12.15 VISIBILITY VARIABILITY AT THE CHICAGO O'HARE AIRPORT: INSIGHTS INTO THE IMPACTS OF RUNWAY VISUAL RANGE (RVR) MEASUREMENTS ON AVIATION OPERATIONS

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1. INTRODUCTION

The FAA's latest 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 Chicago/O'Hare International Airport (ORD) in order to assess the variability of Cat I, II and III conditions there as a function of time of year and time of day similar to a study for Portland, OR and Seattle, WA by Seliga et al. (2001). The findings provide important insights into RVR variability that occurs at ORD. The most severe RVR conditions tend to occur more often in the winter. This is due in large part to the occurrence of snow events during this period. This condition contrasts with the Portland and Seattle results in which snow was not a factor. At ORD, the variability in RVR values are dependent on the time of day; the most prevalent times for Cat II and III events begin in the late evening and extend on through to around 8:00 am LST of the next day. There is a secondary peak from noon to mid-afternoon. The greatest amount of time in Cat II and III conditions occurs from around 01:00 am to 08:00 am. The tendency is for these RVR events to occur in sequences that last for two to three consecutive days. ORD has seven runways. Many of the events affect only a few of the runways at a certain time.

The insights obtained from this and similar analyses of RVR data should prove valuable for air traffic planning and lead to more effective operations.

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 only for extinction coefficient (σ) measurements from visibility sensors (VS) on active runways, the RVR values used here are directly derived from σ, using Kochmeider's Law ($V=3/\sigma$) where V is the visibility in km and σ is in km^{-1}.

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 ORD. Precipitation and obstruction to visibility are as follows: RN – rain; RN+ - heavy rain; SN – snow; BLSN – blowing SN; FG – fog; BR – mist. Events at ORD were primarily due to SN, BLSN and FG.

2. RVR MEASUREMENTS

Data from the RVR systems were gathered remotely via modem at the Volpe Center from Feb 1998 – Oct 2000. There were no missing days in the data during this time. ORD has twelve VS's along seven runways. The configuration designation is given in Table 1.

Table 1. 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

3. ANNUAL VARIABILITY

Data from Feb 1998 – Oct 2000 were compared in terms of average monthly event frequencies. Fig. 1 shows the average monthly percentage of all categories showing that the season with the higher frequencies is winter with the least events occurring during summer months. Although there is a strong general climatological pattern evident, there are also significant monthly differences from year to year. The most active month in 1998 was Mar while Jan was the most active in 1999 and during the entire test period. The most active month in 2000 was also Jan (note: no data for Jan in 1998). There was considerable year-to-year variation in many of the months with July and Aug showing the least variation.

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Jan 1999 was more than twice as active as Jan 2000. Dec 1999 was over thrice as active as Dec 1998. The year-to-year differences in monthly values are more pronounced when Cat III data are examined as shown in Fig. 2. Fig. 3 shows that the conditional percentage of Cat III events, given the occurrence of all events, varies greatly year to year for the data considered, with 1998 dominant for 4 months, 1999 for 5 and 2000 for 3. Fig. 4 shows that the Cat II-III events were significantly greater during 1999 only in Jan and Dec. The resulting expectation is that around 10 -50% of all RVR events will include Cat III conditions and that this result is seasonal, being least probable during the spring.

3.3 Composite Results

The distributions for ORD generally show more activity during the winter with the least activity in summer months. The greatest impacts of runway visibility on operations are therefore highest beginning in the early winter, peaking in the Dec-Jan time frame.

4. RVR VARIABILITY

Distributions of event percentages were plotted from 1998-2000. Events were most likely to occur from early winter to mid spring. The most active month was Jan 1999, which was also the case for Portland, which experienced the highest percentage of RVR min for all categories (Seliga et al., 2001).

