VAISALA NEWS

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Vaisala in Brief

Vaisala is a global leader in environmental and industrial measurement. Building on 80 years of experience, Vaisala contributes to a better quality of life by providing a comprehensive range of innovative observation and measurement products and services for chosen weather-related and industrial markets. Headquartered in Finland, Vaisala employs approximately 1,600 professionals worldwide and is listed on the NASDAQ Helsinki stock exchange.

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Vaisala Celebrates its 80 Years Anniversary

The year 2016 is a special one for Vaisala, as we celebrate our 80 year anniversary. Throughout the past decades, alongside our commitment to quality and customer focus, Vaisala has also maintained its curiosity. We have always been passionate about uncovering novel solutions to problems and issues our customers face every day.

In the 1930s, the scientific community was yearning to measure and better understand weather phenomena, as well as enable weather prediction. Many tried to develop a solution but a reliable method remained elusive. It was Professor Vilho Väisälä who finally developed a device which measures temperature, humidity, and pressure from the upper atmosphere.

Over the decades since, Vaisala has become a truly global company, serving customers in every country, with 17 product areas, and 1600 staff worldwide. Take a look at the articles in this anniversary issue of Vaisala News to learn about our pioneering technologies. Learn about how Vaisala arrived in the United States. We also look at the importance of capacity building, and the difference made when a reliable weather observation network is in use when extreme weather events unfold.

In 2006 - just ten years ago - Vaisala was entering the weather radar business and I had joined the company as President and CEO. It was an exciting time, and gave me the opportunity to see this curiosity at work first-hand. Developing the world's best weather radar system was fueled by the desire to innovate, to provide a better system solution, better than anything else available on the market.

If we skip to the modern day, we can see that the continued desire to understand the unknown drives our R&D efforts. In a world of shifting global economies and environments, exploration and innovation are more important than ever before. For example, the quest to harness the power of the wind in an optimized way has been a fundamental challenge in renewable energy production. For wind farm developers, we offer solutions that bring peace of mind, taking guesswork out of the equation by providing data that reliably demonstrates the potential return on their investment.

Professor Väisälä's legacy lives on in the work we are doing today. We are always looking for new opportunities, helping our customers build reliable weather infrastructure that ultimately helps to save lives. We will continue to work hard to be the partner of choice for our customers. Customer focus is at the heart of everything we do, building solid relationships through our commitment to quality.

We believe in observations for a better world, curiosity, courage, and science-based innovation. Vaisala is always looking towards the future, with a positive spirit.

Kjell Forsén
President and CEO

The Golden Age of Meteorology

Technological advances have transformed processes and procedures in countless fields - and meteorology is no exception. When one looks back at how weather data were acquired, analyzed and applied 40 or 50 years ago, it's staggering to see how different things are today. So what significant changes occurred, how have they impacted people, property and the environment, and what groundbreaking developments can we expect in meteorology in the coming years?

“As 2015 comes to an end, we find ourselves in a world with advances and systems that could only have been imagined 40 or 50 years ago.“

Changing State of the Science

How we view the pace of progress is highly subjective. Throughout the years, many people have argued innovations aren’t happening quickly enough and that they are short on resources – both of which are often true. But often it’s only when one steps away and looks at the big picture that it’s possible to see each development in context and assess what remarkable progress has been achieved in the last half-century.

Dr. **Walt Dabberdt**, corporate science adviser for the Vaisala Group, believes the ability to make numerical predictions has improved dramatically in recent years, largely due to the advances in computing architecture, the ability to employ increasingly sophisticated data assimilation schems, and better parameterization of the underlying atmospheric physics.

“Much, if not all, of that has been enabled by advances in our measurement capabilities,” Dr Dabberdt says. “Better understanding of the atmosphere and atmospheric physics, how to represent the physics in our models allow us to more effectively assimilate our measurements into the models.”

Dabberdt recalled that when he first joined the National Center for Atmospheric Research (NCAR) 30 years ago, radar displays were only just starting to be showed in color. And radar-based wind analyses could take several weeks before the wind field could be reconstructed. However, he believes the ability to do things like this in real-time is now largely taken for granted - a sign of how quickly new innovations can ensconce themselves in the mainstream.

“Many of these advances have occurred over a very short period of time,” he commented. “LIDAR (a laser-based remote sensing technology) is an example of a technology that was strictly a research tool until fairly recently. The ceilometer is probably the best example of a practical, operational application of LIDAR technology in support of meteorology and also air quality. And we are now at the cusp of an era when LIDAR may be used operationally to measure water vapor throughout the lower atmosphere. GPS is another great example of a technology that is having increasing application in meteorology, such as for windfinding by radiosondes, measuring precipitable water in the atmosphere, and deriving estimates of moisture in the uppermost layers of the soil. And let’s not forget the many improvements that have been made in weather radar technology, such as dual-polarization, Doppler windfinding, and signal processing.”

Dabberdt believes advances such as these represent “phenomenal” steps forward that have been made despite the relative scarcity of resources, and that further progress still needs to be made. “There have been remarkable accomplishments in the weather domain and we can see their impacts in the quality of weather products today.”

Data Assimilation

Dabberdt went on to highlight other improvements in remote sensing, both in ground-based and satellite-based systems. However, he believes the ability to take full advantage of these measurement advances has come about largely because of superior data assimilation systems, as they take the measured data sets and assimilate them in a way that enables the data to be effectively used in weather prediction models. As a result, the benefits of the observing systems can be more fully realised.

“Data assimilation is talked about widely today, and it is commonplace today, but it has only been implemented effectively for numerical weather prediction over the past 15 to 20 years,” Dabberdt added.

When technology or operating processes establish themselves firmly in the mainstream, it can be easy to forget what came before. But to do that is to forget the journey that has been undertaken and just how far we have come over the last few decades.

As 2015 comes to an end, we find ourselves in a world with advances and systems that could only have been imagined 40 or 50 years ago. How we observe weather and environmental conditions, exploit the data we gather, and predict the future have been transformed, while the technology we use to process the data and communicate it to others has also evolved considerably.

The end result of this is more accurate and timely environmental information, with decision-makers in key industries such as agriculture, energy and transport better informing their business strategies and future directions.

Nowcasting and Forecasting

Of course, the ultimate goal in nowcasting is to be able to make extremely accurate and precise short-term predictions for the next few hours - as this can help to mitigate the impact of extreme weather events on both infrastructure and populations.

The ability to nowcast effectively continues to improve. For example, Vaisala can provide data and information on lightning activity on both a regional and global scale. This can be used to alert decision-makers in industry and government, both to the dangers of lightning and act as a real-time warning for further high-impact conditions, so they can take steps to mitigate the impact straight away.

There are many situations in which the ability to forecast can be hugely advantageous for key sectors. Indeed, a survey by the UK Met Office vividly highlighted the impact that accurate weather data can have on the UK's retail industry. While 47 per cent of retailers and suppliers said the weather is one of the top three external factors that drive consumer demand, 32 per cent revealed they do not use any weather data throughout their supply chain, and 17 per cent only use free weather data services.

Significantly though, 62 per cent of those who invested in paid-for commercial weather services of some kind were found to offer better customer service. Meanwhile, 57 per cent said their sales forecasts are more accurate as a result, 51 per cent revealed their on-shelf availability has improved, and 43 per cent hailed a cut in waste across their supply chain.

This is a clear indication of how there can be a strong business case for investing in the latest meteorological measuring and forecasting systems, particularly in countries with changeable weather. Being able to respond to short-term and long-term changes in the weather effectively can save millions and have a huge impact on retailers' abilities to meet the expectations of their customers.

Similarly, transport infrastructure operators benefit from anticipating and/or responding speedily to changes in environmental conditions, so they can be fit for purpose regardless of the weather.

For example, the UK Office of Rail Regulation has many procedures and processes in place to keep trains moving during extreme conditions, but many of these depend on being being able to accurately predict the weather before it strikes.

