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# Performance study of Drishti transmissometer at CAT III B airport

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**सार** – दृश्यता और रनवे दृश्य दूरी (आर वी आर) के सटीक मापन के लिए सी एस आई आर- राष्ट्रीय एरोस्पेस प्रयोगशाला (सी. एस. आई. आर.-एन. ए. एल.) द्वारा विकसित स्वदेशी दृश्यता मापन प्रणाली दृष्टि ट्रांसमीसोमीटर को इंदिरा गाँधी अंतरराष्ट्रीय (आई जी आई) हवाई अड्डे, नई दिल्ली में संस्थापित किया गया है। सभी श्रेणियों के हवाई अड्डों जैसे CAT I, CAT II, CAT III A एवं B में कम दृश्यता की परिस्थितियों में दृश्यता सूचना बहुत महत्वपूर्ण होती है। CAT III B हवाई अड्डों में पायलट को घने कोहरे में 50 मीटर तक की कम दृश्यता में भी जहाज उतारना पड़ता है। 30 मीटर की बेसलाइन वाली दृष्टि प्रणाली देश के किसी भी हवाई अड्डे में संस्थापित पहली प्रणाली है। इस शोध पत्र में आई जी आई, हवाई अड्डा, नई दिल्ली में मौसम की विभिन्न परिस्थितियों में जैसे आँधी, वर्षा और घने कोहरे में दृष्टि से ली गई दृश्यता मापन की रिपोर्ट प्रस्तुत की गई है। दृष्टि के आँकड़ों की विदेश से आयातित अन्य ट्रांसमीसोमीटरों के साथ तुलना की गई जिन्हें दृष्टि के सामानांतर अथवा कुछ किलोमीटर दूर हवाई अड्डे में संस्थापित किया गया है। यह पाया गया कि दृष्टि से दृश्यता का मापन बहुत सटीक होता है। वेब के माध्यम से प्रणाली का सुदूर मॉनीटरन, मॉड्यूलर इलेकट्रॉनिक्स के माध्यम से तीव्र और सरल रखरखाव इस प्रणाली के कुछ अन्य महत्वपूर्ण लक्षण हैं। आई जी आई हवाईअड्डा देश का पहला ऐसा हवाईअड्डा है जहाँ तीनों रनवे में स्वदेशी प्रणालियाँ संस्थापित हैं।

**ABSTRACT.** Drishti transmissometer – A visibility measuring system, an Indigenous development from CSIR-National Aerospace Laboratories (CSIR-NAL), has been installed at Indira Gandhi International (IGI) airport, New Delhi for precise measurements of visibility and runway visual range (RVR). Visibility information is critical under poor visibility conditions for all categories of airports *viz.*, CAT I, CAT II, CAT III A & B. In CAT IIIB Airports the pilots have to land with as low a visibility as 50 meters during dense fog. Drishti system with 30 meters baseline is first of its kind installed at any airport in the country. In this paper we report visibility measurements of Drishti during different weather conditions *viz.*, dust storm, rainfall and dense fog at IGI Airport, New Delhi. Drishti data has been compared with other imported transmissometers which have been situated in the Airport either parallel to Drishti or installed few kms away. It has been observed that Drishti measures visibility very accurately. Remote health monitoring of the system through Web-enabling, fast and easy field maintenance through modular electronics are some of the salient features of the system. IGI Airport is the first airport in the country to have Indigenous systems in all its three runways.

**Key words** – Drishti Transmissometer, Runway Visual Range (RVR).

## 1. Introduction

Drishti Transmissometer is a visibility measuring system developed indigenously by CSIR- NAL. The system is conceived from concept to product leading to International Class I certification. Transmissometer is a mandatory equipment to be installed at all runways as per International Civil Aviation Organisation (ICAO) and World Meteorological Organisation (WMO) to aid pilots in landing and takeoff operations [ICAO, 2004; ICAO, 2014; WMO, 2008]. IGI Airport, New Delhi has three near-parallel runways: runway 29-11, runway 28-10, and runway 27-09. Runway 29-11 and runway 28-10 are the only two in South Asia to have been equipped with the CAT III-B Instrument Landing System (ILS) facilities. The most stringent and critical airport of the country is the busiest in the country and RVR transmissometer is a must, particularly during low visibility conditions due to dense fog in the winter. CSIR-NAL installed two numbers of Indigenously developed 'Drishti' transmissometer systems


