ACKNOWLEDGMENT

REGIONAL TRANSPORTATION COUNCIL
Bob Hart, Project Manager
Mark Harrington, Project Manager
Dale Robins
Matt Ransom

TECHNICAL ADVISORY COMMITTEE
Carley Francis, Washington Department of Transportation (WSDOT)
Scott Langer, Washington Department of Transportation (WSDOT)
Justin Sheets, Washington Department of Transportation (WSDOT)
Mike Southwick, Washington Department of Transportation (WSDOT)
Chris Christofferson, City of Vancouver
Ryan Lopossa, City of Vancouver
Jennifer Campos, City of Vancouver
Rob Klug, Clark County
Roger Hanson, Clark County Public Transit Benefit Area Authority (C-TRAN)
David Crout, Clark County Public Transit Benefit Area Authority (C-TRAN)

CONSULTANT TEAM
Garth Appanaitis, Project Manager, DKS Associates
Carl Springer, DKS Associates
Amanda Deering, DKS Associates
Maggie Lin, DKS Associates
Ray Delahanty, DKS Associates
Emily Guise, DKS Associates
Melissa Abadie, DKS Associates
Jim Peters, DKS Associates
Scott Harmon, David Evans and Associates
Angela Rogge, David Evans and Associates
Josh Anderson, David Evans and Associates
Anindita Mitra, CREA Affiliates, LLC
Michael Scarcelli, CREA Affiliates, LLC
Yueru Deng, CREA Affiliates, LLC
CONTENTS

INTRODUCTION ........................................... 1
STUDY AREA ........................................... 1

CLARK COUNTY VEHICLE TRANSPORTATION BY THE NUMBERS .... 3

DATA ACQUISITION AND APPLICATION ................. 4
DATASET SELECTION .................................... 4
WHAT IS THE DATA AND HOW WAS IT COLLECTED? ......... 6
WHAT ARE THE ELEMENTS OF A TRIP? .................. 7
COMMON QUESTIONS .................................... 8
DATA COVERAGE ......................................... 9
DATA SELECTION GUIDELINES ........................... 11
POTENTIAL DATA BIAS .................................. 11
DATA CLEANING PRACTICES ............................. 12

GENERAL APPLICATIONS ............................... 13
HOW THE TOOL AND DATA ARE BEING USED FOR THE UFCO STUDY ... 14
RAMP-TO-RAMP OD MATRICES ........................... 14
LANE-BY-LANE SPEED DIFFERENCES .................... 15
VEHICLE ROUTE DIVERSION ............................ 16

ILLUSTRATIVE USE CASES ............................. 18
CASE #1: COLUMBIA RIVER BRIDGES .................... 18
CASE #2: FREIGHT TRAFFIC AT THE PORT OF VANCOUVER .... 22
CASE #3: COUNTYWIDE ORIGIN AND DESTINATION PATTERNS .... 24

APPENDIX .............................................. 25

FIGURES

FIGURE 1. STUDY AREA MAP .......................... 2
FIGURE 2. HOW TRIPS ARE GENERATED FROM GLOBAL POSITIONING SYSTEM WAYPOINT DATA .................. 6
FIGURE 3. ORIGIN AND DESTINATION TRIP TYPES ..................... 8
FIGURE 4. GENERAL DATASET TRIP PATTERNS BY VEHICLE WEIGHT CLASS .................. 9
FIGURE 5. LONG-RANGE TRIPS TRAVELING TO AND THROUGH CLARK COUNTY .............. 10
FIGURE 6. OVERALL SAMPLE SIZE IS A KEY TO VALID FINDINGS ..................... 11
FIGURE 7. WEAVING BEHAVIORS AND TRIP PATTERNS ..................... 14
FIGURE 8. WAYPOINT DATA INDICATES SPEED DIFFERENTIAL BETWEEN LANES ............ 15
FIGURE 9. WAYPOINT ROUTING INDICATES REGIONAL TRAFFIC DIVERTING THROUGH DOWNTOWN VANCOUVER ..................... 17
FIGURE 10. ALL VEHICLE TRIPS USING THE I-5 BRIDGE ..................... 19
FIGURE 11. I-5 BRIDGE ORIGIN-DESTINATION PATTERNS ORIGINATING IN CENTRAL COUNTY DISTRICT ..................... 20
FIGURE 12. I-205 BRIDGE ORIGIN-DESTINATION PATTERNS ORIGINATING IN CENTRAL COUNTY DISTRICT ..................... 21
FIGURE 13. PORT OF VANCOUVER TRUCK PATTERNS THROUGH DOWNTOWN .......... 22
FIGURE 14. MIDDAY TRUCK TRIPS THAT START OR END AT THE PORT OF VANCOUVER .... 23

TABLES

TABLE 1. SUMMARY OF DATA OPTIONS FOR THE CLARK COUNTY OD STUDY .......... 5
INTRODUCTION

The Clark County Origin-Destination (OD) Study was performed for the Southwest Washington Regional Transportation Council (RTC) to investigate how trucks and cars access the southwest Washington transportation network, and to understand how these roadways operate. The selected OD Study dataset was derived from millions of anonymous mobile devices that were recorded while they traveled around Clark County during a one-year period. This type of travel data is referred to as Big Data, and it provides technical analysts with a dynamic platform to explore not only where the transportation system is constrained, but also why the system demands are not being met. Insights provided by Big Data can yield a more robust and layered understanding of transportation system needs, which provides a better basis for developing alternative solutions.

The findings from the OD study were primary inputs to the Urban Freeway Corridor Operations (UFCO) Study which is an in-depth analysis of freeway operational needs to identify improvements to maximize utilization, reliability, and efficiency of the Vancouver urban freeway system.

