13.1B VISIBILITY VARIABILITY AT SEATTLE, WA AND PORTLAND, OR: INSIGHTS INTO THE IMPACTS OF RUNWAY VISUAL RANGE (RVR) MEASUREMENTS ON AVIATION OPERATIONS

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1. INTRODUCTION

The FAA's new generation Runway Visual Range (RVR) system was first placed into service in 1994 at several key airports in the United States. During the last three years, the Volpe National Transportation Systems Center has monitored RVR data on behalf of the FAA from a number of airports as part of a program to assess the performance of these systems. This paper utilizes data collected on RVR at airports in Seattle, WA and Portland, OR in order to establish the variability of Category I, II and III conditions at these sites as a function of time of year and time of day. The findings provide important insights into both the similarities and differences in RVR that occur at these two airports. The most severe RVR conditions tend to occur during the same periods of the year, starting in late summer and ending around mid-January of the next year. The variability in RVR values are shown to depend 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 11:00 am LST of the next day. The greatest amount of time in Cat II and III conditions occurs from around 5:00 am to 10:00 am. There is also an important tendency for these RVR events to occur in sequences that last for several consecutive days. Although Seattle and Portland are both in the Pacific Northwest and experience similar weather conditions, the periods when Cat II and III conditions occur at these sites do not generally coincide. This is attributed to the location of Pacific storm tracks relative to the location of the airports. The insights obtained from this and similar analyses of RVR data should prove valuable for airline planning and lead to more effective control of traffic at these airports and throughout the National Airspace System (NAS).

1.1 Terminology

Terms used in this report are defined as follows:

RVR or Runway Visual Range is defined as the range of maximum visibility of runway objects as seen by a pilot approaching for a landing in visibility limiting conditions such as fog or snow. In the US, RVR is expressed in units of feet with a range of 100-6,500 feet. The reporting increments are 100 feet for RVR between 100 and 1,000 feet, 200 feet for RVR between 1,000 and 3,000 feet and 500 feet from 3,000 to 6,500 feet. Internationally, RVR is reported in increments of 25-60 meters for RVR up to 800 meters and 100 meters for RVR in the 800-1,500 meter range, according to the latest ICAO recommendations (ICAO, 1995).

RVR Visibility event is defined as any visibility event where the Runway Visual Range is less than 6,500 feet (US) or 1,600 meters (international). The most common causes are fog and snow. In the US, RVR events are divided into three categories – Category I for RVR between 2,400 and 6,500 feet, Category II for RVR greater than or equal 1,200 and less than 2,400 feet and Category III for RVR less than 1,200 feet. Category III is subdivided into: Category IIIa for RVR from 700 to 1,200 feet; IIIb from 150 to 700 feet; and IIIc for RVR less than 150 feet.

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 both SeaTac and Portland. Of particular importance is the precipitation type (RN is rain) and obstruction to visibility (FG is fog, BR is mist).

2. RVR MEASUREMENTS

Data from the NGRVR systems were gathered remotely via modem from Portland, OR International Airport (PDX) and Seattle-Tacoma International Airport (SEA) at the Volpe Center during the following time periods:

PDX – November 1997 - November 1999
SEA – October 1997 – October 1999.

Because of problems with the data acquisition system (DAS) at SEA, data are missing on 2/19/99-3/8/99, 6/23/99 (half day), 7/29/99-9/16/99 and (no data) after 10/23/99. There were no missing days in the PDX data during the above test period.

PDX has six visibility sensors (VS), SEA four VS. The configuration is as follows:

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PORTLAND

There are six VS used on the Portland runways 28R, 28L, 10R and 10L with the following configuration:

	Touch Down	Mid Point	Roll Out
28R	VS#1	VS#2	VS#3
10L	VS#3	VS#2	VS#1
10R	VS#4	VS#5	VS#6
28L	VS#6	VS#5	VS#4

VS01-03 are on the runway closest to the Columbia River, just to the northeast of the airport terminal.

