

Experience from the NATO Exercise STRONG RESOLVE 2002

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MARITIME COMPONENT

by Richard Olsen

For the NATO exercise STRONG RESOLVE 2002, FFI established a Rapid Environmental Assessment Support Centre (REA-SC) in collaboration with the Norwegian Meteorological Institute (met.no), primarily to provide detailed ocean analyses and forecasts to the meteorology/oceanography cell at NATO's Joint Headquarters North in Stavanger, Norway. Forecast and analysis products were based on outputs from ocean circulation models, ocean spectral wave models and from satellite images, and were primarily aimed at supporting the anti-submarine warfare component of the exercise. Products included profiles and sections of sound speed, as well as detailed maps of ocean circulation features indicating the presence of fronts and eddies that can be expected to influence acoustic propagation in the ocean. Some of the key issues facing the oceanographer/analyst are:

- Models provide a wealth of parameters describing the state of the sea and atmosphere in four dimensions (space and time), although not usually at a resolution required for littoral operations.
- At high latitudes and in winter conditions, cloud cover and light conditions – as a general rule – are not amenable to surface observation with optical or IR instruments, so we have emphasized the use of imaging radar. Imaging radar provides very detailed views of the ocean surface, but oceanographic structures are visualized through highly non-linear mechanisms, which sometimes poses difficult challenges for the analyst, and other supporting data becomes very useful.
- Analyses often need to be prepared within short time frames in preparation for handover briefs, as these are never timed to fit with synoptic schedule that the meteorological community works to or to satellite overpass times.
- Making sense of large, multi-parameter, data sets for battlefield environmental assessment therefore becomes a time critical problem, and effective means of analysis, visualization and production are a necessity. The complexity of oceanographic and meteorological processes generally require a great deal of operator analysis to arrive at a product that can be utilized by the warfighter.

Some specialized tools are under development that aim to support rapid METOC analyses for the Royal Norwegian Navy (RNoN). Early versions were used to support operations at the REA-SC during the exercise. They include software for quick analyses of SAR images of ocean features, and combining these with subsets of 4D oceanographic fields for analysis and display in two dimensions. Ocean feature maps are easily drawn and overlaid satellite images and model fields. Outputs include profiles and sections of ocean parameters that can be ingested directly into tools such as the Norwegian sonar performance prediction tool LYBIN, and the Allied Environmental Support System (AESS). The DIANA (Digital ANALysis) tool developed at met.no, is designed to easily overlay different spatial datasets (primarily

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model fields and weather satellite imagery) that come at different resolutions and in different map projections, and to easily toggle on/off different layers of meteorological and oceanographic information. An object-oriented representation of major features on a weather or ocean feature map supports easy subjective analyses of the environmental conditions, allowing the analyst to modify e.g. locations and shapes of major circulation features. Throughout the system, priority has been given to ease of operation and customization to minimize the required number of menu selections and mouse clicks, as well as rapid screen response to, among other things, screen panning and zooming.

The presentation shows some examples of screen shots and output products provided during the exercise.

THE LAND COMPONENT

by Pål Bjerke

At FFI there have been projects on satellite imagery for nearly 15 years. The aim of the projects has been to investigate the kind of information it is possible to extract from the images, and how it can be used for military purposes. Through the years, the commercial satellite images have increased their resolution, both because of improved technology, and also through the authorities willingness to reduce security restrictions. The increased resolution has opened up for new uses of the images. For areas where access on both land and airspace are restricted, satellite images are about the only way to get a view of the area. For “friendly” areas, however, aerial photos will be preferred because of resolution and price.

FFI was invited to participate during the NATO exercise, “Strong Resolve 2002”, held in central Norway in March this year. Aerial photos were acquired and prepared for the exercise, while satellite images were ordered to be taken during the exercise. The aerial photos had different resolutions, all better than what are available from commercial satellite images today.

The aerial photos were all geometrically corrected by FFI. This is necessary if they are to be used for direct measurements, or if they are to be “fused” with other data. The quality of the correction is related to the precision of the reference and the skill of the operator.

Along with the aerial photos, an elevation model for the area of interest was available. Using software which could handle 3D, the aerial photos were overlaid the elevation model. This gave a 3D view of the terrain. To go further, some of the buildings in the area were modelled in 3D, and some features were coloured for clarity. Military planners concluded those 3D-views gave a better impression of the area, not available from the 2D-images or the maps. Measurements in 3D, like line-of-sight and cover-calculations were also appreciated.

After the exercise, 2 satellite images were received. One was taken from IKONOS with 1 meter resolution and the other from QUICKBIRD with 0.7 meter resolution. Although there had been snow and cloudy weather in the region during the exercise, both images were almost free of clouds and other weather-related effects.

The positions of the different military units at the approximate time the satellite images were taken, came from JHQ North at Jåtta in Stavanger. Looking at the images, a lot of tracks from belt-driven vehicles like tanks, were clearly seen going from the roads out in the terrain and back. Most of the tracks were old, but for some of the new tracks, it was possible to see the vehicle at the end of the track. The command posts were more difficult to spot. The tents could be mistaken for huts. With a little help from officers who had operated in the area, most military units were detected in the satellite images.

As a reference for the satellite images, we used the aerial photos and photos taken from a car every 20 meters along the main roads. The aerial photos were rather new, and were used to see what was

supposed to be on the ground, and what could be objects from the exercise. The road photos gave an impression of how things looked in a horizontal view.

The low sun angle combined with the snow, made even small objects detectable because of the contrast of the shadow against the snow. When objects were in groups, the shadows made the individual objects difficult to separate from each other. The increased resolution in satellite images from 1 meter to 0.7 meter was visible but did not add significant information.

The most effective way to handle images is to convert them into an electronic format, for loading on a computer. With the proper software, the manipulation and measurements of the images can be performed in an easy and effective way, and even include 3D-processing not available in any other way. The necessary hardware and software have been available on the market for some years now, but even so it can be very difficult to introduce such methods into the military services. There can be several reasons for that:

- Price
- Complexity
- Reluctance towards new ideas
- Not effective

It is commonly agreed that headquarters and command posts should be connected with computer terminals, but is it effective for soldiers in the field to use computers with keyboards and menus?

A tank commander showed me his “CCI-system” after the exercise SR2002. It turned out to be 4 sheets of 1:50.000 maps nicely taped together, and folded over to fit into a pocket in his uniform. Using an ink pen, all his movements through the exercise were drawn on the map.





Experience from the NATO exercise STRONG RESOLVE 2002

(a) The Maritime Component

by Richard Olsen, FFI

(a) The Land Component

by Pål Bjerke, FFI



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Experience from the NATO exercise STRONG RESOLVE 2002

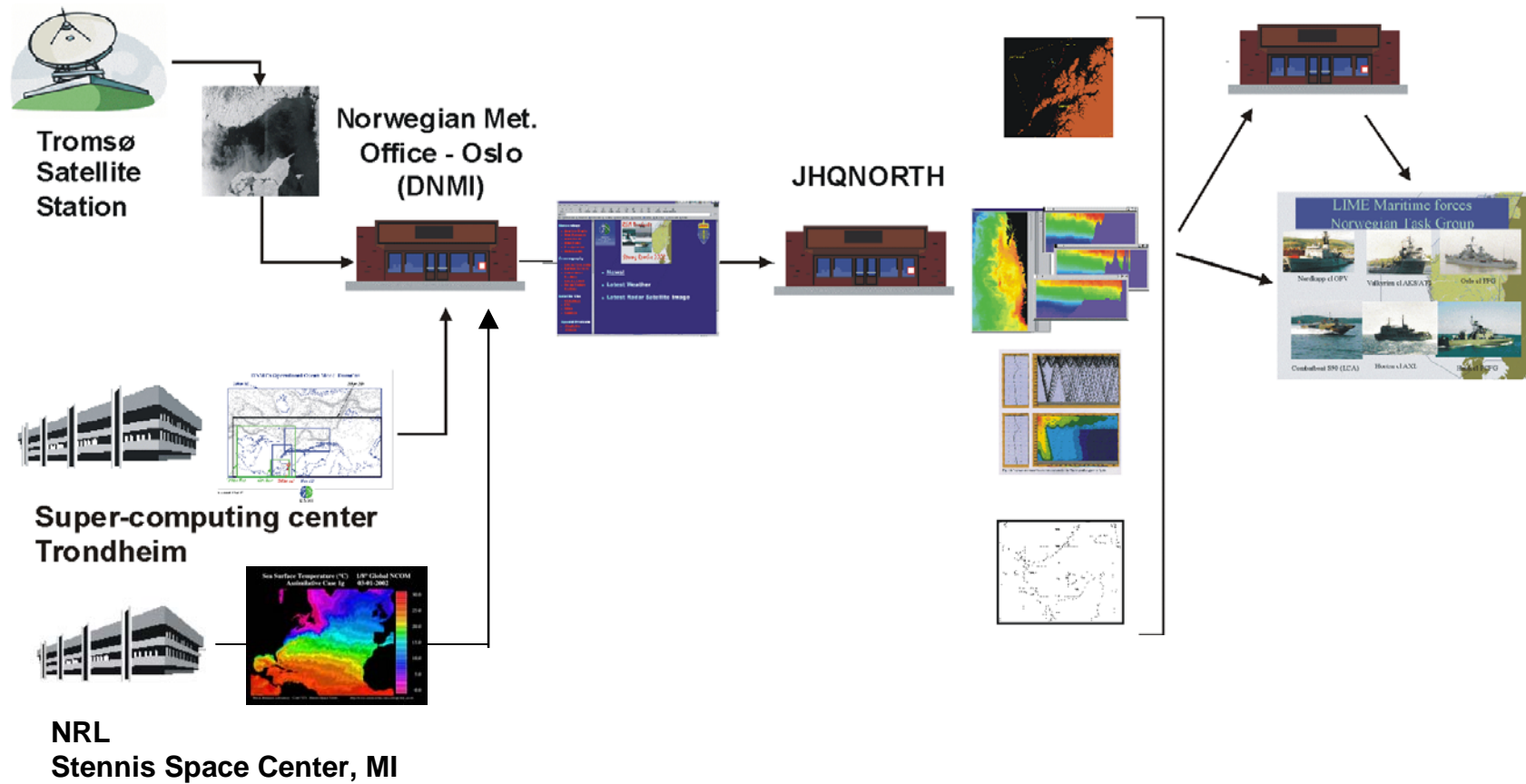
The Maritime Component

by Richard Olsen

Norwegian Defence Research Establishment



Strong Resolve



Meteorology

- [Weather Charts](#)
- [Text Forecasts](#)
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- [Stoplights](#)
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Det norske meteorologiske institutt