THE OD STUDY WAS CONDUCTED IN THREE STEPS:

1. DEVELOP CRITERIA FOR ACQUIRING OD DATA
2. PROCURE AND MANAGE THE DATA COLLECTION
3. DATA ANALYSIS AND REPORTING

STUDY AREA

The UFCO Study consists of the following corridors in the Clark County urban area (Figure 1):

- I-5 from the Columbia River to 179th Street
- I-205 from the Columbia River to I-5
- SR-14 from I-5 to 192nd Avenue
- SR-500 from I-5 to Fourth Plain Boulevard

In addition to the freeway mainline, the UFCO Study also includes freeway-to-freeway connections, and exit and entrance ramps. The data from the OD Study can also be applied for other planning applications.
FIGURE 1. STUDY AREA MAP
CLARK COUNTY VEHICLE TRANSPORTATION BY THE NUMBERS

INRIX WAYPOINT DATA COMPILED FROM THE MOONSHADOW DB4IOT PLATFORM
DATA SAMPLE REPRESENTS JANUARY 1, 2018 TO JANUARY 31, 2019

1 BILLION DATA POINTS WERE COLLECTED
5 MILLION VEHICLE TRIPS WERE RECORDED

NUMBER OF LIGHT VEHICLE TRIPS AVERAGE PER MONTH
166,661

MAY WAS THE MONTH WITH THE MOST TRIPS: 190,094
SEPTEMBER WAS THE MONTH WITH THE LEAST TRIPS: 147,748

10.8 MILES AVERAGE TRIP LENGTH FOR LIGHT VEHICLES
67% OF LIGHT VEHICLE TRIPS WERE 20 MINUTES OR LESS

Note: This data is based on a sample and does not include all trips.
DATA ACQUISITION AND APPLICATION

Origin-destination (OD) data has many uses in transportation planning. It can be used to evaluate travel patterns along corridors, analyze diversion to alternate routes during congestion, and to understand regional travel patterns that inform travel demand models. Several approaches to collecting and using OD data for the Clark County OD study were considered:

- **Manual Field Data Collection:** These methods include the temporary or permanent installation of cameras or other device readers. The trip data would be collected in the field by various methods, including Bluetooth sensors, Wi-Fi readers, and license plate readers.

- **Probe Data (Collected by Third-Party Vendors):** OD data from GPS devices, mobile phones, and commercial fleets can be provided by third-party vendors. When it comes to processing and analyzing the data, there are several private companies that offer aggregated data and visualization tools, in addition to tradition statistical methods, for cleaning the data and preparing it for use.

- **Hybrid Datasets:** OD data collection can also be supplemented with an existing probe dataset compiled from manual field data collection. This approach can be used to provide additional clarity, or confirm critical components of the data.

**DATASET SELECTION**

Six potential sources of OD data were reviewed using the evaluation criteria that are essential for the needs of the UFCO Study. These datasets included both general manual field collection approaches, as well as specific probe datasets.

In order to evaluate the data providers for the Clark County OD Study, a set of evaluation criteria were developed to aid in choosing which dataset would be used to supply the OD data to be used for Clark County OD summaries and the UFCO Study. Table 1 provides an evaluation summary of each dataset and the criteria that were considered. Additional information about the data selection process is included in the Appendix.

Each dataset has benefits and limitations that affect the viability for various potential applications. The evaluation criteria considered the specific application of these datasets for the Clark County OD and UFCO application needs and determined that several datasets did not meet the core needs. Some of the limitations of other datasets that were considered “fatal flaws” that fundamentally did not address the Clark County OD Study needs included:

- Historical data query was not available (data was processed into a model approximation)
- Project schedule could not be met (data was not available in a short timeframe)
- Data pricing and overall cost did not scale well for Clark County and/or fit within the project budget
- Resolution of data did not offer the precision needed to identify a specific segment of road network

Based on the review of evaluation criteria shown in Table 1, the recommended option for the OD study combines the strengths of the INRIX Trips waypoint data, and the processing and visualizing platform of the Moonshadow DB4IoT geographic interface. This combination of data and robust geospatial database tools provides greater flexibility for analyzing routing details on the arterial and freeway system (not available in other tools or datasets), displays the information in a powerful visualization tool, and meets the critical technical criteria for the Clark County OD Study and UFCO Study. This combination of products provides the broadest overall dataset, including both countywide coverage and detailed routing visualizations.
TABLE 1. SUMMARY OF DATA OPTIONS FOR THE CLARK COUNTY OD STUDY

<table>
<thead>
<tr>
<th>TECHNICAL CRITERIA</th>
<th>BLUETOOTH DATA</th>
<th>AIRSAGE</th>
<th>INRIX + MOONSHADOW</th>
<th>STREETLIGHT</th>
<th>TERALYTICS</th>
<th>SIDEWALK LABS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRITICAL FEATURES FOR UFCO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OD Data Resolution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time of Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADDITIONAL FEATURES FOR UFCO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OD Data Sample Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routing Details</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADDITIONAL FEATURES FOR OTHER APPLICATIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip Distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip Purpose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional Trip Details</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date Range (Availability)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOGISTICAL CRITERIA FOR UFCO STUDY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Format</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User Interface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schedule</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FUTURE USE CASE CRITERIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POTENTIAL FUTURE PROJECT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model Updates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interchange Study</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corridor Study</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Non-Freeway)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLEXIBILITY OF APPLICATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Customization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User Accessibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- ![Exceeds Criteria](image)
- ![Meets the Criteria](image)
- ![Does Not Meet the Criteria](image)
- ![Does Not Meet the Criteria to a Significant Extent and Indicates a Fatal Flaw](image)

*Note: Evaluation criteria and scoring were based on datasets for the Clark County OD Study and results may vary for other specific applications.*
WHAT IS THE DATA AND HOW WAS IT COLLECTED?

The INRIX Trips waypoint data is a collection of data points generated by commercial trucks and personal vehicles that are equipped with global positioning system (GPS) devices. About 1 billion trip data points were collected in Clark County during 2018 from cars and trucks. All trip data are anonymous and include no personal information about the vehicles’ drivers.

The vehicle-based GPS devices generate travel data points a few times each minute that have information about its location and speed, and assign a unique device identification (ID) number. For privacy purposes, the device ID changes automatically each day (personal vehicles) or after each refueling (commercial trucks). This helps to ensure that personal information about a vehicle’s driver or occupants cannot be traced over time.

Viewed at a high-level on-screen, these millions of data points look like a red cloud hovering over the County. However, each data point has a code that tells us if it was the start, midpoint, or end of a unique trip. When the right points are connected, they represent a vehicle trip with routing details. Figure 2 explains the steps used to convert waypoint data into a vehicle trip. About 5 million vehicle trips were recorded countywide in 2018.

