# Aeronautical Met Instruments System

UDAY SHENDE

## IMPORTANCE OF AMIS

The impact of a relatively small change in the following parameters on air operations is very high

- **Wind**
- **Temperature**
- **Visibility**
- **Pressure**
- **Cloud base height**

**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 cross wind 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 the runway length is insufficient, take-off weight has to be reduced.

**Pressure**:

The atmospheric pressure measured at the aerodromes is used for altimeter settings of the aircraft

**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 aerodromes

**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.

# Category of airports:

1) Category-I
2) Category-II
3) Category-III A
4) Category-III B
5) Category-III C

# ICAO Definitions (Annex-10)

**Category-I:**

A precision instrument approach and landing with a decision height not lower than 60 m and with either a visibility not less than 800 m or a runway visual range not less than 550 m.

**Category-II:**

A precision instrument approach and landing with a decision height lower than 60 m but not lower than 30 m and a runway visual range not less than 350 m

**Category-III A:**

A precision instrument approach and landing with a decision height lower than 30 m or no decision height and a runway visual range not less than 200 m.

**Category-III B:**

A precision instrument approach and landing with a decision height lower than 15 m or no decision height and a runway visual range less than 200 m but not less than 50 m.

**Category-III C:**

A precision instrument approach and landing with no decision height and no runway visual range limitations.

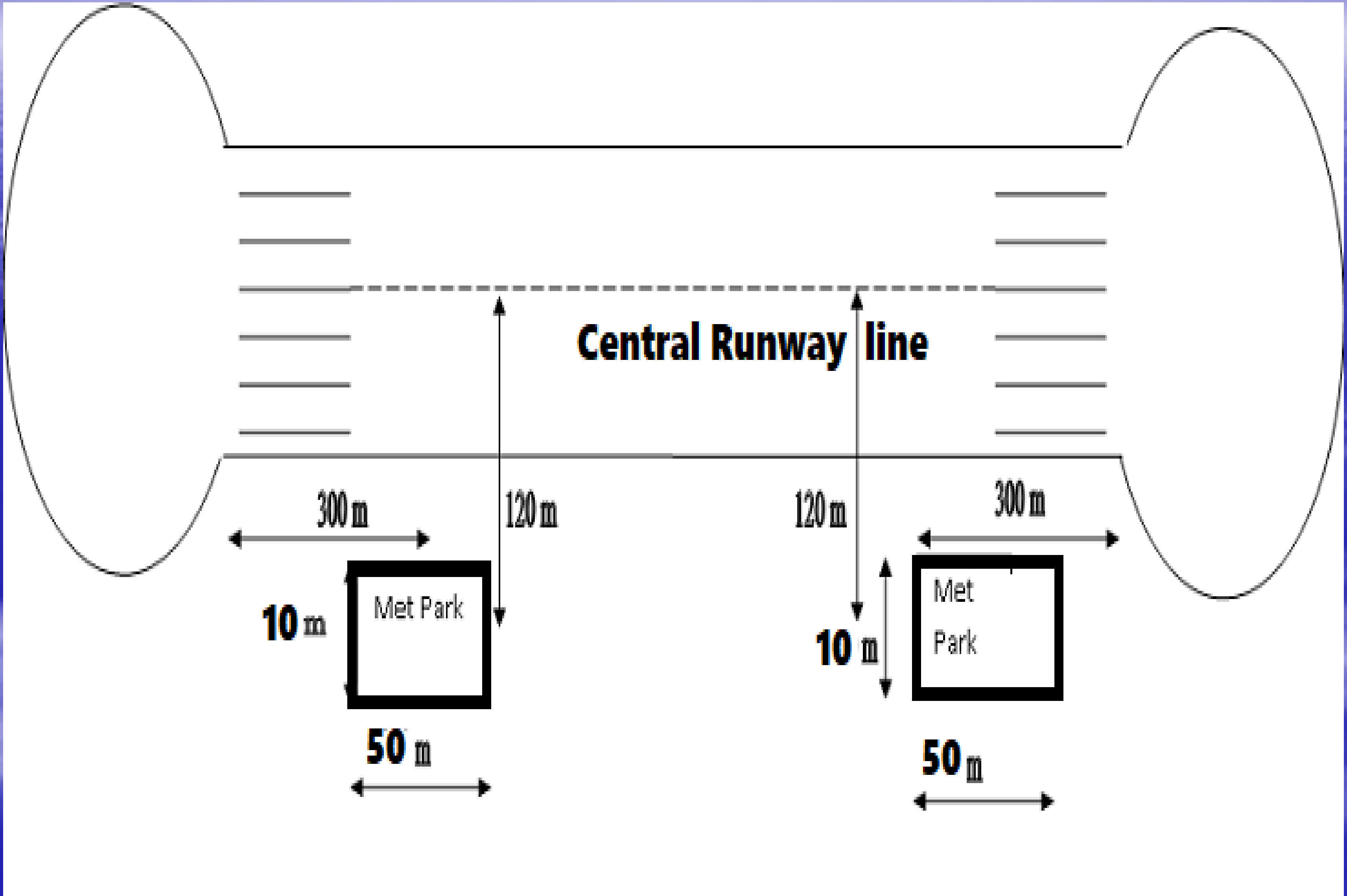
# Instruments required in each category:

| Category | CWIS | Visibility sensors | Ceilometers |
|---|---|---|---|
| I | 1 | 1 | 1 |
| II | 2 | 2 | 1 |
| III-A | 2 | 3 | 1 |
| III-B | 2 | 3 | 2 |

# AMIS Comprises:

- CWIS
- DIWE
- Transmissometer
- Ceilometers
- Integrated systems

# Runway and Met-Park



**(Ref: ICAO Annex.3)**

| Parameters | | Operationally desirable accuracy |
|---|---|---|
| **Wind** | | |
| | **Direction** | ± 10° |
| | **Speed** | ± 1 kt up to 10 kt<br>± 10% above 10 kt |
| **Temperature** | | |
| | **Air** | ± 1°C |
| | **Dew point** | ± 1°C |
| **Pressure(QNH,QFE)** | | ± 0.5 hPa |
| **Visibility** | | ± 50 m up to 600 m<br>± 10% between 600 and 1500 m<br>± 20% above 1500 m |
| **Cloud amount** | | ± 1 okta |
| **Cloud base height** | | ± 10 m up to 100 m<br>± 10% above 100 m |
| **Runway Visual Range (RVR)** | | ± 10 m up to 400 m<br>± 25 m between 400 and 800 m<br>± 10% above 800 m |

# CWIS:

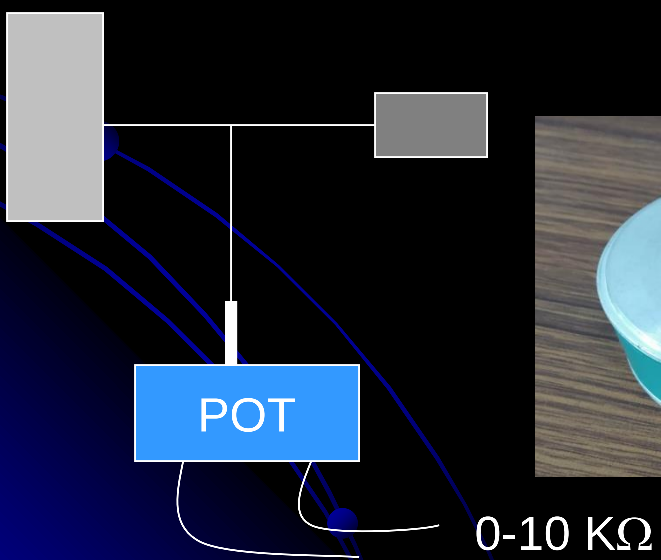
**Current Weather Instruments System (CWIS) is used for continuous monitoring of wind direction, wind speed, Pressure, temperature and dew point at the touch down zone of runway in an airport.**

# CWIS Consists of:

- Sensors at site near touch down zone
- Digital Display in Met Briefing Room
- Slave display in Air Traffic Control
- Wireless/Cable Communication

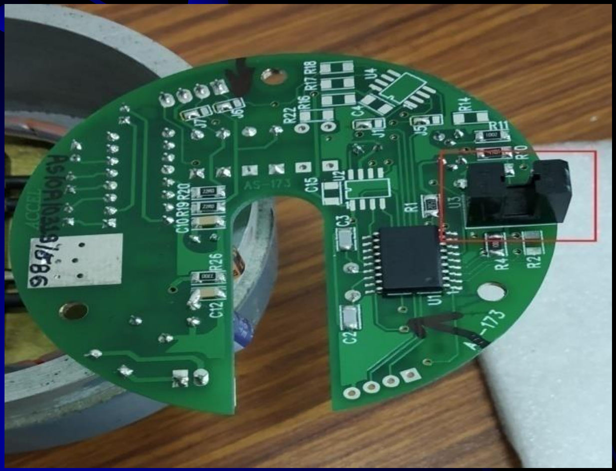
# Potentiometric Wind vane

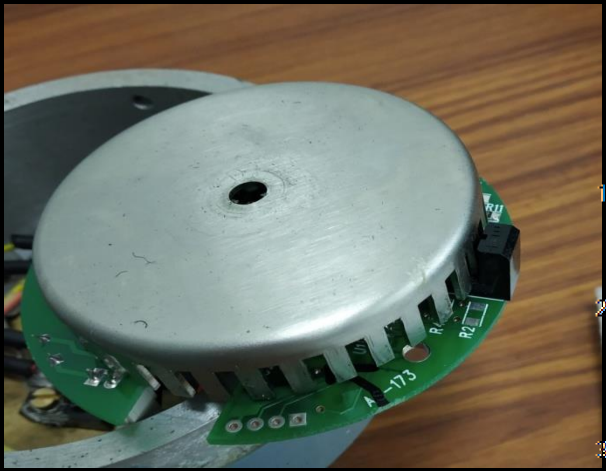
- Servo potentiometer is connected to the fin of wind vane
- 0-360 variations are converted to 0-10K variations.
- Signal conditioner converts 0-10 K variations in to 0-360 milli volts DC