REA Products

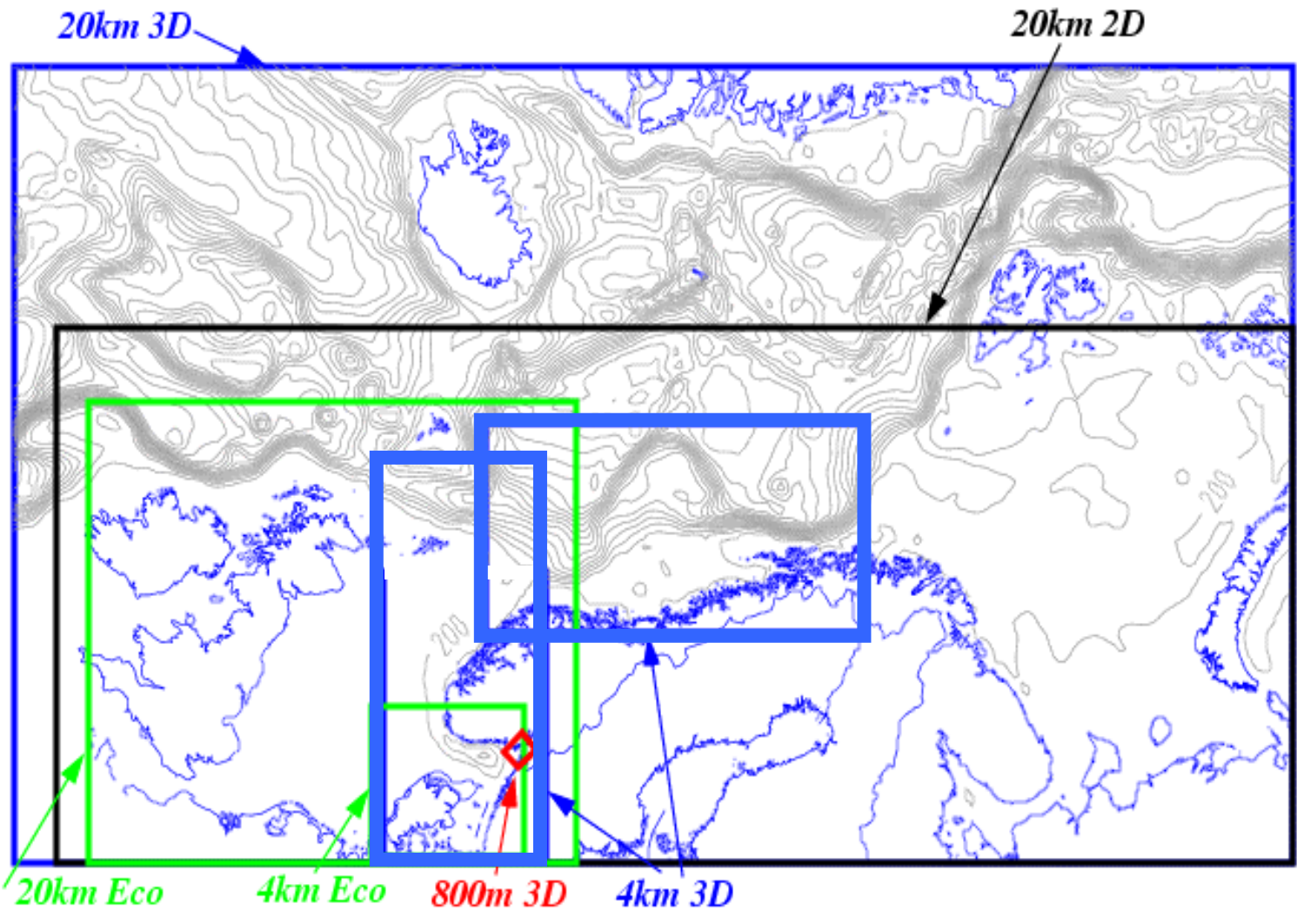


Strong Resolve 2002



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DNMI's Operational Ocean Model Domains

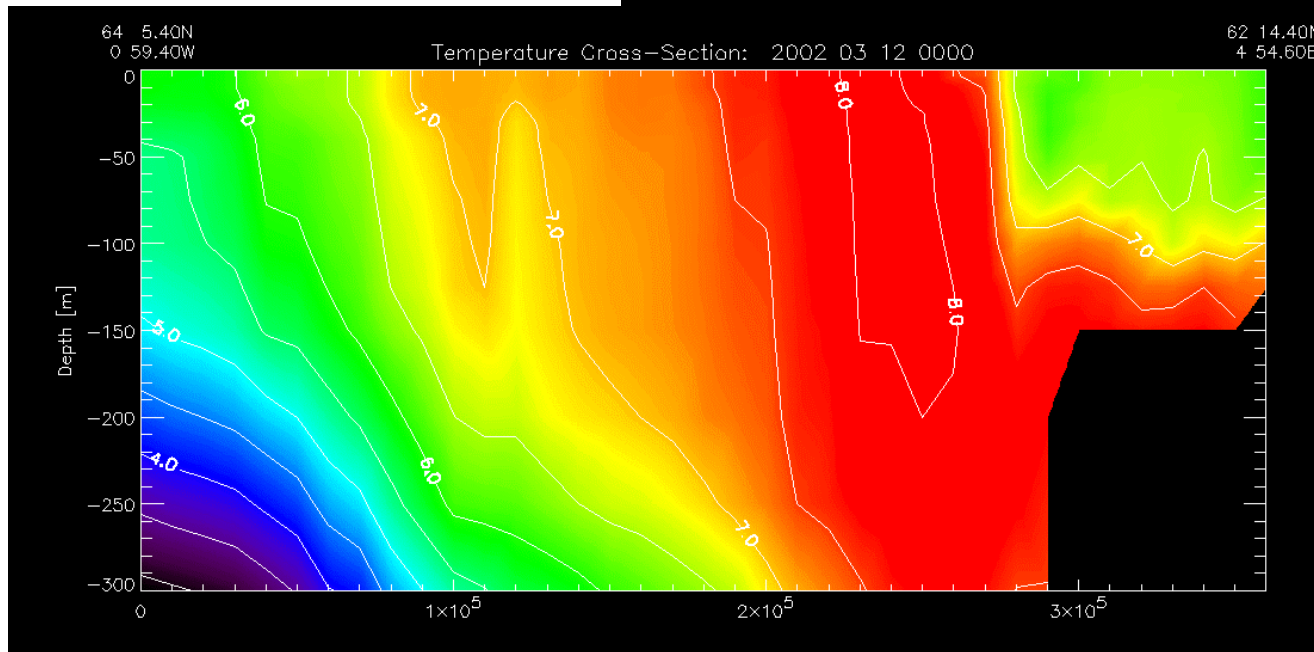
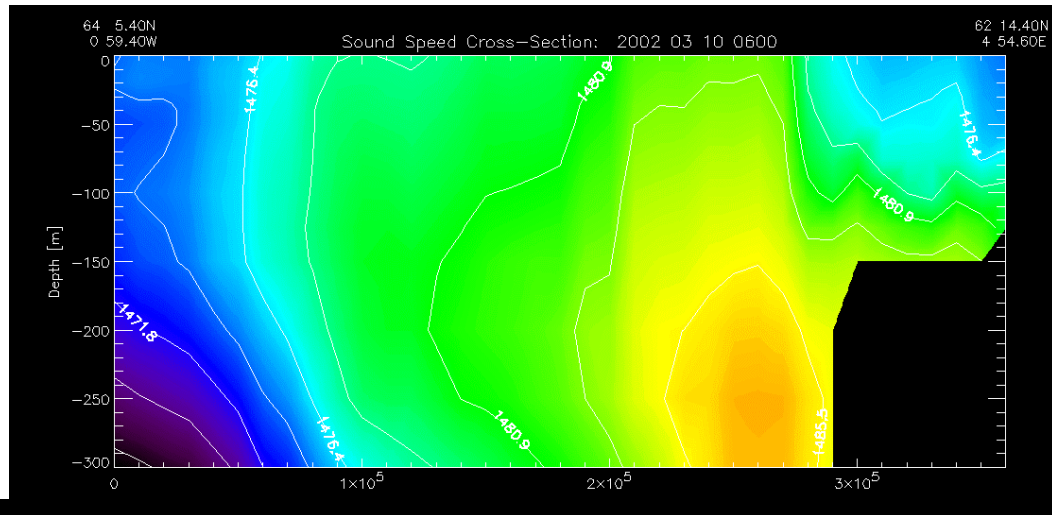