The trip data points are also coded with the speed at the time they are recorded, allowing for a comparison of actual travel speeds to the legal speed limit, which is useful to spot bottlenecks in the system.
WHAT ARE THE ELEMENTS OF A TRIP?

The process of transporting people and goods involves several common elements that can be helpful when analyzing vehicle travel patterns. The elements of a vehicle trip are explained below.

### TRIP ELEMENTS INCLUDED IN INRIX DATASET

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>START POINT</strong></td>
<td>The location and time where the trip begins.</td>
</tr>
<tr>
<td><strong>LENGTH</strong></td>
<td>The distance traveled from the start point to the end point.</td>
</tr>
<tr>
<td><strong>DURATION</strong></td>
<td>The time it takes to travel between the start point and end point.</td>
</tr>
<tr>
<td><strong>END POINT</strong></td>
<td>The location and time where the trip ends.</td>
</tr>
<tr>
<td><strong>SPEED</strong></td>
<td>The speed of a vehicle provided at an individual waypoint.</td>
</tr>
<tr>
<td><strong>VEHICLE TYPE</strong></td>
<td>The general vehicle classification, including light/passenger vehicle, medium truck, and heavy truck.</td>
</tr>
<tr>
<td><strong>WAYPOINT</strong></td>
<td>In the INRIX dataset, any location-based vehicle data point is referred to as a waypoint. These waypoints report a vehicle’s location during a trip and have attributes that identify if the vehicle is the start or end of a trip. If it is neither, then it is a mid-point of a trip. A trip has only one start and one end point, but it can include many waypoints. Chained trips that have multiple stops before returning to the start point are a special case. If the duration of the stop is short, it is still considered to be a single trip.</td>
</tr>
</tbody>
</table>

### OTHER TRIP ELEMENTS NOT INCLUDED IN INRIX DATASET

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PURPOSE</strong></td>
<td>The primary reason that the trip is being made, whether it is commuting to work, venturing to the park or retail shops, or taking the kids to school.</td>
</tr>
<tr>
<td><strong>TRAVELER DEMOGRAPHICS</strong></td>
<td>Data related to the traveler, including age, race, income, etc.</td>
</tr>
<tr>
<td><strong>MODE</strong></td>
<td>The method of transportation that typically includes walking, bicycling, personal and commercial motor vehicles, and transit. This dataset only includes motor vehicles.</td>
</tr>
</tbody>
</table>
COMMON QUESTIONS

Using the DB4IoT platform, we can apply the elements of vehicle trips to investigate observed travel patterns and understand how well the road system serves its users. The common questions that we ask about trip patterns include:

- For a specific roadway route, where do trips generally start and end on a traveler’s journey? For example, on the Columbia River bridges, what portion of trips start or end within Clark County versus trips that are just traveling through on the freeway?
- For a specific geographic area, what travel routes are most popular for traveling to and from this area?
- For multiple specific geographic areas, what travel routes are most popular for traveling between the areas?
- For multiple specific geographic areas, what is the percent distribution of trips between the areas? For example, what neighborhoods in Clark County generate the most trips that end near the Portland International Airport on an average day?

These questions about travel routing provide insights about the general composition of road users, from a geographic basis of where trips start or end. Coupled with roadway performance data, such as traffic volumes, speeds and delays, the combination of how the system performs (plus how the user really wants to use the system) can inform decisions about modifying the system or expanding services to address constraints in the system during peak travel periods. It is important to note that the INRIX data set for the UFCO Study is limited to motor vehicle trips only, so the active transportation systems that support walking and bicycling are not directly addressed through this data.

For all queries of the DB4IoT platform, the findings can be divided by day of the week, time of day and vehicle weight class (light/personal vehicle, medium truck, or heavy truck).

FIGURE 3. ORIGIN AND DESTINATION TRIP TYPES
DATA COVERAGE

The INRIX Trips dataset includes a sampling of trips in 2018 that started, ended or passed through Clark County. The 5 million sampled trips are generally representative of travel activity in the County, and are useful for visualizing the underlying travel demand patterns.

The majority of light vehicle trips start and end within Clark County (about 68% of the daily total), while another 27% either start or end outside of the County. About 5% of light vehicles traveled through the County without stopping, which are referred to as “through” trips. The story is very different for medium and heavy commercial trucks, which has roughly even proportions between these three categories. Notably, the through truck traffic is about 33% of all truck trips. Refer to Figure 4 for a more detailed comparison.

It is also notable that a portion of the captured trips traveled long distances to Clark County, as illustrated in Figure 5. The geographic limits extended roughly 500 miles to Vancouver, British Columbia; Missoula, Montana; and Redding, California.

FIGURE 4. GENERAL DATASET TRIP PATTERNS BY VEHICLE WEIGHT CLASS

LIGHT VEHICLES:
- 27% Start or End Outside of County
- 68% Start and End Inside of County
- 5% Start and End Outside of County

MEDIUM AND HEAVY VEHICLES:
- 37% Start or End Outside of County
- 30% Start and End Inside of County
- 33% Start and End Outside of County

Note: General overview is based on complete dataset without additional filters applied.
FIGURE 5. LONG-RANGE TRIPS TRAVELING TO AND THROUGH CLARK COUNTY
DATA SELECTION GUIDELINES
When selecting a dataset for queries within the DB4IoT platform, it is critical to consider the sample size. Because the trip data represents a limited portion of the total trips that occur within the system, a dataset that is too small can lead to inaccurate findings.

BEWARE A DATA SELECTION THAT IS TOO SMALL
Whenever a query is made in DB4IoT, the user interface shows the data size, number of events, and the selected devices in the upper right corner of the screen. Figure 6 shows how this information is displayed in DB4IoT. The key information in this box is the number of “Viewport events”, which is the number of waypoints being shown on the screen. In this example, there are nearly 67 million. The number of selected devices represents the number of trips, which is approximately 705,000. So, for the example in Figure 6, there is likely ample data to make reasonable findings. These values change when the viewed area is zoomed in to show a smaller geographic area, and/or as other filters are applied, such as a shorter time period. The analyst will need to judge if the number of devices shown is sufficient for their purposes. However, samples less than 100 should generally be avoided.