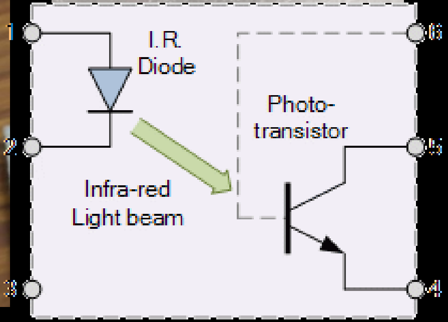



# Cup Anemometer

The sensor is basically chops IR beam using chopper tooth. System uses an opto coupler for this purpose. No of chopped electric pulses per min is proportional to the Wind speed. The square pulses are maintain at 0 to 5Volts using Schmitt trigger IC. Later sent to Micro controller which directly gives value of Wind Speed in RS232 format :







# PCB Design:

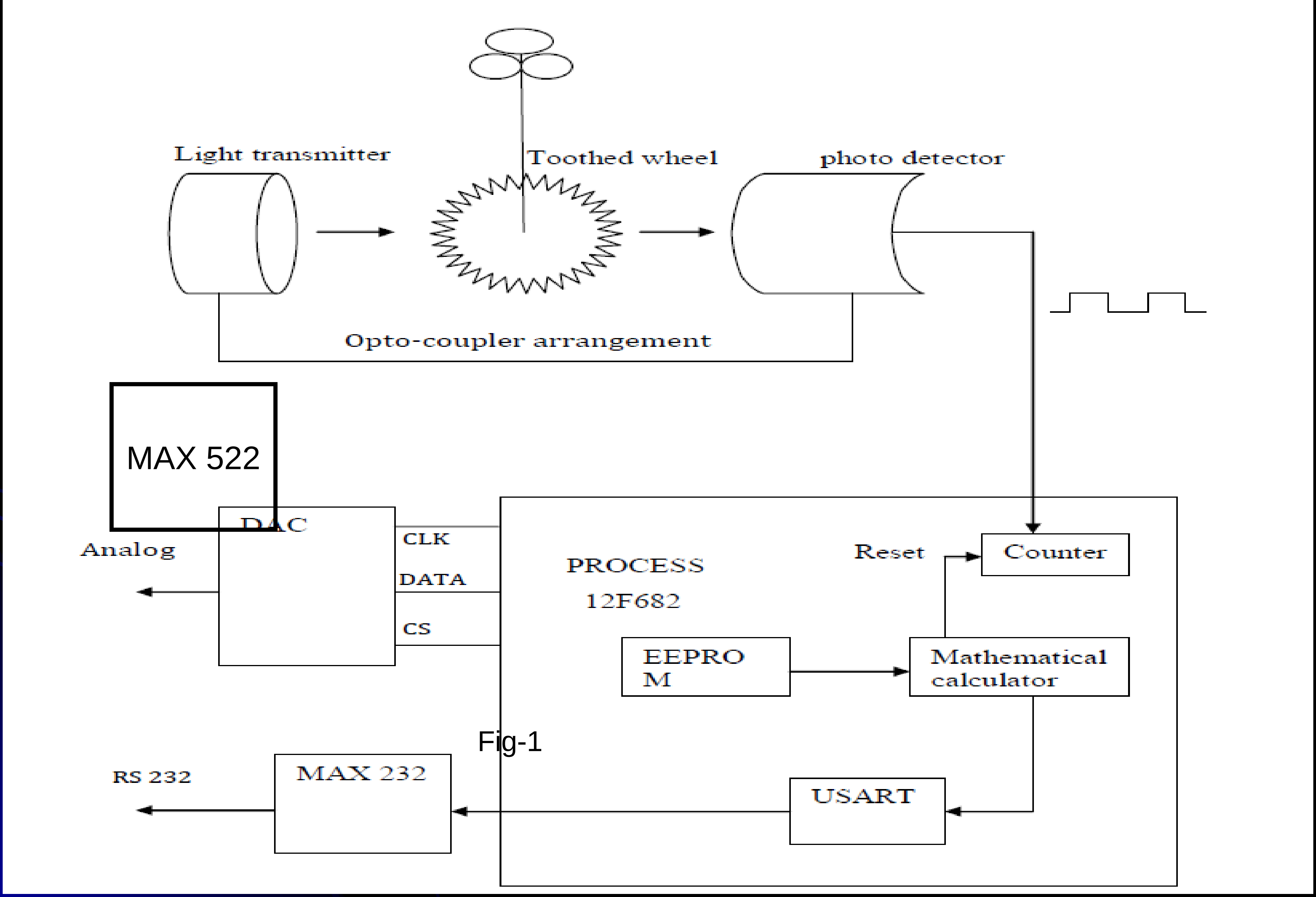



Fig-1

# Combined sensor for Temperature and Humidity

PT-100 as the temperature sensor with range –40°C to +60 °C

- The most common platinum PRT sensor used in the process industry is the **Pt-100** sensor. The resistance is 100 ohms at 0°C. and the resistance increases linearly with the increase in temperature. It has a measuring range of -40 to 60 C$^{o}$ for temperature. Its output is 0-1 volts dc.

- A thin polymer , which is having the property to absorb moisture from the air, and changes its electrical permittivity in proportion to relative humidity Inbuilt signal conditioning to give temperature and relative humidity as 0-1 volts

- Dew point can be calculated using suitable formula

**K = In (RH/100) + 17.502*DB (240.97+DB)**

**DP = 240.97 *K/(17.502-K)**

# Working of Digital Pressure sensors


A micromechanical sensor that uses dimensional changes in its silicon membrane to measure pressure. As the surrounding pressure increases or decreases, the membrane bends, thereby increasing or decreasing the height of the vacuum gap inside the sensor. The opposite sides of the vacuum gap act as electrodes, and as the distance between the two electrodes

changes, the sensor capacitance changes. The capacitance is measured and converted into a pressure readin


Solid State Pressure Sensor

The Accubar pressure sensor is a solid state pressure transducer. A piezo-electric quartz crystal is used for direct measurement of force or pressure.

*A material is said to exhibit piezo electric effect if a mechanical force applied to it produces electric charges. Conversely, when placed in an electric field, there results mechanical strain and distortion.*

## Recommendations:

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)**

# Why Digital CWIS ?

Wind is vector quantity, so vector averaging is required. Conventional analog CWIS can give only scalar averages. Digital CWIS is a software controlled device having the facilities of vector averaging, data storage in PC, etc.

# SENSORS

- Potentiometric wind vane
- Optical anemometer
- Air Temp/RH
- Pressure


This is an optoelectronic, fast-response, low threshold anemometer. In the cup wheel it has three lightweight conical cups providing excellent linearity over the entire operating range, up to 75 m/s. Rotated by the wind, a chopper disc attached to the cup wheel's shaft cuts an infrared light beam 14 times per revolution, generating a pulse train output from a phototransistor

The WAV151 Wind Vane is a counter-balanced, low threshold optoelectronic wind vane. Infrared LEDs and phototransistors are mounted on six orbits on each side of a 6-bit GRAY-coded disc. Rotated by the vane, the disc creates changes in the code received by the phototransistors

Sensors in Use :

PT-100 & Humicap

Basic output:

0-1000mv

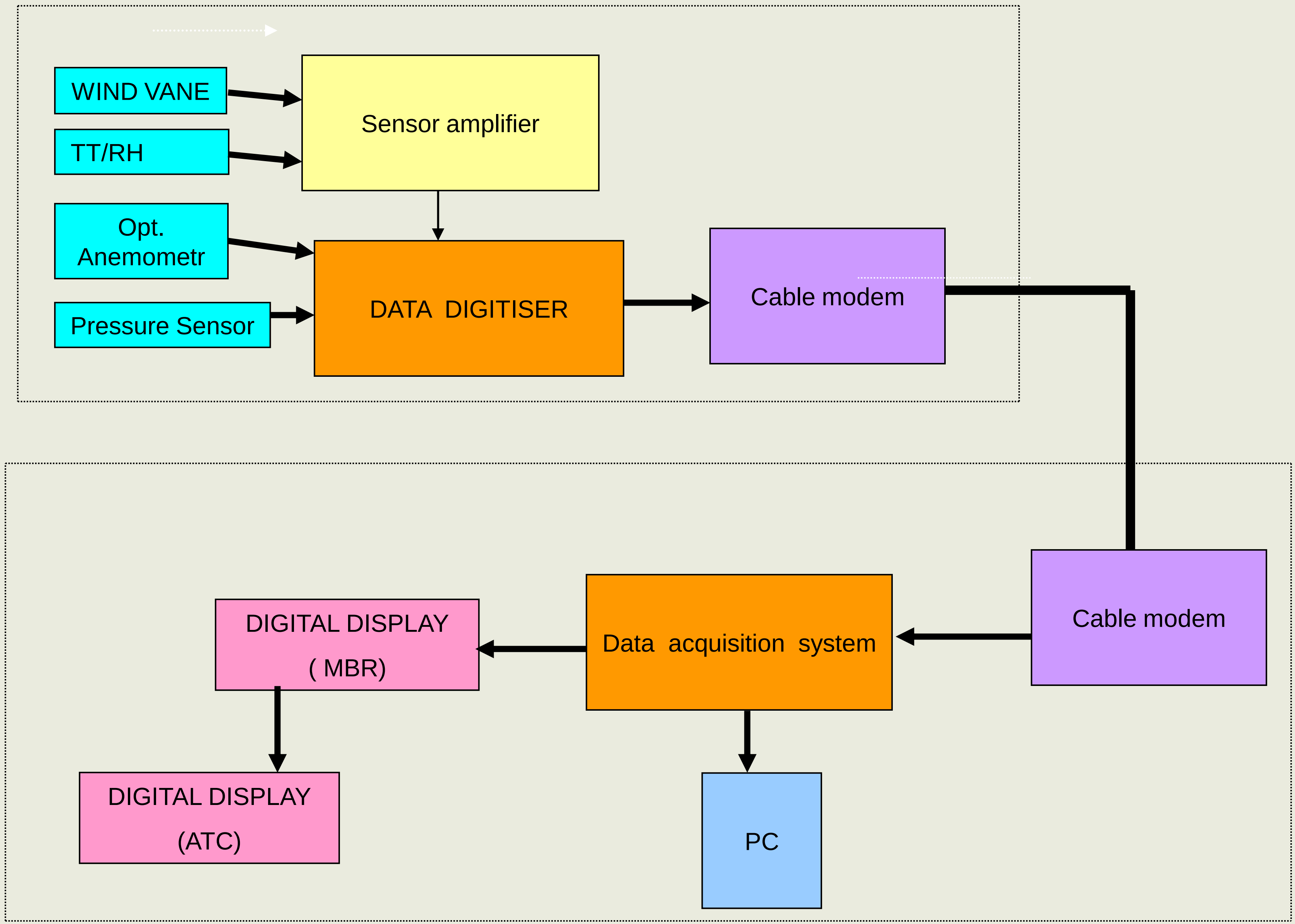
for -40°C to +60°C

and 0-1000mv

for 0 to 100% RH.

- The barometric pressure sensor measures air pressure against a small evacuated chamber and compensates this measurement against the measured air temperature.

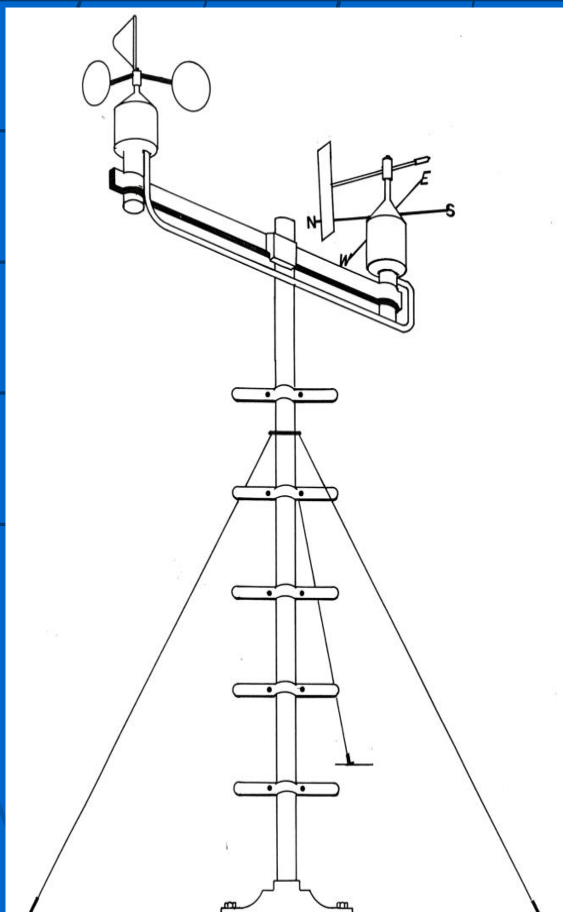
# Block diagram of Digital CWIS

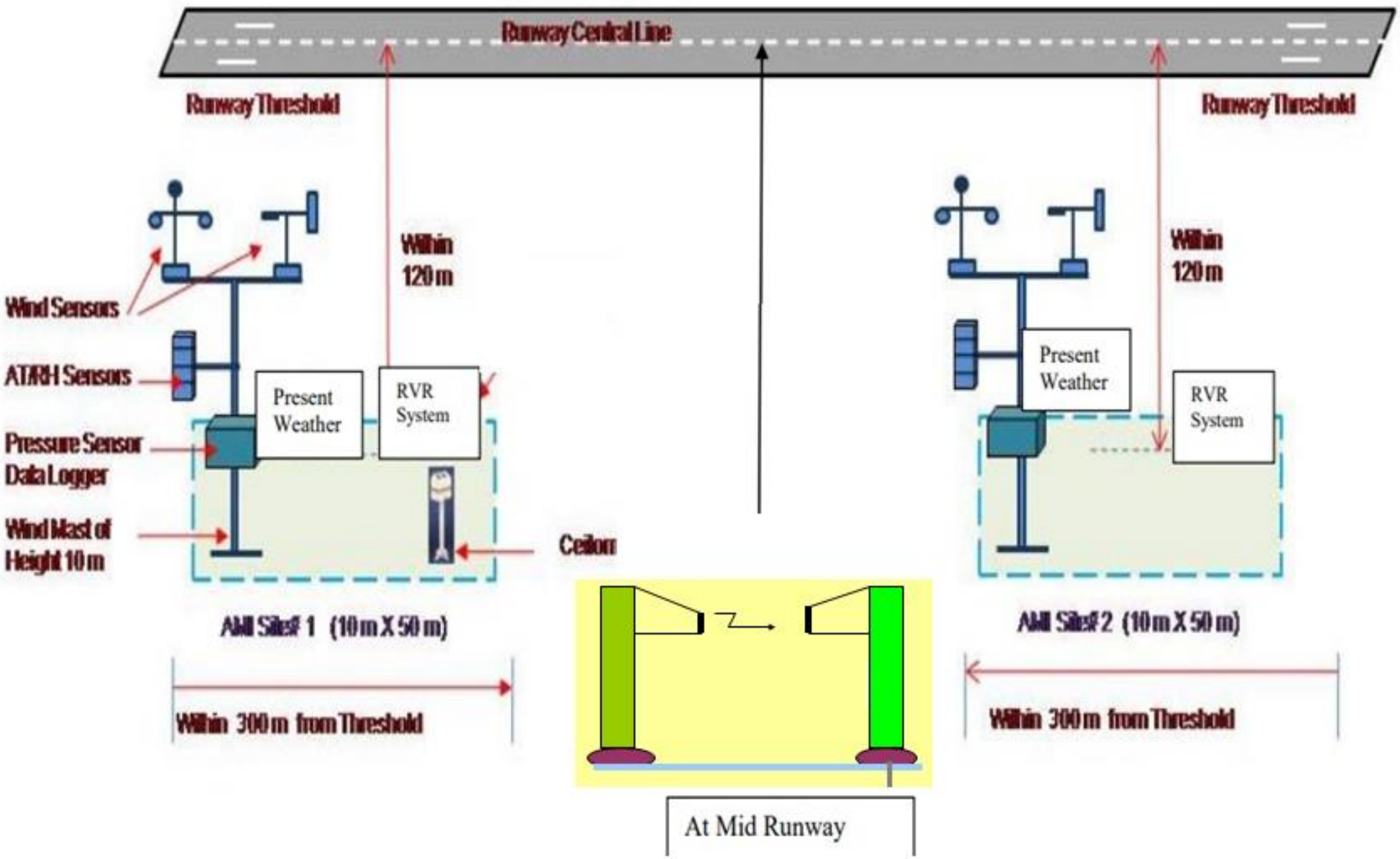


# Advantages of Digital CWIS

- Averaging facility
- Use of software to remove nonlinearity, expressing in different units, and data validity checking.
- Use of various units through software
- Compatible with other sensors like hygroclip
- PC Interfacing