Bruce Hackett 19 March 2001





Temp & Sound Speed

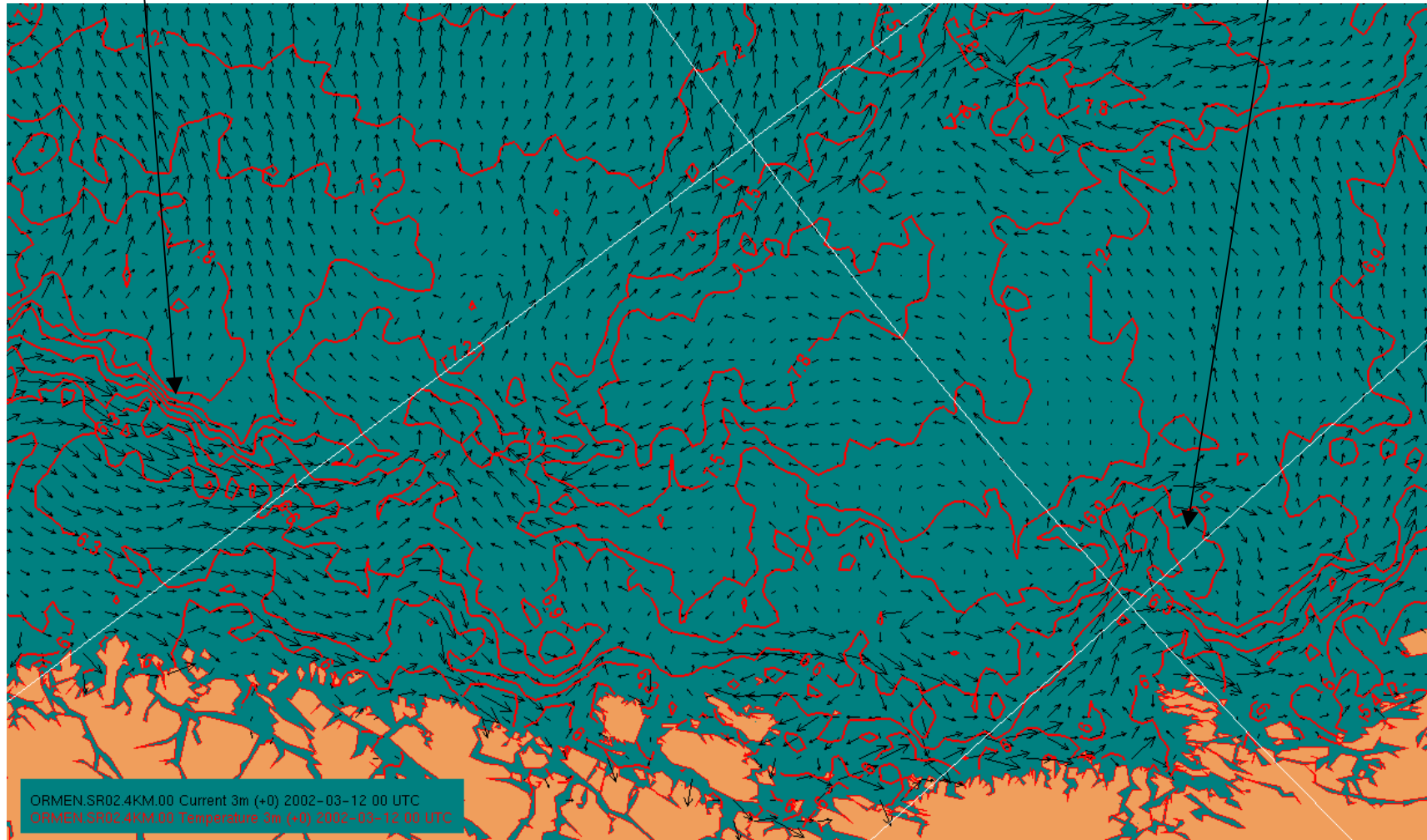


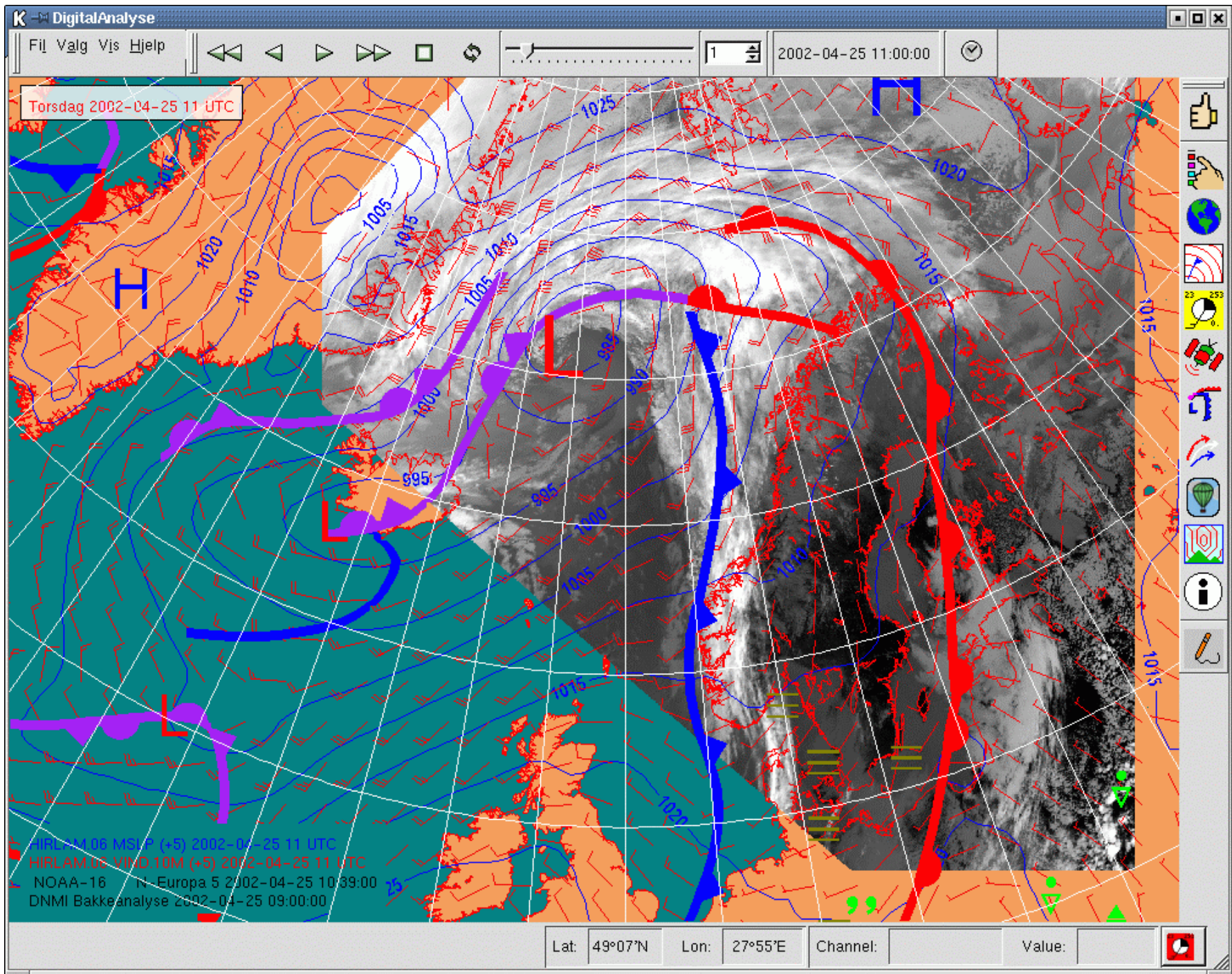


Surface Current / Temp.

