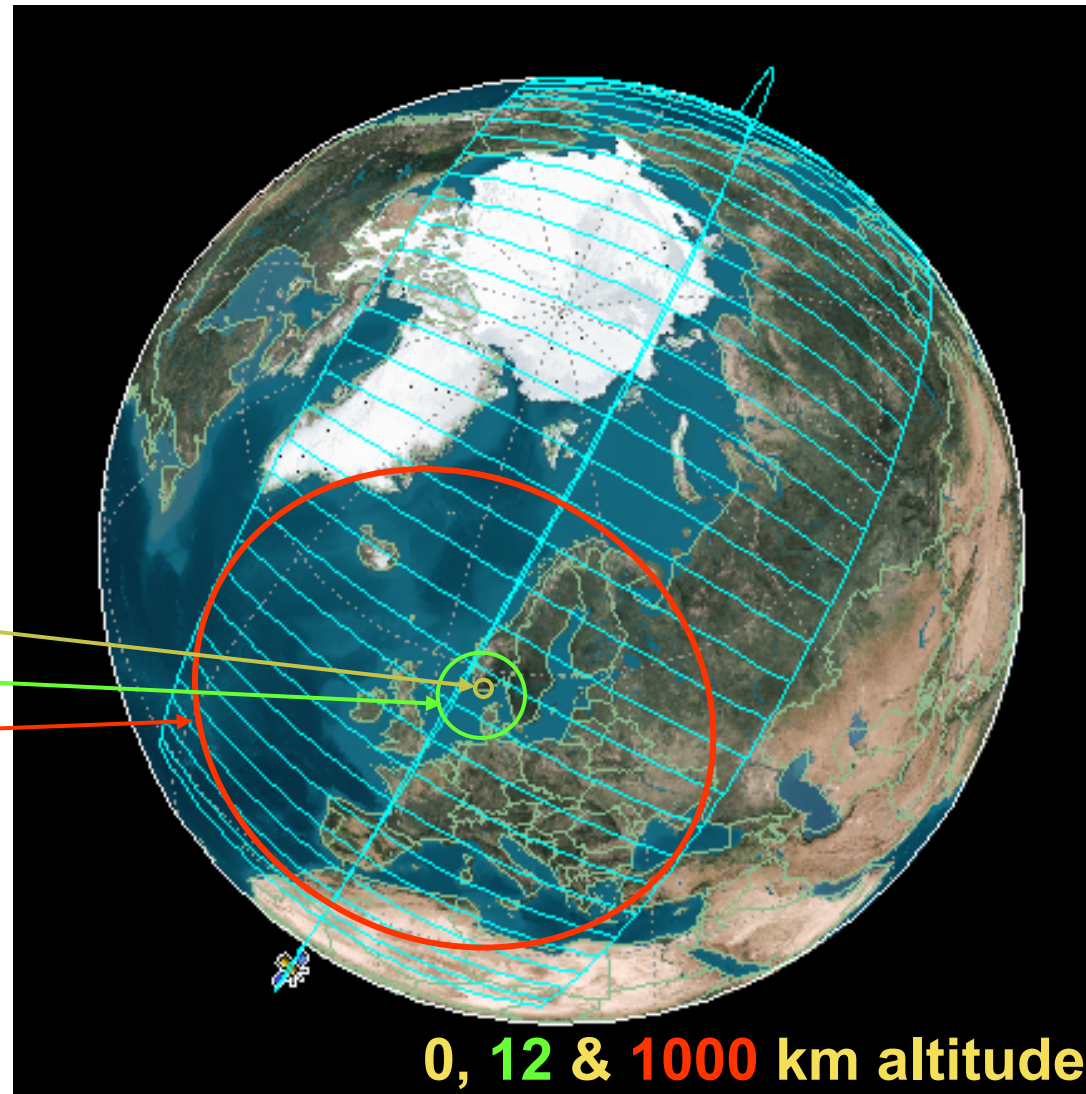**Can elevated AIS sensors provide Long Range AIS services ?**

