Lecture Notes on Aviation Meteorological Instruments

for

Advanced Training in Instrumentation and Information Systems

(Phase-II)

CONTENTS

Chapter 1

Role of Meteorological Instruments for Air Navigation

Weather factors have marked influence on the operation and performance of modern aircrafts. The impact of a relatively small change in parameters like Wind, Temperature, Visibility, Pressure, Cloud base height etc. on air operations is very high.

Wind: Wind observations are used for the selection of runways and for the determination of the maximum allowable take-off and landing weights. Landing is not generally allowed when a crosswind component exceeds 45 kmph

Temperature: Temperature is important in view of engine performance and required take-off speed. High temperature means lower air density which reduces lift, resulting in the need for higher take-off speeds and consequently more runway length. If runway length is insufficient, take-off weights have to be reduced.

Pressure: The atmospheric pressure measured at the aerodrome is used for the altimeter setting of the aircraft. It is evident that pilots must be able to rely absolutely on the pressure values provided by the meteorological stations of the aerodrome during landing.

Visibility: Low visibility is a crucial factor affecting traffic at aerodromes. The minimum visibility at which take-off is allowed depends on the facilities like instruments landing systems at the aerodrome

Cloud base height: An accurate estimate of the height of base of low clouds is very essential for safe landing of the aircraft. This information gives advance warning to the pilot about the height at which he will be able to see the runway markings, edge lights etc. when low clouds persist over the landing area of the aerodrome

So the availability of reliable and representative observations at aerodromes to support take-off and landing operations are of critical importance.

Chapter 2

Accuracy and Resolution

Accuracy: The closeness of the agreement between the result of a measurement and a true value of the measurand.
2.0 Accuracy is a qualitative concept

Resolution: A quantitative expression of the ability of an indicating device to distinguish meaningfully between closely adjacent values of the quantity indicated
Operationally desirable accuracy for measurement

(Ref: ICAO Annex.3)

Parameters		Operationally desirable accuracy	Attainable accuracy (1994)
Wind			
	Direction	± 10°	± 5 °
	Speed	± 1 kt up to 10 kt ± 10% above 10 kt	± 1 knot up to 20 knot ± 5% above 20 knot
Temperature			
	Air	± 1°C	± 0.2°C
	Dew point	± 1°C	± 0.2°C
Pressure(QNH,QFE)		± 0.5 hPa	± 0.3 hPa
Visibility		± 50 m up to 600 m ± 10% between 600 and 1500 m ± 20% above 1500 m	± 50 m up to 500 m ± 10% between 500 m and 2000 m ± 20% above 2000m up to 10 Km
Cloud amount		± 1 okta	In daylight ± 1 okta, but in darkness difficulty may arise
Cloud base height		± 10 m up to 100 m ± 10% above 100 m	± 10 m up to 1000 m ± 30 m above 1000 m up to 3000 m
Runway Visual Range (RVR)		± 10 m up to 400 m ± 25 m between 400 and 800 m ± 10% above 800 m	± 25 m up to 150 m ± 50 m between 150 and 500 m ± 10% above 500 up to 2000m

1.0 ICAO documents dealing with aviation

ICAO Annexure-III : site selection for installation of AMIS, Height of meteorological sensors above runway level, accuracy & resolution & averaging for reporting met parameters, METAR and SPECI reporting criteria, forecasting accuracies for TAF and other reports etc.

ICAO Document-9328 : Instruments for reporting Visibility, Runway Visual Range, Site selection criteria for RVR instruments, Reporting MOR & RVR, All algorithm related for computation of MOR & RVR for all Categories of Instrument Landing System.

Chapter 3

Runway complex and Touchdown areas

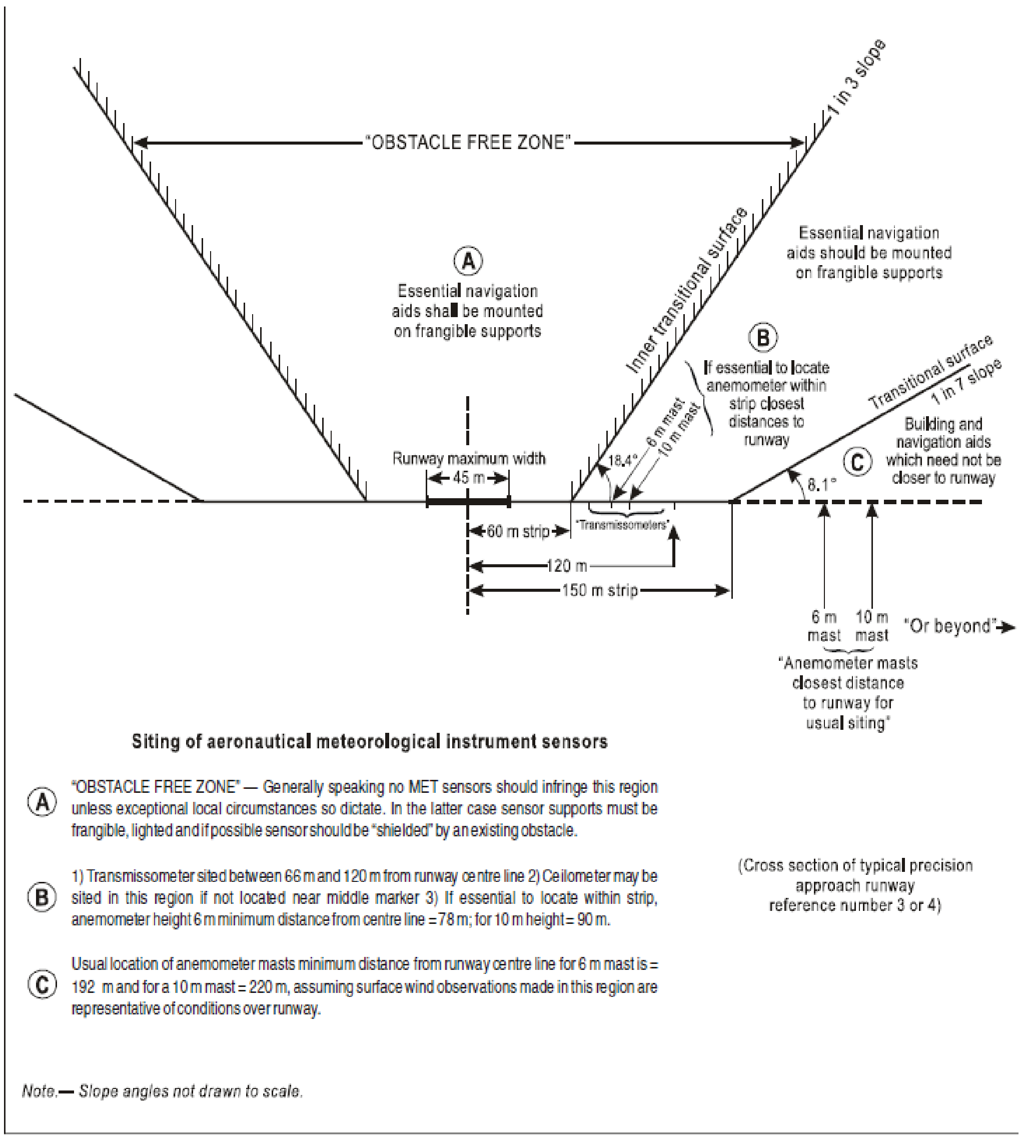

Fig.1

Chapter 4

Criteria for installing airport installation of Met Equipments at airports

1. Site should have free exposure conditions away from nearest boundary wall.
2. Site shall be Free from bushes, leveled and shall be same level as that of Runway.
3. Site Dimensions of   at least 50m X 5mts
4. Site shall be within 120mts from Central line of runway
5. Site shall be within 300mts from runway threshold(ie beginning of runway).

Height of sensors

Wind → 6m to 10m, Temperature: 2m , Visibility, MOR & RVR :2.5m

Variation of wind speed with height

Wind speed is low on surface due to the friction. However as height increases wind speed increase with following relation.

$$V_h = V_{10} [0.233 + 0.655 \log_{10}(h + 4.75)]$$

This formula is called Hellman's formula. V_h is the wind speed at height h metres, and V_{10} is the wind speed at 10 m (30 ft) above the ground

Chapter 5

Definition on category of airports

Category is instrument landing System installed at airport and for minimum RVR required for landing and also decision height/

Category –I. In Cat-I ILS RVR minima is 550m and decision height is 60m.

CAT-II RVR minima is 350m and decision height is 30mts to 60m.

CAT-III RVR minima is 200m and decision height is 15 to 30m.

CAT-II-B RVR minima is 50m and deicision height is 15m.

CAT-IIIC RVR minima & decision height is is zero.

No of instruments required for each category

Category	Runway length	CWIS	RVR	Ceilometer
1	<2400mts	1	1	1
I	>2400mts	2	2	1
II	<2400mts	2	2	1
II	>2400m	2	3	2
III	<2400	2	3	2
III	>2400mts	2	5	2

Chapter 6

Transmission measured values to MBR & ATC

Meteorological measurements are installed at Met park near touchdown of runway. Therefore the met parameter measurements obtained at runway site are to be communicated to MBR via Land line cables (Optical fibre or copper cables) and also through wireless modems.

At MBR further data processing is carried out by a server/Computer. Following are the further data processing

1. Quality control check on incoming data, such as Range check, transient/ Temporal check and special checks are done.
2. Performing manual entry for following parameters for which sensors are not available. Following parameters are required for auto generation of METAR.
   a. Present Weather
   b. Cloud amount
   c. Past weather
   d. Rainfall intensity
   e. Manual data entry of parameters for which sensors are not installed at runway(ex. Ceilometers for measurement of height of base of low cloud, General visibility etc)
   f. Manual entry of sensors which are temporarily not working at site and manual observations carried out by the observer.
3. Communication of processed data and reports to the Air Traffic control and approach radar.
4. Further dissemination of generated METAR/SPECI/TAF to Aviation authorities via AFTN network.

It is difficult for the field equipment to do above data processing at site.

LCD Monitor Slave display display's all processed Meteorological data such as 2min average wind , 1min average of MOR, RVR, Temperature, QFE, QNH, Dew-point Temperature, height of base of low cloud, Wind Shear and also Current METAR & TAF for instruments installed at all runways.

Communication of data from Field to MBR:

The ceilometers may be installed at the touchdown zone of the runway. There is a local display in the ceilometers to show the cloud base height. This can be communicated to MBR and ATC through either landline cable or radioline. Separate displays can be provided for both MBR and ATC parallelly. Data can be stored in a window XP based PC at MBR, where graphical representation of cloud data is also available through a soft ware called **“Cloud Presentation”.** The functional block diagram of the Laser ceilometers is shown in Fig. 2:

The microprocessor sends the calculated cloud height to MBR through RS-232 mode in radio line and FSK mode in landline.