**Fig. 1.** Drishti at Runway 28 and 29 at IGI Airport

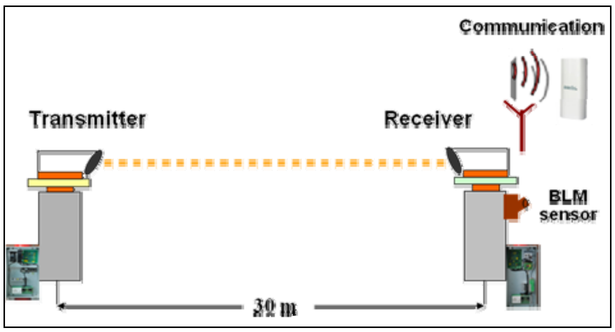


**Fig. 2.** Block Diagram of the Drishti system

at runway number 29 and 11 in Dec 2011 for recording the meteorological visibility and RVR observations [Shubha *et al.* (2011 and 2013)]. Three more Drishti systems were installed at runway 28-MID-10 in Dec 2012. The Drishti systems at runway 29 and 28 are shown in Fig. 1. Recently in February 2015, five more Drishti systems have been added to runway 29 - 11 (3 systems) and Runway 27 - 09 (2 systems). Drishti is capable of measuring the visibility during dense fog, heavy rainfall and dust storms conditions wherein the visibility will go down to less than 25 meters. Drishti has been functioning satisfactorily with perfect response during all visibility conditions, recording the data as stipulated by ICAO [ICAO, 2004]. In this paper, the visibility as recorded by Drishti is also compared with imported systems which are either situated parallel to Drishti or installed few meters away from Drishti. Drishti meets the requirements of operational desirable accuracy of ICAO, and WMO, guidelines .aiding the pilots in their safe landing and take-off operations [ICAO, 2004; WMO, 2008].

Table 1 gives the different transmissometer both Drishti and Imported systems (Flamingo from Finland and Telvent from Australia) installed at IGI Airport in its three runways *viz*., Runways 29-11, 28-10 and 27-09.

**TABLE 1**

**Transmissometer Systems at IGI airport, New Delhi**

| Runway Number | Number of TRANSMISSOMETERS | | |
|---|---|---|---|
| | Flamingo | Telvent | DRISHTI |
| 29-11 | – | 03 | 05 |
| 28-10 | 03 | – | 03 |
| 27-09 | – | 02 | 02 |

## 2. System description

Drishti system at field site consists of a Transmitter and Receiver separated by a characteristic distance called baseline (30 meters in case of Drishti) to meet CAT III-B requirements for RVR [ICAO, 2004]. The Transmitter (lamp) sends a collimated beam of light which is received by an optical detector in the Receiver separated by 30 meters. Fig. 2. gives the block diagram of the system.

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

The Drishti-BLM (DBLM) is a subsystem whose data is used for calculation of RVR and is mounted in the receiver side. Background light, covering the range (2 to 40000 cd/m$^2$) of night, twilight, normal day and bright day can be measured by this system [Shubha *et al*., 2011]. Photopically corrected diode is used as sensor. Drishti BLM has been calibrated using standard calibrated source traceable to standard maintained at WMO.

The sensor data is processed using signal conditioning circuits and is converted into digital signal in Multi-channel 24 bit A/D converter along with a Field Programmable Gate Array (FPGA) embedded real time controller. The FPGA controller is used for accessing and transmitting the data to Met Briefing Room (MBR) and/or Air traffic Control Room (ATC). The data is processed with Drishti embedded software developed by NAL under industry standard LabView platform with Virtual instrumentation (VI) concept. The digital signal conversion and filtering techniques are all performed in real time in FPGA environment. The processed data is sent to MBR /ATC situated at far away place (up to 8 km) through dual mode of communication *viz*., Wi-Fi (operating at either 2.4 or 5.8 GHz) and Landline communication through Modem and RS 232 interface.

