

# VISIBILITY MEASUREMENT TECHNIQUE AND ITS APPLICATION IN AVIATION SERVICES AT INTERNATIONAL AIRPORTS IN INDIA

By

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## A B S T R A C T

The term ‘visibility’ is variously defined, but generally indicates the distance to which human visual perception is limited by atmospheric conditions. The physical mechanisms that influence visual perception during the night in distinguishing lights differ from those in the day time in distinguishing objects illuminated by daylight. 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.

Provision of this visibility within specified accuracy to the pilots and air-traffic controllers has assumed great importance with the advent of high speed high altitude jet and supersonic aircrafts. Meteorological visibility concerns the transparency of the atmosphere as related to human vision. The transparency of the atmosphere is affected by the presence of hydrometeors (rain, snow, mist, fog) or litho meteors (dust, smoke etc.).

A transmissometer is used for measuring the atmospheric transmittance at visibility deterioration (fog, rain etc.). This instrument is mainly installed at the runways of airports in order to determine the visual range for the flight control safety service. The double baseline unit is new generation equipment especially suited to render exact visual range data for flight operation at CAT-II to CAT-III(b) type airports.

In India, New Delhi and Kolkata are equipped with three and two dual baseline transmissometers respectively, catering to CAT-IIIB ILS requirement at these airports.

Continuous data obtained from these transmissometers during 2001-2003 are analysed and presented in this paper.

## 1. INTRODUCTION

Aviation activities have increased tremendously in the recent decade in volume and diversity and will continue to do so in future. India Meteorological Department caters to the needs of aviation services through a network of 4 meteorological watch offices (MWOs) – Chennai, Delhi, Kolkata and Mumbai - 18 Class-I Meteorological Offices and 52 Class-III Meteorological Offices.

With increased operating costs and lower operating minima, a much higher degree of precision sophistication and timeliness are needed in meteorological observations and processed information feeding the aviation sector. The meteorological systems are required to be installed near the runway as per ICAO recommendations and the data obtained from these systems are to be acquisitioned, processed and displayed on line as per the requirements in an airport. These systems are crucial for the determination of the operation characteristics in an airport.

The visibility should be measured and observed by reference objects or lights whose distance from the point of observation is known. Since, in practice the runway visual range (RVR) can not be measured directly on the runway, it is the best possible assessment of the range over which the pilot of an aircraft on the centre line of runway can see the runway surface markings or the lights delineating the runway or identifying its centre line. RVR observations should be representative of the touchdown zone and depending on the category of operation for which the runway is intended and the length of the runway.

## **2. VISIBILITY**

### **2.1 Visual Range:**

Visual range is determined by an observer and defined as the maximum distance at which an object or low intensity light can be distinguished. Visual range and visibility are used here interchangeably.

### **2.2 Runway Visual Range (RVR):**

Runway Visual Range is defined as an instrumentally derived value, based on standard calibrations, that represents the horizontal distance a pilot will see down the runway from the approach end by observing runway lights or runway markers, from a specified height, i.e. 2.5m above ground level, whichever yields the greater visual range.

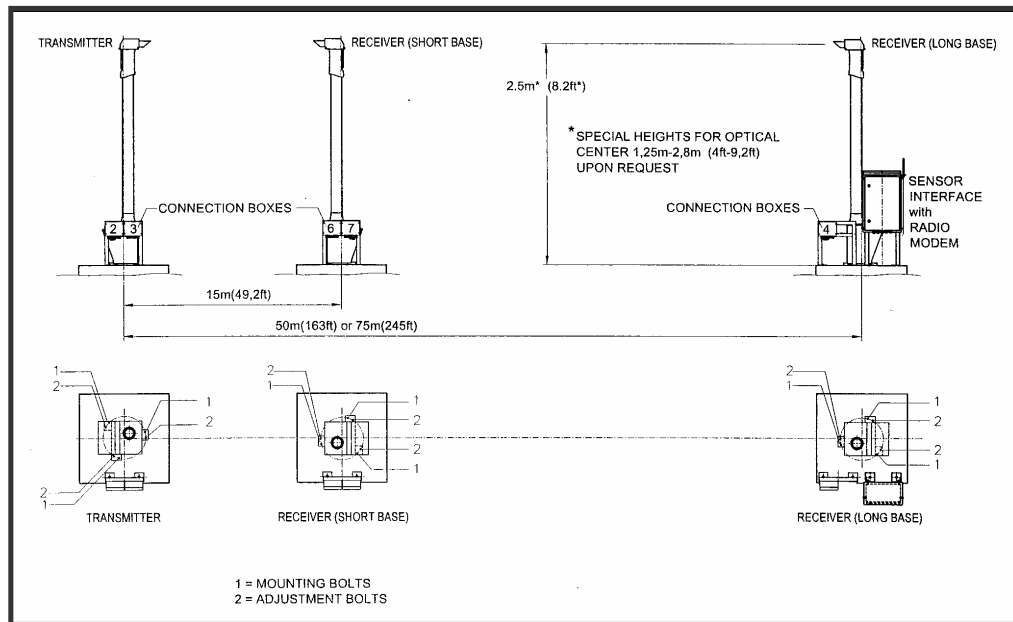
RVR is normally obtained from transmissometers, located along side the runway. Conversion from atmospheric transmittance along the baseline of the transmissometers to RVR is made using Allard's Law for various runway light settings.