SEATTLE

Looking north to south, the parallel runways are 16R (9,000 ft) and 16L (13,000 ft). There are four VS used in the configuration as follows:

	Touch Down	Mid Point	Roll Out
16R	VS#1	VS#2	VS#3
16L	VS#1	VS#2	VS#4
34R	VS#4	VS#2	VS#1
34L	VS#3	VS#2	VS#1

The RVR data that were used in the analysis were calculated from the RVR system's extinction coefficient (σ) measurements from the VS, the ambient light sensor measurements and runway light levels at each site.

3. ANNUAL VARIABILITY

3.1 Portland

Data from 1997-1998 and 1998-1999 were compared in terms of average monthly event frequencies of the time duration of events. Fig. 1 shows the average monthly percentage of all RVR categories showing that event frequency is generally greater beginning in autumn and extending on through winter and much less in the summer. More interesting is how the month-by-month frequencies vary from year to year. The most active month in 1997-1998 was December 1997 while January 1999 was the most active month of 1998-1999. January 1999 was also the month with the highest occurrence of events in all RVR categories out of the two-year period of observation. The most striking variation is the difference between January 1998 and January 1999. The event frequency was about six times more frequent in January 1999 than January 1998. In contrast, there was little difference between December 1997 and December 1998 frequencies. The year-to-year differences in monthly values are more pronounced when Category III average frequencies are examined as shown in Fig. 2. Fig. 3 shows that the conditional percentage of Category III events, given the occurrence of all events, is greater in the 1998-1999 year except for the months of March, June and September. Fig. 4 shows that the Category II and III average percentages were significantly greater during 1998-1999 test period.

