VAISALA *News*

VAISALA

We make the interface
between people
and their environment.

146/1997

New wind products:
Flexible WIND20 and WIND30 displays

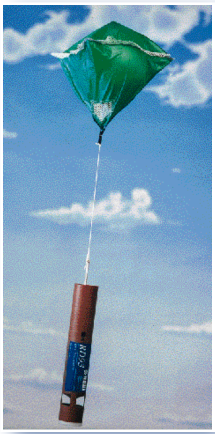
Comparison test results:
Windfinding accuracy of terrestrial Navaids

Advance storm warnings prevent weather-related damage:
Taiwan invests in extensive observation network

Water Vapor Sensing System for commercial aircraft:
Advanced technology for monitoring water vapor levels

The Danish Meteorological Institute (DMI) celebrated its 125th anniversary in 1997. Cooperation with Vaisala began in 1936. Since then, the DMI has prepared nearly 200,000 weather forecasts using Vaisala equipment.

Neste's harbors in southern Finland use Vaisala monitoring systems to help improve the safety and economy of shipping. The system includes a MILOS 500 weather station and an FD12 visibility sensor, as well as water level and conductivity sensors.



The goal of the Fronts and Atlantic Storm Tracks Experiment (FASTEX) is to improve weather observations and forecasting at sea. The newly-developed NCAR GPS Dropsonde, the Vaisala RD93, was used for the FASTEX soundings.

VAISALA News

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Contents

Vaisala in Brief

- We develop, manufacture and market products and services for environmental and similar industrial measurements.
- The purpose of these measurements is to provide the basis for better quality of life, cost savings, protection of the environment, and improved safety and performance.
- We focus on market segments where we can be world leaders, the preferred supplier. We pay high attention on customer satisfaction. Competitive advantage is enhanced by economies of scale and scope. Extensive R&D creates innovative solutions, which lead the way in the industry.

President's Column

Marking Milestones

As a radiosonde manufacturer for more than half a century, we have marked many milestones. Professor Vilho Väisälä made his first successful radiosounding 66 years ago, and this September, Vaisala produced its five millionth radiosonde. Measured in today's demand, five million radiosondes would be enough for at least six years of global soundings. This is an impressive figure and a source of great pride for us. At the moment, Vaisala's history-making radiosonde, a GPS sonde, is on my desk. Soon it will be on display in the Vaisala showroom.

During the same month that we manufactured the five millionth radiosonde, the Omega navigation network was phased out. By early October, hundreds of sounding stations throughout the world had switched to GPS-based wind finding and GPS radiosondes. In regions where coverage is available, Loran-C windfinding was also adopted. Despite some initial concern, the changeover has been very smooth.

Surface wind measurement is one of the most important weather observations. Wind has an effect on many aspects of our daily lives, and wind observations are critical, of course, for meteorological applications. Vaisala was the first to introduce wind display with circular presentation for wind data with the mean value wind measurement integrated into the electronic display. Air traffic controllers, in particular, have appreciated this easy-to-read wind instrument. Now we have developed a new-generation series of wind displays. These products cover various applications and needs, including comprehensive wind systems. Using the latest component technology, we have made the display even easier to read. This equipment is also more compact and convenient to use.

As the articles in this Vaisala News demonstrate, the applications of weather observations cover the full range, from floating launch platforms to cloud generated music. These are two extremes on the scale, with weather representing an obstacle for one and an opportunity for the other. In some cases, the conditions can pose a real threat. In others, weather observations are just 'nice to know'. It might seem that such varying demands and conditions would require many different types of measurement instruments. This is not the case. Because today's products are flexible, programmable and designed for extreme conditions, they are also versatile enough to handle these wide-ranging applications. Whatever the need, Vaisala products offer a solution. Not even the sky's the limit. Only the imagination.

Pekka Ketonen
President and CEO

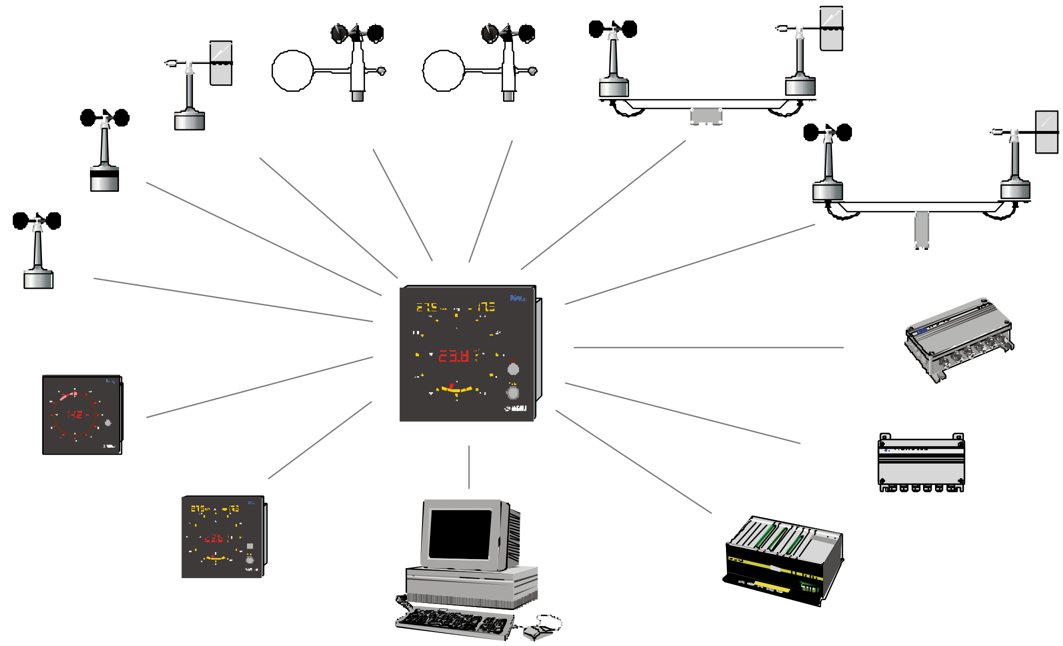


Figure 1. Various wind sensors and wind transmitters can be connected to the display. An RS485 serial line is typically used to communicate with intelligent devices, including other displays, data loggers and PCs.

Tapani Tiusanen, Ph.D. (Phys.)
Product Manager
Surface Weather Division
Vaisala Oy, Finland

WIND30 Multichannel Wind Display Covers Wide-Ranging Applications

Vaisala's WIND30 is a flexible display unit that can be tailored for a wide range of demanding applications. Easy installation and maintenance are two more advantages of this new wind display.

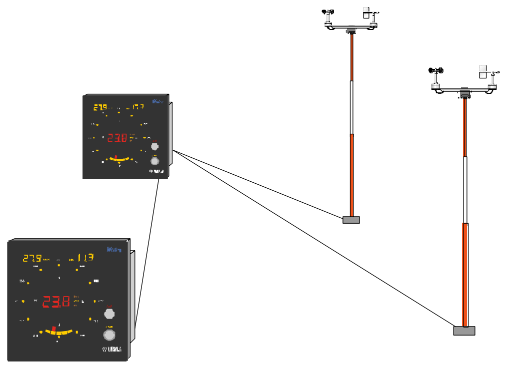
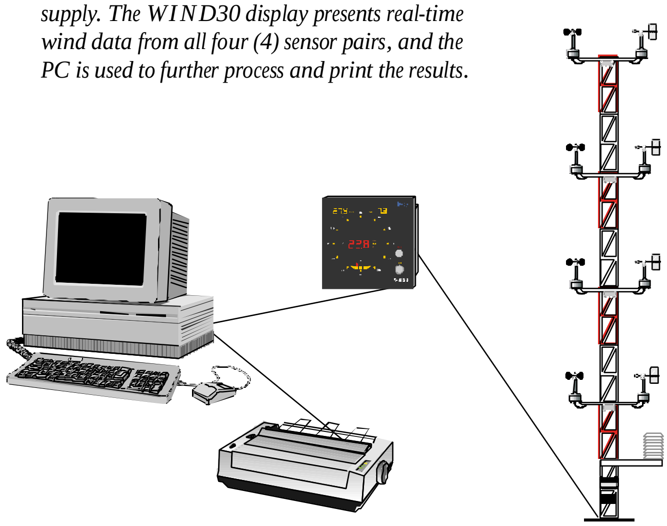


Figure 2. The averaging multichannel wind measurement system over a long distance shows an installation where two wind sites are connected to the display chain. WAT12 analog wind transmitters are used to sample the wind sensors and send current loop signals to the display.

Figure 3. Multichannel wind measurement with other basic parameters such as temperature, humidity, pressure, etc. All the different variables are connected to the QLC50 data logger, which is configured to send data via an RS485 to the office. The whole system is supplied with a local power unit such as a WHP25 outdoor mains power supply. The WIND30 display presents real-time wind data from all four (4) sensor pairs, and the PC is used to further process and print the results.



Vaisala's WIND30 Multichannel Wind Display is a more advanced version of the basic WIND20 model. The unit is designed for applications requiring wind data for everyday operations. Examples include forecasting, harbor operations and industrial applications.

Clear wind speed presentation

The display produces a numerical presentation of wind speed – plus maximum and minimum values – in a 3-digit 7-segment LED field. The wind direction and variance are presented with two separate concentric LED circles, with wind direction represented by the inner circle and variation by the outer. Primary and secondary values are differentiated with two colors; high intensity red LEDs are used for wind speed and direction, while yellow LEDs are used for speed extremes and direction variance. Automatic brightness control and a matt-finished front panel filter offer good contrast and readability in various light conditions.

Operators use a rotating switch and a 3-state push button to select between different wind measurement sites and operating modes: instantaneous, 2 minute, 10 minute averaging. The unit also supports alarm processing, manual intensity control and self testing.

Easy servicing

The WIND30 display has the same housing design and face size (144 x 144 mm) as the WIND20. The compact body can also be mounted to 115 x 133 mm panel openings. The unit comes with a stand, which can be used to mount the display on a wall or ceiling. The WIND30 has been designed for easy servicing even after the unit has been mounted on a panel. The entire display can be dissembled from behind, and the electronics and connectors, as well as the communication module and jumpers, are also accessible from the rear.

Figure 4. The WIND team from the right: Kai Inha, Tapani Tiusanen, Ari Hyväoja, Martti Karjanmaa, Anu Räisänen, Pekka Puura, Mauri Vilpponen, Matti Tammivirta, Seppo Vuohtoniemi, Vesa Nuotio, Elina Ahde and Tapani Lammi. Marja Asikainen is missing in the picture.

Figure 5. The WIND30 Multichannel Wind Display produces a numerical presentation of wind speed – plus maximum and minimum values – in a 3-digit 7-segment LED field.

Versatile equipment configurations

The display can be used with several types of sensors, transmitters and data loggers (see Figure 1).

Vaisala digital wind sensors – WAA151 and WAV151 – can be connected directly to the digital input of the display, and combined wind sensors (WMSs) can be integrated with the analog inputs. The WIND30 and its 100 Ω internal shunt resistors can even process current loop signals – from a WAT12 Analog Wind Transmitter, for example.

The serial interface is basically an RS485 serial line that supports both half and full duplex communications. It also serves as an NMEA compatible opto-isolated serial interface or an RS232 port. The fixed opto-isolated RS485 is typically used as a service line or to chain several displays. This makes it easy to display wind data at several different locations simultaneously.

An optional communication module such as the DMX501 modem allows data reception from several remote measurement sites.

Tailoring the unit for specific needs

The user interface, calculations, I/O devices and telecommunication modes are configured via a serial line using a PC terminal program. The software has a simple ASCII command interface for changing configurations either one command at a time or by downloading a complete configuration file to the display.

Selectable speed units include m/s, kt, km/h and miles/h. Wind speed is presented as an integer or decimal value. If desired, the automatic brightness control feature can be disabled.

Some data processing occurs before the wind data is presented on the display. This includes magnetic deviation correction, speed alarm settings, time out for correct data, etc. All of these settings can be independently specified for each of the four display channels. Using sensor IDs, the data can be displayed on any channel.

When sensors such as the WAA151, WAV151 or WMS301/302 are connected directly to the display, the processor optimizes the sampling and data processing. If current loop signals are used, current scales and the corresponding data scales are freely selectable. So almost any current or voltage transmitter can be used with the display.

The innovative serial interface, an RS485 that supports both half and full duplex communications, also functions as an NMEA compatible opto-isolated serial interface or as an RS232 port. Standard communication parameters such as baud rate, data bits, stop bits and parity can be specified independently for each of the logical communication ports.

For compatibility reasons, the 1.0 version of the program only supports the basic messages commonly used with Vaisala wind systems.

Averaging wind systems

The WIND30 display is a basic instrument that connects wind sensors/transmitters, processes and displays data, and finally distributes it via an RS485, modem line. The multipurpose I/O is supported by configurable software for different types of installations and data processing needs.

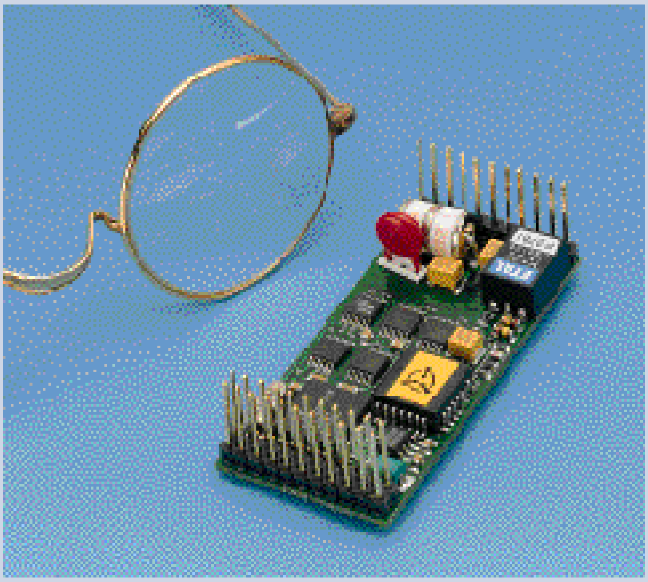
Figure 2 shows an installation where two wind sites are connected to the display chain. WAT12 analog wind transmitters are used to sample the wind sensors and send current loop signals to the display. A local power supply is required at the base of the mast if the distance between the wind mast and display is a kilometer or more, or if shaft heating is used for the sensors.

Longer distances of 10 km or more require an advanced transmitter like the WAT15 instead of a WAT12. In this case, the WIND30 must be equipped with a DMX501 modem communication module. Although the display automatically recognizes the module, some basic communication parameters can be defined to optimize the operation. A local power supply such as the WHP151 is needed for WAT15 wind transmitters. The office equipment consists of two wind displays, with the first transmitting raw wind data via the RS485 line to the second. Both of the displays carry out independent data processing and presentation. ■

DMX501 module communicates over long distances

The DMX501 communication module is a miniature modem for long-distance fixed line communications. It is designed for instruments with a Vaisala communication module slot. The DMX501 contains a USART and a modem chip that is capable of V.21/V.22/V.23/V.21bis (i.e. from 300 to 2400 bit/sec) communication modes.

This modem module is capable of operating in extreme environmental conditions while consuming very little power – a combination that is not available from any other manufacturer.



The DMX501 communication module.

Simple and effective:

WIND20 Display

The WIND20 Display is an economic solution for displaying instant short averaged values of wind speed and direction.

Behind the basic appearance of the WIND20 lies a highly advanced display unit. The flexibility and versatility of this display make it an excellent choice for applied meteorology.

Tapani Tiusanen, Ph.D.(Phys.)
Product Manager
Surface Weather Division
Vaisala Oy, Finland

Vaisala's single channel WIND20 display is an economic solution for displaying instant short averaged values of wind speed and direction. When used with Vaisala sensors, it is a reliable, easy-to-use wind system.

Flexibility plus versatility

With its many advanced features, the WIND20 display is flexible enough to meet most wind measurement and display needs. Wind speed units (m/s, km/h, kt, mph), for example, as well as alarms, magnetic deviation correction and averaging time can all be tailored using a terminal or PC connected to the display's service interface.

An I/O with 20 terminals supports both analog and digital sensors/transmitters, while a 3.5 VDC reference output provides a stable reference for analog sensors such as potentiometer-based wind direction sensors. Pulse/frequency input is typically used with digital anemometers, and a wind speed alarm triggers a 120 mA relay drive.

for Applied Meteorology

The multipurpose serial interface, which supports both RS485 or NMEA-compatible opto-isolated serial lines, can be used to link additional displays at different locations. If the display is located within a few meters of the PC, the data can be sent directly to the PC via an RS232 interface for further processing or archiving.

When used with Vaisala sensors, the WIND20 typically consumes 5 W of 10.5–15.5 VDC, so an economic wall adapter is often enough to supply the display and sensors/transmitters. A local supply is needed, however, if the site is located several kilometers from the display or if sensor heating is used. The unit complies with the EMC directive (89/336/EEC) and is supplied with a CE label.

Easy-to-read, easy-to-use

Wind speed is presented digitally in a 3-digit 7-segment LED field. The wind direction and variation are displayed on a distinct analog LED circle, and the selected speed unit is clearly indicated. The information is shown in conspicuous red and yellow LEDs.

A light sensor responds to ambient light conditions, automatically controlling the brightness of the display. The front panel filter is matt-finished, so it has good optical qualities. These features offer good contrast and make the display easy to read in various light conditions.

The user interface has been designed for ease of operation. The unit has just one push button for manual brightness control, quick check and reset functions. A separate alarm indicator is triggered when wind speed exceeds the specified limit.

Various mounting options

The face size of the WIND20 is 144 x 144 mm (138 x 138 mm body), which complies with DIN panel standards. Thanks to its special slim line body design, the unit can even be mounted to 115 x 133 mm (height x width) panel frames and openings. The stand included in the delivery can be used to attach the display to the wall, ceiling or a table.

Examples of single channel wind systems

With the versatile I/O, various types of sensors or transmitters can be connected to the display. Figures 1, 2 and 3 illustrate several possible options.

In Figure 1, for example, a WAA151 digital anemometer is connected directly to the display. Only three wires (with a shield) are needed. The frequency output from the sensor is connected to the SPEED input of the WIND20 display. The power for the sensor can also be supplied via the display's parallel supply terminals. The entire system can be operated using the same power supply; the power consumption of the sensor is negligible, however, so a small 12 VDC wall adapter is often enough to supply the entire system.

Figure 2 shows an economic solution for measuring both wind speed and direction. A combined wind sensor has been connected directly to the display. This system consumes just a few watts of power and can be supplied with a low-cost power unit.

The data can also be logged or processed with a PC, by simply connecting the display's serial line to the PC's RS232 port. The display also functions as a digital wind transmitter (analog to serial) between the sensor and the PC.