## **3. VISIBILITY MONITORING SYSTEM**

The Transmissometer system is used for measuring the visual range at visibility deterioration (e.g. fog). This system is generally installed along the runways of airports in order to determine the visual range for the flight control safety service. The double baseline unit of this system is installed at both New Delhi and Kolkata, to render exact visual range data for flight operation at CAT-II & CAT-III B.

For the double base-line system, two receivers and one transmitter are installed. In this type of arrangement visibility measuring range of 10m to 3000m and an RVR range from 50m to 3000m are obtained at a baseline of 15 m and 75 m.

The basic equipment of the system consists of a transmitter, receiver and a registration control unit. The optical axes of the transmitter and the receivers are precisely aligned with each other (Fig. 1).



**Fig. 1: Dual Baseline Transmissometer**

### 3.1 Measuring procedure:

The transmissometer measures light transmittance of the atmosphere. The transmitter and the two receivers are optically aligned to each other and located within a precisely determined measuring distance (baseline). The transmitter radiates short light power light pulses with a frequency of approximately 180 flashes/minute. The Intensity of the light pulse i.e. the average of several light pulses is constant. The receiver responds only to these short light pulses and measures their intensity. Increasing visibility deterioration within the baseline causes the light radiated by the transmitter intensity to decrease as it reaches the receiver. A registration and control unit (STATION) indicates this decreasing light transmittance of the atmosphere by showing lower visual range values.

The “Visual range” of the runway lights (RVR – runway visual range at night) can be calculated from the Allard Law :

$$E_t = \frac{I \times T^{R/B}}{R^2}$$

where,  $E_t$  - representing the pilot’s sensitivity to the illumination intensity,

$I$  - The effective intensity (towards the pilot) of the most distant but still recognizable runway lights.

Using the above equation, the RVR can be determined from the indicated transmissometer data (T), by inserting the respective values for light intensity of the runway lights (I) and the visual threshold of illumination ( $E_t$ ). The letter is related to the luminance of the background ( $L_v$ ) against which the light is viewed. This brightness from the background can be determined by a luminance sensor, called Background Luminance Monitor (STILBUS).

#### 4. VISIBILITY CRITERIA FOR INSTRUMENT LANDING OPERATIONS

Measurement of RVR is critical in determining whether or not a pilot can make an approach to the runway. Landing criteria for instrument landing system runways are based on the operational performance categories listed in Table-1 below:

TABLE -1

CATEGORY	RVR LIMIT (m)
I	550 +
II	300 – 550
III(A)	200 – 300
III(B)	50 – 200
III(C)	0 - 50

#### 5. SYSTEM DESCRIPTION

The basic components of a double base line transmissometer system are:

- ❖ transmitter
- ❖ receiver
- ❖ data control unit
- ❖ communication equipment

##### 5.1 Transmitter:

The transmitter basically consists of a xenon flash lamp with a flash frequency of 2.5-3.5 Hz. The optics basically consists of an achromatic, 46mm diameter lens with a focal length of 120mm. This system works on 220 V ac, 50 Hz and the total power demand is 100 VA.