NCUBE Mission Objective

Increased Coverage Area
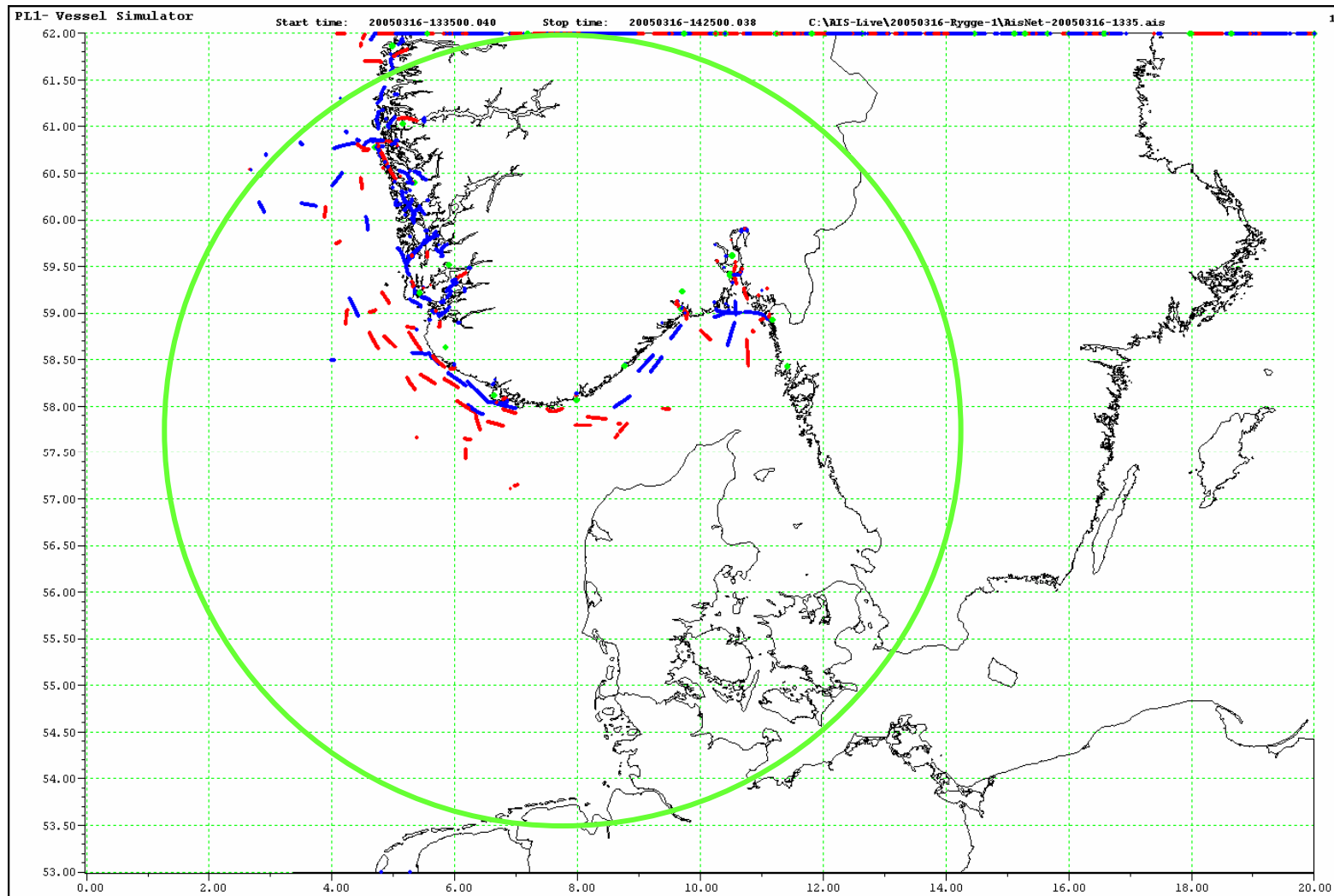

Observation area:
- TDMA
- Aircraft
- Satellite

0, 12 & 1000 km altitude

Elevated AIS sensors - A maritime wide area surveillance tool

Surface-based AIS-Sensor
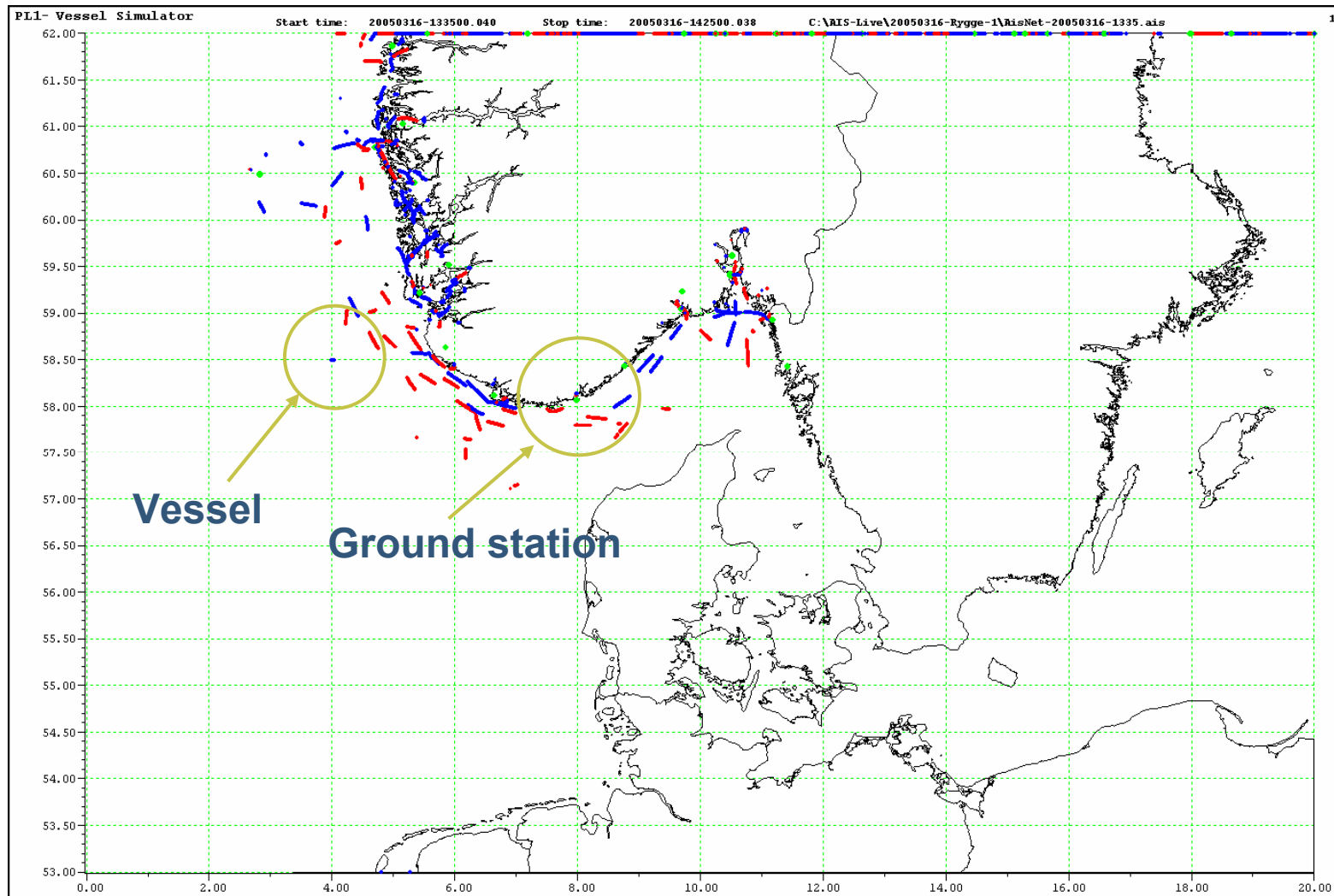
Typical range of 20-50 nm radius

Elevated AIS-sensor (38000 feet)

PL1- Vessel Simulator   Start time: 20050316-133500.040   Stop time: 20050316-142500.038   C:\AIS-Live\20050316-Rygge-1\AisNet-20050316-1335.ais
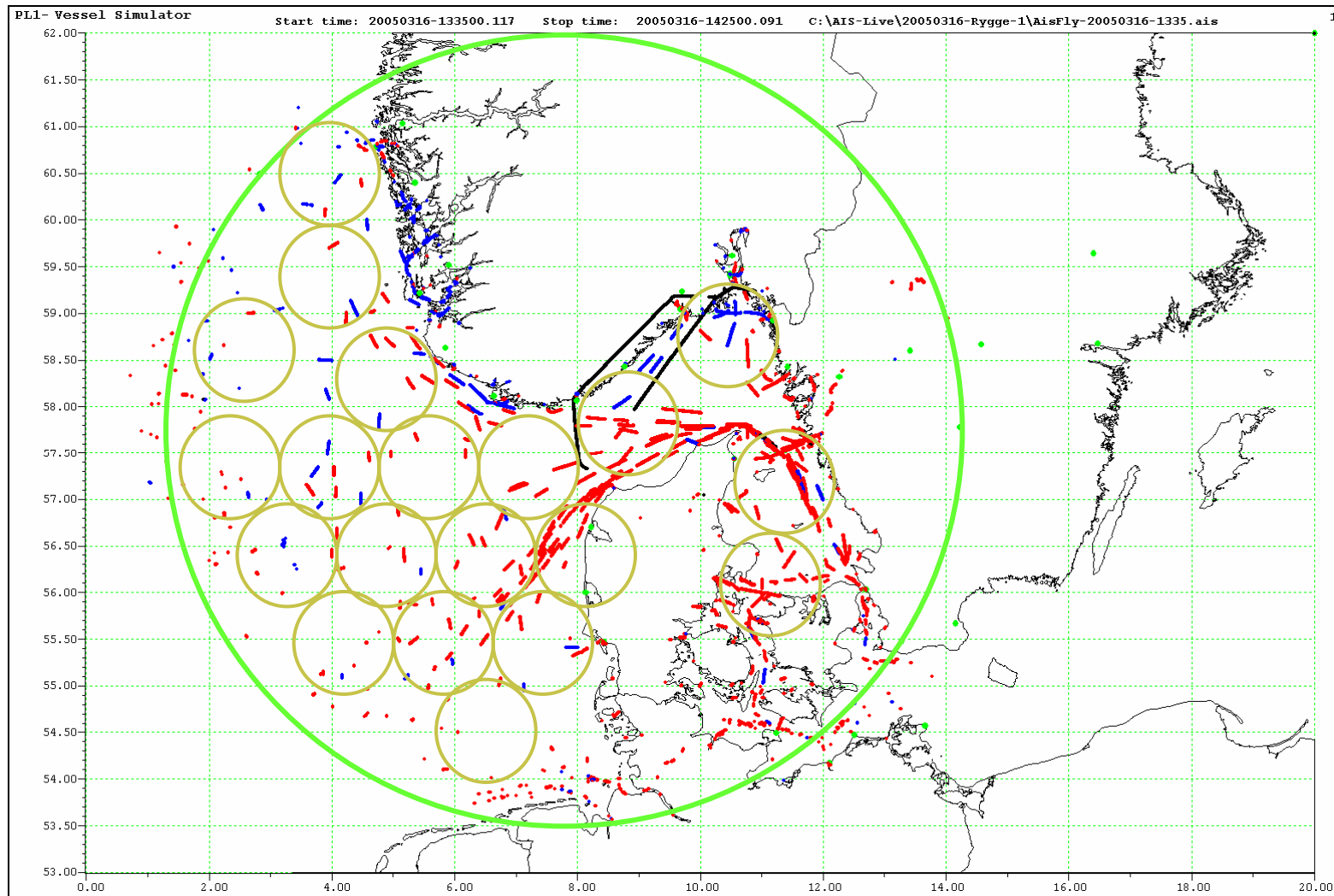
Typical coverage of 440 nm diameter