FRONT

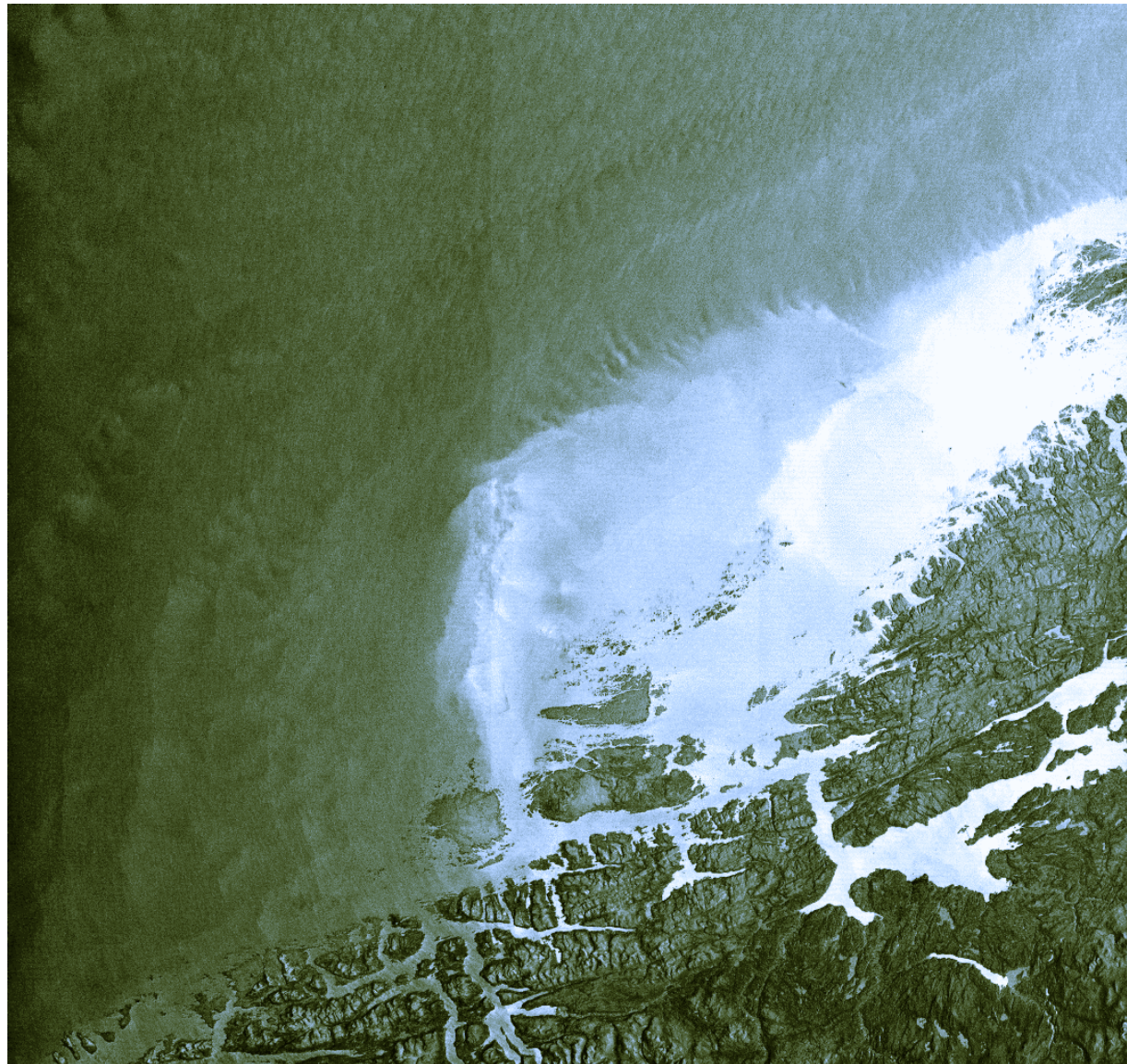
EDDY

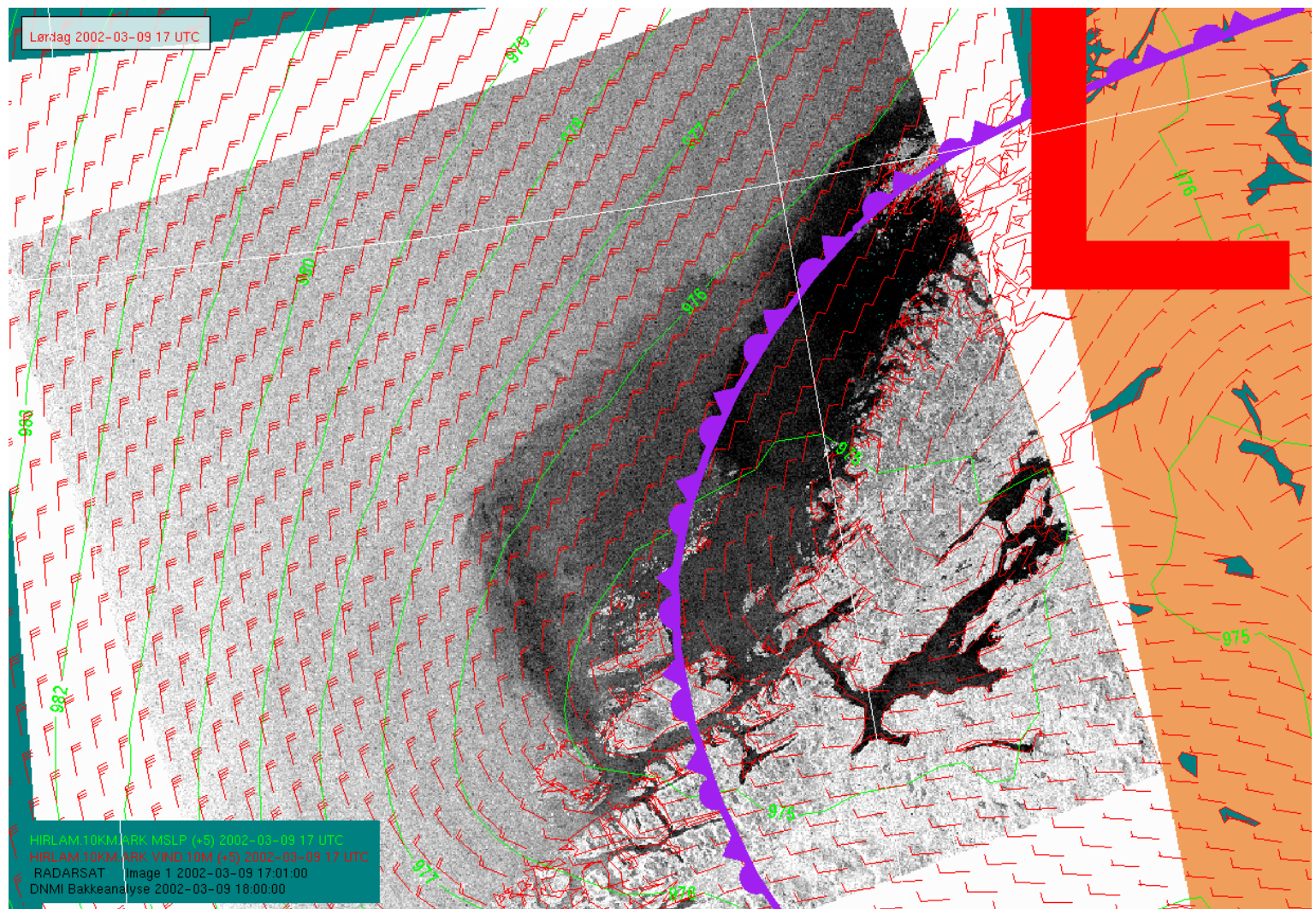




RADARSAT

9 March







Future work

- **Development of tailored METOC data to the Norwegian forces is only just starting.**
- **Will continue to develop analysis and forecast products for direct use in C2I systems (MCCIS, NORCCIS II), electronic chart displays (WECDIS), as well as in support tools such as sonar performance prediction tools (LYBIN).**
- **Closer integration of DNMI and operational HQ will be necessary to meet future requirements for METOC data. Could result in DIANA being available at operational HQ.**
- **Transfers of data from unclassified networks to classified NATO systems remains a challenge – but needs to be resolved if METOC info is to be delivered effectively to deployed units**



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Experience from the NATO exercise STRONG RESOLVE 2002

The Land Component

by Pål Bjerke

Norwegian Defence Research Establishment

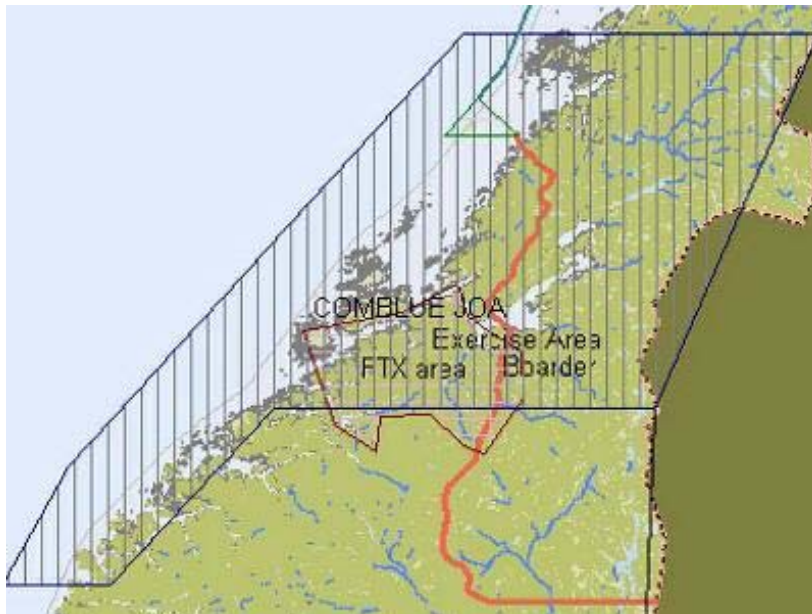


Background

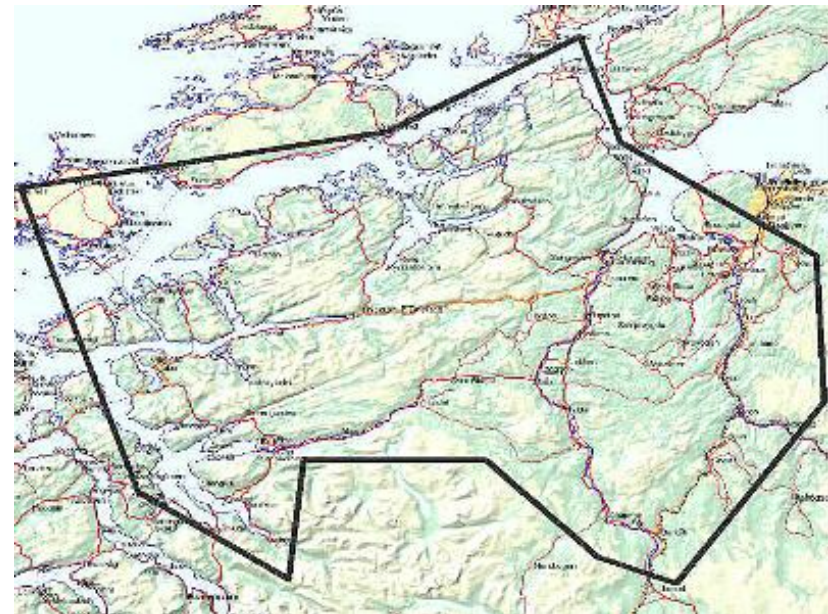
- **FFI has been working with commercial satellite images for military use since 1989**
- **In 2000/01 satellite images from the 1 meter commercial photo satellite IKONOS was evaluated**
- **Participated in the NATO exercise STRONG RESOLVE 2002 with emphasise on :**
 - **QUICKBIRD images (0.7 m resolution)**
 - **Resolutions beyond what are available from commercial satellite images (aerial images)**