For instance, train speed restrictions will be reduced from 125mph to 80mph in high winds, and during icy and snowy weather, snowploughs are deployed to clear key routes. Meanwhile, some locomotives will be fitted with mini-snowploughs and used to clear tracks that are vulnerable to heavy snow. Furthermore, point heaters and insulation have been installed at junctions to prevent them failing in low temperatures. Electric locomotives will be also be sent out on overnight ice patrols to reduce the amount of ice on overhead wires, so regular train services can run as normal without being hit by arcing or power loss.

However, putting these systems in place depends on various factors, from having detailed knowledge of which locations have historically been problem areas during extreme weather events, to having accurate data on where a high-impact event might take place in the future. Without this information and ability to track environmental conditions, many vital precautionary steps might not be taken and a key part of the country's transport infrastructure would grind to a halt.

Climate Change

One of the biggest changes in how environmental conditions are measured and predicted has been driven by the acceptance in the scientific community, governmental authorities and major industries of anthropogenic climate change. While advances in meteorological and climate science helped identify the climate-change problem initially, atmospheric researchers now need to – and in fact they do – play a large role in tackling this challenge and developing the right approaches to

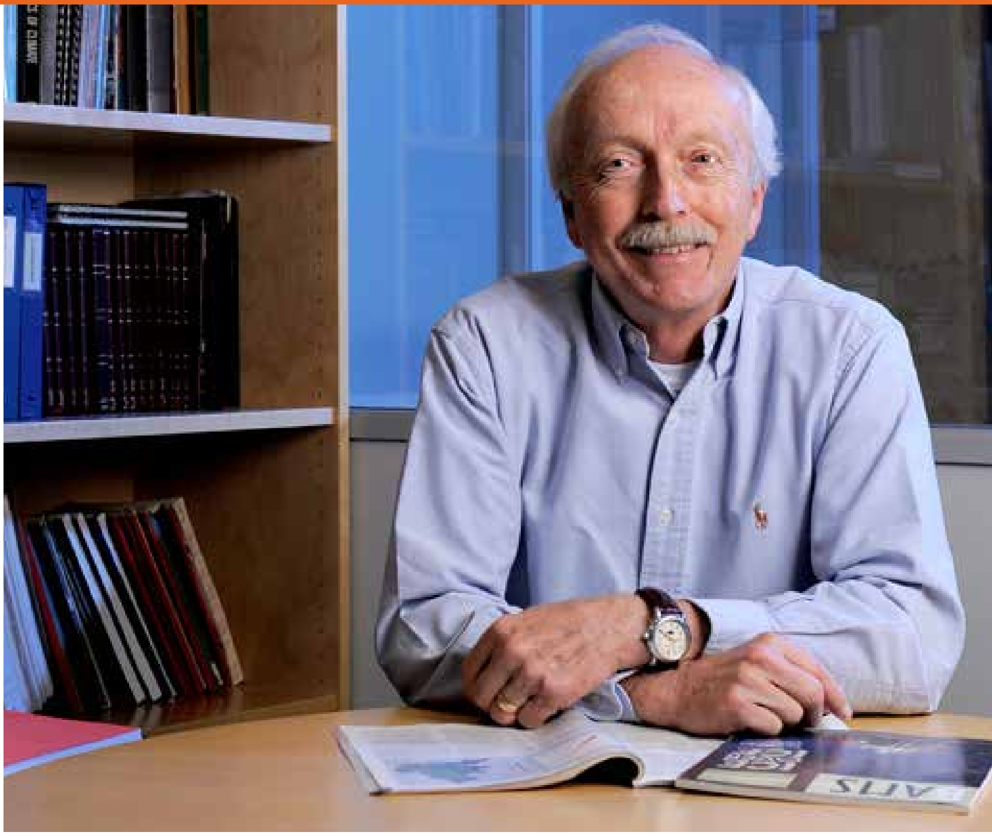
While we might justifiably hail the last 40 or 50 years as the golden age in meteorology, that doesn't mean we've reached the level we've been aiming to achieve.

monitor and predict future changes as well as adaptation and mitigation strategies.

Climate modelling was in its infancy not very long ago, as Walt Dabberdt notes. "I recall going to a meeting of the American Geophysical Union about 35 years ago. I was still at Stanford Research Institute at the time, and I attended a climate session where people were starting to do climate modeling.

"And if you look at the climate modeling back then, you were looking at a gridded output from a very embryonic global climate model, that was so crude that if you looked at it today and you didn't understand the history you'd say this is unusable, nonsensical, because it was so coarse and you compare that with what we have today, where we now have global climate models with global resolution in some models as fine as ten kilometers over the oceans. They are not just atmospheric models anymore, they are truly coupled models that couple the interaction between the atmosphere and the oceans and land, sea ice, glaciers and so on, and this is done a century out into the future and to predict with reasonable certainty what the changes in the atmosphere structure will be as a result of the changes in emissions of greenhouse gases."

Dabberdt also points out these models offer a "remarkable" degree of accuracy when applied in reverse to represent the climate of the past century. Although not 100 per cent accurate, they are robust enough to inform significant political decisions where the will exists to "accept the challenge and implement changes".



What happens next?

While we might justifiably hail the last 40 or 50 years as the golden age in meteorology, that doesn't mean we've reached the level we've been aiming to achieve. As a result, the weather and climate sectors continue to innovate and pioneer new methods and processes, so more unfulfilled ambitions can be realized in the future.

For instance, there are various measurements that are needed to improve understanding of the atmosphere for both weather and climate prediction purposes.

"Water vapour, in particular, is really the remarkable data gap in our knowledge for both weather and climate purposes," he continued. "Of course on the weather side, we're developing new systems to measure water vapour in the troposphere but at the same time, we also need high-quality measurements of water vapor in the lower stratosphere." Since water vapour is the most significant greenhouse gas in Earth's atmosphere, this could be crucial in boosting future understanding of the total climate system.

With highly accurate and timely climate data and the ability to make reliable short- and long-term weather forecasts, professionals across a wide range of sectors can take steps to manage the environment and reduce damage, disruption and potential loss of life. The demand for better and more accurate technology is growing all the time - and in turn, the need to keep innovating remains as strong as ever.

Pioneering Radiosonde Technology

Vaisala radiosondes have provided cutting-edge technology for 80 years. Vaisala continues a strong investment in research and development in sounding systems.

Professor **Vilho Väisälä** was a pioneer in radiosonde development. His first radiosonde prototype, the RS1 “radiometeograph” was lifted up with four balloons in 30.12.1931. The radiosonde measured atmospheric temperature from ground level up to 7200 m altitude.

First Generation Vaisala Radiosondes

The RS11 Radiosonde, developed in 1934 measured “all three” sensors for temperature, pressure and humidity. With the novel measurement circuit, the radiosonde became lightweight and featured more simple construction. The RS11 Radiosonde won a Gold Medal at the 1937 World Fair in Paris. By 1939, it was in use at stations in five countries.

Radiosonde models RS12 – RS18 introduced improvements for more accurate temperature and humidity measurement in the form of double radiation shields and improved hair hygrometers, to mention a few advancements. In addition, dedicated models were developed, especially for research use.

Vaisala’s state-of-the-art HUMICAP® polymer humidity sensor was first implemented into use with radiosondes in the 1970s with the RS21 Radiosonde. The sensor was located in a shield duct. At this time also the wind propeller used for sensor switching was replaced with a wire motor. Radiosonde wind measurement based on the OMEGA network was developed in Vaisala.

Second Generation Vaisala Radiosondes

The introduction of Vaisala’s RS80 radiosonde shaped the outlook of the modern radiosonde by introducing an integrated sensor boom with small-size temperature sensor and polymer humidity sensor (HUMICAP®) and sensor selection with purely electrical means. The latter feature enabled radiosonde construction without any mechanical moving parts. In later RS80 models GPS technology was applied for wind measurement.

Third Generation Vaisala Radiosondes

Vaisala RS90 and RS92 radiosondes introduced the thin-wire capacitive temperature sensor, silicon pressure sensor, and the heated twin sensor humidity measurement concept, capable of preventing sensor icing in freezing sounding conditions.