The Penalty
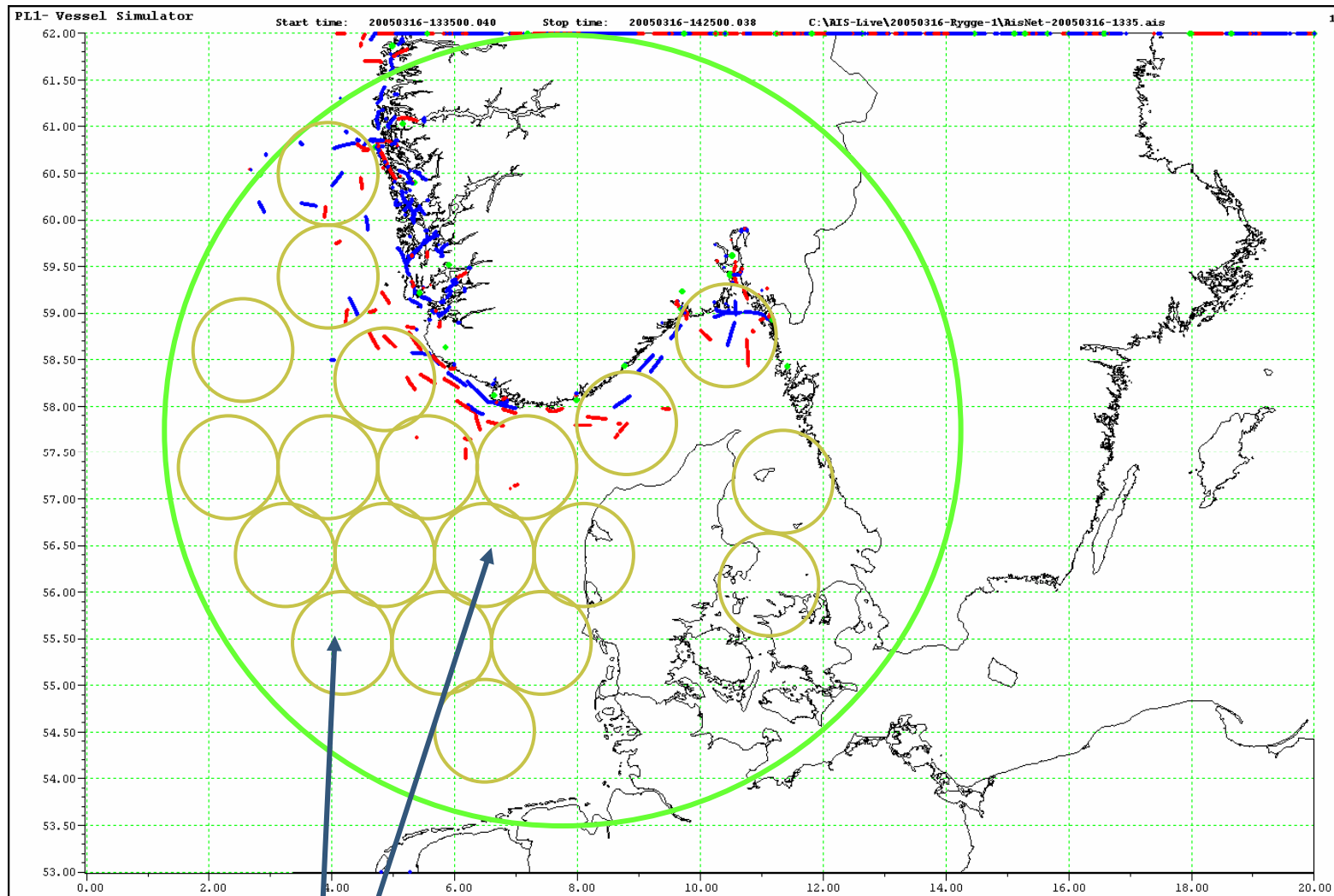
Multiple TDMA areas become visible
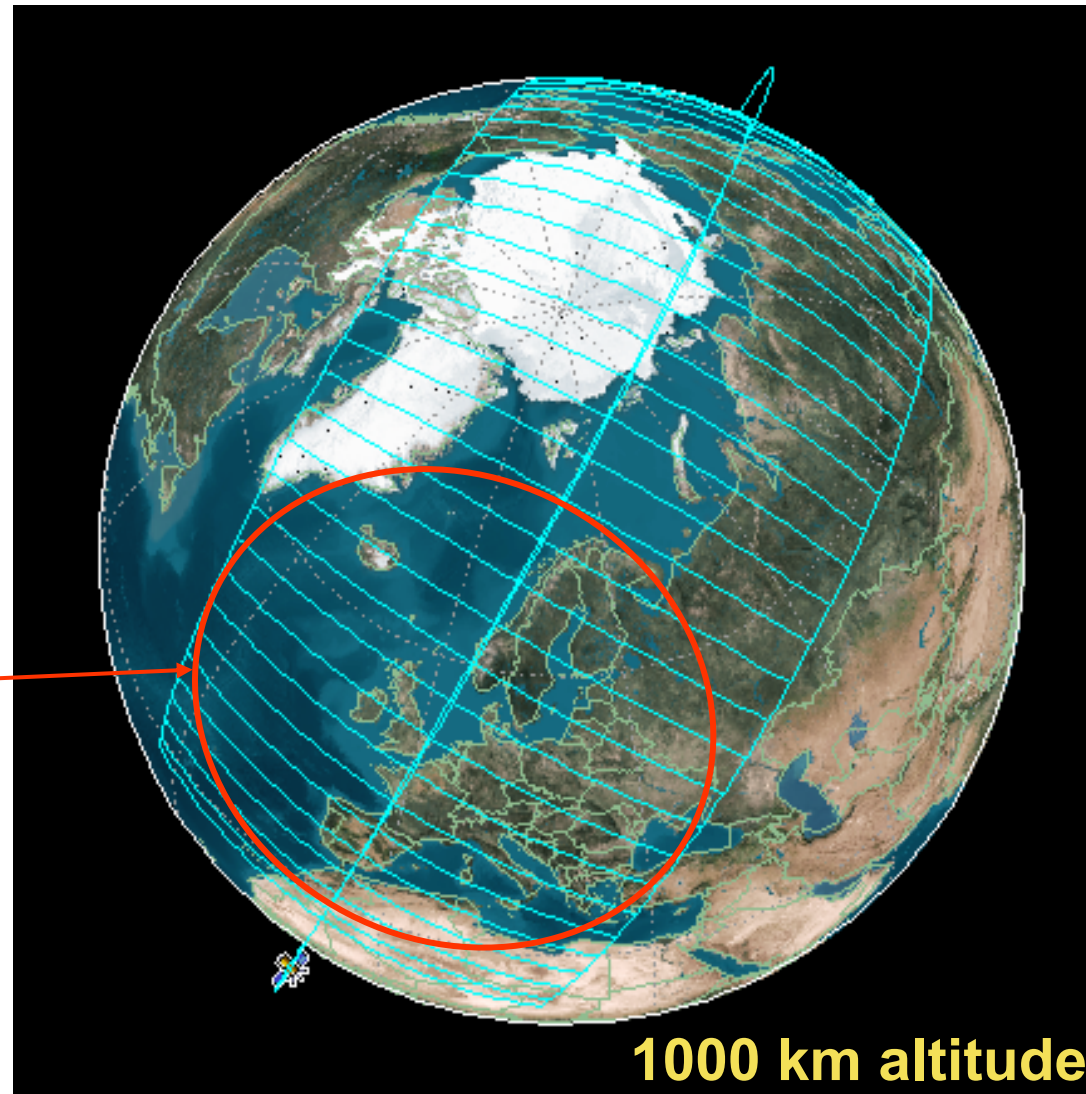
Large Number of Messages

