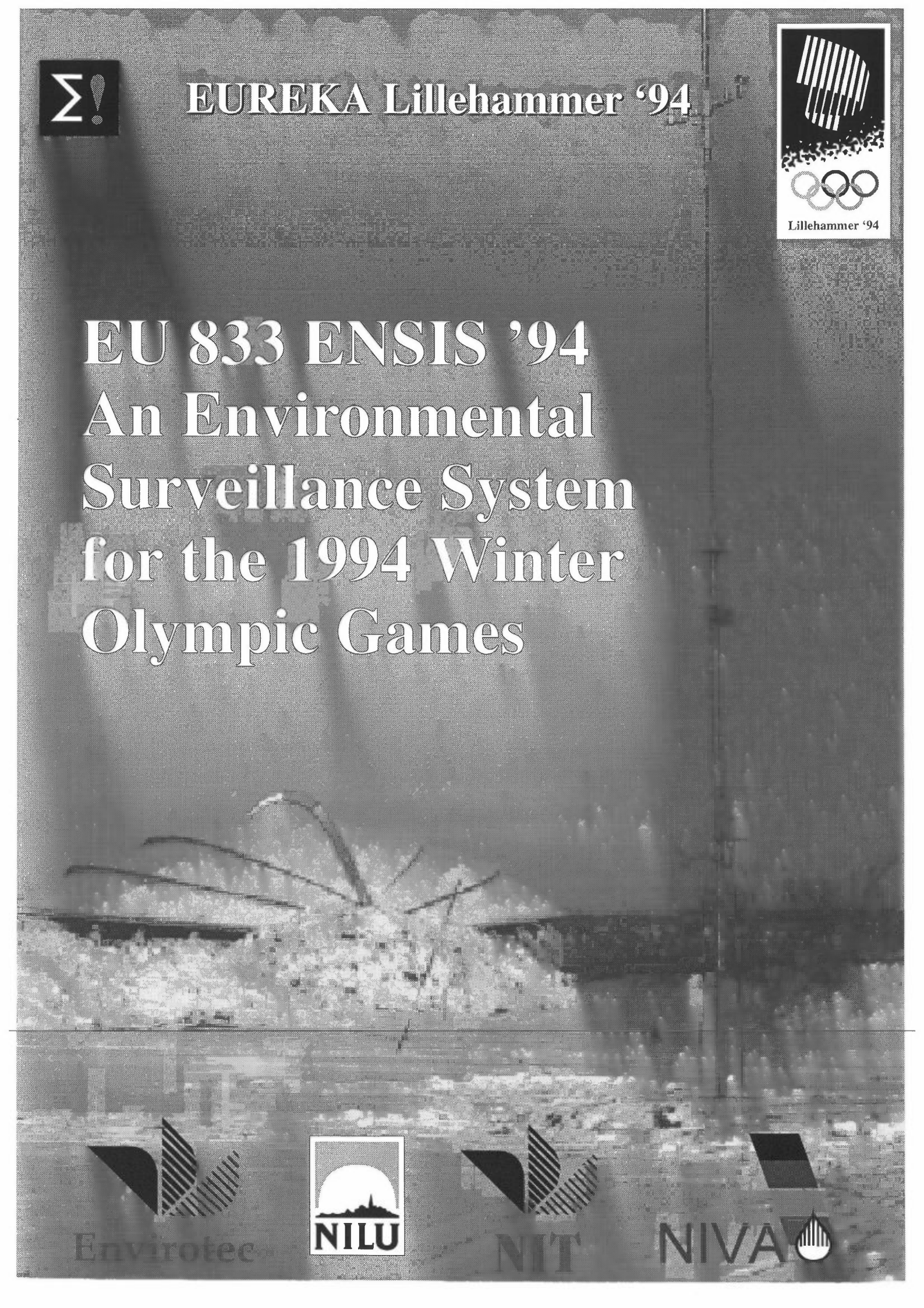


EUREKA Lillehammer '94

Lillehammer '94

EU 833 ENSIS '94 An Environmental Surveillance System for the 1994 Winter Olympic Games

Envirotec

NILU

NIT

NIVA

NILU: OR 50/94

NILU : OR 50/94
REFERENCE : O-92126
DATE : August 1994

EU 833 ENSIS'94

An Environmental Surveillance System for the 1994 Winter Olympic Games

Bjarne Sivertsen

Svein Haagenrud

Preface

This report describes the Environmental Surveillance and Information System (ENSIS) developed within the Eureka framework as project EU 833. The system was operated during the 1994 Winter Olympic Games.

The following Norwegian consortium was responsible for the development of ENSIS:

Norwegian Institute for Air Research (NILU)	-	Project management and project leader for ENSIS AIR
Norwegian Information Technology (NIT)	-	Project leader ENSIS IT
Norwegian Institute for Water Research (NIVA)	-	Project leader ENSIS WATER
ENVIROTEC	-	Project leader industrialization, sales and marketing
Lillehammer Olympic Games Organizing Committee (LOOC)	-	Applications during the Winter Olympic Games

Contents

Page

EU 833 ENSIS '94

An Environmental Surveillance System for the 1994 Winter Olympic Games

1. Introduction

The development of a modern ENvironmental Surveillance and Information System (ENSIS) started in 1992 within the Eureka framework as project EU 833. A first version of a user oriented system for collection, transmission, distribution and presentation of all kind of environmental data was to be applied and demonstrated during the Winter Olympic Games in Lillehammer 1994.

A close co-operation between research organizations and companies dealing with air and water pollution, sensor technologies, data transmission, information technology and geographical information systems (GIS) made it possible during the short period available to develop an operative system referred to as ENSIS '94 during the Olympic Games in February 1994.

During the Games the ENSIS system was linked to the information system, INFO '94, operated by the Lillehammer Olympic Organizing Committee (LOOC). All accredited personnel; journalists, leaders, authorities and visitors could obtain information from ENSIS by linking up to INFO '94 touch screen terminals.