# Anemometer used in IMD DCWIS

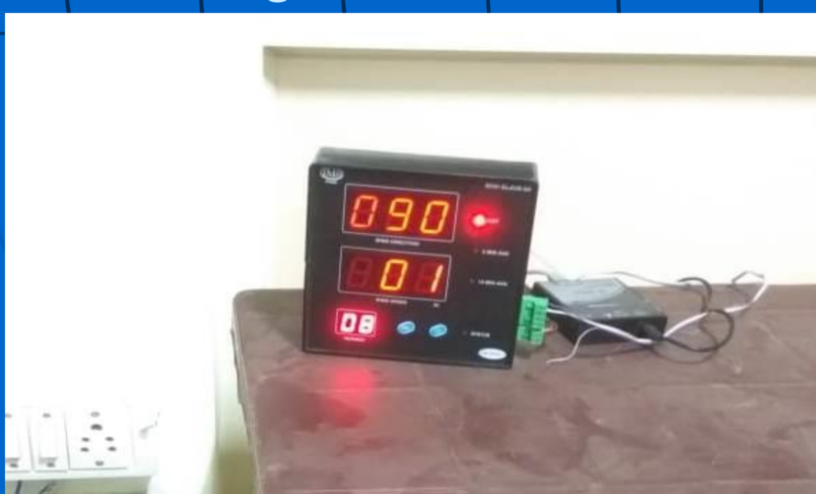


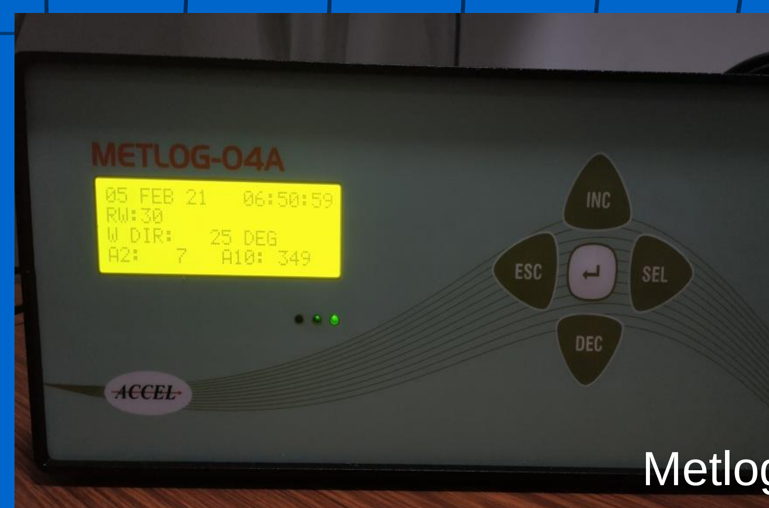



Runway Central Line
Runway Threshold
Runway Threshold
Within
120 m
Within
120 m
Wind Sensors
AT/RH Sensors
Pressure Sensor
Data Logger
Wind Mast of
Height 10 m
Present
Weather
RVR
System
Present
Weather
RVR
System
Ceilon
AWS Site# 1 (10 m X 50 m)
AWS Site# 2 (10 m X 50 m)
Within 300 m from Threshold
Within 300 m from Threshold
At Mid Runway


Digitizer

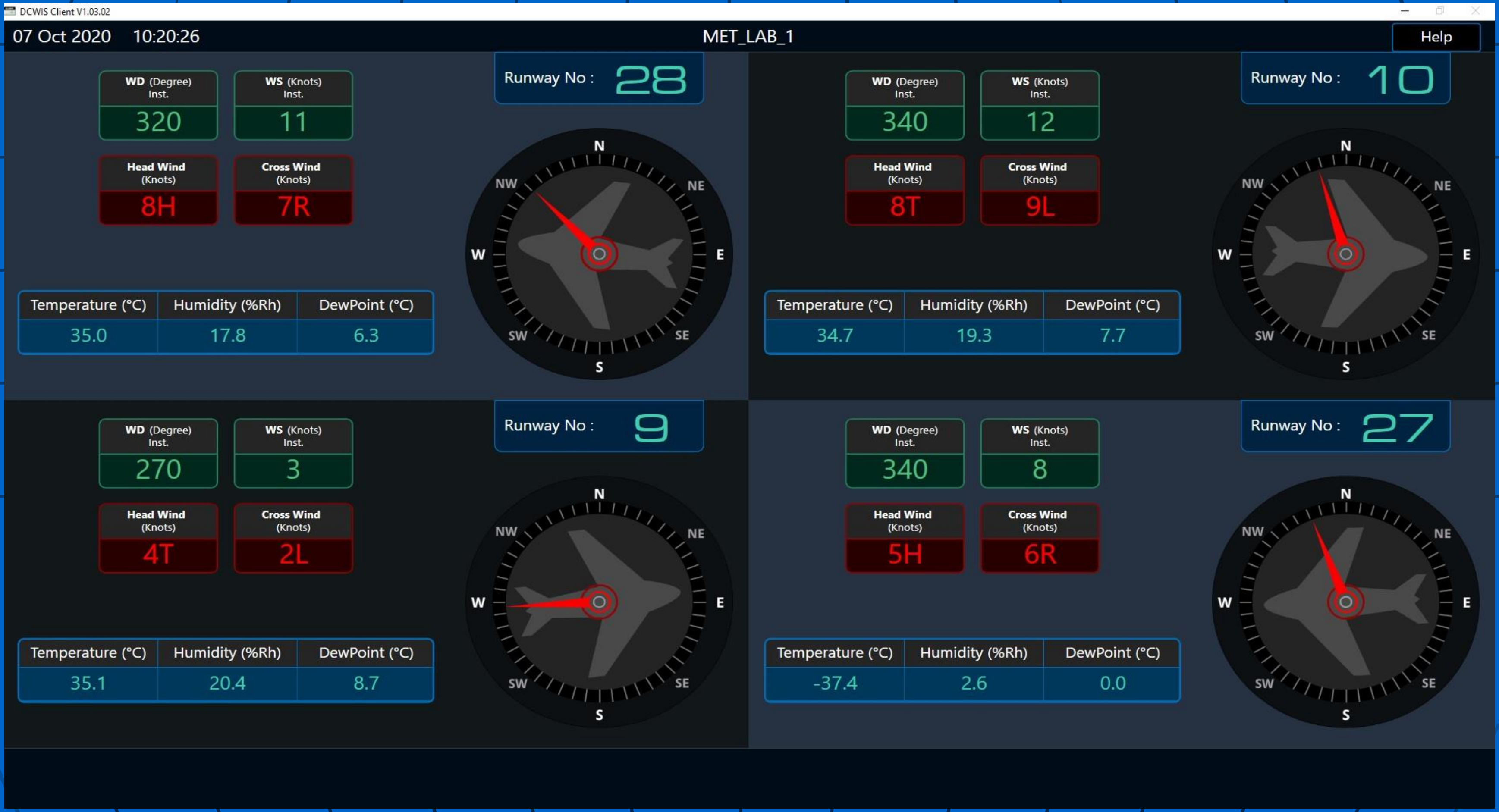
Logger






Metlog 4

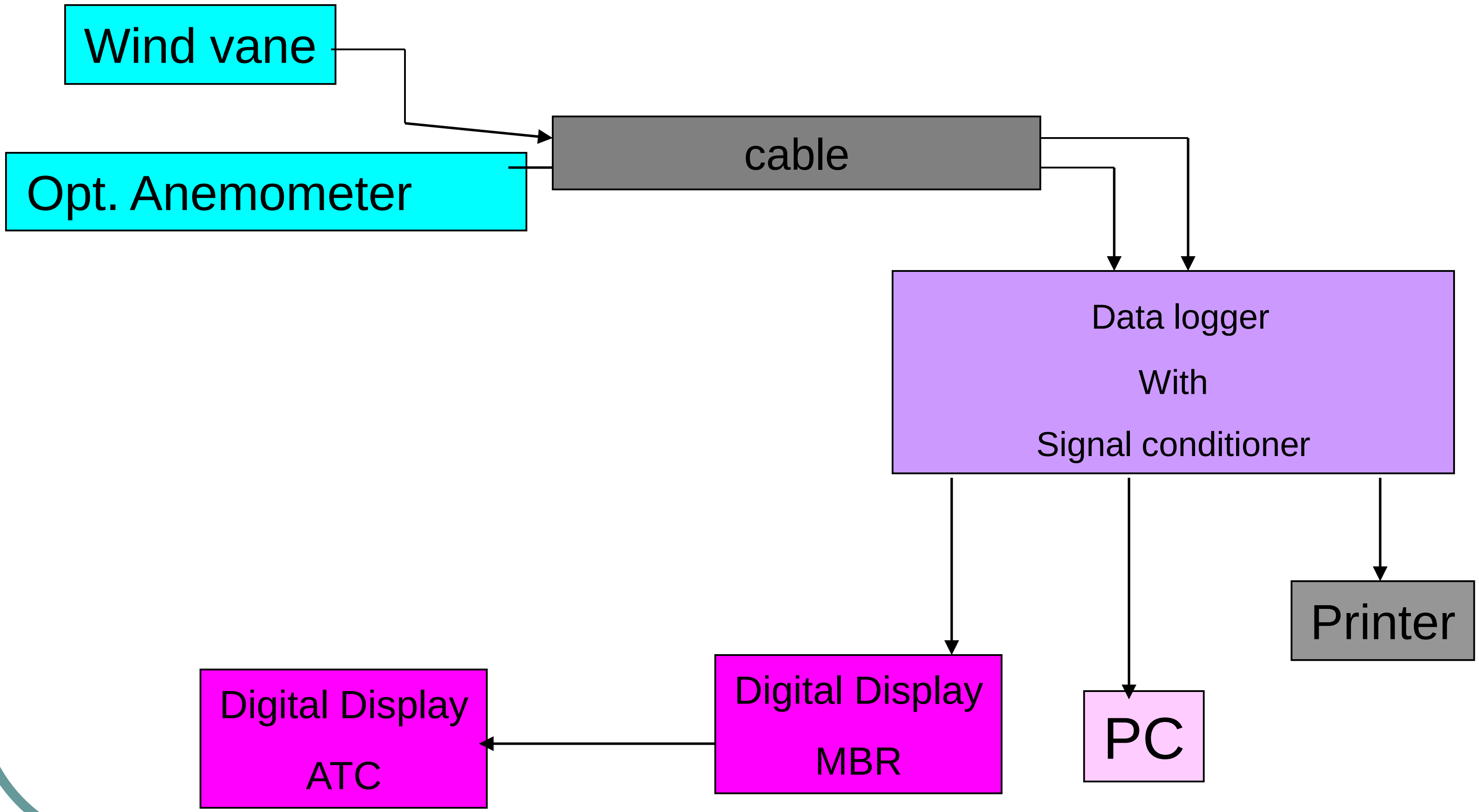
# Multi-Runway Screen



# Digital DIWE

**Distant Indicating Wind Equipment is used for continuous monitoring of wind direction and wind speed at the touchdown zone of runway in an airport.**

# Block diagram of Digital DIWE



# Transmissometers

A transmissometer is an instrument Which takes direct measurement of atmospheric transmittance between two points in space.