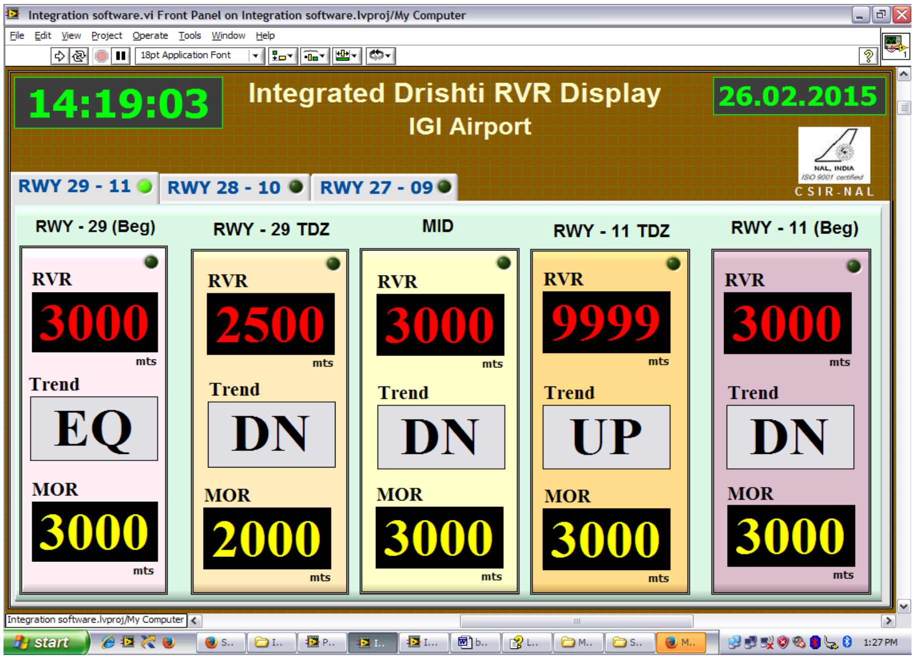


**Fig. 3.** Front Panel of Drishti RVR Software

The Runway Visual range (RVR) and Meteorological Optical range (MOR) is calculated using proprietary "Drishti RVR software" in RVR Computer at MBR using virtual instrumentation concept in Lab view environment. Internationally accepted Koschmieder's and Allard's law [ICAO, 2004] are used for calculation of MOR and RVR. Fig. 3 gives the front panel of the Drishti RVR Software. The software has provision for health monitoring of the system, for showing real time graph of 24 hours data of both RVR and MOR along with the display of Instantaneous values.

The software has provision for displaying RVR data of multiple systems in a runway in single screen as shown in Fig. 3. Three Drishti systems installed at runway 28-MID-10 can be viewed on a single screen. The same is extendable to any number of systems. With a multi tab option runway can be selected from the front panel to view the RVR data from that particular runway. Fig. 3 gives data from Runway 29-MID-11.

The data is archived as a file with time and date stamping for future use and is stored in a file each day. The RVR data along with the trend is web publishable and can be accessed at any remote location through unique IP address. Online calibration of the RVR and MOR is also another feature.

The system has provision for not only accessing the data remotely but can be taken over at any place for health monitoring, maintenance and servicing.

## 3. Alignment & calibration

Any transmissometer system should be calibrated only when visibility is more than 10000 m as per ICAO [ICAO, 2004]. However when Transmissometer needs calibration during fog season, it is difficult to obtain 10 km visibility where pollution levels are high. In such cases ICAO allows to calibrate when ambient visibility > 5 km.

Drishti has a special window in its software wherein the system is auto-calibrated with the input fed by Met. observer of the prevailing general visibility. The receiver is optically aligned with the transmitter system at the field site.