The ENSIS system will in the future be used both for surveillance and planning. The combination of online data collection, statistical evaluations and numerical modelling enable the user to use it both for information, for short term forecast and for future planning purposes. The system can be used to estimate environmental impacts from planned actions. For air pollution impact assessment a future indicator selected may be total human exposure. The ENSIS system is designed and prepared to include also the estimation of this indicator.

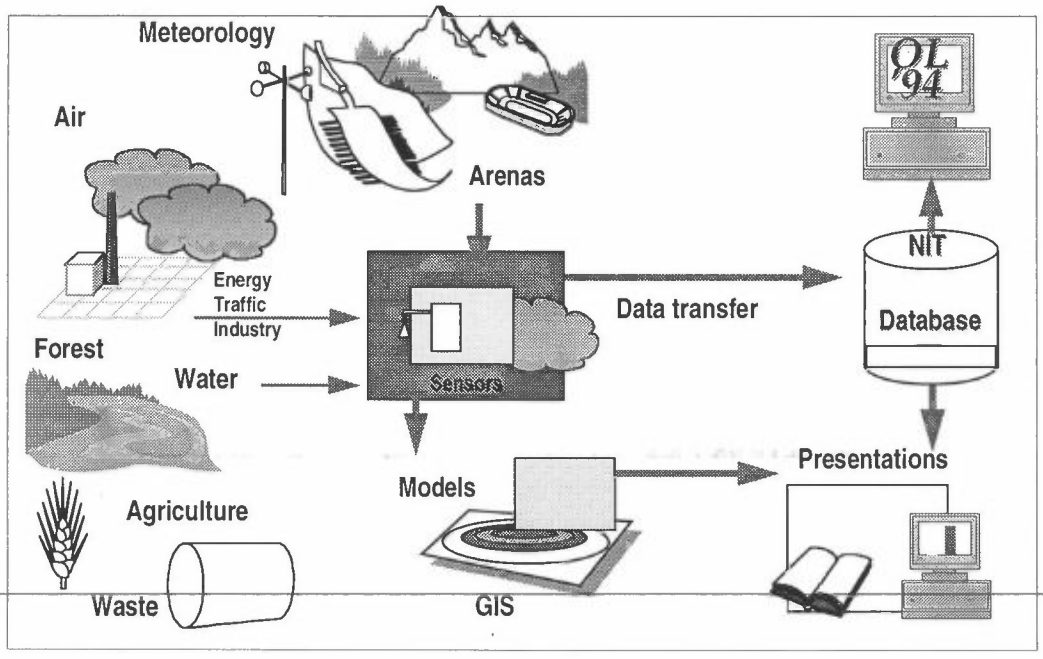


Figure 1: The ENSIS '94 concept; an Environmental Surveillance and Information system for the Winter Olympic Games 1994 in Lillehammer.

2. The ENSIS system

The background for establishing a new generation of surveillance systems is based on the combination of new sensor technologies with modern information technology.

The development has included modifications of already available sensors as well as the development of new sensors based on the most advanced technology available. Data collected by sensors and monitors for meteorology, air quality, water quality, traffic, waste etc. is automatically transferred to a data centre for quality control, for statistical evaluation and for data modification and preparation for input to numerical models. The results are linked to user friendly graphical presentation systems included GIS based presentations, displays and mapping of environmental data.

The development of the ENSIS system has included:

- a new generation of sensors and monitors
- data quality control and data transfer
- establishment of data bases
- use of statistical and numerical models for transport and dispersion
- user friendly graphical presentation system
- presentations based upon a geographical information system (GIS)
- specific application for the Winter Olympics INFO '94 user

To achieve the goals so that the system were to be demonstrated and applied during the Lillehammer Winter Olympic Games the development project was divided into several sub programmes. These programmes included meteorology and climate for the region, air quality sensors, a measurement programme, air pollution dispersion models, water quality and river surveillance and controls, waste water treatment systems, an information data platform, and links to INFO '94 included a result presentation package.

2.1 Sensors and monitors

To improve the data collection procedures including equipment that can monitor the state of the environment continuously and transfer data via data loggers and telephone modems, the old monitoring systems had to be revised. Development of new monitors had to be initiated, even if it was clear that only a first part of this development process could be included in the Lillehammer 1994 surveillance programme.

The development of a new generation of air quality monitors based upon laser spectroscopy was initiated. This development involves a unique "single line spectroscopy" technique including the use of advanced