In Figure 3, WAA151 and WAV151 digital wind sensors are connected to the WAT12 analog wind transmitter, which is used to send two current loop signals to the display. The WAT 12 supports a range of current scales. To achieve the best accuracy, however, 0–20 mA or 4–20 mA scales are recommended. The display itself supports any scale, so it is a flexible current/voltage measuring device. In this example, a commercial analog recorder has been added to the system to plot instant wind data on paper. Another display is linked to the system to show wind data at a different location. The data is transferred between the display via an RS485 serial line. A WHP151 outdoor mains power supply at the base of the mast is needed for shaft heating of the sensors and for transmissions covering a distance of several kilometers. ■

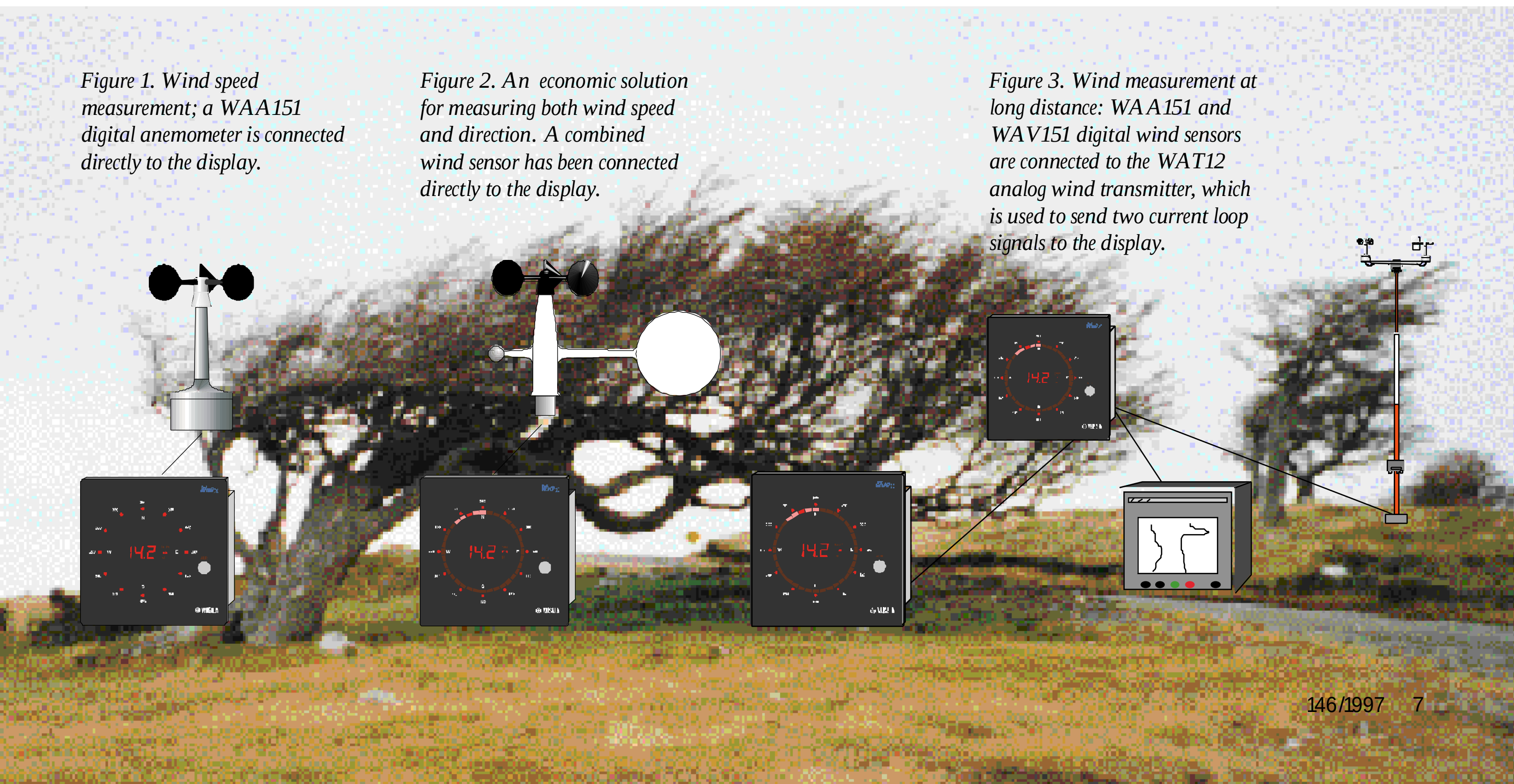


Figure 1. Wind speed measurement; a WAA151 digital anemometer is connected directly to the display.

Figure 2. An economic solution for measuring both wind speed and direction. A combined wind sensor has been connected directly to the display.

Figure 3. Wind measurement at long distance: WAA151 and WAV151 digital wind sensors are connected to the WAT12 analog wind transmitter, which is used to send two current loop signals to the display.

Wind System Upgrade at the Glosholm Coast Guard Station

Petteri Leskinen inside the Glosholm watchtower.

The Glosholm Coast Guard Station is located on Pellinki Island off the southern coast of Finland. The operating area of the station covers Finnish waters in the Gulf of Finland. To improve the station's weather monitoring capability, a new Vaisala wind measurement system was installed early last summer.

A new Vaisala wind measurement system was installed at the Glosholm Coast Guard Station's watchtower in early summer 1997.

From the left: Tapani Tiusanen and Markku Sinkkonen (both from Vaisala), Jorma Rytkölä and Mauri Markkula (both from the station) at Glosholm.

The main responsibilities of the Glosholm Coast Guard Station are to monitor sea traffic and protect Finland's territorial waters. Rescue operations and sea patrols are also part of their work.

The Glosholm station has ten employees, three or four of whom are always on duty. Coast Guard officers work one week on – 24 hours a day – and one week off. When Vaisala News visited, Mauri Markkula, Petteri Leskinen and Jorma Rytkölä were on duty. All three have long experience in the Coast Guard.

A new Vaisala wind system, including a WIND20 display, has been installed at the station. According to the officers, the system is operating well, and they have been satisfied with it. "Accurate wind values are very important for determining wave heights in stormy seas, for instance, and for carrying out rescue operations," explains Petteri Leskinen.

Accurate easy-to-use wind display

As part of the recent wind system upgrade, a Vaisala WIND20 display for applied meteorology, a WAA151 anemometer, a WAV151 wind vane and a WAC151 cross arm were installed on the station's 30-meter high watchtower. There is a duty officer in the watchtower 24 hours a day. He uses the weather radar and other instruments for weather monitoring.

The WIND20 display, the basic unit of the wind system, has flexible features to meet the station's diverse measurement needs. It is an economic and convenient solution for displaying instant wind speed and direction values. Wind speed is presented digitally in a 3-digit 7-segment LED field. Wind direction and variation are displayed with a clear analog LED circle. "The bright display is easier to read, especially at night," says Jorma Rytkölä, who also appreciates the instant readings of wind speed and direction.

Wind measurements help enhance boating safety in coastal waters and at sea. "We are still in the early stages, but so far I have been very pleased with Vaisala's new wind display," comments Mauri Markkula. ■

Vesa Nuotio, M.Sc. (Eng.)
Project Manager
Surface Weather Division
Vaisala Oy, Finland

For low-power applications:

WMS301/302 Combined Wind Sensors

The WMS301 and WMS302 are compact and durable wind sensors for applications where low power consumption is important. Combined with Vaisala WIND displays, they are a low-cost wind system that is also easy to install and maintain.

Vaisala's WMS301 and WMS302 sensors combine wind speed and wind direction sensors in one unit (Figure 2). The rotating cup anemometer on top of the unit provides isotropic and linear response to wind speed. Fast response to wind direction is provided by the vane attached to the body of the unit.

These sensors were developed to broaden Vaisala's wind sensor product range, especially for segments and applications requiring low power consumption.

Durable and rugged structure

The wind sensor core, which is made of anodized aluminum, provides a watertight enclosure for the electronics. The cup wheel and the vane are made of rigid and durable plastic. The result is a highly durable unit that is suitable for various environmental conditions.

The cup wheel shape, dimensions and materials have been carefully selected. In fact, the same cups are used in Vaisala's well proven meteorological opto-electronic anemometers. The conical cups provide linear response between wind speed and the angular velocity of the cup wheel. The PA plastic used for the cups is reinforced with carbon fiber, ensuring the rigidity of the structure even when

Figure 1. A complete low-cost wind system.

exposed to extremely high wind speeds.

The anemometer ball bearing assembly comprises a cup wheel shaft, a pair of low-friction ball bearings and a shaft fixed magnet. The reed relay and electronics in the sensor body convert the cup wheel rotation to pulses. So the sensor electronics can be connected to virtually any data logger, either by counting the number of closures within a fixed time period or by measuring the time between successive pulses. The sensing elements are located inside a watertight compartment, providing full protection for the sensor electronics against water, dust and pollutants.

The balanced wind vane is integrated underneath the cup wheel in the unit housing. The circular tail is located far enough from the body and cup wheel to avoid the turbulence caused by these structures. Made of PA plastic reinforced with fiberglass, the vane is a durable and lightweight structure offering fast response and low inertia.

The angle of the vane is detected using an axial symmetric rotating potentiometer. This potentiometer features low starting and running torque, a linear arc-to-resistance transfer ratio, and long operating life. With a constant voltage applied to the potentiometer, the output voltage is directly proportional to the azimuth angle.

Choice of one or two slide-type potentiometers

The type of potentiometer used is the only difference between the two wind sensor models. The WMS301 is equipped with a one wiper-type potentiometer with an open gap of less than 5 degrees. This type of sensors have been available for many years, so adopting the WMS301 requires minimal work from system suppliers. To overcome the gap continuity problem, the WMS302, which is typically used with Vaisala systems, has two wiper-type potentiometers. For this reason, the transmitter, data logger or other processing unit requires a more complex voltage-to-direction conversion algorithm.

Simple installation, easy maintenance

Simple installation was a high priority in the design of the WMS301 and WMS302. The sensor is supplied with a 30 mm mast-top mounting adapter, a sleeve with a screw joint at the body, and an industry standard 5-pin connector at the bottom of the unit. After attaching the adapter at the top of the mast and guiding the cable and connector through the tube, the installation of the sensor is quick and easy. In fact, it can be mounted and dismounted without any tools.

After several years of use, mechanical sensors with ball bearings typically require service. Thanks to the intelligent design of these wind sensors, bearing service is easy and troublefree. The anemometer bearings assembly can be replaced using a simple open-end wrench. Changing the vane bearings takes just a few more minutes.

WMS sensors combined with Vaisala WIND displays are a cost-effective solution for many applications, including serial output for sharing information between additional displays or PCs. The basic single channel wind system comprises a WIND display, WMS sensor, cable and power supply, as illustrated in Figure 1. ■

Figure 2. Vaisala's compact WMS301 and WMS302 wind sensors combine a wind speed and wind direction sensor in one unit.

Marit Finne
Editor-in-Chief
Vaisala News
Vaisala Oy, Finland

From the left: Klavs Allerslev Jensen, Klaus Hedegaard and Carsten Paludan-Müller at DMI's met garden.

DMI Provides All-Round Weather Observation and Forecasting Service in Denmark

Everybody talks about weather, but the professionals at the Danish Meteorological Institute (DMI) do something about it. Drawing on their extensive resources, DMI analyzes weather information and prepares accurate forecasts, contributing to the safety and economy of many activities on land and sea. Since 1936, the Institute has prepared about 200,000 weather forecasts using Vaisala equipment.

Today, the Danish Meteorological Institute (DMI) is the nerve center of the know-how and databases of the Meteorological Institute, the Aeronautical Meteorological Service for civil aviation, and the Danish Defence Weather Service. DMI is organized into four departments: Forecasting Services, Research and Development, Observation, and Data Processing. The central administration is the responsibility of the Secretariat, which along with the office of the Director-General, Mr. Lars Prahm, Dr. Sc., handles general administration.

The Meteorological Institute was founded in 1872 and celebrated its 125th anniversary in 1997. The cooperation between DMI and Vaisala began in 1936, the year that Vaisala was established.

Mr. Lars Prahm, DMI's Director-General.

Overview of DMI activities

With its staff of about 400, DMI operates under the Ministry of Transport. The Institute is responsible for the meteorological, climatological and oceanographic surveillance of Denmark, Greenland, the Faroe Islands, and the surrounding waters and air space. This represents a large geographic area, many regions of which are not easily accessible.

Based at the Narsarsuaq Airfield, DMI's Ice Observation and Warning Service, for example, makes a major contribution to the safety of shipping in Greenland's waters. The Service provides ice observation and piloting information for ships. The Aviation Weather Service, which is also part of DMI's organization, helps improve air traffic safety and economy. At the Copenhagen Airport alone, 80,000 flight crews rely on their meteorological information every year.

The Jaegersborg sounding station. From the left: Torben Rye Nielsen, Bendt Nielsen, Lars K. Andersen, and Lutz O.R. Niegsch.

Upper air stations turn 50

DMI has a comparatively large network of sounding stations for a country the size of Denmark. There are five stations in Greenland, one in the Faroe Islands, one in Denmark, and two on ASAP ships. The Institute has always worked actively with the ASAP (Automated Shipboard Aerological Programme), reflecting their belief that this cost-efficient program gives the best value for money for upper air profiles over data-sparse ocean areas. Denmark's upper air stations are currently celebrating their 50th anniversaries. The Faroes station, for instance, turned 50 in November 1996.

Mr. Klaus Hedegaard, Ph.D., Deputy Director of DMI's Observation Department, has also been Acting Director since January 1996. The Department has about 70 employees.

According to Mr. Hedegaard, his first contact with Vaisala was in 1989, when he took over responsibility for the then Aerological Department. "DMI has purchased Vaisala radiosondes since 1936, with the only interruption during the Second World War. Vaisala has also delivered a total of 11 DigiCORA and MARWIN ground equipment units for DMI sounding stations, including those in the Faroes and Greenland," he explains. The Aerological Department was established in 1936 and since then has provided high-quality upper air measurements from Danish upper air stations. In 1989, the Department was merged with the general Observation Department.

An extensive upgrade of the Institute's equipment is currently underway, including the automation of their observations. In recent years, DMI has purchased a number of surface weather observation units from Vaisala, including several FD12P present weather sensors, CT25K laser ceilometers, MILOS500 weather stations, and other measurement instruments. The use of unmanned automatic weather stations for surface weather observations is on the increase in Denmark, as lighthouses and other manned observing stations are gradually closed down or automated. DMI's new Cloud Coverage Algorithm, another recent delivery from Vaisala, provides an easy and cost-effective way to produce more information from ceilometer data. By processing this data, the cloud amount and the height of various cloud layers can be calculated.

DMI constantly evaluates the value for money of its investments. "Vaisala provides well documented, high-quality products which require only slight or no additional development at DMI before we take them into operational use. This is an important factor in our effort to maximize the return on taxpayer money, in this case by optimizing our weather observations," comments Mr. Hedegaard.

Extensive software expertise

The Observation Department has technical facilities for developing, testing and preparing observation instruments. On the software side, the department has advanced expertise in data communication and digital image processing. The latest computerized technology has been adopted at DMI.

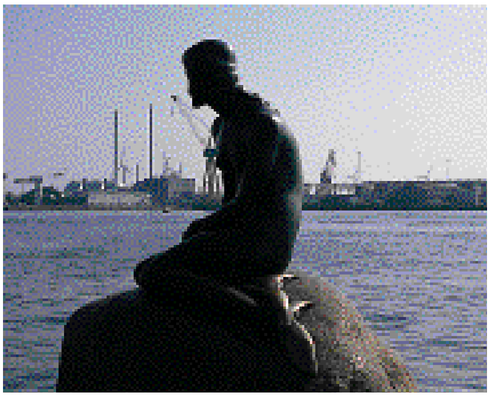
Carsten Paludan-Müller, M.Sc. (Eng.), and Software Engineer Klavs Allerslev Jensen, both from the Technical Division of the Observation Department, are software experts at DMI. Vaisala's MILOS500 weather stations have been one of their latest projects. Mr. Paludan-Müller has worked at DMI for about one and a half years. Mr. Jensen joined the Institute staff in 1976, so he has many years of experience in the field and with Vaisala products.

As Mr. Jensen notes, good quality and first-rate documentation are very important for meteorological systems. Mr. Paludan-Müller adds: "When I need technical support or advice about Vaisala's products, I just give them a call."

Jaegersborg sounding station opts for Vaisala equipment

The Observation Department is responsible for operating DMI's observation stations.

Mr. Torben Rye Nielsen, Chief of the Jaegersborg sounding station near Copenhagen, explains: "Our staff comprises



The statue of the Little Mermaid, made famous by the H.C. Andersen fairy tale, is a well-known tourist attraction in Copenhagen.

The Observation Department oversees the following operations and equipment:

- 7 radiosounding stations
- 2 ASAP ships with marine sounding stations
- a wind profiler

- 50 primary synoptic stations
- aeronautical observations at 11 airports
- 60 secondary synoptic stations
- 45 voluntary observing ships

- 450 precipitation stations
- 20 climatological stations
- 16 hydrographical stations
- 20 stations with tide gauges

- 3 ground stations with satellite reception for images and data
- 3 weather radars
- 4 stations with lightning detection
- 3 geophysical observatories in Greenland
- Greenland Ice Patrol

five permanent employees. We launch one radiosonde twice a day from Jaegersborg. On weekdays, when more than one person is working at the station, we fill the balloons with hydrogen. For safety reasons, we use helium when we have only one person on duty, during the night shift and weekends, for example."

Lars Andersen and Bendt Nielsen were on duty the day that Vaisala News visited, and Lutz O.R. Niegsch was also at the sounding station. Mr. Andersen is a Software Engineer responsible for the programming software for DMI's upper air stations. As he explained, Vaisala's products have proven to be reliable, and he has been satisfied with them. Good quality makes all the difference when instruments must function well in demanding conditions.

Lutz O.R. Niegsch, Commander and Port Meteorological Officer (PMO), is in charge of ship observations. He served in the Danish Navy before joining DMI four years ago. According to Mr. Niegsch, two MILOS500 weather stations will be installed on ships in Copenhagen in the near future.

To measure upper atmospheric conditions, Vaisala radiosondes are launched twice a day from seven DMI sounding stations. When needed, these stations can measure the radioactive profile of the atmosphere. Upper air measurements are also made at two radiosonde stations on board ASAP ships travelling between Denmark and Greenland.

In cooperation with research institutes in Europe and the United States, DMI also monitors the ozone layer and measures ultraviolet radiation in Greenland and Denmark. ■

Tinka Arctica, one of Denmark's ASAP observation ships.

Cost-Effective ASAP

The Automated Shipboard Aerological Programme (ASAP) is a cost-effective source of upper air weather data over data-sparse ocean areas. Denmark has always been actively involved in the ASAP program. Vaisala's radiosondes and ground equipment are used in the country's ASAP ships.

The cost of ASAP upper air sounding is about 15 per cent of the figure for an upper air sounding from a weather ship, and equal to or less than the cost of a land-based sounding. For this reason, the ASAP system is an economical source of baseline upper air data from the oceans and a vital part of global ocean observing systems.

The containerized ASAP system offers important advantages in today's flexible shipping environment. If there is a sudden change in shipping routes, the unit can simply be transferred to a ship that is more suitable for ASAP operations. It has become apparent, however, that the number of ships capable of carrying such a system is limited.

The countries with currently deployed ASAP systems are Denmark (2 units), France (4), Germany (5), Spain (1), Sweden/Iceland (1), the UK (1) and the USA (1).

The ASAP was instituted in its current form in the mid-1980s. It was organized by the ASAP Coordinating Committee (ACC) established by the WMO Executive Council in 1985. From 1994–1997, Klaus Hedegaard from the Danish Meteorological Institute was the chairman of ACC.

"The quality of ASAP data is generally very high, comparable with the quality of data from ocean weather ships, with average sounding heights exceeding 20,000 gpm. Vaisala's radiosondes and ground equipment have been used in Danish ASAP ships from the beginning," comments Mr. Hedegaard.

The total number of ASAP soundings has risen to about 5,000 annually. This corresponds to approximately seven ocean weather ships when based on comparable observation protocols. From this standpoint, ASAP plays a vital role in the World Weather Watch. ■

The ASAP Coordinating Committee (ACC) in Reykjavik, Iceland, in June 1996. From the left (back row): P.E. Dexter, Switzerland; J. Morenz, USA; S. Burns, Germany; and P.J. Kostamo (invited speaker from Vaisala), Finland. Middle row: H. Hjartarsson, Iceland; M. Rochas, France; A. Garcia-Mendez, UK; and F. Sigurdsson, Iceland. Front row: S.M. Norwell, UK; W.H. Keenan, USA; K. Hedegaard (chairman), Denmark.

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Radiosonde production:

Five Million and Counting

Vilho Väisälä, the founder of Vaisala, made the first successful radiosounding in 1931. On 24 September 1997 – 66 years later – Vaisala produced its 5,000,000th radiosonde. Today, Vaisala is the market leader in upper air measurements, and its radiosondes are used in more than 100 countries worldwide.

To commemorate the production of the 5,000,000th radiosonde, Professor Seppo Huovila, former President of CIMO (Commission on Instruments and Methods of Observations) released radiosonde number 5,000,001 from the Vaisala headquarters. Mr. Jan Hörhammer, from Vaisala Oy, in the right.

With the production of its 5,000,000th radiosonde, Vaisala reached a major milestone in September. This RS80-15G radiosonde, a GPS sonde, will be exhibited in the Vaisala showroom. Radiosonde number 5,000,001, also an RS80-15G, was launched from Vaisala on 24 September 1997 to commemorate the new production record.

During its 62-year history, Vaisala has been at the forefront of upper air observation technology. From the start, the company has worked in close co-operation with customers to continuously develop new measurement solutions.

Recent trends in radiosonde development

In the 1980s and 1990s, development has focused on the need to maintain continuous data availability in a changing operating environment. Tighter budgets have had an impact on upper air observations, with the pressure to reduce operating costs leading to greater automation of observations. To ensure reliable low-cost observations throughout the world, new wind finding solutions have also been developed.

In particular, the recent Omega termination prompted a major R&D effort and testing program to develop alternative wind finding methods. Before the phase-out, the Vaisala RS80 radiosonde family, which offers highly accurate results at a low cost, was a popular choice for Omega wind finding. Between 1972 and 1997, Vaisala produced some 2 million Omega radiosondes.

Building on this success, Vaisala introduced the first radiosondes for GPS wind finding in 1995. This new global wind finding solution has gained a strong foothold since then, with further growth expected in the post-Omega era.

Radiosondes offer accurate and reliable measurements at a reasonable cost. They are sure to maintain their strong position for a wide range of observation methods. This is a well-established technology, one that has been developed, tested and improved over a long period of time.