Using Koschmieder's law and Allard's law , the computer in the Transmissometer system computes the values of Meteorological Optic Range (MOR) and Runway Visual Range (RVR)

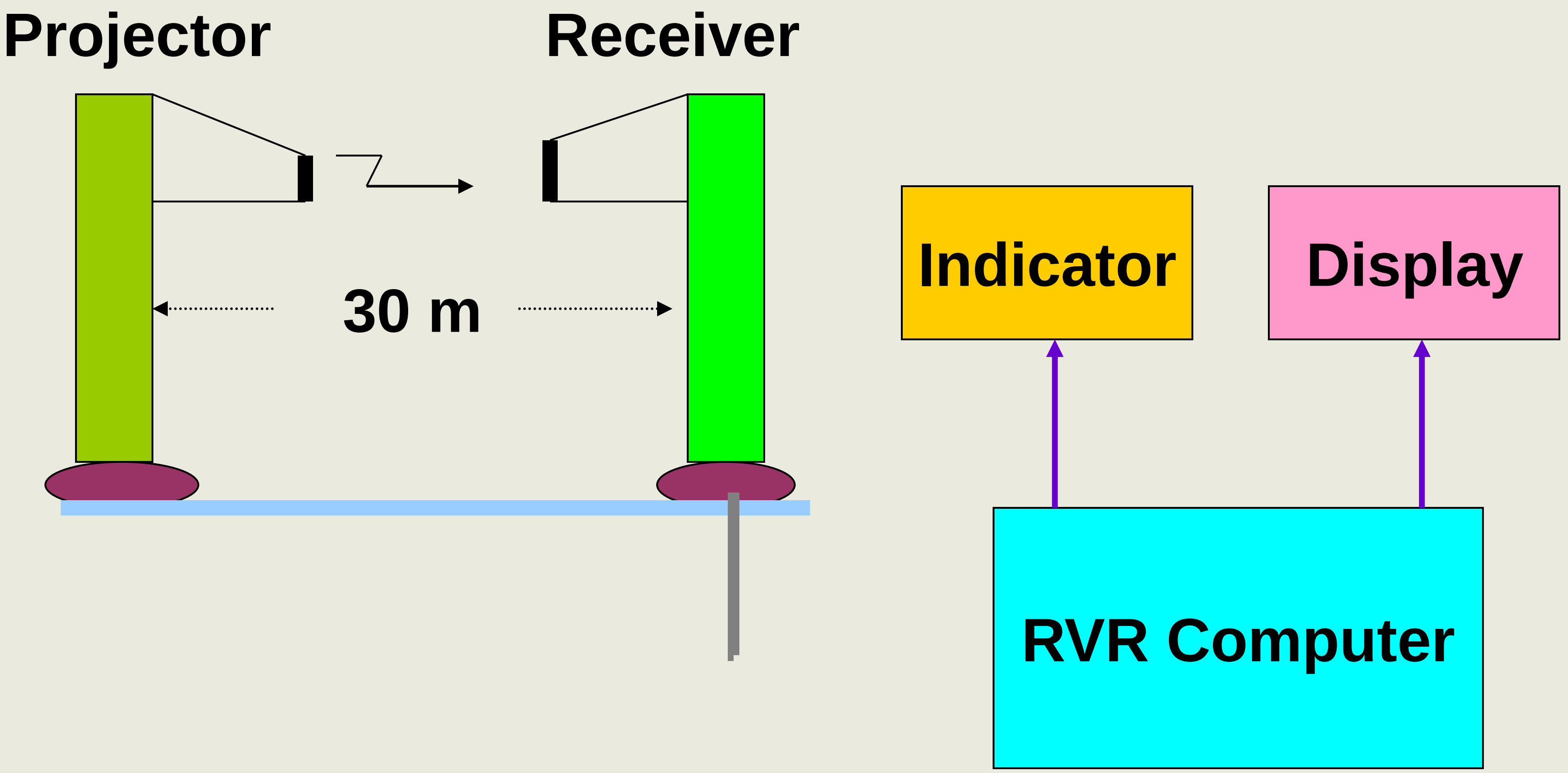
# Transmissometer systems

**Two types**

1. **Single base line Transmissometer**
2. **Double base line Transmissometer**

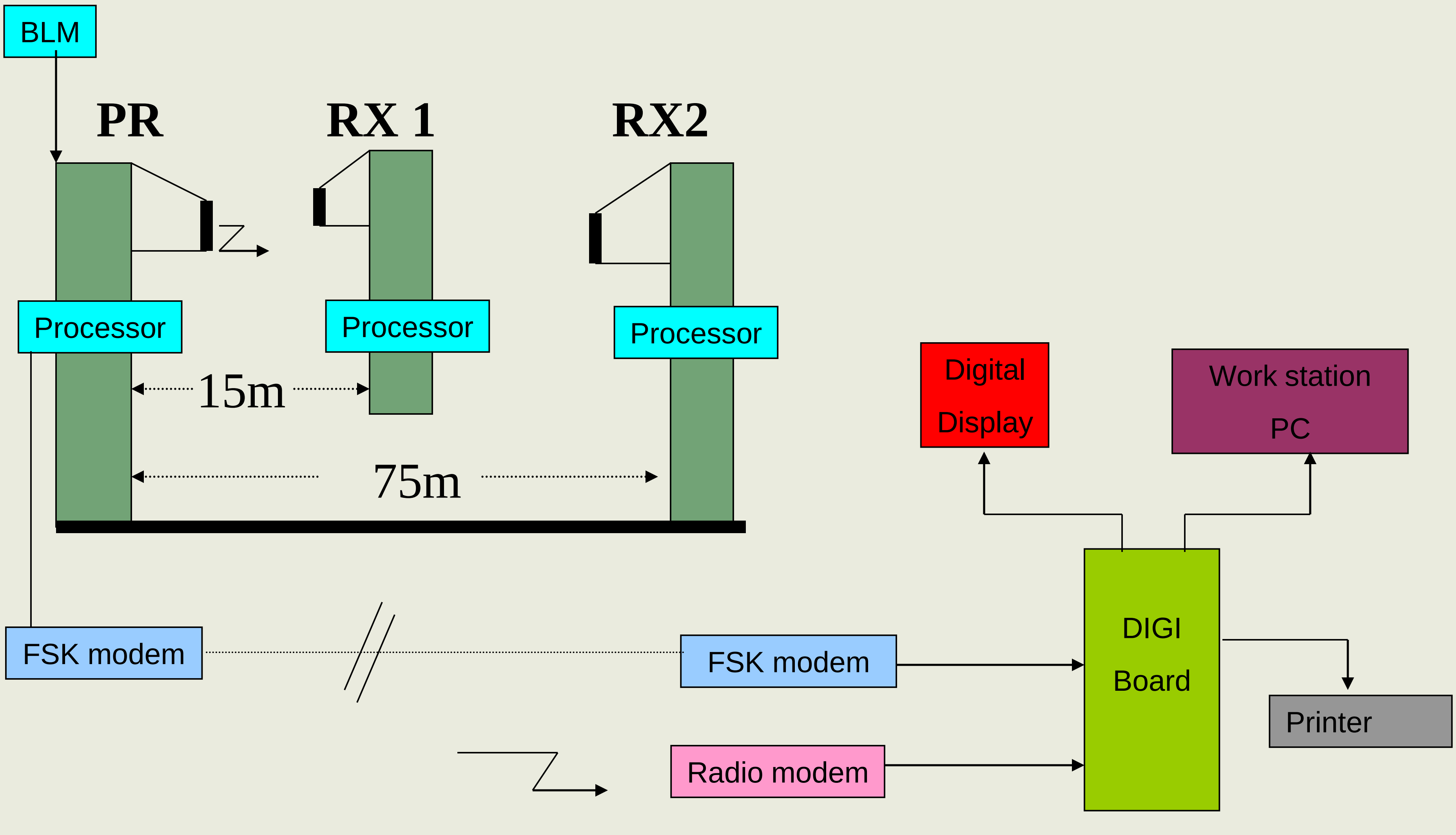
# Transmissometer System consists:

- Projector
- Receiver
- RVR computer system
- Recorder
- Indicator




**Block diagram of single baseline Transmissometer**

# Block diagram of double base line Transmissometer



# Selection of a Transmissometer

From Koschmieder's law and Allard's law , it can be proved that the range of Measurement of MOR and RVR is fully depending on the base line length as per the following equations:

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

$E_t = I.R^{-2}.t^{(R/b)}$ …………………………..(2)

Equation (2) can be used for the calculation of RVR.