The complete system for a typical laser ceilometer can be divided into three units:

1. Field units
2. MBR units
3. ATC units

Field units:

The ceilometer sensor may be installed near the touchdown zone of the runway. There are four connectors in the ceilometers blower out, blower in, ceilometer electronics, and signal output. The first three are for 230V ac power input to the ceilometer systems. There connections are shown in the figure. The last one is the 6 pin signal wire coming out of the laser ceilometer. A-wire and B-wire are for FSK signal. C, D and E are connected to transmitter radio modem(F-wire unused). The mains supply is connected to the surge protector. From there only the power is going to various units. But ceilometer electronics require stabilized power supply. So it is connected through an UPS in the field.

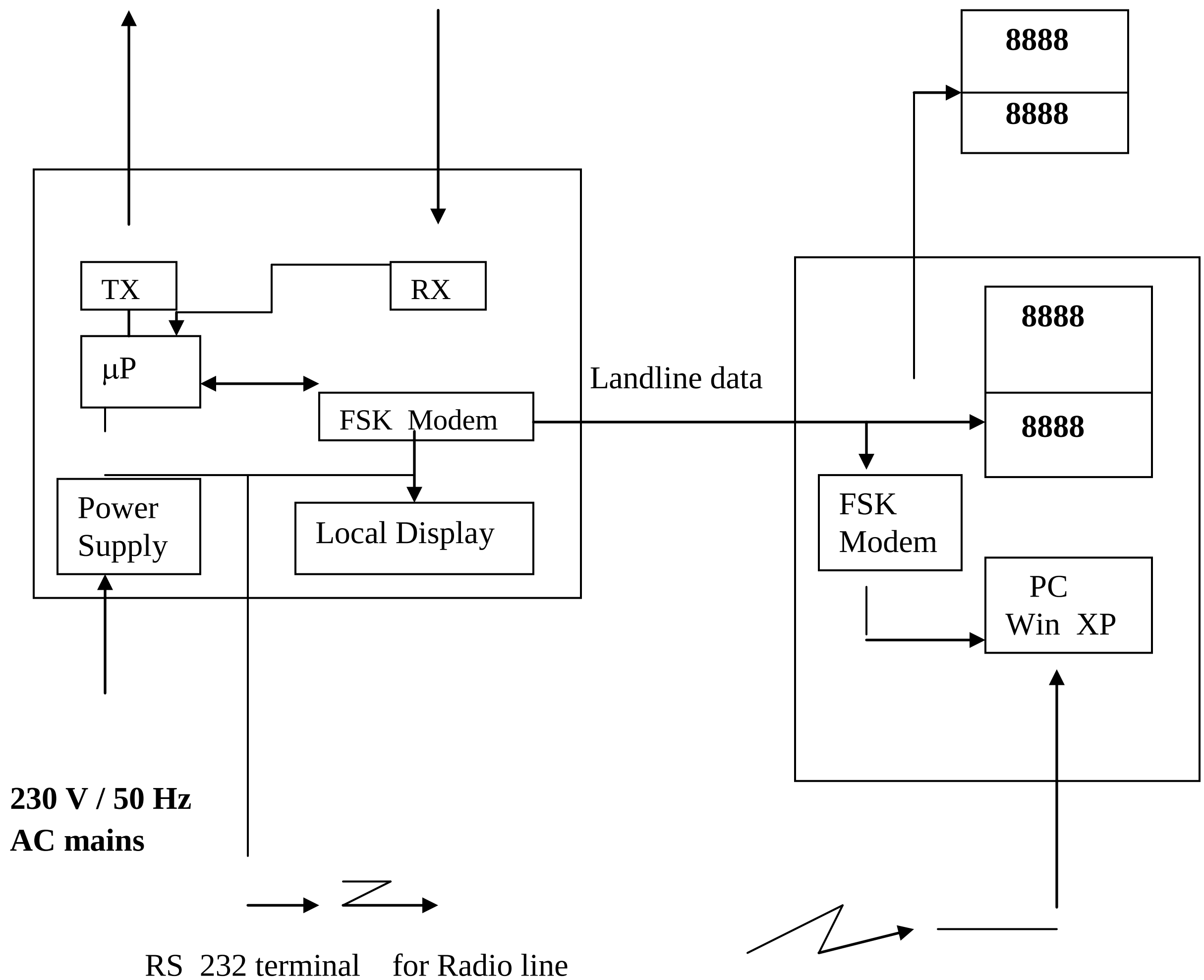

Fig. 2

Communication Modems

For Transmission of data from field site to MBR/ATC communication Modems are used. Modems are wired & Wireless type.

Wired Modems or cable Modems:

For a copper cable the LAN Extender is used. LAN extender does following

1. Convert Ethernet output to TTL
2. Modulated TTL over a carrier for transmission.
3. Transmits over a pair of cable via full duplex mechanism.
4. Checks for reception of signal over same pair of cable
5. Demodulate and convert to TTL.
6. Convert TTL to Ethernet .

Media convertor

Media convertor converts Ethernet signal to TTL and sends over single mode optical fibre cable and also receives over another optical fiber cable and converts back to etherner signals.

Wireless Modems

1. Wireless modem modulate Ethernet signal over a carrier of high frequency and radiated into space. Modern wireless modems scans the carrier frequencies available in space and tune to a frequency having less or no interference.
2. Winless modems are classified into 1. Access point 2. Client Bridge.
   Access point : tune to one channel frequency
   Client Bridge: search of the access point with configured SSID.
3. Configuration settings
   a. Configure to the IP address
   b. Select Access Point or Client Bridge.
   c. Choose band width of modulating signal
   d. Select Transmission Power and distance of Transmission.
   e. Write Service set identifier SSID
4. Liaisoning with aviation authorities
   Following works are required from Aviation authorities due to following reasons:
   a. Selection of site 5m X 50m for Met instruments.
   b. Power supply to the AMI from the essential power supply preferable from ILS or glide path so that power is always present.
   c. Cabling from AMI site to the MBR & ATC shall be done in consultation with aviation authorities so as to not interfere with their cables.
   d. using available cable duct from MBR to ATC provided by Airport authority, for communication of processed data from MBR to ATC.
   e. Making Power available to all Met equipments installed at MBR, Air Traffic control and other operational areas.
   f. Fixing of Met displaysat a place required by AAI.

<u>Transmission of measured data from MBR to ATC</u>

Data from Runway site to MBR is communicated through

1. 10 pair (each pair Twisted), 24AWG, copper cables
2. UN twisted Copper cable of conductor diameter 1.38mm Diameter.
3. Wireless data communication using UHF at 430 MHZ ± 10MHZ band

4. Wireless data communication using 2.4 GHZ ± 22MHZ wireless free band communication operating in 12 Channels.

1. 10 pair Twisted copper cable

a) The cable is used for communicating output of Cable Modem (both RS232 extender and also LAN extender).
   The main specifications are
b) 0.51mm dia/ 24 SWG copper conductor in each pair,
c) Minimum of 10 twists in a meter length of cable for cancellation of induced voltage from adjacent pair so that uninterrupted signal travel over long distance.
d) Cable pair resistance of less than 50 ohms per Kilometer.
e) Cable to Cable insulation capacitance shall be less than 100pF and series inductance shall be less than 100mH per KM

Chapter 7

Theory and principles of Current Weather Instrument System

Wind Direction

Potentiometric wind vane: The sensor used for measurement of wind direction is an IMD-make potentiometric wind vane. The potentiometer in the wind vane is a servo-micro torque potentiometer and has a maximum resistance of 10 kilo-ohms over an end gap of about 4 degrees. The potentiometer is coupled to the wind vane shaft so as to give a resistance output increasing linearly with the increasing of wind direction. Thus 0 KΩ corresponding to the north, 2.5 KΩ for east, 5 KΩ for south, 7.5 KΩ for west and the variation of 0-360 degree corresponds to 0 to 10 kilo ohms

Fig. 3

Calibration procedure for Potentiometric Wind vane:

1. Mark geometric North using magnetic compass.
2. Measure resistance output of pot using multimeter. Move the vane till the resistance is exactly zero ohms.
3. Now arrest vane movement. Rotate North Direction Rod and align to the wind vane position. Fix the north direction rod.(tighten the screws)
4. Fix wind direction sensor without disturbing the position of direction rods. Now rotate whole wind direction sensor (base of the sensor) over the mast using screw mechanism. Align North rod to exact North direction.

A cross sectional view of Potentiometric Wind vane

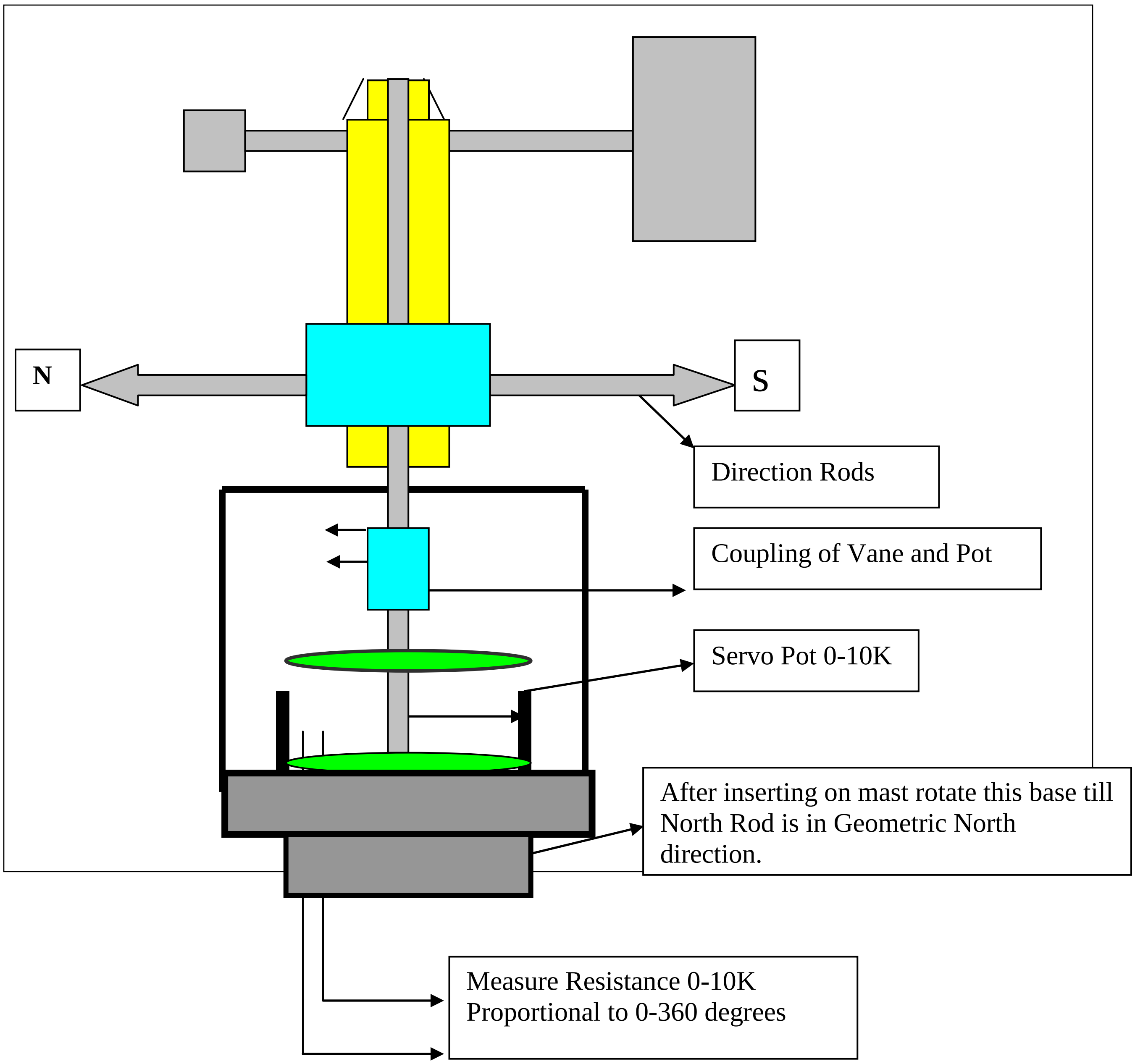

Fig. 4

Gray coded disk (Digital Wind direction sensor)

