# *How-to: Leverage Snap to Network to enrich vehicle observations with roadway information for speeding detection*

Product: [ArcGIS Velocity]

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## *Overview*

In addition to real-time data ingestion and analysis, ArcGIS Velocity offers powerful big data tools and capabilities to perform batch analysis and processing on the IoT and AVL data your organization depends upon. These big data analytics generate insights into patterns, trends, and anomalies.

In this blog, we will demonstrate how to use ArcGIS Velocity to ingest historical vehicle observation data for a fleet in Sacramento, California, calculate motion statistics, snap observations to a local roadway network, enrich observations with relevant roadway attributes, and then process this location data to generate information such as:

- Vehicle motion statistics including speed, distance covered, acceleration and idling for each observation feature
- What road segment the vehicle was traveling on during each observation, including the name and speed limit of that road segment
- The deviation between the speed the vehicle was traveling for each observation and the speed limit for that roadway

## *Get started: Configure data sources*

Big data analytics easily load data from sources including ArcGIS feature layers, Amazon S3 buckets, Azure Blob Stores, Azure Cosmos DB, web endpoints and APIs using HTTP Poller, and RSS web endpoints. To perform analysis, we first need to load two data sources into our analytic.

The first data source is our vehicle location observations. In this analytic, the data is loaded from a delimited text file stored in an Amazon S3 bucket using the Amazon S3 source. This file contains 146,000 point features representing vehicle movement on 11/3/2020. The Track ID is identified as the **Driver_ID** and the Start Time is the **Timestamp** field of each observation.

Our second data source is an ArcGIS feature layer containing polylines of the streets in Sacramento, California. This source loads around 150,000 road segments representing all roadways in this region. For polylines representing a network to be used by the Snap to Network tool, there are three required fields:

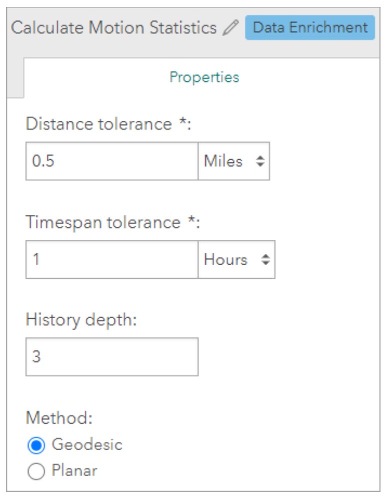
- FID or OBJECTID
- F_AUTOMOBI or F_AUTOMOBILE
- T_AUTOMOBI or T_AUTOMOBILE

The F_AUTOMOBI and T_AUTOMOBI fields indicate the driving direction relative to the digitizing direction of the polyline features. The F_AUTOMOBI and T_AUTOMOBI fields should be string fields with a value of either Y or N. Additional information regarding these field requirements is available in the Snap to Network tool documentation.

## *Calculate motion statistics for vehicle locations*

Our first step in analysis is to calculate motion statistics on the fleet vehicle locations. The Calculate Motion Statistics tool calculates motion statistics and measures for event features based on Track ID and Start Time key fields. Calculations include distance, timespan, height, speed, acceleration, heading, and idling based on the provided time values and geometry of point-based events. If your AVL data already contained a valid speed attribute, you could skip this step.

To configure the Calculate Motion Statistics tool, we simply need to add the tool, connect it to the vehicle locations Amazon S3 source, specify the distance and timespan tolerances, history depth, and method. Distance and timespan tolerances are used to determine whether a feature is idling.

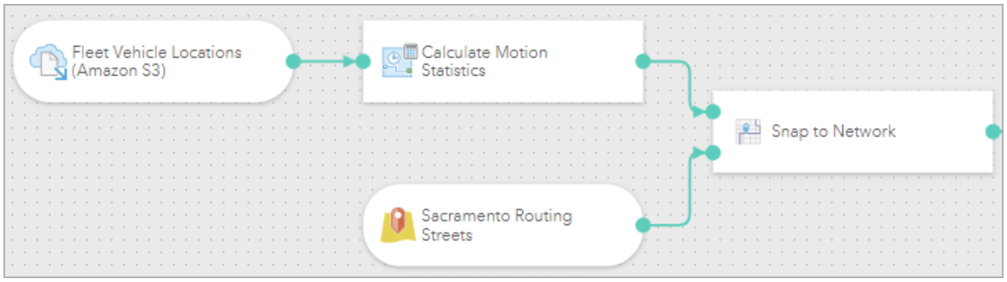



The key variable generated by this tool that we are interested in for this analysis are the speed each vehicle is traveling at that specific observation. Many other variables are calculated and appended to the schema; further details are available in the Calculate Motion Statistics tool documentation.