Proven quality and accuracy

Today's RS80 radiosondes are used for synoptic observations at weather stations throughout the world, and for defense and research applications. The RS80 combines high accuracy and reliability in a cost-effective instrument that has performed well in international comparisons. The RS80 product family includes a range of wind finding options (including GPS), as well as radioactivity and ozonesondes and wind-only models. The transmission frequencies are in the 400.15–406 MHz or 1668–1700 MHz Meteorological Aid Band. Both crystal-controlled and tunable free-oscillating transmitters are available.

Compact, lightweight and easy to use, the RS80 radiosonde can be launched by just one operator, which minimizes sounding costs. The RS80 is also AUTOSONDE-compatible, allowing full automation of upper air stations. ■

Mr. Keijo Mesiäinen ready to launch an RS21 radiosonde in 1973.

AWS Network for the Moscow Circle Road

Vaisala has signed a contract to supply automatic weather stations (AWS) for the Moscow Circle Road that surrounds the city of Moscow. The road covers a distance of more than 100 km.

Once the third part of the project is implemented by late 1997, the Moscow Circle Road system will include seven Vaisala road weather measuring points. Information for ice warning is transmitted to a central station equipped with IceCast software, and the data is also displayed on several workstations in the system. All measuring points have a present weather detector.

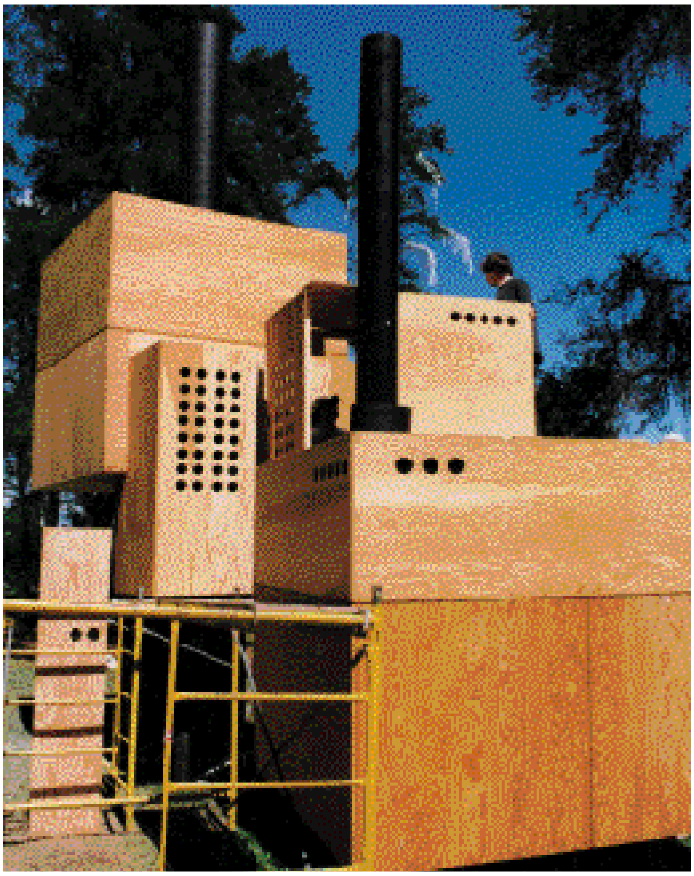
One measuring point was installed in June, during the first phase of the project. The second phase started in September and included the installation of three measuring points.

Konstantin Radetski (right) from the Moscow Hydrometeorological and Environmental Monitoring Center and Leena Puhakka from Vaisala on a visit to a road weather station site in Finland last April.

Nicolas Reeves, Architect
Director, NXI GESTATIO
Design Lab
Department of Design
University of Quebec
Montreal, Canada

Keplerian Harp: Listening

As part of a unique project in Quebec, Canada, the Vaisala CT12K ceilometer has made its musical debut. The Keplerian Harp, played for the first time at the Third Symposium for the Visual Arts, converts cloud height and density information into complex orchestrations. With its mix of art, science and technology, this celestial music has a wide appeal. In the following, Nicolas Reeves reports on the development of this new musical instrument.



The Keplerian Harp from the back during the completion phase. The laser beam is transmitted through the upper pipe.

The Third Symposium for the Visual Arts began on 6 July 1997 in Amos, Quebec. For the Nxi Gestatio Design Lab from the University of Quebec, this marked the culmination of a unique project and the introduction of our Keplerian Harp, a mammoth musical instrument that 'plays' the songs of clouds in real time.

The operating principle of the harp can be compared with a huge reverse CD player. With CD technology, a lens captures tiny laser beam modulations, while a decoding system converts them into music or sound. With the harp, a laser beam is projected skywards, and a telescope captures the laser modulations produced by the cloud cover. A MIDI musical interface replaces the decoding system.

The harp is meant to play night and day, with the orchestration varying according to the time of day, the weather, and the climatic conditions. The unit consists of four caissons that house and protect all the equipment. Its morphology is also derived from the structure of a cloud.

to Cloud Songs

The complete Keplerian Harp team (from the left): Mario Trudel, Catherine Lambert, Celine Bietlot, Nicolas Reeves, Chryso Bashonga, Bilal Jamous and Sebastien Duceppe.

Last-minute search for a ceilometer

The hardest part of the project was to find an appropriate laser/telescope combination. To avoid the need for fine-tuned adjustments and alignment, we decided on an integrated system. A Canadian research center promised the loan of a powerful lidar, and the harp was designed accordingly. Unfortunately, the lidar became unavailable just a few weeks before the Symposium.

At this point, we started making urgent telephone calls to lidar manufacturers and research centers – any place that could spare a lidar or ceilometer for a few weeks. Although intrigued by our project, no one was able to provide a lidar at such short notice. We spent a full week on the phone and Internet. Finally, we found a solution to our problem – in the form of an e-mail message from Mr. Selwyn Alpert at Vaisala's office in Woburn, Massachusetts (USA).

Speaking for everyone at the lab, I cannot overemphasize the kindness and helpful attitude of Mr. Alpert, who understood our desperate situation and obtained a CT12K ceilometer for us within just a few days.

Perfect solution for the harp

We knew the CT12K because our neighbour, McGill University in Montreal, has one installed on their roof. We were impressed with the ruggedness of this instrument, which can operate year-round in Quebec's extreme weather conditions.

Unlike other turnkey systems, the CT12K is not blinded by certain atmospheric conditions such as heavy rain or hail. This was another key factor, since everyone was curious to hear the music generated by a massive thunderstorm or even a heavy blizzard.

Two other features of the system were also important. Standard connections allow easy configuration, and the infrared beam – a low power, pulsed laser – is much safer to use than a regular beam. In addition, the output serial port provides ASCII messages, so there is no need for an expensive data acquisition card, and we did not have to write a new driver.

Once the lidar was installed, we plunged into the operation manual, made all the connections – and the data began flowing into the computer.

Converting clouds to music

We knew then that the harp would be ready on schedule, but there was still a lot of work to be done. The cloud-to-music interfacing software was the core of

Nicolas Reeves talks with Montreal composer Helmut Lipsky.

our instrument, and since the CT12K was different from the system we originally planned to use, we had to re-write parts of our software.

The main difference was the frequency of data transmission. The CT12K delivers a message every thirty seconds, with each message providing a maximum of five or six 'music-usable' numbers. To produce the simplest kind of music, we needed about eight thousand numbers per minute. Every note requires about twenty parameters, and we wanted to be able to play up to eight notes per second.

To solve the problem, we had to reconstitute the cloud variations between the messages. We developed a simple fractal equation that allowed us to produce the required amount of data after a few minutes of scanning. Later we learned that our art-inspired method has already been used by several scientists – and that more complex equations had not proved better or more physically realistic.

A selection of 228 instruments

The final software was designed with a user-friendly interface allowing users to toggle between two different displays. The cloud screen shows the lidar information, while the music screen displays music-related data, with the sixteen windows corresponding to one channel each.

With this advanced software, the orchestrations can be freely saved and loaded. Five categories of cloud conditions have been assigned: clear sky, one or two cloud layers, partial cloud cover, complete cloud cover. When the cloud cover changes, the orchestration changes automatically.

Each of the sixteen channels can play one of 228 instruments. Many of these instruments are already polyphonic, so at times the harp sounds like a complete orchestra. The atmosphere can be divided in numerous altitude ranges, with each one corresponding to an instrumental section and mapped to a certain frequency interval. An altitude of 0 to 600 feet can be reserved for the percussion, for example; 400 to 1000 feet, for the brass; 1000 to 1100 feet, for the timpani; 1000 to 2000, for the violins and cellos; and so on, up to maximum altitude range of 12,500 feet. In this way, the atmosphere becomes a huge musical score.

The MIDI interface divides the range of frequencies into 128 notes, from 0 to 127, separated by half-tone intervals. Noting this, we decided to associate an altitude of 12,600 feet with a totally obscured sky, and an altitude of 12,700 feet with clear conditions or with any cloud cover out of the lidar range. On this basis, we were able to define the fundamental harp setting, with each 100-foot range mapped to one half-tone. Thus, any person with a trained ear can 'hear' the height of the cloud.

Orchestrations for various cloudscapes

When we first started playing with the system, we set almost all the music parameters – volume, duration, tempo, length of the notes, etc. – to fixed values. Only the note to be played was defined by the cloud. After we learned to recognize the sequences produced by different kinds of clouds, we let the cloud control more and more of the parameters.

We spent hours experimenting with different orchestrations, trying to find arrangements particularly suited to different 'cloudscapes'. Needless to say, the experience was fascinating. At one point, we had defined a very primal and minimalist arrangement, simulating three wind flutes playing in the bass, baritone and tenor registers. A heavy thunderstorm came up, with lightning striking all around us, and almost continuous thunder. Surrounded by great pines, with low-tone rumbling flutes, under cascades of water and a natural light show, this was a unique and awe-inspiring experience.

The debut performance for the general public triggered a mix of responses, from incredulity on the one hand to fascination on the other. Some people just could not believe that such an instrument was possible: they looked for a hidden tape recorder in the unit. The great majority of people, however, appreciated this encounter between art, science and technology, and the poetic background underlying the project.

Wide-ranging plans for the future

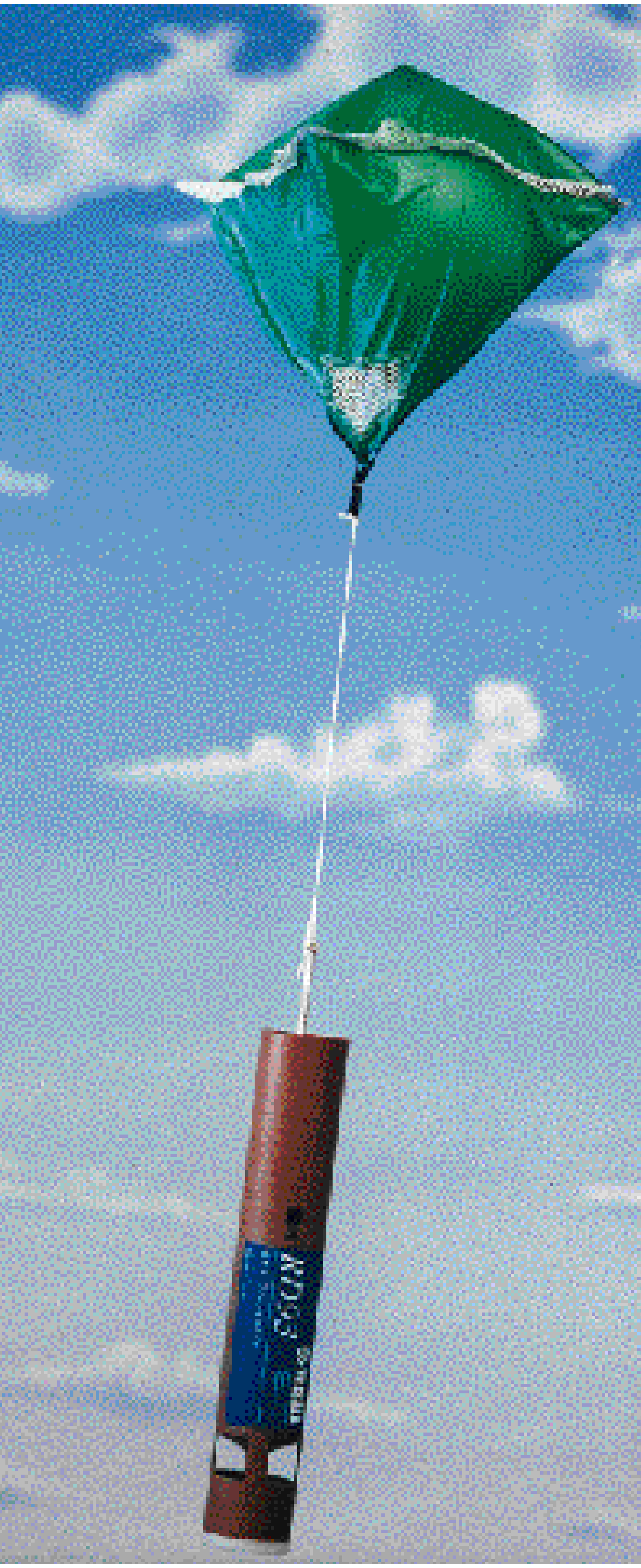
We have many plans for the future. By installing a visible laser beam near the lidar, we would like to show the audience where the laser enters and 'plays' the cloud. We also plan to sample noises from the environment, allowing the harp to play sequences that incorporate voices from the audience. Our final plan is to install a complete Keplerian Harp at a fixed location. This harp will feature seven long-range vertical YAG laser beams at 20–50 meter intervals. The impact of these seven green beams is sure to be impressive.

All of these plans will require lidar equipment, the availability of which is uncertain. From the beginning, we knew that implementing the harp project would require partners with uncommon curiosity and an open mind.

Although we are not sure which equipment we will use in the future, we would like to continue with Vaisala instruments. Their compact size, sturdiness, ease of use, flexibility and overall features, as well as the kindness of the Vaisala people in Woburn, allowed us to complete our project on time – to the great satisfaction of our audience and our design team. ■

The NXI GESTATIO Design Lab is housed in the Pavilion of Design of the University of Quebec in Montreal. Directed by architect Nicholas Reeves, the lab is dedicated to exploring the potential of computer information in the fields of arts (visual arts, media arts, literature, music), architecture and design. Artists, students and recent graduates from many countries have worked in the lab, for periods varying from two weeks to one year.

The Keplerian Harp project was conceived, designed and managed by Nicolas Reeves. The implementation team comprised Celine Bietlot, architect and engineer, from Belgium; Chryso Bashonga, sculptor and designer, from Zaïre; Bilal Jamous, programmer, from Lebanon; and Catherine Lambert, Mario Trudel and Sebastien Duceppe, design students, from Canada.



The newly-developed NCAR GPS Dropsonde, the Vaisala RD93, was used for the FASTEX soundings.

Fronts and Atlantic Storm Tracks Experiment

RD93 Flies with FASTEX

Even today, weather observations at sea are far from the quality and regularity of land observations. To improve this situation and the reliability of short-term forecasting, the Fronts and Atlantic Storm Tracks Experiment was established. As part of the experiment, dropsonde soundings were made over ordinarily unobserved regions in the North Atlantic. The newly-developed NCAR GPS Dropsonde, the Vaisala RD93, was used for these soundings.

Forecasting the development of oceanic storms continues to be a challenge, largely because there are fewer weather observations at sea than over land. During the winter of 1996–1997, the Fronts and Atlantic Storm Tracks Experiment (FASTEX), a major international field program involving scientists from eleven countries, NCAR and NOAA (National Oceanic Atmospheric Administration), studied the fierce winter storms that move eastward across the Atlantic Ocean from Newfoundland to Ireland and western Europe.

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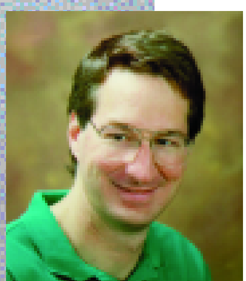

Terry Hock, El. Eng.
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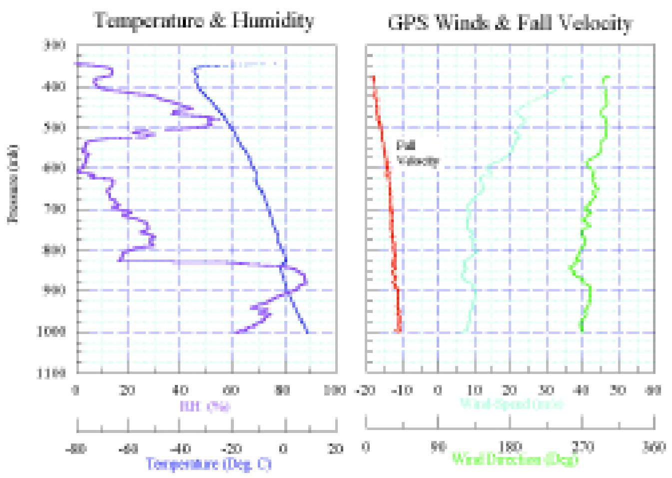


Raw unfiltered FASTEX PTU and wind data from the RD93. The data is very clean, thanks to the digital RF telemetry link with CRC error checking. FASTEX GPS Dropsonde data, Lear 36, Drop No. 5, 11 January 1997.

Dropsonde soundings over the North Atlantic

The principal scientists involved in FASTEX planned an 'adaptive observation' strategy of dropsonde soundings over the North Atlantic. During the project, more than 750 RD93 GPS Dropsondes were deployed from NOAA's new Gulfstream IV and an NCAR-leased Lear 36 aircraft. In addition to the dropsondes, several other instruments were used. These included radiosondes and wind profilers on research ships and doppler radar on other aircraft (NCAR Electra and NOAA P-3).

The FASTEX project began on 6 January 1997 and ran through February 1997. During this time, the G-IV, based in Shannon, Ireland, performed ten objective targeting missions and seven other missions over the North Atlantic, dropping a total of 550 RD93 GPS Dropsondes. The Lear 36, based in St. John, Newfoundland, carried out 13 missions in the North Atlantic, dropping 214 RD93 GPS Dropsondes. Both aircraft were equipped with NCAR-developed four-channel aircraft data systems.

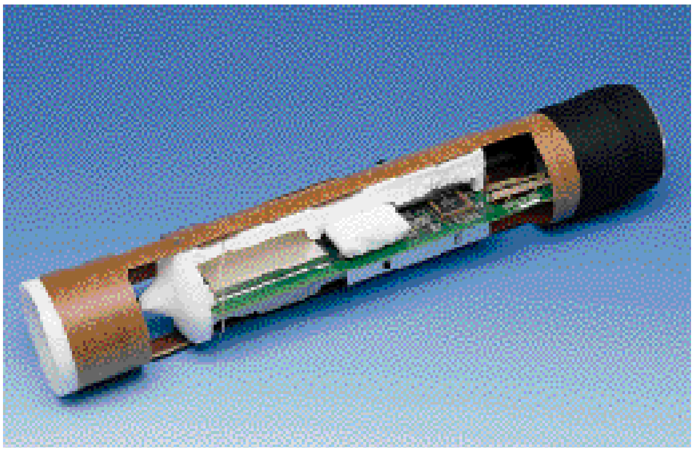
Once the aircraft were in the targeted area, the dropsondes were generally deployed at 10-minute intervals at altitudes ranging from 26,000 ft. to 40,000 ft (7,925–12,192 m). The Lear 36 typically released 17 dropsondes, while the G-IV released 30. In a few cases, up to 50 dropsondes were deployed during a single mission. With the four-channel aircraft data system, four dropsondes can be in the air simultaneously, and this proved to be a valuable asset during FASTEX.

First results very promising

The dropsondes were deployed under varying atmospheric conditions. This provided an extensive data set for preliminary evaluation of the overall performance of the dropsondes. The pressure performance was outstanding, as calculated using the hydrostatic equation and integrating the pressure data from the surface to the aircraft. This was then compared with the geopotential altitude of the aircraft. The temperature accuracy was difficult to evaluate; however, 34 soundings had obvious melting levels, which offered a natural single point calibration opportunity. The majority of the dropsondes were within ±0.2 °C and the rest within ±0.5 °C. The humidity data from FASTEX is currently being evaluated for overall accuracy.

The GPS winds provided exceptional detail on the wind fields. Since independent wind measurements were made every 0.5 seconds, the vertical resolution was outstanding. The winds in the boundary layer to the surface were easily observed with the GPS Dropsonde. The GPS navigation system has significantly improved the capability of dropsonde wind performance. Even though dropsondes have been used as meteorological instruments for almost 30 years, the new NCAR-developed GPS Dropsonde takes this measurement capability to a new – and unprecedented – level.

