

An integrated automatic aviation meteorological instrument system at C. S. I. airport, Mumbai

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सार – मई 2008 में मुंबई अंतर्राष्ट्रीय हवाई अड्डे में एक समाकलित स्वचालित विमानन मौसम विज्ञान उपकरण प्रणाली (आई. ए. ए. एम. एस.) लगाई गई। यह प्रणाली आधुनिकतम है और इसमें वायुवाहित पॉयलट को विमानन मौसम रिपोर्टों के स्वचालित प्रसारण के लिए ए. टी. आई. एस. (स्वचालित टर्मिनल अंतरापृष्ठ प्रणाली) और उपयोगकर्ता ऐजेंसियों को विमानन मौसम रिपोर्टों के प्रसारण हेतु एम. ई. टी. ए. आर./एस. पी. ई. सी. आई, ए. एफ. टी. एन. (वैमानिकीय अचर दूरसंचार संजाल) संपर्क वाली विमानन रिपोर्टों के स्वचालित उत्पादन जैसी विशेषता है। इन विशेषताओं के अलावा इस प्रणाली में कार्मिकों द्वारा मौसम प्राचलों की प्रविष्टि करने की सुविधा है जिनके लिए विमानन रिपोर्टों के उत्पादन हेतु मेघ आच्छादन, विगत मौसम, वर्तमान मौसम जैसे संवेदक उपलब्ध नहीं हैं। यह प्रणाली विश्व मौसम विज्ञान संगठन के दिशानिर्देश (वि. मौ. सं. 1992) के अनुसार पवनों के वेक्टर औसतन और अंतर्राष्ट्रीय नागर विमानन संगठन (आई. सी. ए. ओ. 2004) के प्रचालनात्मक वांछनीय परिशुद्धता की आवश्यकताओं को पूरा करती है। मुंबई हवाई अड्डे पर पिछले एक वर्ष में इनकी प्रेक्षणात्मक अनुक्रिया सहित इस नई प्रणाली की विभिन्न तकनीकी विशेषताओं को मुख्या रूप से इस शोध पत्र में बताया गया है। इसी प्रकार की प्रणाली अन्य प्रमुख हवा अड्डों नई दिल्ली (चार स्थानों) चेन्नै, हैदराबाद, बंगलूरु, अमृतसर, जयपुर और गुवाहाटी लगाई गई है। टेलवेंट कंपनी, आस्ट्रेलिया द्वारा इस प्रणाली की आपूर्ति की गई है और संस्थापित की गई है।

ABSTRACT. An 'Integrated Automatic Aviation Meteorological Instrument System' (IAAMS) is installed at Mumbai International Airport in May-2008. The system is State-of-the-Art and has features like automatic generation of aviation reports; METAR / SPECI, AFTN (Aeronautical Fixed Telecommunication Network) connectivity for dissemination of aviation weather reports to user agencies and ATIS (Automatic Terminal Interface System) for automatic broadcasting of aviation weather reports to airborne pilot. Besides these features system is having facility to enter manually weather parameter for which sensors are not available such as cloud coverage, past weather, present weather for generation of aviation reports. The system meets the requirements of operational desirable accuracy of International Civil Aviation Organization (ICAO, 2004) and vector averaging of winds as per World Meteorological Organization guidelines (WMO, 1992). The paper is mainly focusing on the different technical features of this new system along with its observational response in last one year at Mumbai airport. Similar system has been installed at other major airports; New Delhi (4 sites), Chennai, Hyderabad, Bangalore, Amritsar, Jaipur, and Guwahati. The system is supplied and installed by Telvent Company, Australia.

Key words – WMO, ICAO, AFTN, METAR, SPECI, VOLMET.

1. Introduction

At CSI Airport, Mumbai, there are three operational CAT-I runways; namely 27 RWY, 09 RWY and 14 RWY. The runways are named in terms their directions from 000° to 360° in azimuth. At Mumbai airport, 27 RWY is the main runway and is mostly in operation for landing

and take off operations. At each of these sites it is mandatory to provide meteorological observational support for aircraft operations as per the ICAO guidelines (2004) stipulated in Annexure - III.

Prior to installation of this new system, the required meteorological observations from these three sites were

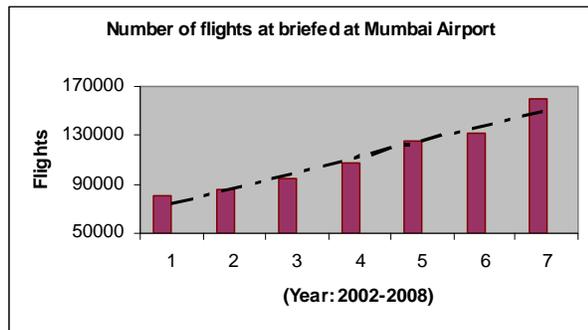


Fig. 1. Increase in the number of flights at Mumbai airport in recent years.

available through analog systems round the clock. But since the systems were working in discrete mode, most of the operational requirements were manually generated and was leading to a tough task at one of the busiest international airport like Mumbai. Fig. 1 displays the rise in number of flights being briefed manually in the last few years at CSI airport, Mumbai. Now at Mumbai airport, 'On-Line Meteorological Briefing System' (OLBS) is operational, through official web site <http://amssmumbai.gov.in>, in place of conventional manual meteorological briefing to the pilots.

To be in phase with the rapid advancements in aviation field globally, there was an urgent need to modernize the aviation meteorological services and improve upon substantially the quality of aviation products. Study of recent developments in aviation meteorological services by Tyagi (2000) and De and Majumdar (1997) have clearly indicated this aspect. At some of the airports in the country for measurements of wind data, temperature and dew point, the existing CWIS systems have been replaced four channels Integrated Automated Current Weather System, Biju *et al.*, (2008). The new IAAMS installed at CSI airport, Mumbai integrates all meteorological parameters; wind speed, wind direction, temperature, dew point, meteorological optical range (MOR), runway visual range (RVR) and pressure (QNH, QFE) from multiple sites and processes it to give desired operational output.

2. System description

At CSI airport, Mumbai, the IAAMS consists of 3 Met sites (27, 09 and 14 runway) linked to meteorological briefing room and ATC control tower, through landline and wireless network, as shown in Fig. 2. Site selection and system installation is as per ICAO requirements.

