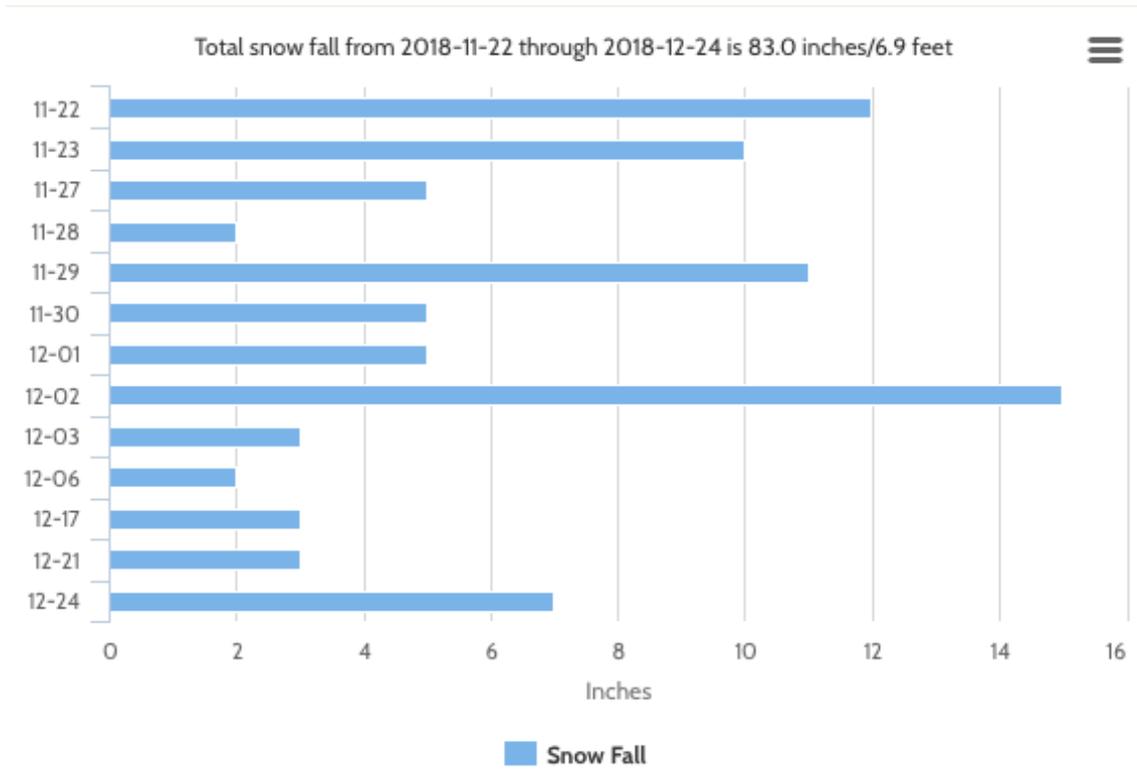


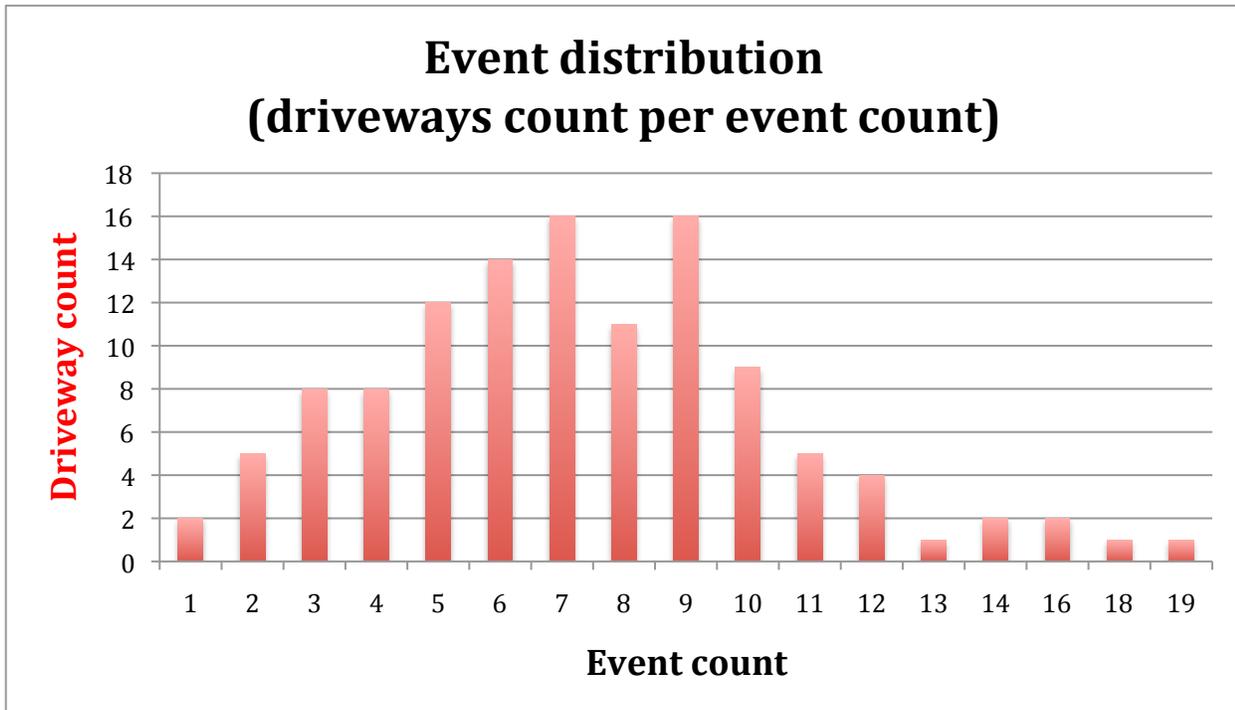
Driveway Snow Removal GPS Tracking Analysis

At a KMPUD committee meeting where GPS tracking was discussed, I was asked if I could do a statistical analysis of the driveway snow removal (SR) data to assess the size of the missed landmark issue. I received data up to the end of 2108, a period without big storm. In that period, there was 13 snow days, of which 12 were plowed (the district did not mobilize on Nov 28) as shown below (source: KMPUD website).

