

# SPREAD THE MESSAGE

## The 'Moving Weather' message system

The senior manager of meteorological services in Dubai reviews the systems and operations supporting not only Dubai International, but other existing and developing airports in the UAE

**I**n Dubai, double-digit growth in passenger traffic was reported for a third consecutive month in August 2009. Paul Griffiths, Dubai Airports CEO, has stated that Dubai International's sustained growth supports projections for a record-breaking year for the region's leading airport.

Dubai Met provides aviation meteorological services to Sharjah and Ras Al Khaimah International Airports in the northern Emirates, as well as Dubai International. Services will be further extended to Al Maktoum International at Dubai World Central when the new airport facility opens for business mid-2010.

In 2006 Dubai was booming, Emirates airline had (and still has) 'out of this world' expansion plans, and Dubai International Airport was looking to increase capacity to meet the forecast traffic growth. In the Meteorological Services department a reliance on in-house data handling, weather prediction, and forecast production systems was not only proving to be a serious risk to the operation, but was also clearly inappropriate to support the service levels essential for meeting key stakeholders' future requirements. A strategic plan was put in place to overhaul the entire operation to ensure meteorological systems provided the required stability, redundancy and capacity to meet the increasing pressures being placed on the service.

It has long been a focus of the Dubai Met management to work closely with strategic partners, providing constructive feedback relating to product development. This strategy is not entirely altruistic, although meeting the specific goals is obviously a key objective. The development of operational systems that are fully configurable to allow for a changing environment as well as implementation in a range of meteorological services around the world is also a high

priority. Work is done on the premise that the wider the customer base, the more diverse the user requirements and feedback will be, hence the more sophisticated the product development.

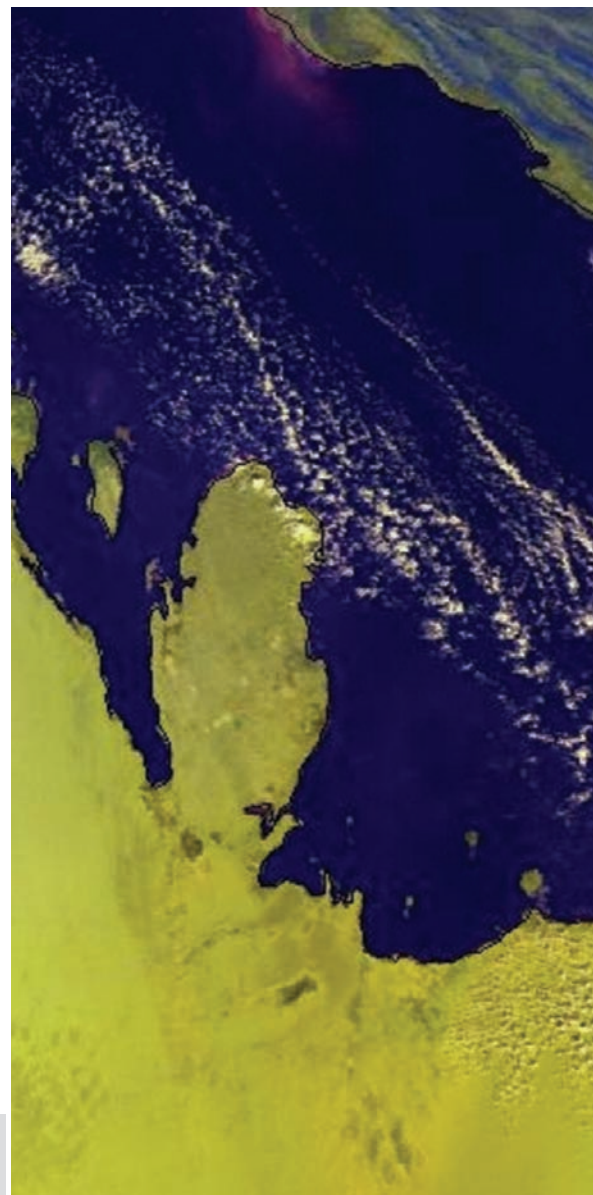
Due to budget restrictions the implementation of a plan had to be phased over a number of years. The starting point was the replacement of the internal data handling with a message switching system. This acquisition, twinned with an upgrade to SADIS 2G, marked the beginning of a valuable relationship with IBL Software Engineering of Bratislava in the Slovak Republic.