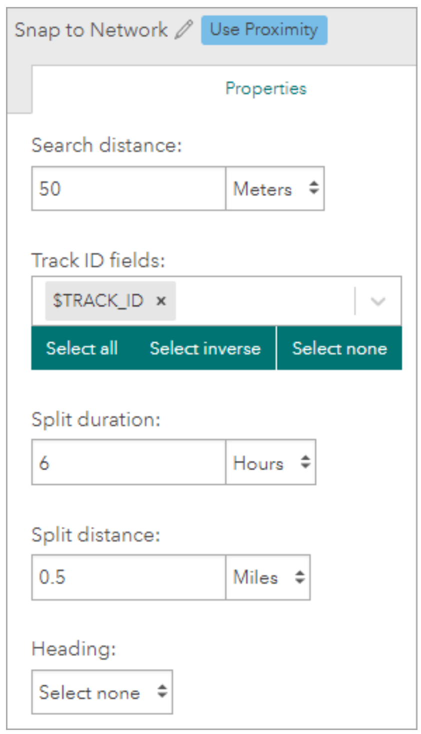
## *Snap vehicle observation points to the road network*

Next, we want to update point vehicle observation geometry to be snapped onto the provided polyline network. This allows us to update point observation geometry to be "on-the-network" to correct for GPS inaccuracies, as well as enrich features with the associated Line ID to be utilized in attribute enrichment from street segments, such as street name and speed limits.

Add the Snap to Network tool to your analytic and configure the output of the Calculate Motion Statistics tool as the target input to the Snap to Network tool. Then, connect the streets source as the join input to the Snap to Network tool. Once the sources are configured, we can specify tool parameters.




In this case we will utilize a search distance of 50 meters, leave the automatically identified Track ID, a split duration of 6 hours, a split distance of 0.5 miles, and no heading specified. Search distance controls how far to check for network features to snap to. Split information is utilized to split processing to a separate track as needed. Providing heading values can improve snapping accuracy but is not required as a heading is automatically calculated by the tool.




The output of this tool includes all provided point observations, however the point geometry has been snapped to the road network and each feature has been enriched with attributes including the LineID the feature was snapped to and other related information. The following fields are added to each point processed by the snap to network tool:

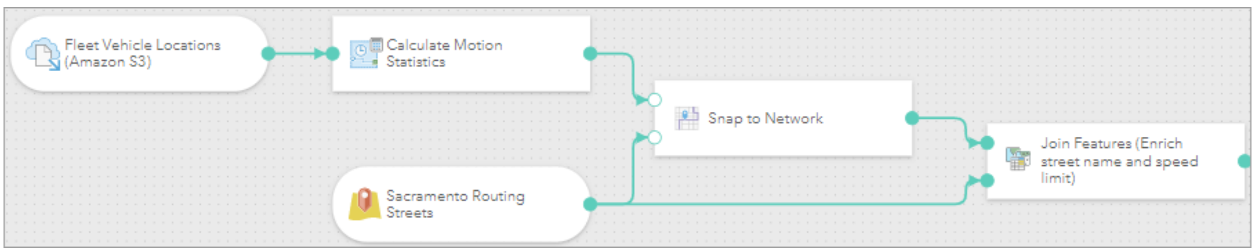
- OrigX: The original X coordinate of the point (before being snapped)
- OrigY: The original Y coordinate of the point (before being snapped)
- LineID: The OBJECTID or FID of the network polyline feature that the point feature was snapped to
- FractionAlong: The percentage fraction along this polyline upon which the point feature was snapped

- DistanceToLine: The distance from the original feature to the point along the polyline where it was snapped
- SnapScore: The relative estimated accuracy of the snap operation
- HeadingOriginal: The heading as calculated by the original position of the point (and its immediate prior point)
- HeadingSnapped: The heading as calculated by the snapped position of the point (and its immediate prior snapped point)