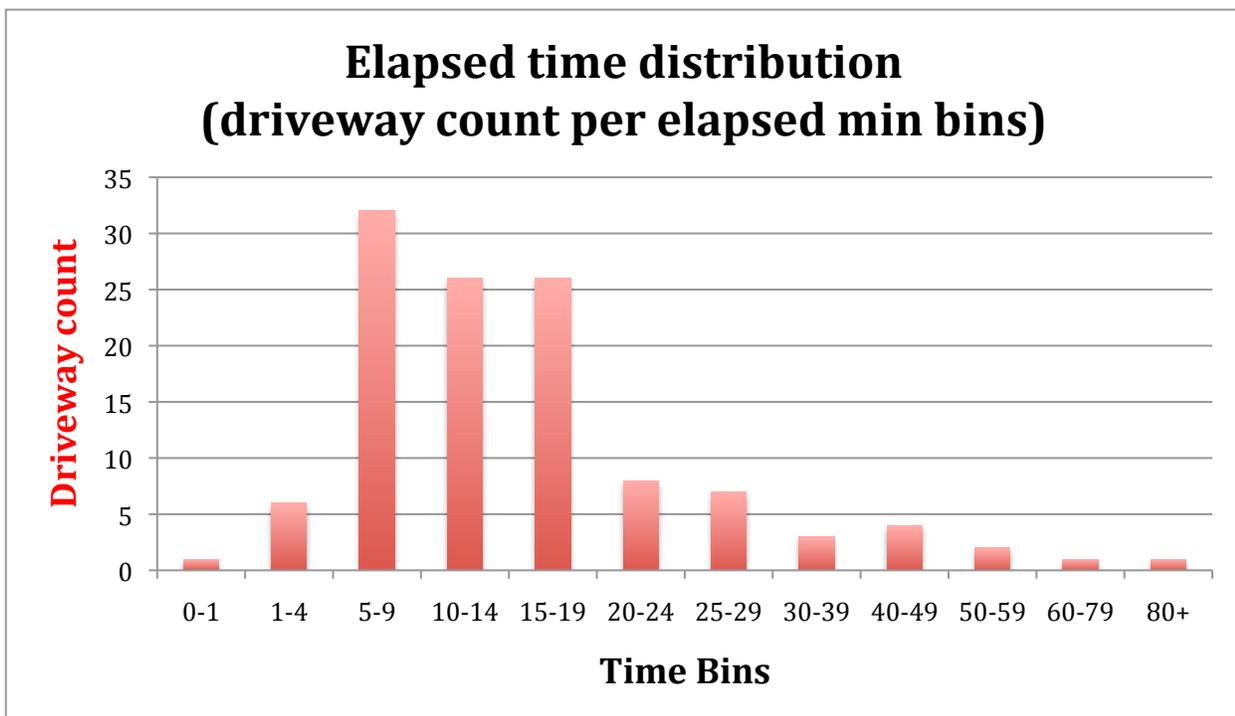


Below is a short analysis of this uncurated GPS driveway data, up to the end of 2018 year. 859 snow plowing events were distributed among 117 driveways, which is an average of 7.3 events per driveways. That looks like underreported. Standard deviation is 3.4, which is quite high at 46% of average. While there should be a few discrepancies, one would expect each driveway to have typically at least one snow plow event per storm for this period. Thus one would expect most driveways to have between 10 to 12 events for that period. I have binned driveway by their numbers of snow plowing events. The first graph below is the distribution of all the driveways plowed by KMPUD. The bins span from 1 to 19 events per driveway! I am positive SR staff would confirm that they do plow all driveways during or after a given storm. I expect that the few with greater snow plowing events inherit some of their neighbor events. However the bulk of the driveways got less than 9 events, indicating missed events. This represents statistically 465 missing events, a whole third of them. These numbers reflect a global analysis, but some driveways would fared better than others, adding to the uneven driveway GPS. The missing events are most likely logged into HOA time, when the SR engine moves to the following driveway through the HOA polygon.

In the first histogram, driveways were binned by their number of (GPS-tracked) snow removal events. This does not take in consideration time spent on a given driveway. One would expect most driveways to fall in a few bins, like from bin 8 to bin 12. The broad distribution is indicative a high level of missed landmarks by the GPS-tracking systems. The smaller the driveway is, the highest the chance to miss a driveway polygon. I could not look at the driveway size factor as I did the analysis blind and did not have the contract cost that could have shown if size was a confounding factor (one would expect that in average, small driveways are done quicker than long ones and contract cost to be correlated with time spent).



Next I did the same analysis using the SR time spent on each driveway. I binned driveway by (start of the season) combined elapsed time (min), as shown in the histogram below. Since driveways are different (driveways vary in size and complexity), one would expect a greater variability than when looking just at event distribution. Except that there are so many missed events, that using elapsed time as a variable has a narrower distribution than shown in the first graph. While binning has an impact on distribution, the trend is obvious. This underlines how mixed up the driveway GPS data log is.



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Conclusion: The two histograms showing the distribution of driveways per event count and elapsed minutes, underline an excessively wide distribution for GPS tracking of driveway snow plowing. The magnitude of the issue makes me skeptical this could be fixed by curation. First, it would be a huge work to sort out the missed landmarks and second, how to correct the elapsed time, and impossible to do without adding more errors to this dataset. Third, one would also have to look in the HOA data to retrieve the driveway time erroneously allocated to HOA. I do not think this is actually doable. This driveway GPS-tracking problem contaminates the HOA GPS tracking, with HOA being assigned some driveway time, when landmarks are missed.

In my opinion, this is beyond fixable by curation. The current GPS-tracking system accuracy and scan time does not have the resolution required for handling small GPS polygon like driveways.