Simultaneous message arrival causes loss of messages
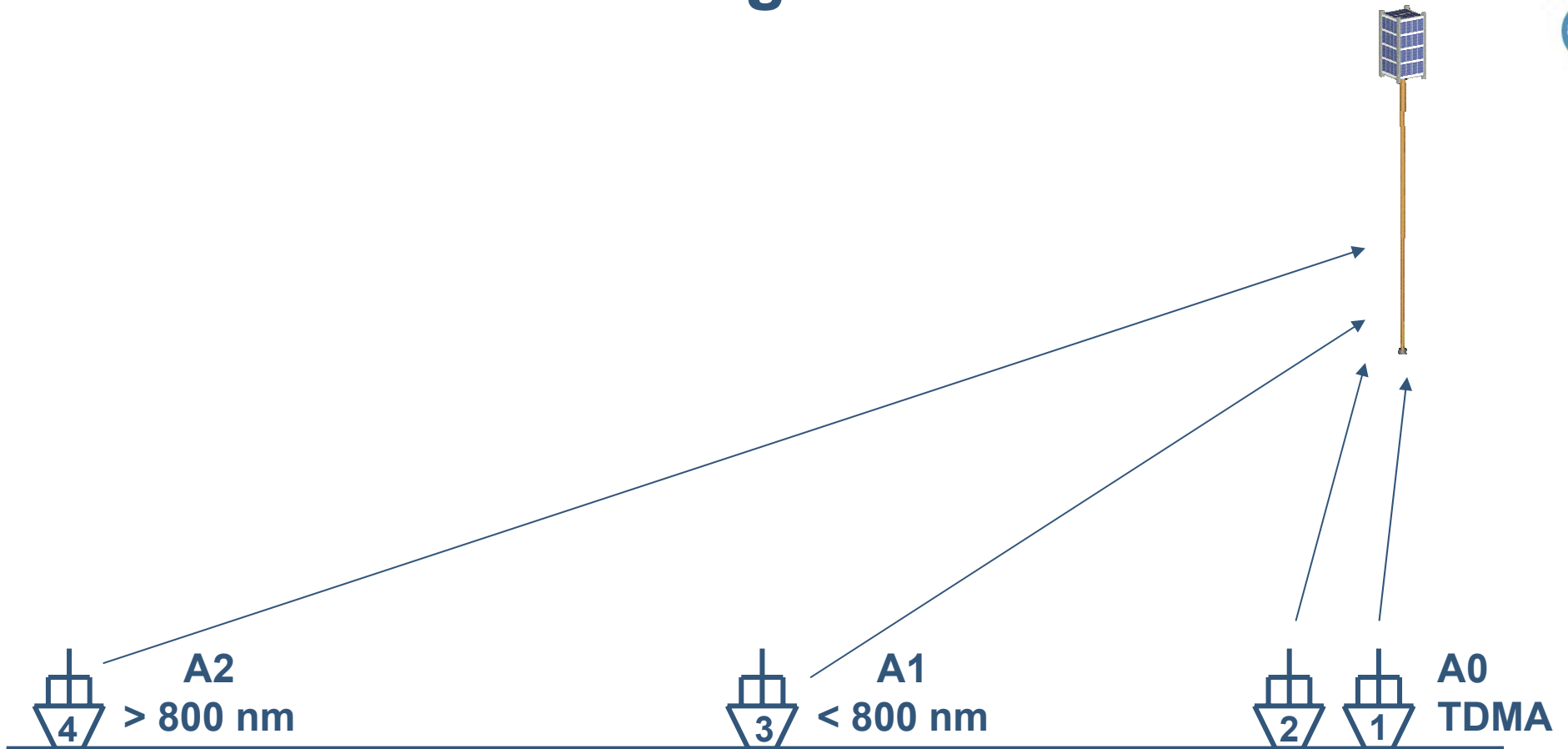
Even more messages at Low Earth Orbit