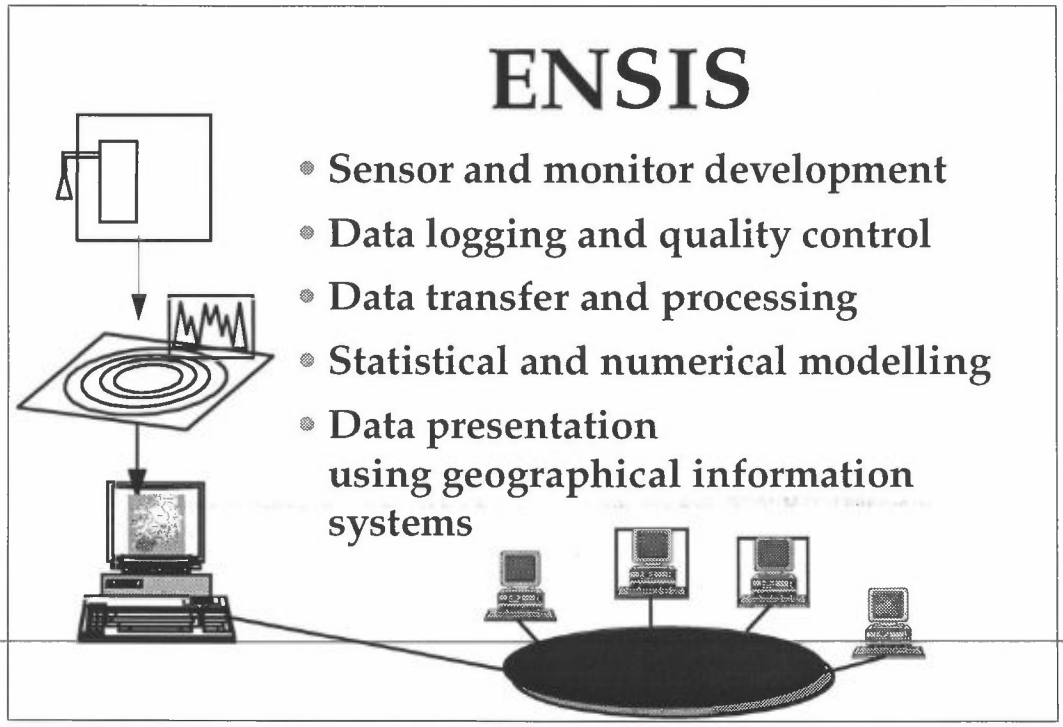


Figure 2: Several parts of the ENSIS system had to be developed and specially designed for ENSIS applications.

optical filters or tuneable diode lasers emitting light at one particular wavelength. A new instrument for measurement of airborne particles, PM_{10}, was demonstrated, and a similar instrument for NO_2 is under way.

A newly developed UV radiation and total ozone monitor was installed and used at three locations during the Olympic Games. The best available monitors for other relevant air quality indicators were selected as part of the total system. Other parameters such as noise is being established for the system. Also a special designed sensor for monitoring temperature and humidity on building material surfaces (Wetcorr) will be included.

The new generation of water quality sensors will result in new applications for process control, water management and information. ENSIS Water is an example where several modular applications were developed to meet different needs in the Olympic region. The modules may be used individually, or integrated in a total environmental surveillance and information system for air, water, noise, soil and traffic.

The ENSIS Water system aimed at developing applications in an integrated concept including the following objects:

- Hygienic control of the drinking water
- A surveillance system for early warning in case of changes in the water quality at the municipal water works
- Reduction of H_2S corrosion in the sewers
- Increased treatment efficiency, sludge reduction and cost reduction in the wastewater treatment plant
- Improved water quality in rivers influenced by acid rain
- Environmental information for watercourses and technical plants for drinking water and wastewater in a region.

A pilot system for online process control in waste water treatment plants was demonstrated. The ENSIS-ProCon is a product where advanced knowledge in waste water coagulation process is combined with chemometrics, fuzzy logic and real-time monitoring technology.

2.2 Data logging, transfer and quality control

A specially designed data logger for meteorology and air quality has been included as part of the system, The logger is robust and may serve as a local backup storage in case of line break down (lightening, storms etc.) The logger is directly linked to the modem.

Data quality control is performed at different levels in the data collection process ; in field during automatic and manual calibrations and controls, at the central data collection base, where calibration and raw data controls are performed and in the approvals of the final storage data base, where simple statistics and data graphics are used to check the validity and representativity of the data.

2.3 Statistical and numerical models

Various atmospheric transport and dispersion models have been developed and included in the ENSIS system. These models represents air pollution on all scales; traffic in street canyons and along roads, industrial emissions, pollution within the urban areas on a 500 metre grid scale and regional air pollution.

The models links the emission data established for the area through meteorological data, to the measured air quality. Traffic is the most important source for air pollutants in the Lillehammer region. To estimate air quality from hour to hour emission estimates were based upon hourly distributed traffic data, online hourly meteorological data, and measured air quality data. The latter were used to estimate secondary air pollutants.

2.4 The database

The ENSIS database is constructed for storage and presentation of environmental information and related data. The database structure meets most of the requirements specified by the main users such as LOOC and different Authorities.

The ENSIS data model includes specifications and descriptions of different objects such as:

- A code table including common fixed tables and registers,
- environmental institutions responsible for measurements and data,
- environmental data, groups of data and parameter specifications,
- references to thematically ordered information about the environment,
- editorial office for environmental newsletters,
- a user field covering all necessary entities for access control and accounting,
- sensor and monitor developers and suppliers,
- maintenance covering entities related to equipment maintenance and control, and
- measurement methods.,

The data base has been developed in a way so that modifications and additions can be easily undertaken if needed. There are also routines for safety copying and reconstruction of the data base.

The different data producers are operating in different systems, which required the establishment of different communication systems. All environmental data have been pre qualified before stored into the data base. Only during the Olympics Games almost two million data were generated for the data base.

Before transferring data to the main user, which was the LOOC INFO '94 system during the Olympic Games, data were technically controlled. Operational manuals were developed and the data were accessible on 1130 terminals located in all parts of the Olympic region.

2.5 The GIS system

For the presentation of measurement data and results from model estimates, the ENSIS system has selected a geographical information system based upon ArcInfo and Arc View. All kind of geographically linked environmental data are presented on various maps for the area. In general the ENSIS system has been developed also to serve other types of geographical information systems.

The geographical information system is directly linked to the data bases, from which statistical evaluations, graphical presentations and spatial distributions from numerical models can be presented.

3. Applications during the Winter Games, February 1994

In co-operation with local authorities environmental information centres were established in Lillehammer and in Gjøvik. Data from the ENSIS system were presented continuously both on the INFO '94 platform and on more advanced computers with GIS based graphical mapping of the various environmental data.