So a single base line Transmissometer of 75 m can measure a minimum MOR of 45 m and RVR of 225 m.

Hence for CAT-II and CAT-III operations ,a dual baseline Transmissometer is essential to meet the requirement.

## Advantages of Dual base line Transmissometer

- It is accurate for both lower and higher ranges of measurement of RVR

- Better sampling space, as the assessment is based on two sampling spaces

- If one receiver fails, the other can give the RVR data.

# What is Drishti !!!

**Visibility is a very important parameter for Pilots during landing and take off operations**

**Communication**

**Block diagram of DRISHTI**

**Lamp**


**Transmitter (lamp)**
Sends parallel beam of light

**30 meter baseline (distance between transmitter & Receiver is optimum for both low (< 50 meters) and high visibility (10000 meters) conditions**

**Receiver**


**Background light monitor**

**Receiver: An optical detector**
receives light from transmitter

30 m

DRISHTI

Field Instrument

→ Meets all Challenges

Virtual Instrumentation concept
Modular Electronics - Reduced part count & Environmentally controlled miniaturised optics Increased reliability

System facilitates automated measurement of RVR (50m-3km) and MOR (10m -10km) as required by WMO & ICAO

# DRISHTI TRANSMISSOMETER

**System facilitates automated measurement of visibility as required by WMO & ICAO**

Wi-Fi system @ 2.4 GHz

Data from Field site

Wi-Fi


RS 232

Land Line

ATC


At ATC

RVR Computer at MBR


RS232 or Ethernet Link


Web Enabled

At Radar Room

Real time operating system -- Continuous operation of 24hrs x 365 days

High mean time between failures- Rugged system

Drishti is capable of working for CAT– I, II III A & B Operations with choice of base lines from 15 to 75 meters

**VISIBILITY MONITOR**
**Access to Drishti System at different Airports**

# DRISHTI SOFTWARE

Single Station


Dual Station


Triple Station


**Software is based on Industry Standard LabView FPGA, Real time & LabView Platform**

**Multiple systems data in a single computer**

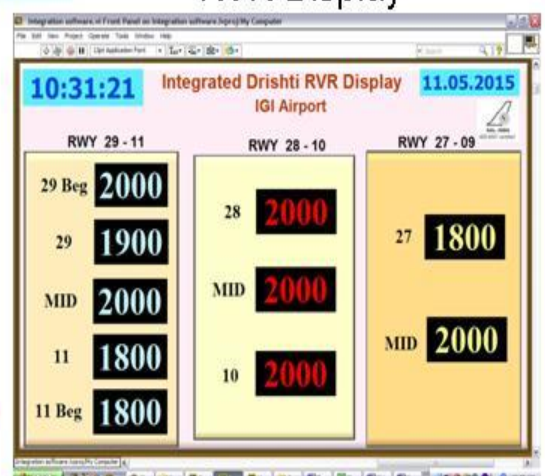
**Software with 120 Virtual Instrumentation Modules**

Multiple Drishti Systems RVR data from 3 RWYS at IGI Airport in a single screen

Display at ATC, RADAR Room & IMD Website

Sensor details & Calibration window


Integrated Drishti RVR Display



**Drishti Transmissometer**

Drishti system at field side consists of Transmitter and receiver separated by base length 30m.

Transmitter lamp (LED white light) send collimated beam of light which is received by an optical detector in the receiver ( photodiode).

Receiver measure the attenuation of light intensity received from the light source traversing through the atmosphere. The attenuation factor depends on the atmosphere condition between transmitter and receiver like dust particles, fog and rain etc which is representative condition of runway.

BLM is mounted on the receiver side which gives the background light of atmosphere ie bright light, twilight, night, normal day light. Photodiode used as a sensor.

Sensors data will be processed through signal conditioning circuit and converted into digital using 24 bit A/ D converter. Real time embedded controller named FPGA( Field Programmable Gate Array) is also used to convert digital signals. FPGA controller is used to asses and transmits the data to MBR (Met Briefing Room). Data is further processed by drishti embedded software developed by NAL under industry Lab-View platform with visual instrumentation concept.

Processed data sent to MBR upto 10km through two mode of communication (wifi and Landline).

RVR and MOR calculated by Lab view environment by Drishti RVR software using internationally accepted Allard’s and Koschmieder’s Law at MBR PC server.