##### 5.2 Receiver:

Receiver consists of a photodiode (OSD-100) which converts the received light signal into proportionate electrical values. It also has an optical system consisting of an achromatic lens of 46mm diameter with a focal length of 200mm. It also has a provision to receive the data in 0 - 5 mA range from STILBUS, which monitors the ambient light. The data output is selectable RS232/RS422/RS485/MODEM form. Interface for the test purpose is made available in 0 – 1 mA range corresponding to 0 – 100% transmission. Serial data transmission RS232C is having ASC11 format with 8 data bits, 1 stop bit, no parity and transmitted at 9600 baud maximum.

##### 5.2.1 STILBUS:

STILBUS is a background luminance sensor. The luminance of the background has a strong influence on the observer's perception of lighting element. The STILBUS provides stepless measuring range of 1 – 10000 Cd/m<sup>2</sup> on a decadic logarithmic scale. The measuring range includes important decision thresholds for calculations.

Ambient Conditions	Background Luminance
Night	< 40 Cd/m <sup>2</sup>
Twilight	50 – 1,000 Cd/m <sup>2</sup>
Day	1,000 – 12,000 Cd/m <sup>2</sup>
Bright Day	> 12,000 Cd/m <sup>2</sup>

These four illuminance values have proven effective in the calculation of RVR.

The transmitter and the two receivers with communication interface unit are installed in the field, whereas data control unit and slave display units are located in Meteorological Briefing Room (MBR) and ATC which are generally 5-10 km away from the field sensors. The data communication between the sensor output and data control unit is achieved via 4-core underground armoured cables as a serial transmission over a distance of about 10 km through cable modem. The wireless data communication system between the sensor and

data control unit is achieved via radio modems operating at different frequencies in UHF modem, in the range 433-434 MHz, as given in Fig 2. Furthermore, a background luminance sensor is connected for monitoring ambient light condition, the status of which is included in the data transmission telegram (message).

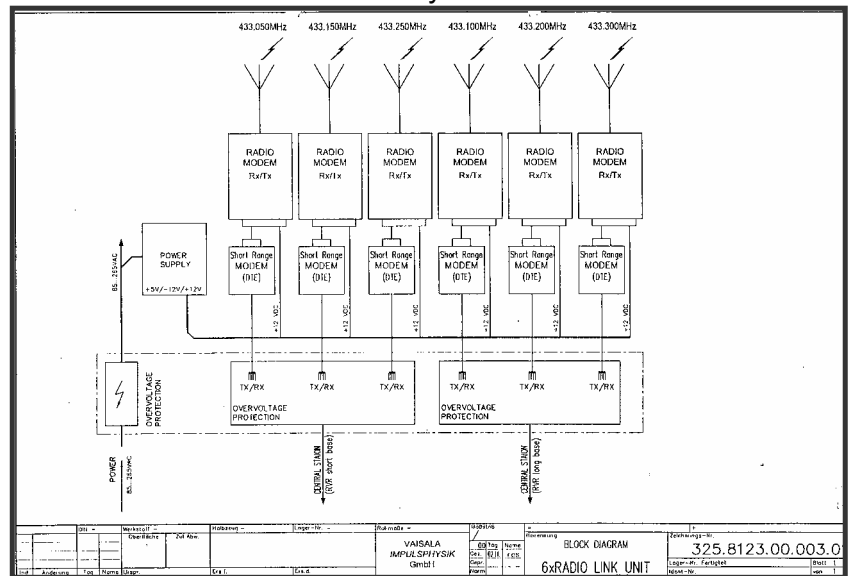


Fig. 2: Wireless communication system.

A typical transmissometer installation fulfilling CAT-III RVR requirements at New Delhi airport is presented in Fig. 3. The processed data and on line display output of MOR and RVR in graphical form is presented in Fig. 4. The slave display output in front of ATC controller is presented in Fig. 5.