Three journalists were contracted to produce more than 30 articles about the environment based on the

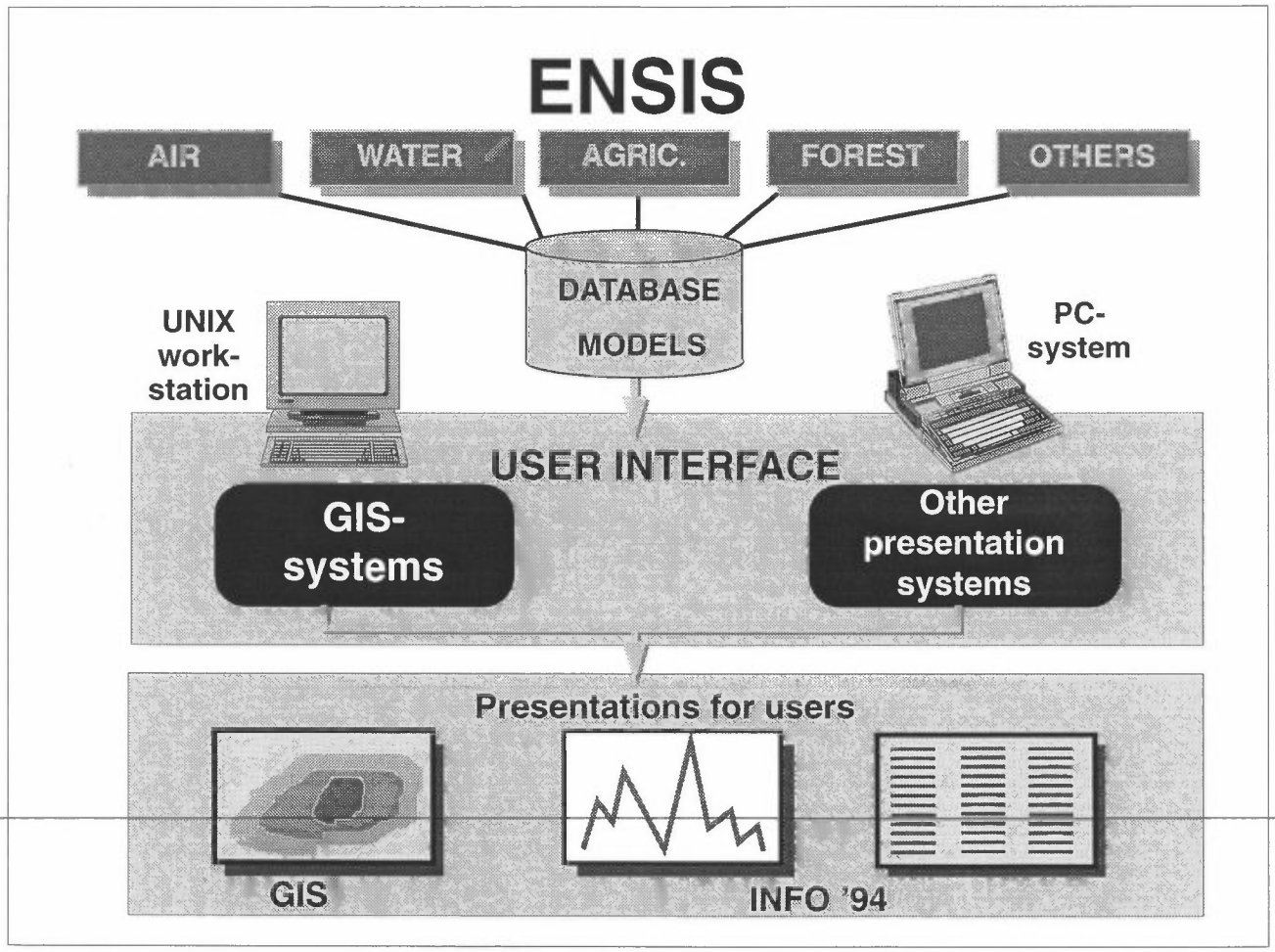


Figure 3:The environmental data were distributed through statistical and numerical models into a data base for graphical presentation to the different end users.

ENSIS programme. These articles and other general environmental background information were also fed into the INFO '94 data base.

More than 50 institutes and organizations received information about ENSIS, and more than 60 users received automatically daily environmental data on fax during the Olympics Games.

The use of INFO '94 was based upon transactions and look ups of information, lists, texts, tables and graphics. A total of 1130 terminals were operated, and between 4000 and 10000 transactions were performed in search for environmental and weather data every day. The maximum number of transactions occurred on 14 February. Two thirds of the requests were for environmental information adding to a total of 100 000 requests for environmental data during the Olympic Games.

3.1 ENSIS Air

3.1.1 Measurement programme

The measurement programme was installed in Lillehammer, Gjøvik, Hamar and Øyer during 1993. All measurements and data transmissions were tested well ahead of the Olympic period.

Wind was measured at several locations, four linked directly to the air quality programme. Temperature, stability, humidity and UV radiation was measured at three air quality stations.

The air quality indicators selected were:

NO_X, NO_2 and NO at 6 locations

SO_2 at 3 locations

Ozone, PM_{10}, CO at one location

3.1.2 Modelling

Local air pollution models for the Lillehammer area were operated during the Olympic Games. Models were established for street canyon impacts, concentrations along the road system and area concentrations estimated in a 500 by 500 m grid network.

An air pollution emission inventory was based upon collected and calculated data on oil consumption, emissions from industrial processes and road traffic. Industrial sources represented 70% of the SO_2 emissions. The road traffic accounted for 89% of the NO_X emissions. Home heating, mainly by wood combustion and small industries were the main sources for suspended particulate matter. Hourly variations of traffic patterns were included to enable the estimation of diurnal variations of air pollution impacts from traffic.

The NILU developed source oriented transport and dispersion model "EPISODE" was applied to estimate hourly concentrations of SO_2, NO_X, NO_2 and PM_{10}. The models CONTILINK and ROADAIR were used to estimate emissions along the road system and maximum concentrations along streets and roads. *(see Figure 5).*

All model results were displayed on the ArcInfo based GIS system. The system operated perfectly during the Olympic period, and updated air quality data