The photodiode response is calibrated using optical filters of known transmittance factor. The non linear response of the photodetector is corrected using polynomial curve fitting for linearising the response of the sensor. The difference in error between observed and calculated should be <1%, as per ICAO guidelines [ICAO, 2004] when calibrated Drishti met the required stipulations.

## 4. Drishti visibility data under different atmospheric conditions at IGI airport

Data recorded from Drishti systems during fog, rain and dust storm conditions have been shown in the following section. Comparison of the data of different runways from Drishti and other imported systems like

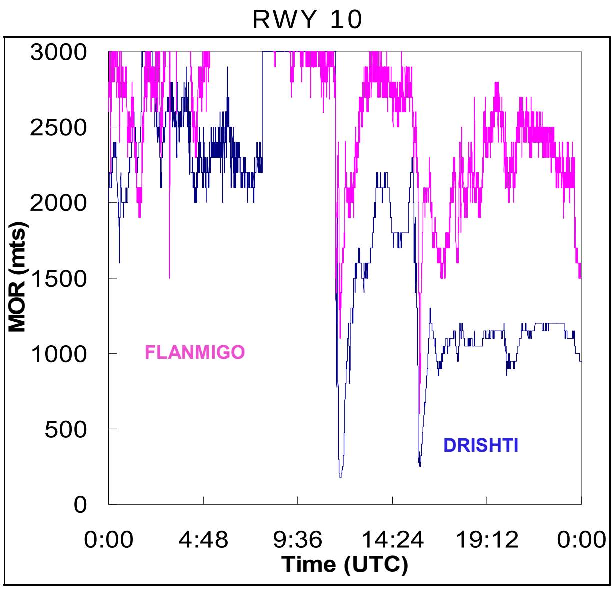


**Fig. 4.** Sandstorm data of Runway 10 and Mid from Drishti and Flamingo

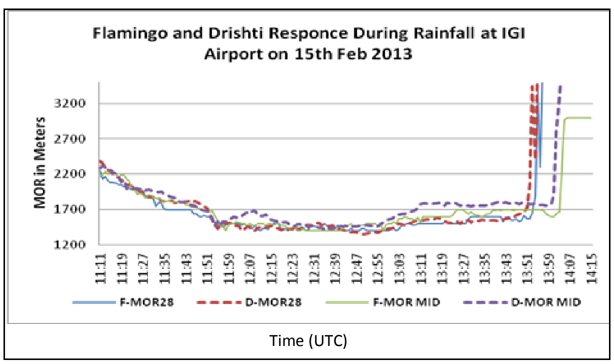


**Fig. 5.** Drishti and Flamingo response during Rainfall at IGI airport

Flamingo and Telvent are also given. The response of Drishti system when compared with co existing transmissometer is on par or better than the imported systems. Drishti is a single baseline (30 meters) system whereas both Flamingo and Telvent are dual baseline (75 and 15 meters) systems. The responses in real time have been compared during all the above mentioned atmospheric conditions.

*4.1. Dust storm event at IGI airport*

Sand storm also known as dust storm is a localized phenomena. Fig. 4 depicts the sand storm data of Drishti and Flamingo at Runway 10 at IGI Airport observed on 2nd April, 2013. As sand storm goes like a whirl pool it is a very fast and localised phenomena.