Using the RD93 GPS Dropsondes, the findings of FASTEX will lead to better forecasts for the western coasts of both Europe and North America, as well as a better understanding of how oceanic winter storms affect world climate. ■



Cutaway view of a GPS Dropsonde.

Figure 1a.

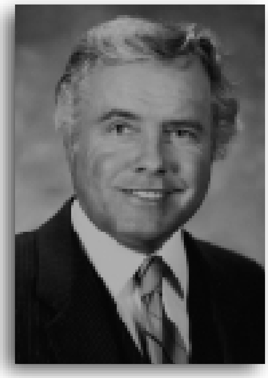
A close-up of the Water Vapor Sensing System (WVSS) probe. The probe extends three inches into the atmosphere and five inches beneath the surface of the fuselage.

Figure 1b.

The probe is located on the left side of the aircraft tailward of the cockpit door (in the area of the black stripe). Photos courtesy of Lockheed-Martin, BF Goodrich Rosemount Aerospace, and United Parcel Service.

Real-Time Water Vapor Measurements

Water vapor information is essential in aviation and atmospheric science, and the data provided by the current 12-hourly radiosonde network is inadequate. In response, the FAA initiated a project to specify a Water Vapor Sensing System (WVSS) that could be used to measure real-time water vapor content from commercial aircraft. The system ensuing from this project uses Vaisala's HMM30D module, and the first WVSS unit has been working on a Boeing 757 for five months now without failure.



Rex J. Fleming, Ph.D.
Director
Climate Observations, NOAA/OGP
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With the introduction of the WVSS, a new tool has been added to the observing systems for weather prediction and other atmospheric science applications. This system, which is now operational on a Boeing 757 aircraft, complements the author's early work in 1979 on obtaining winds and temperatures in real-time in the U.S. as part of the Global Weather Experiment. The following article briefly outlines the events leading to the current water vapor project, the status of the project and its expected future direction.

Federal project targets water vapor information

The U.S. Federal Aviation Administration (FAA) funded the Commercial Aviation Sensing Humidity (CASH) program in 1991. The original purpose was to establish the feasibility of obtaining water vapor information from commercial aircraft and to develop formats for providing such data in real-time to researchers involved in the FAA's Aviation Weather Program.

A history of the use of commercial aircraft as platforms for environmental measurement is provided by Fleming (1996). Portions of that paper also provide more details about the CASH program and real-time aircraft communications.

A lack of knowledge about water vapor has become a major impediment in the mainstream of socio-economic applications of atmospheric science. One of these areas involves mesoscale weather and aviation.

Mesoscale weather systems affect aviation efficiency, capacity and safety. Profiles of winds, temperature, and water vapor are needed far more frequently than the current 12-hourly radiosonde network can provide. Thus, the original intent of the CASH program was to help contribute to this water vapor measurement challenge.

Defining the sensing system

The accuracy of water vapor measurements on commercial aircraft was an important factor, but only one of many to be considered in the test program. Since the purpose was to generate specifications for the procurement of a Water Vapor Sensing System (WVSS), only a few of the thirteen or so identified measurement concepts were actually feasible for real-time commercial aircraft applications.

The sensor system had to be lightweight, compact, rugged, sensitive and shielded from contaminants. It also had to provide reliable performance at a wide range of temperatures, pressures, Mach numbers and water vapor conditions. The criteria for the WVSS included easy installation on existing aircraft and accurate performance over at least a three-month unattended period. Any maintenance required at that point in time had to be completed in less than one hour.

In addition, the response time of the WVSS had to be short enough to accurately resolve the vertical structure of the water vapor in the lower troposphere at typical aircraft ascent/descent rates. The vertical structure of water vapor in the lower atmosphere is especially important to aviation – as well as to the full spectrum of other atmospheric applications: weather prediction, hydrology, chemistry, pollution and global climate change.

The test program was fairly complete and included tests in a laboratory chamber, in a wet wind tunnel, and on a well-instrumented research aircraft. The complete test results (Hills and Fleming 1994), including the potential problem areas revealed during the tests, were distributed to all potential bidders for the WVSS procurement phase. Based on scientific requirements for the ascent/descent region, operational constraints, and the FAA test results, specifications were prepared and a competitive government procurement was conducted. Three excellent proposals were received which addressed the limitations identified in the test results. The winning contractor was Lockheed Martin Corporation (LMC). The main characteristics of the WVSS are identified below.

The winning solution

Every commercial aircraft has a temperature probe for measuring the total air temperature outside the boundary layer next to the aircraft skin. The dynamic heating effect of the moving aircraft is taken into account to calculate the ambient air temperature from the total air temperature measurement. The WVSS probe is more advanced than conventional probes and has better aerodynamic properties. Both probes extend about 3 inches (see Figure 1a) from the aircraft skin. A 'can' beneath the aircraft skin houses the conditioning electronics. This can is about the same size as the container used for the angle of attack probe (3.2" in diameter and 5" deep).

The air carriers wanted assurance that the new probe would have no impact on their normal operations. The key features for them are the WVSS maintenance interval of three to six months, sensor replacement in twelve minutes, and the complete system weight, including cables, of about 10 pounds. The original specification for sensor replacement was sixty minutes or less and a weight of 15 pounds. The maintenance interval could be anything greater than three months as long as it coincided with normal scheduled maintenance check periods.

For users, the key features of the WVSS data are response time and accuracy. The response time of the sensor – a Vaisala thin-film capacitor – is 2–3 seconds in the lowest 20,000 ft. of the atmosphere. Since ascent and descent were the key areas of interest for the FAA, the accuracy specification was also over this lower 20,000 ft. The expected accuracy of the WVSS in this range is 3–5 per cent.

Formats and the initial data

Of the over 40,000 wind and temperature Aircraft Communication Addressing and Reporting System (ACARS) reports received every day in the United States, 95 per cent are at flight level. Since virtually all aviation weather activity is related to mesoscale phenomena – even flight level winds on the synoptic scale are often disturbed by mesoscale outflow from convection – obtaining mesoscale profiles of winds, temperatures, and water vapor was a highly desirable part of the FAA's Aviation Weather Program. Severe operational constraints had to be addressed in the design of the new ascent/descent formats. These design goals are listed below in priority order:

(1) Maximum vertical measurement resolution

(2) Minimum communications cost

(3) Minimum communications traffic at busy air terminals

(4) Greater horizontal measurement resolution at flight levels

(5) Further optimization for other operational requirements.

The new 'ascent' format, which is sent as a single message, represents a compromise between (1), (2) and (3) above. A report using the standard or default value of every six seconds provides data every 300 feet or 100 meters for typical climb-out rates. The permissible report interval is every 3–20 seconds.

Today, the typical carrier provides the ACARS winds and temperature information by sending a single report every 6–7 minutes. The new 'en route' format has a standard sampling rate of every three minutes (permissible range 1–60 minutes). Data is concatenated into six consecutive reports and sent as a single message as a compromise solution to (2) and (4) above. At typical aircraft speeds, the three-minute sampling interval represents about 40 km horizontal resolution.

The 'descent' format takes into account factors (2), (3) and (5) above. The standard data sampling rate for 'descent' is every 60 seconds with 10 reports concatenated and sent as a single message every 10 minutes. This sampling rate is allowed to vary by 20–300 seconds within the format. The rate itself can be changed to match the terminal situation by an ACARS message.

These new formats are now accepted by the Airline Electrical Engineering Committee (AEEC). They are included as part of the ARINC 620 specification, and are now being used routinely by United Parcel Service (UPS).

First WVSS unit in use

LMC has obtained FAA certification for the WVSS on Boeing 757 aircraft, and the first unit has been working for over five months without a failure. Figure 2 shows a sounding taken from a real display of the data on the Internet.

The water vapor information is obtained by a Vaisala model HMM30D, the basic element of which is a relative humidity sensor. Even though humidity is measured, it has been shown (Fleming 1996) that greater accuracy can be achieved by downlinking the atmospheric water vapor mixing ratio on a dynamically moving aircraft.

Although the data is still under evaluation, an excellent dynamic range of mixing ratio information has been achieved, the data comparison between ascent and descent from the same air terminal has been consistent, and comparisons against radiosondes, when possible, have been quite good with consistent vertical changes in degrees of wetness.

Six production units have been produced as part of the contract. These six WVSS units

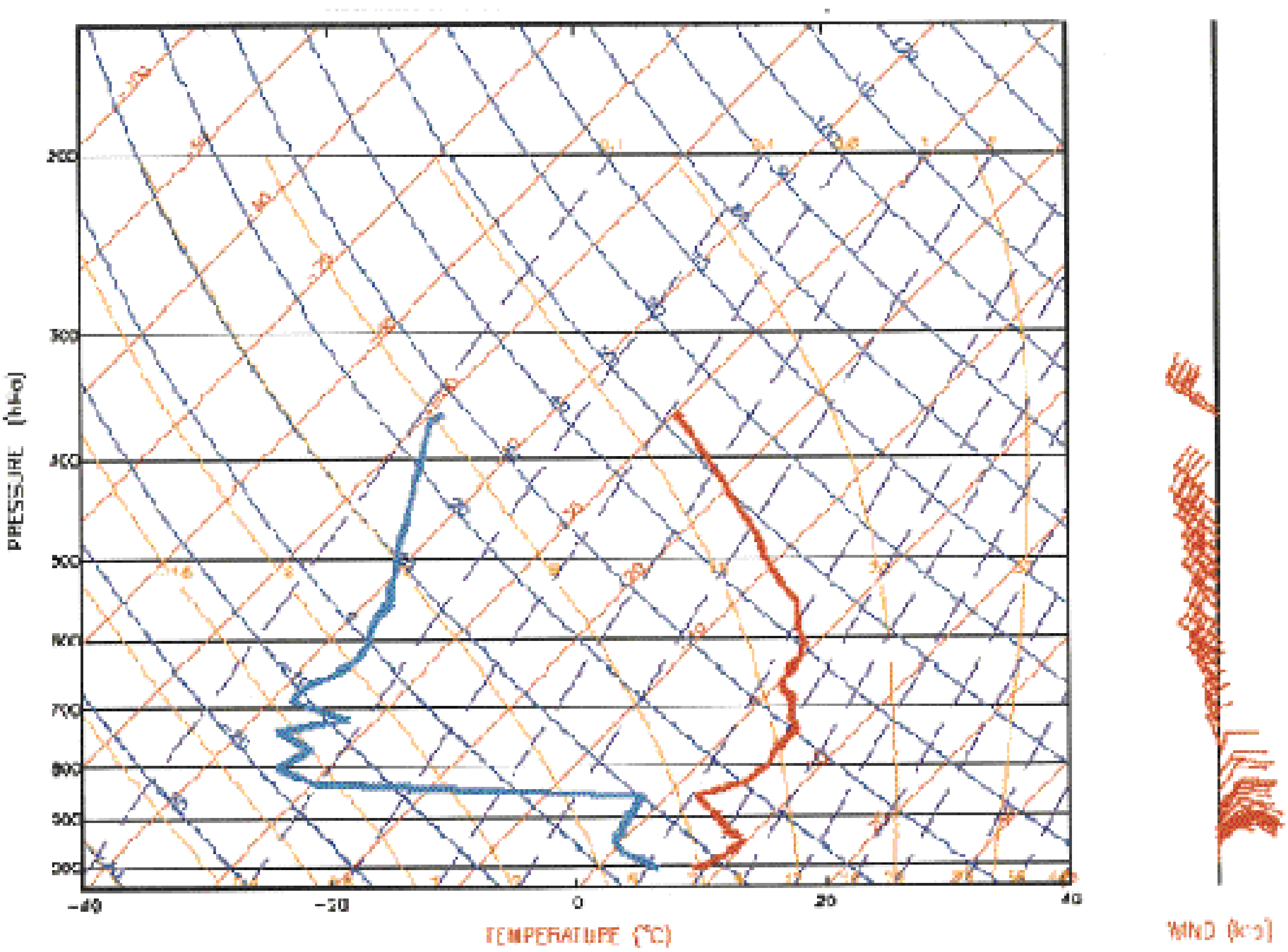

Figure 2. Ascent sounding, 1 km from Louisville, Kentucky, starting on 22 May 1997 at 8:31 UTC, lasting 14 minutes and covering 145 km.

are installed on United Parcel Service Boeing 757 aircraft (see Figure 1b). The aircraft operate out of Louisville, Kentucky, and fly to destinations throughout the United States.

Looking to the future

The National Oceanic and Atmospheric Administration (NOAA) has contracted for an additional 60 WVSS units, which will be installed beginning in February 1998. A further option for 100 more units will be exercised later in 1998. These units will be added to the UPS fleet and primarily to other U.S. air carriers.

Once a sufficient number of WVSS-equipped aircraft are flying, a data analysis of the forecast impacts and an official 2-year Demonstration Program for the FAA can begin. This program will determine the impact of ascent/descent profiles of winds, temperatures, and water vapor on aviation weather products and industry operations.

The Integrated Terminal Weather System (ITWS), to be deployed in the near future (cf. Evans and Ducot, 1995), will be a key application of the data. The WVSS information will make a significant contribution to the radars and automated surface systems in the air terminal environment – thus helping to reduce the frequency and severity of flight delays and improve the safety of air travel.

The NOAA Office of Global Programs is also funding the WVSS procurement. Data from the WVSS fleet, which will support more accurate water vapor flux information, will be used by scientists involved in the Global Energy and Water Experiment (GEWEX) Continental-scale International Project (GCIP). Data is being provided directly to this project, and the full WVSS fleet will fly at least until September 2000, covering the last three years of GCIP. Water and energy budget studies (with and without the WVSS information) will be conducted. The data will be available through the GCIP data management system. ■

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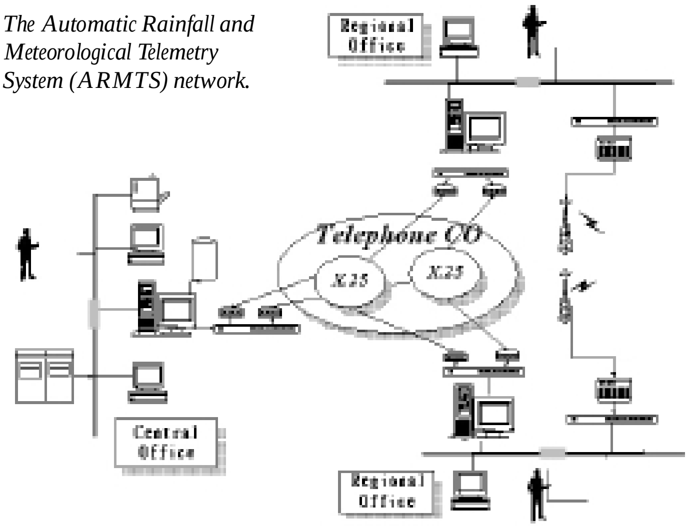
Further information about the WVSS project may be obtained on the Internet. Contact: www.joss.ucar.edu/wvss/

Vaisala helps prevent weather damage:

ARMTS Up and Running in Taiwan

The climatic conditions affecting Taiwan are very complex. Typhoons, monsoons and thunderstorms leave their mark on the country: the average yearly damage from severe weather is around USD 330 million. To provide advance warning of storms and floods and to prevent weather-related damage, Taiwan has built an extensive meteorological observation system covering the entire country.

The Automatic Rainfall and Meteorological Telemetry System (ARMTS) network.



Joel Hsu
President
Environmental Science & Eng'n Corp
Taipei, Taiwan

A MILOS500 weather station in Taiwan.

The objective of Taiwan's Automatic Rainfall and Meteorological Telemetry System (ARMTS) is to study the characteristics of heavy rain and thunderstorms in small and mesoscales. This information is used to improve prediction of local heavy rains and provide flood and other warnings.

The main island of Taiwan is about 200 km wide and 400 km long, with a central mountain up to 4,000 m in height running north to south. Geophysically, the country falls within the subtropical monsoon zone, and it is on the main typhoon path in the western Pacific.

Taiwan's complex terrain and climate conditions cause dramatic seasonal variations in the weather. These are often accompanied by severe weather conditions such as typhoons in the summer and autumn, cold fronts in the winter, thunderstorms in the spring, and monsoons in the early summer. All of these weather phenomena have the potential to cause heavy damage.

Fighting the battle against weather damage

According to statistics from 1961 to 1985, the average yearly damage from severe weather was about USD 330 million; of this amount, typhoons accounted for 70 per cent and heavy rains for 26 per cent. In response, the government initiated a large-scale 5-year hazard prevention project in 1982. The Central Weather Bureau (CWB) was responsible for implementation of ARMTS.

The ARMTS project started with the western region of Taiwan in 1986, followed by the eastern region of the country in 1994. The entire network was

PHOTO COURTESY: KARI TYLLINEN

The climatic conditions affecting Taiwan are very complex.

completed in August 1997, including 223 rainfall stations, 102 meteorological stations, 14 regional data processing stations and 2 central stations. In line with small and mesoscale requirements, these stations have been installed upstream, mid-stream and downstream of the major rivers in order to measure rainfall and meteorological conditions in the catchment area.

Vaisala Oy and Environmental Science & Eng'n Corp. (ES&E), the local Vaisala Surface Weather Observations' agent, handled the project implementation in the Taipei area and the entire eastern region. The project included the siting of the stations, radio path planning, system installation and commissioning, training and after sales service. The project team was set up in July 1994.

Vaisala was responsible for hardware sourcing, design, manufacturing and QA for all field stations. ES&E provided the software and system setup, siting and radio path planning for the central and regional stations. The subsequent installation, commissioning and training were a joint effort.

Design specifications for the new observation system

After discussions with the Weather Bureau and a review of the past performance of the existing system in the western region, the following design criteria were specified:

- To meet the system objectives, the real-time rainfall data (every 0.5 mm) has to be transmitted and received by both the central and regional stations as quickly as possible, within 1–2 seconds. To preserve the accuracy of the time relationship, the rainfall data and measurement time have to be stored in long-term data memory at the site for later retrieval.
- Since all field stations will be unmanned, sufficient system status diagnostics must be implemented to allow full management of system operation and effective response to possible system failures.
- Since the system communication will be based on a radio link, the data validation process should be carefully designed and implemented to avoid interference that would distort rainfall measurements.
- To ensure uninterrupted operations especially in harsh weather conditions, all hardware should be manufactured and installed following high industrial standards.

Now fully implemented, the ARMTS system in the western region comprises 46 rainfall stations, 40 meteorological stations, 13 single repeater stations, 7 dual repeater stations, 4 regional data processing stations and one central station. Over two-thirds of the stations are located in mountainous areas.

All field stations are powered by solar energy and use a one-way UHF radio link to contact the regional stations. After data validation, real-time rainfall data and hourly meteorological data are transmitted to the central station through two redundant X.25 networks.

Reliable rainfall measurements

Each rainfall station has an orifice 30 cm in diameter and a 0.5 mm tipping bucket rain gauge installed on a 4-meter high stand. The large orifice reduces wind effect and provides more accurate rainfall measurement, while the 4-meter installation height prevents damage by wild animals and obstruction by bushes and trees. The system accuracy is within ±2 per cent for rainfall rates of up to 250 mm/h. For stations at over 1,800 meters, the rain gauge has an electronically controlled heating device that starts heating at 2° C and cuts off at 5° C.

The rain gauge has two read switches, one for an on-site recorder and one that triggers real-time transmission. The long-term recorder, the QL10ET, provides real-time recording of rainfall with a capacity of up to 16,000 counts. The battery capacity is sufficient for at least 3 years.

The stations are also equipped with a QLI50 Sensor Collector for encoding and radio control. When the bucket tips, the QLI50 turns on the radio transmitter after a preset interval and sends out encoded data, including the accumulated rainfall value, the station ID, system status and a checksum. The system status report includes the solar panel charging state, battery High/Low, Open/Close of the enclosure door, 'Test', 'Alive', etc.

This report keeps the operators in the regional office informed about the situation in the field. The system is designed for one-way transmission. When no rainfall has occurred for 60 minutes (or during a user set time interval), the QLI50 initiates a transmission to notify the operator that the station is still 'Alive'.

The rainfall stations are powered by solar panel and batteries, with a capacity of at least 20 days without sunshine. All the electronics and batteries are inside the rain gauge stand. The lightning rod, antenna and solar panel are mounted on an antenna mast ranging from 7 to 30 meters in height, depending on the radio path design.

Meteorological stations measure rainfall, wind and temperature

The meteorological stations share the same rain gauge design as the rainfall stations. In addition, they have a 6-meter high instrument mast for meteorological instruments such as wind speed, wind direction and temperature sensors, and the enclosure used with the MILOS500 Automatic Weather Station and DPA21 pressure sensor.