Satellite coverage area

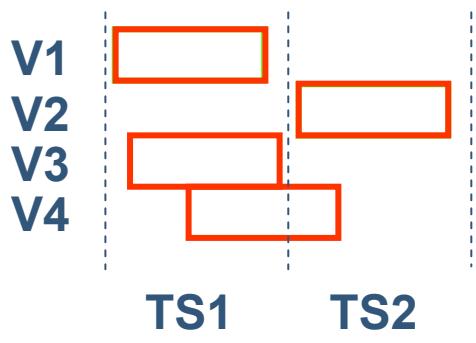**1000 km altitude**

Many more TDMA areas become visible (2880 nm diameter)
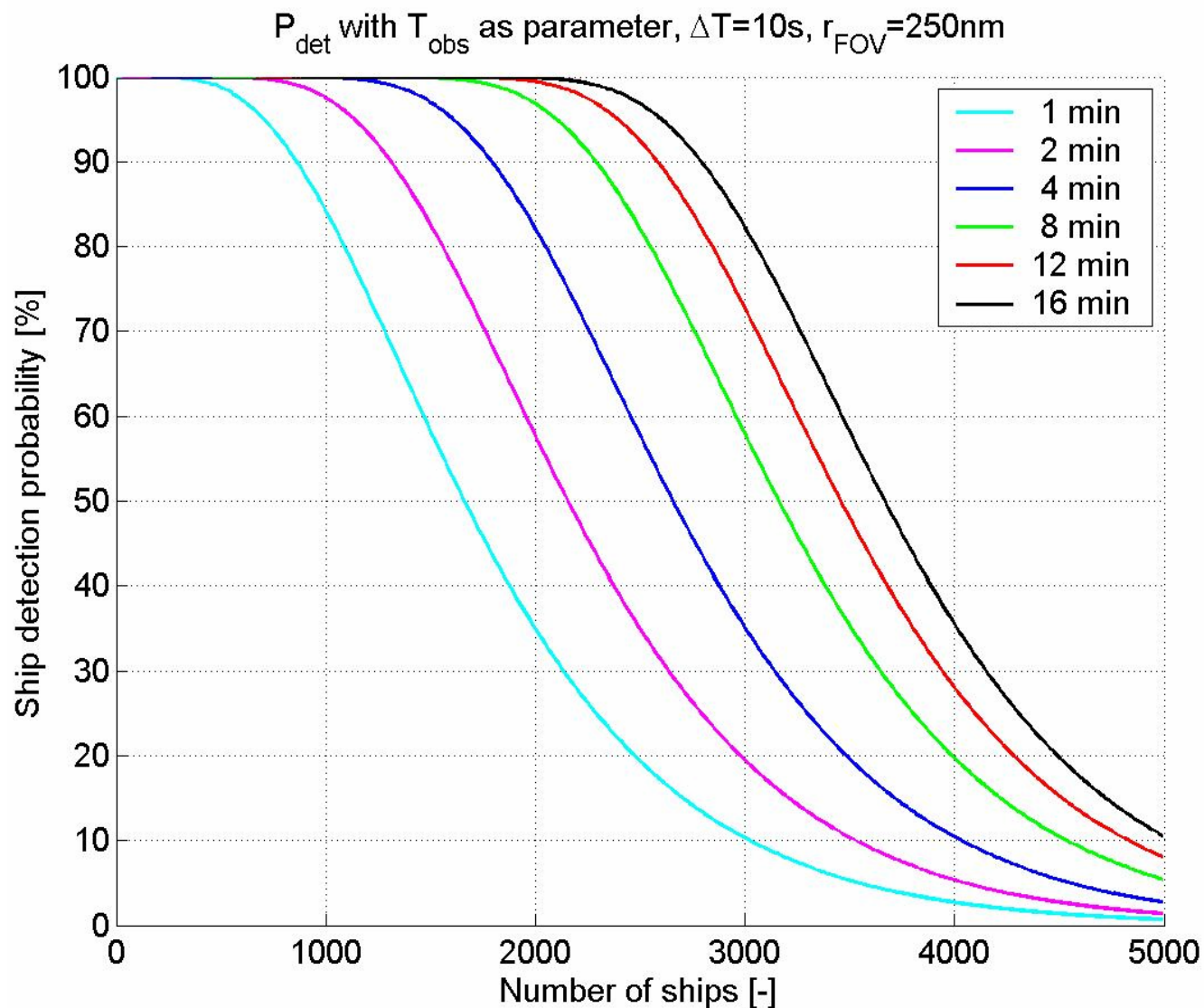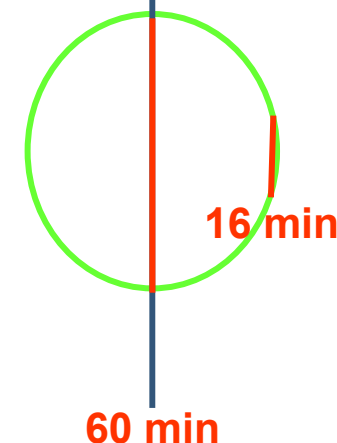
Effects of AIS Message Collisions

A2
> 800 nm

A1
< 800 nm

A0
TDMA

4 3 2 1

The message collision problem

V1
V2
V3
V4

TS1   TS2

No messages received

Nadir

Detection Probability - Aircraft

P_{det} with T_{obs} as parameter, $\Delta T = 10s$, $r_{FOV} = 250nm$

Aircraft
38000ft
500 mph

16 min

60 min

Legend:
- 1 min
- 2 min
- 4 min
- 8 min
- 12 min
- 16 min

Ship detection probability [%] vs Number of ships [-]

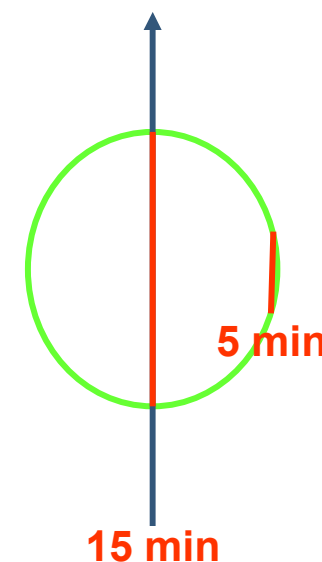**Simulation results for a swath width of 500 nm (Type 1-3 messages)**

Detection Probability - Satellite

$H_{sat}=1000km, \Delta T=6s$

Legend:
- $T_{obs}= 15min$ (blue)
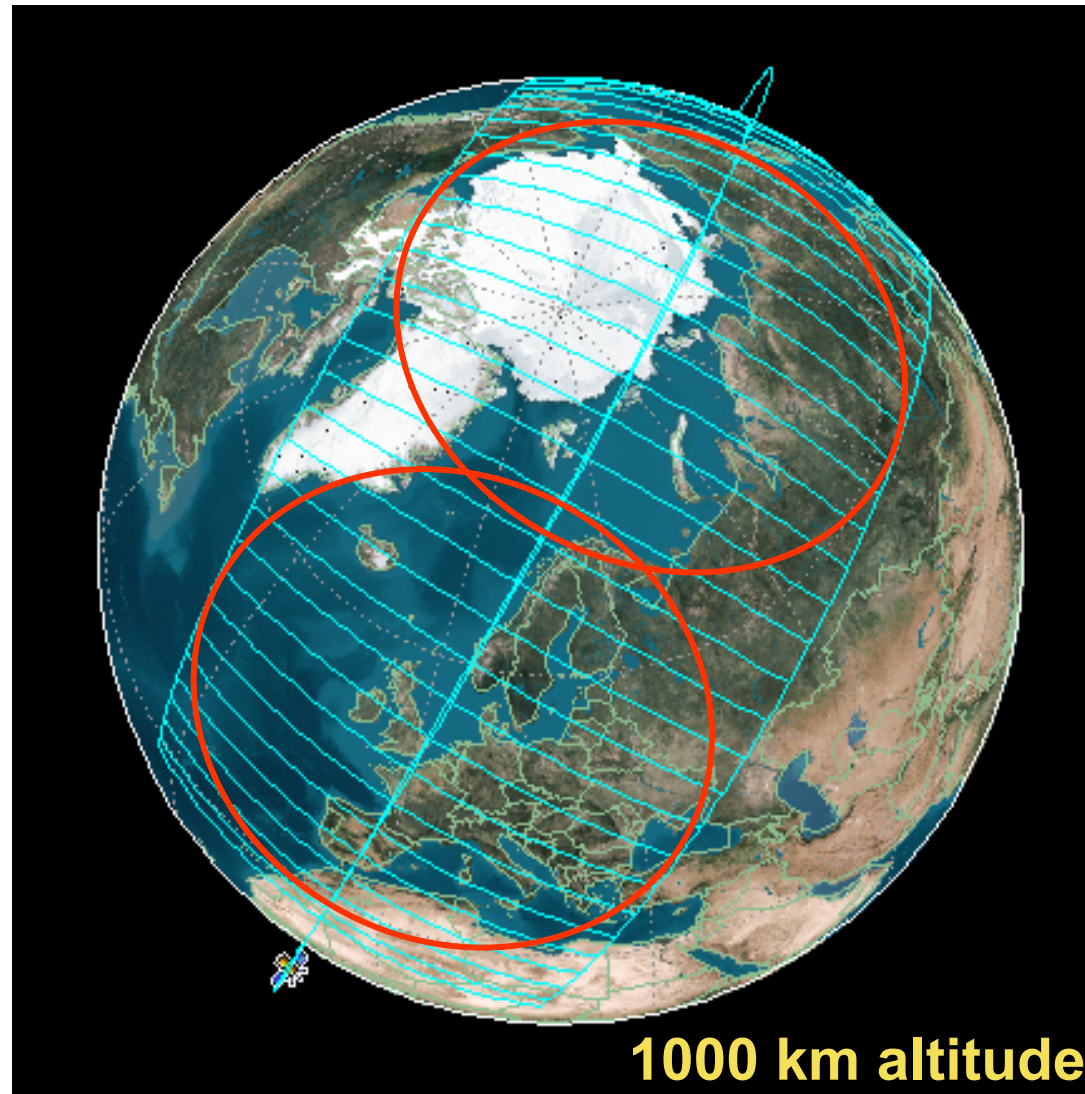- $T_{obs}= 1h$ (green)
- $T_{obs}= 24h$ (red)