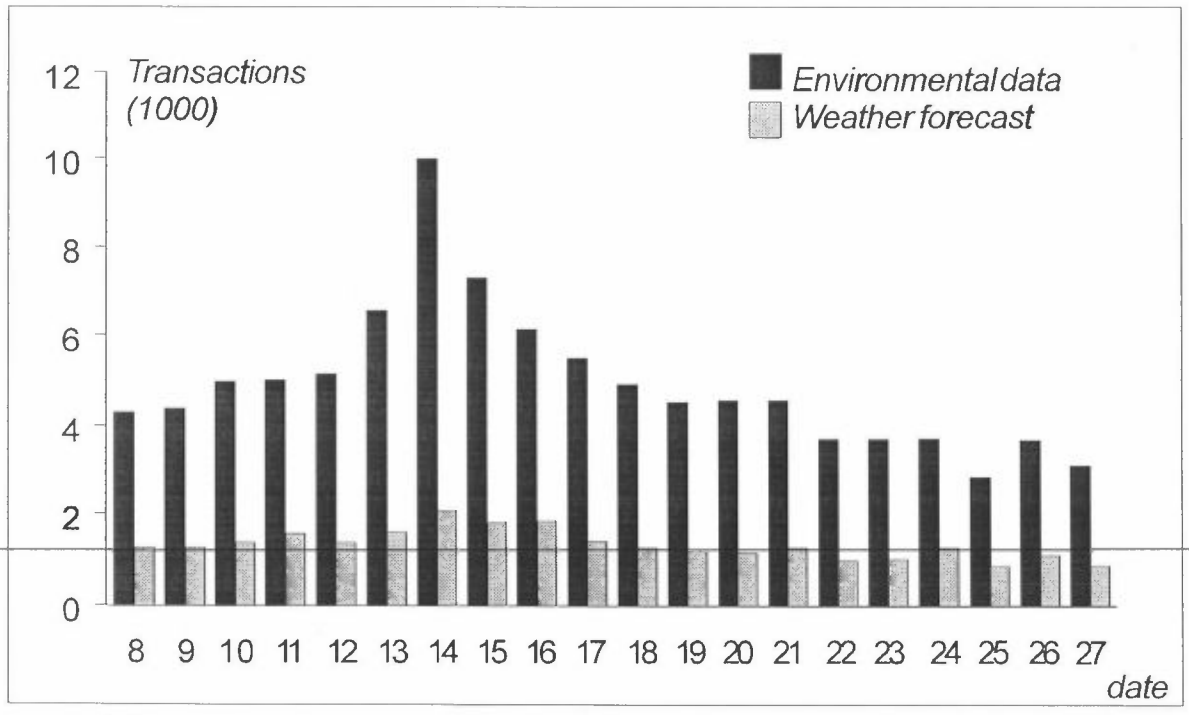


Figure 4: The daily number of transactions of environmental information during the Olympic Games.

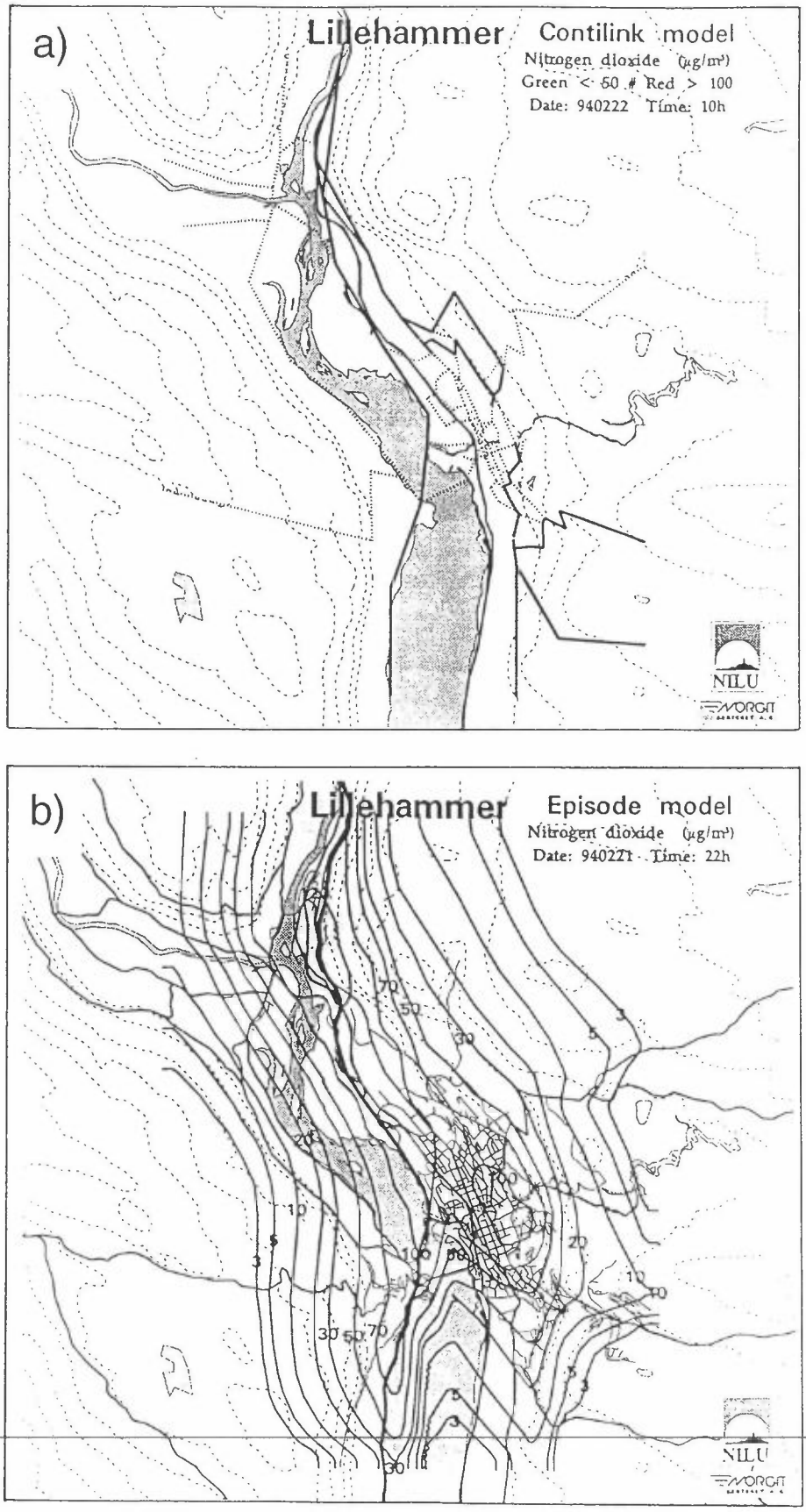


Figure 5: Model estimated concentrations of NO_2 ($\mu g/m^3$)
a) along the roads at 10:00 hrs on 22 February 1994
b) spatial distribution in a 500 m grid at 22:00 hrs on 21 February 1994

and model estimates were presented every hour during the period.