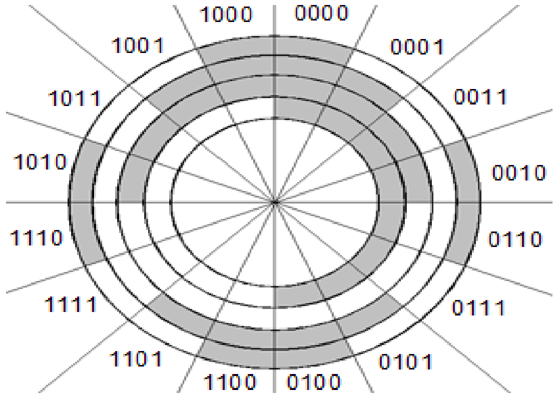

Fig. 1

Fig. 5

As shown above disk is divided con-circally into 4 divisions. Outermost represents LSB bit of gray code and innermost represent MSB of gray code. Since there are four bits and 360 deg angle, therefore resolution of WD sensor is 360^{deg} /2^4 =22.5 Degrees of wind direction. In above circle holes are punched where bit is 1 at every angular resolution of 22.5 deg. At top, Disk illuminated constantly with Light. And below the disc six photo diodes are fixed over PCB. As disk moves photo diode is sending position of disc in the form of gray code in the table. The gray code is again converted to binary by processor. Gray code is having advantage that all transparent and opaque are together hence error is not done during photo detection.

Optical anemometer:

Optical anemometer gives digital as well as analog outputs with respect to the wind speed in knots. Suitable scaling has been provided in the data logger for other units, such as Killometers per hour, meters per seconds etc. Fig.2 shows the schematic diagram of the optical anemometer. The basic operating element is an opto-coupler, which is having a transmitter and a receiver with a toothed wheel connected to the shaft of the cup anemometer. The receiver, which is a photo detector, receives infrared light from the transmitter through the gaps between the teeth of the wheel generates pulses proportional to the true wind speed. These pulses are counted by an inbuilt counter in the 16–bit microprocessor (Microchip make model no.12F682). The counter resets every 250

Fig-6

milliseconds, and hence 4 samples per second can be measured. A piecewise linearity is derived between the wind speed in knots and no. of pulses from the anemometer during the course of calibration in wind tunnel. The required range of measurement is fixed as 0-100 knots. This range is obtained in three segments with three slopes due to the different levels of friction at different stages as shown in Fig.3. Wind speed can be calculated by using the mathematical formula:

$$Y = MX + C$$

where, Y is the wind speed in knots, X is the number of pulses, M is the slope of the segment and C is threshold speed. The values of slopes for the three segments are stored in the inbuilt EEPROM of the processor and all calculations are made by the mathematical calculator, which is register in the processor contains all the programs. In built USART (Universal synchronous/Asynchronous Receiver/Transmitter) generates the TTL logic (5 Volts→High and 0 Volts→ Low) and is converted into serial by using an external level shifter (IC No. MAX 232). Analog out put is generated by using an external Digital to Analog converter (DAC IC No.4821).

The following table shows the average number of generated pulses from the optical anemometer at different wind speeds in knots. These values are obtained at the time of calibration of the anemometer in wind tunnel.

No.of Pulses	22	56	76	165	200	290	340	396	525	600	650	790
Wind speed in knots	2.5	6.3	8.5	18	22	33	38.6	45	60	68	72	89

The above values are tabulated within range of calibration of the existing wind tunnel of IMD. But the range of measurement of optical anemometer is tested with the help of high rpm motors, and proved that the system can give a maximum of 100 knots.

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Relationship between number of pulses and corresponding true wind speed of optical anemometer

Fig.7

Hygroclip: Hygroclip is a combined sensor for both temperature and relative humidity. The basic sensor for relative humidity is a thin polymer, which is having the property to absorb moisture from the air, and changes its electrical permittivity in proportion to the relative humidity. The polymer is placed between the parallel plate capacitor as a dielectric. The basic sensor for the temperature is Pt-100 whose resistance is 100 ohms at 0°C. and the resistance increases linearly with the increase in temperature. Hygroclip requires 5 V dc power at field. It has a measuring range of 0-100% for relative humidity and -40 °C to 85 °C for temperature. Its output is 0-1 volts dc. Dew point can be calculated by using the following formula (for 1000 mb level stations)

$$K = \ln (RH/100) + 17.502 \times DB / (240.97 + DB)$$
$$DP = 240.97 \times K / (17.502 - K)$$

Where RH is the relative humidity in %, DB is the dry bulb temperature in °C, and DP is the dew point in °C

Calibration of sensors

Wind and Temperature sensors can be calibrated at IMD Pune, before putting it in to field. Anemometer is being calibrated in a wind tunnel and the temperature sensors are calibrated in a temperature chamber.

Wind tunnel: Wind tunnel in use at IMD Pune is an open-ended type wind tunnel having a cross section of 2′× 2′ at the test section, as shown in figure (1)

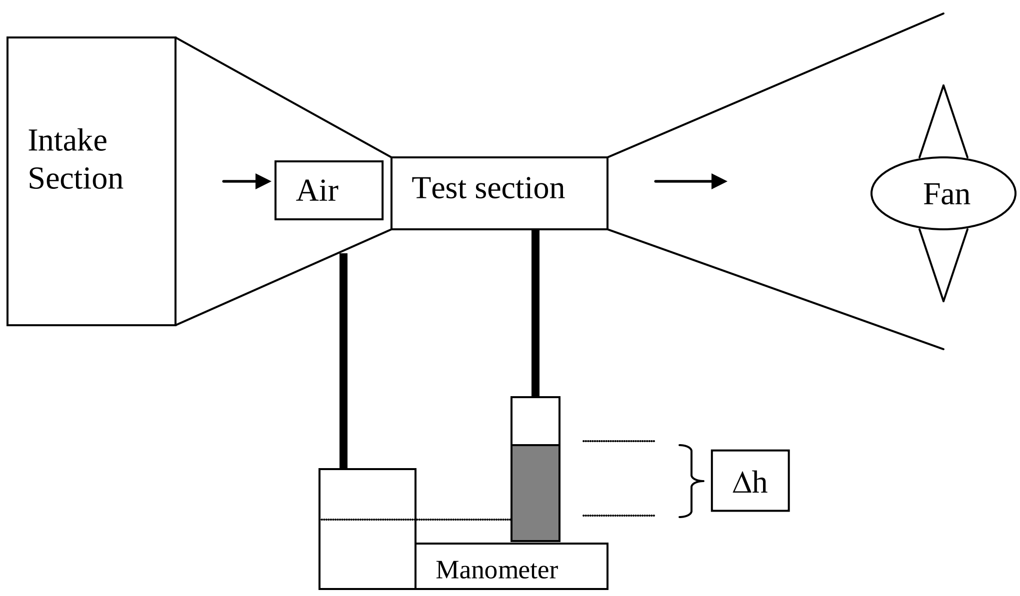


Fig. 8

Alcoholic manometer is provided with the tunnel to measure the difference of pressure at the intake and test section. According to Bernoulli’s theorem the pressure difference is proportional to the square of the velocity at the test section.

$$v \propto \sqrt{P}$$

finally the equation appears as

$$v\ (\text{knots}) = 7.8218\ \sqrt{\Delta h}$$

Where h is the manometer height difference corresponding to the pressure difference between the intake and test sections.

Wind speed inside the wind tunnel can be varied between 0-125 kmph. This can be done by opening and closing of a window in the path of the airflow. The flow of wind through the test section is streamlined. The test anemometer is placed at the center of test section and subjected to various known wind speeds. The speed indicated by the anemometer is compared with the actual speed calculated from manometer readings using the above equations.

Temperature chamber:

At IMD, Pune an environmental test chamber is used for calibrating the temperature and humidity sensors. The range of the chamber for temperature is –60C to +150C and for humidity is 10% to 95%. The temperature and humidity inside the chamber can be set by using a high quality temperature controller (Eurotherm). The sensors to be calibrated are placed inside the chamber and temperature/humidity readings are taken for various standard values.

Instruments for monitoring wind and temperature

Two types of instruments are used for the measurement of Wind and Temperature parameters

1. Current Weather Instruments System
2. Distant Indicating Wind Equipment

<u>Current Weather Instruments System (CWIS)</u>

A Current Weather Instruments System is used for the continuous monitoring of wind direction, wind speed, temperature, and dew point at the touch down zone of runway in an airport

India Meteorological department designed and developed both analog and digital current weather instruments system and installed at various international airports throughout the country.


METLOG-03
Pressure
997.7
TX
RX
COM1
COM2
COM3
COM4
COM5
COM6
PGM
INC
SHIFT
ESC
IMD
IMD
PUNE
CWIS-SLAVE DISPLAY02
24
RUNWAY
PRESSURE (mbar)
0997.7
BAROMETRIC
1009.1
QNH
0997.7
QFE
CURRENT
2 MIN AVERAGE
10 MIN AVERAGE
32.7
TEMPERATURE °C
249
264
262
WIND DIRECTION (DEGREES)
22.7
DEW POINT °C
04.7
06.0
05.9
WIND SPEED
09.6
WIND SPEED

Fig. 9

Digital CWIS

Recommendations of WMO:

1. At aeronautical meteorological stations, the mean direction and speed of the surface wind should be measured and reported as two- and ten- minute averages.

(WMO-No. 731, Art 2.2.2.1.1.)

2. The averaging period for surface wind observations used for take-off and landing should be two minutes. For meteorological reports disseminated beyond the aerodrome, the averaging period should be ten minutes.