4.1 Episodes/Events

In general, RVR events, particularly those in the Cat II-III status, over a period of hrs; these are associated with fog, snow and rain events according to METAR reports. The events are most frequent in winter and spring. SN and BLSN are more likely to be associated with Cat II-III conditions than rain alone. In general, the months with the higher event times have more Cat II-III due to FG, with SN being an important during winter. Other factors relevant to operational impact are discussed below.

4.2 Time Of Day

Since most air traffic occurs from about 07:00–22:00 LT, Cat II-III events during these times will likely affect all traffic. In Jan 1999 at ORD, the peak time for all RVR categories was 09:00-10:00 where about 17.5% of the data indicated Cat I, II or III. Over 10% of the data recorded from 23:00-16:00 had Cat I, II or III. The peak combined Cat II-III percentage was at 02:00-03:00 when about 8.9% of the data for that time were in those conditions. More than 5% of the data recorded between 01:00-15:00 were in Cat II or III. Hence, the maximum expected operational impact at ORD, during Jan 1999 from Cat II or III RVR, was in the late evening, with some impact also occurring during the daily operational period.

4.3 Onset

The onset of events may be gradual or sudden from examination of the VS data during FG. There is evidence of considerable variation in onset times from VS to VS, again depending on FG uniformity. Onset times ranged from a few min to over an hr and are longer when the wind is calm or near-calm. VS data from ORD indicate that, for the more uniform Cat II and III events, the onset of FG moves along definable paths.

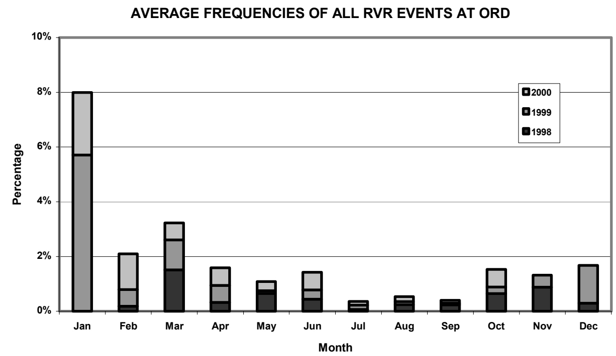

Fig. 1

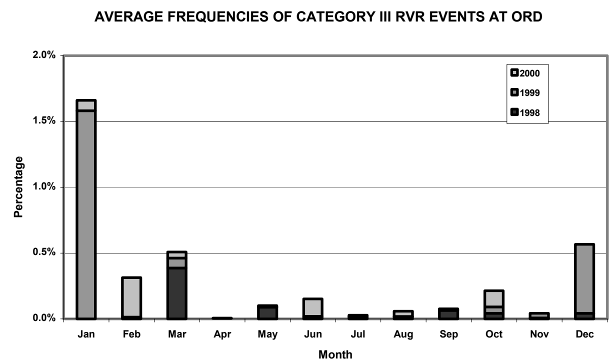

Fig. 2

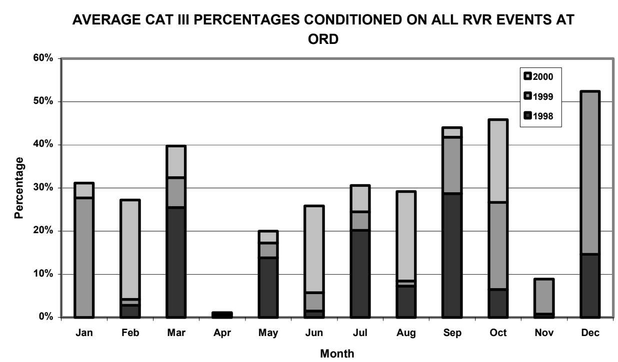

Fig. 3

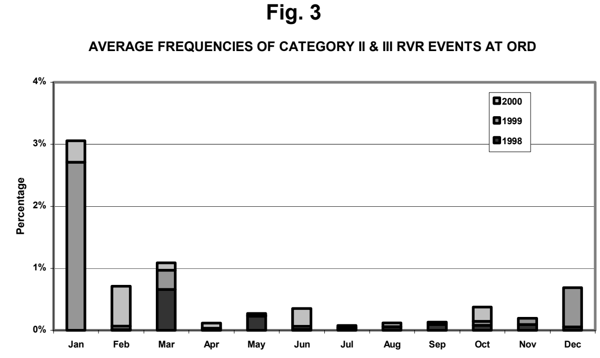

Fig. 4

4.4 Persistence

The persistence of RVR events relates to how long a particular FG event lasts or in terms of how many consecutive days Cat II or III RVR associated with FG occurs.