FIGURE 6. OVERALL SAMPLE SIZE IS A KEY TO VALID FINDINGS

POTENTIAL DATA BIAS
Another related element to highlight is that data for light/personal vehicles should not be mixed with data for medium and heavy trucks. In general, there is a disproportionately higher amount of trucks represented in the data than actually occur because more commercial trucks have an active GPS system. So, the analyst should control for vehicle weight classes and not mix the results, in order to avoid inaccurate findings.

Potential data bias may be introduced by other factors in addition to over-representation of trucks in the dataset. The dataset contains raw data and has not been processed to account for sampling bias. Bias may be introduced by a host of factors related to how the data is sourced (representation of a vehicle class, purpose of the trip, demographics of the traveler, etc.) that can influence both the roadway and time of day. These factors should be considered when reporting findings from the dataset to understand limitations and underlying context of the data. For example, these potential biases may affect:

- Share of vehicle classes using a freeway (trucks are typically over-represented)
- Traffic profile by time of day (may be influenced by fleet, trip purpose, or traveler demographics)
- Some origin-destination patterns (some OD pairs may be over or under-represented based on traveler income and device technology)
DATA CLEANING PRACTICES

There are many filters available in the DB4IoT platform to examine different slices or aspects of the raw trip information. However, care should be taken to ensure proper filters are applied to the data to get the intended results. These filters can be used to sift through and eliminate outliers before downloading data and drawing conclusions. Generally, when working in the platform, trips that do not contain complete database values (e.g., some attributes may be marked as “unknown” or “undefined”) may be removed unless it is confirmed that the field/value does not impact the results of the query. It is also suggested that trip-making trends are filtered by vehicle weight class and day type (weekday versus weekend) as these criteria may change the resulting trends.

In addition to these basic criteria, other filters may be applied to eliminate outliers, such as trips with very short travel times (e.g., less than five minutes) or waypoints with abnormal raw speeds (e.g., less than 5 mph, greater than 100 mph, or unknown speed). The raw speed filter can help filter out trips with waypoints that may appear off the roadway (e.g., in the Columbia River), which are not likely to be motor vehicle trips.

While there are many filters that can be used to query the raw data, care should be taken when filtering for time of day. Typically, it is best practice to use time periods of one hour or greater. To capture trip behavior during peak periods, it is best to use several hours to obtain a larger sample and capture all trips that occur during that time (e.g., 6 a.m. to 9 a.m. for the morning peak). Additionally, when filtering for a geographic area (e.g. off-ramp or zip code) it is best to not include “unknown” or “undefined” locations. This ensures that only trips tagged with that particular geography are selected and not others that may be shown by default.

Once the data is downloaded, it can be further cleaned by looking for trips between OD pairs that are geometrically infeasible or unlikely. If the number of trips is insignificant, they can be removed as part of the cleaning process. If not, the data query may need to be revisited to understand what is being captured between the queried OD pair. Additionally, if there are any “unknown” origins or destinations, those should be removed from the OD matrix and totals.
GENERAL APPLICATIONS

A broad array of applications of INRIX Trips data are possible using the DB4IoT tool to summarize area travel for the Clark County OD Study. The breadth of potential applications is feasible due to the coverage of data (trips through Clark County), the sample size, and filterable criteria within the dataset. The range, and creativity, of potential applications is enabled by the range of the transportation question that one seeks to address.

The data can be summarized by many combinations of filters applied to geographies, time periods, vehicle types, etc. The data represents a sample set that provides insights into relative patterns of travel. However, reported data points and sampling rate should not be considered as an absolute constant – both will vary by time and location.

Some of the primary applications of the data include the following analyses:

<table>
<thead>
<tr>
<th>TRAVEL ORIGINS AND DESTINATIONS</th>
<th>TRAVEL ROUTING</th>
<th>TEMPORAL TRENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Distribution of vehicle trips that travel along specific roadway routes, based on where they start and end</td>
<td>• Traffic diversion analysis to show how corridor congestion influences drivers to use other routes</td>
<td>• Annual</td>
</tr>
<tr>
<td>• OD trip matrices for travel between two or more specific geographic areas</td>
<td>• Traffic speed and volume profiles for corridors, based on the time of day</td>
<td>• Seasonal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TEMPORAL TRENDS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Special Days* – Concert at the fairgrounds, major bridge closure, major freeway incident, etc.</td>
<td></td>
</tr>
</tbody>
</table>

*A constrained filter (e.g., a specific day) will limit the selection results and minimize the data sample size. Analysis and findings may be limited to qualitative observations, due to a limited sample size.
HOW THE TOOL AND DATA ARE BEING USED FOR THE UFCO STUDY

One of the primary factors in the procurement of the INRIX Trip data and Moonshadow’s DB4IoT tool was to provide regional data that could support the UFCO Study. The UFCO Study analyzes near-term operational and system management improvements on four urban freeways (approximately 35 total miles) in the Vancouver region. The objective of this study is to make the transportation system operate more efficiently and predictably, and to reduce the amount and/or severity of collisions.

The INRIX Trip data was used in conjunction with the Moonshadow DB4IoT tool to review the transportation system travel in several key areas:

- Create OD matrices for freeway ramp combinations
- Review locations with potential speed differential
- Review locations with potential routing diversion

RAMP-TO-RAMP OD MATRICES

The Moonshadow data supports the freeway corridor analysis by creating ramp-to-ramp OD matrices for each of the four corridors. The matrices inform the analysis of freeway weaving behaviors and trip patterns. When a freeway entrance ramp is close to a downstream exit ramp, vehicular weaving occurs between the ramps as vehicles entering the freeway merge to the left, and vehicle looking to exit, merge to the right. To correctly analyze weaving areas along the freeways, one must understand the portion of mainline and entrance ramp volumes that are destined for the mainline or the next exit ramp. Figure 7 shows these movement patterns.

Ramp-to-ramp OD summaries were prepared for each of the following combination of variables:

- Each freeway (I-5, I-205, SR 500, SR 14)
- Each direction (north and south, or east and west)
- Each peak period (6:00 a.m. to 9:00 a.m. morning peak and 4:00 p.m. to 6:00 p.m. evening peak)
- Each vehicle class (light/passenger vehicles, medium truck, or heavy truck)

FIGURE 7. WEAVING BEHAVIORS AND TRIP PATTERNS
LANE-BY-LANE SPEED DIFFERENCES

The Moonshadow DB4IoT tool was also used to review the speed profiles during peak periods, as shown in Figure 8. The project team had access to other data sources that aggregated the speed across all lanes of each segment of the corridors. This included areas where stop-and-go operations in only the right-most lane(s) were averaged with free flow operations in the left-most lane(s), resulting in only moderate slowing being presented (with details lane difference lost). Because one of the largest contributors to more severe crashes is larger speed differentials, these locations are of specific concern for the UFCO Study project team. The DB4IoT tool identified those locations and provided an explanation for buildup and release of congestion through the analysis of 15-minute time bins.