NATO exercise "STRONG RESOLVE 2002"



Total exercise area

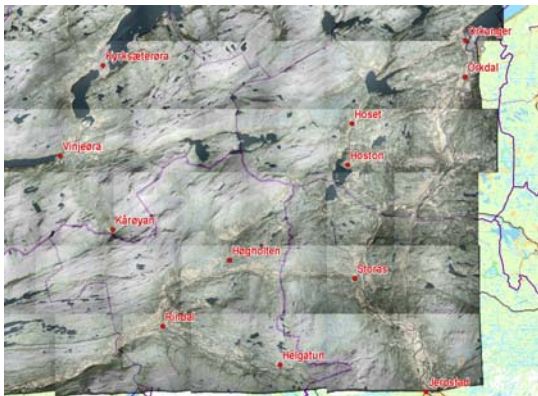


Landpart exercise area



Aerial photos aquired for the exercise

Each rectangle covers the central part of the land-exercise



**0.50 m
resolution**



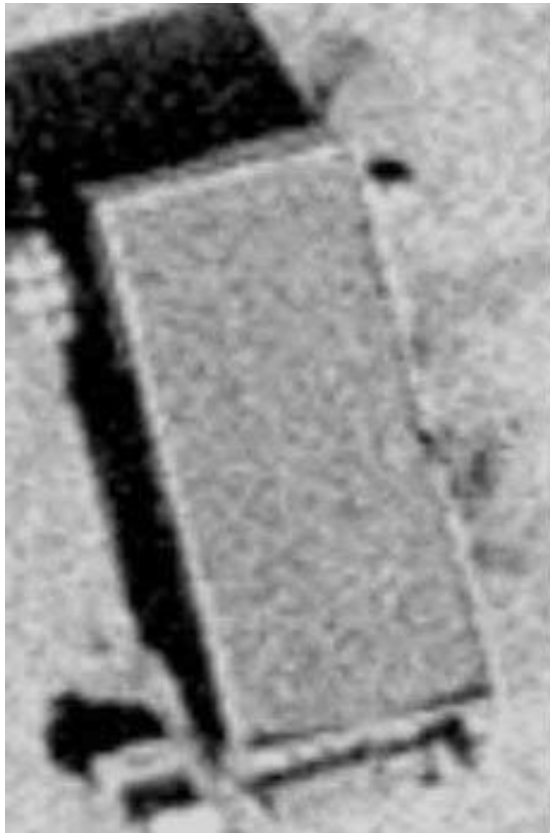
**0.25 m
resolution**



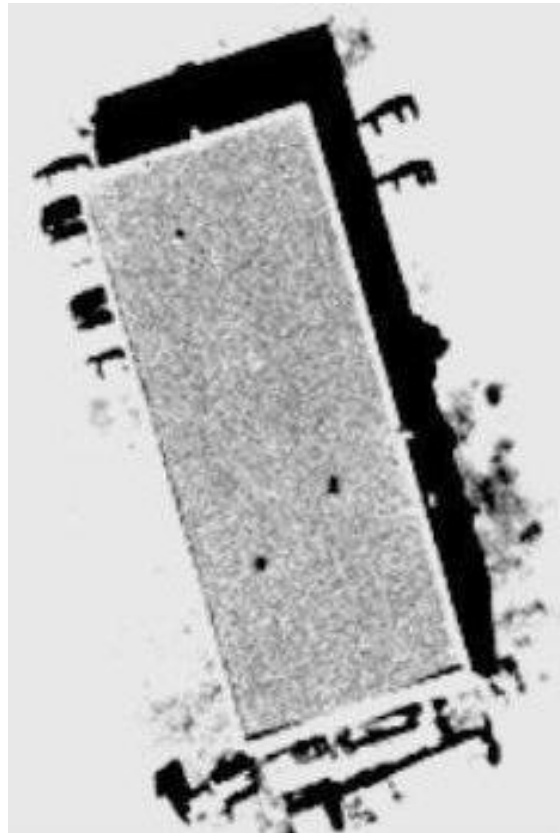
**0.10 m
resolution**



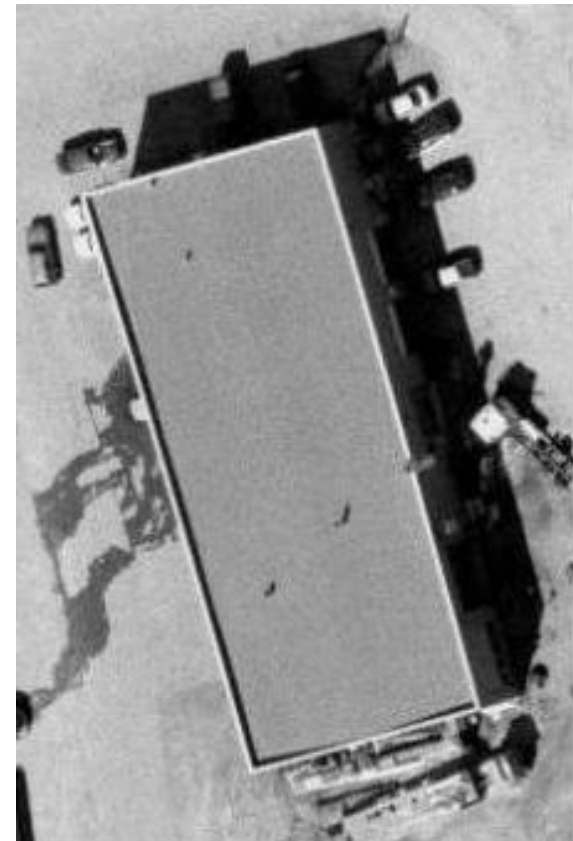
Comparison of resolution



**0.50 m
resolution**



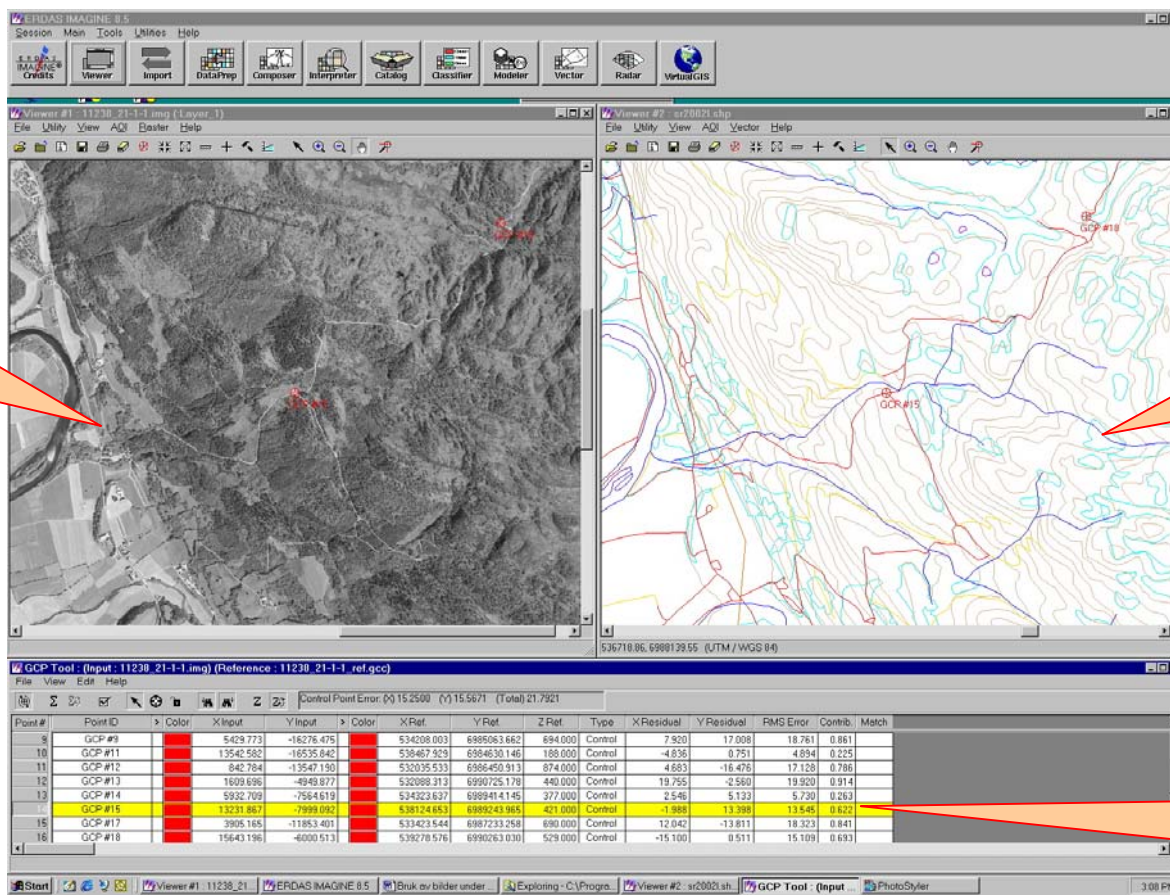
**0.25 m
resolution**



**0.10 m
resolution**

Software for geometric corrections (ERDAS)