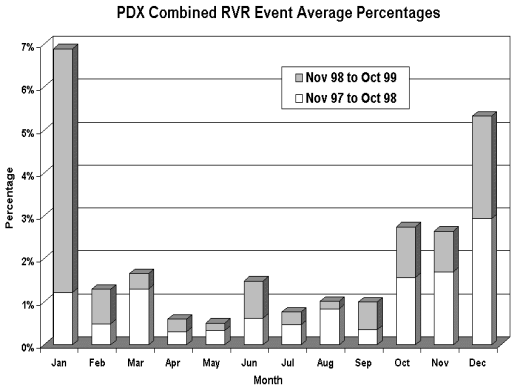

Fig. 1

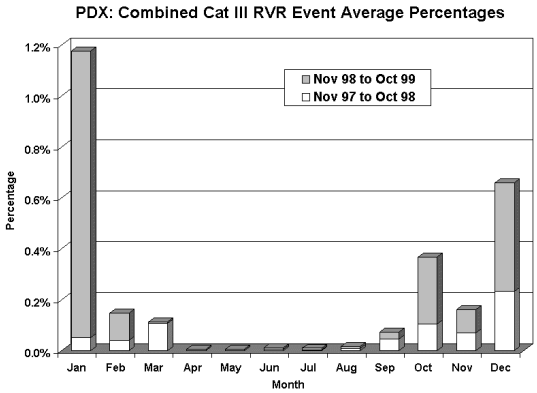

Fig. 2

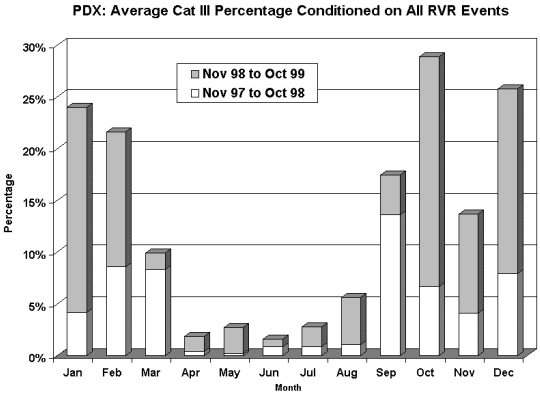

Fig. 3

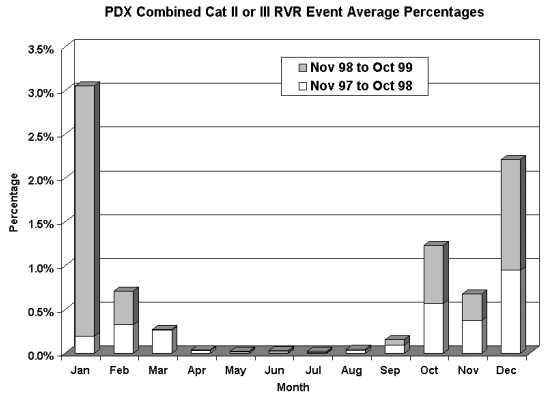

Fig. 4

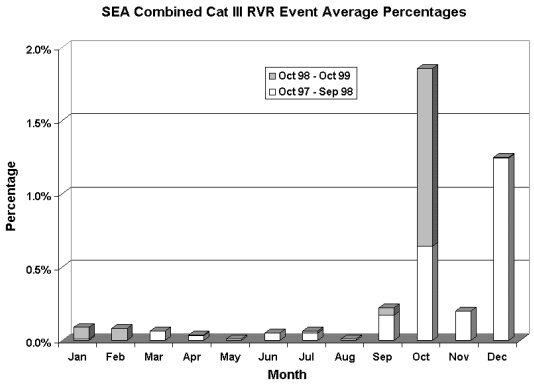

Fig. 6

3.2 Seattle

Fig. 5 shows, similar to PDX, RVR categories tend to occur most frequently starting in autumn and extending through winter. 1997-1998 was a more active year for RVR events except for the month of October where the average frequency between 1997 and 1998 were similar. Problems with the DAS prevented collection of data in August 1999. The months with the most year-to-year variation were November and December. The peak month for 1997-1998 was December 1997 and, for 1998-1999, it was October 1998. Fig. 6 shows considerable variability in terms of average Category III percentages. The only consistently active month between the two years was October. December 1997 and October 1998 were the two months with the greatest average percentage of Category III activity. October is again the month with the highest average percentage of Category III, conditioned on all RVR events as seen in Fig. 7. When Category II and III are combined, October is again the only consistent month as seen in Fig. 8. December 1997 produced the most time in RVR conditions out of the 23 months sampled.

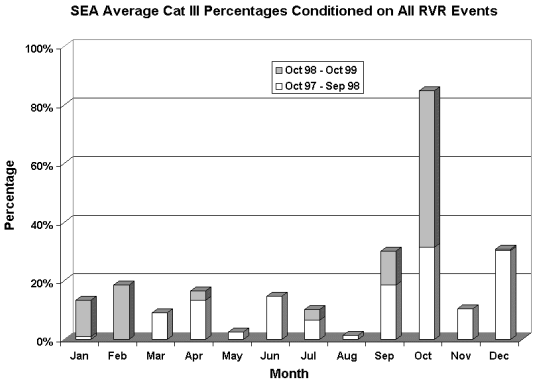

Fig. 7

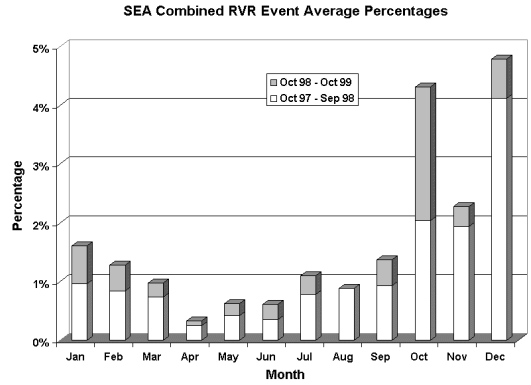

Fig. 5

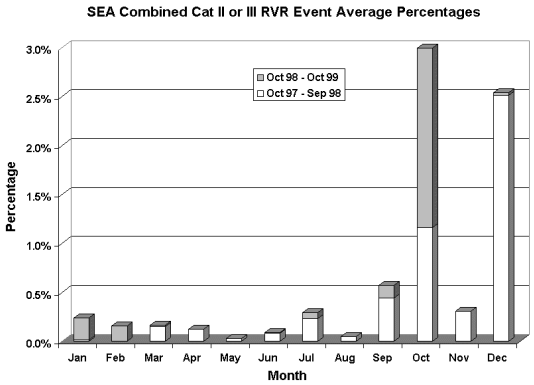

Fig. 8

3.3 Composite

The distributions for both SeaTac and Portland appear generally bimodal with low occurrences in summer months. The greatest impact on runway visibility begin in the early fall and attain a peak in the December and January time frame at both airports.