(WMO No.731 Art 2.2.1.1)

Wind is vector quantity, so vector averaging is required. Conventional analog CWIS can give only scalar averages. So the concept of Digital CWIS is introduced. Digital CWIS is a software controlled device having the facilities of vector averaging, data storage in PC, etc. A complete block diagram of Digital CWIS is shown in Fig. 10

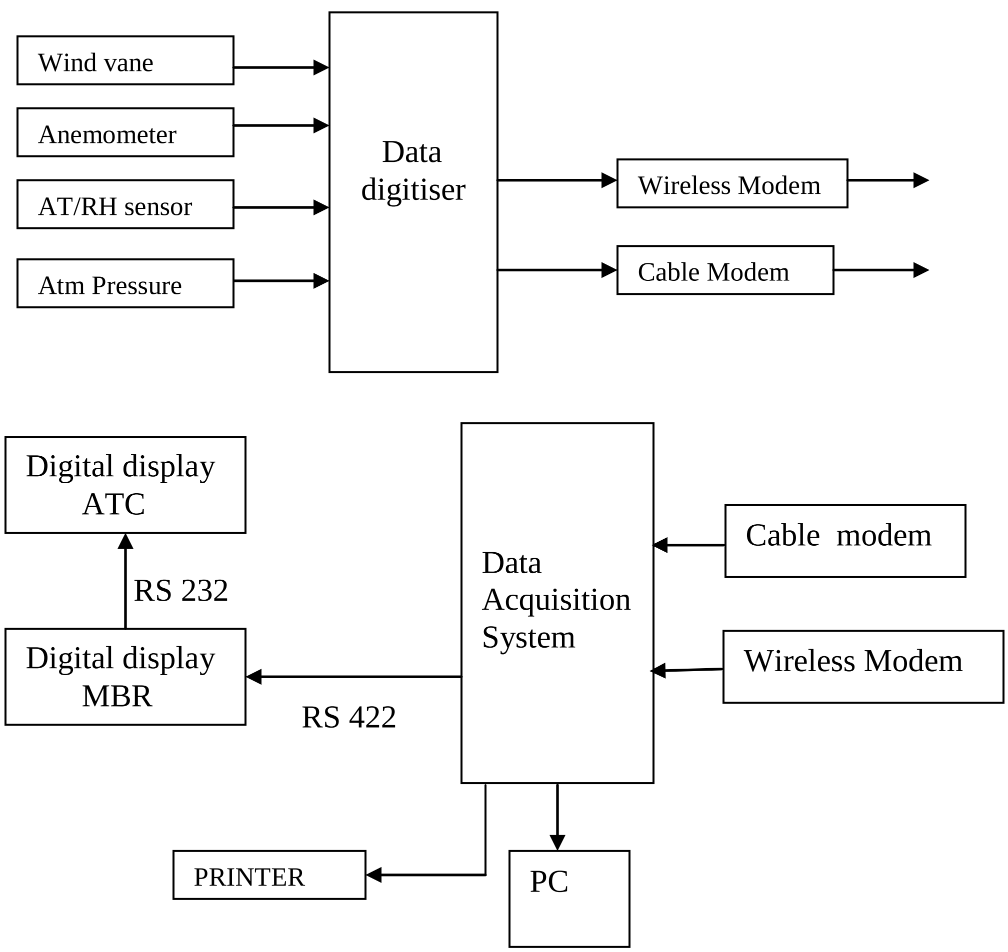


Fig.10

Data digitiser:
Data digitiser reads the analog output voltage from signal conditioning amplifier digitises the data and converts the analog value to corresponding engineering units. The processor used, Philips 89C51RD2, is compatible with Intel 8051 series micro controllers. The components interfaced with the processor includes Analog multiplexer (IC 4052), Analog to Digital converter (IC 7135), 32KB Nonvolatile RAM, 512KB EPROM’s (4 nos), and communication IC (MAX 232).

Analog multiplexer selects one out of the four channels (wind direction, wind speed, temperature and dew point or humidity) under the control of the processor. Analog to Digital conversion is done by Dual slope integration technique. Here 7135 series ADC is used which generates 14 bits output, 2000 counts (i.e. 2V input voltage will give 20000 count output) with resolution of 0.1 milli volts to 2V range. The output is sent serially to the processor. In this unit also the processor sends Conversion ready pulse as per the program instructions.

Philips 89C51RD2 micro controller is an 8-bit processor coming under Intel 8051 series processors. It has 8-bit data bus and 16-bit address bus with internal code memory (64 KB). The processor linearise the data, sets the calibration factor, and converts the humidity in to dew point. Programming a processor using assembly language is tedious and time-consuming job. So all the programs are written in high-level language using ‘C’ language and the ‘C’ code is compiled to get Hex.file. “Philips flash programming utility” is used for the down loading of Hex file in to the processor.

A 32 KB Non volatile RAM is doing 1 minute, 2minute, and 10 minute averaging of data and its storage. The averaging is decided by a real time clock (RTC). It has the decision capability of the completion of 1 minute, 2 minute, and 10 minutes. Calibration parameters, configuration parameters, Baud rate etc are stored in four numbers of 64 KB E^2PROM. The signal generated by the processor is in TTL level (Bit 1 $\rightarrow$ + 5 Volts, Bit 0$\rightarrow$ less than 0.8 Volts). It can be converted in to RS 232 signals (Bit 1 $\rightarrow$ + 5 Volts, Bit 0$\rightarrow$ -5 Volts) by the communication IC MAX 232.

Data Acquisition System:

The Data Acquisition System reads the transmitted data from the data digitiser. The complete system of DAS includes a microprocessor, Non Volatile RAM, Flash memory, Analog MUX, IC MAX 232, Converter 75176, and a Complex Programming Logic Device (CPLD). The received data i.e. wind direction, wind speed, Humidity, Temperature, and Dew point are read and stored in Non volatile memory (32 KB) for printing. One minute averaged values are stored in flash memory. Such data of approximately 30 days can be stored in the flash memory. Also, the received data is displayed on the 16×12 jumbo LCD display. The same data along with 2-minute average, and 10-minute average values are transmitted to the slave displays as RS 422 signals.

A complex programming logic device is used to assist the main processor while doing printing. It contains lot of latches and hardware logics to save the processing time. These latches keep the data until and unless the printing is completed. Programs can specify the connections of these logic devices. The design tool can be down loaded from the web site. Chip selection of flash memory also done by CPLD.

The data for one hour/three hour printing can be stored in a 32 KB Non volatile RAM. When the 1-hour/3 hour storage is completed, the data will be transferred to the CPLD along with computations of graphical format of data. Thirty days data can be stored in 512 KB X4 flash memories with one-minute average of all parameters.The signal received through cable is RS 232 format signals, which can be converted in to TTL logic by IC MAX 232. These logics can be processed and stored in flash memory. The processor extracts data from the flash memory and transmits through Analog MUX as RS 232 signal. Then IC 75176 converts the signal in to RS 422 format and sent to the slave displays.

Distant Indicating Wind Equipment (DIWE):

Distant indicating wind equipment is used for the continuous monitoring of wind direction and wind speed at the touchdown zone of runway in an airport

The function of DIWE is similar to that of CWIS, but no monitoring of temperature and dew point.

Fig. 11

Installation, calibration, and maintenance of DIWE is same as that of Analog CWIS

Block diagram of Digital DIWE

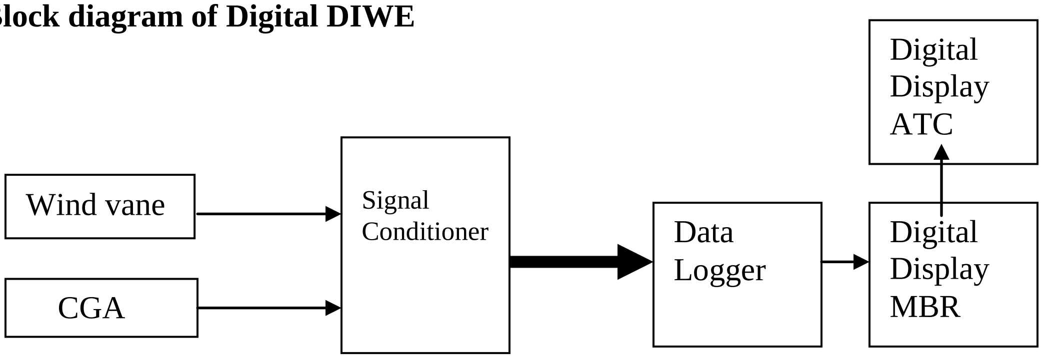


Fig.12

Chapter 8

Measurement of Visibility

(Ref: WMO.No.8, ICAO Annex.3 and ICAO Doc. 9328/AN-908)

The term visibility generally indicates the distance to which human visual perception is limited by atmospheric conditions. The physical and physiological mechanisms that influence visual perception during the night in distinguishing lights differ from those in the day time in distinguishing objects illuminated by day light. Basically, however, visibility describes the transparency of the air in the horizontal direction and represents the maximum distance that one can see in the atmosphere at any given time.

During the daytime, the more distant a dark object is from an observer, the brighter it usually appears, and it becomes indistinguishable from the horizon sky at far distances. This limiting distance is the daytime visibility and is determined by the visual contrast threshold of the observer's eye. The increase in brightness of an object with increasing distance from an observer is due to the scattering of sunlight by the air and to the diffuse reflection of sunlight and skylight by underlying terrain. The scatterers of light in the atmosphere range from air molecules, condensation nuclei, dust, and fog to precipitation elements such as large water drops and snowflakes. Air molecules and particles that are smaller than the wavelengths of light scatter light according to the Rayleigh theory with an intensity that is inversely proportional to the fourth power of the wavelength of the light. Thus, small particles scatter sunlight more in the blue than in the red wavelengths, and therefore, the presence of light haze or smoke in the atmosphere is identified by the bluish appearance of dark objects and distant terrain features or by the yellow-to-orange colour of the horizon sky at sunrise and sunset. Particles larger than the wavelengths of visible light scatter light independently of wavelength. Their presence in the atmosphere is detected by a whitish appearance of the sky, especially towards the sun. White cirrus clouds and fog and the whitish appearance of distant terrain under conditions of relatively high humidity are also visible evidence of light scattering by large particles. An atmosphere free of particles shows a decrease of spectral purity towards the horizon, and consequently the horizon sky can be white even without large particles. Most cases of reduced and poor visibility are due to the scattering and attenuation of light by the larger particles, especially those found in fog and precipitation elements.

Aeronautical visibility:

Meteorological visibility is a quantity to be estimated by a human observer. But this estimation is subjective, and varies with the individual. The essential meteorological quantity that can be measured objectively is the transparency of the atmosphere, and is represented by Meteorological Optical Range (MOR). In aviation there are two types of visibility measurements; one is meteorological visibility and the other is runway visual range. But WMO has adopted Meteorological optical range (MOR) as the measure of visibility for both general and aeronautical purposes. Runway visual range (RVR) is the range over which the pilot of an aircraft on the centre line of a runway can see the runway surface markings or the lights delineating the runway or identifying the centre line. It is not an observation like surface winds, visibility etc, but it is an assessment based on (a) atmospheric factors such as extinction coefficient of the atmosphere (b) physical/biological factors such as visual threshold of illumination and (c) operational factors like runway light intensity.

RVR measuring techniques

1. Instrumented technique

2. Human observer technique

Instrumented technique:

Common practice is to use **Transmissometer** to measure transmittance of the atmosphere or to use **Forward-scatter** meter to measure the atmospheric extinction coefficient. Then RVR is calculated by considering other factors like characteristics of light and expected detection sensitivity of the pilot's eye under prevailing conditions of background luminance

Human observer technique:

An observer counts the number of runway lights or markers visible from an observing position near the runway. This number is converted to runway visual range,making due allowance for the differences in light intensity, background, etc.,from different viewing positions of the observer and pilot

Limitations of Human observer technique:

- Accuracy and consistency are poorer than those of instrumented RVR systems.
- Multiple locations along the runway must be monitored simultaneously.
- Updating frequency and averaging period as required cannot be adhered to, and
- Fluctuations of RVR, including tendencies, cannot be indicated

Characteristics of Weather Phenomena reducing the Visibility

Mist and fog are, in many parts of the world, the primary causes for visibility restrictions.