Image
to
correct



The screenshot displays the ERDAS IMAGINE 8.5 software interface. It features a main menu bar (Session, Main, Tools, Utilities, Help) and a toolbar with various processing tools. Two main viewports are visible: the left viewport shows a satellite image of a terrain, and the right viewport shows a corresponding topographic map with contour lines and roads. Below the viewports is the 'GCP Tool' window, which contains a table of control points used for geometric correction. The table includes columns for Point #, Point ID, Color, X Input, Y Input, Color, X Ref, Y Ref, Z Ref, Type, X Residual, Y Residual, RMS Error, Contrib, and Match. The table lists 8 control points, with GCP #15 highlighted in yellow.

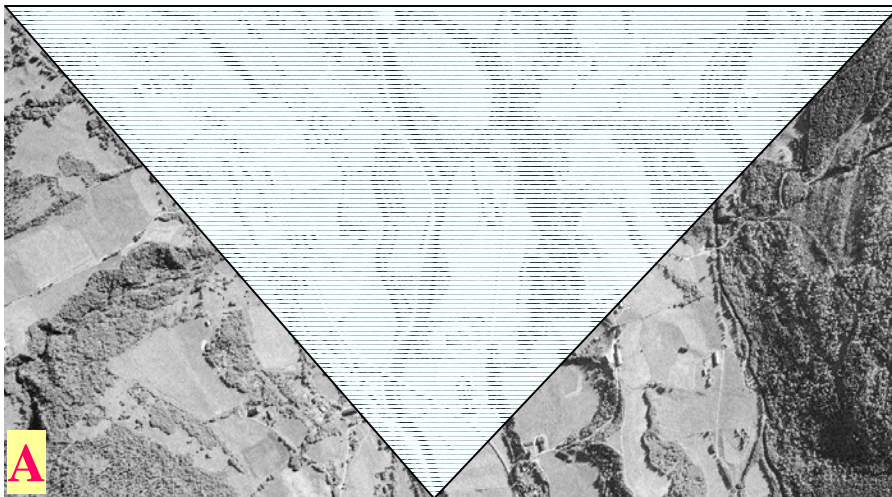
Point #	Point ID	Color	X Input	Y Input	Color	X Ref	Y Ref	Z Ref	Type	X Residual	Y Residual	RMS Error	Contrib	Match
8	GCP #8	Red	5429.773	-16276.475	Red	534208.003	6895063.662	694.000	Control	7.920	17.008	18.761	0.861	
10	GCP #10	Red	13542.582	-16535.842	Red	538467.529	6984630.146	188.000	Control	-4.836	0.751	4.894	0.225	
11	GCP #11	Red	842.784	-13547.190	Red	532035.533	6986450.913	874.000	Control	4.683	-16.476	17.128	0.786	
12	GCP #12	Red	1609.696	-4948.877	Red	532088.313	6990725.178	440.000	Control	19.755	-2.560	19.920	0.914	
13	GCP #13	Red	5932.709	-7554.619	Red	524323.627	6989414.145	377.000	Control	2.546	5.123	5.720	0.263	
14	GCP #14	Red	13231.861	-7998.082	Red	538124.653	6990243.983	421.000	Control	-1.989	13.388	13.545	0.822	
15	GCP #15	Red	3905.165	-11853.401	Red	531423.544	6987233.258	690.000	Control	12.042	-13.811	18.323	0.841	
16	GCP #16	Red	15643.196	-4000.513	Red	539278.576	6990263.030	529.000	Control	-15.100	0.511	15.109	0.693	

Geometrical
reference
e. g. a map

List of
reference
positions



3D visualization of terrain



A Ortophoto

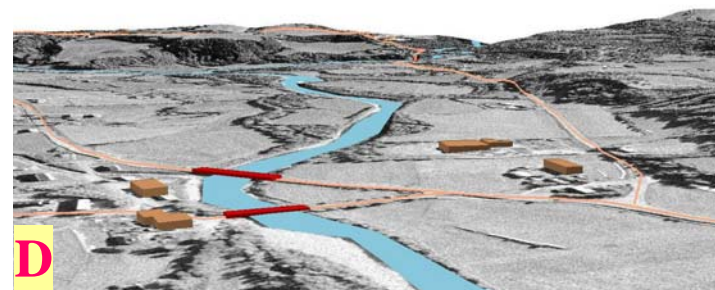


B Pseudo-colored elevationmodell



C Aerial image overlaid elevationmodell

D Aerial image overlaid elevationmodell
with buildings raised and features colored





Increased resolution in satellite images (Litsa-fiord on the Kola-peninsula)