## *Enrich snapped vehicle observations with road segment attributes*

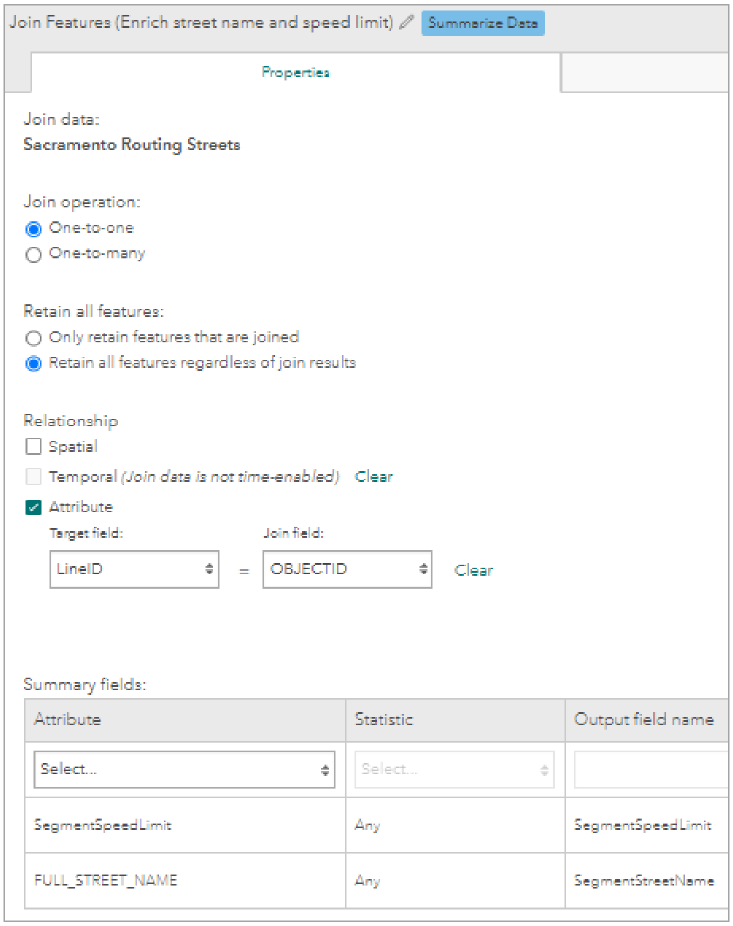
Next, we will determine the name and speed limit of the street segment to which each point vehicle observation was snapped. This will help us in later analysis when investigating driver speed.

To achieve this, the Join Features tool is added to the analytic. Connect the output of the Snap to Network tool as the target data source for the Join Features tool. Then, connect the streets source as the join input to the Join Features tool. Once the sources are configured, we can specify tool parameters.




This will be a one-to-one join operation as a feature can only be snapped to one road network. We will retain all features regardless of join results in case some vehicle observation features were not snapped to the road network. This will be an attribute relationship join where the target field is the **LineID** field generated by the Snap to Network tool. The join field for this attribute relationship will be the **OBJECTID** or **FID** field that uniquely identifies road segment features.

Additionally, we will configure summary fields to add the values from the corresponding road segments for speed limit and street name to each point observation. Our Sacramento road network has fields called **SegmentSpeedLimit** and **FULL_STREET_NAME** that we want appended to each snapped point. We will configure these with statistic *Any* which simply transfers the value present, and specify new field names of **SegmentSpeedLimit** and **SegmentStreetName**.