FIGURE 8. WAYPOINT DATA INDICATES SPEED DIFFERENTIAL BETWEEN LANES
The individual waypoints in the INRIX Trip data are each geocoded to provide point speed data. This raw data provides detail that is not available at the aggregated segment level – both vertically (what milepoint on the segment is experiencing a given speed) and horizontally (approximate lane of travel). While GPS is more accurate spatially than other positioning techniques (e.g., cell tower triangulation), the technology provides four-to-seven meter accuracy. This level of accuracy limits the quantitative statistical queries that can be used to compare speed among lanes on a multilane roadway. However, the data allows for a qualitative visual inspection of potential speed differential. While some individual data points and colors overlap, clear speed differentials can be identified, as shown in Figure 8.

**VEHICLE ROUTE DIVERSION**

The visualization capabilities of the DB4IoT tool was also used to identify locations where diversion occurs. For example, as southbound I-5 congestion worsens in the morning, some vehicles exit at the Main Street interchange and head south through downtown Vancouver to get back onto I-5 southbound at an interchange further south. Figure 9 is a screen capture of this phenomenon. As shown, vehicles exiting at Main Street are using the 39th Street, Fourth Plain Boulevard, and Mill Plain Boulevard entrance ramps to get back onto I-5 southbound to cross the Columbia River. If freeway congestion were to improve, we would expect to see a portion, if not all, of these trips stay on I-5, instead of diverting through the City and County roadways.
FIGURE 9. WAYPOINT ROUTING INDICATES REGIONAL TRAFFIC DIVERTING THROUGH DOWNTOWN VANCOUVER

- All trips using the off ramp are shown.
- Some trips re-enter the freeway after going through downtown to avoid freeway congestion.
ILLUSTRATIVE USE CASES

This section presents Illustrative Use Cases that represent how this toolset can be applied. Each case describes a major question being asked of the data, how the user can select or filter the data to get the outputs they desire, and a description of the results that are generated.

CASE #1: COLUMBIA RIVER BRIDGES

How do Clark County travelers use the two Columbia River Bridges each day?

DATA SELECTIONS AND FILTERS

- **Period of Data Queried:** All of 2018.
- **Travel Time Period of Interest:** Average weekday (24-hours).
- **Geographic Areas:** Clustered RTC model transportation analysis zones (TAZs) for the greater Portland Metro Area. There are 60 clustered zones for this query. The default RTC model has over 2,200 TAZs, which would generate a very large data table (nearly 5 million cell matrix).
- **Weight Class:** Light/passenger vehicles
- **Pass-Through Area:** Two polygons were drawn to include the I-5 and the I-205 bridges over the Columbia River.
- **The Query:** Show all vehicle trips that pass through the bridge area polygons that start or end within one of the 60 clustered zones.

OUTPUTS

- **For both bridges, the tool generated an OD trip matrix based on the performed filters.**
- **The screenshot of the results are shown in Figure 10.**
- **Since each trip matrix has 3,600 values (60 origins multiplied by 60 destinations), a few data vectors were selected to illustrate how trips can be visualized.**
- **To further simplify the illustration, the 60 zones were combined to form five mega districts north of the Columbia River and four mega districts to the south. Figures 11 and 12 illustrate the results.**
FIGURE 10. ALL VEHICLE TRIPS USING THE I-5 BRIDGE
The travel patterns illustrated in Figure 11 represent one slice of the OD dataset. For this case, the diagram shows the percent of trips that start in the Central County area, near Salmon Creek, and cross the I-5 bridge into Oregon. The majority of those trips have destinations in Central Portland (40%), Tigard and Tualatin (35%), Beaverton and Hillsboro (16%) and smaller amounts traveling into Clackamas County and continuing south on I-5.

*The remaining 10% of trip destinations were less than 1% at each location.*
Figure 12 illustrates the percent of trips that start in the Central County area and cross the I-205 bridge into Oregon. The majority of those trips have destinations in Clackamas County (42%), Central Portland (37%), Tigard and Tualatin (9%), and smaller amounts continuing south on I-5 and southeast on US-26.

FIGURE 12. I-205 BRIDGE ORIGIN-DESTINATION PATTERNS ORIGINATING IN CENTRAL COUNTY DISTRICT
CASE #2: FREIGHT TRAFFIC AT THE PORT OF VANCOUVER

How does freight traffic access the Port of Vancouver distribution centers?

DATA SELECTIONS AND FILTERS

- **Period of Data Queried:** All of 2018.
- **Travel Time Period of Interest:** Weekday morning, midday, and evening peak hours.
- **Pass-Through Area:** One polygon around the Port of Vancouver distribution center area.
- **Weight Class:** Medium and heavy trucks only.
- **The Query:** Show all medium- and heavy-truck trips that start or end within the Port of Vancouver.

OUTPUTS

- Trip waypoint diagrams of trucks trips shown over an area aerial image in Figure 13 and onto I-5 in Figure 14. The waypoint dot density in both figures represents higher truck volumes.

FIGURE 13. PORT OF VANCOUVER TRUCK TRAVEL PATTERNS THROUGH DOWNTOWN
FIGURE 14. MIDDAY TRUCK TRIPS THAT START OR END AT THE PORT OF VANCOUVER
CASE #3: COUNTYWIDE ORIGIN AND DESTINATION PATTERNS

What are the travel patterns to, from, and through Clark County?

DATA SELECTIONS AND FILTERS

- **Period of Data Queried**: All of 2018.
- **Travel Time Period of Interest**: Average weekday.
- **Geographic Areas**: Clustered RTC model transportation analysis zones (TAZs) for the greater Portland Metro Area. There are 60 clustered zones for this query. The default RTC model has over 2,200 TAZs, which would generate a very large data table.
- **Pass-Through Area**: None.
- **Weight Class**: All vehicles (separated into light/personal and heavy).
- **The Query**: Show all motor vehicle trips recorded within the dataset, and divide them according to where the trips started or ended within the Portland Metro Area.

