2.7 CASE STUDIES OF SELECTED RUNWAY VISUAL RANGE (RVR) EVENTS AT THREE MAJOR USA AIRPORTS

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1. INTRODUCTION

The FAA's forward scatter-based Runway Visual Range (RVR) system began service in 1994 at several key airports in the U.S. Since then, the USDOT Volpe Center has monitored data from a number of airports in order to test RVR system performance. This paper utilizes data collected on RVR at Portland International Airport (PDX), Chicago/O'Hare International Airport (ORD) and Denver International Airport (DIA) in order to assess the variability of Cat I, II and III conditions during selected events of January 1999. Previous studies showed that this month produced the most RVR events over a two-year period at ORD and PDX (Seliga et al., 2001; Hazen et al., 2002). Those findings also provided important insights into RVR variability that occurs at three airports (PDX, SEA and ORD). The most severe RVR conditions tended to occur more often in the winter at ORD and late fall and winter at PDX and SEA. This is due in large part to the occurrence of both fog and snow events at ORD during this period. This condition contrasts with the PDX and SEA results where snow was not a factor. The criticality of the events (occurrences of Cat II and III) at all three airports was found to often affect only a few of the runways at a time.

The insights obtained from this and the previous papers on RVR behavior should prove valuable for air traffic planning and lead to more effective operations in the future.

1.1 Terminology

Terms used in this report are defined as follows:

RVR or Runway Visual Range is the distance of maximum visibility of runway objects as seen by a pilot approaching for a landing in visibility limiting conditions. In the US, RVR ranges from 100-6,500 ft. Reporting increments are: 100 ft for RVR between 100-1,000 ft; 200 ft for RVR between 1,000-3,000 ft; and 500 ft from 3,000-6,500 ft. Internationally, RVR reports are in m: 25-60 m for RVR up to 800 m; and 100 m for RVR in the 800-1,500 m, (ICAO, 1995).

RVR Visibility Event is defined as any time when RVR is less than 6,500 ft (US) or 1,600 m (international). The most common causes are fog and snow. In the US, the 3 categories of RVR are: Cat I for $2{,}400 \leq RVR \leq 6{,}500$ feet; Cat II for $1{,}200 \leq RVR < 2{,}400$ ft; and Cat III for $RVR < 1{,}200$ ft.

Since RVR products are computed and reported to controllers from extinction coefficient (σ) measurements using visibility sensors (VS) on active runways, the RVR values used here are directly derived from σ using Allard's Law for nighttime using a runway light setting of 10,000 candela (cd.) where V is the visibility in km and σ is in km^{-1}. Actual values of RVR to controllers are affected by choice of runway and the specific lighting conditions on those runways.

METAR Data Format is the international standard for official reporting of surface weather conditions based on either human observations or automated observing systems. All weather conditions reported in this paper are derived from METAR data recorded at the three airports. METAR visibilities are reported in statute miles (SM). Precipitation and obstruction to visibility are as follows: RN – rain; RN+ - heavy rain; SN – snow; BLSN – blowing SN; FG – fog; FZFG – freezing fog; BR – mist. Events at ORD and DIA were primarily due to SN, BLSN and FG. PDX events were primarily due to fog while ORD and DIA were affected by both fog and snow.

2. RVR MEASUREMENTS

Data from the RVR systems were gathered remotely via modem at the Volpe Center. Tables 1-3 give the VS configurations. The runway configurations applicable to the various VS's are also listed.

Table 1. ORD Visibility Sensor Designations

RUNWAY	VS
4R22L	VS01 and VS10
4R27L	VS02 and VS12
14R32L	VS04, VS05 and VS06
18-36	VS11
27R9L	VS03 and VS09
22R4L	VS03 and VS11
32R14L	VS07, VS08 and VS09

Table 2. DIA Visibility Sensor Designations

RUNWAY	VS
35R17L	VS01, VS02 and VS03
17R35L	VS04, VS05 and VS06
16-34	VS10, VS11 and VS12
7-25	VS13 and VS14
8-26	VS15 and VS16
There are no VS07, VS08 or VS09 at DIA.	