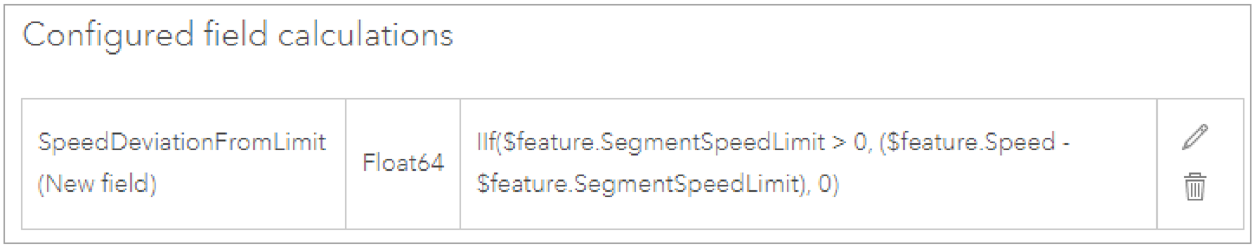

## *Determine driver speed deviation from roadway speed limit*

It is of key importance for organizations to ensure that fleet drivers are not dangerously or routinely exceeding posted speed limits by significant amounts for the roads on which they drive.

At this point in our model, we know the speed the driver was traveling at for each observation using the Calculate Motion Statistics. Additionally, we know the speed limit of the road they were traveling on using the Snap to Network and Join Features tools. Therefore, we can perform a simple field calculation to determine the driver's deviation in speed from the posted speed limit of that road segment.

To achieve this, we add the Calculate Field tool to the model and connect the output of the Join Features tool as the input to Calculate Field. Our new field will be called **SpeedDeviationFromLimit**, the field type will be Float64, and the expression will be `IIf($feature.SegmentSpeedLimit > 0, ($feature.Speed - $feature.SegmentSpeedLimit), 0)`. This IIf Arcade conditional handling function will accommodate the situation in which the road segment speed limit is null. If the road segment speed limit is null, the deviation will be set as 0. Otherwise, we will subtract the SegmentSpeedLimit from the observation speed.

In the resulting data, if the value for this field is positive it represents the MPH (miles per hour) above the speed limit of that observation. If the value for this field is negative the driver was traveling below the speed limit.

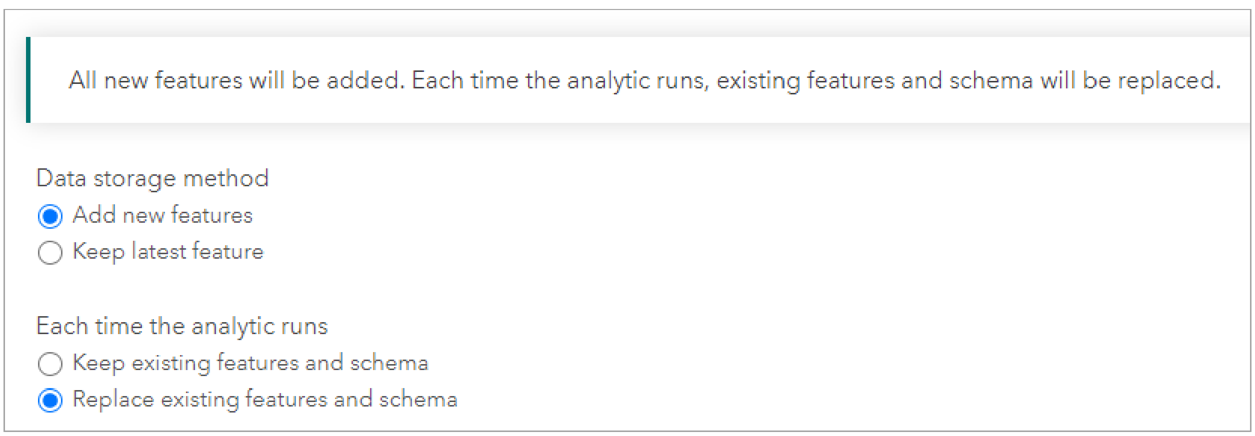


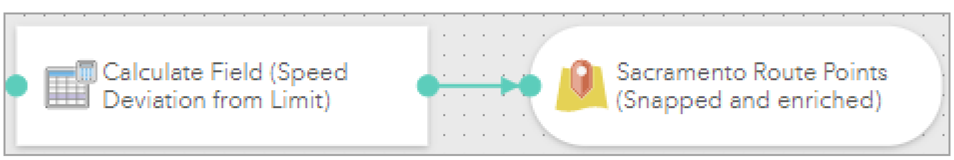

## *Configure output: snapped and enriched vehicle location observations*

At this point, we have taken our vehicle observation features, calculated motion statistics for them including speed, snapped them to the corresponding roadway segment of travel, enriched with roadway name and speed limit, and calculated the observation speed deviation from the roadway limit.