Mist is reported when the visibility is at least 1000 m but not more than 5000 m with relative humidity greater than 90%. Fog is reported when the visibility is less than 1000 m. Heavy precipitation may also cause low visibilities restricting aircraft operations. Snow is one of the most common factor reducing visibility in cold climates. Sand storm and dust storm reduce visibilities in arid and desert areas

Weather parameter	**Typical MOR value**	**Absorbing**	**Wavelength dependent**
Sand storm		Yes	Possible
Dust storm		Yes	Possible
Smoke		Possible	Possible
Haze	1000-5000	Possible	Yes
Mist	1000-5000	No	No
Fog	30-1000	No	No
Drizzle	>1000	No	No
Rain	>1000	No	No
Snow	>300	No	No
Blowing snow	>30	No	No

Definitions related to Meteorological Visibility

Some important terms related to the measurement of visibility are defined as follows:

a) **Meteorological Optical Range** is defined as the length of path in the atmosphere required to reduce the luminous flux in a collimated. beam from an incandescent lamp, at a colour temperature of 2700 K , to 5% of its original value. Luminous flux is a quantity represents the magnitude of the response of the human eye to the light beam. MOR has been adopted by WMO as the measure of visibility for both general and aeronautical uses.

b) **Visibility, meteorological visibility (by day) and meteorological visibility at night:** are defined as the greatest distance at which a black object of suitable dimensions (located on the ground) can be seen and recognized when observed against the horizon sky during daylight or could be seen and recognized during the night if the general illumination were raised to the normal daylight level.

c) **Airlight:** is light from the sun and the sky which is scattered in to the eyes of an observer by atmospheric suspensoids (and, to a slight extent, by air molecules) lying in the observers cone of vision. Airlight is the fundamental factor limiting the daytime horizontal visibility.

d) **Visual range (Meteorological):** distance at which the contrast of a given object with respect to its background is just equal to the contrast threshold of an observer

e) **Luminous flux (F):** is the magnitude of light energy emitted, received or transmitted per second. Unit is lumen

f) **Luminous intensity (I):** is the luminous flux per unit solid angle. Unit is candela.

g) **Luminance (L):** is the luminous intensity per unit area. Unit is candela per square metre.

h) **Illuminance(E):** is the luminous flux per unit area. Unit is lux.

i) **Luminance contrast (C):** is the ratio of difference between the luminance of an object and its background and the luminance of the background.

j) **Contrast threshold (ε):** is the minimum value of luminance contrast that the human eye can detect. i.e. the value which allows an object to be distinguished from its background. This quantity varies with the individual.

k) **Illuminance threshold(E_t):** is the smallest illuminance, at the eye, for the detection of point sources of light against a background of specified luminance. The value of E_t varies with lighting conditions.

l) **Extinction coefficient (σ):** is the proportion of luminous flux lost by a collimated beam, emitted by an incandescent source at a colour temperature of 2700 K , while traveling the length of a unit distance in the atmosphere. The coefficient is a measure of the attenuation due to both absorption and scattering.

m) **Transmissivity** or **Transmission factor** or **Transmission coefficient (T):** is defined, for a collimated beam from an incandescent source at a colour temperature of 2700 K , as a fraction of luminous flux which remains in the beam after traversing an optical path of a unit length in the atmosphere.

n) **Transmittance (t_b) :** is the transmissivity within an optical path of a given length (say b) in the atmosphere.

Basic equations related to visibility measurement

The basic equation for visibility measurement is Bouguer-Lambert law:

$$F = F_0\ e^{-\sigma\chi} \text{ ....(1).}$$

This equation is true only for monochromatic light, but may be applied to spectral flux to a good approximation

Transmittance for a baseline length b can be written as;

$$t = (F/F_0) = e^{-\sigma b} \text{ ……………………...(2)}$$

Transmissivity $T = e^{-\sigma}$ …………………………….(3)

When F = 5% of F_0 , the distance traveled is known as MOR

$$\therefore\ 0.05 = e^{-\sigma(MOR)} \text{ …………………….(4)}$$

$$MOR = (1/\sigma) \log_e (1/0.05)$$

$$= (1/\sigma) * 3$$

$$\therefore \quad MOR = (3/\sigma) \text{ ………………………...(5)}$$

Using equation (2) , $MOR = (3*b)/\log_e(1/t)$……………….(6)

Meteorological visibility in daylight:

Luminance contrast of an object is:

$$C = (L_O - L_B)/ L_B \text{ ………………..(7)}$$

Where L_O is the Luminance of the object and L_B is the Luminance of the horizon. Luminance of the horizon arises from the airlight scattered from the atmosphere along the observer's line of sight.

For black objects $L_O = 0$, $\therefore\ C = -1$

In 1924, Koschmieder established a relationship, which later known as Koschmieder's law, between the apparent contrast (C_χ) of an object, seen against the horizon sky by a distant observer, and its inherent contrast (C_O), i.e.the contrast that the object would have against the horizon when seen from very short range. Koschmieder's relationship can be written as:

$$C_\chi = C_O\, e^{-\sigma\chi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

If a black object is viewed against the horizon (C_O = -1) and the apparent luminance contrast is -0.05, then the equation(8) will be reduced to:

$$0.05 = e^{-\sigma\chi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(9)$$

While comparing with equation (4) shows that when the magnitude of the apparent luminance contrast of a black object, seen against the horizon, is 0.05, then that object is at MOR. As per Koschmieders law MOR and RVR are same.

Meteorological visibility at night:

The distance at which a light (a night visibility marker) can be seen at night is not simply related to MOR. It depends not only on MOR and the intensity of light, but also on the illuminance at observer's eye from all other light sources.

In 1876, Allard proposed the law of attenuation of light from a point source of known intensity (I) as a function of distance (χ) and the extinction coefficient (σ). The illuminance (E) of a point light source is given by :

$$E = I.\ \chi^{-2}.\ e^{-\sigma\chi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

When the light is just visible, $E = E_t$ and the distance can be treated as runway visual range(R):

$$E_t = I.R^{-2}.e^{-\sigma R} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(11)$$

As per equation (2) $$e^{-\sigma} = t^{(1/b)} \ldots\ldots\ldots\ldots\ldots\ldots(12)$$

$$\therefore \quad E_t = I.R^{-2}.t^{(R/b)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(13)$$

Equation (13) can be used for the calculation of RVR.

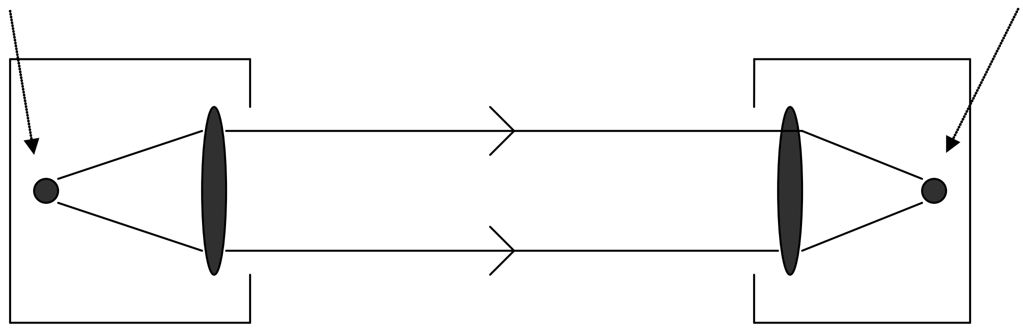
Instrumental measurement of MOR and RVR

1) Transmissometers

An instrument that takes a direct measurement of the transmittance of the between two points in space over a specified path length or base line is known as transmissometers.

The main components of a transmissometer are a light source and a photo detector, where the former forms the transmitter unit and the latter forms the receiver unit. The distance between the transmitter and the receiver is called the baseline length of a transmissometer.

LIGHT SOURCE PHOTO
DETECTOR



TRANSMITTER UNIT RECEIVER UNIT

Fig 13

When considering the choice of a transmissometer for an RVR system, it is first necessary to decide the range of RVR to be assessed as this determines the optimum base line lengths of the transmissometer.

From the Koschmieder equation,

$$MOR = (3*b)/ \log_e(1/t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

The minimum transmittance value that can be detected by a latest photo detector assembly as per ICAO is 0.005. So the minimum MOR permissible with the above baseline length B is

$$MOR\ (min) = (3*b)/ \log_e (1/0.005)=(3/5.3)*b$$

$$\approx (3/5)*b \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

differentiation of equation (14) by keeping B constant gives,

$$\Delta\ MOR = (3*b)* \{1/ \log_e(t)\}^2 * (1/t)* \Delta t \ldots\ldots\ldots\ldots\ldots (16)$$

eliminating t form equations (14) and (16) gives

$$\Delta\ MOR = (MOR)^2/ (3*b) * \{EXP(3*b/MOR)\}* \Delta t \ldots\ldots\ldots (17)$$

As per ICAO ,the accuracy for MOR at higher ranges should not exceed 10% of the MOR.

Therefore $\Delta\ MOR = 0.1 * MOR$

Substituting in equation (17) with Δt as 0.005 gives,

$$20 = (MOR)/(3*b)* \{EXP(3*b/MOR)\} \ldots\ldots\ldots\ldots(18)$$

At the maximum value of MOR , $EXP(3*b/MOR) \approx 1+ (3*b)/ MOR$

$$\therefore \quad 20 = (MOR)/(3*b) + 1$$

Hence, $MOR (max) = 54*b$ ………………………………..(19)

So the minimum and maximum value of MOR measurement is completely depending on the value of base line length.

Similarly the minimum value of RVR also can be computed by using Allard's law.

In the equation

$$E_t = (I/R^2)* t^{(R/b)}$$

Put $t = EXP\{(-3*b)/MOR\}$, Then

$$E_t = (I/R^2)*EXP\{(-3*R)/MOR)\}$$

$$\therefore (3*R)/MOR = log_e(I) - log_e(E_T) - 2*log_e(R)$$

$$R = (MOR/3)*\{ log_e(I) - log_e(E_T) - 2*log_e(R)\} \ldots\ldots(20)$$

For night conditions, $E_t = 10^{-6}$ lux (which minimum value compared to other occasions), and put the standard value of I= 10000 candelas

$$R \approx (MOR/3)*18$$

The minimum values of MOR = (3/5)*b

$$\therefore RVR\ (minimum) \approx 3*b \ldots\ldots\ldots\ldots(21)$$

So the range of accurately measurable MOR and RVR values related to the baseline length as:

MOR = (3/5)*b………54*b

RVR = 3*b…………..1500

As per WMO(1990), a single baseline length transmissometer operating on 75 metres can be expected to give values of MOR of reasonable accuracy over a range of MOR of relevance for the operation of aircraft. But the minimum measurable MOR and RVR for 75 metres baseline is about 45 m and 225 metres respectively. This is sufficient for CAT-I, CAT-II, and CAT-IIIA operations. But for CAT-III B and CAT-IIIC operations baseline length should be less than 75 meters. But lowering of baseline length may affect the accuracy in the higher ranges of MOR and RVR. So a dual baseline length transmissometer is proper solution for the accuracy of measurements in both lower and higher ranges of visibility.