### Moving Weather message

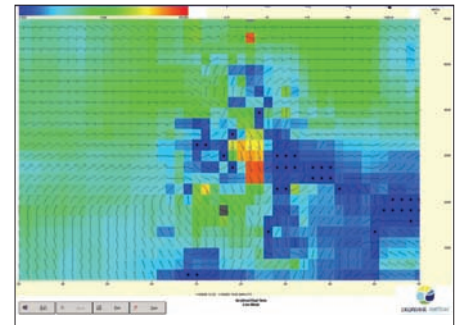
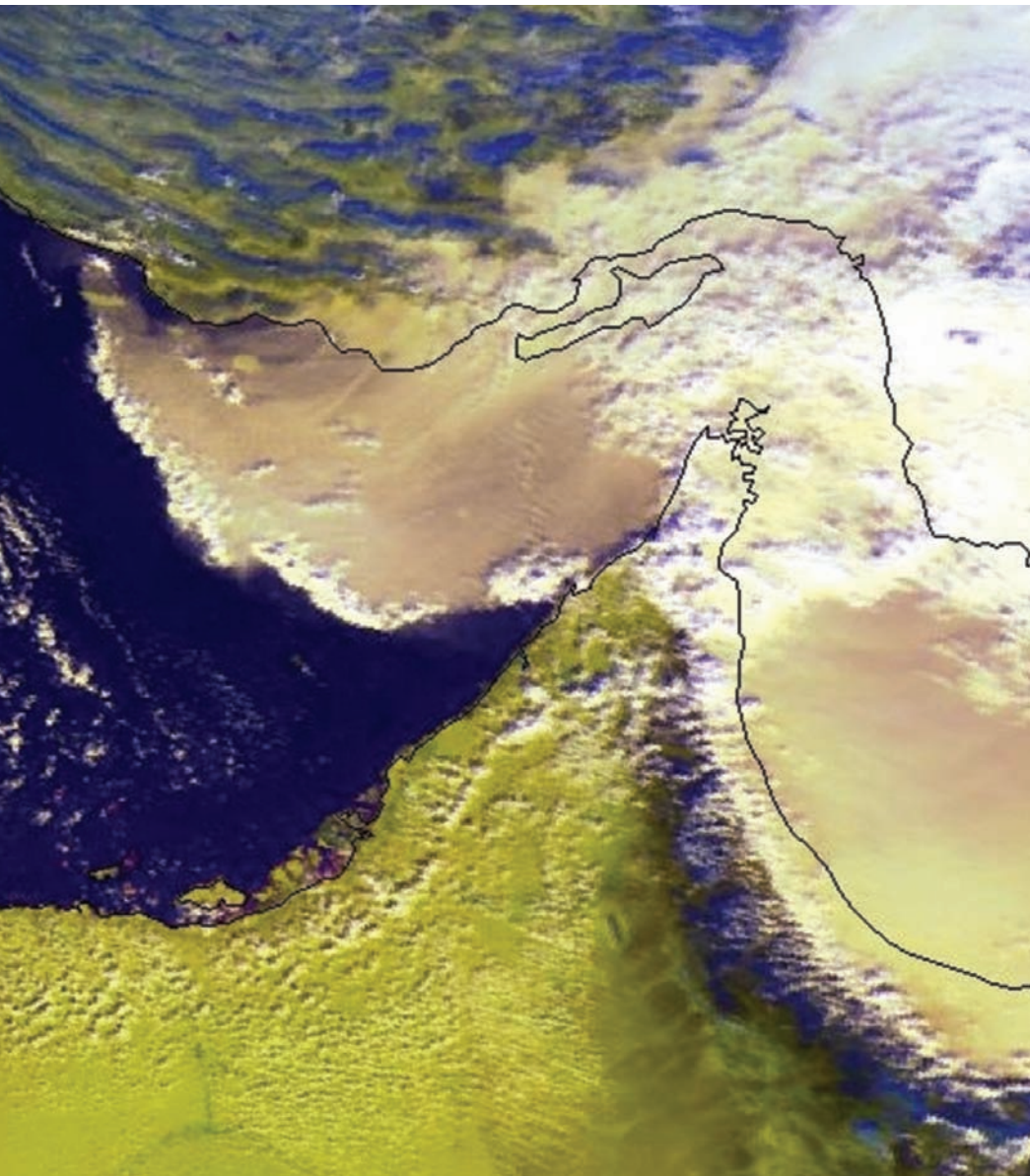
The installation of a Moving Weather (MW) message switching and data handling system provided a stable platform around which the rest of the plan could be built. IBL proved to be an ideal partner, keen to develop system functionality based on customer feedback, suitably enhanced by its exceptional software capabilities. MW ingests all met data feeds, ensuring efficient data storage, archiving and distribution around the network.