LANDSAT
32 m resolution

© USGS



SPOT
10 m resolution

© SPOT Image

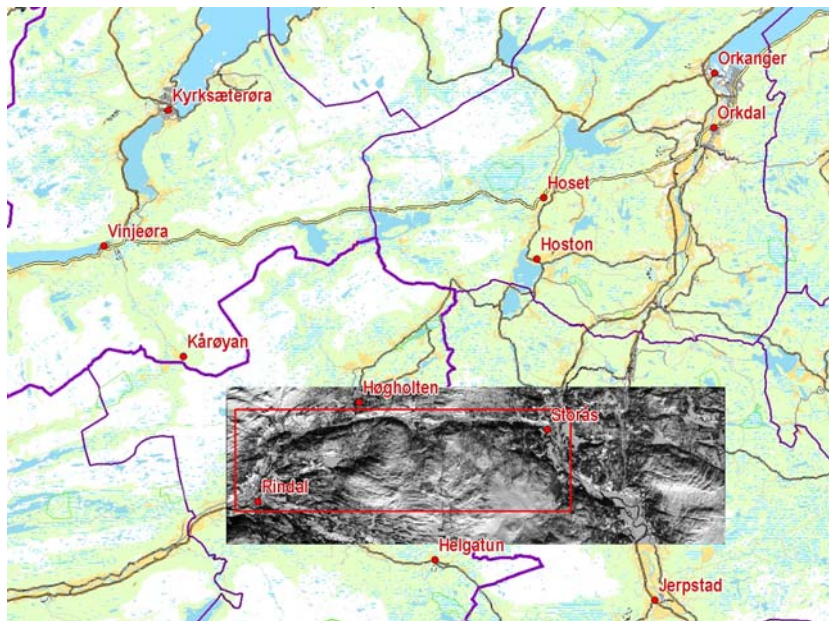


IKONOS
1 m resolution

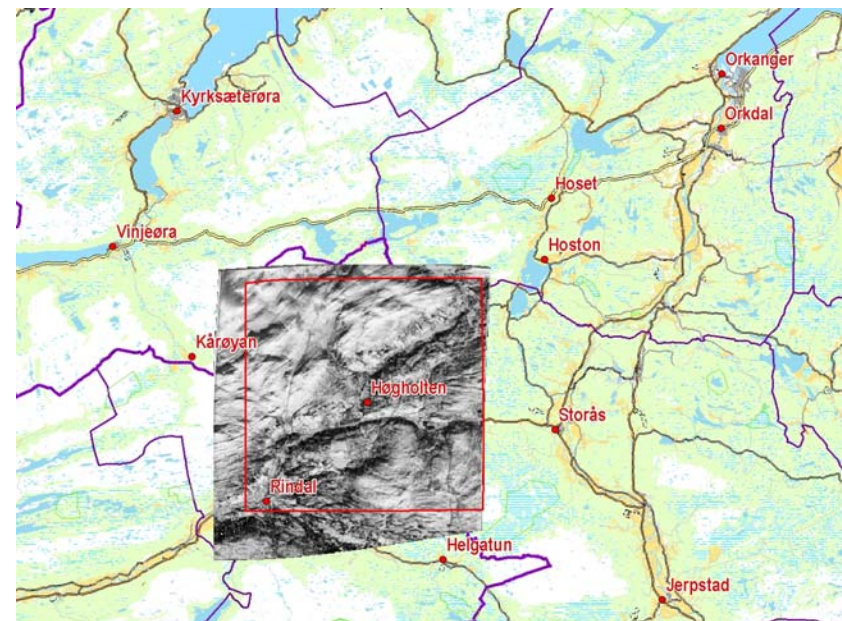
© SpaceImaging



Satellite images taken during the exercise

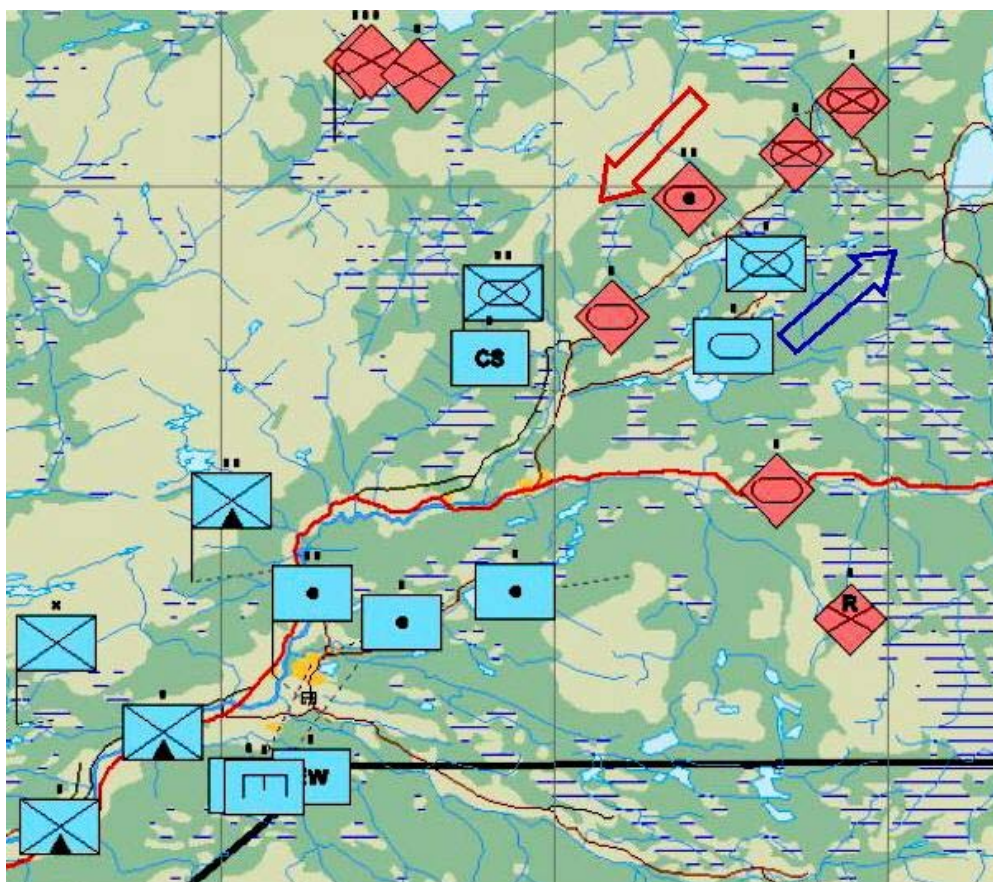


IKONOS 1 m resolution
Wednesday March 13. at 11:17 GMT



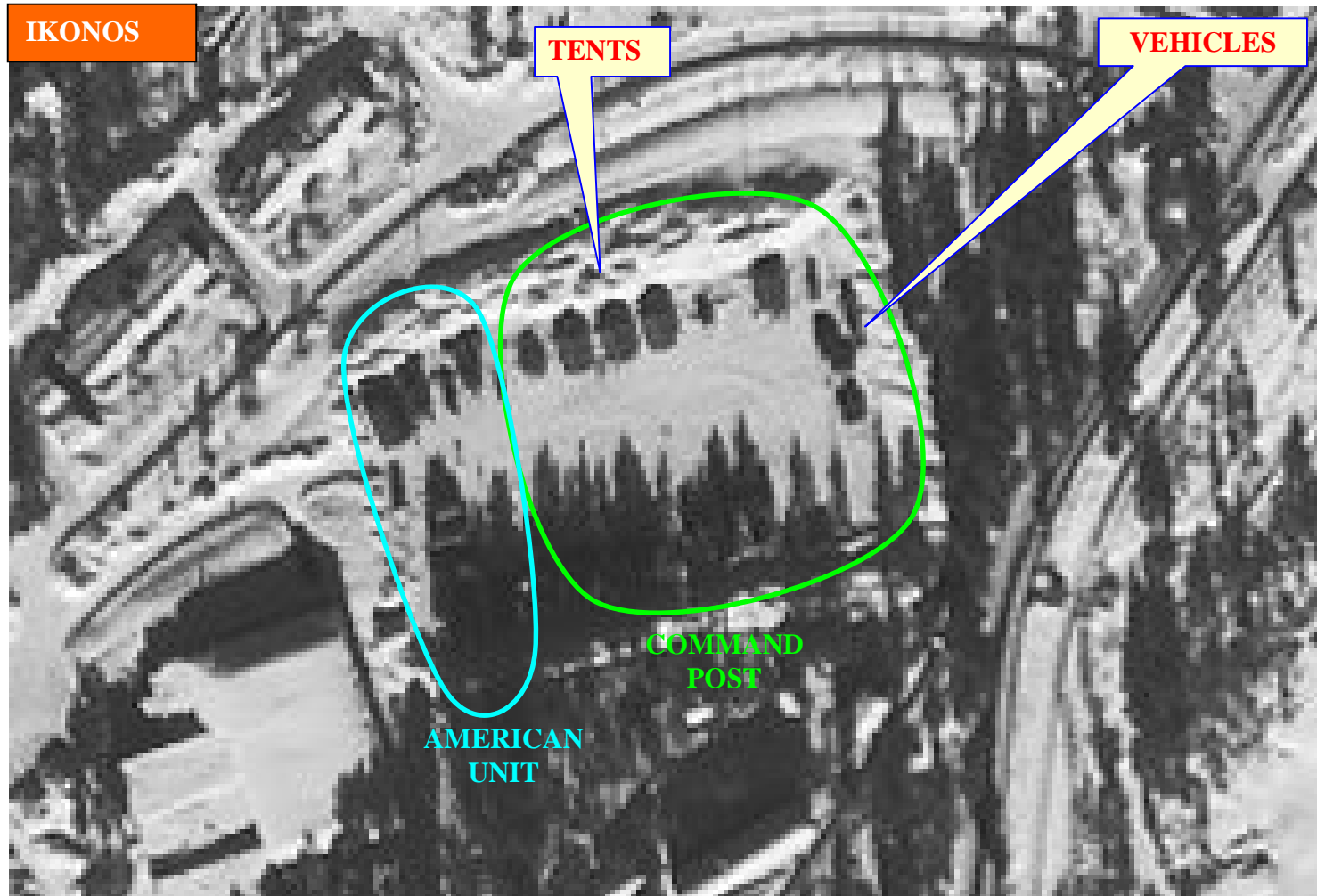
QUICKBIRD 0.7 m resolution
Thursday March 14. at 10:47 GMT