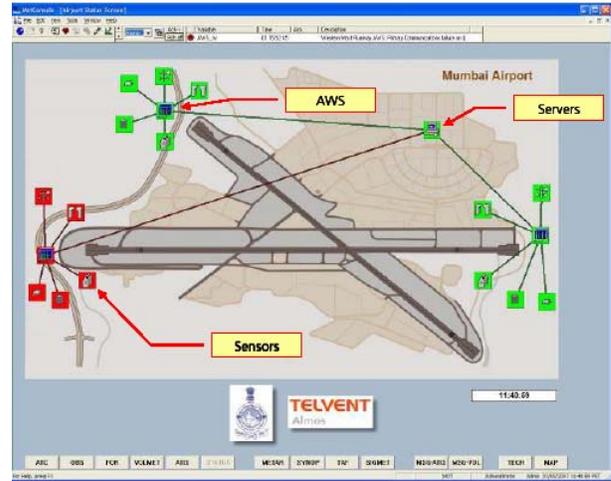


Fig. 2. Airport meteorological instruments sites at Mumbai airport

Each meteorological observation site at Mumbai airport near TDZ consists of following setup; Operational measurement uncertainty requirements and instrument performance is as per WMO Guide No. 8, Annex. IB (2006)

(a) Digital current weather instruments

It consists of 16 bit Data Logger (Telvent Make), Temperature & Humidity sensor (Young Model), Wind Speed/Wind Direction sensor (Vaisala Make), Atmospheric Pressure sensor (Vaisala Make) with Automatic Weather Station (AWS) for measurement of; temperature (-5 to +60°C), relative humidity (0 to 100 %), surface wind speed (0 to 65 knots), wind direction (0° to 360°), mean sea level pressure QNH and station level pressure QFE values. For temperature and humidity measurements sensor is combined.

(b) A dual base Transmissometer for measurement of meteorological optical range (MOR) near touchdown zone, background luminance for assessment of runway visual range (RVR) during poor visibility.

(c) Ceilometers used for cloud ceiling (30ft to 25000ft) and cover measurement.

(d) Communication system for data transmission to main server in meteorological office.

Sensors sample weather every one second interval except for Meteorological Optical Range (MOR) & Runway Visual Range (RVR) which is every 15 sec as per ICAO. Data is sent *via* Cable Modem over 10 pair twisted cable and as a redundancy data is sent *via* wireless modem

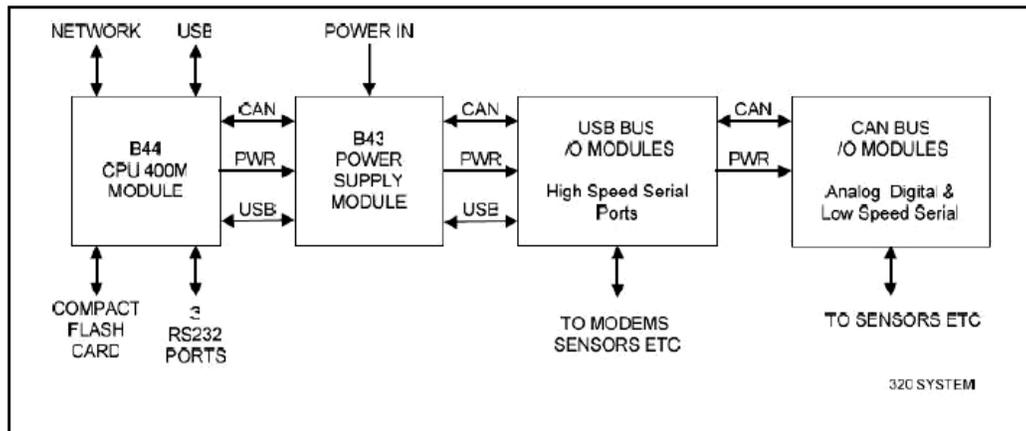


Fig. 3. Block diagram of Automatic Weather Station (AWS)

operating at 2.4GHz. Data is received at Dual Hot Redundant Central Data Processing Server at Meteorological Briefing Room (MBR). Server computes RVR (1min and 10min average), 2min and 10min average winds, and METAR / SPECI reports. The description of each unit along with sensors used is given below.

2.1. Data Logger (AWS)

Telnet320 is a new generation modularized Data Logger has functionality to interface number of meteorological sensors; from precision temperature, voltage and current measurement, to communications interfaces for intelligent sensors. (Including special optical sensors for wind measurements) Data Logger receives data from Transmissometer, Laser Ceilometer and sensors of wind direction (WD), wind speed (WS), atmospheric pressure sensor; temperature (TT), humidity (HH), sends data *via* cable modem and wi-fi modem as redundancy. Wind and temperature / humidity sensors are mounted on the mast. Barometric pressure sensor is enclosed in Nema Data Logger enclosure. RVR (Transmissometer) and Ceilometer units are connected to AWS through modems.

The block diagram of the AWS is shown in Fig. 3. The system consists of 400 MHz CPU for handling most complex software algorithms and interfacing requirements. It has removable flash memory card and onboard RAM card for storage. Operating system used by the Telmet320 is Windows-CE responsible for processing the information read from meteorological sensors.

100/10 Base-T Ethernet interface and high speed serial ports are available for communications. USB BUS I/O provides the interfacing for sensors requiring high data rate. CAN BUS I/O provide interface to all the

sensors, other than high speed sensors located on USB bus. Power supply section provides regulated power to all the modules. Data Logger housed is in a sealed Nema enclosure mounted on the 6m wind tower near Touch Down Zones (TDZ) of runways 09, 27 and 14 at Mumbai airport. Tower is provided with a lightning rod, grounding connections and LED obstruction lights. The height of the Data Logger enclosure is 1m above ground on the tower to protect the unit in case of flooding.

The primary communication channel between AWS at site and main met-server is through DDW100 SHDSL (Single pair High speed Digital Subscriber Loop) modem. Three of these modems located in the main server rack, connecting to each AWS. Communications redundancy between Met Console and AWS is provided with 802.11g wireless network. The data is also transmitted (3.0 watt signal) to Kalpana satellite, by right circularly polarized 'Yagi' antenna, mounted on AWS at 402.75MHz to be received at Pune and Delhi IMD earth stations each hour. Three numbers of ALWIN1 digital displays are at each AWS sites for data monitoring.

Telnet320 Data Logger operates on a 12V/100AH maintenance free battery with a float charge through 220V AC mains and solar panel as a redundant charge source.