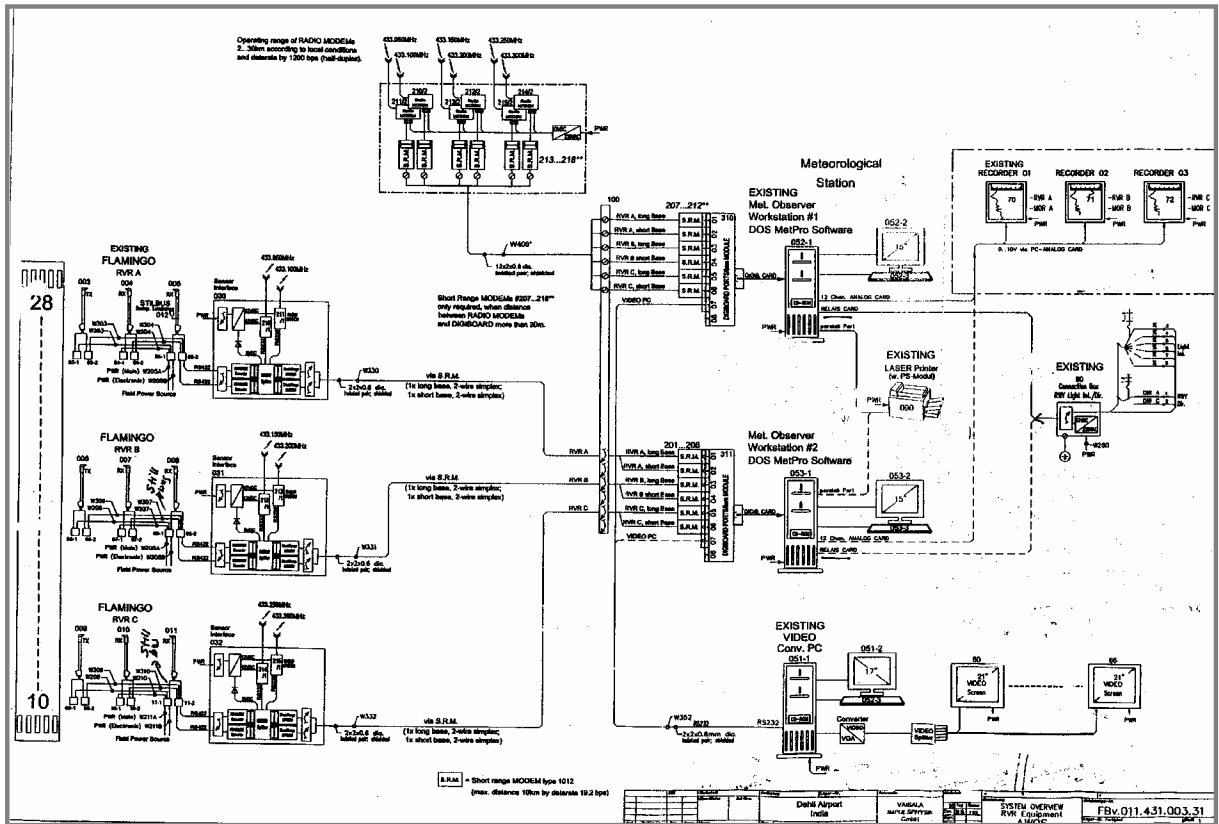


Fig. 3: Complete installation at Delhi airport.

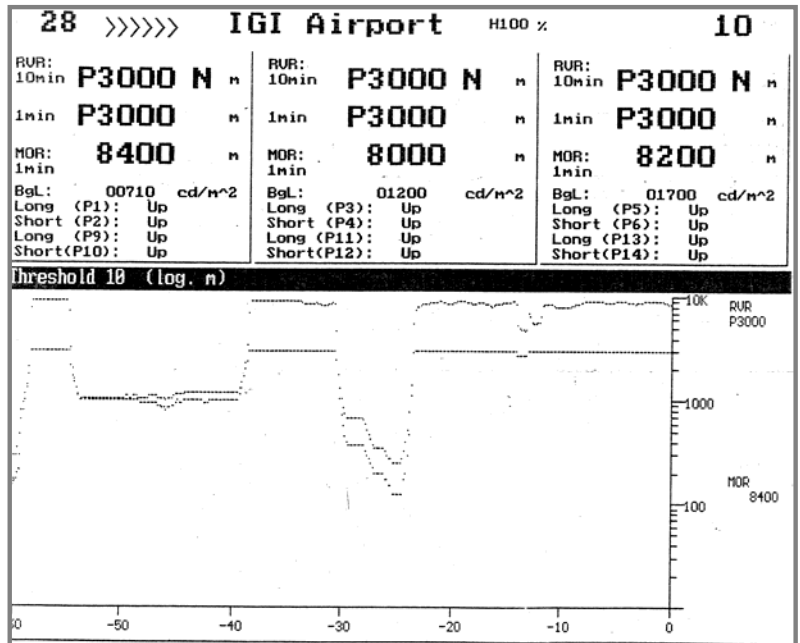


Fig. 4: Processed on-line data presentation

VIDP	24 JUL 01	07 46 18
28	>>>>>	mid 10
RVR:	P3000	P3000 P3000
Trend:	N	N N
MOR:	7900	7700 8400