3.1.3 The air quality during the Olympic Games

Concentrations of SO_2 and CO were in general low at all stations during the Olympic Games. The highest one hour average SO_2 concentration measured was 25 µg/m³. The similar registration for CO was 5.4 mg/m³. Both values were only about one fourth of the air quality guideline value for Norway.

High concentrations of NO_2 and PM_{10} occurred at the same hour in the late evening of 14 February, during the coldest and most stable night of the Olympic Games. The NO_2 concentration was measured at 123 µg/m³ which is above the Norwegian guideline value of 100 µg/m³. The PM_{10} concentration was during the same hour 87 µg/m³. The highest NO_2 concentration measured during the Olympic period, 187 µg/m³, occurred on 15 February. The average NO_2 concentration for the whole period in the central parts of Lillehammer was about 50 µg/m³. *(see Figure 6)*

Strong diurnal variations of air pollution can be seen from the data. These variations are due to traffic density variations and changes in meteorological dispersion conditions. The strongest variations seem to be linked to strong nocturnal surface inversions during extreme cold weather conditions.

During day 2 to 5 of the Games the NO_2 concentrations were above the normal situation for the region. A press release was issued explaining that some of the reasons for the high air pollution levels were increased traffic and home heating in addition to strong inversions. People were requested to reduce car driving and to use electric heating where possible.

3.2 ENSIS Water

Automatic surveillance, controls and treatment were undertaken during the Olympic Games concerning drinking water, waste water treatment, rivers and fresh water systems in the region.

3.2.1 Drinking water

During the Olympics a newly developed method was used by the regional Public Health Agency to monitor drinking water sources. The results agreed well with the standard methods that were used.

The Olympic Games was a great challenge to the water supply services from the municipal water works at Korgen. The water works was expected to provide safe and stable water delivery secured by appropriate upgrading of the water works. This comprised first and foremost a thorough inspection of mechanical equipment as pumps, valves and pipes, replacement of inappropriate components or upgrading of these to a standard significantly reducing the risk of breakage and faulty delivery. The water works operated satisfactorily throughout the Games.

During the Games, data from one of the probes was transferred to the operation centre via a temporary connection. The municipality established a continuous monitoring with early warning on changes in the ground water quality, resulting in an improved possibility for appropriate mitigating measures earlier than previously. This gave a higher degree of preparedness and a safer system. No water quality anomalies demanding actions were observed during the period.

A software programme and a modem in a PC for telephone communication with the ENSIS database, was established for the transmitting of data to INFO '94.

3.2.2 Waste water treatment

A pilot system of ENSIS-ProCon was demonstrated in a wastewater treatment plant during the 94 Winter Olympics.

ENSIS-ProCon is a product where advanced knowledge in wastewater coagulation process is combined with chemometrics, fuzzy logic and real-time monitoring technology. The result is an efficient coagulant dosing for chemical and chemical/biological municipal wastewater treatment plants.

Any municipal wastewater treatment plant having an individual or simultaneous coagulation process can use the ENSIS-ProCon, independently of the coagulant type, type of preceding or succeeding treatment processes or physical configuration of the plant. The plant must have a coagulant dosing pump controllable with an external signal, and some on-line monitoring instruments. The efficiency of ENSIS-ProCon increases with the amount of on-line measuring instruments. Where available ENSIS-ProCon can receive effluent quality signals from the existing mainframe systems.

3.2.3 Surveillance of rivers

As an example of the results from the monitoring programme during the Winter Olympics the figure below shows the concentration of nitrate in Skeielva before, during and after the Olympic Games.

There was an increase in the average nitrate concentration during and after the Olympic games. The water quality was reduced from Class II (clear water) to Class IV (very polluted water). The water samples were taken downstream the outlet from the municipal