2.2. IAAMS Meteorological Sensors

2.2.1. Temperature / Humidity Sensor

RM Young (USA) 41382VC, Atmospheric Temperature and Relative Humidity sensor is used. It is installed on cross arm of the wind mast at correct height, away from electrical or other devices that may generate heat. As humidity changes, the thin glass film inside the

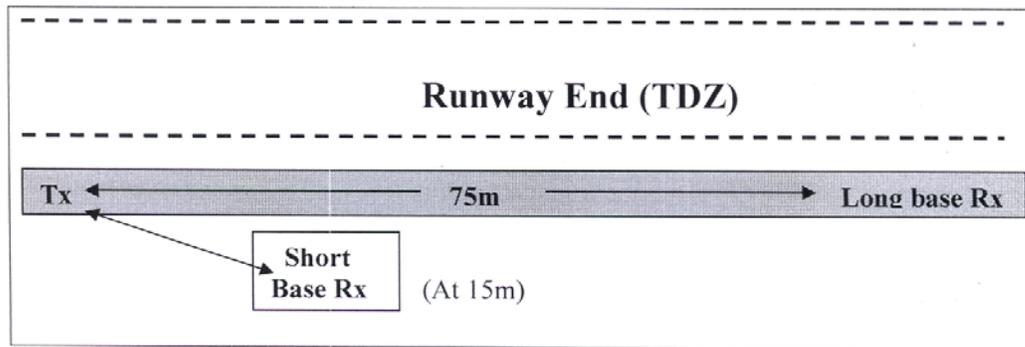


Fig. 4. Layout of Transmissometer unit near Touch-down zone of runway

sensor dampens or dries and causes change in the capacitance. This capacitance is converted to an output voltage linearly proportional to ambient relative humidity. A temperature sensor mounted in the instrument provides an air temperature reading and allows the probe to automatically compensate for temperature effects on the humidity measurements.

Range and Accuracy

Air temperature : Range -50°C to $+50^{\circ}\text{C}$;
accuracy at 0°C : $\pm 0.3^{\circ}\text{C}$

Humidity : Range 0-100 % RH; accuracy
at 20°C : ± 2 % RH

Calculated dew point uses the accuracy of the temperature and humidity sensors, providing approximately $\pm 0.2^{\circ}\text{C}$ accuracy. Data processing of temperature and humidity sensor is performed by Data Logger. Dew point is computed by Data Logger using the actual temperature and humidity data.

2.2.2. Barometric Pressure Sensor

Vaisala PTB220B sensor is used for measurement of pressure. The sensor is installed in the AWS enclosure (for rain water protection and effects of winds for maximum accuracy) interfaces *via* combined RS232 signal and power cable. Two of these sensors are used at 27 RWY and 14 RWY. The barometric pressure sensor measure air pressure against a small evacuated chamber and compensates this measurement against the measured air temperature.

Range and Accuracy : 500 to 1100 hPa, ± 0.2 hPa
accuracy.

The barometric pressure value is station level pressure (QFE). From this data and known station level

height with temperature information, mean sea level MSL pressure (QNH) and isothermal pressure (QFF) are computed in met server for displaying in hPa or inches.

2.2.3. Wind Speed and Direction Sensors

Vaisala WAA151 Anemometer sensor is used for wind speed and Vaisala WAV151 Wind Vane for wind direction. Both these sensors are mounted on supplied wind cross arm, with WAV151 sensor on the northern most point of the cross arm and WAA151 on southern most point of the cross arm.

WAA151 is an optoelectronic, fast-response, low threshold anemometer, providing linearity over entire operating range (up to 75m/s). The output of sensor is train of pulse generated from a photo transistor, can be regarded as directly proportional to wind speed.

WAV151 Wind Vane is counter-balanced, low threshold optoelectronic wind vane with infrared LEDs and photo transistors mounted on GRAY coded disc. This disc creates changes in the codes. The code is changed in the step of 5.6° .

There is a heating element inside the shaft assembly of both wind speed and wind direction sensors, to keep the temperature of bearings above freezing level in the cold climates. A thermostat is recommended for switching the heating power below $+4^{\circ}\text{C}$.

2.2.4. Transmissometer (Revolver) Unit

Dual baseline Transmissometer (Revolver) is installed at all the three runway sites. Transmissometer consists of transmitter, long base receiver at 75m from transmitter and a short base receiver at 15m from the transmitter as shown in Fig. 4. Transmitter emits sharp xenon flashes at the rate of 60 to 6 flashes/min, depending on the prevailing visibility.