**Fig. 5: Slave Display – in front of ATC Controller.**

## 6. DATA PRESENTATION

The data used for the presentation is obtained from the transmissometers installed at New Delhi and Kolkata airports for the period December 2000 to January 2004. The hourly average RVR values are used for presentation. The critical months when air-traffic is affected due to low visibility condition at both the airports is observed to be in December and January. Hence, sample data for both the months at these airports have been analyzed and presented in the graphical form.

**Graph-1:** Variations in RVR with respect to time, due to low visibility condition (fog) on 24 Dec., 2003 at Delhi airport.

**Graph-2:** Variations in RVR with respect to time, due to low visibility condition (fog) on 06 Jan., 2004 at Delhi airport.

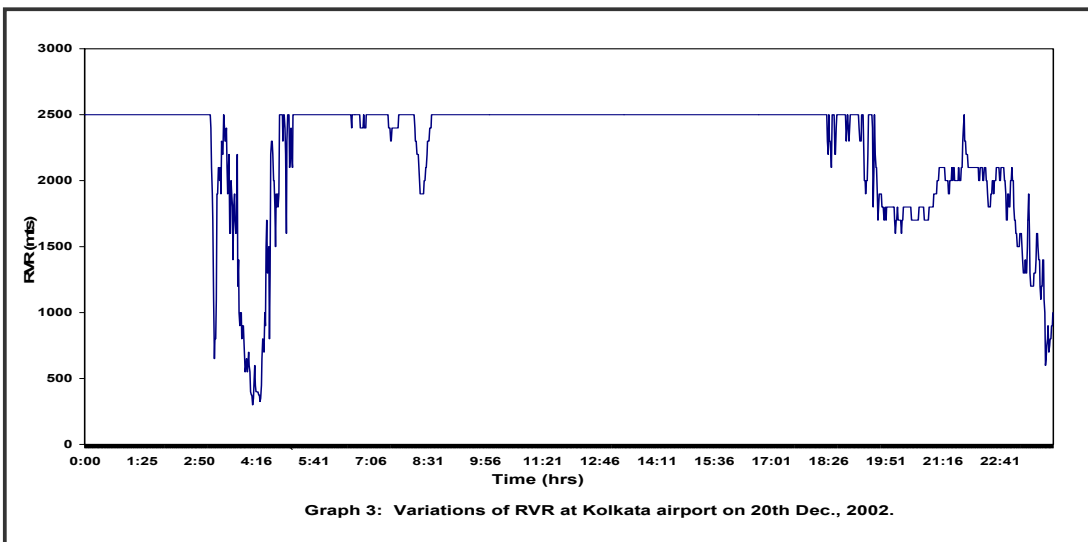
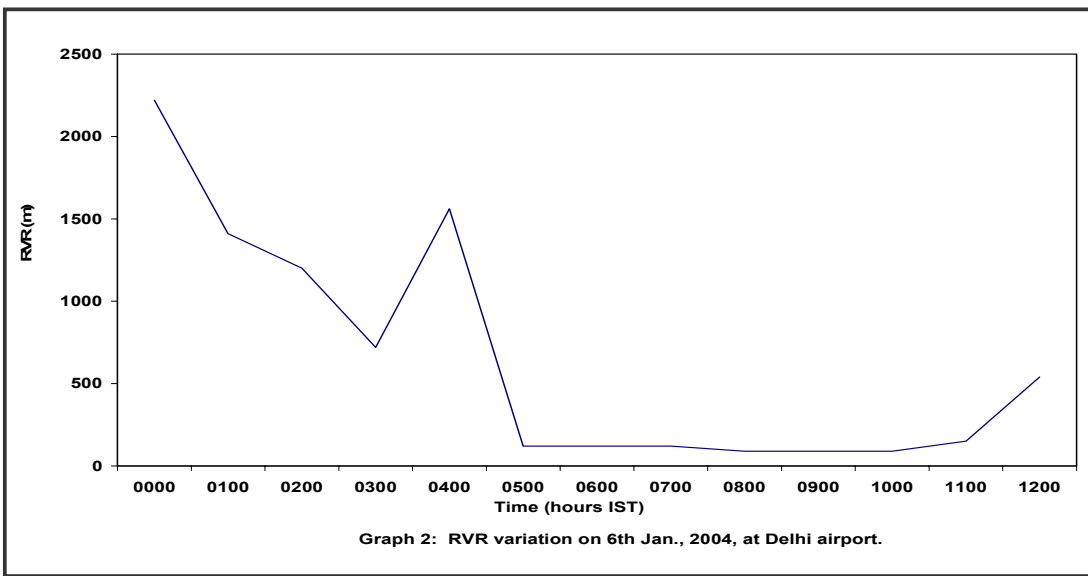
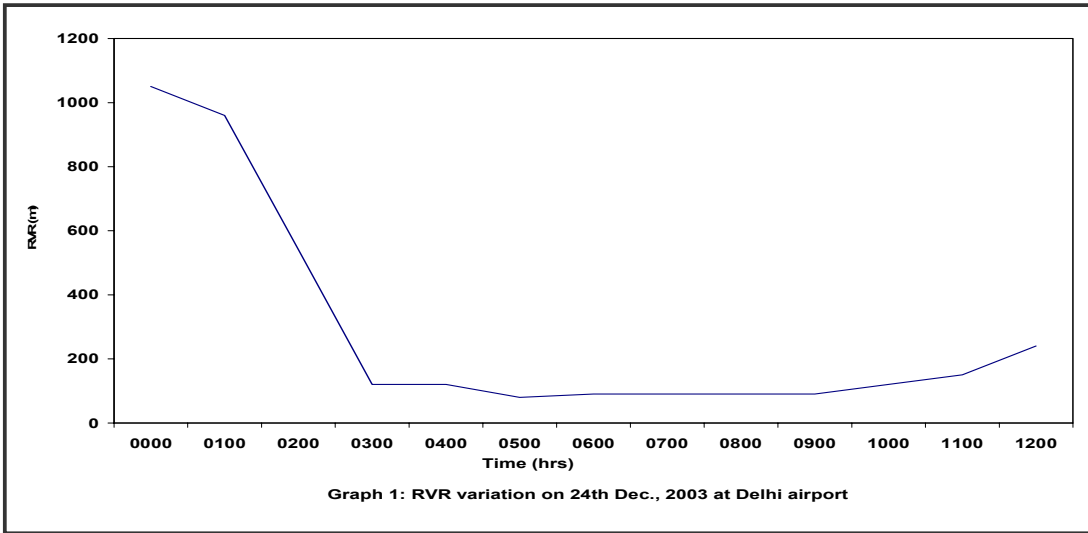
**Graph-3:** Variations in RVR with respect to time, due to low visibility condition (fog) on 20 Dec., 2001 at Kolkata airport.

**Graph-4:** Variations in RVR with respect to time, due to low visibility condition (fog) on 16 Jan., 2002 at Kolkata airport.