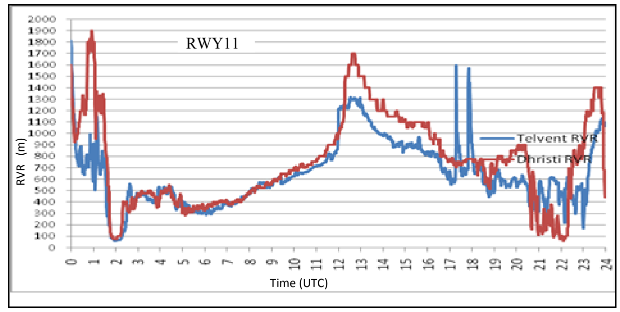


**Fig. 6.** Drishti and Telvent Systems response during dense fog

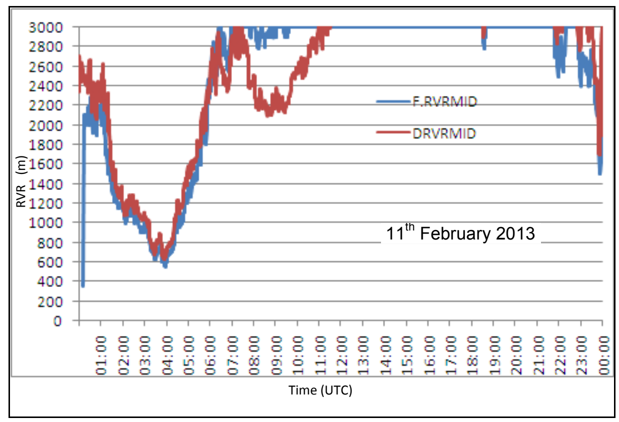


**Fig. 7.** Comparison data of Drishti and Flamingo on a low visibility day (11 January, 2013)

It should be noted that the visibility response was very fast in the case of Drishti with a single baseline system (30 m) in comparison with that of Flaminge which was dual base line system (75 &15 m). The visibility as observed by Drishti dropped down to < 200 meters in Runway 10 whereas the dual baseline Flamingo could only reach around 1000 meters as the sand storm is a fast moving phenomena. Before the Flamingo system could shift over to 15 meter baseline the sand storm had moved away. The super fast response of Drishti could record the event going down to < 200 meters as it is a single baseline system devoid of any switching over requirement.

*4.2. Heavy rainfall condition*

Response of Drishti system during the rainfall on 15th February, 2013 is compared with that from Flamingo system at runway 28 (Fig. 5). From the comparison graph it is very clear that the response of both the systems are almost in agreement with each other. It should be noted here that the Flamingo system from Finland, is a dual baseline system (75 m and 15 m) wherein the visibility < 500 meters is recorded by 15 m baseline system. Drishti is a single base line system catering to both low and high visibility proving the fast response of the system.

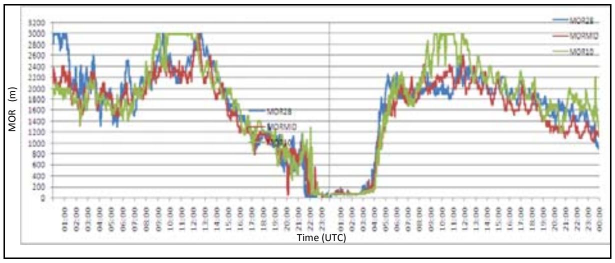


**Fig. 8.** Dense fog making visibility near zero for 7 hrs at Runway 28-Mid-10 of IGI Airport, New Delhi on 17th & 18th February, 2013 as measured by Drishti