Y-axis: Ship detection probability [%]
X-axis: Number of ships [-]
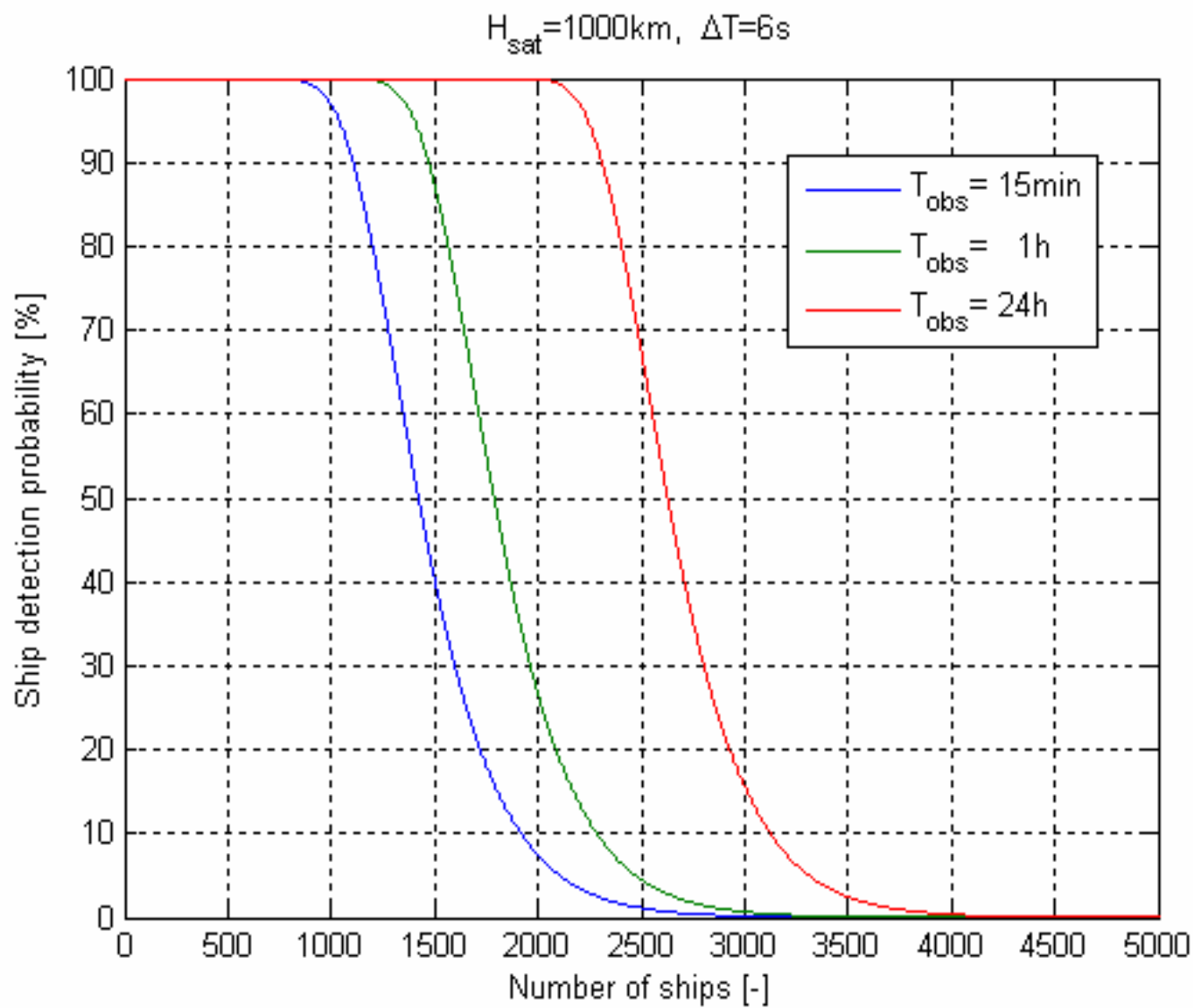
Satellite
1000km
7.5 km/s

5 min

15 min

Simulation results for a swath width of 2880 nm (Type 1-3 messages)

Vessel Density is Region Dependent

1000 km altitude

Low density in Polar regions, High in Europe

Two satellite passes

Ground track. Pass # Norway1 .
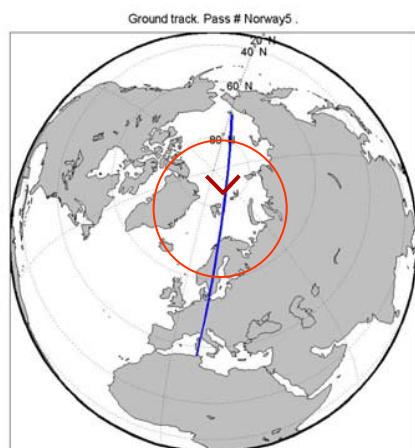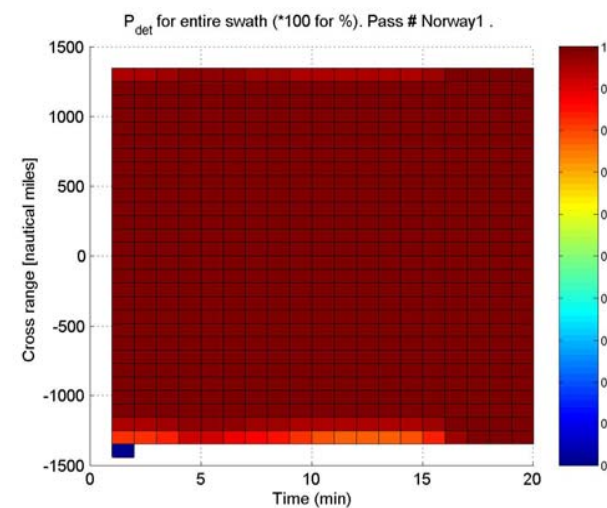

No of ships. Pass # Norway1 .

P_{det} for entire swath (*100 for %). Pass # Norway1 .

Ground track. Pass # Norway5 .

No of ships. Pass # Norway5 .