Because of the complexity of meteorological measurement, the MILOS500 is used for data processing, logging and control. To provide hourly average and daily extreme values, the MILOS500 runs in continuous mode. The meteorological stations transmit rainfall data in the same way as the rainfall stations, on an hourly and daily basis. All transmitted data also includes the station ID, system status and a checksum. Along with a QL10ET for rainfall recording, a 1 MB capacity PCMCIA card is used for the storage of meteorological data.

Repeater stations relay the data

The ARMTS contains single and dual repeater stations. A single repeater is simply a radio transceiver for data relay. Dual repeater stations are used in more critical radio paths. They contain two redundant transceivers. One is in the active mode and the other in the hot standby mode. The data received by both units is transmitted to the MILOS500 for data validation, including error checking and limit checking of the station ID. The message is then directed through the first transmitter.

At the same time, the transmitted data is picked up by the third receiver and fed again to the MILOS500 for checking. If the transmission fails, the MILOS500 re-initiates transmission through the second transmitter, inserting a failure message along with other system status messages.

Regional and central stations process meteorological data

Each regional data processing station has three to four different frequency antennas and radio receivers, depending on the area radio path design. The receiving station is also equipped with a MILOS500 unit for removing any corrupt characters that may arise from the random nature of rainfall and the meteorological station transmissions. The data transferred to the data receiving and processing computers is therefore free from any corrupt characters. All serial lines are buffered, so simultaneous reception of data does not cause any data loss.

The data processing system contains a LAN with a DEC3300 RISC-based server, a DEC PC work station and communication devices such as a router and modems.

The software is based on a Client-Server structure with the following functions :

- Data Reception
- Data Calculation and Processing
- System Fault Identification and Alarm Logging
- Detailed Station Information
- Data Storage
- Data Transfer between Regional and/or Central Computers
- Report Generation and Graphics Display

The networking between the regional stations and the central station is provided by two X.25 links operating in load balancing and load sharing modes.

The central station has the same software and similar hardware (a DEC3800 server) as the regional stations. The data from all regional stations is transmitted to the Central Weather Bureau's forecasting center via CWB's intranet in real-time, and then stored for other users.

Meteorological data plays a valuable role in damage prevention

Among many other benefits, the ARMTS provides effective real-time rainfall and hourly meteorological data for weather watches and the prediction of heavy rains. When combined with radar and satellite information, it is also used for localized weather system study and quantitative analysis. Through the computer network, it provides valuable data for flood warnings, reservoir operation, water resources study, and even environmental impact studies for land development.

The ARMTS supplied by Vaisala and ES&E uses only two intelligent devices, a QLI50 and MILOS500, to implement the complete system. This simplicity underlies the success of the ARMTS. With a correlation within 2 per cent between the real-time and on-site recording data, the ARMTS is a reliable and advanced system. ■

The Icebreaker 'Apu' Lives Up to its Name

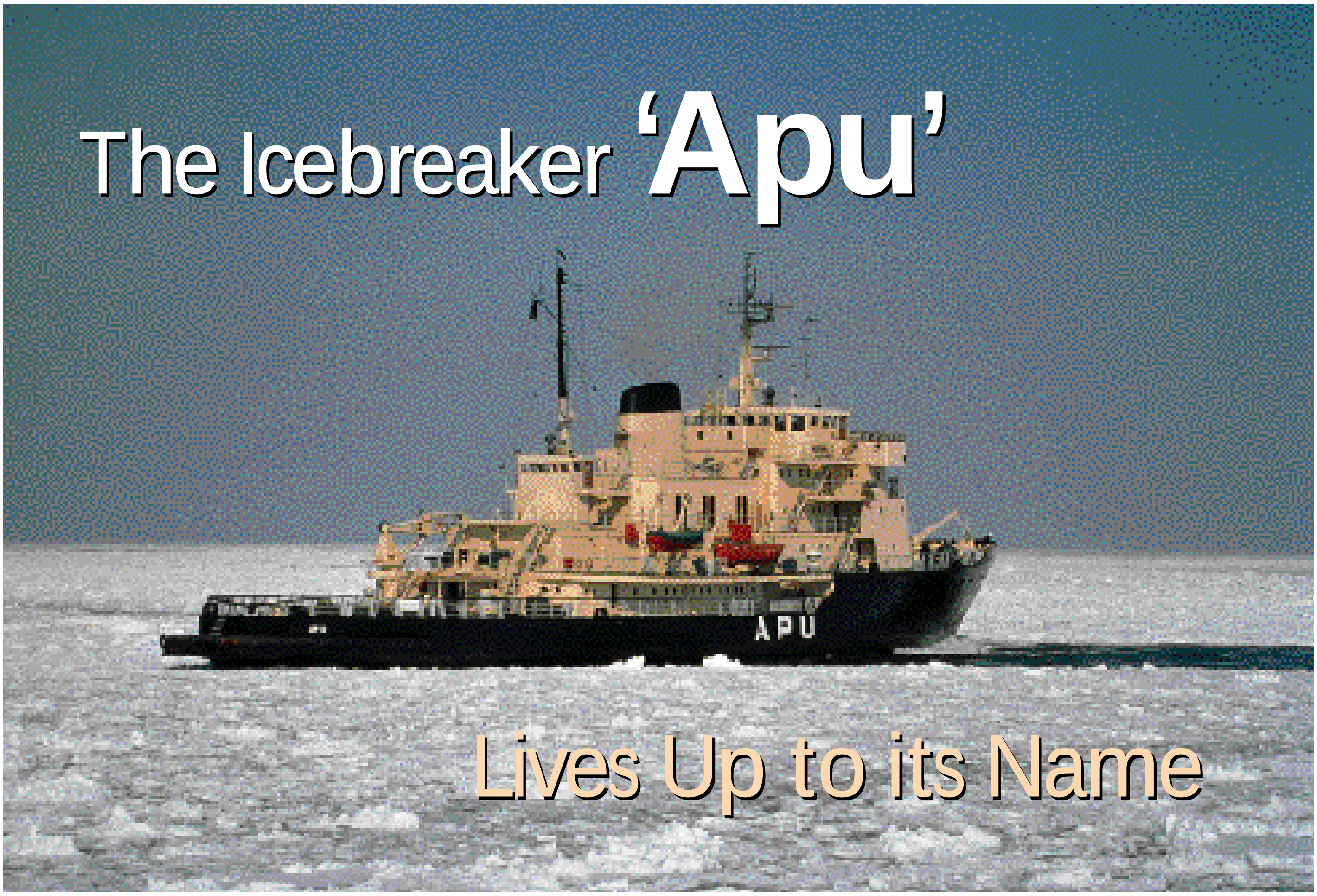
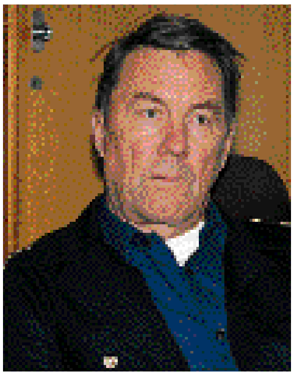


PHOTO COURTESY : THE FINNISH MARITIME ADMINISTRATION

The icebreaker Apu was built in 1970. She operates mainly in the Gulf of Finland.



Commander Per-Henrik Nyström of the icebreaker Apu.

Finland's icebreakers are busy from December to May keeping the country's ports open on the Gulf of Bothnia. High winds and extreme temperatures make this a particularly demanding application for weather instrumentation. Using a MILOS weather station, the icebreaker 'Apu' – or 'Help' in English – collects important data, as well as assisting vessels at sea.

Marit Finne
Editor-in-Chief
Vaisala News
Vaisala Oy, Finland

Finland's icebreaker fleet of 9 vessels operates under the Finnish Maritime Administration. One of them, the icebreaker Apu, was built in 1970. She operates mainly in the Gulf of Finland.

Harsh conditions at sea

Mr. Per-Henrik Nyström, Commander of the icebreaker Apu, has served on various icebreakers for 23 years, including 10 years on the Apu. During the winter season, his crew numbers from 34 to 40. According to Commander Nyström, Vaisala's weather instruments have functioned well on the Apu. The ship's MILOS weather station and meteorological sensors for temperature, humidity, pressure, wind speed and direction were installed in 1987.

As Commander Nyström explains, the icebreaker and his crew must contend with harsh weather conditions: "During severe storms, winds can reach over 30 m/s and even close to 40 m/s. The ice moves with great force, making it very difficult to keep a channel open. In some cases, cargo ships have to be towed. Our weather instruments must withstand these extremely harsh weather conditions and still work reliably. This was the reason behind our choice of Vaisala's observation instruments."

On-board weather station

The Apu's MILOS weather station measures wind speed and direction, relative humidity, temperature, pressure, and sea temperature, combining this information with ship speed (from the log and position), which it receives from the navigator. The station calculates mean values as well as true wind values.

This information is displayed on the bridge for navigation. The data is also sent to the Finnish Maritime Administration three times a day, for use with daily ice forecasts. Merchant vessels operating in the Gulf of Bothnia need information on ice formation, ice melting and real-time ice conditions. ■

The MV Spirit of Tasmania makes regular daily crossings of Bass Strait, ferrying vehicles, freight and passengers between Melbourne and Devonport.

Outfitting the MV Spirit of Tasmania for weather observations

On-Board AWS Provides More Reliable Wind Data at Sea

Truly representative information about wind direction and speed at sea cannot be obtained by observing the weather on the coast. Australia's Bureau of Meteorology has outfitted the MV Spirit of Tasmania for maritime weather observations. Every time the ferry crosses Bass Strait between Mainland Australia and Tasmania, an automatic weather station measures wind, pressure, temperature and humidity.

Competitors in the renowned Sydney to Hobart yacht race are more than familiar with the treacherous waters of Bass Strait. Situated between the southern corner of mainland Australia and the island of Tasmania, the strait is regarded as one of the most dangerous stretches of water around Australia.

Regular weather observations from Bass Strait

The MV Spirit of Tasmania makes regular crossings of Bass Strait, ferrying vehicles, freight and passengers between Melbourne and Devonport. For some years, the Bureau of Meteorology weather forecasters, particularly in Tasmania, have been eager to establish a more regular weather reporting mechanism using the MV Spirit of Tasmania. The ship maintains a strict schedule in all but the most extreme weather events, so it is an ideal platform for recording weather observations during its traverse of Bass Strait.

Automatic Weather Stations (AWS) are the most practical tool for obtaining weather reports. They enable accurate, reliable and regular measurements without imposing on the ship's crew. Because the ship and the AWS are moving, a number of factors must be kept in mind to ensure accurate measurements and reliable data transmission to the Bureau Head Office. This requires a certain amount of flexibility from the AWS, which was one of the reasons behind the choice of the MILOS500. The Bureau has purchased four Vaisala MILOS500 ship AWS units, with the installation on the Spirit of Tasmania being the pilot project.

AWS works independently

The MILOS500 measures wind, pressure, temperature and humidity from sensors located above the bridge of the Spirit of Tasmania. An INMARSAT-C satellite transmitter with an internal GPS receiver is used to transmit observations back to the Bureau's network. The GPS receiver provides information on the ship's position and speed and its course over the water.

A flux gate compass provides information on the Spirit of Tasmania's heading, so the AWS is completely independent of the ship's own navigation and communication systems. A laptop PC on the bridge displays real-time information on the AWS measurements. It also enables manual entry of observations such as visibility and sea state.

The cost of data transmission from the Spirit of Tasmania is an important consideration. For this reason, the standard Synop message is converted to a short binary report prior to transmission and then decoded back to the standard Ship Synop code at the Bureau. This enables the

From the left: Robert Ireland (Vaisala) and Ross Hibbins (BoM) installing the MILOS500 weather station on board the Spirit of Tasmania.

use of very short data transmissions. The benefits are two-fold. Observations can be made as frequently as once per hour, and costs are significantly lower compared with other satellite carriers.

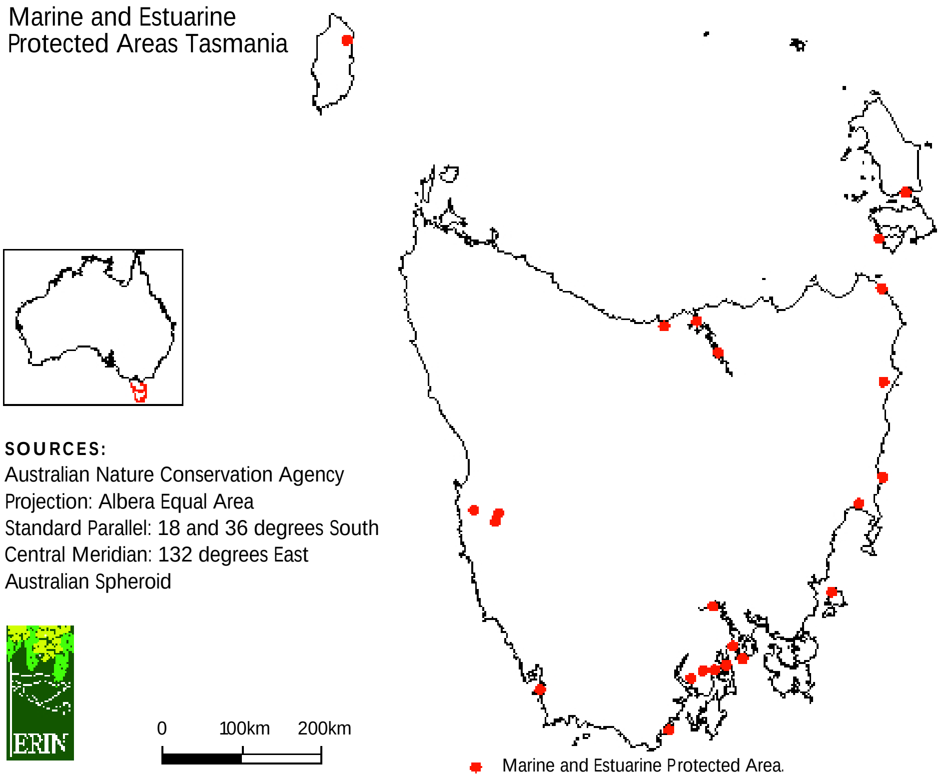
Improved wind data at sea

Once the system is fully operational, observations retrieved from the Spirit will be of great benefit to forecasters in both Tasmania and Victoria. At present, the Bureau's coastal weather observations sites do not always provide wind speed and direction data that is truly representative of winds at sea. These sites tend to be located in areas that are either very sheltered, such as townships located in river valleys, or very exposed, such as capes and promontories where winds tend to accelerate around a geographical feature.

Ship observations are therefore the only source of reliable information for determining true wind speeds over water. For this reason, the AWS data from the Spirit of Tasmania will significantly contribute to improved accuracy of forecasts. The greater frequency of observations will also enable a study of wind patterns across Bass Strait, as part of an effort to enhance the Bureau's computer derived forecasts and improve forecasting for Bass Strait.

Bass Strait forecasts will not be the only beneficiaries of observations from the Spirit of Tasmania. The data will provide more accurate information about the location of cold fronts in Bass Strait, and this will help forecasters predict the movement of these fronts through Tasmania and the southern mainland. This information is extremely important for forecasts during the summer, particularly for fire fighting and aviation.

Other ships of the Australian Voluntary Observing Fleet (AVOF) will be fitted with Vaisala MILOS500 Ship AWS units over the next serveral years. ■



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Australia

Every year, 16 million tons of raw materials and products are shipped through Neste's harbor in Porvoo, for a total of 1,200 ship visits. Vaisala wind sensors have been installed on the mast in the background.

Hydrometeorological Observation System Supports Harbor Operations

The Finnish oil company Neste has purchased two harbor weather stations from Vaisala. The complete hydrometeorological observation systems were installed in 1997, one at the Porvoo harbor in the spring and another in Naantali in the early summer. Located in southern Finland, Neste's modern harbors offer convenient shipping connections to and from the Baltic countries.

Measured in cargo volume, Neste's harbor in Porvoo is the largest in Finland. Vaisala has installed a complete hydrometeorological monitoring system to help improve the safety and economy of shipping from both Porvoo and Naantali. Vaisala's system comprises a complete MILOS500 automatic weather station, as well as an FD12 visibility sensor and sensors for water level and conductivity. For back-up purposes, water levels are measured using two different principles: hydrostatic pressure and ultrasonic.

The measurements are displayed on a graphical terminal and on large outdoor numerical displays that can be seen from the deck of approaching ships. They are also integrated into the real-time air quality monitoring system of the Environmental Laboratory at Neste's refinery, which is located close to the harbor. The same data is available throughout the PC network.

Versatile harbor weather stations

Mr. Risto Rajala, Development Manager, is in charge of developing the technical and working methods at Porvoo's harbor. As he explains: "Every year, 16 million tons of raw materials and products are shipped through the harbor, for a total of 1,200 ship visits. The harbor has seven wharves, with a maximum water depth of 15.3 meters. The shipping traffic served by the harbor includes sea-going freighters on the Baltic. To ensure the safety of cargo shipments at sea, we rely on advanced hydrometeorological observation systems."

As Technical Supervisor of Harbor Services, Mr. Erkki Heikkilä is responsible for system maintenance. "Accurate, real-time hydrometeorological data is essential for shipping operations in the harbor. Neste's modern oil refinery and chemicals units are conveniently located on the southern coast of Finland, allowing competitive cargo shipments to countries on the Gulf of Finland. From Neste's harbors, there also is a direct sea route to the rest of the Baltic Rim," he notes.

Improved operational efficiency

Neste uses Vaisala equipment to measure and monitor the temperature and salinity of the sea water, as well as the water level, wind speed and direction, air temperature, and visibility. The salinity observa-

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Vaisala's MILOS500 weather station for hydrological monitoring at Neste's harbor in Porvoo.

The control tower at the harbor in Porvoo.

tions are used in the determination of cargo weight limits.

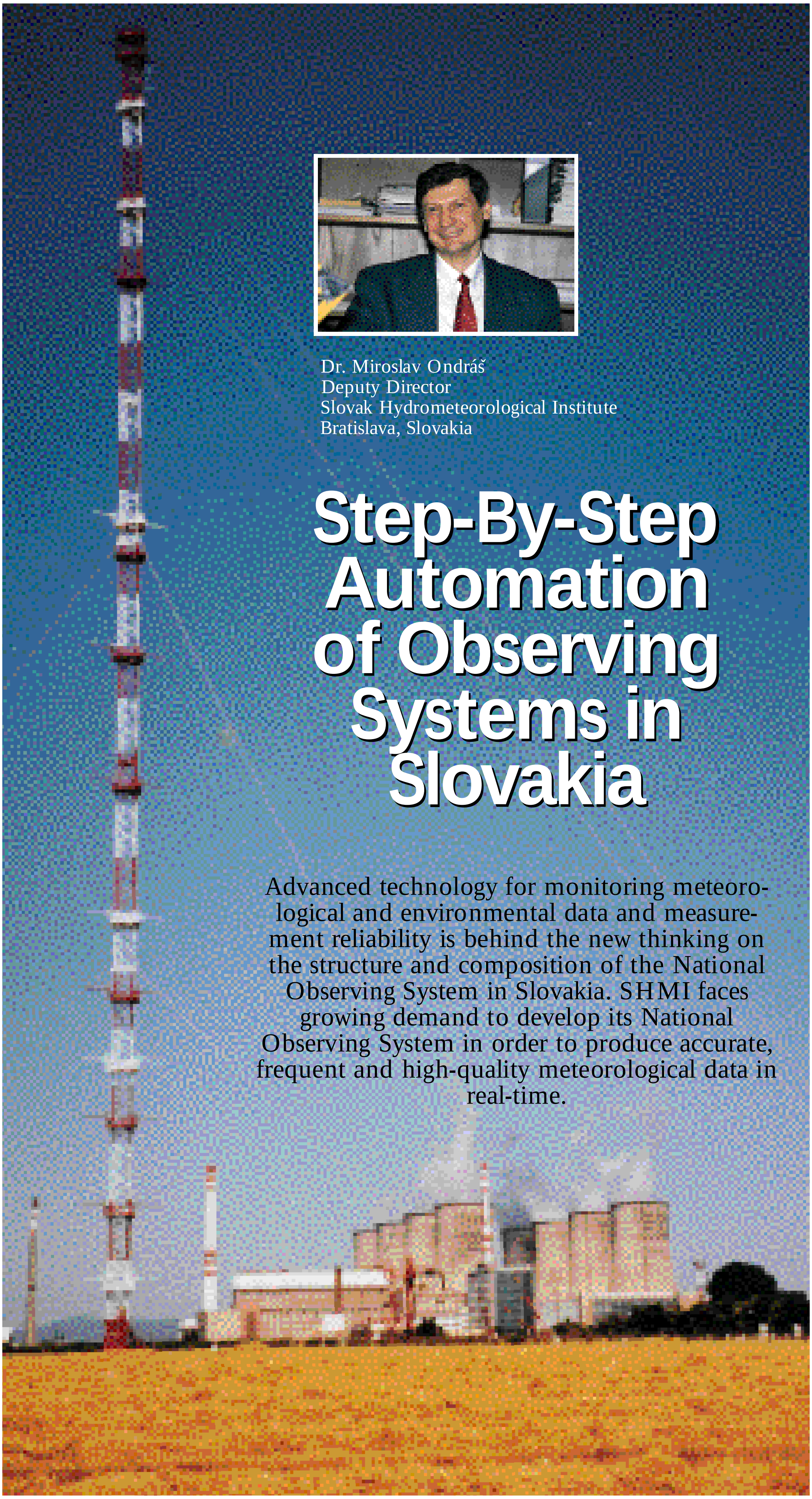
The measurements are stored in a database that is also integrated into the air quality monitoring system of the Environmental Laboratory. If needed, the data can be used to trace emissions.

