

Appendix A
Rolling Average Algorithm

ROLLING AVERAGE ALGORITHM

Let l be a link between two reader field sites with attributes l_{th} , the link threshold for link l , l_{tt} , the current rolling average travel time for link l , and l_s , the current rolling average speed for link l . Let t_c be the current time and t_w be the duration of the rolling average window in seconds.

Let MI be the set of all tag matches, m , received for link l . Let each match m have the following attributes: m_t , the time that match m was received, m_{tt} , the travel time measured by match m , and m_s , the speed measured by match m .

Let the current set of valid tag matches, MI' , be defined by the following:

$$MI' = \{m \mid t_c - t_w < m_t < t_c \text{ and } (l_u - l_{tt} \times l_{th}) < m_{tt} < (l_u + l_{tt} \times l_{th})\}$$

The rolling average travel time for link l , l_{tt}' , and the rolling average speed, l_s' , can be calculated by the following equations:

$$l_{tt}' = \frac{\sum_{m=1}^{|MI'|} m_{tt}}{|MI'|}$$
$$l_s' = \frac{\sum_{m=1}^{|MI'|} m_s}{|MI'|}$$

Rolling Average Examples

A *tag match* is produced whenever a tag is received by an adjacent pair of reader sites that are defined as a source-destination pair in the configuration file. Tag matches are stored in a table along with the time that they were received and the travel time and speed measured for the tag as it passed between the two readers. Table A.1 shows an example of a table for link identifier IN0035I-RANDO-WALZE, which is one (1) mile in length.

Table A.1 - Tag Match Table for link IN0035I-RANDO-WALZE

MATCH NUMBER	TAG IDENTIFIER	TIME	TRAVEL TIME (SEC)	SPEED (MPH)
1	189	10:05:00	65	55
2	94	10:05:02	54	53
3	256	10:05:10	66	40
4	343	10:05:11	64	59
5	984	10:05:19	62	68
6	598	10:05:25	56	67
7	501	10:05:28	60	62
8	402	10:05:35	69	67
9	639	10:05:39	59	55
10	54	10:05:42	68	56
11	798	10:05:44	90	58
12	603	10:05:52	61	64
13	402	10:06:03	53	60
14	609	10:06:09	54	52
15	799	10:06:20	58	61

Periodically, the average travel time and speed for each link are calculated using a rolling-average algorithm. Two parameters are used to control the function of this algorithm: the *rolling-average window* and the *link threshold*.

The rolling-average window is used to determine the period of time that should be considered when calculating the rolling-average. For example, if the rolling-average window is 60 seconds, only the tag matches received in the past 60 seconds will be used to calculate the rolling average. The average that is produced from this calculation would be referred to as a *60-second rolling-average*.

The second parameter, the link threshold, is used to filter tag matches. For example, if the link threshold is 20%, any match which is 20% greater or less than the previous rolling-average travel time will not be included in the calculation.

The rolling-average is calculated by taking the sum of all tag matches which were recorded within the past rolling-average window and which have travel time values that

fall within the link threshold. This sum is then divided by the number of matches that were included in the sum.

Example A.1

Assume that the current time is 10:05:20, the tag match table for link IN0035I-RANDOWALZE is as presented in Table A.1, and the previous calculation for the rolling-average travel time was 59 seconds. Using a rolling-average window of 20 seconds and a threshold of 20%, all matches received since 10:05:00 with a travel time between 47.2 seconds and 70.8 seconds will be considered. This produces the following equation:

$$\begin{aligned}
 Ml &= \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15\} \\
 Ml' &= \{1, 2, 3, 4, 5\} \\
 |Ml'| &= 5 \\
 l_{tt} &= \frac{\sum_{m=1}^5 m_{tt}}{5} = 62.2
 \end{aligned}$$

Equation A.1 - Calculation of Rolling-Average Travel Time for Example A.1

The link rolling-average speed, l_s , can be calculated in a similar fashion by replacing the match travel time, m_{tt} , with the match speed, m_s . This would produce a rolling-average speed of 58.2 mph.

Example A.2

Assume that the current time is 10:06:10, the tag match table for link IN0035I-RANDOWALZE is as presented in Table A.1, and the previous calculation for the rolling-average travel time was 62 seconds. Using a rolling-average window of 30 seconds and a threshold of 20%, all matches received since 10:05:40 with a travel time between 49.6 seconds and 74.4 seconds will be considered. This produces the following calculation:

$$\begin{aligned}
 MI &= \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15\} \\
 MI' &= \{10, 12, 13, 14\} \\
 |MI'| &= 4 \\
 l_{tt} &= \frac{\sum_{m=1}^4 m_{tt}}{4} = 59.0
 \end{aligned}$$

Equation A.2 - Calculation of Rolling-Average Travel Time for Example A.2

Note that in Equation A.2, tag match number 11 is not included in the current match set, MI' , because its travel time value, 90, falls outside the valid range of travel times. The link rolling-average speed, l_s , can be calculated in a similar fashion by replacing the match travel time, m_{tt} , with the match speed, m_s . This would produce a rolling-average speed of 61.75 mph.