P_{det} for entire swath (*100 for %). Pass # Norway5 .
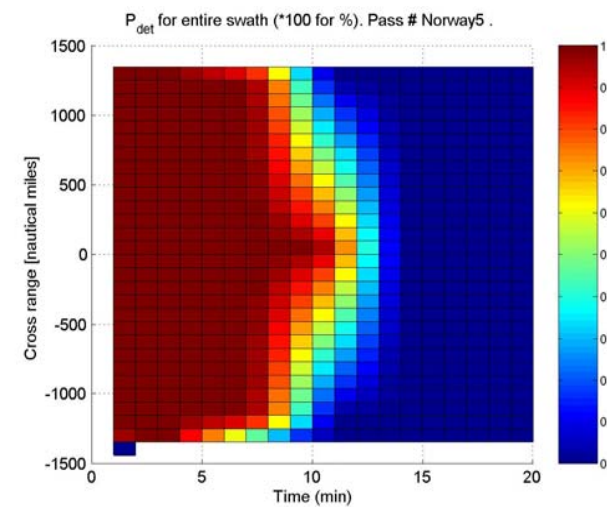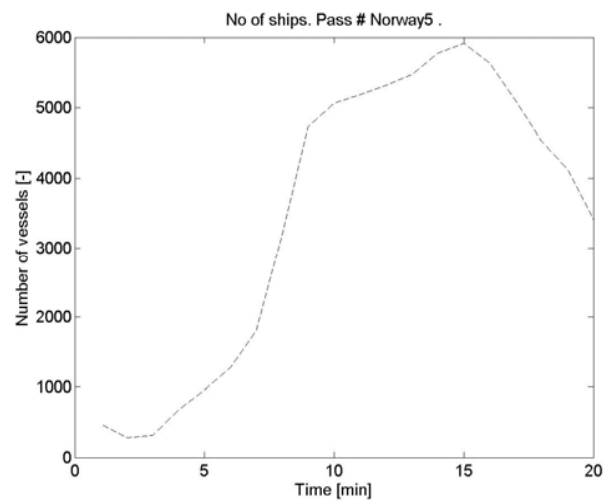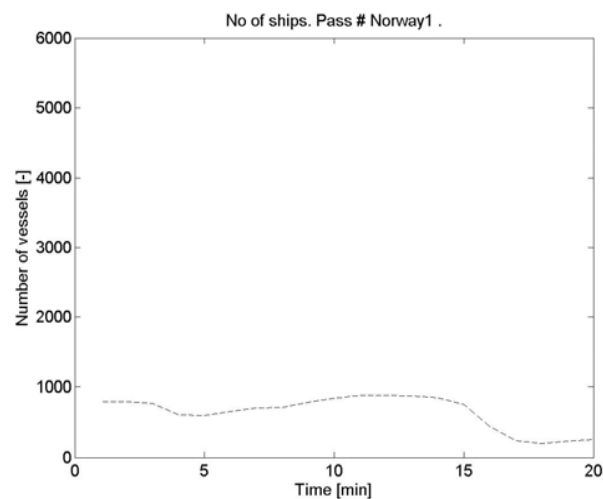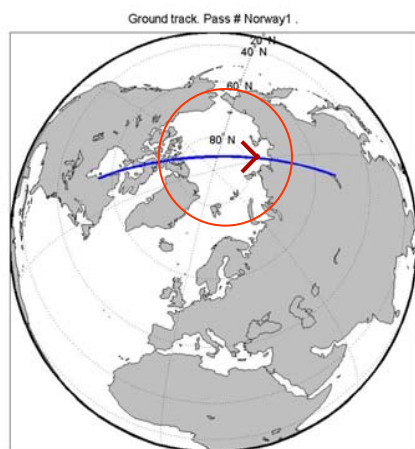
"AIS as is" will work in Polar regions

Global AIS Detection Probability Map
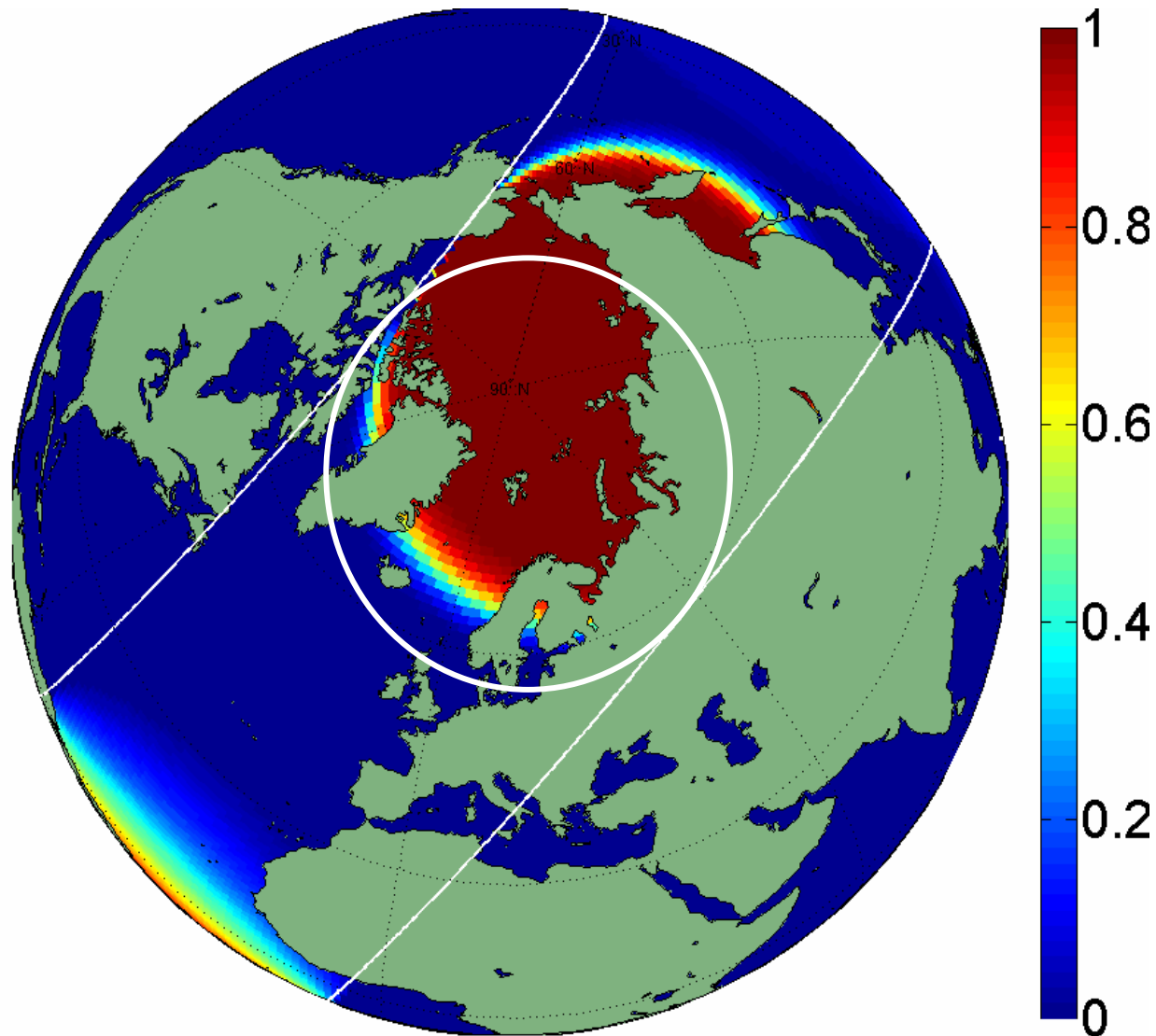
NOTE: This is an example only !!

# Three Conclusions and a Question

- "**AIS as is**" seems well suited for aircraft-based identification and tracking of maritime vessels

- "**AIS as is**" seems less suited for space-based global long range identification and tracking
  - AIS-sensor saturation at vessel densities >2000

- "**AIS as is**" seems feasible for Norwegian ocean areas where the number of vessels is rather small

- Can a small modification to the AIS concept reduce the number of messages received in space, and thereby enable global LR-AIS coverage?