A major shortfall in the United Arab Emirates, and indeed the Middle East region in general, is the lack of upper air data, which is vital for accurate weather prediction. A single UAE upper air station at Abu Dhabi International Airport, 115km to the southwest of Dubai, launches a weather balloon twice daily. Due to local weather patterns this ascent does not accurately represent the boundary layer conditions prevalent in Dubai. **Accurate fog prediction was top of the list of priorities voiced by Emirates Airline, fog being the major**

**Satellite image, depicting a severe sandstorm approaching Dubai from the north east**



“A major shortfall in the Middle East is the lack of upper air data, which is vital for accurate weather prediction”

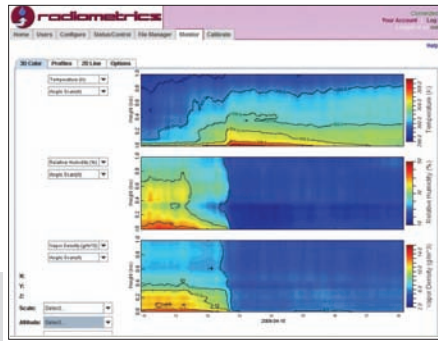


An example of a diagram showing wind profiler gravity waves over Dubai

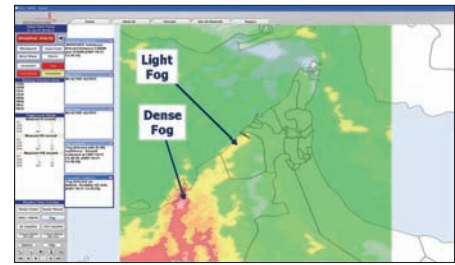
weather threat to its rapidly expanding hub operations. The second concern was low-level wind shear, producing high energy approaches, leading to go-arounds affecting cost and airport capacity. Before being able to address these concerns it was apparent that further weather surveillance equipment would be required to generate a clear picture of the atmospheric conditions within the boundary layer. It was with these concerns in mind that a project was launched to acquire a wind profiler and radiometer to provide quasi real-time vertical profiles of wind, temperature, humidity, and vapor density at the airport.

A second strategic alliance with Weather Decision Technologies (WDT) of Norman, Oklahoma, USA was born as this project evolved. The final solution delivered by a consortium of companies led by WDT encompassed not only the wind profiler and radiometer but also an aviation weather decision support system (AWDSS) and a mesoscale weather prediction model.

The AWDSS fulfils a multitude of roles: ingesting data from all surveillance equipment at the airport, including MSG satellite, radar, AWOS, OPMET, wind profiler, and radiometer data. The system enables data overlays to be toggled on and off, producing a detailed situation display of current weather conditions. WRF model data is used to add the predictive elements for low-level wind and temperature requirements. Zoomed in, the AWDSS will present individual AWOS sensors along the dual parallel runways, or on a regional setting, the synoptic situation for the whole UAE and southern Arabian Gulf. The critical aviation safety side of the AWDSS provides automated real-time nowcasts in the form of



Aviation weather decision support system radiometer graph showing temperature vs. height



Aviation weather decision support system showing incoming fog south-west of Dubai

alerts and warnings for meteorological conditions such as fog, thunderstorms, low-level wind shear, squalls, microbursts, inversions, gust fronts, and sea-breeze fronts. The failsafe feature monitors all data inputs and visually disables warnings should the alert algorithm be compromised by lack of critical data. An audio alert warns meteorologists that input systems have failed.

A prime reason for working with WDT was its licensing agreements with key research facilities including the Massachusetts Institute for Technology (MIT)/Lincoln Laboratories, Canada's McGill University, and the National Severe Storms Laboratory. These relationships made it possible for the AWDSS to incorporate leading-edge monitoring, analysis, and forecasting technologies.

### Wind shear and nowcasting

Radar-based wind shear detection and nowcasting algorithms used in the AWDSS include: Integrated Terminal Weather

System (ITWS) microburst detection algorithm, which detects microbursts within 40km of the airport and maps the aerial extent of aviation hazards associated with the microbursts.

The ITWS runway alerting and along-runway microburst wind shear estimation system uses output of ITWS microburst detection algorithm to determine if microbursts or divergent wind shears are impacting the runway or near-ground operations areas, and determines expected air speed loss along the flight path.

The TDWR Machine Intelligent Gust Front Algorithm (MIGFA) detects gust fronts, synoptic fronts and other convergent boundaries and predicts their movement up to 30 minutes in advance.