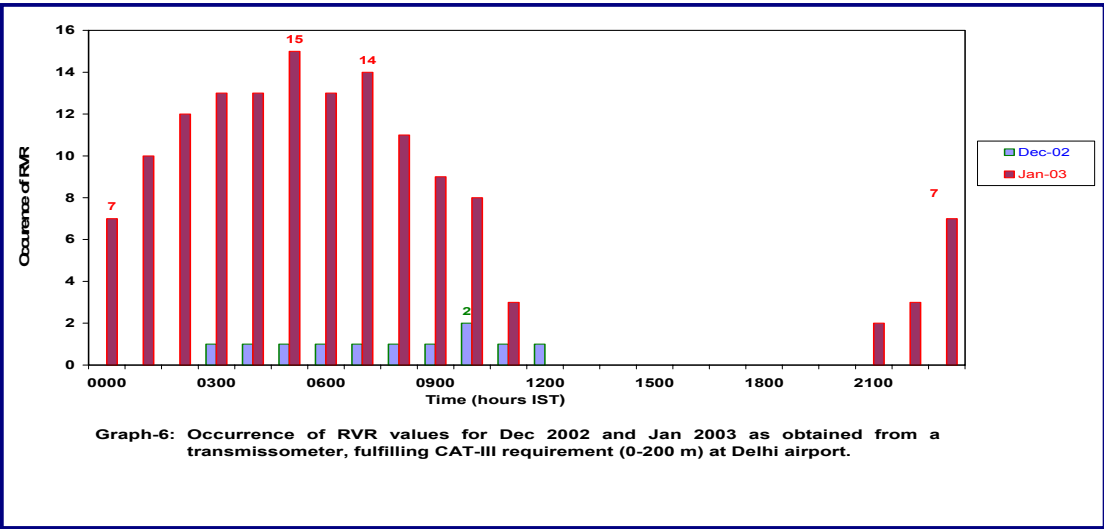
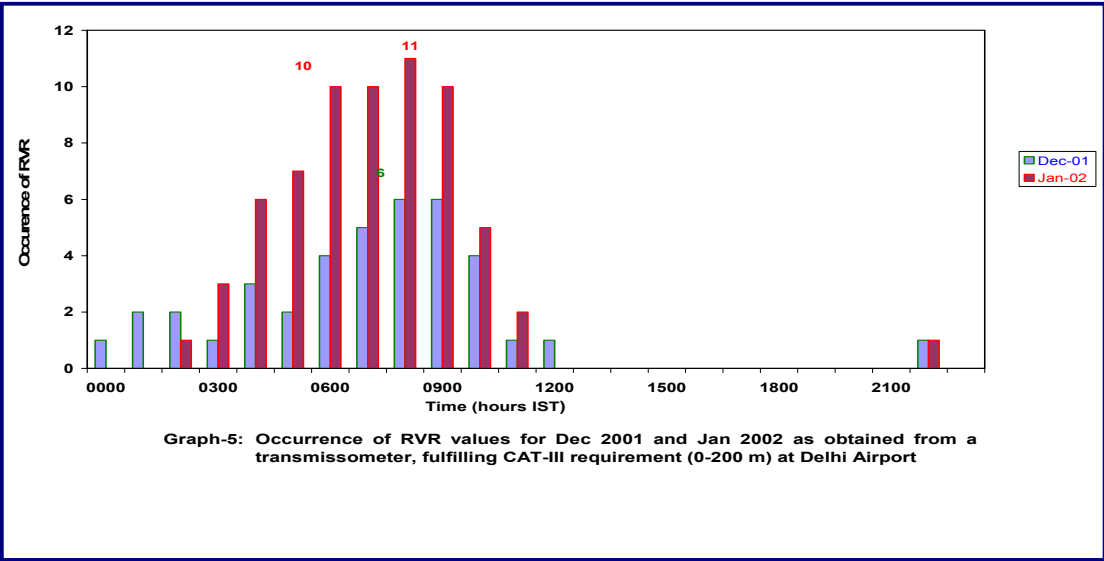
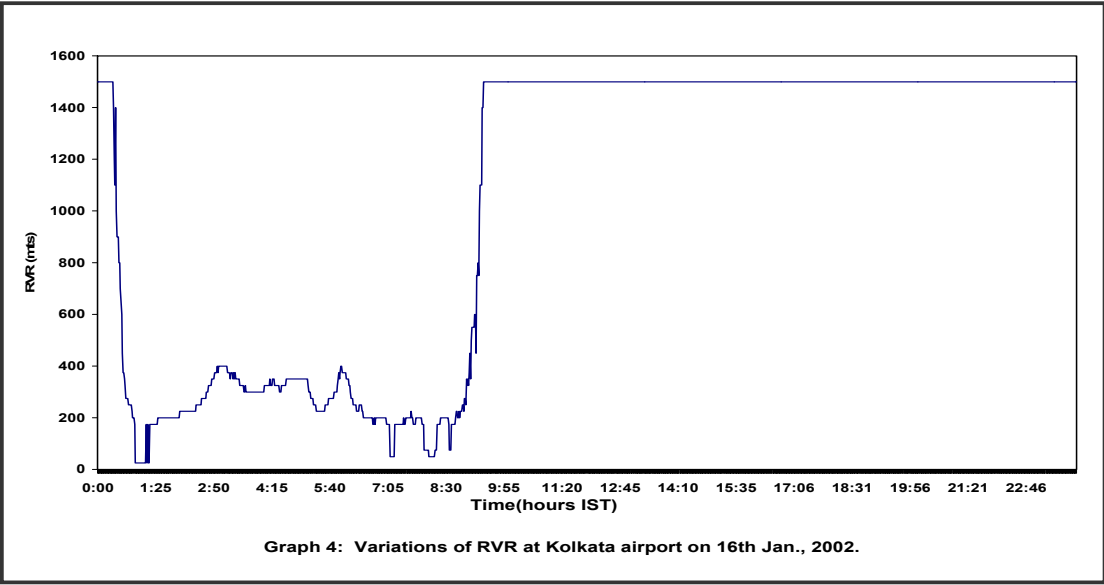
**Graph-5:** Occurrence of RVR values, based on hourly average for Dec. 2001 and Jan.2002 as obtained from Transmissometer fulfilling ILS CAT-III requirements (50 to 200 m) at Delhi airport.