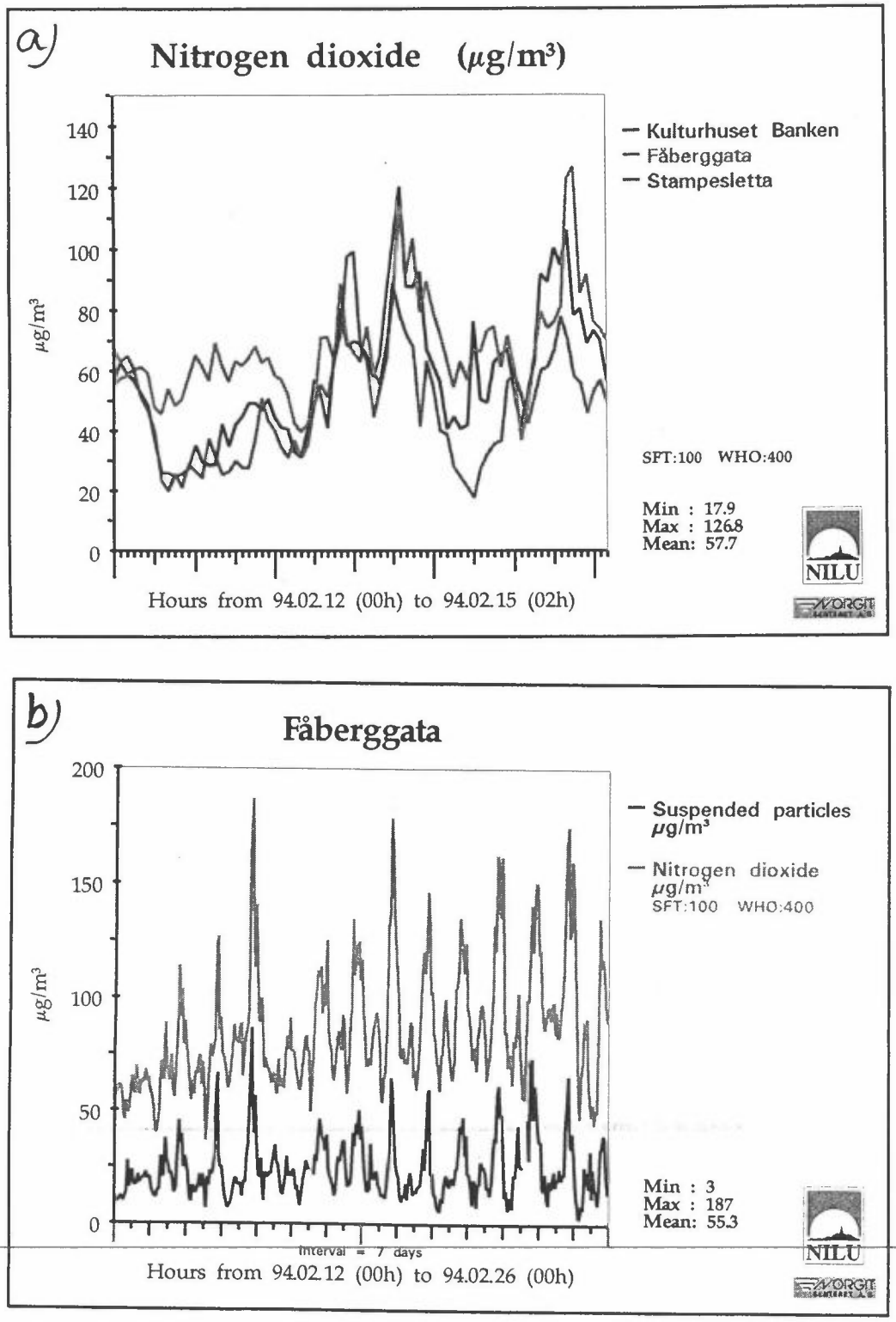


Figure 6: Air quality measurement data during the Olympic period.
a) NO_2 at three locations from 12 Feb. to 15 Feb. 1994
b) NO_2 and PM_{10} at Fåberggata, central Lillehammer from 12 Feb. to 26 Feb. 1994.

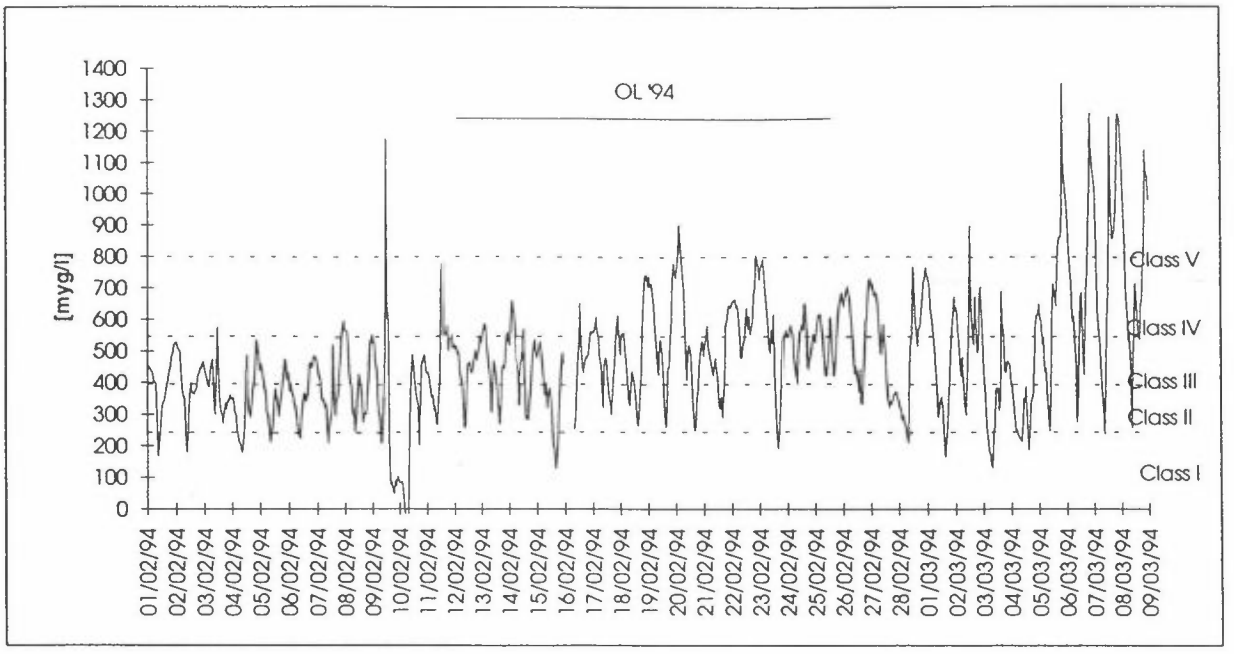


Figure 7: Nitrate concentrations in the river Skeielva from 1 February to 9 March 1994. (The water quality classes are given for total nitrogen).

wastewater treatment plant (WWTP), but after complete mixing with the outlet. The daily variation in water quality was considerable, but periodic. This is probably due the outlet from the WWTP, where these daily variations are normal. In the period under and after the Olympic games the WWTP was sometimes overloaded and the sewage was bypassed. The effects in water quality was significant, especially on the phosphate concentration. The surveillance did also indicate that there probably were other pollution sources as well in the area.

3.3 The ENSIS information centre

The ENSIS information centre in Lillehammer was established from 7 February. All equipment, the network, models, graphics and presentations were tested. An official opening of the centre took place on 9 February covered by radio and newspaper releases. On 10 February the centre was visited by officials from the international Olympic Committee (IOC) and from state and municipal authorities.