2) Forward scatter meter:

The attenuation of light in the atmosphere is due to both scattering and absorption. In general case absorption is negligible , and the scatter phenomena may be more prominent. Then scatter coefficient may be equal to the extinction coefficient. A forward scatter meter is used for the measurement of MOR through extinction coefficient in the case of absence of sunlight. But in Indian climate weather phenomena like sand storm, dust storm,haze,mist etc are frequent. So a forward scatter meter is not advisable in Indian climate.

Working systems

1) Single base line Transmissometer:
The instrument consists of a projector, a receiver, a recorder, an indicator, and an RVR computer

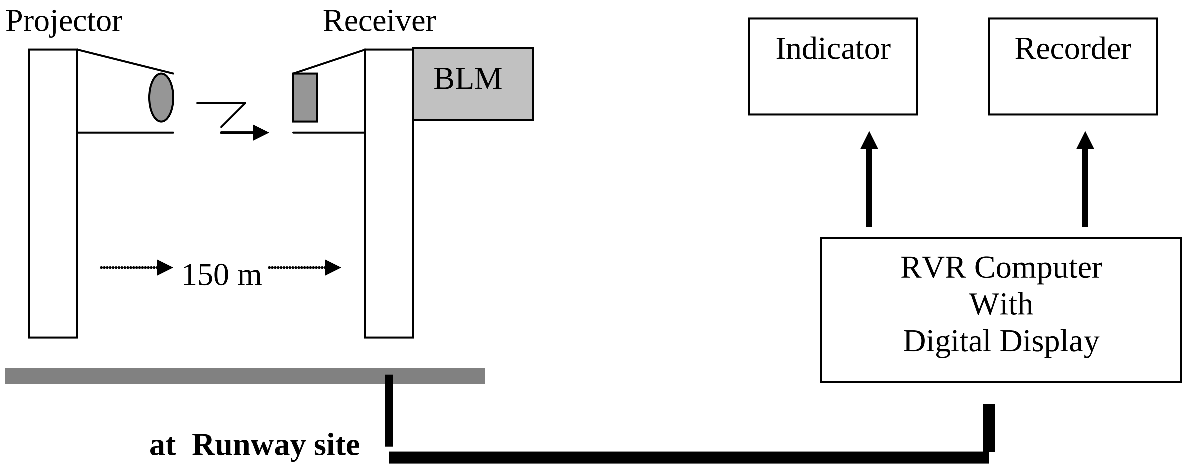


Fig. 14

Projector: The projector emits light pulses (90 flashes /minute) of high intensity and directs the beam towards the receiver kept at a distance of 150 m.
Receiver: The receiver optics consists of a quartz lens at the focus of which is a special photodiode, which responds to the projector light pulses. The output of the photodiode is amplified and fed to an RVR computer.
RVR Computer systems: This consists of an RVR computer with a digital display. The computer receives three inputs (1) atmospheric transmittance from the Transmissometer, (2) the background luminance from the background luminance sensors, and (3) runway light intensities through push button switches and computes the RVR values and depicts the same on the digital display.

As per ICAO document 9328/AN-908 Background luminance at various conditions are shown below:

Condition	**Illumination Threshold**	**Background luminance** Cd/ m^2
Night	8×10^{-7}	<=50

Twilight	10^{-5}	51—999
Normal day	10^{-4}	1000—12000
Bright day	10^{-3}	> 12000

The RVR values can be updated at intervals varying between once each second to once each minute depending on the requirement. The computer has a suitable output for feeding to a stripchart recorder.

Recorder: A twin channel recorder for both visibility and RVR is used. The chart is calibrated to read visibility in one channel and RVR in the other. The RVR input to the recorder is derived from the RVR computer.

Indicator: The indicator scale is graduated in standard visibility values in metres and transmission percentages. It is possible to have a digital display indication of visibility using suitable Digital Panel Meter (DPM)

Working of the system :

The projector and receiver are installed at runway site with a baseline distance of 150 meters. A Xenon arc lamp in the projector emits 90 light pulses per minute. The receiver consists of a photodiode coupled to a sensitive amplifier. The analog output of the receiver is sent to the MBR through underground cable and it is fed to the RVR computer.

The baseline distance can be reduced to 75 meters or lower, if there is need for lower values of RVR to be reported for aviation purposes. Normally lowest RVR value that can be given by a transmissometer is twice the baseline distance between the projector and receiver.

Chapter 9

Measurement of Cloud Base Height

The height of the base of low clouds is required especially during landing of an aircraft, as the pilot must have an idea at what height he will be able to see the runway and its markings. Visual estimates made from an observing point is subjective and at time highly erroneous. So instrumental techniques are essential in the measurement of cloud base height.

Methods using ceiling balloons and searchlights were used in the early stages, but nowadays ceilographs and laser ceilometers are widely used for the measurement of height of the base of low clouds.

Ceiling balloon method:

In this method hydrogen filled balloons were released and the time taken from the time of release to the time when the balloons disappeared behind the clouds was noted. Assuming a known rate of ascent, the height of base of low clouds was estimated. This method suffered from two major drawbacks:

(a) The assumed rate of ascent was never constant as they used to vary with wind conditions

(b) Theoretically , the balloon was expected to rise vertically. This will never be the case. As such, height calculated was not always correct.

Search light method:

In this method, a projector with a powerful lamp kept at the focus of a mirror used to send a vertical beam of light. Clouds present used to produce a bright spot with incident light. This spot was viewed through an alidade by an observer. Knowing the horizontal distance between the observer and the projector and the angle at which the spot of light was visible, the height of base of low clouds was estimated.

Ceilometer systems:

The ceilometer systems installed in all international airports in India for the continuous and automatic recording of the height of the base of low clouds, makes use of triangular method for the determination of the cloud ceiling.

Ceilometers consist of a projector, a receiver, a computing machine, recorder, and indicator. See figure (15).The projector using powerful lamp placed at the focus of a parabolic mirror emits a very high intensity pulsed light beam of very short duration, pointed vertically at the cloud base. This causes a pulsing light spot to appear at the cloud base with appreciable return. A light pulse receiver kept aligned at a known distance from the projector contains a special photo diode at the focal point of the detector optics. The receiver scans automatically from the horizon to zenith in plane that intercepts the entire pulsed beam of the projector. Receiver sends the angle (ϕ) in 0-1mA current to the computing machine. Then the height can be calculated as:

$$h = b \times \tan(\phi)$$

b is the base line distance between the projector and the receiver and ϕ is the angle between the receiver axis and the baseline at the of intersection with the lighted cloud base. There is provision to record the graphically, and the values can be displayed on a local display or indicator

The instrument is normally capable of measuring and recording cloud level from 30 to 800 m with a baseline of 76 m.

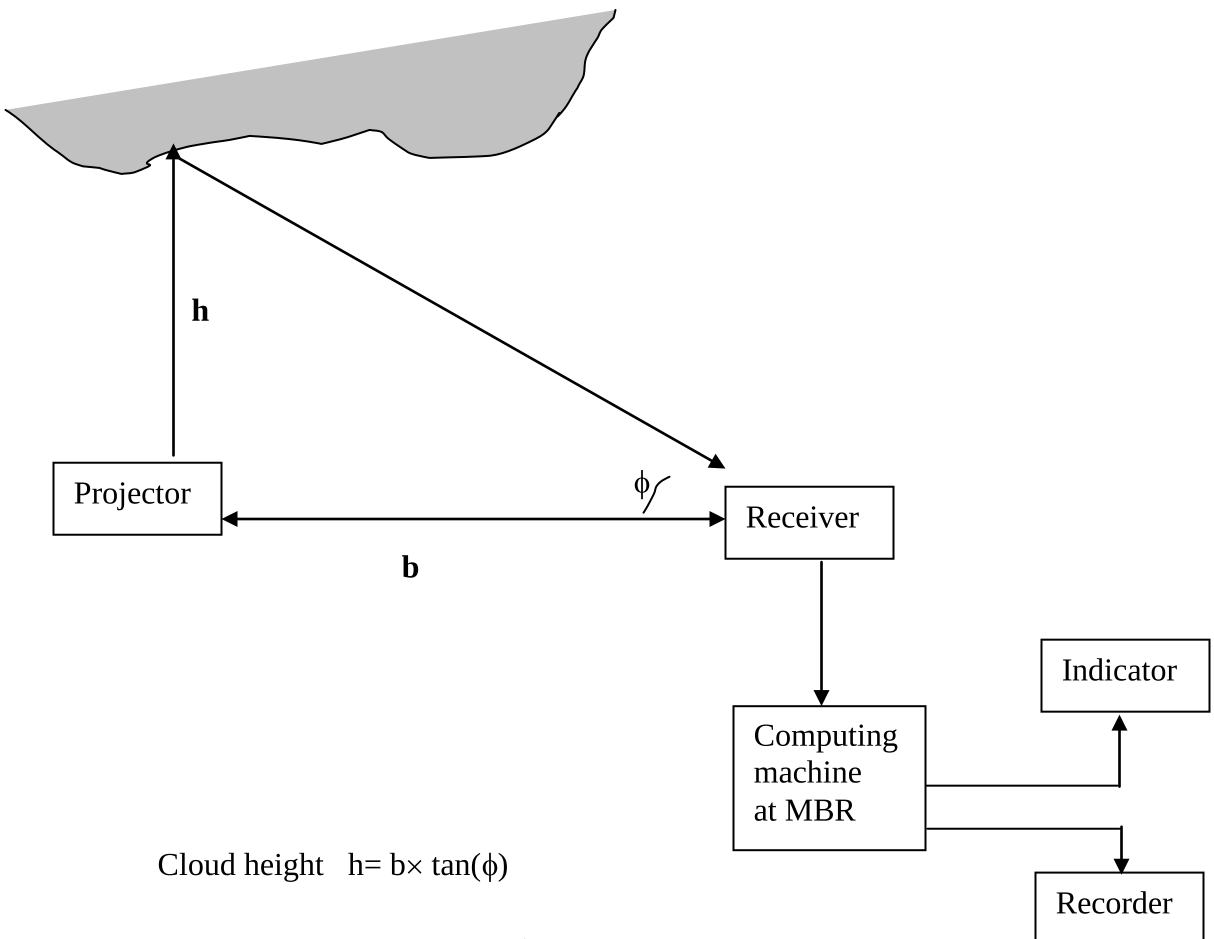


Fig.15

Limitations of Ceilometers (Ceilograph)

- The cloud has to be over the projector.
- It cannot indicate cloud height during rain as the projector beam gets attenuated by rain without forming any marked spot on the base of the cloud.
- It cannot record fast moving cloud as the receiver telescope arm takes one minute to complete one cycle.
- It can record only height of lowest cloud.