Neste has always taken pride in maintaining the high technological level of its refineries. To meet market demand and implement the latest refining technology, production processes are systematically upgraded during shut-downs. Neste has invested in design innovations to reduce emissions at the Porvoo refinery, which produces ten million tons of petroleum products every year. The use of low-sulfur crude oil and VOC (volatile organic compound) recovery systems reduces the environmental load of the refinery. Neste regards environmental, health and safety issues as an integral part of its operations. In this light, says Mr. Heikkilä, "Vaisala's products have performed well. They have also improved the efficiency of our harbor operations."

According to Mr. Rajala, "Weather conditions have a dual significance for us. First of all, information about wind speed and direction and water levels is essential in our daily operations. We also use the database for long-term analyses of general weather and water conditions and for air quality monitoring by Neste's Environmental Laboratory. The ability to access information on our own workstations is an important practical advantage for us. We chose Vaisala because of its good reputation and accurate products." ■

Mr. Risto Rajala, Development Manager, is in charge of developing the technical and working methods at Neste's harbor in Porvoo.

Mr. Erkki Heikkilä is the Technical Supervisor of Harbor Services.



Dr. Miroslav Ondráš
Deputy Director
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Step-By-Step Automation of Observing Systems in Slovakia

Advanced technology for monitoring meteorological and environmental data and measurement reliability is behind the new thinking on the structure and composition of the National Observing System in Slovakia. SHMI faces growing demand to develop its National Observing System in order to produce accurate, frequent and high-quality meteorological data in real-time.

Figure 2. The first fully automatic measurement system – for the Jaslovské Bohunice nuclear power plant – was introduced in 1974.

The Slovak Hydrometeorological Institute (SHMI) is responsible for obtaining quantitative and qualitative information about the status of meteorological and hydrological phenomena. To evaluate environmental conditions and changes in Slovakia, it is essential to develop, process and file this information.

Three-stage NOS automation project

According to a recent survey of SHMI specialists, the automation of the National Observing System (NOS) improves the frequency and efficiency of data collection, the accuracy and consistency of the collected data, and data availability. Automation also allows on-line evaluation of data quality and improved data storage. Along with these technical issues, economic benefits are also a factor.

The automation of SHMI's observing system is being carried out in three overlapping stages: the first, from 1990–1998; the second, from 1995–2000; and the third, scheduled to begin in 1999. The time frame depends on the funds available and the implementation of individual projects. Although the current project was started in 1990, the automation of observations at SHMI dates back to 1974, when the first fully automatic measurement system for the Jaslovské Bohunice nuclear power plant was introduced.

Slovakia's National Observing System comprises several observing systems for various purposes, reflecting the historical traditions of manual weather observations.

For this reason, the surface weather section of NOS has Partial Observing Systems (POS) for Aviation (10 stations), Synoptic Meteorology (13), Nuclear Safety (2) and Climatology (851). Over the years, however, the Partial Observing Networks have adopted a mixed observing program, thus serving all users.

Current parameters and sensor systems

Today, SHMI operates twenty-one Vaisala MILOS500 automatic stations (AS), four ESC 8800 AS units, five SHMI IS-32 AS units, three Vaisala MIDAS600 systems, and one Vaisala-MPS-SHMI tower automatic system in either fully automatic or semi-automatic mode. The older ESC 8800 equipment will be replaced by Vaisala's MILOS500 systems within the next two years. Depending on the observation program, automatic stations are used for monitoring the following data, many parameters of which are computerized: wind speed and direction on the surface and at different atmospheric levels; air temperature and humidity; ground surface temperature; soil temperature; barometric pressure; global, diffuse and UVB radiation; radiation balance and Photo Active Radiation (FAR); sunshine duration; precipitation; evaporation; horizontal visibility and Meteorological Observation Range (MOR); background luminance; cloud base level; present weather; and gamma radiation doses.

Some sensor types are used for historical reasons. Today, the general trend is to use a specific type of sensor or at least sensors from one manufacturer.

SHMI has plans to monitor ozone and certain air quality parameters near the surface, as well as lightning strikes and lightning activities. For this reason, the number of parameters and sensors will be extended.

In the semiautomatic mode, the MILOS500 and ESC 8800 automatic stations are linked to the IMS (Integrated Meteorological System), which is a PC-based multi-purpose system. When needed, the system can interface with a human observer who can input his own observations and supervise the system. Data pre-processing, data checking and control, archiving, the compilation of meteorological messages and data transmission are done automatically using the IMS to transmit data to the Message Switching System (MSS) of the National Telecommunication Centre.

In fully automatic mode, the MILOS500 automatic stations can work with or without the IMS. This allows redundancy in the performance of some jobs, particularly data pre-processing, data checking and control, archiving, the compilation of meteorological messages and data transmission. When an automatic station is installed at a typical meteorological station, the IMS, which is situated at the observer's room, is linked to the automatic station.

Both the IMS and AS send compiled messages to the Message Switching System independently in fully automatic mode, although data from the IMS has priority. This provides a back-up in case of a breakdown of the IMS or a lack of personnel. In purely field installations, of course, the AS works without the IMS System. This provides the flexibility for all possible installations – fully and partially manned and unmanned meteorological stations.

The semiautomatic mode is used in fully manned meteorological stations that operate 24 hours per day. The automatic and semiautomatic modes run continuously, so it is possible to switch automatically to the automatic mode in case of a failure without losing any measurements. The automatic mode is used at partially manned meteorological stations, which operate 18 hours a day, and also in field conditions. Reflecting the continuing decrease in the total number of observers in the field, the automatic mode is replacing the semiautomatic mode. In this respect SHMI is working to develop a fully automatic station, not only for synoptic, but also for aviation purposes. Existing hardware is being used to achieve this goal.

Extensive data check routines

Both the Automatic Station and Integrated Meteorological System process raw data by producing 1-minute, 10-minute and 1-hour data sets that are sent to the MSS via the Private Data Network. The 10-minute data is sent every 10 minutes; the 1-minute data, once a day or on request; and the 1-hour data, every hour.

In addition, compiled messages like SYNOP, METAR, CLIMAT, INTER or local types of messages and various pre-processed data in tables (monthly sheets) are also produced. The Automated Weather Observation System at Bratislava Airport compiles messages on horizontal and vertical wind shear,

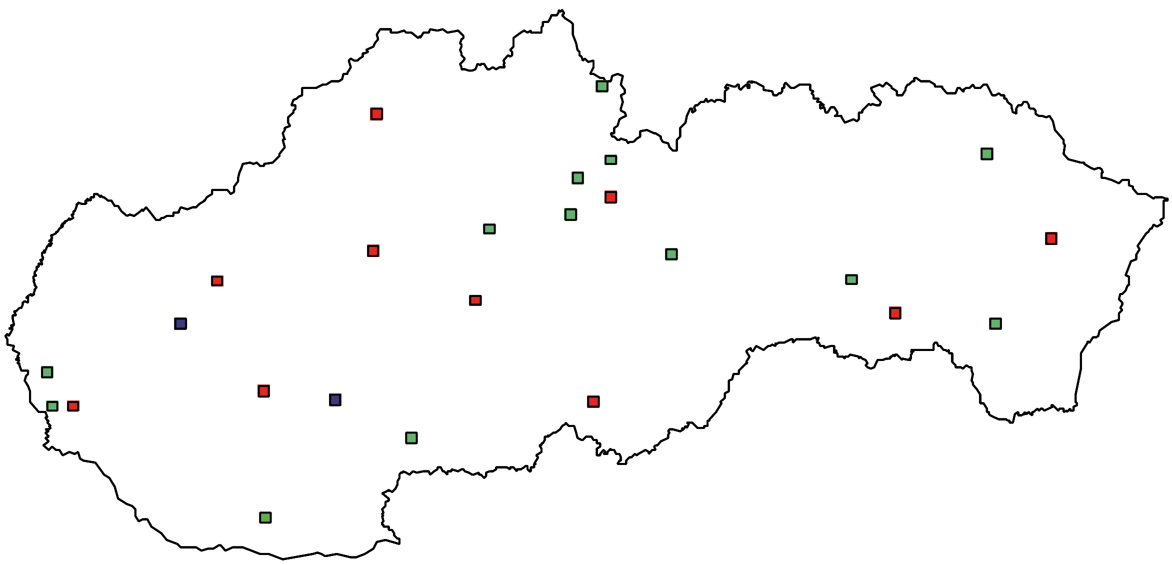

Figure 1. The network of the National Observing System in Slovakia (including three subsystem A, B and C).

as well. The automatic data check routines are run in the AS and IMS to ensure the internal validity and consistency of the raw data and compiled messages. Manually measured parameters are compared with AS data at three-hour intervals. It is the observer's responsibility to take action if any discrepancies occur.

In the future, an automatic check of 10-minute data will be introduced. There is a temporal (approx. from 60 to 90 days) storage on site in both the AS and IMS. Diskettes are used for further on-site storage. From the MSS, all data is sent to local users on line and to the KMIS (Climatological and Meteorological Information System). Data sets and compiled messages are saved hourly in the KMIS, which runs comprehensive data check routines. The 1- and 10-minute data sets, which are only monitored at the Central Forecasting Office, are saved on an optical disc in the original form. In the future, all data will be stored in the KMIS. In case of missing data or messages, an automatic function is being developed to retrieve data from the original AS or IMS. Further post-processing is done by the KMIS, where other data control is applied and if necessary, data corrections are made.

Flexible communication network

The SHMI's communication network is an integral part of an information system that has been designed to meet the need for data and information distribution on a national and international level. It is a packet-switching private network using the X.25 protocol.

The connection between the main nodes of the backbone network is made via leased lines. The aviation and synoptic meteorological stations and regional offices are connected to the backbone mostly by leased lines, and occasionally by dial lines.

Figure 3. The Koliba Observatory in Slovakia.

Operation and maintenance procedures

Operation of all Automatic Stations is monitored continuously, and action is taken in case of a breakdown. Regular maintenance and repairs are contracted to local companies on a monthly or quarterly basis. For this reason, a sufficient quantity of spare parts is kept in stock, and operators receive maintenance training. There is occasionally some discrepancy, however, between theory and reality. In some cases, SHMI allows local contractors to use our Communication Network for remote control and maintenance of the software.

SHMI guarantees the accuracy of measurements by calibrating all sensors regularly in our own calibration laboratories or elsewhere. SHMI's Measurement Standards are compared with the National Measurement Standards in the Slovak Metrology Institute or with international standards. All calibration equipment is now being replaced by advanced technology, and new methodology and calibration techniques are being developed for integration with both the old and new instrumentation.

Meeting the challenges of automation

Automation is an essential component of new observing methods and procedures, many of which differ significantly from the older ones. At manned stations, weather observations or subjective parameters are estimated by an observer at a certain location based on spatial integration. The observation of cloud amount and present weather is one example. An automatic system, on the other hand, estimates the same parameters from measurements made at a certain location based on temporal integration. This represents the principal difference between the behavior of an observer and an automatic system when estimating these weather phenomena. The crucial point in the development of new automatic weather stations is to find not only new sensors, but also new algorithms that allow the calculation of the spatial distribution of a parameter from point measurements.

Automatic weather stations will inevitably introduce incongruities into the old climatic records because of changes in sensor design, the physical principle of measurements, observation techniques, observation time and data processing algorithms. For this reason, an effort should be made to study the homogeneity of data over time after the change in instrumentation.

Hardware protection against lightning strikes and over-voltage surges poses a special challenge for the automation of the observing network. SHMI is investing a great deal in this area after a series of problems in 1995.

Without automatic measurement of weather phenomena (cloud height and amount, visibility, present weather), which up to now were the observer's domain, the automatic station is not complete. With this in mind, FD12P present weather sensors were installed at three MILOS500 stations for a testing and development period. CT25K ceilometers, moreover, were also included in the framework of the project, the goal of which is to develop a fully automatic station. The problem, however, has turned out to be more complex than expected, and requires extended study.

Measurements of soil temperature by the ESC 8800 were affected by an incorrect sensor design and their short period of operation. This is not a problem with the MILOS500 station.

Precipitation measurements during the winter are affected by the heated elements of the rain gauge, and this can result in an underestimation of rainfall.

A careful approach to automation

The aim of this article was not only to describe the progress in the automation of Slovakia's NOS (particularly the automation of the surface aviation and synoptic network), but also to discuss several related issues.

The continuously increasing demands for regular, timely and on-line data from all of Slovakia's territory are the main driving force behind the automation and restructuring of NOS operations. Even so, automation should be implemented very carefully with respect to current limitations and opposing trends.

One of these issues is the conservative approach required on the part of climatology. This is why the Partial Observing System for climatology will be the last to be automated. Even then, a substantial number of stations will maintain their old instrumentation and observing methods. A long-term comparison of data from automatic stations and classical instrumentation has been initiated for this reason. Negotiations are being held with Vaisala to take part in this project. ■

Report on the results of comparison tests:

Windfinding Accuracy of Terrestrial Navaids

Juhana Jaatinen, M.Sc. (Eng)
and
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Upper Air Division
Vaisala Oy
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Terrestrial navigation aids (Navaid) are still an attractive option for windfinding. The merits of various Navaids, as determined on the basis of comparison tests, are discussed below. Loran-C and VLF-Navaid windfinding systems were included in the study.

Despite the termination of the Omega Navigation System on 30 September 1997, there is continuing interest in the use of terrestrial navigation aids (Navaid) for windfinding. This is partly due to the lower cost for radiosondes compared with GPS systems.

Loran-C and differential Loran-C in particular provide excellent accuracy, exceeding numerical forecast requirements. The accuracy of the Vaisala Loran-C is comparable to GPS and precision radars (ref. 1, ref. 8, ref. 9).

VLF-Navaid (Alpha+Com VLF) provides sustained windfinding accuracy that meets numerical forecast requirements.

Windfinding accuracy and the effect of sounding geometry on windfinding are discussed in the following article. The findings are based on a series of triple soundings and the analysis of the windfinding accuracy of Loran-C, Omega and VLF-Navaid (Omega+ Alpha+Com VLF).

Windfinding accuracy

The accuracy of windfinding systems can be affected by many factors, including the atmosphere, climate, time of the day, time of the year, signal propagation direction, the characteristics of the propagation path, system electronics, system software and the geometry of the system transmission stations and receivers.

Although most of these influences cannot be controlled, their effect on the windfinding solution can be estimated.

Detailed accuracy estimations

The accuracy estimates presented in this article are based on the master's thesis of Erkka Pälä (ref. 9), which contains a detailed mathematical analysis of data from a series of triple soundings.

Of all the windfinding accuracy estimation systems reported to date, most have been based on the use of a stationary reference method such as precision radars. The ultimate objective of the current study was to develop a spatially and temporally independent measuring system that could be used anytime and anywhere without the need for a stationary reference method.

Wind data can be expressed in the form of two vector components: north wind component and east wind component (N and E quantities, respectively). As Figure 1 illustrates, wind speed (magnitude) and wind direction can be calculated from these two components. The procedure presented here produces accuracy estimates for all four wind quantities, providing a method independent of location for determining the accuracy of different windfinding methods.

The effect of sounding geometry

The location of the navigation transmitters relative to the radiosonde can have a significant effect on windfinding. It is therefore very useful to be able to estimate the feasibility of windfinding at a particular sounding station.

The common practice is to use Dilution of Precision (DOP) factors to describe the effect of the geometric transmitter distribution on the accuracy obtained for the windfinding solution.

[1] $\sigma = DOP \cdot \sigma_0$

where σ_0 denotes the standard deviation of the observed pseudo-ranges, and σ is the standard deviation of the horizontal or vertical precision, for example. A discussion of DOP factors can be found in Leick (ref. 7).

As the above equation clearly shows, a small DOP factor is preferable. The higher the DOP, the greater the noise in the windfinding solution, and after a certain point the windfinding solution becomes unstable.

An estimate of good and bad DOP can be made by analyzing a number of successful and unsuccessful Loran-C soundings. This leads to the following rule of thumb:

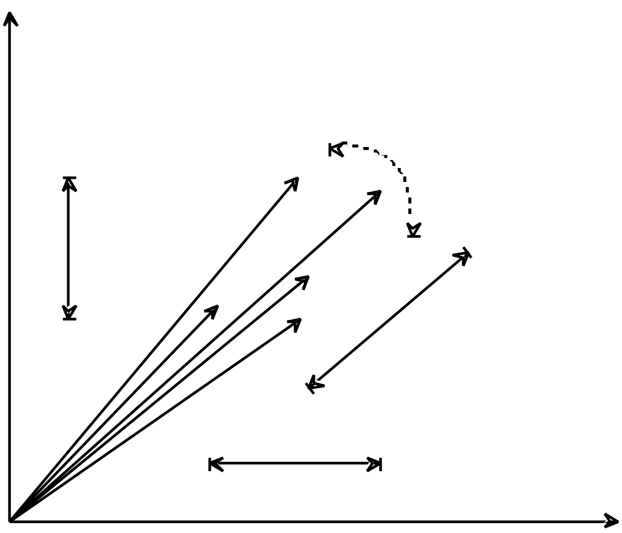

Figure 1. Variability between the four different wind quantities. Wind error vectors start from the origin.

DOP	Influence in windfinding
< 5	GOOD geometry, reliable winds
> 10	POOR geometry, missing winds
> 20	BAD geometry, probably no wind

Table 1. Dilution of Precision (DOP) rule of thumb.

From experience, it is also known that the DOP is below three in a GPS-sounding with good geometry.

Figures 2–7 give three examples of different transmitter distributions. The horizontal dilution of precision (HDOP) describes the effect of the geometric transmitter configuration on windfinding accuracy. Two figures illustrate each example.

Figure 2 shows the transmitter locations with respect to the sounding station. This is an ideal case, with transmitters situated all around the sounding station.

Figure 5 shows the corresponding horizontal dilution of precision (HDOP). The sounding station is located in the center of the graph. The dilution of precision is calculated at several locations around the sounding station. This 200 km x 200 km area forms the grid on the graph.

Figure 3. When all the available transmitters are facing in one direction, the sounding geometry may become a problem. The smaller the angle, the worse the situation.

Figure 6. As the radiosonde moves to the northwest, there is a steady decrease in the angle formed with the transmitters. This causes the horizontal dilution of precision to increase.

Figure 4. The last example is even more drastic. As the radiosonde moves to the west, the 6731-M and 6731-X Lessay chain transmitters finally fall on the same line when viewed from the radiosonde receiver.

Figure 7. When this happens, the horizontal dilution of precision increases to infinity, and windfinding becomes impossible. During easterly winds, severe windfinding problems could be expected with this set of transmitters.

Optimum transmitter sets are not always available. Service breaks and bad radio propagation conditions may result in missing transmitters, and this has an immediate effect on the sounding geometry.

Procedure for estimating accuracy

The procedure for estimating accuracy is based on a comparison of the estimation method data with accurate reference data. In the first phase of the procedure, the accuracy of the reference method is verified.

In the second phase, two simultaneous data sets are acquired, one from the reference radiosonde and the other from the radiosonde being evaluated. This simultaneous data acquisition is achieved with a double sounding with the estimate and reference radiosonde.

Finally, during the third phase, the difference calculated from the double sounding results is combined with the previously determined reference method accuracy to evaluate the windfinding accuracy of the estimation method.

Choosing the best reference method

The Global Positioning System meets all the critical criteria for a reference method, offering accuracy, continuous availability, worldwide coverage and unbiased estimates. This does not exclude the use of other reference methods with this procedure if required. Loran-C is also a feasible alternative.

There are three ways to calculate the windfinding accuracy of the reference system. The first option is to calculate the accuracy using the residuals of the GPS windfinding solution. The second option is to make a double sounding with two reference type radiosondes, and the third is to make a zero wind measurement with the reference type radiosonde.

GPS residuals should be used if reliable reception from five or more satellites is possible during most of the sounding time.