OUTPUTS

- Origin-destination trip matrix that reports the total number of observed motor vehicle trips between the 60 zones.
- Rather than illustrating a 3,600 value table, a sample interactive website was prepared. **Click on this link to access the website**: http://dks.cloud/maggie.lin/Districtod/
CLARK COUNTY
ORIGIN DESTINATION STUDY

ORIGIN DESTINATION DATA COLLECTION METHODOLOGY AND EVALUATION
## CONTENTS

**CHAPTER 1: INTRODUCTION AND BACKGROUND** .................................................. 3

- PURPOSE OF THIS DOCUMENT .................................................. 3
- MANUAL FIELD DATA COLLECTION ........................................... 4
- PROBE DATA COLLECTION ..................................................... 4

**CHAPTER 2: DATA SOURCES CONSIDERED** ............................................. 4

- COMPARING PROBE DATA ........................................................ 8
- OVERVIEW OF EVALUATION CRITERIA ...................................... 9

**CHAPTER 3: EVALUATION** ........................................................................... 9

- DATA EVALUATION ................................................................. 10
- DATA SOURCE EVALUATION SUMMARIES .................................. 11
- EVALUATION SUMMARY .......................................................... 13
- OPTION 1 (RECOMMENDED) – INRIX + DB4IOT .......................... 16
- OPTION 2 – STREETLIGHT DATA .............................................. 16
- OPTION 3 – OD DATA PRODUCT PLUS INRIX SPEED PROFILE ....... 16

**CHAPTER 4: RECOMMENDATION** ............................................................. 16
CHAPTER 1: INTRODUCTION AND BACKGROUND

The Southwest Washington Regional Origin-Destination Study summarizes regional travel patterns in the Vancouver metropolitan area, including access to and from the freeway system. This study was conducted in conjunction with the Urban Freeway Corridor Operations (UFCO) study for the Southwest Washington Regional Transportation Council (RTC). Although this regional OD study will initially provide inputs to the UFCO study, the broad regional data that it provides may inform other future transportation planning applications.

**Note:** The summaries of datasets and methods were compiled in late 2018 and focused on the specific application and needs of the RTC OD Study. These (and new) datasets continue to evolve and other transportation applications may have different needs.

**PURPOSE OF THIS DOCUMENT**

Origin-destination (OD) data has many uses in modern transportation planning. It can be used to analyze travel patterns along corridors, analyze diversion to alternate routes during congestion, and to understand regional travel patterns than inform travel demand models.

This paper evaluates several approaches to collecting and using OD data for a regional OD study (and freeway ramp to ramp patterns) in southwest Washington. There are several approaches to collecting and processing origin-destination data, which are generally categorized as:

- **Manual field data collection.** These methods may include the temporary or permanent installation of cameras or other device readers. Trip data can be collected in the field by various methods including Bluetooth sensors, Wi-Fi readers, and license plate readers.

- **Probe data (collected by third party).** Additional OD data from GPS devices, mobile phones, and commercial fleets are available from third party vendors. When it comes to processing and analyzing the data, there are several companies that offer aggregated data and visualization tools in addition to traditional statistical methods for cleaning data and preparing it for use.

- **Hybrid datasets.** A third approach to OD data collection includes supplementing an existing probe dataset with manual field data collection. This approach provides additional clarity and corroborates critical components of a dataset.

This paper reviews six potential sources of origin-destination data, the inclusion of which was guided by the selection criteria developed to meet the needs of the UFCO study. The datasets include general manual field collection approaches as well as specific probe datasets.

**Disclosure note:** DKS Associates has previously coordinated with several of the data providers summarized in this report to participate in demonstrations for products and maintain awareness of state of the practice transportation tools and datasets. In some cases DKS has user accounts to explore and evaluate some of these datasets on an on-going basis to consider for potential use. DKS Associates does not have a commercial interest in any of these data providers.

The following sections include:

- Overview of data sources and case studies
- Evaluation criteria and results
- Recommendation
CHAPTER 2: DATA SOURCES CONSIDERED

This chapter provides an overview of the six data sources considered for analysis in the regional OD study to support the UFCO study. The data sources range from manually-deployed field data collection methods to crowd-sourced data collection provided by third-party big data vendors.

MANUAL FIELD DATA COLLECTION

Manual field data collection may generally include the temporary or permanent installation of cameras or other data collection devices. This approach to data collection fundamentally differs from third-party probe datasets in that there is not a pre-existing database (national or other scale) that can be filtered or queried for a specific application. The collection of field data requires some physical effort to prepare and collect, however automated processes can be applied (to some extent) to summarize the collected data. This method of OD data collection is well-established in the transportation field and has been used for about two decades.

Travel pattern data can be collected passively from Bluetooth-enabled devices by setting up sensors at key locations along a corridor. The sensors record Bluetooth device IDs and timestamps, which are aggregated and anonymized to provide linked origin-destination information for trips through the study area. A similar process can be performed by reading Wi-Fi signals from mobile devices using roadside sensors. Automatic license plate reader (ALPR) software is another early method of OD data collection, but is less common now due to the availability of easier, cheaper methods.1 Since the most commonly used of the above field collection methods is Bluetooth, this source is discussed in more detail below.

BLUETOOTH DATA

Bluetooth data collection and processing can be provided by various data collection companies, including those located in the Portland/Vancouver metropolitan area. The outputs from this data collection are fairly basic and usually include a breakdown by percentage of trips for each origin-destination pair and the travel time between each OD pair. Location capture requires a device placed at any internal (mid-point) or external (gateway) desired. The data visualization features vary by provider, but generally the OD data is available for limited time frames (how many days data were collected) and locations (how many locations at which data were collected). The capture rate is approximately three to ten percent.2 Clark County currently has approximately 60 Bluetooth devices installed to monitor the travel patterns and conditions of the arterial street system. The data is archived with similar regional transportation data in PORTAL.3 This currently reports travel time and does not summarize OD patterns through the PORTAL interface.