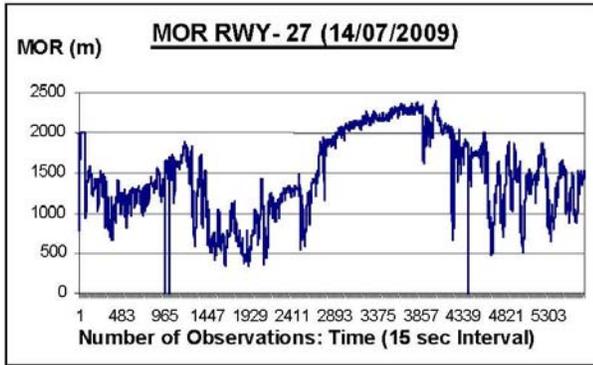


Fig. 5. Meteorological optical range at runway 27

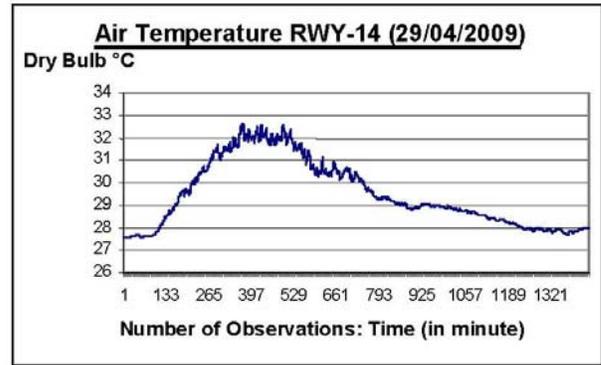


Fig. 9. Air Temperature Observations at runway 14

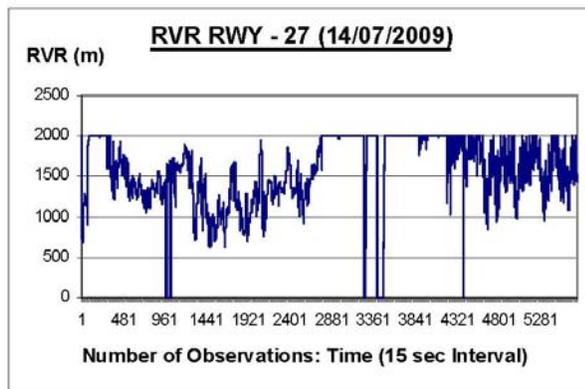


Fig. 6. Runway Visual Range at runway 27

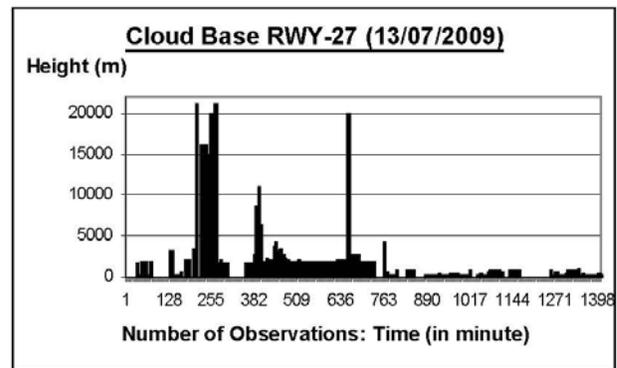


Fig. 10. Cloud Base Observations at runway 27

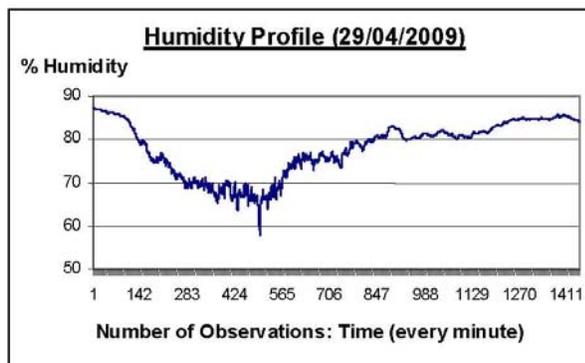


Fig. 7. Humidity Observations at runway 14

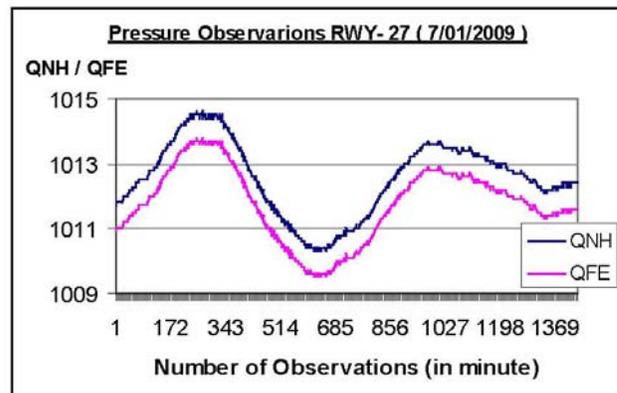


Fig. 11. QNH and QFE Observations at runway 27

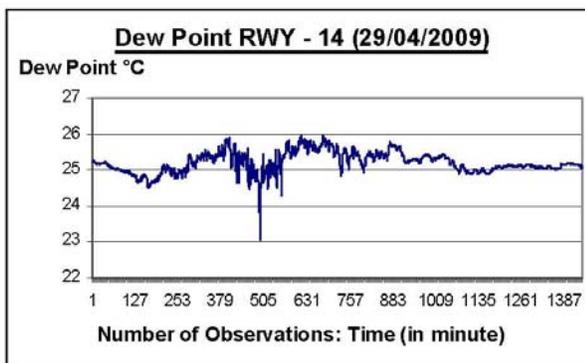


Fig. 8. Dew Point Observations at runway 14

Flash propagates through medium between transmitter and receiver, suffers two loses, scattering and absorption. Resultant flash after suffering scattering and absorption is received by long base receiver and short base receiver, through revolver glass window (this is having facility for rotating at six fixed positions by stepper motor placed inside receivers as well as transmitter). Receiver measures intensity of received flash. The revolver transmitter microprocessor communicates with the transmitter, long base receiver and short base receiver and RVR interface boards *via* 5-wire RS422 links. The

revolver microprocessor also communicates with the automatic weather station (AWS) / PC via a 1200 baud N81 DPSK two wire modem line. The ratio of the raw receiver intensity value to the raw transmitter intensity value is used to generate the scaled value. The scaled value is adjusted to compensate for the contamination of the revolver glass disks; the result is then adjusted to compensate for low visibility during the calibration process. This is then compared to the values measured during the calibration process (the calibration factors) to find the current transmittance value. The receiver uses a highly selective 532nm optical filter to ensure the visibility measurement is taken at the peak sensitivity of the human eye. The light source transmitter optical module includes a light detector to monitor the light output level of each light pulse. After the microprocessor obtains the transmitter and receiver intensity measurements, it calculates the current MOR. These results are then sent to the AWS or to a remote PC for further processing to calculate the current RVR.

A dual baseline system uses either the long receiver or short receiver intensity, depending on the current visibility. Normally Revolver is programmed so that long base is active for decreasing visibility up to 100m and improving visibility up to 400m. In other cases short base receiver is active. (However these values can be changed as per user requirement).

2.2.5. Transmissometer optical alignment of system

Measuring the beam of light requires that the light transmitter and receiver units are precisely aligned to face each other. This optical alignment is critical for reliable operation of the Revolver and is carried out in two stages. First a manual coarse adjustment is done by the installation engineer, followed by an automated fine adjustment performed by the software.

2.2.6. Transmissometer contamination check and compensation

Front glass window of transmitter, long base receiver, and short base receiver is having facility for fixing at six positions automatically with help of stepper motor facility. When revolver window glass is cleaned (for all three sub units) and calibration check is performed, Revolver system computes transmittance for all six positions. The position at which Transmittance is the highest is identified as clean position. Contamination factor of other five positions are computed by the calculating ratio of transmittance of that position with reference to the clean position. Revolver calculates contamination factor one every 10min interval (during which there are no changes in prevailing visibility) for

transmitter, long base receiver and short base receiver. When contamination factor is more than tolerable value, glass takes another position till all five positions are effected, then Revolver sends dirty signal to central processing computer server, so that Revolver glass can be changed with that of cleaned one. Contamination factors are used by processor in the transmitter for incorporating correction in the Transmittance computation. For this special feature this Transmissometer is named as Revolver.

2.2.7. Laser Ceilometer (CBME 80)

Ceilometer detects height of base of three successive cloud layers from 30ft to 25000ft with accuracy of $30\text{ft} \pm 2\%$ of the true height of the cloud. It works on principle of LIDAR. Ga-As Laser diode (905nm) is used as transmitter, sends pulses at the rate of 1.0 KHz with pulse width of 100nm. Laser pulse partially transmits through cloud and also gets reflected. Reflected laser is received by avalanche photo diode in the receiver biased at near breakdown region. Height of base of cloud is calculated from travel time of laser pulse using formula;

$$h = (c \times t) / 2$$

'c' is velocity of light.

't' is travel time.

'h' is the height of base of cloud.

CBME 80 is also having facility for computing amount of cloud coverage in OKTA. If for last 10min interval Ceilometer continuously receives echo at same height without any break Ceilometer assumes cloud coverage as 8 OKTA (overcast condition). Laser Ceilometer samples every 30sec (sample interval can be changed in user settings) and finally generates a string containing cloud heights and thickness of three layers. String is sent in RS232 format.