Options two or three should be used with Loran-C and other reference methods. The same applies to GPS residuals if only four satellites can be received at the time of the reference accuracy measurement (simultaneous reception of transmissions from four GPS satellites is the minimum requirement for successful GPS windfinding).

Zero wind soundings

Two series of zero wind measurements were completed for the current study. The first series was made with a Loran-C radiosonde (Vaisala RS80-18L) and the second with a GPS radiosonde (Vaisala RS80-18G).

In zero wind soundings, the radiosonde is attached to a stationary pole for the entire duration of the sounding. Hence, the name zero wind. Each of the current soundings lasted for 120 minutes.

GPS residual measurements

The residual accuracy calculation method is accurate and easy to use.

GPS raw wind data, i.e. data that has not been filtered in any way, is acquired twice a second, and the GPS windfinding equation group is solved every time. The pseudo-range residuals of this equation group describe the amount of error, or variability, of the range of the radiosonde from each of the satellites in the windfinding result.

To obtain the actual windfinding variability, the effect of the satellite geometry at the time of every windfinding measurement (twice every second) must be taken into account.

Triple soundings with GPS, Loran-C and VLF-Navaid (Omega+Alpha +ComVLF)

A series of nineteen triple soundings was made to determine the accuracy of GPS windfinding using residual calculation, Loran-C windfinding

Component error	GPS zero wind [m/s]	GPS residuals [m/s]	Loran-C zero wind [m/s]
N mean	0.01	0.00	0.0
N standard deviation	0.04	0.13	0.4
E mean	0.01	0.00	0.0
E standard deviation	0.04	0.13	0.5

Table 2. Accuracy of the reference method.

Component error	Loran-C [m/s]	Omega [m/s]	VLF-Navaid [m/s]	Radiotheodolite [m/s]
N mean	0.1	0.6	0.5	0.4
N standard deviation	0.6	1.8	1.9	0.5
N wind error estimate	0.7	2.5	2.5	1.1
E mean	0.1	0.2	0.0	-0.2
E standard deviation	0.5	1.8	2.4	0.5
E wind error estimate	0.6	2.2	2.4	0.8

Table 3. Windfinding accuracy.

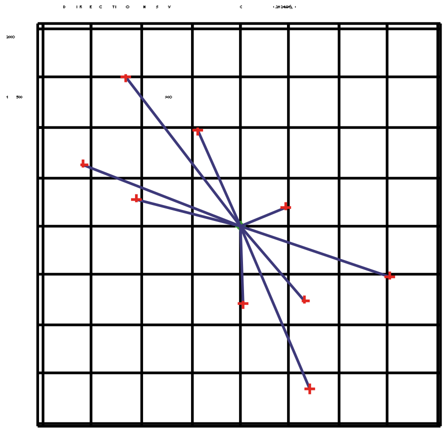

Figure 2. Excellent sounding geometry.

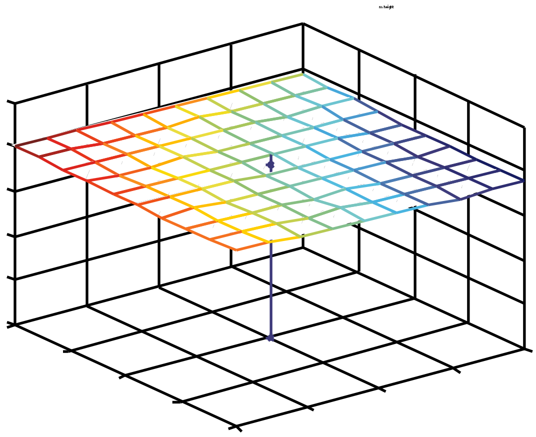

Figure 5. Good dilution of precision.

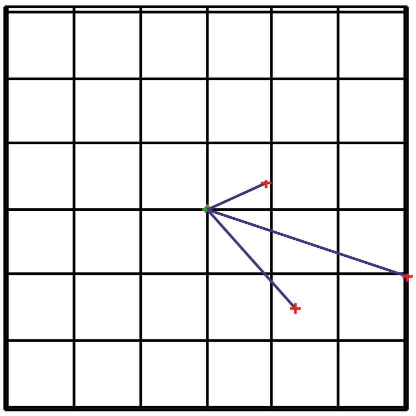

Figure 3. Mediocre sounding geometry.

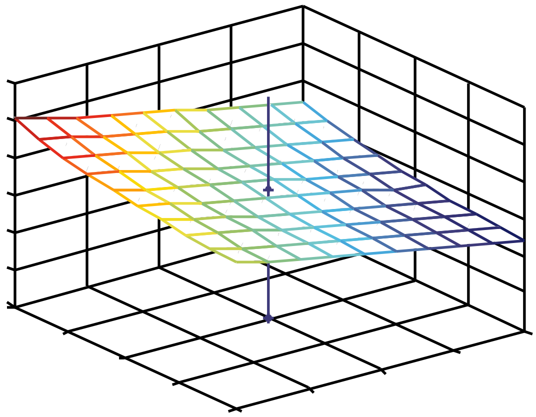

Figure 6. Mediocre dilution of precision.

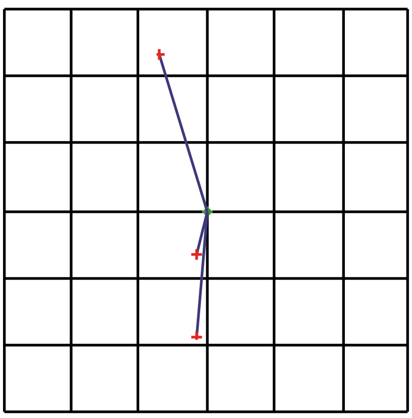

Figure 4. Poor sounding geometry.

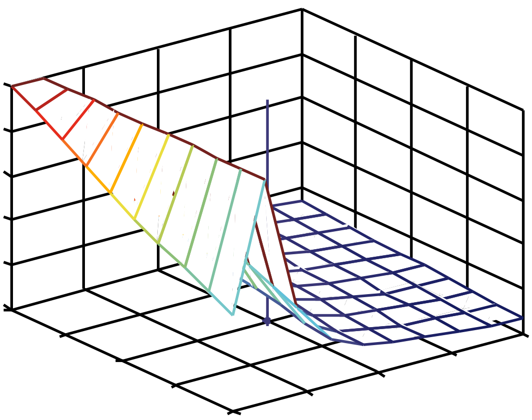

Figure 7. Poor dilution of precision.

and Omega (together with Alpha and ComVLF) windfinding. The test series was made during the last three weeks of September 1997. Each sounding lasted between two and three hours.

For the triple soundings, the radiosonde was attached to a specially designed triangular frame. This improves the stability of the radiosondes and the quality of GPS reception compared with the traditional string hanging system (see Figure 8).

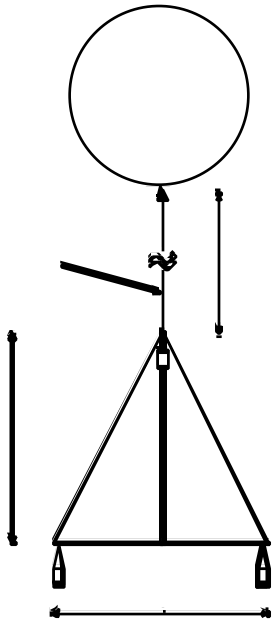

Figure 8. The radiosonde attachment frame used for the triple soundings.

Accuracy calculations

In the third and final phase of the windfinding accuracy calculation, the accuracy of the estimation method was determined.

The windfinding results of the double sounding with reference (GPS) and estimation method radiosondes are independent in nature. With independent measurements, the variances in windfinding errors are related to each other as follows:

$$[2]\ \sigma_E^2 = \sigma_D^2 - \sigma_W^2$$

where σ_E^2 is the variance of the estimation method error, σ_D^2 is the variance of the difference of two windfinding data sets, and σ_W^2 is the variance of the reference method error.

Similarly, due to the independence of the windfinding methods, the following holds for the means of different variabilities:

$$[3]\ \mu_E = \mu_D - \mu_W$$

where μ_E is the mean variability of the estimation method windfinding accuracy, μ_D is the mean difference of the two windfinding data sets and is the mean variability of the reference method windfinding accuracy. If μ_E equals zero, then the estimation method is unbiased.

Accuracy estimation results

The accuracy estimation results are shown in Tables 2 and 3.

Reference method accuracy

GPS residual calculation was used to estimate the accuracy of the reference method. For comparison, a series of GPS zero wind soundings was also carried out.

A Loran-C zero wind sounding series was made to test the accuracy of another reference method with GPS.

Windfinding accuracy

The results shown here are deduced based on the average values for the sounding test series. The typical Loran-C test sounding geometry is shown in Figures 2 and 5.

The dilution of precision (DOP) factor can be used to estimate the feasibility of Loran-C or Alpha+ComVLF windfinding at a particular sounding station.

For a comparison with Navaid-based systems, the accuracy of the Vaisala radiotheodolite is also shown. The radiotheodolite is an independent system using a low-cost radiosonde.

In the light of these findings, the most accurate windfinding system is GPS, offering a windfinding accuracy of 0.1 m/s. Loran-C-based windfinding, which offers a windfinding accuracy between 0.5–1.0 m/s, is the second most accurate system. Radiotheodolite windfinding (Vaisala model RT20), providing an accuracy of 1.0 m/s, is ranked third. Finally, the combined Omega, Alpha and ComVLF windfinding system was the most inaccurate of the systems investigated, offering a windfinding accuracy of 2.0–2.5 m/s. These results are in line with other findings (ref. 1, ref. 8). ■

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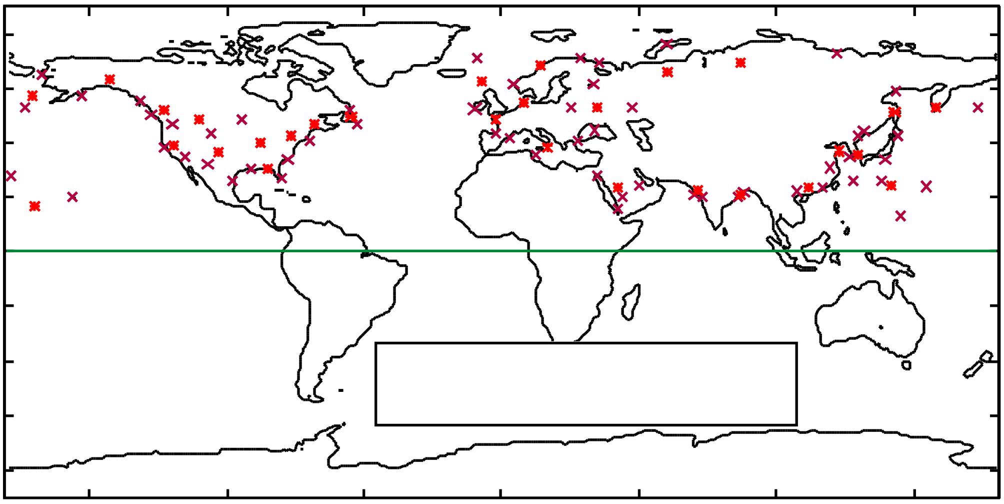

Number of available stations, accuracy -2 — +2

Loran-C coverage throughout the world.

Replacement Systems for Omega Wind Measurement

In recent years, changes in the operating environment have set the course of development for Vaisala's upper air wind finding methods. The Omega phase-out, for example, has prompted an intense R&D effort, as well as extensive tests and studies of the availability and usability of alternative wind finding methods.

This work forms the basis for recommendations that guarantee a suitable Omega wind finding replacement for Vaisala customers worldwide. Some 600 GPS and nearly 200 Loran-C upgrades to DigiCORA and MARWIN systems have been completed in 1997.

Omega stations throughout the world ceased operations on 30 September 1997, at 0300UZ. The very last Omega sounding was performed at Vaisala at 05:30 Finnish time. Since then, all aviation, maritime and meteorological users have had to find alternative solutions for their navigation and wind finding needs.

Over 250 upper air stations in the synoptic network relied on Omega transmissions in their operations. If they have not yet installed an alternative wind finding method, these stations can no longer receive wind data. Omega equipment and radiosondes can only be used to acquire pressure, temperature and humidity (PTU) data. Vaisala offers three replacement solutions for Omega wind finding: Loran-C, GPS, and RT20. Where available, the VLF-Navaid network with a GPS back-up also provides a low-cost alternative.

High accuracy with Loran-C

Where adequate reception is available, Vaisala recommends the use of Loran-C for wind finding. This is an attractive alternative in North America, large areas of Europe, the Middle East, eastern China and Japan. Loran-C offers higher accuracy for about the same cost as Omega, and is therefore a suitable replacement for Omega at sounding stations with Loran-C coverage, i.e. within range of at least three Loran-C transmitters with good geometry.

Satellite-based GPS

The Global Positioning System offers truly global coverage and can be used anywhere. GPS has proven to be very accurate and provides the same level of operational reliability as the Omega system. In particular, GPS is a good solution for sounding stations in areas without adequate VLF-Navaid and Loran-C reception. The GPS wind finding method, however, translates into slightly higher operational costs than Loran-C, RT20 or VLF-Navaid because the inherent complexity of GPS signals is reflected in the price of GPS radiosondes.

Radiotheodolite wind finding

The RT20 radiotheodolite offers independence from fixed navigation systems. While especially suitable for mobile systems, the RT20 can also be used for synoptic observations. The price of the ground equipment is higher, and the upgrading process is more complex than the card-based MW upgrades for Loran-C and GPS wind finding. The cost for radiosondes, however, is lower with an RT20 system. For sounding stations outside Loran-C and VLF-Navaid reception, an upgrade to GPS or RT 20 is recommended.

VLF-Navaid option

VLF-Navaid transmissions are available in some areas. From the user's standpoint, however, VLF-Navaid wind finding based on the simultaneous use of the Russian Alpha and Communications-VLF (ComVLF) is not sufficiently dependable. Continuous wind data availability cannot be guaranteed because of maintenance breaks in the Alpha system and the intermittent transmissions of the ComVLF system. For these reasons, Vaisala discourages complete reliance on VLF-Navaid for wind finding and recommends the use of Loran-C, GPS or RT20 as either a primary or backup system. VLF-Navaid may be used as the primary system in Alaska, Canada and northern Asia.

Flexible upgrades

Any Vaisala DigiCORA or MARWIN system can be upgraded for GPS, Loran-C or radiotheodolite wind finding. The upgrade includes either a GPS or Loran-C receiver & processor module that is mounted inside the DigiCORA and MARWIN frame. All necessary cables, connectors and tools are included in the upgrade set, along with easy-to-follow instructions. The upgrade is extremely easy to carry out, even for less experienced operators. Radiotheodolite upgrades are more complex, and we recommend that Vaisala's trained personnel perform them. For further information, please contact Upper Air Division's Technical Support, tel. +358 9 8949 345, e-mail techuad@vaisala.com. ■

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Using Loran-C for Upper Air Winds

The article 'Countdown to Omega Termination Continues' that appeared in the 142/1997 issue of Vaisala News provided a list of alternatives for obtaining upper air winds following termination of the worldwide Omega navigation system. Omega transmissions ceased on 30 September 1997, after providing signals used by upper air windfinders for more than 25 years.

In the article, the use of Loran-C, a long-range but regional radionavigation system, was cited as one of the attractive options that could be used where coverage is available. Unfortunately, during the editing process, the use of Loran-C was described as being a 'more uncertain' option while the original text stated that the Loran-C option was one 'that has more certainty'. We apologize for this error.

Winds determined using Loran-C are generally more accurate than those obtained by Omega, but unlike Omega, whose signals could be received worldwide, Loran-C coverage is regional. The Northwest Europe Loran-C System (NELS) is expected to be fully operational in 1998, and planning is in progress to extend this coverage to the east and into the Mediterranean region using Chayka, the compatible Russian system. The European Union, in a 1992 resolution, calls for Loran-C in the future mix of radionavigation systems, and this is reflected in the European Radionavigation Plan currently in preparation. The Loran-C Far East RadioNavigation System (FERNS) which China, Korea, Japan and Russia operate jointly continues to be upgraded. Loran-C is also operating in other parts of the world, including Canada and India.

The Loran-C picture in the United States is still uncertain and confusing. The 1996 Federal Radionavigation Plan released in hard copy in September 1997 continues to state that Loran-C will be terminated in the United States in the year 2000, but the U.S. Congress has appropriated funds and stipulated that the Department of Transportation upgrade the transmitting stations and plan for operation after the year 2000. Congressionally mandated reports defining this plan are in preparation for submission to Congress within the next six months.

Where coverage is available, Loran-C provides wind finding capability at a cost comparable to that of Omega. The alternatives are to use GPS at a higher cost or the more traditional method using the radiotheodolite.

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The Technical Support team from Vaisala's Upper Air Division plays a key role in after sales processes. The team helps customers with technical issues related to the installation, operation, use and maintenance of their upper air systems. Customer feedback is critically important to the entire team, which is committed to providing comprehensive service and support to customers worldwide.

The eight-member Technical Support team in the Upper Air Division (UAD) includes Olavi Alanko, Aleksander Bondarenko, Jarmo Franssila, Markku Järvinen, Ismo Kupiainen, Jarmo Mononen and Mikko Niininen. Keijo Mesiäinen, a former team member and familiar face to many Vaisala customers over the past forty years, retired on 1 November 1997.

Technical Support personnel are specialists in system engineering fields, with expertise covering autosondes, radiotheodolites, special sensors, etc. They also know the basics of all Vaisala's upper air observation products. English, Vaisala's corporate language, is the main language used for communication with customers, although some team members also speak French, German, Spanish, Russian, Swedish and of course Finnish.

Introducing Technical Support:

Comprehensive Service for Upper Air Weather Systems

The Technical Support team, from the front: Vesa Koivula, Markku Järvinen, Aleksander Bondarenko, Jarmo Mononen and Olavi Alanko.

Extensive testing process

Thorough testing is conducted before a product or system is released for customer use. During the release test, which takes several weeks, Technical Support staff check the new software and carry out soundings with the complete ground equipment system and all combinations of wind measurements. Every effort is made to ensure that all products have been thoroughly tested before delivery to the customer's site. The release test is also an integral part of Technical Support's internal training procedure. After completion of these tests, in-house studies and internal training by R&D specialists, the next step is to provide customer training. These courses are conducted by Vaisala's system engineers at Vaisala Helsinki or the customer's premises.

Before a delivery, the Technical Support team also participates in the Factory Acceptance Test performed at Vaisala. If an installation is needed at the customer's site, a system engineer travels to the sounding station for the Site Acceptance Test. Most of the team's system engineers put in more than 100 travel days per year.

Equipment upgrades worldwide

The Omega Navigation Network ceased transmissions on 30 September 1997. Since then, the UAD's Technical Support team has been extremely busy, upgrading customers' sounding equipment throughout the world – in Europe, Asia, Africa, Australia and the Americas. This huge upgrading project has required extra resources, and for this reason, UAD's R&D and production people have stepped in to visit and upgrade sounding stations. This has also given them the opportunity to see the customers' applications on site.

Vaisala supports four options for replacing Omega wind finding: GPS, Loran-C, VLF-Navaid and the RT20 radiotheodolite. Typically, the upgrade takes just a few hours, depending on the ground equipment model and level of customization. Very often, it involves the installation of other systems, including PCs with Metgraph software, for example.

The upgrade procedure, which covers both hardware and software, is very well documented in the upgrade manuals. The old Omega-based hardware is removed, and new wind cards, cables and antennas are installed, as well as new software with all the necessary options. All the standard features of Vaisala's latest software release are also included in the upgrade. The system engineer always makes sure that the sounding station is operational after modifications, the first test soundings are made during his visit.

Customer training is often arranged at the same time. There are several operating differences between various wind finding methods, so this is a good opportunity to provide maintenance and other training for local staff.

Help line and e-mail contacts

The Vaisala Upper Air Division's Technical Support team operates a help line to provide customer assistance with technical issues. Customers can also contact Vaisala's operator, who will connect them with the help line. The line is staffed during office hours, and night callers can leave a message in the voice mail box. All messages are answered as soon as possible. ■

UAD Technical Support
Help Line phone number:
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E-mail address:
uadtech@vaisala.com
Telefax **+358 9 8949 252**

From the left: Ismo Kupiainen and Mikko Niininen.

From the left: Aleksander Bondarenko and Jarmo Franssila.

The upper old town of Zagreb .

Croatia Upgrading Its M

Marit Finne
Editor-in-Chief
Vaisala News
Vaisala Oy, Finland

The Customer Comes First at Zagrel

Strong confidence in the growth of the Croatian market, Vaisala's products and a successful future – these are the underlying beliefs at Zagrel, Vaisala's representative in Croatia. Backed up by its technical strengths, Zagrel can provide customers with full service as well as high-quality products.