These snapped and enriched vehicle observation features are a valuable informational product that could be useful in maps, applications, or other downstream systems. ArcGIS Velocity big data analytics can send data to outputs including ArcGIS feature layers (new or existing), ArcGIS stream layers, Azure Blob Store, Amazon S3 buckets, email or text messages, HTTP endpoints, or Kafka brokers.

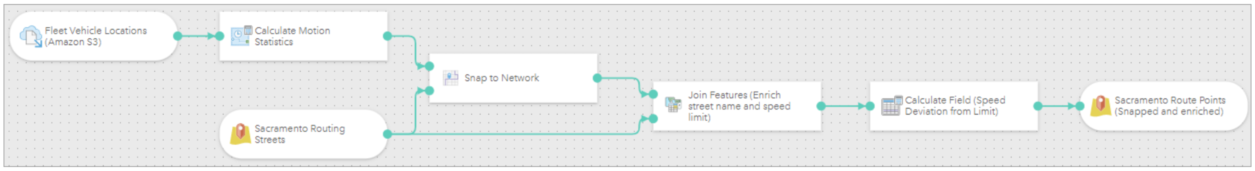
We will configure an ArcGIS feature layer (new) output with a data storage method of adding new features. A choice is also available to keep existing features and schema or replace existing features and schema each time the analytic runs. We will choose to replace existing features and schema on each run, but your use case may involve a repeated run of such analysis to generate an archive of vehicle observations with enriched speed and road segment information.



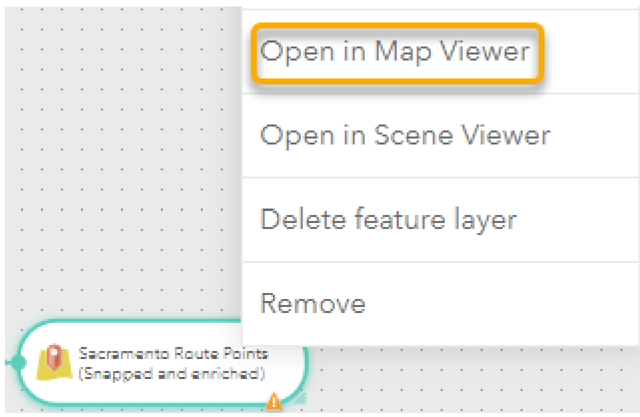

## *Review analytic configuration*

At this point, we have the following analytic configuration designed to calculate motion statistics, snap observations to a roadway network, enrich each observation with the relevant roadway attributes, and calculate driver deviations from the roadway speed limit. This is a good opportunity to review your analytic configuration for any warnings or errors before starting it. Your next step is to start the analytic to that it can process and analyze features.