Fourth Generation Vaisala Radiosondes

In the development of Fourth generation “Gen4” radiosonde, great emphasis was also put on improving the consistency of the observations as well as the usability of the products. In addition to this, Vaisala’s Radiosonde RS41 introduced technological improvements for an even higher level of in-situ observation accuracy and quality. The radiosonde temperature measurement relies on resistive platinum temperature sensor technology, commonly used in temperature reference measurement applications. The radiosonde incorporates optimized capabilities for atmospheric moisture profiling with its humidity sensor with integrated on-chip heating and temperature measurement features, ensuring icing-free measurement and eliminating the need for additional solar radiation corrections.

Jarkko Sairanen Appointed Executive Vice President for Weather Business Area

Jarkko Sairanen (51), M.Sc in Industrial Management and MBA (INSEAD), has been appointed Executive Vice President of Vaisala Weather Business Area. He will be a member of Vaisala Management Group and will report to Kjell Forsén, President and CEO of Vaisala. Jarkko Sairanen will start at Vaisala latest on May 2, 2016.

Jarkko Sairanen joins Vaisala from Pöyry PLC where he is working as Executive Vice President in charge of the Management Consulting Business Group since 2011 serving energy sector and forest industry. Prior to his career at Pöyry, Jarkko Sairanen was President of Elektrobit Automotive Software during 2007-2011.

Jarkko Sairanen has also served Nokia in several executive roles and worked as partner in the Boston Consulting Group.

Kjell Forsén, President and CEO of Vaisala: "I am pleased to have Jarkko Sairanen onboard Vaisala. Weather Business Area's number one strategic goal is to grow by providing comprehensive offering for weather impacted customers and through expanding information services. Jarkko's wide experience from technology and consulting businesses will be a great asset in leading Weather Business Area and further developing its strategy."

Vaisala Wins PennDOT Bid for Statewide RWIS Network

Vaisala has won a multi-year, competitive bid to deliver and manage a statewide Road Weather Information Network for the Pennsylvania Department of Transportation (PennDOT).

Road Weather Information Partnership

PennDOT is investing in their road weather operations to add relevant weather and pavement conditions so that they can provide safe and optimal traffic conditions along state roads and highways.

Roadway maintenance & operations can make better decisions and keep traffic flowing with reliable, accurate road weather information.

Contract Details

The contract includes delivery of a network of Vaisala Road Weather Information System (RWIS) stations, which provide atmospheric observations for wind, pressure, air temperature and humidity, precipitation, visibility and surface temperature and conditions. The contract also includes data management with hosting and visualization services, custom winter severity and performance index values, as well as maintenance and service of the entire network.

Join the Vaisala Weather Challenge

Are you interested in exploring open weather data and creating new applications that make a difference?

We are looking for curious minds to leverage weather data in innovative ways.

Every day, millions of people are touched by the technologies Vaisala creates. Our technologies provide information on weather and other environmental phenomena to meteorologists, road authorities, and other renewable energy industry players, as well as controlled industrial environments, for example.

We believe that weather data, much of which is free and open to anyone, are underutilized. Open weather data can be used to create and deploy disruptive technologies, or develop applications that can address weather and/or climate-related issues around the world.

Call for Action!

Through the Open Weather Data Challenge, we are looking for software and weather enthusiasts to leverage open weather data in innovative ways. Please make sure your submission fills the following criteria:

Novelty

We are looking for novel ideas and applications. Your idea and application should demonstrate originality and uniqueness, with a focus on innovation.

Potential for Impact

At Vaisala, we believe that weather observations can lead to a better world. From this point of view, we will gauge the potential your idea has at impacting weather- and climate-related issues.

Feasibility

The key to any innovation is its ability to be realized.

How feasible is it that your idea can make the impact you are setting out to achieve?

To join the challenge, use any open source of weather data in an innovative way to develop a solution that addresses a weather related challenge. You can find examples of weather data sources in the bottom of the page. Create a solution and demonstrate your idea to participate the challenge.

20,000 € Award

The winner will be announced on March 31st 2016 and awarded a 20,000 € and acknowledged publicly as the Vaisala Open Weather Data Challenge winner.

Why the World Must Improve its Weather Detection Capacity

Human civilisation has made two major advances in the last century that fundamentally change our relationship with the weather:

1. Development of the computer enabled the creation of meteorological technology to monitor and measure weather with an accuracy and sophistication never before seen.
2. Ongoing development of an advanced, highly interdependent global society and economy depends on understanding and managing the effects of the weather to function effectively.

Yet despite our ability to forecast weather that impacts our movement, sustenance and very survival, available technology is still woefully underused. Ignoring the many potential applications of weather monitoring continues to cost our society billions of dollars and thousands of human lives.

Weather Forecasting & Crisis Management

Dr Joan Bech, an associate professor at the University of Barcelona who specialises in meteorological sensing, said detection is "essential" in preventing storm damage, and often defines how well a country deals with a crisis. "For large-scale storms, damage can be widespread and very extensive, so it's very important to take preventative measures well in advance," she added.

A lot of data is available through international collaboration between organisations like the US National Hurricane Centre and the Met Office, although there is still room for improvement.

In 1995, the Rhine region in Europe was hit by a combination of heavy rainfall and mild temperatures that melted mountain snow. These combined into a deluge of water that caused severe flooding in Belgium, Germany and the Netherlands.

The economic costs were huge, as 1,550 square km of farmland was flooded. In Germany, the cost of the damages was almost $300 million, while the Netherlands had to pay out billions in compensation to its citizens.

Despite this example of a failure in regional collaboration, Dr Bech says "there's still a role to be played by local measurements". One advantage of monitoring the impact of weather events from a local perspective, compared to international warning systems, is decisions about how to respond can be made more quickly and in the context of the impact in a specific area.

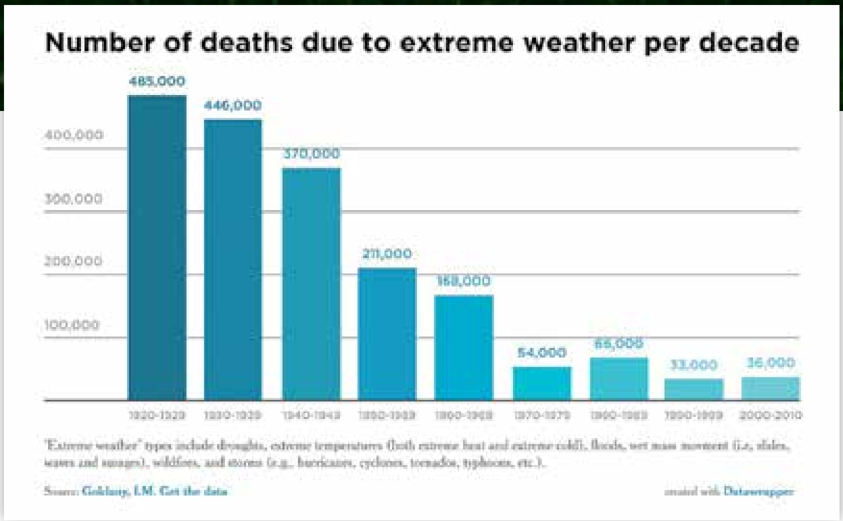
In a 2008 study, it was discovered that having 12 hours warning of a flood in the US meant that, on average, the amount of damage was reduced by 60 per cent. When that warning time was reduced to two hours, the damage reduction fell to 20 per cent.

As the following case study demonstrates, the role of weather detection is critical in preparing for crises.

The use of weather monitoring systems and sophisticated storm preparations days in advance enabled Vietnam to minimise the impact of Haiyan, allowing it to avoid some of the catastrophic damage that had hit the Philippines.

Despite Haiyan weakening as it approached, the Vietnamese government activated and maintained its highest state of preparedness, moving thousands into shelters to protect them from the storm. The only casualties the nation suffered happened during this period of evacuation.