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Table 3. PDX Visibility Sensor Designations	
RUNWAY	**VS**
28R10L	VS01, VS02 and VS03
10R28L	VS04, VS05 and VS06

3. EVENT SELECTION

Data from Dec 1999 were examined for RVR events and compared in terms of average monthly event frequencies. Table 4 lists all events considered at the three sites where either Cat II RVR readings were uniformly reported during some part of the event or SN was reported. In Table 4, the column 'Times' is for the periods of the events in Greenwich Mean Time (GMT), conversions to local time are: subtract 6 hours for ORD, 7 hours for DIA and 8 hours for PDX; 'Type' is event type; 'Max σ' is the maximum σ and 'Min Cat II' is the time all VS reported Cat II or III simultaneously during the event. These events are based on RVRs calculated during nighttime conditions with 10,000 cd light settings.

Table 4: RVR Events Studied					
Site	**Day**	**Times (GMT)**	**Type**	**Max σ**	**Min Cat II**
DIA	6-7	2200-0355	FZFG	24	0
DIA	7	0400-0915	FZFG	24	0
DIA	24	1430-1810	FZFG	18	0
ORD	2	0345-1135	SN	19	0
ORD	23	0000-1030	FG	47	237
PDX	5	1200-2400	FZFG, FG	63	208
PDX	11	0100-1545	FG	84	452

4. EVENTS

4.1 Portland

Jan 5 – FZFG with temperature and dew point at –1° C, then increasing to 0° C at 1056 PST, then to 2° C by the end of the event at 1200. Winds were calm with peaks from the SSE at 4kts at 0356 and ESE at 3kts at 0716, 0726 and 0856. Visibility was reported at < ¼ SM during much of the event

Very thick fog was most frequent along RW 10L28R which is closest to the river although the fog was thickest at ~0500 where Cat II was experienced near midpoint at RW 10R28L. There was a brief respite at 0515; fog was coming in after 0530 with the thickest fog nearest the river. By 0700, almost the entire runway area was in Cat II fog. Cat IIIa fog came in at 0715 moving from 10L to 28R. From 0745-1000, most or all of RW 10L28R was in Cat III fog, with the other runway in Cat III fog at times. Afterwards, the Cat III fog receded and the event continued to decay until the end at 1200. A sample frame of the event is shown in Fig. 1, showing Cat IIIa conditions occurring on the northern part of the runway area and close to the river. Fig. 1 shows the spatial variation of σ that seems to be strongly influenced by the airport's close proximity to the river.

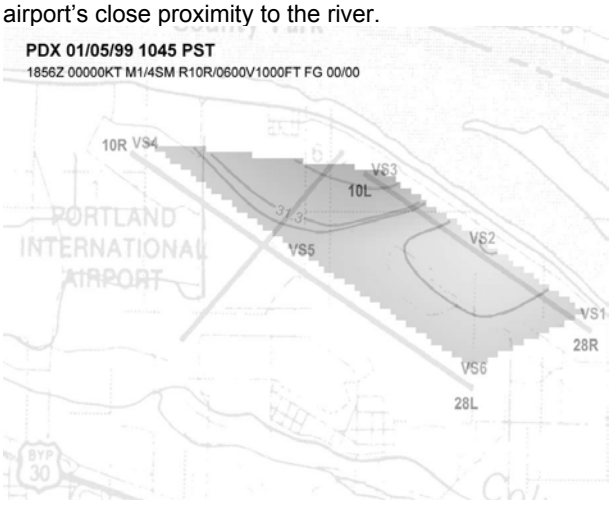

Fig. 1 – Frame from animation of Jan 5 event at PDX.

Jan 11 - FG with temperature and dew point the same until the end of the event. Temperature was 6° C at the start of event, then generally falling to as low as 2° C by 0356. Winds were generally calm, being easterly to SE at 1756 on the 10th with speeds of 3-7 kts. Visibility was ¼ SM or less during much of the event. Occasional RN fell at the end of the event.