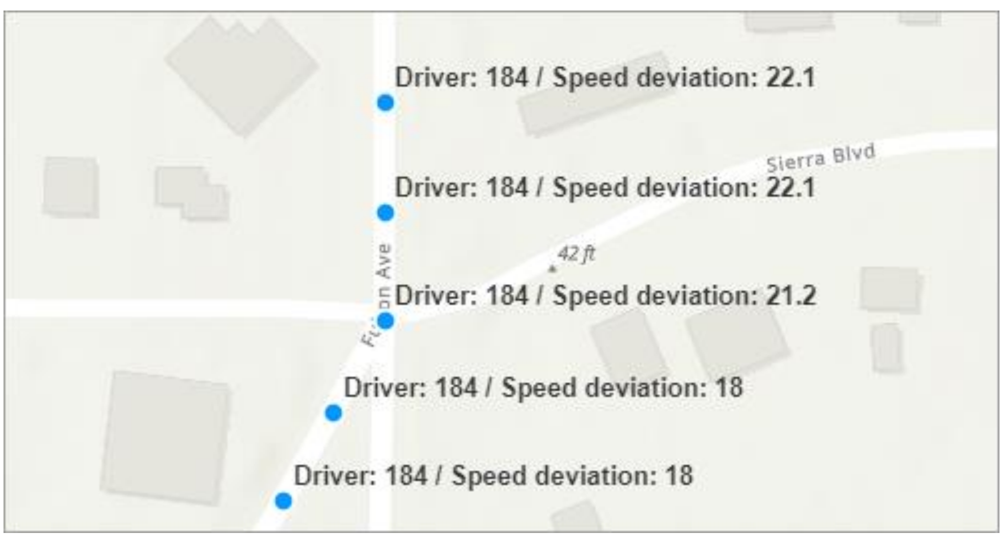


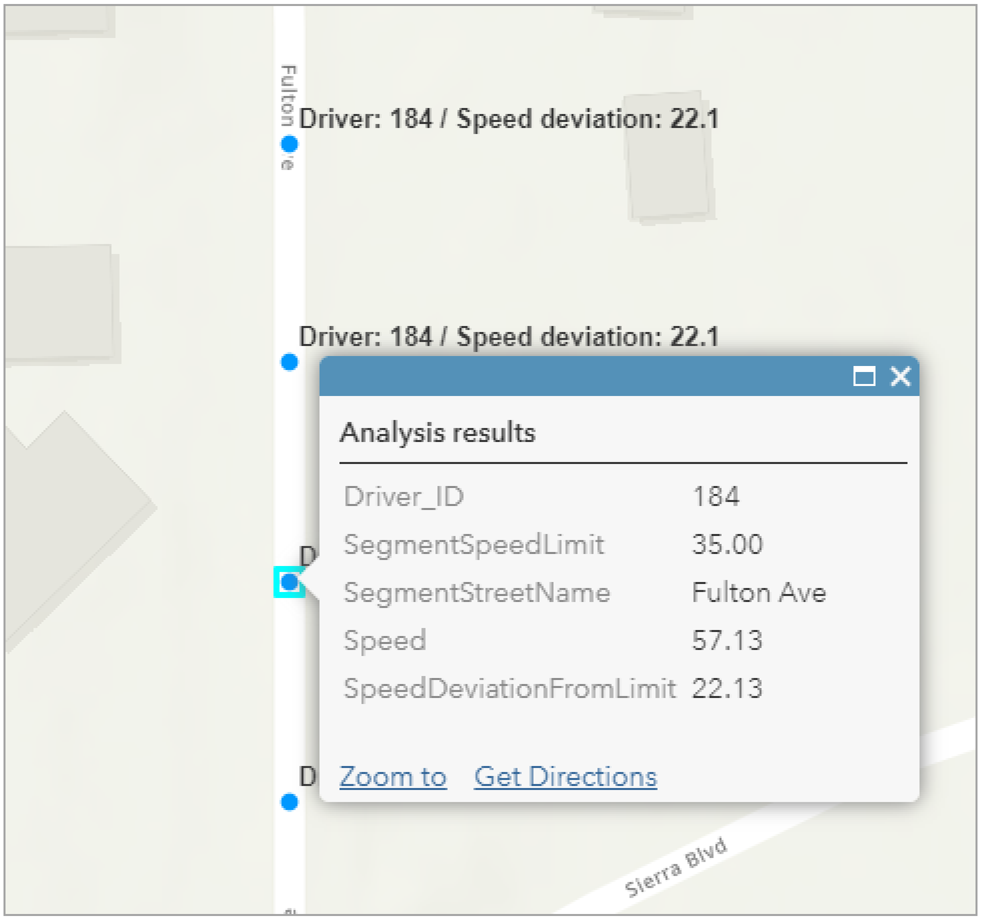

## *Inspect analysis results*

Once we have successfully started the analytic and it has completed, we can inspect output results. To do this, right click the output feature layer and select **Open in Map Viewer**.




This will open an ArcGIS Online web map with our output layer added. By enabling labels and configuring a custom labeling expression to show driver ID and speed deviation, we can view the most severe speeding events that were identified. For example, we see below that a driver was identified exceeding speed limits of road segments by over 22 miles per hour!






## *Conclusion*

In this how-to workflow, were able to generate motion statistics, correlate spatiotemporal observations of vehicle movement with roadway network data, enrich with various roadway attributes, and determine whether fleet drivers are significantly exceeding safe speed thresholds.

The methods employed and information generated in this scenario can be utilized for various business purposes including detailed observation archiving, verifying driving policy compliance, understanding the relationship between AVL sensor data and the roadways which vehicles traverse, and much more!