The steps Vietnam took protected its citizens and their economic livelihood. The UN's resident coordinator for Vietnam, Pratibha Mehta, said the



Typhoon Haiyan: The facts

Average wind speed	195 mph*
Max. wind speed	235 mph*
Max. height of sea surge	25 feet
Rainfall at the storm's centre	60mm per hour
Height of stormclouds	6.2 miles
*Upon making landfall on the Philippines	

In 2013, Typhoon Haiyan passed over the Philippines and Vietnam with catastrophic consequences for both countries.

nation's preparedness "played a key role in minimising the impact and number of lives lost".

Chile's Atacama Desert Flood

Northern Chile is home to the driest non-polar desert in the world: the Atacama. Chilean authorities rarely expect rainfall, so generally have no need to prepare for it. When heavy rainfall struck the region in early 2015, Chile suffered financial costs and loss of life due to farm destruction, disease – 89,000 influenza vaccinations were distributed – and looting.

The shock flooding was not caused by an extreme storm, but instead by ordinary weather events. The first was a cold nucleus – a sudden cold condition in the air – which was forecast around three days in advance. This combined with a large amount of moisture in the atmosphere to produce a high precipitation, leading to extreme flooding where water could not sink into the dry ground of the Atacama Desert.

Preventing situations like those in either case study requires reliable weather detection technology. By predicting meteorological events - both the extreme, like Typhoon Haiyan, and simple occurrences like the rainfall in the Atacama – allow nations to prepare sufficiently. The extra time such technology can give a country to react makes all the difference, allowing authorities to act and mitigate the impacts of weather phenomena.

Day-to-day Benefits of Weather Detection

Studies in 2006 showed that weather information had an average value of $109 per US household each year. This equates to an overall economic benefit of over $12 billion per annum. The picture is similar in other countries across a range of sectors.

Forecasting is a Vital Element

The World Meteorological Organisation says weather forecasting "is a vital element" needed "in order to meet the food, fodder, fibre and renewable agri-energy needs of rapidly growing populations".

- In the US, improved climate forecasting in the corn belt is expected to bring in an extra $1.2 billion to $2.9 billion over a ten-year period.
- The US National Weather Service estimated in 2002 that a one per cent improvement in hydroelectric power generation due to better weather forecasting would result in an annual benefit of $81 million.
- The World Bank Group estimates that improved global weather forecasting would result in increases in productivity worth $30 billion per year, as well as reducing asset losses by $2 billion per year.

Tourism & Transport

Being able to forecast and plan for the future when it comes to the local climate is a major advantage when it comes to planning tourism facilities. The transport sector can also benefit, as infrastructure can be set up to measure road surface conditions to improve traffic safety.

- A 2014 study found that Switzerland's transport sector could save between $56.1 million and $60.1 million by using meteorological data.
- In 1985, Qantas Airways Limited started using weather forecasts to determine how much fuel each plane should carry. This decision reduced overall fuel consumption, saving them between $19.1 million and $30 million per year.

All of these factors and more add up to an improved quality of life for citizens of a country that invests heavily in weather detection infrastructure. Being better prepared for the weather generally means more money in a nation's economy, leading to better quality of life.

Making Weather Forecasting Count

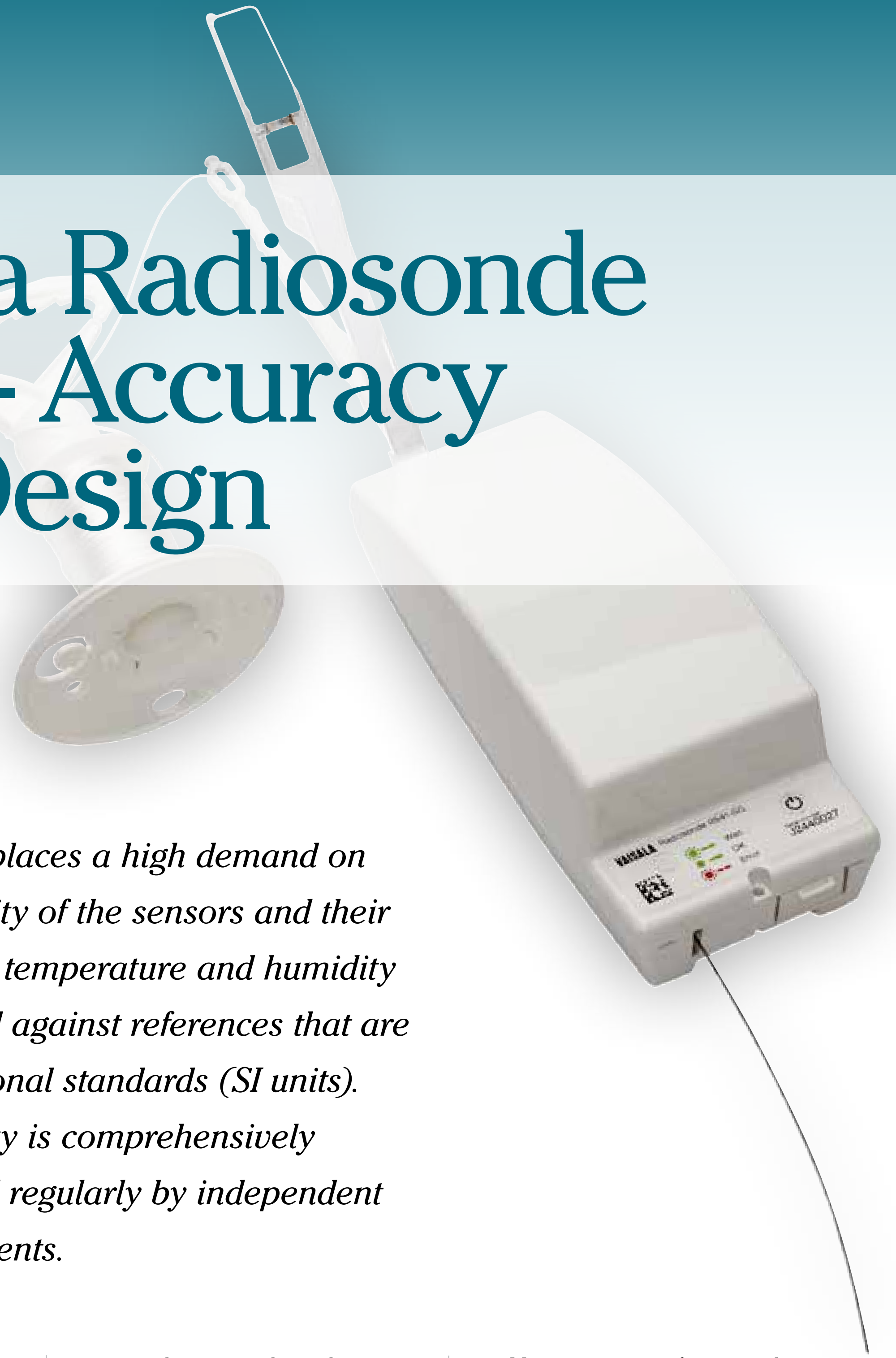
Taking a holistic view across all available data sources offers significant advantages. For example, rainfall measurement is useful on its own, but for the best level of flood prevention and detection it is essential to also look at drainage information and local sewer systems.

Most meteorological infrastructure is surprisingly versatile. For example, the same radar system that can detect oncoming storms will also be useful for gathering general rainfall data for the farming sector. Being able to predict and forecast the weather also allows for data to be gathered to build up a more detailed picture of a nation's climate, and trends within it.

Vaisala offers a range of products and systems that can be used for this purpose, from simple pressure instruments to full-scale automatic weather stations.

Smaller businesses can benefit from multi-weather sensors, combining wind speed and direction, liquid precipitation, barometric pressure, temperature, and relative humidity detectors in one instrument. Larger organisations can invest in weather radar, lightning detectors and a range of other systems to allow for the collection of detailed data.