# Cloud base height measurement

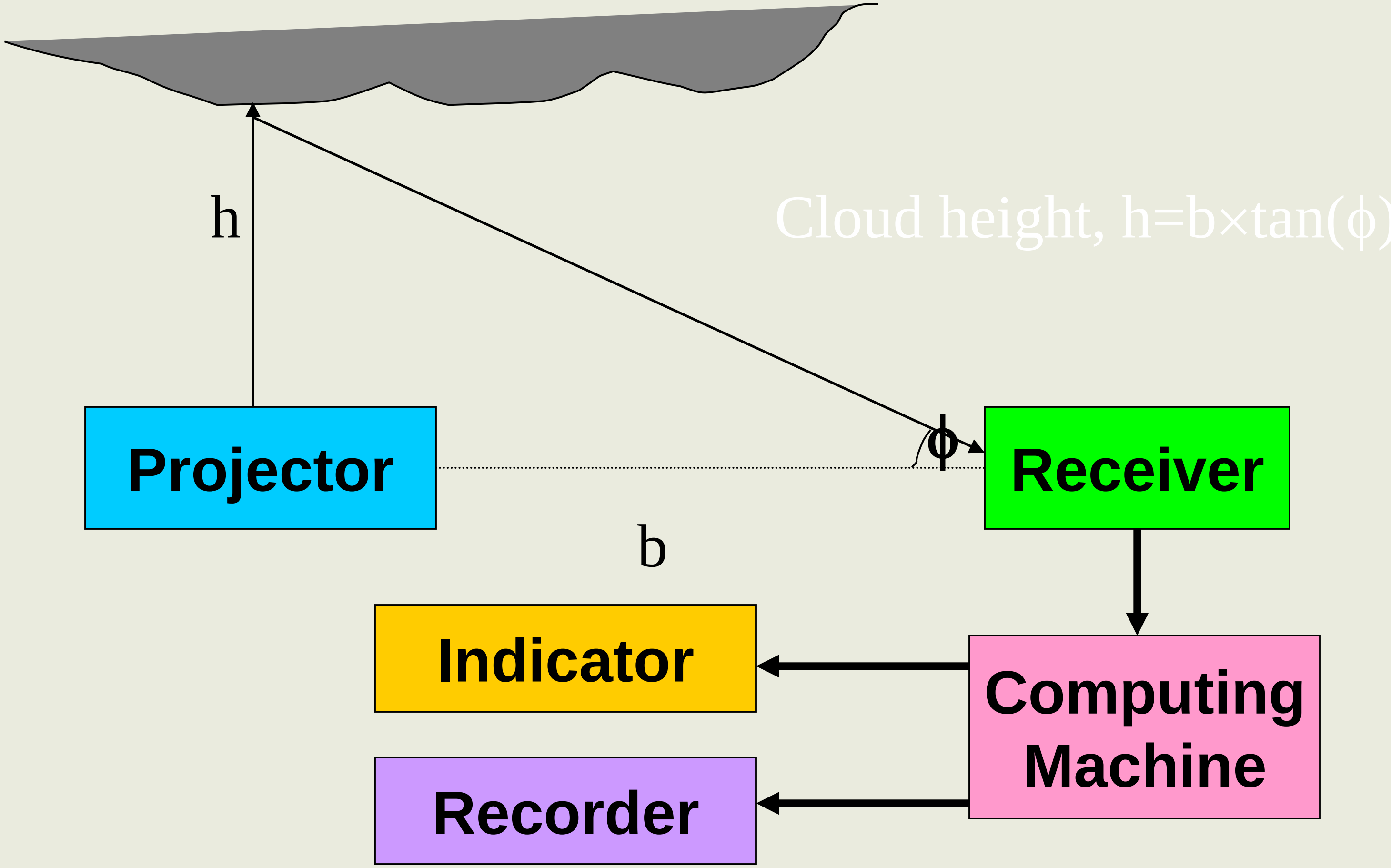
***Primitive methods:***

- **Ceiling balloon method**
- **Search light method**

***New methods:***

- **Ceilometers or Ceilographs**
- **Laser Ceilometers**

# Ceilometers / Ceilograph Systems

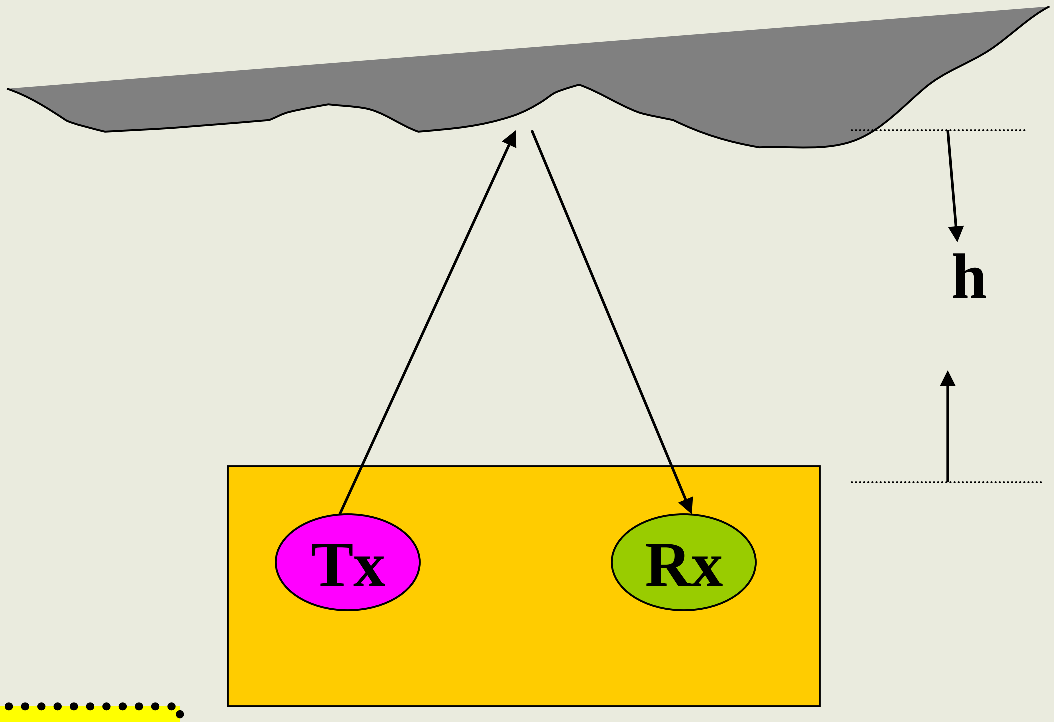


# Limitations of Ceilometers/Ceilograph

- **The cloud has to be over the projector**
- **It cannot indicate cloud height during rain**
- **It cannot record fast moving cloud**
- **It can record only height of lowest cloud**

# Laser Ceilometer Systems

**Based on LIDAR principle**




$$h = \frac{t \times c}{2}$$

The transmitter in the ceilometers is a Gallium 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).

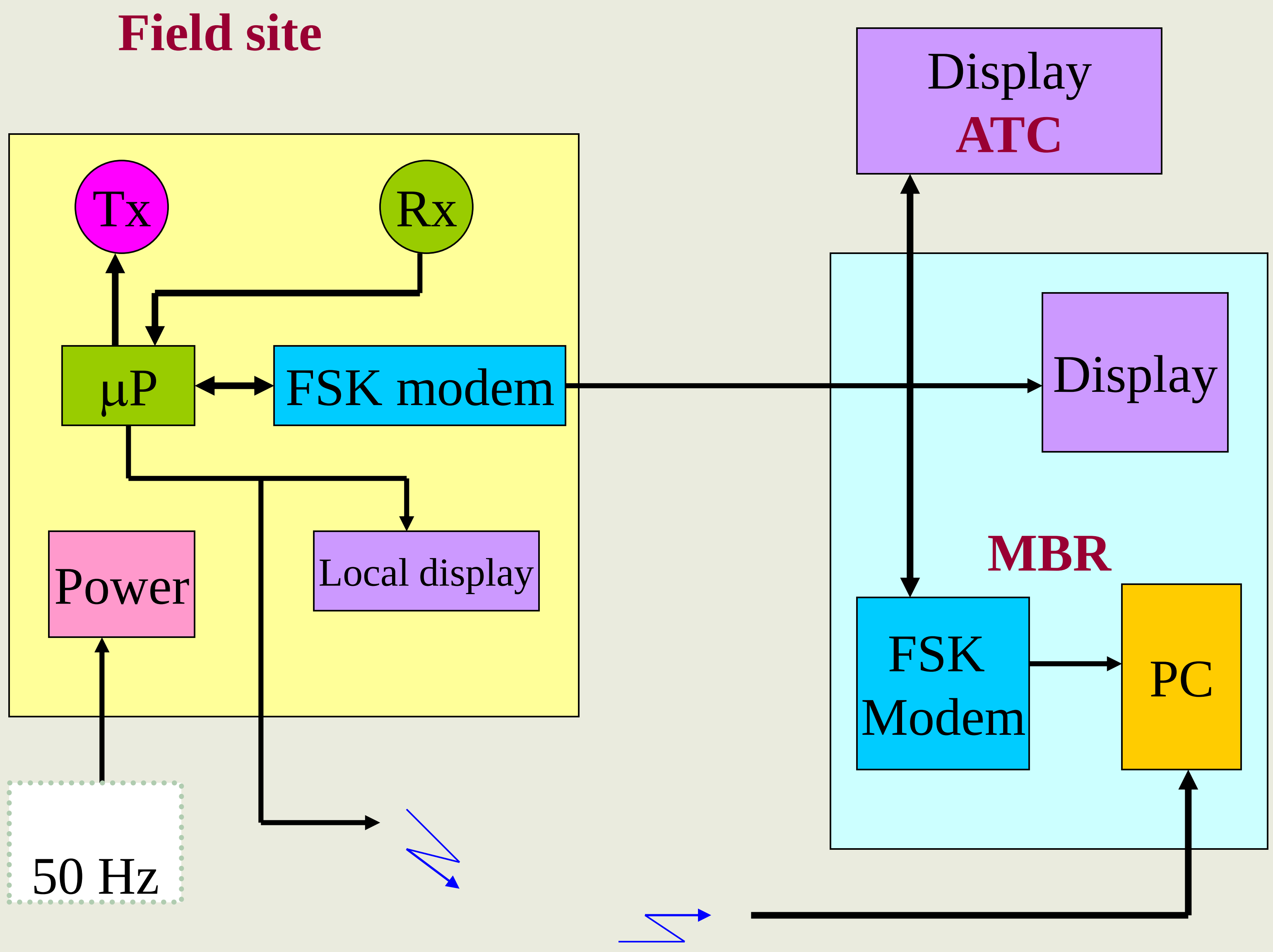
When the light pulses penetrates a cloud some parts of the light energy is reflected straight back.

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 $\mu$sec, the cloud height will be displayed as 2400 meters

# Functional block diagram of Laser Ceilometers system



# Features of Laser Ceilometers

- Laser pulses for transmission. Both transmitter and receivers are controlled by a microprocessor (80236).
- FSK modulated signal is used for landline communication.
- RS 232 signal is used for Serial communication.
- Data storage in Windows based PC. Graphical presentation of cloud data through “Cloud presentation” software

# Advantages of Laser ceilometers:

- It can indicate clouds during rain, fog etc.
- It can record fast moving clouds. It can record all types of cloud up to 7500 metres.
- Two types of communication from field to MBR.
- Data can be stored in a PC.