To overcome the above limitations, an improved version of ceilograph, which uses laser pulse as source , has been developed. This incorporates LIDAR principle for measurement of cloud height. There are ten such Laser ceilometers are working at various international airports of India.

Laser Ceilometers Systems

Laser ceilometer is an equipment used for measuring the height of the base of clouds, which are hazardous to aviation services, up to a maximum limit of 7500 meters.

Laser ceilometers function according to LIDAR principle. Very short light pulses are sent vertically against the clouds from the transmitter units of the Ceilometers, and reflected light energy from the water droplets in the cloud is received by its receiver units. The time elapsed between the transmission and reception of the light pulses is a measure of cloud height. See **Fig.16**

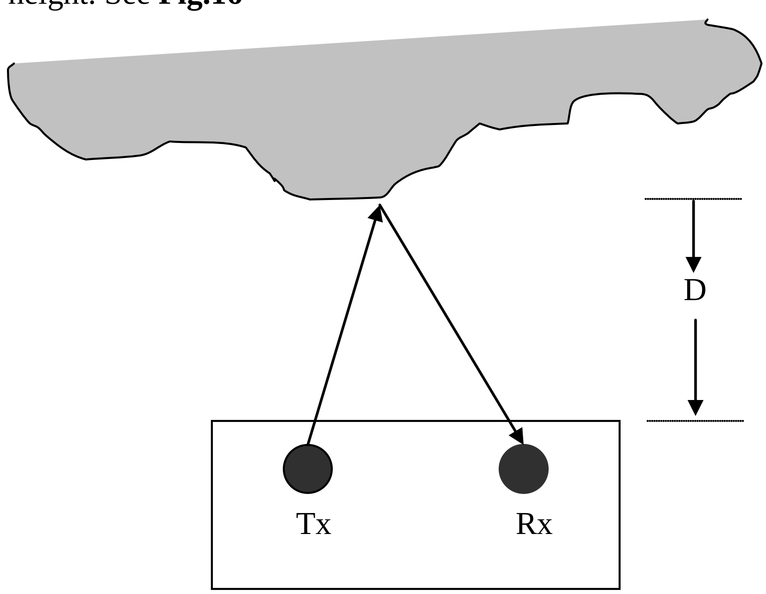


Fig.16

$$\text{Cloud base} = \frac{\text{Time} \times \text{Speed of light}}{2}$$

. i.e $D = \frac{t \times c}{2}$, where t is the time and c is the speed of light

The transmitter in the ceilometers is a Galium Arsenide (Semiconductor) laser diode which emits very short light pulses of 905 nm wavelength and repeat frequency of 1 KHz toward the overhead clouds, under the control of a microprocessor(80286). When the light pulses penetrates a cloud some parts of the light energy is reflected straight back. The reflected light is received by a photodiode in the receiver. After analog to digital conversion and filtering of echo signal, microprocessor can calculate the time between the transmission and reception of pulses.

For example if the time is 16 μsec, the cloud height will be displayed as 2400 meters

Chapter 10

Signal Cables and Radio modems

Details of Cable Modems for communications

a. **RS232 extender**

   In RS232 extender is used for communicating RS232 output from Data Logger to Computer Server at MBR.

   The cable Modem converts RS232 signal to a UART i.e. TTL signal and the TTL signal are modulated over two carrier frequencies in the voice band (300HZ to 3 KHZ) . 1KHZ for "0" bit and 800HZ for "1" Bit. The frequency train travels via long distance cable and hit again demodulated from Voice band to TTL and further to RS232.

   The Cable Modem also uses another set of frequencies for forward and return communication. The baud rate used here is between 300 to 9600.

   Distance of transmission is 12KM at 2400 Baud and 24Km at 1200Baud etc.

b. **LAN Extender**

   LAN is a Cable Modem fro communicating signal over longer distance via twisted pair cable. LAN extender uses a fixed IP address for identification and communicating via cable. The Modem uses Packet switching.

   Converts Ethernet signals to TTL and modulates (QPSK)and sends over a pair of cable and also receives QPSK signal demodulates convert TTL and finally to Ethernet signal.

   General Configuration of LAN Extender

<u>Configuration of Team Link 3002 DSL Modems</u>

Items required for Configuration

1. Computer with Window XP/ Window 7 with at least one COM Port
2. HyperTerminal Software in the computer.
3. Cable with RJ-45 type connector at one end and DB-9 Type at other end.

Procedure

a. Connect RJ-45 side of cable to console port of DSL Modem and DB9 connector to COM1 Port of this computer.
b. Switch ON the Modem
c. In computer go to HyperTerminal and select COM1 Port and Baud rate= 115200, Data Bits =8, Stop Bits =1, Hard ware control= None
d. After establishing connection. Enter Login = admin and Password= teamlink

You will see following menu

1. Config Menu
2. Status Menu
3. Diagnostic Menu
4. System Menu
5. Reset Menu
6. Exit

Choose 1 (Config menu)
You get

1. MAN Config Menu
2. SNAP Config Menu
3. Local Modem Config Menu
4. Ethernet Switch Config Menu

Choose 3 (Local Modem Config Menu)
You get

1. Terminal Type : Control {For Master}
2. Speed : 2048KBPS
3. Clock : Internal
   Choose 2 (Speed 2048KBPS)
   Enter SHDSL Speed [N Val fm 0-31] enter 1 enter
   Goto Main Menu by entering b(back) and b(back)

   1. Config Menu
   2. Status Menu
   3. Diagnostic Menu
   4. System Menu
   5. Reset Menu
   6. Exit

Choose 4 (System Menu) enter
You get

1. Local Default Configuration
2. Local Save Configuration

Select 2 (Local Save Configuration) and enter
System will save and reboot
Then Switch of Master DSL Modem

Do above for Slave Modem also.
Only difference between Master and Slave DSL Modems are as follows
Terminal Type : Control for Master and Remote for Slave.

II. Wireless Modems

Wireless Modems used in the field of aviation instrumentation for communication of data from Runway site to MBR/ATC. The frequency used for Transmission is 2.4 GHZ or 5.8GHZ ± 22MHZ with at least 12 Channels. These modems are to be configured for establishing communication. The Modems can transmit up to 29dBm radiating power with internal antenna of 10dbi gain so that no external antenna is required. The minimum receiving signal strength capability is up to -90dbm. The modems is capable of communicating in a free air with no obstacle up to 10KM radial distance however during heavy rain or Fog the max range of communication may be limited to 8Km or more due to some percentage of scattering and reflection of 2.4GHZ or 5.8GHZ signal.

Type of modulation: The modem Technique employed is Direct Sequence Spread Spectrum (DSSS) in 602.11b standards up to 10mbps data. For 802.11g and n standards, Orthogonal Frequency Division Multiplex (OFDM) for higher data bandwidth.

Direct Sequence Spread Spectrum (DSSS): In telecommunications, **direct-sequence spread spectrum** (**DSSS**) is a spread spectrum modulation technique. Spread spectrum systems are such that they transmit the message bearing signals using a bandwidth that is in excess of the bandwidth that is actually needed by the message signal. This spreading of the transmitted signal over a large bandwidth make the resulting wideband signal appear as a noise signal which allows greater resistance to intentional and unintentional interference with the transmitted signal.

One of the methods of achieving this spreading of the message signal is provided by DSSS modulation. In DSSS the message signal is used to modulate a bit sequence known as the Pseudo Noise (PN) code; this PN code consists of pulses of a much shorter duration (larger bandwidth) than the pulse duration of the message signal, therefore the modulation by the message signal has the effect of chopping up the pulses of the message signal and thereby resulting in a signal which has a bandwidth nearly as large as that of the PN sequence. In this context the duration of the pulse of the PN code is referred to as the chip duration and the smaller this value, the larger the bandwidth of the resultant DSSS signal and the more immune to interference the resultant signal becomes.

Influence of rain/ Fog on Wireless Data communication

The particle size of rain and Fog are 01 to 3mm (1.5mm radius) and 50µ m respectively. The scattering coefficient (X) = $2\pi R / \lambda$. For 2.4 GHz signal λ = 125mm

For a rain drop = 2 X 3.14 X 1.5mm / 125mm = 0.07, follow Raleigh scattering. Rayleigh scattering happens when X value is between 0.2 to 0.002 for X<0.005 there is negligible or No scattering. Hence drizzle to light rain does not have any impact on the 2.4GHz communication. However, heavy rain whose diameter of the rain particle exceeding 1mm slightly get scattered and resultant signal at reception is slightly less. Heavy Rain attenuate 2.4GHz data communication slightly.

For a Fog, particle of size is less than 0.1mm hence X <<0.005, hence Fog cannot scatter 2.4GHz, hence **no attenuation** due to Fog.

Configuration of Wireless Modems

For communication, wireless modems are to be configured, such as IP address, SSID (Subscriber Service Identifier), MAC address (if any), 802.11 b/g/n

B is oldest standard for communication uses up to 11mbps data band, 802.11g uses up to 54mbps bandwidth. 802.11n uses up to 300mbps.

For achieving long distance communication 802.11b shall be used. However bandwidth in this case is limited as mentioned above.

Wireless modems are to be configured for Access point (where Carrier frequency for communication is fixed) and Client Bridge (where the carrier frequency is tuned to the carrier from Access point for which SSID is the same. After recognizing Access point the communication protocol is established.

ENH-200 Wireless Modem

For Enginus -202/200 modem the typical configuration settings are given

I. Configuring Access Point

1. By default any ENH-202 modem is at IP address 192.168.1.1 therefore in the desktop/Laptop, in network settings are to be configured to open Radio Modem.
2. In Laptop/Desktop, Network settings, Properties/ TCP/IP change IP address as 192.168.1.3/, Subnet mask 255.255.255.0, default gate way 192.168.1.1. and make Ok.
3. Connect St cable between POE to Radio Modem, Cross cable between POE to Computer/ Laptop. Check whether Local Are connected or not. If not connected again check the setting in the computer.
4. Go to internet explorer and input IP address 192.168.1.1 and enter.
5. Enter user name as admin and password also admin all in small letters.
6. Go to Operation mode (under system) select country name as “India” and Access point and update.
7. Goto the wireless network and select 802.11 b of 802.11 b/g/n
8. Goto Wireless network under (Wireless). Under wireless network under SSID, Enginus1 press edit. Against SSID input “IMD”. And save and “Accept”.
9. Go to Wireless Advance Settings
10. Transmit Power → 27dbm, distance → 10KM. . Press Accept.
11. Go to Status (Yellow) and press Save/ reload:11
12. Save & apply
13. Access point configuration is Over and ready to use.

II. Client Bridge

1. Enter user name as admin and password also admin all in small letters.
2. Go to Operation mode (under system) select country name as “India” and Client Bridge and update.
3. Go to the wireless network and select 802.11 b or 802.11 b/g/n
4. Go to Wireless network under (Wireless). Under wireless network under SSID, Enginus1 press edit. Against SSID input “IMD”. And save and “Accept”.
5. Go to Wireless Advance Settings
6. Transmit Power → 27dbm, distance → 10KM. . Press Accept.
7. Go to Status (Yellow) and press Save/ reload:11
8. Go to IP address and change IP address as 192.168.1.100
9. Save & apply
10. Client Bridge point configuration is over and ready to use.