Zagrel d.o.o. was founded in 1991 and has been Vaisala's representative in Croatia ever since. The connection between Zagrel and Vaisala, however, dates back much farther. Zeljko Bašić, now Program Manager at Zagrel, visited Vaisala in 1982 when he was still working for the Croatian Hydrometeorological Service. This was the start of the warm relationship between the two companies.

"Mr. Jussi Paananen and Mr. Ismo Kupiainen are my oldest contacts at Vaisala and also my friends. Jussi even calls me 'his best long-term investment'," says Mr. Bašić with a smile.

Zagrel focuses on control and automation

Zagrel is a private company with offices in the center of Zagreb. The company's activities cover a wide range, including the engineering, development, production, marketing and servicing of electronic equipment and machinery.

Zagrel's main focus is on remote control and telemetric systems for hydrotechnical, water supply, electric power and radio communication systems, as well as radio networks. Industrial automation and measurements also account for a major part of their business. Vaisala is one of Zagrel's most important partners.

To date, Zagrel's largest Vaisala customers, including the Croatian Air Traffic Safety Authority, Meteorological and Hydrological Service, National Electricity Company and Croatian Army, have mainly ordered meteorological equipment. Sales of measurement instruments, however, are also growing.

Tomislav Domac, Director of Zagrel, believes in the continuing success of Vaisala's products in the Croatian market.

"Our cooperation with Vaisala has been very successful," comments Mr. Bašić, Program Manager from Zagrel.

Full service guarantees customer satisfaction

Program Manager Zeljko Bašić is one of the company's thirteen employees. "We try to form as close a connection between the end user and Vaisala as possible. We are also committed to understanding our customers' needs and offering them the best possible technical solution. After the equipment has been delivered and installed, we provide assistance with equipment service and maintenance. In this respect, our cooperation with Vaisala has been very successful," says Mr. Bašić .

"Zagrel is a technically strong company, so we can offer full service. In our view, this is the best way to satisfy our customers."

Mr. Domac is confident about Vaisala's future in Croatia. Today, the market growth reflects increasing demand for advanced measurement systems. "Vaisala's research and development work is thorough and extensive, and the company plays a leading role in the world market. We can learn a lot from Vaisala, but I hope this process is a two-way street, with both parties learning from each other and raising the level of customer satisfaction even higher." ■

Meteorological Systems

MHS: Ready for Future Challenges

Vaisala and the Croatian Meteorological and Hydrological Service (MHS) have worked together in the fields of upper air and surface weather observations for more than a decade. In 1994, the Finnish Meteorological Institute (FMI) donated ground equipment to the MHS. After Vaisala refurbished the system, it was presented to the MHS in February 1995.

A balloon launch at the Zagreb–Maksimir Observatory. From the left: Mr. Milan Filipčić (head of the observatory) and Mr. Ivica Dundović.

Croatia has had an organized meteorological observation system for over 150 years. The predecessor of the Croatian Meteorological and Hydrological Service (MHS) was founded in 1947, so 1997 marked their 50-year jubilee.

The Meteorological and Hydrological Service is the main meteorological authority in Croatia. It is involved in all aspects of meteorology, from weather forecasting and hydrology to agrometeorology, marine meteorology, research and hail suppression.

As soon as MHS became a member of the World Meteorological Organization in 1992, it began to establish close links with other WMO members, especially in Europe, to exchange data and experiences.

Cooperation for over ten years

Vaisala's first contact with the MHS was in 1984, when Mr. Jussi Paananen gave a presentation about Vaisala's radiosounding equipment. MHS began to use Vaisala radiosondes in 1995, and ever since, radiosondes and ground equipment have been key Vaisala products for MHS.

Vaisala also gave presentations about upper-air and surface meteorological instruments in the mid-1980s. In 1995, a MILOS500 automatic weather station was sited at the Zagreb–Maksimir Meteorological and Aerological Observatory for six months, as part of a presentation.

The observational network of meteorological stations in Croatia is defined in accordance with WMO guidelines and generates all the measurements required for meteorological data exchange. The network has not yet been fully automated.

In the future, there are plans to build one radiosounding station in Zagreb, two stations along the Adriatic coast and one in Slavonski Brod.

Ground equipment from FMI

The Finnish Meteorological Institute (FMI) donated a Micro-CORA system to the MHS at the end of 1994. The ground equipment had been in use at the Jokioinen Observatory, Finland, and after refurbishing at Vaisala, it was presented to the MHS in February 1995.

Dr. Erkki Jatila from FMI and Mr. Jussi Paananen from Vaisala played an active role in arranging the donation. Vaisala also pro-

Zvonimir Katušin
Assistant Director
Meteorological and Hydrological Service
Zagreb, Croatia

vided training in the use and maintenance of the MicroCORA system to Dr. Krešo Pandzic and Mr. Ivan Šmaljcelj from the Croatian Meteorological Institute. Mr. Zeljko Bašic from Zagrel, Vaisala's distributor in Croatia, also attended the training session.

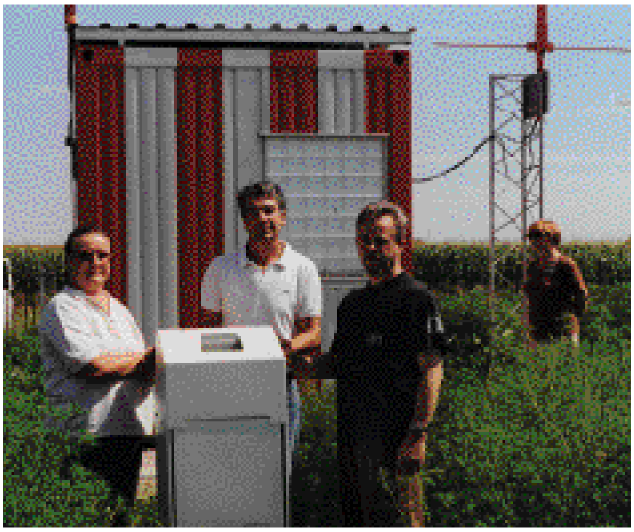
The MicroCORA was started up on 25 February 1995 after a short ceremony at the Zagreb–Maksimir Meteorological and Aerological Observatory. The ceremony was attended by Dr. Mikko Alestalo, Head of the Technical Department at FMI. Mr. Tomislav Vučetić, Director; Mr. Mladen Matvijev, Vice Director; and Mr. Zvonimir Katušin, Assistant Director and Head of the Climatological, Meteorological and Upper Air Measurement Department, represented the MHS. Mr. Eero Puhakka was on hand from Vaisala, as well as Domac Tomislav, Director, and Mr. Zeljko Bašić from Zagrel, Vaisala's distributor in Croatia. The ceremony was also followed by everyone from MHS, the Croatian Army and Croatian Air Traffic Control who is involved in upper air measurement.

Future needs

Now that the Omega system has been discontinued, MHS is using Vaisala's RT20 radiotheodolite and a 1680 MHz RS80-67 radiosonde at the Zagreb–Maksimir Observatory. Looking to the future, this radiosounding system might be replaced by GPS or Loran-C wind measurement, after international tendering. ■

Air Traffic Safety Authority Prepares for Increasing Air Traffic

The growth of tourism in Croatia is generating more air traffic. To help ensure passenger safety, the country's eight international airports need up-to-date instrumentation. Since 1994, the Croatian Air Traffic Services Authority has relied on Vaisala instruments.



From the left: Ms. Aleksandra Krašovec, Mr. Zeljko Bašić, Mr. Miroslav Jelacic and Ms. Bozica Gelo at the Zagreb airport.

Croatia is a beautiful Mediterranean country and an increasingly popular tourist destination. Today, the country has eight international airports, most of them on the Adriatic Coast, as well as some smaller airports for general aviation. With the growing number of tourists visiting the country, the airports must be prepared to handle the increase in air traffic. The number of airports, moreover, particularly small ones, is also expected to grow.

The Croatian Air Traffic Services Authority (CATSA) is part of the Ministry of Maritime Affairs, Transport and Communications. Along with its management and area control service center in Zagreb, CATSA has airport control service centers at each airport. All air traffic services in Croatia are handled by CATSA, which is a complex organization with responsibility for managing the operations in the units of the Air Traffic Service (ATS), Aeronautical Meteorology and Technical Division. Mr. Drazen Ramljak, Director General, manages the organization with the help of three Deputy Directors, Mr. Vlado Bracevic (ATS), Ms. Bozica Gelo (MET), and Mr. Franjo Kiseli (Technical Support).

Compliance with ICAO regulations for flight passenger safety is also in the hands of CATSA. Ms. Aleksandra Krašovec heads CATSA's Navigation and Meteorology Department within the Technical Division. The department is responsible for installing and maintaining the navigation and meteorological equipment at the Zagreb airport. They also help other airports solve any equipment problems that may arise. In cooperation with his technical colleagues, Mr. Miroslav Jalacic, Meteorologist, coordinates all calibration and maintenance of meteorological equipment.

Quality costs less in the long run

Vaisala made its first product presentation to CATSA in Zagreb in 1992. The first purchases were made soon after, and Vaisala WAD21M wind systems were installed at the Dubrovnik, Split and Zagreb airports.

Product quality was the focus of special attention in the selection of the Vaisala products. As Ms. Krašovec explains: "Good quality is less expensive in the long run. While the price may be higher to start with, you can count on quality later on." CATSA also has a policy of buying observation systems

CATSA representatives at the Vaisala training course. (from the left): Mr. Nenad Rodic, Mr. Damir Kovac, Mr. Zeljko Knjaz, Mr. Harry Alm and Ms. Liisa Nummela (both from Vaisala), Ms. Aleksandra Krašovec, Mr. Augustin Kastelan and Mr. Tomislav Kosta.

only from well-known and reputable manufacturers.

This year, a loan from the European Bank for Research and Development made it possible to order updated AWOS and RVR systems for the Zagreb airport. Again, CATSA turned to Vaisala. ALMOS Systems from Australia supplied the central unit and software, while Vaisala supplied the field sensors, including RVR, software, anemometers and pressure, temperature and humidity sensors.

"We have found the quality of the products to be very high, and we have been happy with the service, too," notes Ms. Krašovec. "We also have a good relationship with Zagrel, Vaisala's local representative. They have been very helpful."

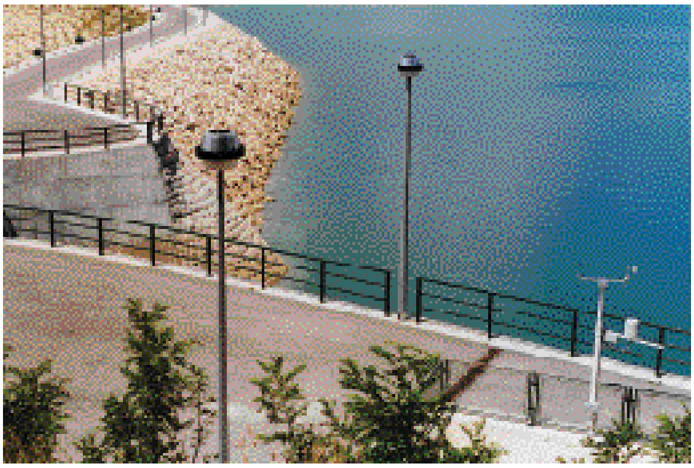
Technical training in Finland

In the summer of 1997, a group of CATSA's technicians visited Vaisala to learn more about their new equipment. Six experts received training in the installation, use and maintenance of WAA15A and WAV15A wind systems, CT12K ceilometers, HMP35D humidity and temperature probes, DPA12A pressure transmitters, and MITRAS RVR systems. Vaisala's Project Manager Liisa Nummela was the instructor of the training course.

Aleksandra Krašovec was one of the trainees: "In my 22 years at CATSA, I have worn many hats. In a small organization like ours, it is important for everyone to pitch in when needed. I like working in the field. It's the best way to learn about the equipment."

Zagrel did a good job organizing the training session, in cooperation with CATSA and Vaisala. According to the trainees, the course was very useful, thorough and even fun. Ms. Krašovec sums up their feelings: "We were very happy to see the factory where our products were made. Even the weather was beautiful." ■

AWS Plays a Key Role in Power and Water Management



Designed to gather weather information, a Vaisala automatic weather station was installed at the Peruća dam in 1996.

Hrvatska ElektroPrivreda, Croatia's national electricity company, needs weather information for planning its future power and water management systems. The first Vaisala automatic weather station (AWS) for this application was installed at the Peruća dam in 1996.

Branko Grgić, M.Sc.
Development Department
Hrvatska ElektroPrivreda d.d.
Zagreb, Croatia

Hrvatska ElektroPrivreda d.d. is responsible for electricity generation, transmission and distribution in Croatia. To plan and optimize the construction and utilization of future power and water management systems, the company is installing a series of automatic weather stations (AWS) throughout the country. The climatic, meteorological and hydrological parameters that the stations collect will be used in system planning.

Hrvatska Elektroprivreda d.d. operates under the supervision of Croatian government authorities.

AWS helps determine rainfall and runoff

The first new weather station was installed in 1996 at the Peruća dam, which had been severely damaged during the recent civil war. The installation of the station coincided with the start of dam repairs. Now fully operational, the station gathers data used to determine the relationship between rainfall and runoff in the dam catchment area.

Vaisala's automatic weather station is equipped with a QLI50 sensor collector integrated with LabVIEW software. This combination is a flexible and accurate tool for comprehensive data acquisition and analysis. Good references and the high quality of Vaisala's equipment were deciding factors in Hrvatska ElektroPrivreda's choice. As they report, the system seems to be very solid and up-to-date, based on their experiences so far.

Mr. Branko Grgić stands beside Vaisala's automatic weather station, which is equipped with a QLI50 sensor collector integrated with LabVIEW software.

First of five installations

The Peruća dam is the first in a series of five installations planned in Croatia. Hrvatska ElektroPrivreda intends to chart the meteorological and hydrological characteristics of the entire region, which covers the Cetina, Krka and Zrmanja river basin. To complete the system, four more weather stations will be needed in the near future. ■

RT20 Radiotheodolite Stands Up to Harsh Field Conditions

The Croatian Army is dedicated to developing its personnel, equipment and procedures to a high operational level. The procurement of reliable meteorological measurement equipment is one aspect of this development effort. Vaisala's RT20 radiotheodolite met the army's need for an easy-to-use, easy-to-transport system that works in any weather conditions, day or night.

Jarmo Mononen from Vaisala provided operator training in the use of the RT20 radiotheodolite at the Center of Strategic Studies. From the left (the first row): Mr. Zeljko Bašić (Zagrel), Ms. Dunja Plaćko (HQ Meteo), Mr. Jarmo Mononen (Vaisala); a group of operators and military personnel stand behind them.

The Croatian Army gives high marks to the all-weather reliability of Vaisala's RT20 radiotheodolite.

Since then, the Center of Strategic Studies (CSI) has been contributing to the army's development. The center's long-term aim is to become a military research and development institution specializing in military technology. Studies that are critical to defence and the armed forces, and to national and global security are among CSI's activities.

Demanding measurements in the field

The Croatian Army needed equipment to measure meteorological parameters – including temperature, humidity, pressure, wind direction and wind speed – at altitudes of up to 20,000 meters. In 1994, local Ministry of Defence experts and experts from the State Meteorological Institute joined forces to determine the best measurement solution.

They decided on Vaisala's RT20 radiotheodolite. This choice was based on the RT20's measurement capability in all weather conditions and during the night, and its easy assembly and transportation. The passive measuring method of the RT20 and the relatively low probability of jamming – by radar or radio stations – were also significant factors in their decision. It takes just one or two people to operate the RT20, and the learning time is short.

Multiple uses in the infantry, navy and air force

The Croatian military has found many different uses for the RT20 radiotheodolite – by the infantry, navy and air force alike. Examples include the measurement of atmospheric conditions for artillery and rocket launch practices.

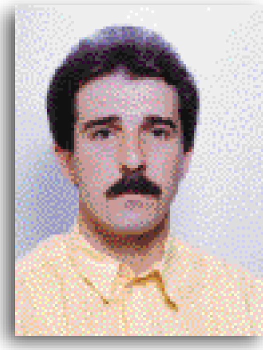
Strong winds create dangerous turbulence, so wind information is particularly important for the air force. The RT20 can also be used to determine the chance of freezing, which is another benefit of meteorological measurements for flight applications. Based on this information, airplanes can be prepared for flight accordingly.

The meteorological data is also used in the development of long-term and short-term forecasts, and to determine the atmospheric conditions for decision-making in extreme weather conditions and ecological catastrophes.

Tested reliability

Vaisala's RT20 radiotheodolite enables highly sophisticated information processing of wind, pressure, humidity and temperature readings. The information can be displayed, and the output can be produced in the desired format and medium.

The RT20 has been tested in the harshest field conditions. Poor visibility and severe weather conditions have not affected the operation of this advanced and reliable radiotheodolite.



Fistonić Igor, M.Sc., M.Eng.
Headmaster, Brigadier
Center for Strategic Studies,
Ministry of Defence
Croatia

Dr. Bruce W. Forgan wins the 12th Professor Vilho Vaisala Award:

New Calibration Method for Reference and Field Pyranometers

Dr. Bruce W. Forgan from the Australian Bureau of Meteorology won the 12th Professor Vilho Vaisala Award. His new method improves the accuracy of solar radiation measurements, which are a critical tool in climate research.

Dr. Forgan's winning paper was published in the highly regarded Journal of Atmospheric and Oceanographic Technology in June 1996. "The paper provides a detailed description of a powerful but simple technique that produces highly accurate pyranometer calibrations. Pyranometers are used worldwide for measuring solar radiation. The newly developed method, which can be applied to calibration centers, is easier and cheaper to use than the previous method," says Professor Obasi, Secretary-General of WMO.

Results from models and field calibrations have shown that the uncertainties of Dr. Forgan's method are less than 1 per cent for solar zenith angles less than 75 degrees. By using his method, the accuracy of solar radiation measurements within operational networks can be improved. This is an important advantage for all applications of radiation data, especially in the field of climate research, where the precise determination of the radiation balance is essential.

The award ceremony was held in November 1997 at the headquarters of the Bureau of Meteorology in Melbourne. From the left: Dr. John W. Zillman, Professor G.O.P. Obasi, Dr. Bruce W. Forgan, Hon. Senator Ian MacDonald, and Mr. Pekka Ketonen.

The award ceremony was held in November 1997 at the headquarters of the Bureau of Meteorology (BoM) in Melbourne. Professor Obasi presented the award to Dr. Forgan. The Hon. Senator Ian MacDonald, Parliamentary Secretary of the BoM; Dr. John W. Zillman, President of WMO and Permanent WMO Representative from Australia; and Mr. Pekka Ketonen, President and CEO of Vaisala, were also present at the ceremony.

The Professor Vilho Vaisala Award was established in 1985 to promote WMO's work and commemorate the late Professor Vilho Väisälä. The World Meteorological Organization grants this award every year to a distinguished researcher who has successfully used weather instruments and observation methods to support WMO programs. The winner is selected by the WMO Executive Council. The award consists of a diploma, medal and cash award. ■

Sea Launch Meets the Growing Need for Commercial Satellite Launch Services

The market for commercial launch services is growing rapidly. The new 'Sea Launch' joint venture has already secured 18 orders for satellite launches from global telecommunications companies. Vaisala upper air sounding systems and automatic weather stations will provide accurate meteorological data for the launches.

Pekka Kostamo, B.Sc. (Eng.)
Development Director
Vaisala Oy, Finland

Meteorological information is critically important for successful space launches. Thanks to their compact size, high level of automation, proven reliability in marine environments and low lifecycle costs, Vaisala meteorological systems are well suited to this demanding application. These benefits contributed to the choice of Vaisala upper air sounding systems and automatic weather stations for the 'Sea Launch' commercial satellite launching facility.

The first satellite launch, scheduled for October 1998, will be carried out at a launch platform in the Pacific, approximately 1,500 miles south of Hawaii. The home port for the Sea Launch operations is Long Beach, California.

Sea Launch is a major joint venture formed to serve the rapidly growing market for commercial launch services. The four joint venture partners are Boeing Commercial Space Co., which is the system integrator and overall operations manager; Kvaerner Maritime A/S of Norway, which is responsible for the marine elements of the project; KB Yuzhnoye/PO of the Ukraine, which is supplying the two-stage Zenith launch vehicle; and RSC Energia of Russia, which is contributing the upper rocket stage and launch operation services.

Along with the specialized port in Long Beach, the Sea Launch facilities also comprise a converted off-shore semi-submersible launching platform and a specially built Assembly and Command Ship. The ship will transport the launch vehicles and satellites from the port to the platform and serve as the command center during the operation.

The launching system is compact and highly automated. No personnel will remain on the launch platform during lift-off. ■

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