## Disadvantage:

- The cloud has to be over the transmitter

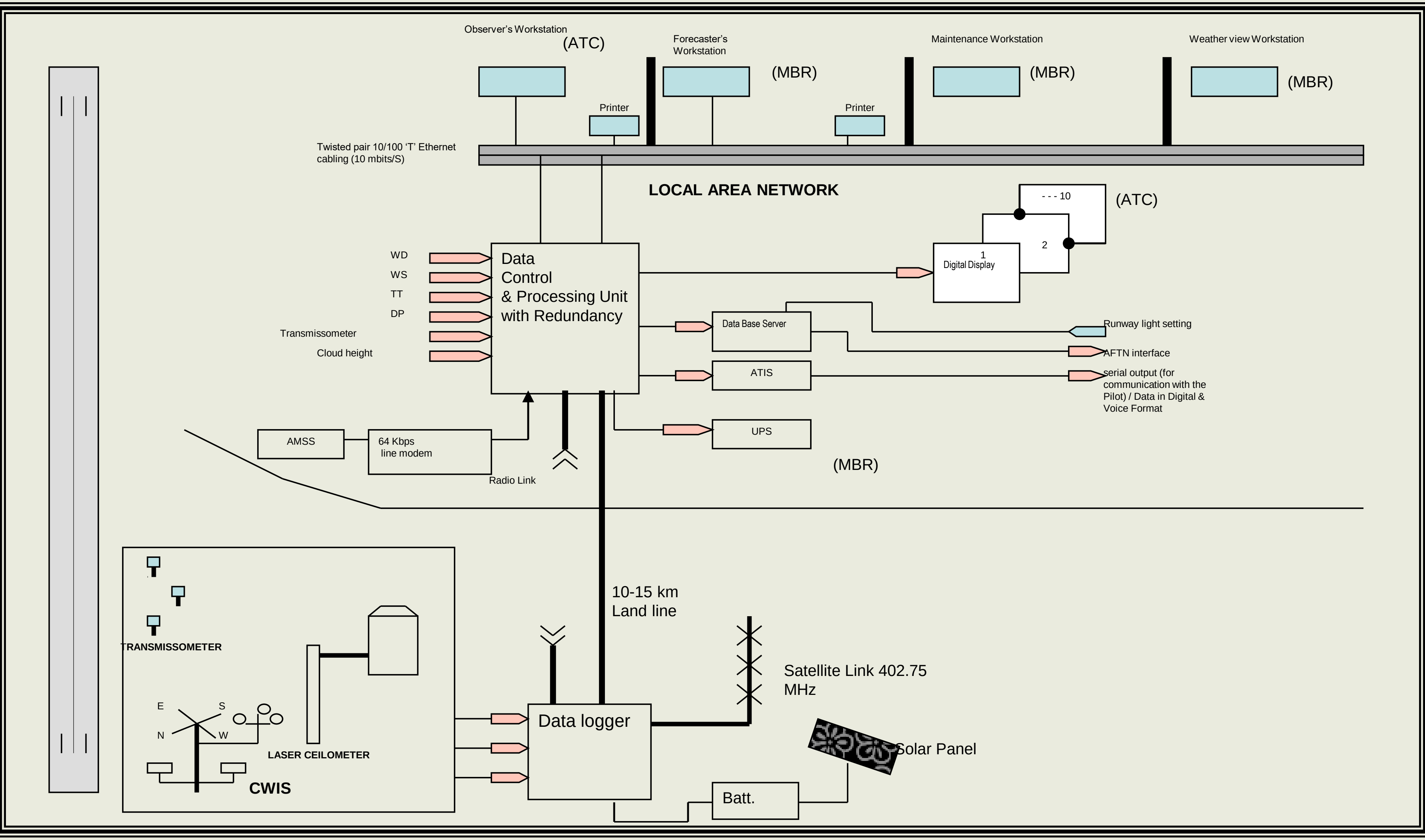
# Integrated Aviation Met Systems

- **An integrated automatic aviation met instruments system is an integration of weather sensors such as wind, temperature, pressure, Visibility, cloud height,etc.**

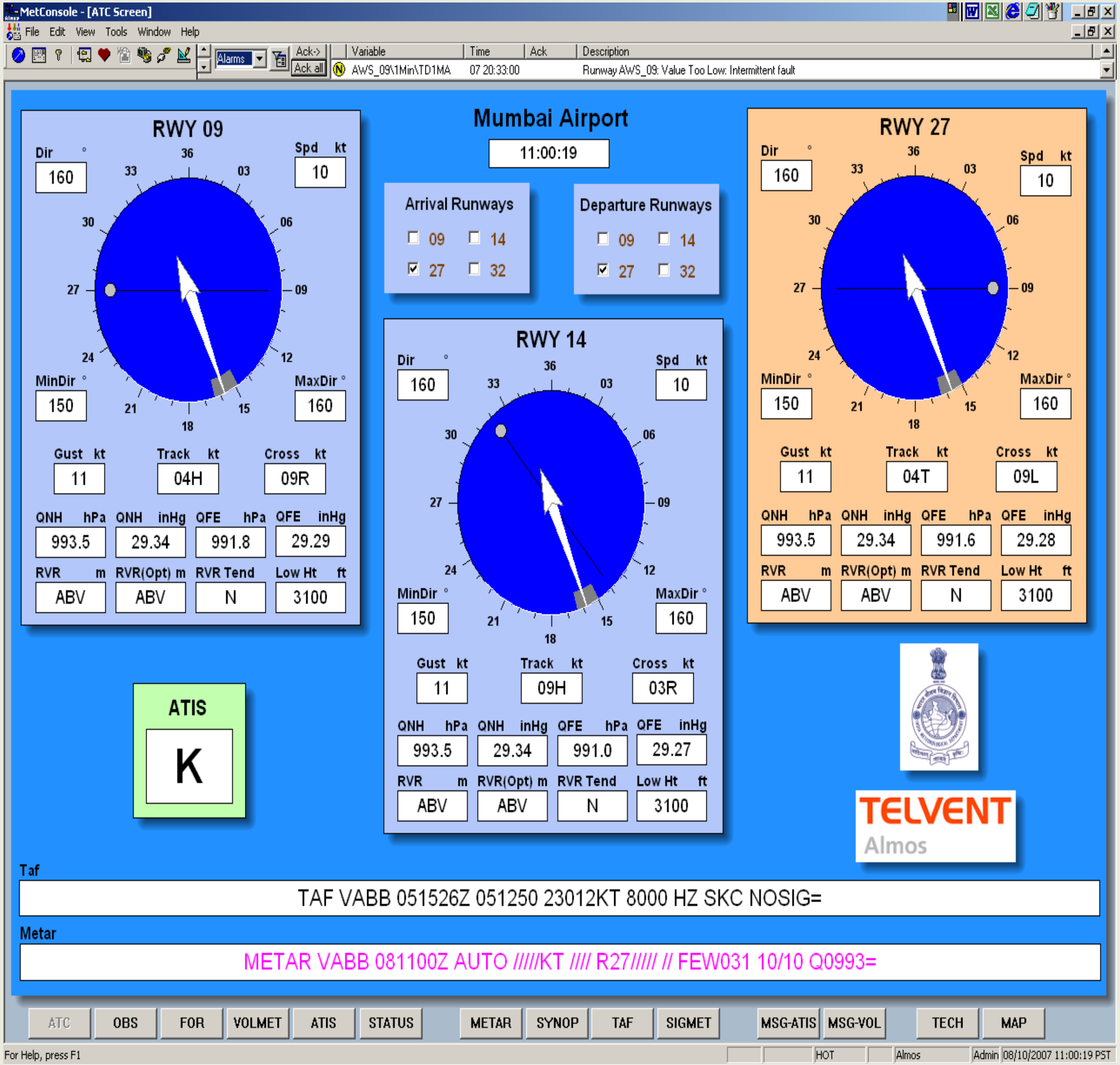
- **The parameters which cannot be measured using sensors at present, can be entered manually**

- **The output of the system is compatible for communication to ATIS, AFTN, Satellite**

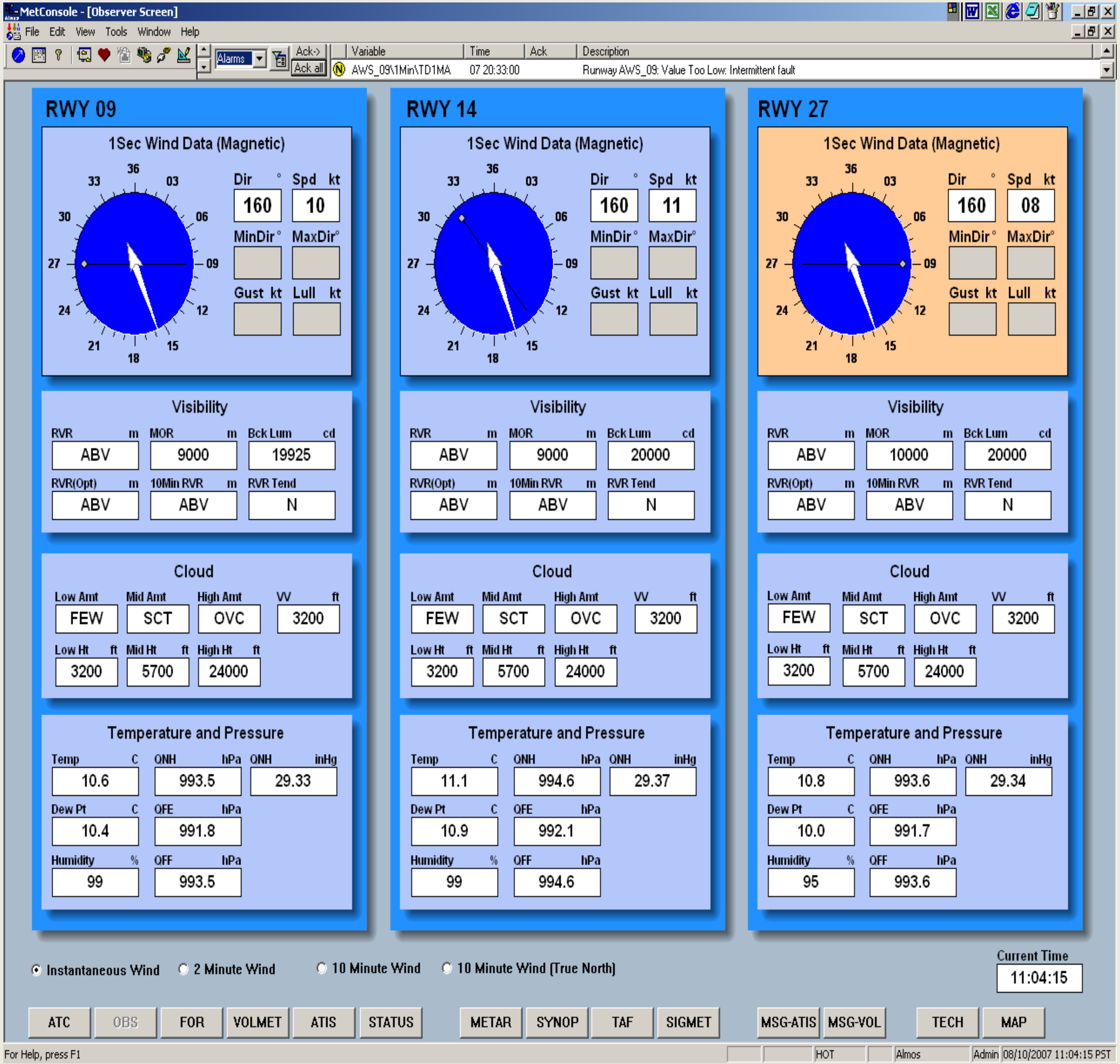
# Block diagram of an integrated system



# Mumbai ATC Screen



# Mumbai Observer Screen



# THANK YOU !