After configuration is over check whether Link or connectivity signal strength is very good (i.e. Green LED should glow for confirming connectivity between access point and Client Bridge.).

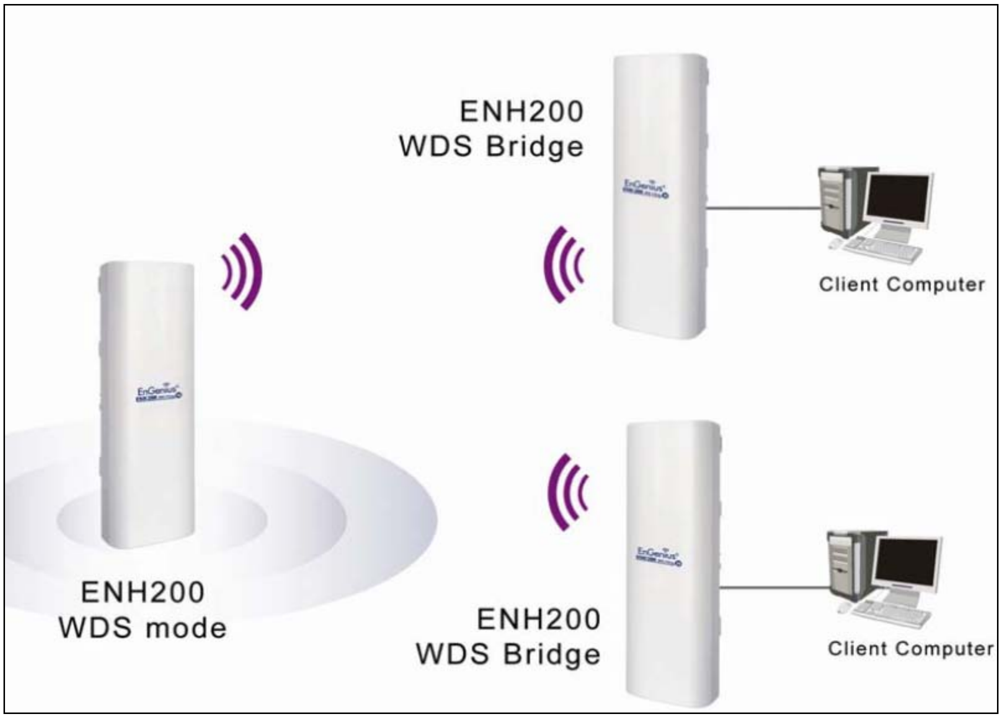
After switching ON the radio Modems the Power LED in both Access Point and Client Bridge will be ON. Then WLAN starts blinking indicating hand shaking between AP and CB, then link connectivity signal strength is indicated.
LED's on Radio Modem and its meaning.

Name of LED	Status
Power	ON→ Powered, OFF→Not Powered or defective
LAN	OFF/ON→ Not communicating with Modem/PC, Blinking→ Transmitting and receiving data
WLAN	ON/OFF→ No wireless data communication, Blinking→ Communicating
Link Quality	RED→ Poor, Yellow→ Medium, Grenn→ Good quality and Link with network.

If multiple radio modems are used at airport, SSID shall be changed for each pair of radio modems.

<u>WDS Bridge</u>

This type of configuration is used for connecting all wireless modems in a network. i.e. one receiving modem at air traffic control building for accessing data from modems at multiple runways (provided that all transmitting modems are in line of sight with receiving modem)



In WDS mode the wireless modems are in a network. This configuration is used for one Radio Modem communicating with many.

Configuration

Step-1→ select IP 192.168.1.1 and open using admin, admin

Step- 2→ Select channel frequency same for all modems in network (under wireless network select Channel/frequency same for all in WDS mode)

Step-3→ Setup authentication settings (All same SSID)

Step-4→ WDS Link settings (Enter MAC address of all access points). For ex if data from four Radio Modems to be connected in a network fill the Mach address of these point in following columns under WDS Link settings

1	MAC11	MAC12	MAC13	MAC14	MAC15	MAC16
2	MAC21	MAC22				
3						
4						

Now 4 modems will communicate its data to 5th Modem. The Ethernet output of 5 Modem is the combination of all remote 4 clients data + 5th data from the self.

Frequencies used for wireless data communication at airports.

As 2.4GHZ is used widely for communication of data from Runway site to MBR/ATC. **Following are the main benefits of using Frequency of 2.4GHZ or more.**

1. Wireless free band and no WPC licence is required.
2. Having 12 Channels ie 12 carrier frequencies. If the radio modem encounter any interference in channel-1 , both AP and CB is switched over to channel-2,3,4 so on till there is no interference observed. The time taken fro tuning is less than a second hence practically data communication is not effected at airport.
3. The higher frequency the size of antenna is smaller and Radio modem with carrier frequency around 2.4GHZ for 10dbi gain antenna is very small approximately 10cm X 10Cm and may be accommodated within the radio Modem. Hence no external antenna required for communicating over 10KM range. Whereas the modems operating in UHF band is larger and not accommodated in the radio modem.
4. To communicate data over a range of 10KM, only 27dbm power is required ie 500mW is sufficient, whereas for same distance in UHF require at least 1Watt or more. Hence can be operated with solar panel & battery
5. Wide band data communication is possible only using 2.4GHZ or higher.

Chapter 11

Measurement of Wind Shear

Wind Shear Systems

Low Level Turbulence which may be associated with a frontal surface, with thunderstorms or convective clouds, with microbursts, or with the surrounding terrain, is particularly hazardous to aircraft departing or arriving at an aerodrome. Wind shear is usually associated with one of the following weather phenomena:

- Frontal surfaces;
- Jet streams;
- Thunderstorms or convective clouds especially cumulonimbus or towering cumulus;
- Mountain Waves;
- Microbursts.

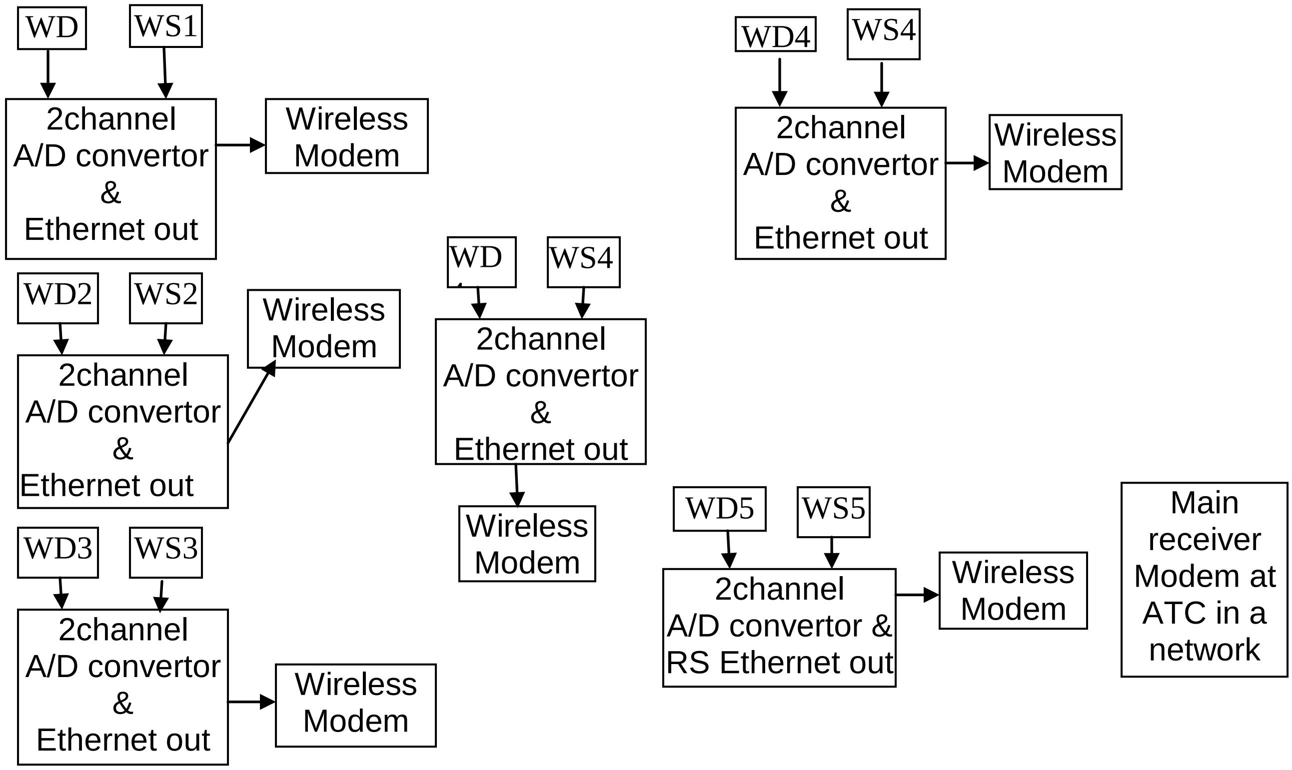
The main effects of wind shear are:

- Turbulence
- Violent air movement (up- or down-draughts or swirling or rotating air patterns)
- Sudden increase or reduction of airspeed
- Sudden increase or decrease of groundspeed and/or drift.
-

Instruments for measurement of wind shear

Over aerodrome both Horizontal and Vertical wind shear effect the landing and also take off. For measurement of Horizontal wind shear wind sensors are installed along the runway at a distance of 1km-2km over the entire runway length. Ie for Runway length of 3-4KM five wind sensors are installed. Every wind sensor data is communicated to central data processing server via wireless network in WDS bridge mode. Central server computes Horizontal wind shear i.e. Knots / KM for along the runway and also perpendicular to the runway. The same is reported in METAR.

All wind sensors installed along runway including radio Modems work with solar panel and battery with/without mains power.



Block Diagram of Wind sensors array along the runway

Vertical Wind Shear

Aerodrome requires vertical the current wind shear up to 1KM above the Runway level. The vertical and horizontal wind shear is also measured using Terminal Doppler Weather Radar.

Another method of obtaining Vertical wind shear is using wind sensor array along runway and also at ATC building and also a tall tower nearby aerodrome like chimney or tall building r where wind sensor are installed. At least ATC tower and three more towers in different directions are chosen. Wind sensors are installed on this tower. Communicates to server via wireless modems the wind data along with height above the runway level. Server computes vertical wind shear from this data.

Chapter 12

Liaisoning with Airport Authorities of India

Following works are required from Aviation authorities due to following reasons:

a. Selection of site 5m X 50m for Met instruments.
b. Power supply to the AMI from the essential power supply preferable from ILS or glide path so that power is always present.
c. Cabling from AMI site to the MBR & ATC shall be done in consultation with aviation authorities so as to not interfere with their cables.
d. \using available cable duct from MBR to ATC provided by Airport authority, for communication of processed data from MBR to ATC.
e. Making Power available to all Met equipments installed at MBR, Air Traffic control and other operational areas.
f. Fixing of Met display set at place required by AAI.

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