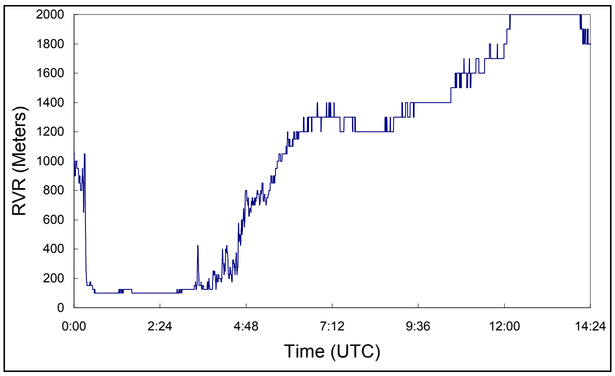


**Fig. 9.** Low visibility data of Drishti for Runway 28 on 22nd December, 2014

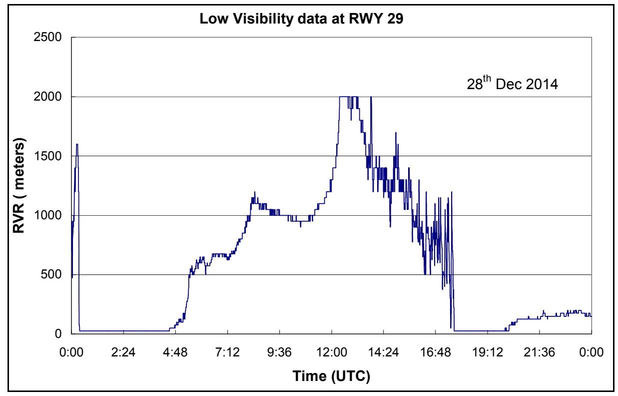


**Fig. 10.** Near Zero visibility recorded by Drishti at RWY 29

### 4.3. *Dense fog conditions at IGI airport*

IGI airport is normally severely affected by thick fog in winter season for several hours lowering the visibility to <50 m. Fig. 6 gives comparison data of dense fog situation observed on 14th January, 2013. As seen from the graph, the instantaneous responces of the RVR by Drishti and Telvent is matching very well in phase and magnitude. The pulsating nature of the graph also indicates that the response is very quick to the finer variations in visibility. Both decreasing and improving responses for RVR are synchronous.

Fig. 7 gives the comparision data of Drishti and Flamingo on a low visibility day (11th February, 2013) at runway 28-Mid at IGI Airport, New Delhi. It is clearly observed that single baseline Drishti system data is in perfect agreement with the data of dual baseline Flamingo.

Fig. 8 gives the low visibility data of all the three Drishti systems installed at runway 28-Mid in the early hours of 18th February, 2013. Intense fog giving near zero visibility condition persisted for nearly 7 hours. As the fog was very dense all the three Drishti systems which are nearly 1.5 kms apart registered near zero visibility from 21 hrs on 17th to 4 hrs on 18th February, 2013.

Fig. 9 gives the Low visibility data at Runway 28 from Drishti system at IGI Airport in the month of December 2014. RVR recorded very low values close to 100 meters at RWY 28 on 22nd December, 2014 which lasted for nearly 3 to 4 hours. Fig. 10 gives another typical data of low visibility recorded on 28th December, 2014 at RWY 29 wherein Drishti system recorded near zero visibility for nearly 5 hours.

## 5. Conclusions

RUNWAY VISUAL RANGE (RVR) is very crucial for Pilots particularly in low visibility conditions for either landing or take off. The visibility requirement varies according to the category of the Airports and is most stringent for CAT III B *viz*., IGI Airport. If a system is proved under this category, then it will be well suited for any other category like CAT I, CAT II and CAT IIIA. From the observed data of visibility under different atmospheric conditions as reported by Drishti (Figs. 4 to 9), it has been concluded that single 30 meter baseline Indigenous Drishti transmissometer is suitable for all categories of airport providing accurate MOR and RVR measurements, especially under very low visibility conditions caused due to heavy rainfall, dust storms and dense fog. The accuracies of Drishti are well within the limits recommended by ICAO. The sand storm comparison data of Drishti and Flamingo clearly indicates the super fast response of Drishti. The indigenous single baseline system performance matches well with and in some weather conditions far superior to that of imported systems with dual baseline.

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**References**

ICAO, 2004, "Manual of Runway Visual Range observing and reporting practices", ICAO Doc. 9328- AN/908.

ICAO, 2014, "Airport CDM – Adverse Weather and Fog Operations", by AAI, WP -14, Hong Kong, China, 24-28 February, 2014.

V. Shubha, Mohan, K. N., Sivakumar, G., Arul Paligan, A. and Krishnamurthy, R., 2011, "Drishti Transmissometer for IGI Airport, New Delhi", NAL technical publication PD-MT-11-22.

V. Shubha, Ramesh, T. G., Sivakumar, G., Arul Paligan, A., Krishnamurthy, R., Jithuraj, V., Kannadasan, D. and Mahesh Kumar, C. R., 2013, "Drishti-A visibility measuring system", NAL technical publication SP-1301, MT.

V. Shubha, Sivakumar, G., Arul Paligan, A. and Krishnamurthy, R., 2011, "Calibration of Miniaturized Background Luminance Meter", NAL technical publication PD-MT-11-2.

WMO, 2008, "Guide to Meteorological instruments and methods of observation", Volume **8**.