2.2.8. Central Data Processing Server and ALWIN Display Hub

Central Data Processing Unit (CDPU) server computes RVR, generates aviation weather reports such as METAR / SPECI. Server is of dual hot redundant, *i.e.*, failure of one server causes system to switch over to redundant server without loss of data and *vice versa*. CDPU sends outputs processed weather information containing numerical and graphical reports to work stations. Server gets manual data through following work stations.

- *Observer's Work Station* : Manual data such as cloud coverage in OKTA, Past Weather, Present Weather for generation of reports and manual data in case of sensor failure or erratic, can be entered in this screen.
- *Forecaster's work Station* : TAF/ SIGMET reports.

Server outputs following information :

- *Maintenance Work Station* : Information pertaining to status of working of sensors, Power supply to sensors, Health status from sensors / accessories at runway site, Status of communication, which enables service engineer to attend fault in minimum time.
- *Weather View Work Station* : In the ATC for viewing current METAR / SPECI / TAF information, numerical display of sensor data from three runway sites etc. SPECI are generated automatically by the system depending upon the changes in the meteorological parameters like temperature, pressure (QNH), dew point, MOR, RVR, clouds, vertical visibility, wind speed, wind direction and present weather. SPECI criteria are configured in accordance with ICAO recommendations.

Data processing is performed by Met-Console software package specially developed for the system. The software has different features like; login window, data quality, data range, force variables, history of records, data property, unit of measurements, status bar and extensive help tool. The system collects data from the remote sensors and external interfaces, processes and displays it, compiles required meteorological and ATC messages and outputs them to defined external interfaces. Central data processing server disseminates reports through AFTN Network to various user agencies. All servers are having 30min power backup UPS.

Sensor data is entering into ALWIN Display Hub (ADH) in addition to CDP. Processor in ADH computes RVR, Numerical weather information (instantaneous, 2min average, 10min average) to Digital Slave LED Display (144 mm × 144 mm size). The purpose of ADH is even in case, CDP server fails at least Numerical Weather Data will be available on LED displays to manage the operational works.

3. User login screens

Different graphical screens are available for users and system administrators depending upon their requirements. Some of the login screens are shown in Figs. 14 - 16.

- *Observer's Screen* : This is showing sensor info and runway threshold (Fig. 14).
- *ATC Screen* : Air Traffic Controllers may view data showing the threshold stations. Navigation buttons are provided, for user to go to message preparation templates / other operational screens (Fig. 15).
- *Technician Screen* : For showing sensor status data (Fig. 16).
- *Forecaster's Screen* : To display weather parameters that the Forecasters shall use in performance of their duties.
- *User Trend Screen* : For detailed graph to be made of the chosen weather parameters.
- *Current VOLMET Screen* : To display current VOLMET bulletin (meteorological information to aircraft in flight).
- *Current outgoing ATIS Screen* : To monitor current outgoing ATIS and its content.
- *Airport Status Screen* : To overview the operational status of the system components used.
- *Message Screen* : To generate / amend messages, sending / canceling the message.
- *METAR / SPECI Screen* : Allows editing of the METAR / SPECI messages.
- *Synop Message Screen* : Allows manual generation of the Synoptic message by the user.
- *TAF Message Screen* : Allows manual generation of the TAFOR message by the user.
- *Sigmat Message Screen* : Allows generation of the SIGMET message by the user.
- *Map Screen* : This provides a view showing the threshold stations.

4. Calibration of meteorological sensors and transmissometer

4.1. Temperature sensor

RM young sensor offered by the firm is checked against standard PT100 Digital Thermometer in a temperature and humidity chamber at 'Instrument Division, IMD Pune' and the error is within the acceptable

limit of 0.2°C as per requirements. Even this error is corrected using software through serial port in the sensor so that sensor is calibrated.

4.2. Humidity sensor

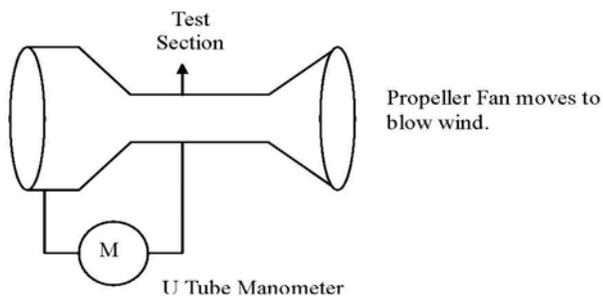
It is compared with buffer solution; saturated vapor pressure over a salt solution is fixed and constant at a given temperature. Error is corrected using serial port of air temperature / relative humidity (atrh) sensor

4.3. Pressure sensor

Pressure Sensor is compared from 850 hPa to 1050 hPa using standard sensor; Druck DPI-540, which is in turn compared against dead weight tester. Error values are checked within 0.2 hPa through out the range and error is fed back to the processor of sensor for auto correction. Also temperature is changed from 0°C to 50°C to check whether software in the sensor is compensating against temperature.

4.4. Wind Speed Sensor

It is checked in wind tunnel against alcohol manometer, with the sensor put in Test Section as shown in Figure below.



By controlling propeller speed using controlled current wind of desired value can be created. Wind creates low pressure in test section compared to section having more area of cross section. As a result differential pressure raises alcohol column in U tube manometer, and raise in alcohol column is a measure of wind speed. Raise in alcohol level is proportional to square of wind speed. Wind speed computed is compared against sensor in test section for total range and error value is fed back to sensor in calibration settings and got corrected. Sensor used is Vaisala make WAV151 works on principle of optical chopper.

4.5. Calibration of Transmissometer

Calibration of Transmissometer is performed on clear visibility day with MOR more than 10 km. This

involves fine optical alignment with the help of software at site and then using the standard optical filters of 50% and 13%. Clean all the windows of Transmissometer with distilled water and smooth cloth. Now introduce optical filters in front of transmitter optics, after giving 'Clean' command to the system.

With 50% filter the observed MOR reading is 324.6m for long base and 64.9m for short base. With 13% filter MOR is 110.3m for long base and 22.1m for short base. With both filters together (6.5%), MOR is 82.3m for long base and 16.5m for short base. Maximum of 1% deviation of the observed value is acceptable as per ICAO recommendations and this 1% deviation can be compensated in server computation. In case of deviation is more than 1%, then optical alignment is required to be repeated.

5. Meteorological Observations Recorded by IAAMS at CSI Airport

Since time of installation of the system, meteorological observations were continuously available for operational use at the airport. To understand the different operational features of the system, some of meteorological observations recorded by the system on different days are represented graphically in Figs. 5-11. Due to high sampling rate of observations by the sensor, the plot resolution is high as seen in the Figs. 5-10.