Cat II fog entered the runway area from the river to the north after 1830 on the 10th, receded briefly at 1845 then covered variable sized parts of the area until 1945. At 1945, Cat IIIa fog covered the parts of the runway closest to the river, that is near VS3 and VS4, with the midpoint of RW 10L28R and most of RW 10R28L between VS5 and VS6 having $\sigma<4.1$ km^{-1}. By 2015, the entire area was in Cat III fog, with Cat IIIb fog covering the area closest to the river, including an area of RW 28R10L between VS2 and VS3. That runway was in Cat III fog until 2300 when the fog began to relax briefly to Cat I and II except 2200 where most of the runway was in Cat II fog. Cat III fog returned again at 0015 on the 11th with RW 28R10L at least partly in Cat III fog until 0345. The other runway was in Cat III fog as well at times. The fog relaxed again from 0415-0500, then returned with Cat II fog affecting RW28R10L from 0530-0600, relaxed again near 0615, then Cat II fog affected much of the area from 0630-0700. After 0715, the fog lifted starting nearest the river and the event was ending after 0730.

4.2 Chicago/O'Hare

Jan 2- This was the most persistent event at ORD when all or nearly all VS's reported Cat II or III RVR for around twelve hrs. The event was due to SN and BLSN. The onset occurred almost simultaneous at all VS's. SN began to fall at 21:50 on Jan 1 with a visibility of 9 SM. The wind blew mostly from the east throughout the event, often with gusts. The highest sustained wind was 27 kts, and the peak gust was 34 kts. SN was moderate during much of the event, with brief periods of SN+ reported at 09:56, 13:56 and 14:21. The peak σ ranged

from 8-19.5 km^{-1}, occurring between ~07:10-07:30. The event subsided to Cat I on all VS's by the end of the day. SN and BLSN continued through the following day.

Jan 22-23 – This series of FG events (with the most potential impact on operations due to timing) were the closely spaced events on Jan 22 - 23. The onset period 06:55-07:08 was 13 min between the first VS and the last VS reaching Cat I conditions. Eight VS's had simultaneous onsets. There was much non-uniformity between VS's during peak σ's (~8-40 km^{-1}). σ decreased somewhat between 16:00-17:30 then increased again during RN. A few VS's were still reporting Cat II. σ increased the next day with peaks of 30-48 km^{-1}. This event was actually more uniform and lasted longer than the event on the 22nd. Nearly all VS's reported Cat III RVR. σ's from about 21:00-02:00 Jan 22-23 varied considerably both with time and spatially. The runway area was in Cat II and IIIa fog almost all of that time period, however. From about 01:00-03:00, σ decreased to Cat I with periods of RN following the dense FG period. A frame from the event animation is shown in Fig. 2 showing a small area of almost-Cat III fog near RW32L west of the terminal, Cat IIIa fog covering an area northeast of the terminal, including RW 14R and almost at RW 9L and at RW 18 and 22R. Cat II fog covered almost the rest of the remaining runway area. There is considerable spatial variation of σ in the runway area.

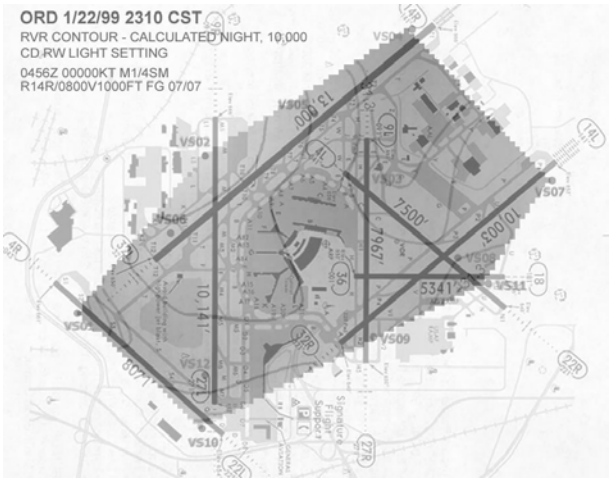

Fig. 2 – Frame from ORD Jan 23 event animation

4.3 Denver

Jan 6 – FZFG with temperatures falling from –2^{o} C to –4^{o} C then increasing to –3^{o} C towards the end of the event; the dew point depression during this period was ~ 0-1^{o} C. SN- was recorded at the end of the event. A moderate east wind was present early in event, lessening later to light to calm.