During the first week of the Olympic Games the centre received a number of official visitors, gave interviews, issued press releases and worked hard to explain the increased air pollution that occurred during the extreme cold weather conditions.

In summary the ENSIS' 94 system as applied and demonstrated during the Winter Olympic Games operated satisfactory. The data access and quality was very good presentation system. All data into LOOC's INFO '94 servers for external users worked perfectly.

Air quality, meteorological data and the necessary traffic information data were presented during the whole measurement period in the ArcInfo system within one hour after the collection of the data. A first quality control and scaling of the data was already performed at the data collection centre (NILU).

Water quality data were transferred to the presentation system every morning, and presented for each hour in the ArcInfo geographical presentation system. These data were also evaluated and treated for transfer to the INFO '94 system.

Experience drawn from the ENSIS '94 Lillehammer applications has lead to further developments and improvements. Some of the numerical models requires considerable computer capacity. The models has to be executed on work stations. The presentation tools, however, is being developed for PC users in ArcView, to improve the access to environmental information.

Other improvements include more flexible use of the ArcInfo mapping system, so that changes in input data can be performed more easily. This will represent the most important step towards the use of ENSIS as a planning tool.

4. Future applications of ENSIS

4.1 Different users, different applications

For future application of an integrated environmental surveillance and management system, ENSIS has been demonstrated during the Winter Olympic Games in Lillehammer to meet most of the requirements presented by various users and the research organizations involved in the development.

ENSIS has been developed as a user oriented continuous surveillance and information system for all types of environmental data. It includes sensors, monitors, data quality controls, transmission systems, various models, graphics, a GIS system and data displays and presentations. As a management system it can be used for planning and automatic controls. It also represents the basis for a forecast and alarm system.

The ENSIS system contain a number of different applications and tools. Based on the needs and requirements of the user, the ENSIS concept can be used to establish a tailor made application for any need of environmental information.

Some potential users can be:

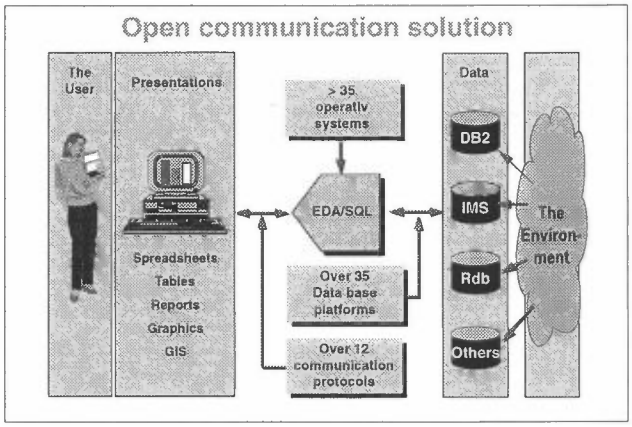
- Local traffic and urban authorities,
- various industries,
- national and international environmental agencies
- organizers of large events like future Olympics, World Fairs etc.

The system may differ in content and size dependent on the needs and requirements. The basis for all establishments will be a technological and scientific platform including the most updated technologies. The aim will always be to establish user friendly applications and presentations .

4.2 Further distribution of environmental information

Based on a national infrastructure for standardized access to electronic information (NISE), developed in Norway, the distribution of all environmental data can be made easier. Users at all levels of public and private sectors can through the NISE distribution network get access to data that will be made available for this purpose.

Through a flexible graphical user interface based on Windows 3.1. any type of data can be presented in the NISE concept. Open communication solutions realized through EDA/SQL software make the presentations independent of the supplier. More than 50 data base platforms can be served with 35 operative systems into more than 12 communication protocols. The external users can operate on different desktop applications



This future application of the ENSIS system is presently being discussed with national and regional authorities. Some of the functions and features will be:

- Common graphical user interface,
- standardized access through structured inquiry language, SQL,
- electronic catalogue services and
- security functions.

The final phase of the present ENSIS development has started by commercialization of the product. The general aspects of the programme will be further modified and developed for an international marked.

Several local authorities in Norway are considering the establishment of ENSIS type surveillance and management systems. The ENSIS concept is also used in the modifications and modernization of the national surveillance system for Norway. Countries in central and eastern Europe and in Africa are discussing the establishment of ENSIS type surveillance systems. A safe future for ENSIS will be the continuous development of updated technologies combined into a user friendly presentation and application tool. ♦

Norwegian Institute for Air Research (NILU)
P.O. Box 100
N-2007 Kjeller - Norway

REPORT SERIES	REPORT NO. OR 50/94	ISBN-82-425-0602-7	
OPPDRAGSRAPPORT			
DATE 6.9. 1994	SIGN.	NO. OF PAGES 11	PRICE 30,- NOK

TITLE

EU 833 ENSIS '94. An Environmental Surveillance System for the 1994 Winter Olympic Games.

PROJECT LEADER

Svein E. Haagenrud

NILU PROJECT NO.

O-92126

AUTHOR(S)

Bjarne Sivertsen and Svein E. Haagenrud

CLASSIFICATION *

A

CLIENT'S REF.

REPORT PREPARED FOR

Ministry of Environment/State Pollution Control Authority, Norway, The Norwegian Industrial and Regional Fund The Research Council of Norway, The Ministry of Transport and Communications/Directorate of Public Roads, Norway, Ministry of Local Government and Labour, Norway, Ministry of Agriculture, Norway

ABSTRACT

The report summarizes the Environmental Surveillance and Information System (ENSIS) developed and applied for the Winter Olymic Games 1994 in Lillehammer. The userfriendly system of sensors, data transmission, quality control, statistical and numerical methods and a graphical presentation system based on GIS, was successfully demonstrated during the Winter Games.

NORWEGIAN TITLE

KEY WORDS		
Monitoring	Surveillance	Environment

ABSTRACT (in Norwegian)

* *Classification*

A Unclassified (can be ordered from NILU)
B Restricted distribution
C Classified (not to be distributed)