4. RVR VARIABILITY

Distributions of event percentages were plotted for both SEA and PDX from 1997-1999. At both sites, events were most likely to occur from late fall to mid winter. The worst month at either site was Portland in January 1999; it attained the highest percentage of minutes for all categories.

4.1 Episodes/Events

In general, RVR events, particularly those in the Category II and III status occur for a few consecutive hours; these were associated with fog and/or rain events according to METAR reports. These events are most frequent in late autumn and early winter. Rain alone is only occasionally associated with Category II and III conditions. In general, the months with the higher event percentages have more Category II and III events from fog. Factors important in terms of operational impact are discussed below.

4.2 Time Of Day

The times of RVR events is important because most traffic at both airports occur from about 7:00 AM-10:00 PM local time. Category II and III events occurring during these times will likely have their greatest impact in terms of delaying arrivals. During January 1999 at PDX, the peak time for all RVR categories was 1300-1400 GMT (0500-0600 PST) where about 23% of the data recorded during that time of day had Category I, II or III conditions. Over 10% of the data recorded from 0400-1700 GMT (2000-0900 PST) had Category I, II or III conditions. The peak combined Category II and III percentage was at 1600-1700 GMT (0800-0900 PST) where about 13.5% of the data for that time of day were in those conditions. More than 10% of the data recorded between 1500-1700 GMT (0700-0900 PST) were in Category II or III RVR. The percentage of data recorded that had Category II or III RVR conditions between 0300-1400 GMT (1900-0600 PST) ranged from 6-10%. Hence, the maximum expected operational impact at Portland during January 1999 from Category II or III RVR conditions was in the morning, with some added impacts expected throughout most of the remaining daily operational period.

4.3 Onset

The onset of events may be gradual or sudden from examination of the VS data during fog as reported in the official METAR reports. Also, there is evidence of considerable variation in onset times from VS to VS at either airport again depending on the uniformity of the fog. The time of events at different sensors may range from a few minutes to over an hour. The time tends to be longer when the wind is calm according to the METAR reports. Examination of VS data from Portland indicates that, for the more uniform Category II and III events, the onset of the fog appears to be associated with travel of a well-defined wave front. The passage of these wave fronts varied but typically approached the airport from the north.

4.4 Persistence

The persistence of RVR events may be discussed in terms of how long a particular fog event lasts or in terms of how many consecutive days Category II or III RVR events occur.

In general, most Category II/III events last only a few hours with occasional events lasting for up to a day. Fog persistence can vary considerably between different VS at the same site during the same event. Depending on timing of onset, longer event persistence may have a greater impact on arrivals. The most persistent January 1999 event at Portland occurred on January 11th where all VS reported Category II or III RVR for eight hours.

Examination of daily data plots indicates there were Category II-III events (hereafter 'events') on the 1st, 2nd, 4th, 5th, 6th, 8th, 9th, 10th, 11th, 12th, 13th and the 25th with at least one VS reporting Category II or III conditions during January 1999. Note that all but one of the events occurred on the first half of the month. This means runs of two to six consecutive days of events. In all, eight days of the month had an event occurring on the following day. There were five runs of three consecutive days, three runs of four days, two of five days and one of six days. Of these events, all six VS reported Category II or III conditions simultaneously (hereafter termed 'uniform events') on the 1st, 2nd, 4th, 5th, 8th, 9th, 11th, 13th and the 25th. There were three runs of two consecutive days of uniform events, meaning that on three days of the month, a uniform event occurred on the following day. The days in which Category II and III conditions were uniform during normal traffic hours were on the 1st, 2nd, 5th, 8th, 9th, 11th and the 13th with morning operations potentially impacted on all except the 11th. There were only two runs of two consecutive days of uniform events potentially impacting normal traffic operations. Evening operations were potentially impacted on the 9th, 11th and the 13th. A comparison with other active months shows that January 1999 had the most consecutive days of Category II and III activity. Durations of uniform events range from about one hour on the 13th and 25th to about 8 hours on the 11th.