Vaisala Radiosonde RS41 – Accuracy with Design



Correct functionality places a high demand on the consistent reliability of the sensors and their calibration. The RS41 temperature and humidity sensors are calibrated against references that are traceable to international standards (SI units). Calibration uncertainty is comprehensively analyzed and verified regularly by independent laboratory measurements.

RS41 platinum resistive temperature sensor is characterized with excellent stability, very fast response time, small solar radiation error and effective coating against wet bulb cooling error.

RS41 humidity sensor is based on the capacitive Vaisala HUMICAP® polymer technology, with heating functionality to prevent freezing and on-chip temperature measurement to eliminate solar radiation error.

Usability and error preventive design of the radiosonde and the MW41 user interface bring efficiency and reliability to operations. Ground Check Device RI41 is an important part of reliable operations. Each radiosonde is checked prior to launch to detect possible injuries e.g. during transportation.

Measurement performance has been tested thoroughly in laboratory and in several test campaigns in different climates. All this contribute to measurements that give the best possible reliability in weather forecasting.

By Raisa Lehtinen, Senior Scientist, Vaisala

Accuracy Matters in Radiosonde Measurements

Radiosondes measure critical atmospheric variables with accuracy and precision that cannot be obtained with other meteorological observations, and provide continuous profiles from the ground to altitudes of 30 km and above. Radiosonde profiles are important input for medium- and long-range computer-based forecasts, for climate datasets, and a valuable source of information for meteorologists. The quality and reliability of the measurements are essential.

Accurate weather forecasts are not possible without observations. The better we know the state of the atmosphere, the better the forecast will be. Numerical weather models are increasingly better able to benefit from the high spatial and temporal resolution data provided by radiosondes. To a meteorologist, good-quality radiosonde profiles are an essential tool in predicting severe weather – thunderstorms, lightning, wind gusts, heavy rain and hail. Radiosondes are the reference against which the validity of numerical weather models is evaluated.

Inspection of the profile establishes initial conditions and helps analyze how weather will be changing. Numerical weather models are less capable of predicting small-scale phenomena in the atmospheric boundary layer (0 – 3 km) where radiosondes provide detailed information. A radiosonde observation in the upstream direction of the weather system may give a good basis of estimating the evolution of the air mass.

Quality of Radiosonde Measurements is Critical

The balloon-launched radiosonde rises at around 5 m/s velocity and transmits continuous observations of temperature, humidity, pressure and wind as it travels through the atmosphere. Meteorologists are interested in several phenomena that are visible in the radiosonde profile, including cloud layers, dry layers, temperature inversions, jet streams and wind shear.

The radiosonde measurement must be accurate and of high precision to be useful. It is important that radiosonde sensors work reliably in changing conditions throughout the harsh environment of the upper atmosphere. Erroneous measurements could entirely change the initial state of the atmospheric analysis that drives the forecast. For example, the following challenging conditions could occur in cloudy weather situations.

As the radiosonde emerges from a cloud, the temperature sensor is in danger of experiencing a 'wet bulb' error, generated as water or

ice evaporates from the surface of the sensor. This may lead to incorrectly measuring the strength of the temperature inversion. Such erroneous observations can reduce the magnitude of the detected layer or even entirely mask the feature in the profile. This may lead the meteorologist to conclude that convection will start earlier in the day with less energy released into convection, or to predict that rain will start earlier and cool the land surface, with thunderstorms unlikely to form.

If the humidity sensor freezes while passing through clouds, the radiosonde may not correctly detect 100% relative humidity later on. Multiple cloud layers are then incorrectly detected. The upper cloud layers can block solar radiation from reaching the ground and inhibit convection.

Case Study:

Convective Weather

A real-world example can show how even small details in the radiosonde profile can be critical for understanding convective weather. During convection warm air near the ground starts rising until it cools and becomes balanced with its surroundings. Strong convection in very humid atmosphere can lead to thunderstorms.

On Tuesday August 9, 2005, a weather front approached the Helsinki capital area from South-East Finland and caused one of the most dramatic moments during the course of the 2005 World Athletic Games. The historic open-air Helsinki Olympic Stadium was hit by an intense thunderstorm with pouring rain and severe wind gusts. Emergency services issued an evacuation of the stadium and electrical power was interrupted.

The storm also caused over 200 emergency incidents near the capital area, including fires, traffic accidents and injuries from fallen trees. Railway services and ship traffic from Helsinki harbor were affected, and thousands of households were left without electricity. Despite sports fans' disappointment, everyone was able to feel safe and in good hands. The authorities had been working hard since the early morning. The Finnish Meteorological Institute had issued several thunder alerts and kept the emergency organizations up-to-date as to the changing weather.

What does the radiosonde profile tell us?

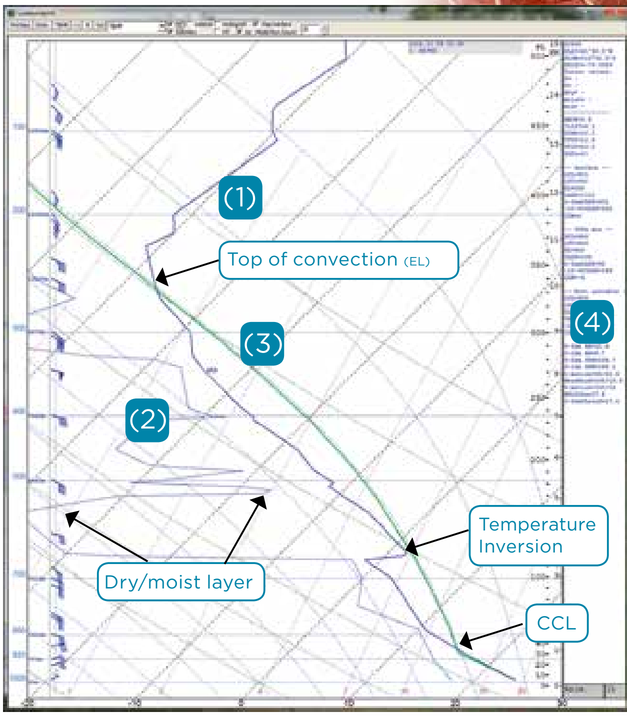
In a convective situation the analysis of the latest radiosonde profiles in the region is an essential step in forecasting. At noon on August 9, 2005, the Jokioinen sounding station in southwest Finland provided the observation depicted on the thermodynamic diagram in Figure 1. The graph summarizes the state of the atmosphere and gives the basis for understanding how the weather will evolve in the next hours. This graph gives clear indication of potentially strong convection.

The most interesting details in the graph in Figure 1 show how temperature and humidity (described by the dew point) behave through the atmosphere:

- The moist adiabatic lapse rate reveals there will be free convection, or updraft of air, starting from 925 hPa height and speeding up to 250 hPa to the Equilibrium Level (EL), where the temperature of the ascending parcel reaches the air mass temperature. The deep convective layer indicates a strong chance for thunderstorms, and the top of convection shows that thunderclouds will reach heights of around 10 km.
- There is a capping temperature inversion — a layer of warmer air — at above 700 hPa. This stable layer is difficult for an ascending air parcel to penetrate. Correct observation of the strength of the inversion is important: in this case it is not going to stop the convection.
- Humid and dry layers in the profile indicate the energy available in the atmosphere. A deep dry layer can eat moisture from lower layers and thus prevent deep convection.
- Cloud layers affect the amount of solar warming on the surface.
- The stability index CAPE (Convective Available Potential Energy) of 1,121 J/kg in this case indicates an unstable atmosphere with a potential for moderate to strong convection in a cold climate.
- The radiosonde profile shows clear evidence of the possibility of thunderstorms forming during the day. It is an important source of information for the meteorologist, especially when used with other observations and numerical weather models.

What if the radiosonde profile cannot be trusted?

The correct interpretation of convective weather requires precise and accurate observations. This example radiosonde measurement has several details where a low-quality radiosonde providing erroneous profile details could have changed the forecast entirely:



(1) Radiosonde measured temperature profile.

(2) Radiosonde measured dew point profile. Dew point is the temperature where condensation begins, and describes the moisture content of air.