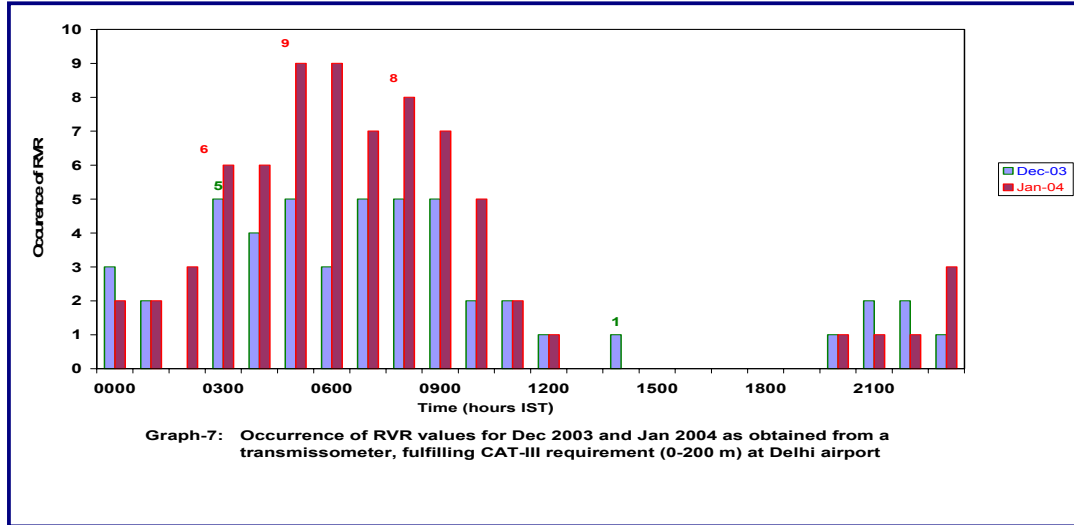
**Graph-6:** Occurrence of RVR values, based on hourly average for Dec. 2002 and Jan. 2003 as obtained from Transmissometer fulfilling ILS CAT-III requirements (50 to 200 m).

**Graph-7:** Occurrence of RVR values based on hourly average for December 2003 and January 2004 as obtained from Transmissometer fulfilling ILS CAT-III requirements (50 to 200 m) at Delhi airport.









## 7. CONCLUSIONS

Measurements of RVR are critical in determining whether a pilot can make an approach to an instrument runway. Landing criteria for instrument runways are based on operational performance of the system under each category.

The operational performance of the transmissometer system, fulfilling all the requirements up to ILS Cat-IIIB is satisfactory, since their installation at Delhi and Kolkata airports. It has been observed that the RVR values reported by the instruments are well within the accuracy limits as recommended by ICAO.

## REFERENCES

1. 'Guide of Meteorological Instruments and methods of observations'. WMO No. 8 [2001].
2. ICAO Annex 3, Meteorological Services for International Air Navigation, 2001.
3. Manual of Runway Visual Range Observing & Reporting Practices, March 2001.