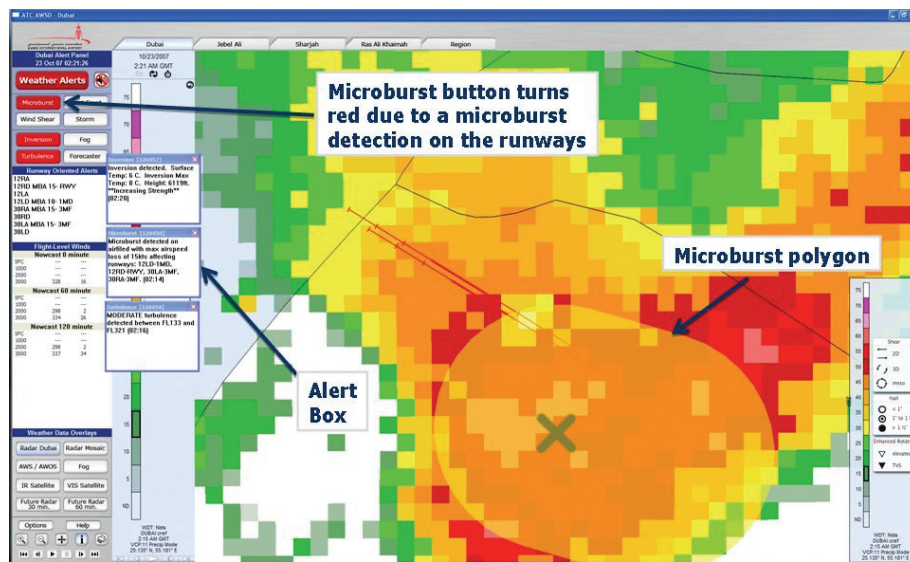
Finally, the TDWR runway alerting and along-runway gust front wind shear estimation system utilizes output of TDWR gust front detection algorithm to determine if gust fronts or other convergent wind shears are (or will) impact the runway or near-ground operations areas, and

determines expected air speed gain along the flight path.

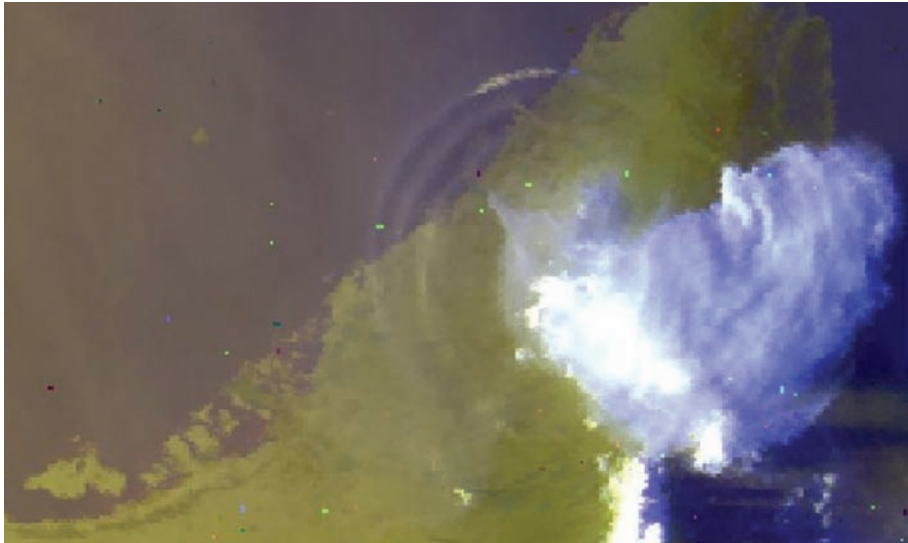
Wind profiler and radiometer data has dramatically increased the understanding of the boundary layer structure during the occurrence of various weather phenomena that routinely affect the airport. From a forecasting viewpoint the data has confirmed long-standing theories that were unverifiable prior to the installation. A scenario that was locally referred to as 'too humid for fog' has been proved and empowered forecasters to reduce the frequency of fog forecasts when surface conditions alone would indicate a high-risk event. Radiometer data has shown that a very humid boundary layer in excess of 1,000ft deep cannot radiate sufficient heat to reach saturation during the course of the night. Cooling at the top of the boundary layer frequently leads to stratus development, further limiting radiative cooling.

Other scenarios have produced details that have come as a complete surprise, or identified features that were previously completely unknown. A good example is seen in the HRPT satellite image and wind profiler time cross-section (Figure on p37) concentric gravity waves triggered by an isolated thunderstorm to the southeast of Dubai on September 11, 2009, which passed over Dubai during the late afternoon. Although surface winds remained light throughout the transit of the waves, the wind profiler identified the feature by a brief period of increased southeasterly winds between 3,000ft and 4,000ft.