(3) Moist Adiabatic Lapse Rate. Shows the rate at which air packet which has reached 100% humidity is cooling when ascending.

(4) Stability indices such as CAPE and CIN describe the likelihood of thunderstorms forming.

Figure 1: Radiosonde observation shown on a thermodynamic diagram on the Finnish Meteorological Institute meteorologist's workstation.

Incorrectly measuring the depth of the temperature inversion (Figure 2)

An evaporative cooling error of 1.0 °C when the radiosonde emerges from a cloud reduces the depth of the observed inversion layer. The temperature sensor is measuring too low values (red curve) while water is evaporating from the surface of the sensor. The estimated weak inversion layer may lead the forecaster to predict the start of convection earlier in the day, with less energy and without forming thunderstorms.

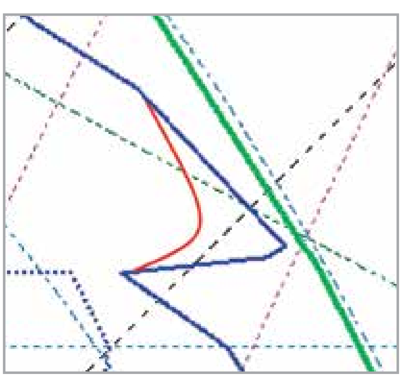


Figure 2

Incorrectly detecting multiple cloud layers (Figure 3)

If the humidity sensor freezes while passing through clouds, or is not fast enough, the radiosonde may not correctly detect 100% relative humidity in upper cloud layers. These cloud layers may be relevant in blocking solar radiation from reaching the ground, and preventing the start of the convective process.

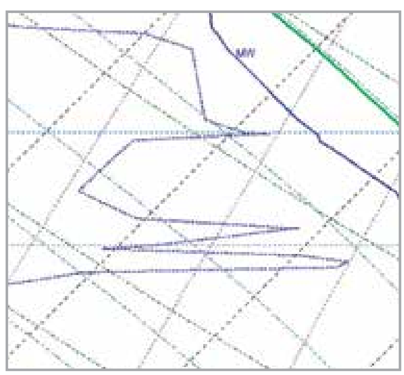


Figure 3

Incorrectly detecting a capping inversion (Figure 4)

A one-degree error in the dew point measurement near the surface turns the inversion layer at 925 hPa into a capping inversion. A similar effect could occur if the temperature profile has offset due to incorrect calibration. The resulting thermodynamic diagram indicates that solar warming of the surface will not create enough lift and energy to break the air parcel through the warmer inversion. This prevents the release of convective energy in upward drafts and the formation of thunderstorms. In these weather conditions, it is important to measure accurately the temperature and especially the humidity in the lowest kilometer.

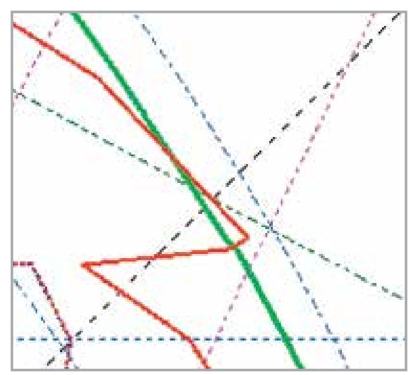


Figure 4

Summary

Radiosonde profiles like these are an essential part of a meteorologist's decision making process in weather forecasting. Their information is relevant for both long-range forecasts and for estimating how weather will change in the next few hours. An erroneous radiosonde measurement may lead the meteorologist to underestimate or overestimate the arrival of severe weather. Correct measurement helps protect lives and property.

Vaisala Goes to America

with Steve Chansky & Ken Goss

Vaisala exports 97% (2014) of its products to countries around the world. The history of Vaisala entering these international markets between the 1950s and the 1980s is exceptionally interesting and important. One of the most challenging markets to enter was the United States. Steve Chansky, former President of Vaisala Inc., and Ken Goss, former Director of Sales, Meteorology, North America, played a pivotal role in the establishment and success of Vaisala Inc. as a market leader in the US.

Vaisala's First Sale

Vaisala's story in the United States begins with the foundation of the company itself. **Vilho Väisälä** received an order on April 14th, 1936 for 20 radiosondes from Professor **Carl Gustav Rossby** of the Massachusetts Institute of Technology (MIT) in Cambridge, who was planning an expedition to Cuba and needed radiosondes for the trip. The radiosondes were shipped from Finland on July 30, 1936. This sale is considered to be the starting point for Vaisala as a company. The sale included not only a radiosonde device but the exporting of an entire system and the methodology for conducting reliable soundings.

Of course, the invention of a functional radiosonde, sounding equipment, and methodology to acquire weather data had generated interest before the order arrived from MIT. Vilho Väisälä received an inquiry, on February 20, 1936, from the US Navy to license the manufacturing of radiosondes in the United States. In his response, Prof. Väisälä stated that this could be a possibility, however this did not lead to further negotiations.

Despite the company's impressive history, Vaisala spent decades trying to enter the US market. In fact, Vaisala was entering markets all around the world successfully, from Africa to Latin America and Australia to mention a few. Vaisala Sudamericana was for example established already in 1960 in Argentina. The same year, Vaisala SAF was established in South Africa. Asian markets opened up for Vaisala in the mid-sixties.

Entering the US Marketplace

In the United States, a company called LaBarge had been producing special radiosondes for the GATE-research program. **Pekka Kostamo**, Development Manager at Vaisala, met with LaBarge during his travels in the United States in the mid-seventies and learned that they wanted to expand its operations into meteorology. The company was interested in a cross-licensing agreement to be able to provide radiosondes to the United States Weather Bureau. Vaisala had learned that there was no way to successfully operate radiosonde business in the US without in-country manufacturing. It was also too risky to begin such operations alone. There was synergy between the two companies and Vaisala already had gained experience in licensing negotiations in the 1970s from Algeria, Brazil, Italy and South Africa. Several negotiation rounds were held in 1976. Vaisala was tempted by the large US radiosonde market, and there were three alternatives: direct sales into the country, partnering with LaBarge, or establishing Vaisala, Inc.

The negotiations were complicated and ended without resolution. In the end, Managing Director, Yrjö Toivola decided to enter the US market with the establishment of Vaisala Inc.

Vaisala's US Subsidiary Established in Boston

Heikki Kellomäki, was a senior Vaisala executive, with extensive international management experience. When the decision was made to enter the United States market in earnest, Heikki and his family moved to Boulder, Colorado for one year. The idea was to explore the option of setting up Vaisala Inc. in Boulder, which was already an established location for the atmospheric sciences. However, it soon became clear that initial business activity would grow with industrial applications rather than meteorology.

Therefore, the decision was made to locate Vaisala's subsidiary in Boston. From a recruitment perspective, many bright business professionals were located in Boston including graduates from MIT and Harvard. The first location, a 2500 square foot site in Woburn, was found by Heikki, who quickly started the process of recruiting a President of the newly formed subsidiary. Heikki was very knowledgeable and experienced in Vaisala's business. He began to recruit candidates that were alumni from MIT and Harvard. **Steve Chansky**, was one of the first recruits, hailing from MIT.

Steve Chansky was not looking for a job but had his resume on file at MIT. Steve, who had a background in occupational health instruments, explains, "I got a call from Heikki asking if I wanted to be interviewed. I was then asked to fly to Helsinki, where I met with Yrjö Toivola, **Jan Hörhammer**, and **Rauno Sirola** and others." The interview took place in the summer of 1981. "Vaisala was a small company then, somewhere between 30-40 million dollars per year. What impressed me the most however was the advanced technology and semiconductor production facility. I said to myself, after looking at the humidity instruments, I can really screw up and still be successful – because the technology was so much more superior to any competitor products." Steve knew that despite the fact that the industrial humidity business was starting from scratch in the US - and the chance for success was low with this unknown Finnish company, he felt confident that Vaisala would be successful, because the products were so strong and the technology was solid.

Together Steve and Heikki hired more people; **John Kussman** was

Vaisala Woburn office, Massachussetts, early 1980s.