PROBE DATA COLLECTION

Collecting transportation data from probe vehicles via in-vehicle GPS and cellular devices has become more popular in recent years with the technological advancement of processing capabilities for large data sets and the increasing prevalence of GPS and connected vehicle technology in vehicle fleets and personal vehicles. Third party companies that collect this data either aggregate and process this

1. While not used as frequently, it is generally recognized that license plate surveys provide the most complete sampling available since inclusion is not predicated on having technology within the vehicle.
3. PORTAL is the official transportation data archive for the Portland-Vancouver Metropolitan region https://portal.its.pdx.edu
data themselves or partner with private data vendors to develop data products that are used in the transportation field. While initially used for travel time, these probe data sets can also be used to determine trip characteristics such as origin-destination pairs, route choices, and trip purpose.

Several of these private data vendors are reviewed in the following section. While each vendor’s offerings are slightly different, these transportation data providers have several features in common. These OD data sets allow customization of zone size used, as well as temporal customization (time of day, day of week, length of analysis period). Trip data is usually reported as a proportion of total population or roadway volume based on the sample size. Several prior use cases were reviewed and summaries are provided within the specific datasets, as applicable.

**TRIPMATRIX, AIRSAGE**

AirSage was an early provider of passive probe OD data in 2009, mainly using cellular data. Since this data is sourced from probe vehicles (individual travelers or vehicles traveling within the traffic stream) that are already on the road for other purposes and the collection process is non-invasive, it is considered “passive”. Cellular data from mobile phones are received via wireless signals to determine location, which can then be tracked from origin to destination. Cellular data sets generally have a relatively high capture rate (around 15 percent) due to the prevalence of cell phones, and don’t require the presence of a vehicle to be tracked. However, location information using cell towers is often not as precise as other methods (such as GPS or location-based services). In 2015, mobile phone GPS was introduced as an OD data source as well.

AirSage’s TripMatrix is their origin destination dataset product that reports OD pairs as person-trips. Trip queries can be customized by day of the week, day parts (e.g. one hour), and zone size. Additional characteristics that this source can provide are resident/visitor classification, trip purposes (e.g. home-based work), demographics, and long distance trip filters. However, TripMatrix lacks an online visualization platform and the data can only be downloaded in spreadsheet form.

Cell data sets like TripMatrix are often used for origin destination model estimation (ODME) and travel model updates. According to a 2014 OD study in Tyler, Texas, cell data may have a non-commercial vehicle bias; however, the proportion of resident vs non-resident trips in the area matched traditional survey results well. Several regional travel models for the Tennessee DOT and the Kentucky Cabinet of Transportation were calibrated with AirSage OD data between 2014 and 2016.

**TRIPS, INRIX**

INRIX, founded in 2005, is a provider of traffic data obtained from both road sensors and vehicle data, primarily GPS sourced. INRIX offers multiple traffic data products, but the OD dataset most directly relevant to the RTC OD study is called INRIX Trips (launched in 2015).

INRIX Trips data includes data on origin and destination zones, including aggregated, anonymized datasets with route details and waypoint information, trip matrices, and information on possible diversion routes and corridor trends. INRIX Trips data is available in several formats: online visualization tool, report/download of summary data, and detailed waypoint data. The online data platform (provided directly from INRIX) provides various data visualizations, with customization for zone size and location, vehicle mode, time of day, and day part. However, the combined data filters are limited for a single query (e.g., origin or destination profile by time of day provided,). The profile for a specific OD pair is not available. Advanced data queries are available as a report/download, without the web interface. As a third option, raw waypoint data (individual location “ping” data by time along a route) is available for download, and INRIX has partners (Streetlight, Moonshadow Mobile’s DB4IoT, and UMD RITIS) that provide separate data platforms with additional query features. Both Streetlight and DB4IoT are further
evaluated in this report.

INRIX’s GPS data was used in a 2016 OD study in Texas, where it was compared against Bluetooth data and cellular OD data (AirSage) sources. The key findings were that the GPS data, such as INRIX’s, had a lower capture rate and a high representation of commercial vehicles (i.e. heavy vehicles). Waypoints are useful to track routes between origins and destinations. Ohio DOT also uses the full suite of INRIX traffic analytics tools.4 OD data has been used to assess weaving movements on a toll road corridor and to update travel demand models. Due to the nature of GPS collection, it is easier to accurately separate commercial trips from personal trips. However, possible bias is present in the population that the GPS data is collected from.

INSIGHT, STREETLIGHT DATA
Founded in 2011, StreetLight Data offers large scale historical transportation data in either pay-per-project or subscription formats. They offer both GPS and location-based services (LBS) data, sourced from partners INRIX and Cuebiq, respectively. LBS data (sample size of about 20 percent) is obtained from mobile phones using applications with location services enabled. In 2015, StreetLight launched their InSight platform, which provides a single access point to create, access, and visualize various transportation data projects.

StreetLight projects include OD analysis for custom zones, OD aligned to specific geography, visitor home-work analysis, segment analysis, and zone activity analysis. These projects provide metrics such as OD matrices, travel times, roadway volumes, and information on trip purpose, vehicle type, and traveler demographics. Projects are customizable by zone or segment location and size, time period, day of week, and day part to the hour. The InSight platform also provides several interactive visualizations in the form of maps and charts. The data is also available to download in spreadsheet format.

StreetLight data has been used by several public agencies to perform corridor studies and city-wide analyses. The Mid-Ohio Regional Planning Commission used StreetLight data to study the travel patterns, seasonal variation, and freight patterns for the regions surrounding the Rickenbacker Airport. This study used StreetLight’s GPS dataset for OD analysis, using pass-through zones at the external gateways. StreetLight’s “middle filter” (used to identify the portion of trips for an OD pair that also pass through an intermediate location) was used to examine routing choices for commercial trips. The dataset and availability of four years of historical data at the time of the study revealed travel pattern characteristics that would otherwise be very difficult or costly to obtain.

Georgia DOT used StreetLight OD data in 2016 for their Downtown Connector Study.5 Zones were set up at external and internal locations to determine travel patterns through key routes using the middle filter capability. The OD data was compared with 2016 count data for ground-truthing validation and was found to match very well. This dataset was purchased as a single project as part of the Connector Study, but due to a good experience and beneficial results, Georgia DOT is pursuing a regional subscription to StreetLight Data services.