Meteorological Optical Range (MOR) and Runway Visual Range (RVR) are sampled every 15 sec interval. With MOR going below 2000m, RVR is being reported as per the guidelines. [ICAO/ (2004) Doc. 9328-AN/908]. Here the observations of 14th July, 2009, recorded for runway 27, are graphically represented in Fig. 5 and Fig. 6 (Santacruz station reported rain fall of 147.6mm on 14 July 2009 and 274.1mm on 15 July 2009). From the graph it is seen that the due to rains at Santacruz station, the MOR recorded by the transmissometer is varying throughout and correspondingly, computed values of RVR are also varying, with lowest MOR reported as 336m at 0708 UTC and corresponding computed RVR is 624.68m. The quick response of the system during the deterioration of the visibility due to rains and later during improvement in the visibility is clearly seen here. On few occasions due to communication error, zero values are being reported as seen in the graph; they are filtered while reporting.

Figures 7 to 9 are humidity, dew point and air temperature profiles recorded for 14 runway site, on 29th April, 2009. Here the observations are recorded every minute. Percentage humidity is indicating significant variations from 87.22 % at 0001 UTC (early morning) to

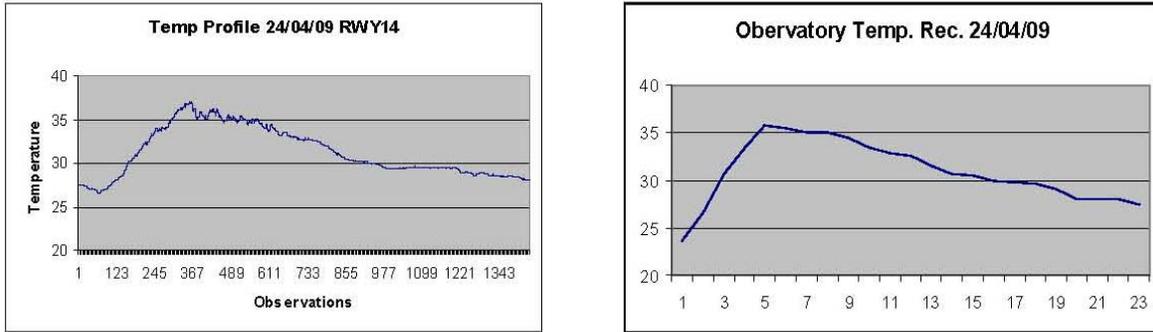


Fig.12 (a). Comparison of IAAMS and Observatory temperature recorded

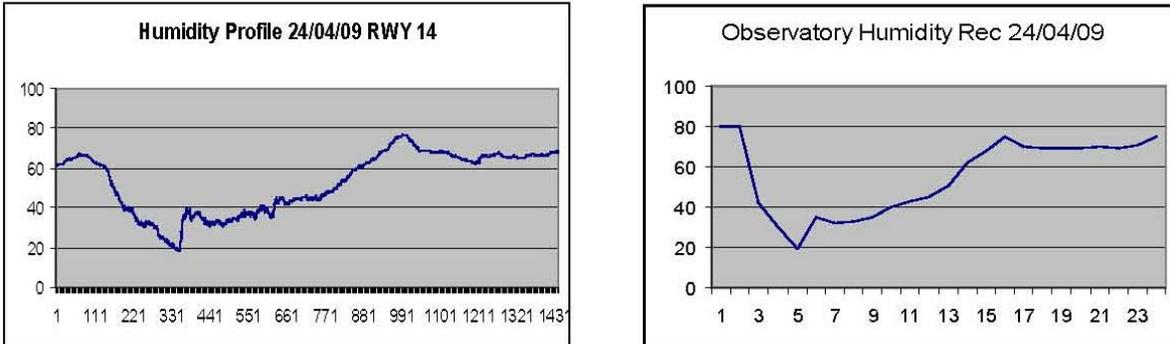


Fig. 12 (b). Comparison of IAAMS and Observatory humidity recorded

60.7 % at 0811 UTC (late afternoon) with the rise in temperature during the day. Later again percentage humidity shows a rising tendency. Correspondingly the dew point (in the system it is computed from temperature and humidity values) is showing variation from 23.08°C at 0813 UTC to 25.94°C at 1119 UTC. The span of dew point variation is about 3°C as compared with about 5°C span of air temperature variation in 24 hours. It is seen that the temperatures are varying from 32.67°C (maximum temperature) at 0607 UTC to 27.53°C (minimum temperature) at around 0014 UTC. The maximum temperature recorded from nearby Santacruz observatory was 34.0°C and minimum was 26.8°C, which fairly agrees with the IAAMS observations. Efficiency of jet engines depends upon the difference between the outside air temperature and the maximum temperature attainable in the combustion chamber (Handbook of Aviation Meteorology, 1994). Hence take off load crucially depends on dry bulb temperatures indicating necessity of accuracy of measurements.

Fig. 10 indicates the measurements of 13th July, 2009, by the Laser Ceilometer installed at 27 runway site. The observations are recorded every minute and height is expressed here in feet. From the histogram it is seen that the maximum height of the base of the cloud reported was 21000ft. This is also called as vertical visibility (VV) and is very useful to the pilot at the time of landing especially when in cloudy conditions. Varying heights of the base of the clouds recorded by ceilometer indicate detection of different types of clouds at throughout near touchdown zone. Alternatively, at aerodromes with a number of runways and even so more touchdown zones several ceilometers should be installed, as stated in Manual of Aeronautical Meteorological Practice (ICAO 2004/Doc 8896), to report the cloud base being representative for the location. It should be remembered that it is a point observation and met observer in the tower must assess the sky cover and clouds amount carefully. Depending upon the stipulated conditions of the VV, special report (SPECI) is generated automatically by the system.