The event started at the northeastern part of the runway area. The first Cat II conditions were reported at 1640 RW 17R affected just east of the terminal. The Cat II fog area spread out to cover much of the terminal area and all of RW 17R35L east of the terminal by 1658. In general, there were considerable spatial and temporal variations with Cat II conditions most frequent on runways east of the terminal with the runways to the west affected only occasionally. RW 7-25, located southwest of the terminal was almost never in Cat II. The event subsided to Cat I or less by 2110, with snow falling between 2129 and 2206.

Jan 7 - FZFG was reported with temperatures between –4^{o} C and –3^{o} C and dew point depressions of ~ 0-1^{o}. Visibilities were ¼ SM or less during much of the event. Winds blew east at 12 kts early in event, then relaxed to light or calm (<5kts) with varying wind directions.

This event began right after the Jan 6th event ended with Cat I conditions covering areas near the terminal and along much of RW 7-25 southwest of the terminal. The first area of Cat II fog was at 2305 where an area to the far northwest of the terminal was affected, including midpoint of RW16-34. Cat II conditions were experienced most frequently west of terminal during the first part of the event. Cat II conditions covered most of the runway area from ~0025-0120. At 0105, Cat II conditions covered the whole area except at and just east of the terminal. The wind peaked at 8kts blowing from SW. The fog was lifting by 0140 and there was no fog west of the terminal by 0220. Cat II fog returned to an area northeast of the terminal from about 0225-0250. The event ended quickly after 0255.

Jan 24- SN with FZFG and BR with visibility ¼ SM or less, temperatures –4^{o} to –3^{o} C and dew points a degree or two less. Winds were easterly at 12-15 kts, relaxing to 9kts near the end of the event.

The event started NW of the terminal with Cat I fog first appearing towards RW 16 north of the terminal at 0810. Cat II fog then spread from NW to SW of terminal after 0830 with RW 17R affected. Cat II fog covered most of the runway area E and N of the terminal at 0840, then S of terminal at 0850 and moving E. The fog begins lifting by 0910 and decay continued until event ended at 1100. Fig. 3 shows Cat II fog covering an area southeast of the terminal and showing fairly uniform distribution of σ throughout the runway area.

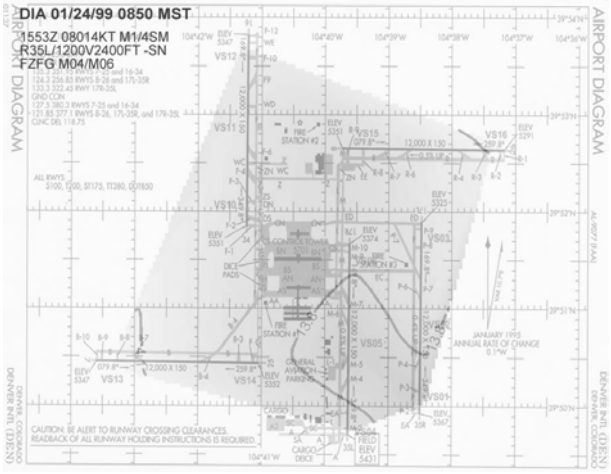

Fig. 3 – Frame from DIA Jan 24 event animation

5. CONCLUSIONS

This paper examined a few selected RVR events at DIA, ORD and PDX for Jan 1999. The results provide important insights into behavior of RVR events that would relate to operations. Sensors around the periphery of the runways would improve the monitoring of RVR events. More extensive study is clearly required with the individual event data placed within the context of forcing mesoscale conditions. Data should be gathered and analyzed over many years at many airports in order to fully understand RVR variability. Relating these to actual and projected airport operational scenarios is also needed to enhance safety and efficiency of airport operations.

6. REFERENCES

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