Continuing the relationship with IBL, the company's Visual Weather forecaster's workstation was installed in late 2008. Visual Weather was already a powerful visualization tool, but with the development of the Message Editor forecast production tool the IBL system has become what all other forecaster workstations strive to be: it is the complete package for a forecaster – a truly integrated system. The Message Editor was developed by IBL based primarily on the Dubai in-house system but with



Display for air traffic controllers, showing a microburst alert for a storm that is impacting Dubai airport



**High-resolution picture transmission showing gravity waves over the Dubai area**

considerable streamlining and enhancements to the functionality. Wherever possible, model data is used as a 'first guess'; repetition of data entry has been eliminated and the delivery of multiple products to multiple destinations is completed with a single mouse click. The Message Editor works in parallel with the Personal Task Manager – a rolling forecaster work schedule and platform from which charts for analysis or forecast products are launched. The efficiencies introduced by these tools, together with multiple alerting systems, gives the forecaster greater freedom

server problems. The model is run on a local cluster that has 32 available nodes and currently outputs data at 12km horizontal grid with NX of 257, NY of 193, NZ of 36 and a 72 second time step using eight nodes.

A second model run with a similar configuration runs concurrently on another eight of the nodes for testing purposes. This second test run was helpful in finding isolated problems with the input data to the three- and four-dimensional assimilation systems, which enabled important improvements to the main model's forecast output data. Two problems were identified

## “A major shortfall in the Middle East is the lack of upper air data, which is vital for accurate weather prediction”

and confidence to concentrate more time on weather forecasting and less on the systems and product dissemination.

### Weather research and forecast

In parallel with the AWDSS, WDT installed a weather research and forecasting (WRF) mesoscale numerical weather prediction system. This model is run in advanced research WRF (ARW) dynamic solver mode every three hours for a 48-hour (hourly output) forecast period.

Each run is cold-started using GFS (global forecast system) for initial data and boundary file data input, with 3D-Var and FDDA (Four-Dimensional Data Assimilation) assimilation systems used on locally available input data. High-resolution sea surface temperature data is also assimilated at the start of the model run. Additional GFS data is also downloaded to act as backup in case of internet or GFS

in the early stages of tuning relating to local data ingest. Several data-sparse regions encompassing mountain and desert areas were included within the model boundaries. Isolated observations in these locations had an unrepresentative influence on the model output. Data quality both locally and regionally, also proved problematic. Two important changes were therefore made to the way local input data was handled. First, the radius of influence of the point observations in the FDDA system was reduced to 50km; second, the quality control program, which handles preliminary ingestion of observations, was modified to enable blacklisting of selected parameters on selected sites. This surgical selection ensures that good data is not thrown out with bad in the preliminary QC stage. Local sources include vertical data from the radiometer and wind profilers, regional automatic weather stations and marine observing

stations, providing higher-density data assimilation than the global scale model systems can provide.

The output from the model is used in various ways. GrADS is used to display and analyze model output on a Linux workstation. NAWIPS (Advanced Weather Interactive Processing System) is also used for display and comparison of model output for evaluation purposes. The RAOB program (RAwinsonde OBServation) visualizes ascent and time cross-section products. IBL's Visual Weather workstation also ingests model output for display and overlay purposes. Finally, model data is used within AWDSS to display vertical wind and temperature data at various levels for ATC purposes.

A high level of redundancy is built into the WDT hardware configuration, but by way of a totally independent backup a SOO/STRC (Science and Training Resource Center) WRF-EMS (environment modeling system) is configured and ready to run on a standalone standard desktop PC.

Although not specifically part of the strategic plan, a long-standing relationship has been developed with Vaisala of Helsinki, Finland. A MIDAS IV automatic weather observing system (AWOS) was installed in conjunction with the construction of the second runway. Vaisala is also presently involved in the installation of its new AviMet AWOS at Al Maktoum International. As Met and ATC approach radar services will be provided from Dubai, the installation contract includes the integration of the AMI AWOS with the Dubai system. An additional contract has been awarded for the upgrade of the Dubai AWOS to AviMet, to ensure complete compatibility between the airports by mid 2010.

Moving forward, further development of these strategic partnerships will remain a priority, improving weather surveillance and data gathering with a view to meeting the exacting service levels demanded by our key stakeholders. ▀

*Dave Thomas is senior manager of meteorological services for Dubai Air Navigation Services*