4.5 Decay

The decay of Category II and III events associated with fog and occasionally rain, as reported in the METAR data, tend to follow definable paths from VS to VS even somewhat more than the onsets from examination of VS

data. The VS to VS decay path is not necessarily the same as the corresponding onset path for the same event. There does not seem to be much correlation between wind and the decay behavior between VS to VS. The time span to cover such a path can be as little as a few minutes, or for less uniform events, as many as two hours. The decay may either be gradual or sharp.

5. TRANSIENT OBSERVATIONS

Statistics for the uniform events at Portland during January 1999 are shown in Table 1. Category II or III conditions were reported on at least one VS for times ranging from 145 minutes on the 1st to 711 minutes on the 11th. All sensors on Runway 28R10L (VS01 to VS03) reported simultaneous Category II and III conditions between 15.5% and 79.3% of the event duration. The other parallel runway (VS04 to VS06) had simultaneous Category II and III conditions from 30.3% to 78.6% of the event duration. Completely uniform Category II and III conditions were reported between 6.5% and 66.9% of the total event minutes.

TABLE 1 – Uniformity Percentages of Category II and III During January 1999 RVR Events at Portland

DAY	ANY VS	RUNWAY 28R10L	RUNWAY 28L10R	ALL VS
1	145	79.3%	59.3%	53.1%
2	436	20.2%	30.3%	15.4%
4	380	78.4%	30.5%	29.7%
5	344	68.9%	70.9%	65.1%
8	421	24.2%	78.6%	23.5%
9	497	30.6%	48.5%	27.0%
11	711	70.7%	78.6%	66.9%
13	291	15.5%	30.6%	6.5%
25	373	29.5%	28.7%	16.9%
AVE	399.8	45.9%	52.9%	35.4%

Of the events during January 1999 at Portland the event on the 11th had the longest duration of Category II and III RVR conditions with eight hours of uniform Category II and III conditions and a total event time of nearly 13 hours. The 11th also had the densest fog with σ up to 90 km^{-1} reported on VS03 and 80 km^{-1} on VS02. Table 1 shows that it was the most uniform of all the January 1999 events

The January 11, 1999 event at Portland had the following onset sequence: VS06, VS05, VS04, VS02, VS01 and VS03 between 0130-0215 GMT (0530-0615 PM PST). The wind was calm during the onset period except for a three-knot east wind at 0156 GMT and 0326 GMT according to the METAR reports. The visibilities were variable between VS and over time until about 0400 GMT (0800 PM PST). Then, from about 0400-1200 GMT (0800 PM – 0400 AM PST), all VS were reporting RVRs mostly in the Category II and III ranges. The METAR reports indicated visibilities of 0.25 miles or less during that time with either calm or light SE winds and fog reported. Peak σ > 60 km^{-1} was reported first on VS03 at about 0410 GMT, then VS05, VS02 and VS01 in that order between 0420-0510 GMT. Final decay of the event occurred in the following sequence: VS03, VS02, VS01, VS04, VS05 and VS06. The decay took roughly 40 minutes between the first and last VS in the sequence. The wind blew from SE to ESE during the decay period according to the METAR reports.

6. CONCLUSIONS

This paper presented several preliminary approaches to analyzing data from two airports with RVR systems in terms that should prove relevant to air traffic operations. It was also noted that the majority of the major events appear to transit the airport as a plane wave front. This was determined through examination of the onset and decay of RVR events at each VS location. Seasonal frequencies of RVR events were examined. Results indicate that events were most likely to occur beginning in autumn and extending through winter. Frequencies for a given month can, however, vary greatly from year to year. The most frequent month for RVR events was January 1999 at Portland. RVR event frequencies versus hour of day were also determined for January 1999 at Portland. Results show a broad range of times in which RVR events were most frequent. The pattern of days in which events occurred were also studied showing a tendency to occur in clusters.

This preliminary investigation of RVR variability at two major airports revealed useful insights that should prove valuable to future planning and operation of these airports. Clearly, additional study is required along with more data to provide more complete statistical insight on RVR variability. For example, the percents of time that Category I transitions into Category II and Category II transitions into Category III needs to be determined. Relating these to operations and to weather patterns (for predictive purposes) is essential.

7. REFERENCES

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2. International Civil Aviation Organization (ICAO), "Meteorological Service for International Air Navigation", Annex 3 to the Convention on International Civil Aviation, Twelfth Edition, July 1995.