Vaisala Woburn office, 2015

hired to run direct sales humidity business, and **George Anderson** was hired to manage representatives. In the autumn of 1981 the team worked together on getting the industrial humidity business off the ground for Vaisala in the United States. Steve says, "we were placing ads in journals, and following up on leads. We were also given a whole bunch of leads from Finland that had been gathered previously to follow-up on."

Starting from Scratch

There were some challenges in starting two different business models simultaneously. Specifically, one business sold instruments to thousands of (primarily) industrial customers. The other model involved selling instruments and systems primarily to government customers with long buying cycles, a different procurement process that required preparation of lengthy proposals, and going up against entrenched US competitors.

The first big successes came with the industrial business in selling humidity products. "We identified markets, placed ads in papers, got leads and did sales visits, very aggressively from the get go. This model continued successfully and quite soon after the subsidiary was established, Vaisala was in competition for a major government authority contract. "There was a request for tender in the Commerce Business Daily for several hundred instruments to be used at airports. We saw this as a major opportunity, and started communicating with the Helsinki office." Steve and the team managed to push for R&D to focus on this opportunity quickly. As a result, a prototype design was developed to suit the FAA tender, with modifications to existing instruments, and this allowed us to make a sales call to the FAA. We won the business, a 300,000 US dollar contract." According to Steve, the ability to move quickly and deliver a prototype and convinced the FAA that we are a legitimate competitor was the first major victory for Vaisala in the US. "We took the competitor completely by surprise and won the tender right from under their noses." Steve explains.

Getting the Radiosonde Business Started

As the industrial humidity business began to gain traction, the next priority was to hire a Sales Manager to head up the meteorology business. In April 1982, **Ken Goss** was hired to help ramp-up sales for weather observation equipment. Ken recalls having lunch with Steve and Heikki and got an offer to join this small company.

Ken joined and actively began to pursue the National Weather Service (NWS) radiosonde business. There were also some defense opportunities that were quickly identified. Ken picks up the story, "unfortunately, at the time, the NWS had a very close relationship with another radiosonde manufacturer. They were the preferred supplier of radiosondes at the time. When the opportunity finally came, there was tremendous enthusiasm in the company to work with the NWS. Unfortunately this first bid was not successful. Ken adds with a smile, "but we won the next one." In 1990, Vaisala won its first NWS radiosonde contract, an important strategic objective for the company in the United States.

It was not all doom and gloom however, as that same year, in 1985, a huge multi-million dollar contract with the Navy opened up. This was for 100 sounding systems and radiosondes, and this time Vaisala was ready with the Marwin system. Based on specific US Navy needs, Steve and Ken met with the Navy who was working with another competitor at the time. "We were able to convince the US Navy to buy an off-the-shell product, COTS (commercial, off-the-shelf). This Vaisala sale was actually the first-ever COTS purchase by the US Navy."

Vaisala began to plan the setup of a new facility in the United States to build radiosondes. One key reason was that the US government was very reluctant to buy products made outside the country. "There was a strong 'Buy American' sentiment, it was the era of the Cold War, and Finland was not understood very well, in fact people were rather suspicious of Vaisala. Therefore, to be able to sell products in the US, we had to set up a production operation in-country and were forced to transfer proprietary technology to the US, including manufacturing documentation. Without this facility we would not have been able to sell to NWS or the US defense forces, and this was a requirement that everyone understood in Helsinki as well."

Ceilometers Take Off

"In the 1980s there was an opportunity to sell ceilometers," Steve explains. "At that time, Vaisala had purchased a ceilometer manufacturing line from a French company just before the opportunity came about."

Ken explains that the technical requirements were beyond the capabilities of the recently acquired French design. "Working with **Risto Kalske** however we were able to redesign the product to meet the 5000ft specification requirement in testing and qualified to offer on the bid."

To prepare for the NWS opportunity, Steve flew to Helsinki and a proposal was created in two weeks, demonstrating to the NWS that Vaisala can build and deliver a working ceilometer.

"Vaisala won the business, over 1,000 ceilometers." Ken says.

This was a big victory for the company, the result was that Vaisala gained 80% world-wide market share for ceilometers. The US production contract alone was worth millions of dollars over several years. "That was a key success story for Vaisala Inc." Steve recalls. At this time, ceilometer production was started in Boston as well.

Acquisitions and Establishing Boulder Operations

Vaisala had been aggressive in its US strategy and this included the acquisition of companies with weather-related products. In 1999, for example, Vaisala purchased AIR, a radiosonde manufacturer as well as Handar, who had been awarded a contract for automated surface observation systems, ultrasonic wind sensors, and also a visibility product contract for a major customer. Through these acquisitions, Vaisala gained new business and industry-leading expertise.

Boston was home for Vaisala Inc until 2001, when the decision was made to relocate US headquarters and move production to Boulder, Colorado. Vaisala had also started to manufacture dropsondes for hurricane research and operational storm reconnaisance.

In March 2002, Vaisala acquired Global Atmospherics Incorporated of Arizona, which was the world's largest lightning detection equipment manufacturer and lightning data services operator. With this acquisition, Vaisala strengthened its lightning capabilities and began to operate the National Lightning Detection Network® (NLDN).

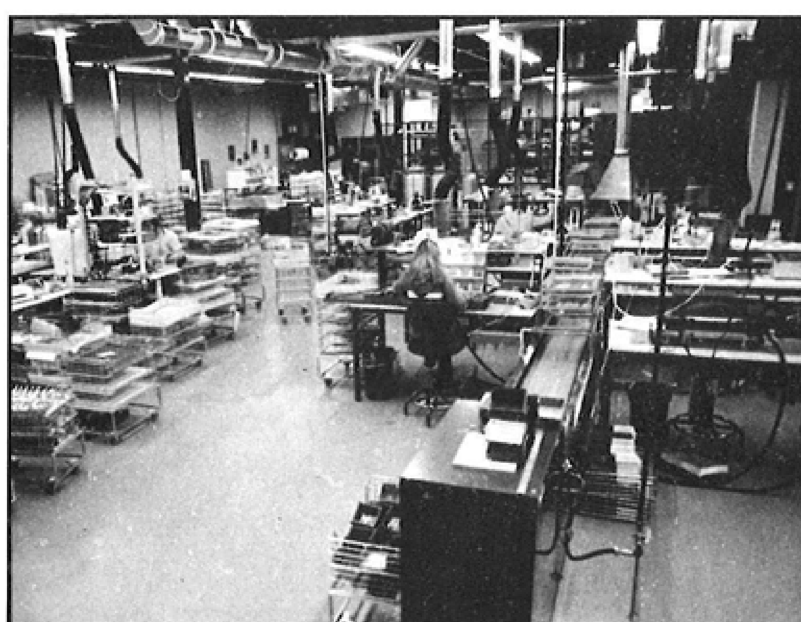
In 2006, Vaisala was working to develop its weather radar business and soon acquired Sigmet, located in Westford Massachusetts, to build up this capability. Today, Vaisala weather radars are setting industry standards around the world.

In total, Vaisala has acquired 13 US companies in the United States during its 80-year history. Most recently, Vaisala acquired two US companies, Second Wind and 3TIER, to strengthen its ambitions for the renewable energy market.

Future Positive

When asked about the future of meteorology and his thoughts on what lies around the corner for Vaisala. Ken says that, "information services is a challenging business area, but it is a core competence that Vaisala

Vaisala's radiosonde manufacturing facility in Woburn, MA.



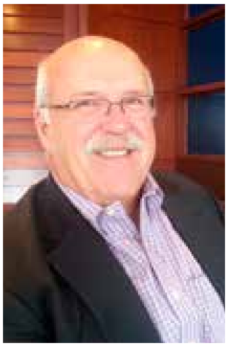
Ken Goss (left) and Steve Chansky (right) in the radiosonde factory, 1984.

has. The strategy is the same, Vaisala has good products to sell, and they are superior to the competition, so let's go out there and look for the opportunities."