In general, most Cat II/III events last only a few hrs with occasional events lasting up to a day. FG persistence can vary considerably between different VS's during the same event. Depending on the onset time, longer event persistence may have a greater impact on operations. The most persistent Jan 1999 event at ORD occurred on Jan 2 when all or nearly all VS's reported Cat II or III RVR for around twelve hrs.

Examination of daily data plots indicates there were Cat II-III events on Jan 1:2:3:6:11:17:18:20:22:23:25 with at least one VS reporting Cat II or III conditions. In all, 4 days had an event occurring on consecutive days. Two of these events were over three consecutive days. Of the total number of events, all twelve VS's reported Cat II or III conditions simultaneously (2:11:20:22:23); these are termed 'uniform events'. There was one occasion with two consecutive days of uniform events. The days in which Cat II and III conditions were uniform during normal traffic hrs were on 2:11:20:22:23 with AM operations potentially impacted on 2:11:20. No uniform events occurred over two consecutive days. Evening operations were potentially impacted on the 23rd. A comparison with other active months shows that Jan had the most consecutive days of Cat II and III activity. Durations of uniform events ranged from about one hr on the 11th to about 12 hrs on the 2nd.

4.5 Decay

The decay of Cat II and III events, associated with FG and occasionally RN and SN, tends to follow definable paths, somewhat more than the onsets from examination of the VS data in time and space. The decay motion of RVR can occur in time scales ranging from min to hrs. The decay boundary may either be gradual or sharp.

5. TRANSIENT OBSERVATIONS

Of the Jan 1999 events at ORD, the event on the 2nd had the longest duration of Cat II and III RVR conditions with 12 hrs of uniform or nearly uniform Cat II and III conditions and a total event time of nearly 19 hrs. The 17th had the densest FG with σ up to 90 km^{-1} reported on VS03 and 76 km^{-1} on VS05. This event was never uniform, however, since the surface weather observation reported calm or very light winds and shallow FG during much of the event. Fig. 5 shows an interpolated map of σ based on the 12 VS's.

The longest Cat II & III event was on Jan 2, 1999, due to SN and BLSN. The onset was 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 about 07:10-07:30. The event subsided to Cat I σ's on all VS's by the end of the day. SN and BLSN continued through the following day.

Fig. 5

The FG events with the most potential impact on operations 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. Eight VS's experienced 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 on the following 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. From about 01:00-03:00, σ decreased to Cat I with periods of RN after dense FG.

6. CONCLUSIONS

This paper examined the variability of RVR at ORD for the period Feb 1998 - Oct 2000. The results provide important insights into the times of year and day when RVR would most affect operations. More extensive study is required with data gathered over many years at many airports in order to fully understand RVR variability and its effects. Relating these to actual and projected airport operational scenarios should enhance safety and efficiency through improved airport operations.

7. REFERENCES

Seliga, Thomas A., D. A. Hazen, L. Jacobs, and D. B. Lawrence, 2001,"Visibility Variability at Seattle, WA and Portland, OR: Insights into the Impacts of Runway Visual Range (RVR) Measurements on Aviation Operations," *17th Int. Conf. on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrolog*y, 13-18 Jan 2001, American Meteorological Society.

International Civil Aviation Organization (ICAO), 1995, Meteorological Service for International Air Navigation, Annex 3 to the Convention on International Civil Aviation, 12th Edition.