AIS vs. LR-AIS Detection Probabilities

H_{sat} = 1000 km, T_{obs}=15min

AIS
LR-AIS

ΔT=3 min

ΔT=6 sec

Requires a 3rd AIS frequency
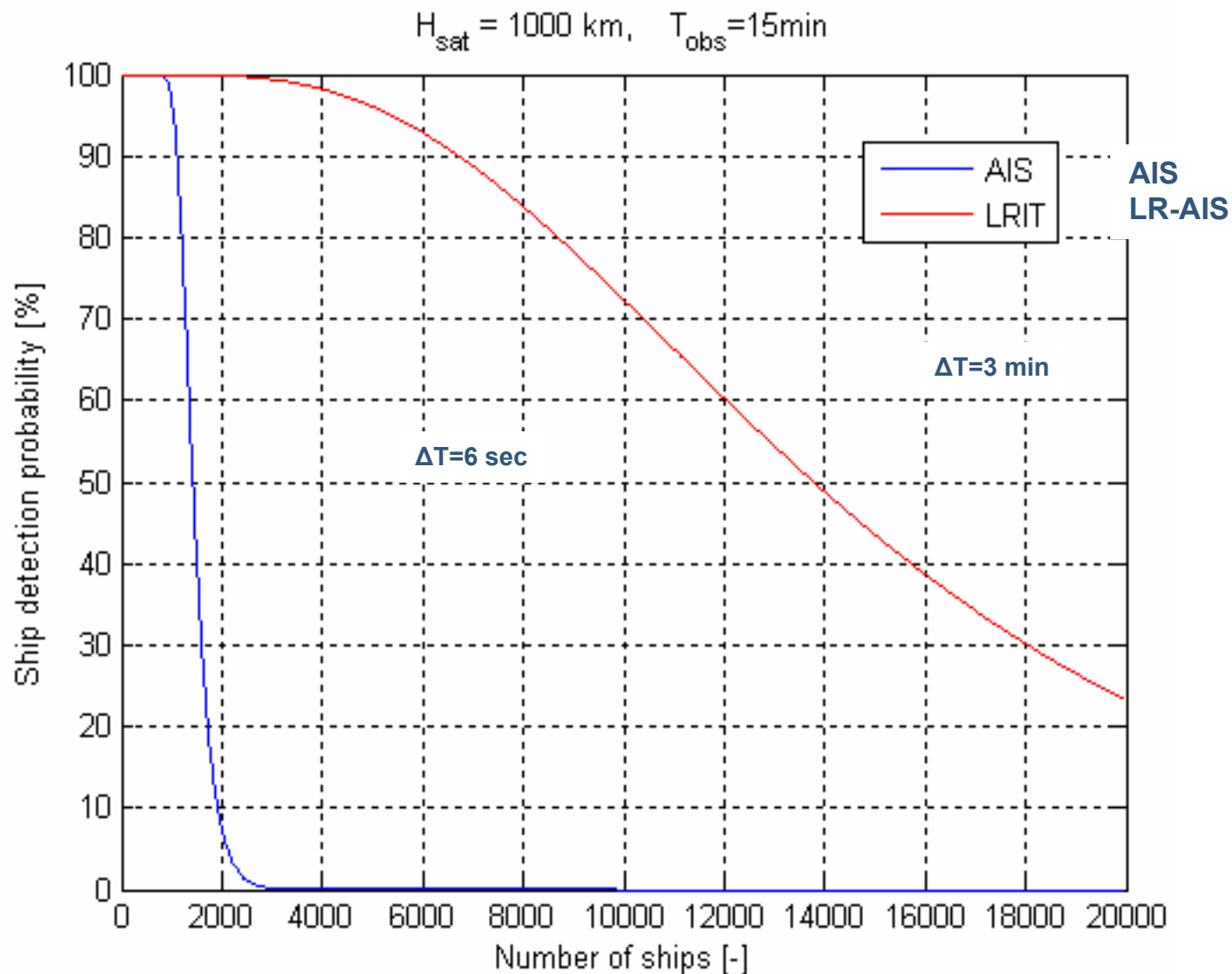
Simulation results for a satellite at 1000 km altitude

LR-AIS Satellites
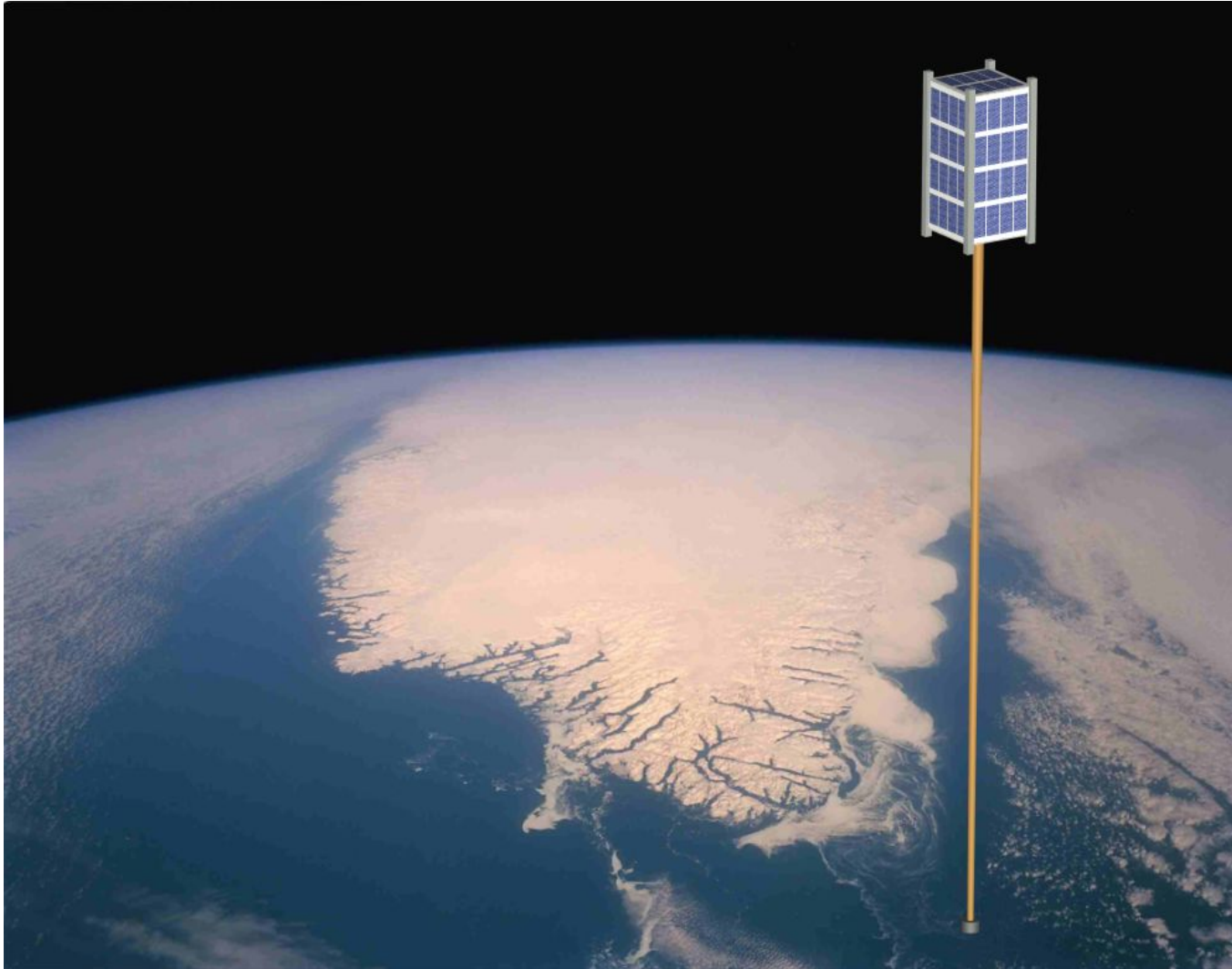
Can be based on low cost pico-satellites (TriCube)

NCUBE-1 and 2
AIS Detection Probability

Thank you for listening

Bjørn T Narheim (btn@ffi.no)
FFI, Kjeller, Norway