Today, headquartered in Boulder, Colorado, Vaisala Inc. employs some 450 staff and has offices across the country serving all Vaisala customer groups; Meteorology Infrastructure, Transportation, Energy, Life Sciences and Industrial Measurements.

Steve Chansky Bio:
Education: Bachelor of Science, Chemical Engineering followed by Master of Science, Chemical Engineering, Massachusetts Institute of Technology (MIT), 1967. Steve completed his MBA at Northeastern University in 1976.

Steve worked for Vaisala from 1981 through 2004, and served as President and CEO, Vaisala Inc., Woburn, MA. Currently, Steve is a Board of Directors member at Aerodyne Research Inc.



Ken Goss Bio:
Education: BA degree in Biology from Boston University followed by an MS degree in Environmental Science from University of Massachusetts.

Ken worked 33 years at Vaisala as Director of Sales and Marketing for the Meteorology business. Ken's focus was on selling meteorological instruments and systems to government customers building a team to serve the operational, defense, and research market segments.

Focus on High-Quality Measurement

Vaisala and MIKES Metrology, now part of VTT Technical Research Centre of Finland Ltd, share a long history of cooperation already from the early 1990s.The mutual interest of both parties' lies in the high-quality, reliability, and accuracy of measurement.

What Is MIKES Metrology?

MIKES Metrology specializes in measurement science and technology and is part of VTT Technical Research Centre of Finland Ltd. MIKES realizes the SI units (the International System of Units) in Finland, carries out top level research in measurement science, develops measurement techniques for the industry and society, and offers calibration and specialist services, and training.

MIKES's high-quality laboratories provide the most accurate measurements and calibrations in Finland – over 1600 certificates per year. MIKES also performs high-level metrological research and develops measuring applications in partnership with industry.

Past Projects

In a recent interview, Dr Martti Heinonen, Research Team Leader of MIKES, mentions one of the early mutual projects with Vaisala: developing a calibration system for the Vaisala radiosonde.

Cooperation Today

Currently Vaisala and MIKES Metrology are participating in the European Metrology Programme for Innovation and Research (EMPIR) within a project named as HIT. This project develops measurement and calibration for relative humidity at high temperatures, over +100 °C, and for dynamic measurements. Vaisala is a partner in this research project. Vaisala and MIKES have also been partners in developing new, optical measurement technologies in CLEEN Oy's 5–year SHOK–program called Measurement, Monitoring and Environmental Assessment (MMEA).

The MeteoMet project – metrology for meteorology – is another project where Vaisala and MIKES are participating. The project aims to ensure the metrological traceability to the International System of Units (SI) through national standards in met eorological observations and climate data. The project covers several aspects of meteorological observations from upper air to ground based-measurements. It includes development and testing of novel instruments as well as improved calibration procedures and facilities. The project also includes in-situ practical calibrations, an instrument intercomparison under real dynamic conditions, and dissemination of best practices. Additionally, Vaisala's reference dew point transmitters are calibrated at MIKES Metrology and also NIST-traceability for humidity measurement is recognized by MIKES.

Mutual Benefits of Cooperation

According to **Heikki Turtiainen**, Technology Manager at Vaisala, cooperation with MIKES has always been very fruitful. Dr **Martti Heinonen** continues, "It's a pleasure to work with an equipment manufacturer who is genuinely interested in the quality of measurement. Rather than conducting studies for the sake of them, we can find useful solutions that have large global impact." Cooperation with MIKES Metrology will continue in the future, not only in the field of calibration but also as MIKES Metrology develops new and advanced measurement technologies

AstraZeneca Increases Efficiency with Continuous Monitoring System in Leading Manufacturing Facility

Astra Zeneca is a global, science-led biopharmaceutical business. They are one of the handful of companies to span the entire life-cycle of a medicine from research and development to manufacturing and supply, and the global commercialization of primary care and specialty care medicines. Operating in more than 100 countries, Astra Zeneca employs around 57,500 people worldwide. The company has manufacturing in 17 countries, and their innovative medicines are used by millions of patients worldwide. To ensure the products are protected during manufacturing, packaging and storage, AstraZeneca maintains strict controls over environmental parameters. The company adheres to cGMP (Current Good Manufacturing Practices) and strives to meet or exceed all requirements that ensure the purity, safety and efficacy, from manufacture to final distribution.

Astra Zeneca's leading high technology facility is located in Södertälje, Sweden, and it is one of the biggest tablet manufacturing facilities in the world. In 2015, it employed around 3200 persons.

In 2013, AstraZeneca Sweden Operations decided to acquire a new monitoring system for the Södertälje plant. They wanted to further improve their monitoring capabilities, for example, in regards to automating the checking of the measurement points.

Project Manager **Mats Andersson** was responsible for the selection and installation project of the system for AstraZeneca: "We made a careful evaluation of various systems. Vaisala was one of the candidates, as we had a long experience with their monitoring instruments. We were rather sure their system would fit our needs, and our thorough evaluation proved it was so."

AstraZeneca's key considerations for the new monitoring system were reliability of the measurements, the monitoring options, and the possibility to extend the system according to the needs.

"With no need to check the monitoring points manually, we can further increase the efficiency of our operation", says **Mikael Ruda**, Associate Director for maintenance at the Södertälje plant.

The project was phased, and started in full swing in 2014. In the first phase, Vaisala installed and validated their part of the project in one week. After that, AstraZeneca continued with own validation and other preparations. In the next phases of the installation project, AstraZeneca added a lot of instruments to the system by themselves: "In a vast facility such as in Södertälje, it's a big benefit that we can add and especially validate new instruments by ourselves, and expand the system with new and even with existing instruments. We have done many extensions since the start of the project", tells Mats Andersson.

After the initial installation for a group of super users at the end of 2014, AstraZeneca extended the system also for other factory personnel, who uses the system in their daily work.

With Vaisala's Continuous Monitoring System, AstraZeneca collects information about temperature, humidity and differential pressure in the production facility. This information is being used to safeguard the product quality. Since Vaisala's Continuous Monitoring System fulfills the regulatory requirements as well, AstraZeneca can easily show their compliance for regulators as well.

The Challenge

Historical reporting
To ensure compliance all pharmaceutical companies must have reporting capabilities that prove adherence to the strict regulations within the industry, and satisfy auditors.

Guaranteed Product Quality
Astra Zeneca adheres to the cGMP practices (Current Good Manufacturing), and have their own strict quality standards. The production environment consists of several environments, which are kept in certain, regulated conditions.

Internal Efficiency
Astra Zeneca wanted to have a modern and reliable system with automated readings, which would enable more efficient way of working.

The Solutions

High Performing System
Vaisala's Continuous Monitoring System can use a wide array of high-performance sensors to measure temperature, humidity, differential pressure and more. Flexible, user-selectable notification options allow alarms to be sent via-email or text to PC's and mobile phones. viewLinc monitoring software supports several languages, with Swedish among them.

Meet Quality Standards
When monitoring the environment real-time, AstraZeneca can ensure that they fulfill their own high quality standards, and the strict regulations of the industry.
An extensive humidity and temperature mapping carried out by Vaisala in a large part of AstraZeneca's production environments in Södertälje gives Astra Zeneca detailed information to further improve their operations.

Increased Internal Efficiency
The Vaisala Continuous Monitoring System provides secure, permission based access from any PC on AstraZeneca's existing network. The license allows for an unlimited increase of the number of loggers or users to the system. The real-time, distant readable data increases internal efficiency, when manual readings of the loggers are no longer necessary.

Compliance with Strict Industry Regulations
Reports are compliant with FDA 21 CFR Part 11, including audit trail and several graphing / reporting options.

Benefits

Scalable solution. The ViewLinc software is fully scalable without extra costs, so AstraZeneca can add new loggers in the system, and extend it to as many users as they consider necessary.

Efficiency. Reduction in man-hours through remote and automatic reporting and monitoring.

Regulatory Compliance. Quick, easy reporting allows AstraZeneca to prove compliance to multiple governmental and regulatory agencies.

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