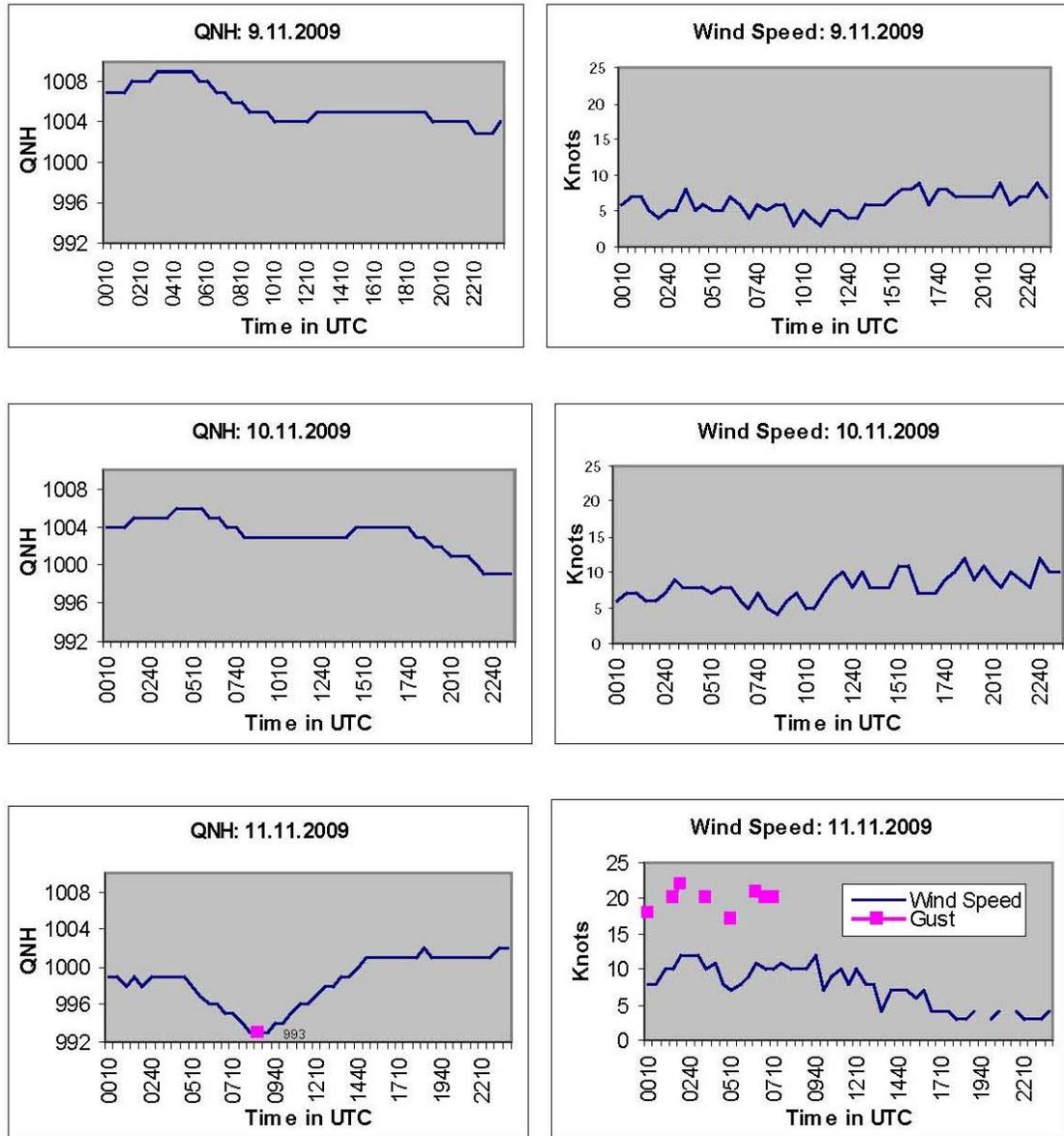


Fig. 13. Observations recorded by IAAMS from 9th-11th November, 2009 during 'Phyan'

Aircraft altimeter setting is very critical especially for its landing operations and with the help of QNH / QFE values recorded by meteorological pressure sensors; the pilot is able to set the altimeters in the aircraft. Hence accurate measurement of these parameters is very much essential. Fig. 11 indicates the variation in the QNH and QFE values for 27 runway site in 24 hours on 7th Jan, 2009. From the graph the diurnal variation of pressure as expected is clearly seen with two maxima and two minima. For a given site, the difference between these values is always constant and hence both the curves follow each other. At Mumbai airport as mentioned

earlier, two semiconductor pressure sensors are installed at 27 and 14 runways. Earlier QNH and QFE values were reported by the single aneroid altimeter installed in ATC tower met panel.

6. Meteorological observations during recent cyclonic storm; 'Phyan'

Observations of QNH and wind speed, from 9th-11th Nov, 2009 recorded during the recent cyclonic storm 'Phyan' in Arabian Sea, are shown in Fig. 13. 'Phyan' crossed Maharashtra coast between Alibag and Mumbai

TABLE 1

A comparison between earlier analog Current Weather Indicating System (CWIS) and the present IAAMS

	CWIS	IAAMS
Data Transmission	Analog signals through underground Signal cables	Digital signal transmission through underground twisted pair cables and wireless mode
Interference / Losses	Subject to interference due to analog signals and also cable losses	No interference problems and also no losses.
Data Storage / Backup	No such facility	Online storage of data in server and backup.
Slave Displays	Limited to 2 or 3	More than 30 slave displays
Display Console	No such facility	GUI based console with different application screens for users
Power Supply	Regular power supply	In addition to UPS, solar panel is also available
Wind Averaging	Scalar averaging	Vector averaging as recommended by WMO
Humidity Sensor	Conventional Dew cell	Capacitive Sensor
Pressure Sensor	Single Aneroid based unit in the briefing room	Each site is provided with semiconductor pressure sensor
Auto Report Generation	No such facility	Auto generation of Aviation reports

TABLE 2

Desired data accuracy of meteorological elements

Meteorological Elements	Operationally desirable accuracy of measurements ICAO (2004)	Accuracy from IAAMS of India Meteorological Department	Accuracies actually observed
Wind Speed	± 2 kmph (1 kt) up to 19 kmph (10 kts)	± 2 kmph (1 kt) up to 19 kmph (10 kts)	± 1 kt up to 10 kts
	± 10 % above 19 kmph (10 kts)	± 10 % above 19 kmph (10 kts)	± 5 % (approx) above 10 kts
Wind Direction	$\pm 10^\circ$	$\pm 10^\circ$	$\pm 10^\circ$
Temperature	$\pm 1^\circ\text{C}$	$\pm 0.2^\circ\text{C}$	$\pm 0.1^\circ\text{C}$ to $\pm 0.15^\circ\text{C}$ as checked with standard at site
Dew Point	$\pm 1^\circ\text{C}$	$\pm 0.2^\circ\text{C}$	$\pm 0.2^\circ\text{C}$

between 1000 UTC and 1100 UTC of 11th Nov, 2009 as reported in “Cyclone ‘Phyan’: A Preliminary Report” (2009). It is seen that from 10th Nov, 2009 with north-northeastward movement of cyclone, pressure values indicated rapid decreasing tendency. QNH dropped to as low as 993 hPa, between 0800 UTC to 0900 UTC on 11th Nov, 2009. Average winds 5-8 knots of 9th Nov, picked up on 10th and 11th Nov to 8-12 knots with gusting of winds from 18-22 knots as seen from the graphs.

7. Data quality and comparison

Newly installed IAAMS has many advantages as compared to conventional current weather indicating system (CWIS) as indicated in Table 1 and has desirable accuracy as per ICAO (2004) standard is listed in Table 2.