Situation on Thursday March 14. at 0800 GMT



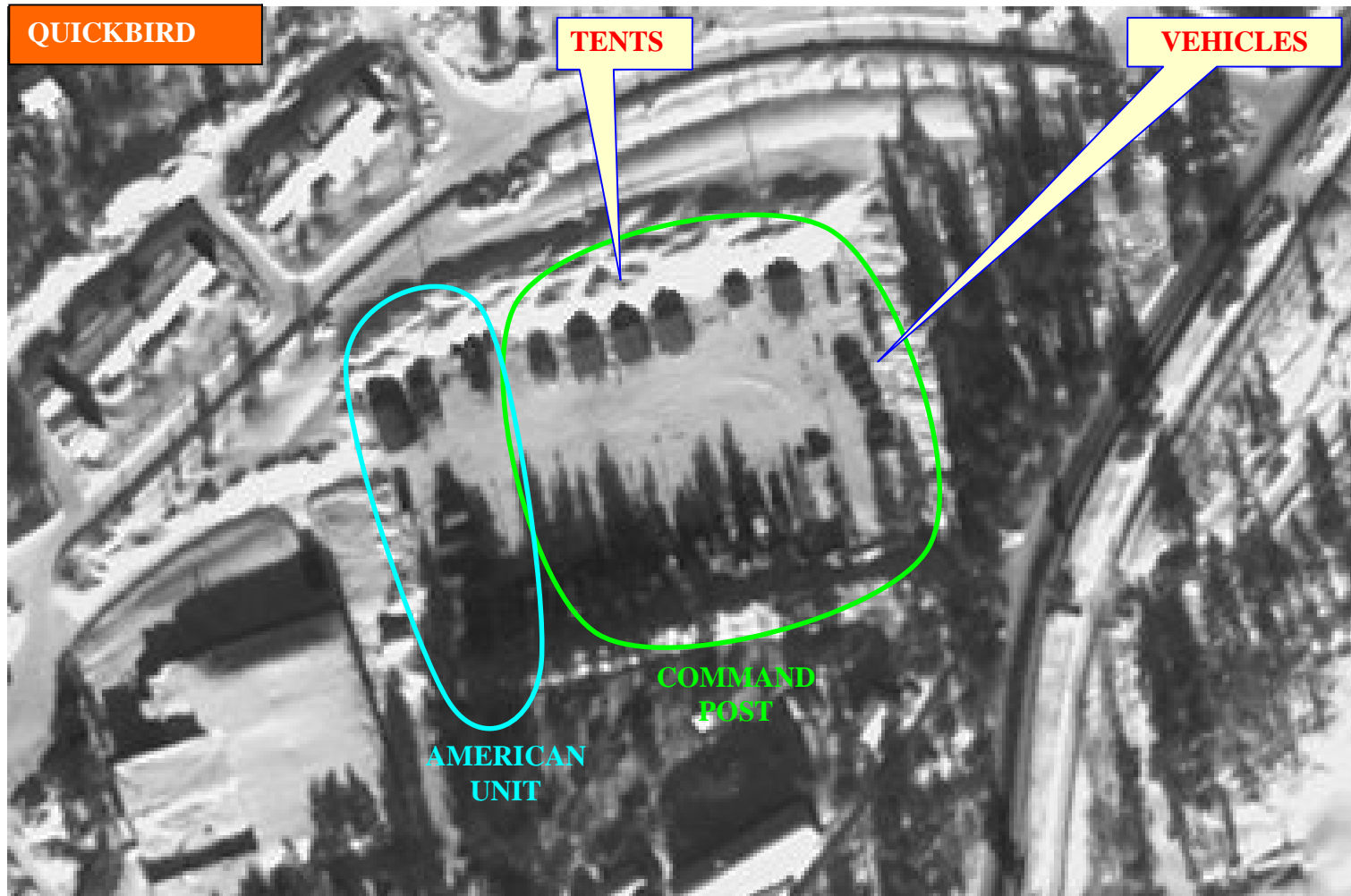


Command post for Spanish batalion



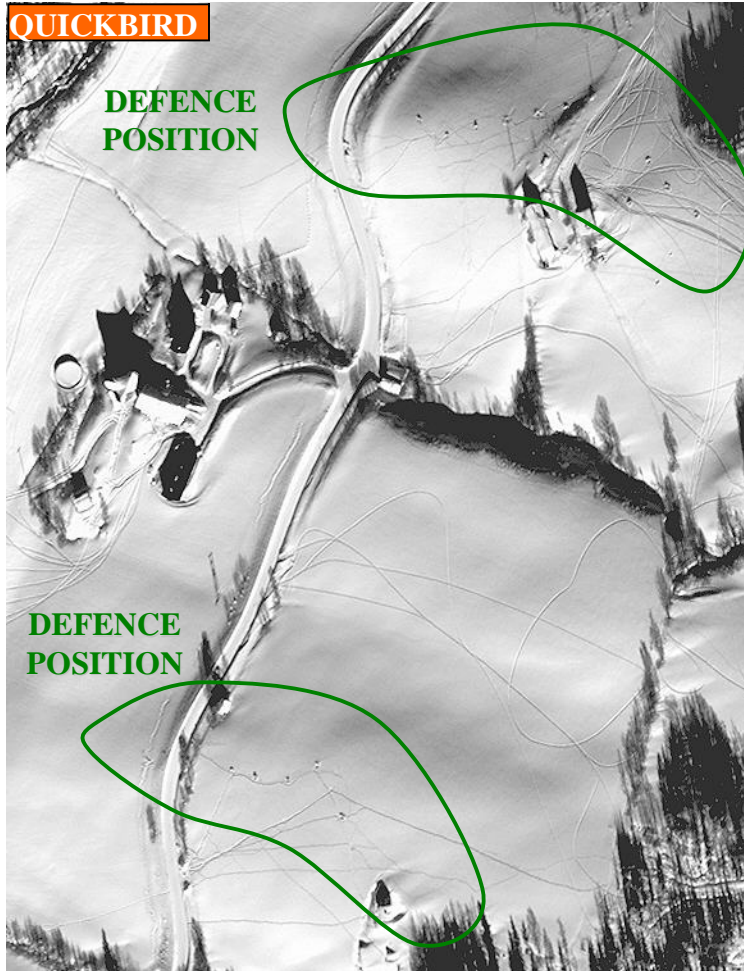


Command post for Spanish batalion





Defence positions for Spanish batalion





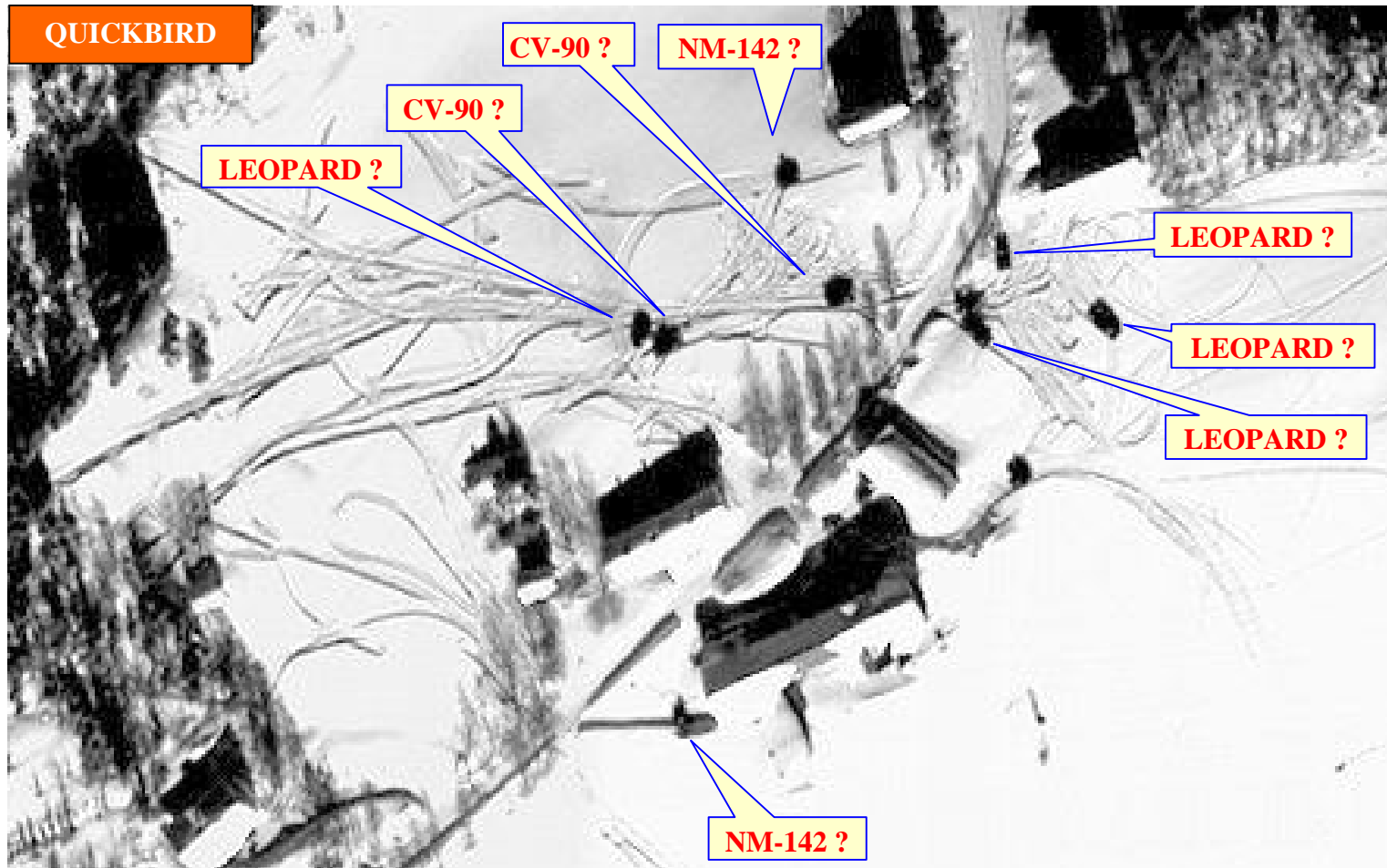
German communication post

IKONOS



QUICKBIRD







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American LAR

(Light armoured reconnaissance)
unit

Increased dynamic
range of
2048 graylevels
makes it possible
to see objects
in the shade





Recognition through improved resolution



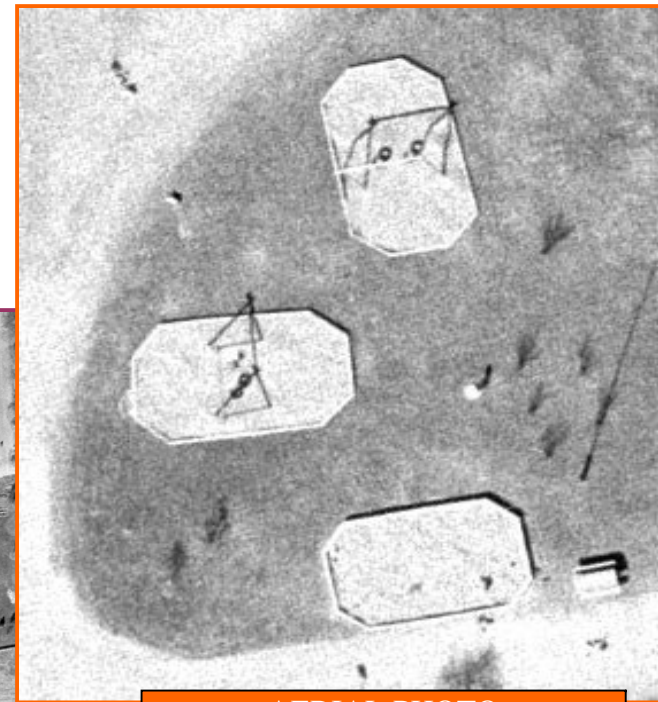
IKONOS 1 m resolution



AERIAL PHOTO
0.5 m resolution



AERIAL PHOTO
0.1 m resolution



AERIAL PHOTO
0.1 m resolution



Conclusion

- **Increasing resolution in satellite images from 1 m to 0.7 m does not add significant information.**
- **Because of the snow, tracks of almost any activity outside the road were shown in a revealing way.**
- **The low sunangle produced long shadows, making single small objects to appear, and making clusters of objects to vanish in each other shadows.**
- **Satellite images and aerial photos are not in much use in Norway for military planning. Probably there are personell out there who could gain on that kind of information. The job is to find them !**