The meteorological elements such as temperature and humidity measured by the IAAMS are compared with

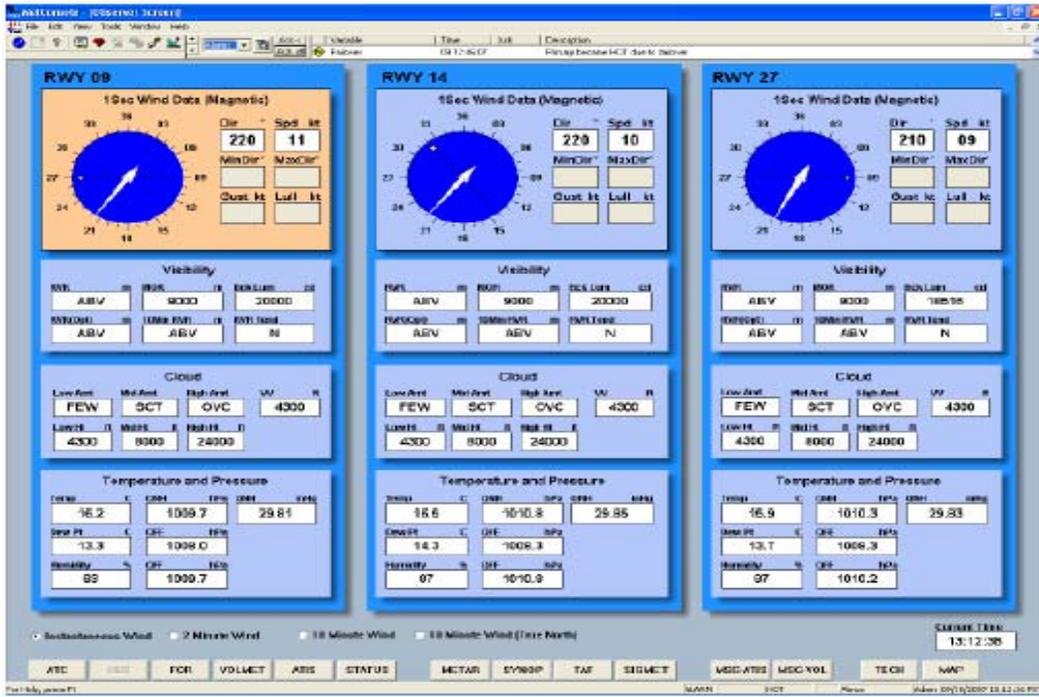


Fig. 14. Observer's Home Screen

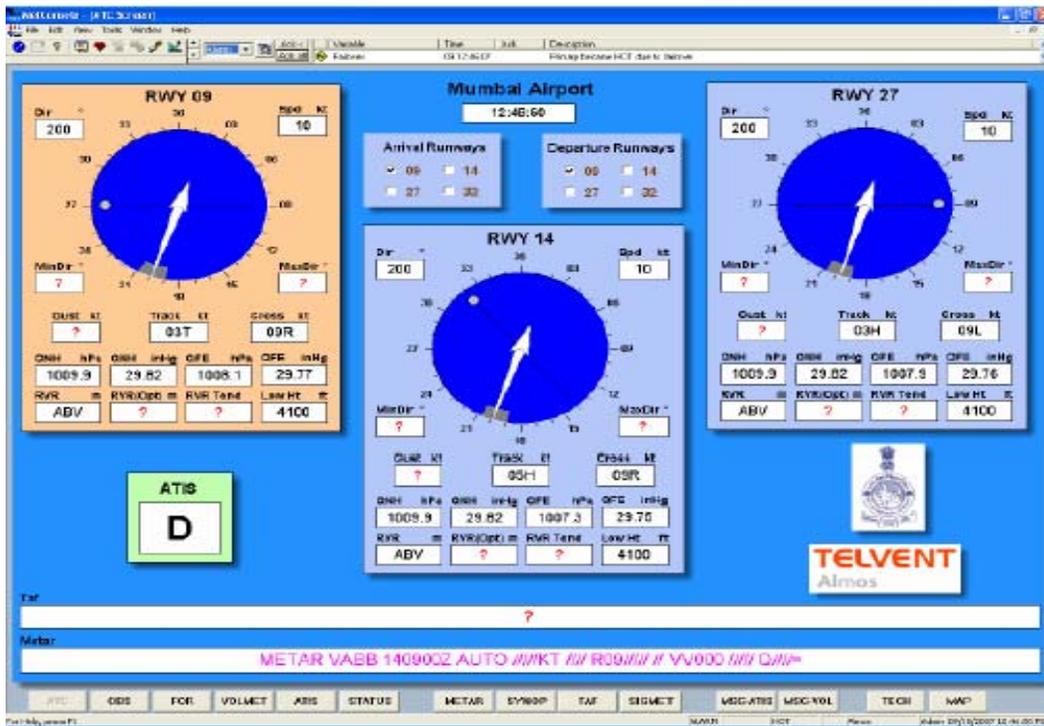


Fig. 15. Air Traffic Controller Screen



Fig. 16. Technician Home Screen

The hourly measurements from nearby Santacruz observatory as shown in Figs. 12(a) and 12(b). It is seen that the trend and values recorded agree with each other. Since the observations taken by IAAMS are at every minute, the resolution is much better and variations recorded are clearer. As the observations recorded by IAAMS are in digital format, the further archival or analysis is easily possible.

8. Summary and conclusion

New IAAMS installed at three runway sites at Mumbai airport is a state-of-the-art system, having digital data acquisition system including pressure sensor data from sites. Features like vector averaging of winds, auto generation of aviation reports and technical reports, AFTN connectivity, self test and calibration, has improved data quality and reliability. Contamination check and compensation in the dual base Transmissometer is very

crucial, especially during very low visibility due to thick fog or heavy rains.

Data communications from the sites have improved appreciably with the availability of land line as well as wireless mode with auto switch over facility. To strengthen the wireless signals, at Mumbai airport dedicated antennas are installed in the ATC tower for reception of data from wide spread meteorological sites. Data communication through satellite link from the system to Delhi and Pune, IMD offices is an added advantage. Acquired data is saved online in the server and can be archived using built-in application; 'Met Query'. This program allows the user to download the data as per requirement.

With the availability of different user screens, depending upon the applications, system administration and operations has been clearly identified. At the sites, as

well in-house the system is powered up with UPS with sufficient backup time, to avoid any interruptions in meteorological data due to power failures or fluctuations if any. Solar panels at sites are redundant charge source. With hot standby configuration, UPS backup and communication redundancy, the system is found to be working smoothly round the clock at Mumbai airport.

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