Washington State DOT (WSDOT) has an existing one-year contract with StreetLight Data that will expire in summer 2019. This contract includes regional subscriptions for three of the larger urban regions in Washington (City of Seattle, Spokane County, and Yakima/Benton/Franklin Counties), and pay-per-use subscriptions for the remaining regions, including the Southwest Region. The pay-per-use subscription limits the number of zones that can be used and only allows for one final project dataset per project purchase. The features included in the pay-per-use contract include all OD analysis project types and annual average daily traffic (AADT) projects. Only WSDOT employees or contract employees have access to StreetLight data.

---

4. This includes other INRIX products outside of INRIX trips and added functionality that may require additional packages
The application of Streetlight data for the UFCO project falls outside the terms of the WSDOT agreement and additional cost would be incurred if this data provider is used for the UFCO study.

TERALYTICS
Founded in 2012, Teralytics is a data analytics company based in Switzerland. It provides aggregated and anonymized cellular data for use in infrastructure, public transport, mobility providers, and other transportation sectors. They recently launched Matrix, an analytics platform powered by artificial intelligence to gather insights from several years of historical mobile carrier data. This data includes traveler demographics, travel times, vehicle type, and trip mode. Customization is available for time periods, day of the week, day part, and analysis zone size. The visualization platform is interactive with mapping and diagrams available to better understand the data. The web-based platform primarily uses filters on a static dataset for origin-destination studies. The platform is not used to query larger data sets or run analysis on the project data set.

REPLICA, SIDEWALK LABS
Founded in 2015, Sidewalk Labs is an Alphabet Inc. company that uses technology and passively collected data to improve urban infrastructure. The newly released Replica is billed as a “next generation urban planning tool that can help cities answer key transportation questions”.

Replica is fundamentally different than other datasets reviewed - Rather than providing a data archive with filterable queries of raw data, Replica is an aggregated model of existing conditions built for cities and urban areas from anonymized mobile location data, a synthetic population generator, and computer simulation. The models report traffic volumes, travel times, transit ridership, trip purpose, and trip ODs and are updated every three months with new inputs. The tool claims a five percent capture rate. The outputs are calibrated with data from public agencies.

Unlike typical travel models, Replica produces trip data for all streets at all times of the day. This means the tool can be queried for data by time of day and day of week for typical existing conditions, but not specific historical dates. It has an online platform query tool that can be customized by time of day and day of week for typical existing conditions, by mode and for locations. The results are illustrated through charts and maps. The fact that this tool is a model and not a historical dataset differentiates it from the previously described data providers and may not meet the needs of data sources for the UFCO Study.

This tool has been deployed in the Kansas City metropolitan area. The Kansas City model covers an eight county area. Staff at the Mid-America Regional Commission (the Kansas City MPO) said the model is calibrated off data provided by MARC and five other regional partners and noted that Sidewalk Labs has provided good customer service. The Replica model was implemented in the summer of 2018 and the current contract lasts for one year. So far, the metrics that have been pulled from the model include transit trips and ridership and travel times data to compare with a household travel survey. MARC currently has a request for OD data and will be using that data in 2019. Replica is projected to be deployed in several urban areas over the coming year including Portland Metro, which may include data for Clark County.

---

COMPARING PROBE DATA

The following table highlights the key characteristics and distinguishing features of the probe data providers described in the prior sections.

<table>
<thead>
<tr>
<th>PROVIDER</th>
<th>DATA SOURCE</th>
<th>ONLINE PLATFORM</th>
<th>ROUTE IDENTIFICATION</th>
<th>PURCHASE OPTION</th>
<th>OTHER FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip Matrix, AirSage</td>
<td>Cellular</td>
<td>No</td>
<td>No</td>
<td>Project</td>
<td>Resident/Visitor Classification</td>
</tr>
<tr>
<td>DB4IoT, INRIX</td>
<td>GPS</td>
<td>Yes*</td>
<td>Yes</td>
<td>Project or Subscription</td>
<td>Trip Mode</td>
</tr>
<tr>
<td>Insight StreetLight</td>
<td>LBS, GPS</td>
<td>Yes</td>
<td>Yes</td>
<td>Project or Subscription</td>
<td>Vehicle Type</td>
</tr>
<tr>
<td>Teralytics</td>
<td>Cellular</td>
<td>Yes*</td>
<td>No</td>
<td>Project</td>
<td>Vehicle Type, Trip Mode</td>
</tr>
<tr>
<td>Replica, Sidewalk Labs</td>
<td>Cellular</td>
<td>Yes</td>
<td>No</td>
<td>Subscription (Model)</td>
<td>Trip Mode, Transit Ridership</td>
</tr>
</tbody>
</table>

Note: * Online platform provides some features, but may be limited relative to other providers. Additional information provided in narrative.
CHAPTER 3: EVALUATION

The following sections summarize the evaluation process used to evaluate the OD data sources and key findings from the evaluation.

OVERVIEW OF EVALUATION CRITERIA

In order to evaluate the data providers for the regional OD study, a set of evaluation criteria was developed. These criteria were used to decide which provider will be used to supply the OD data for the UFCO study and potential future work. The following table describes the general criteria that were considered in the evaluation.

### TABLE 2. EVALUATION CRITERIA FOR UFCO STUDY

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TECHNICAL CRITERIA</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CRITICAL FEATURES FOR UFCO</strong></td>
<td></td>
</tr>
<tr>
<td>OD Data Resolution</td>
<td>The smallest division of geographic area for determination of origins and destinations or the type of geographic area used (e.g., zip code, census tract, user-defined)</td>
</tr>
<tr>
<td>Time of Day</td>
<td>Smallest time segment (time slice) available for origin-destination data (e.g. 15 minutes, hour, peak period)</td>
</tr>
<tr>
<td>Day Type</td>
<td>Ability to specify day of week, weekday vs weekend, or specific dates</td>
</tr>
<tr>
<td><strong>ADDITIONAL FEATURES FOR UFCO</strong></td>
<td></td>
</tr>
<tr>
<td>OD Data Sample Size (Capture Rate)</td>
<td>Sample size of data reported as a percentage of total population or total trips</td>
</tr>
<tr>
<td>Travel Time</td>
<td>Duration of trips for a certain origin-destination pair (either at the link level or for the entire origin-destination trip)</td>
</tr>
<tr>
<td>Routing Details</td>
<td>Specific information on the routes used for each origin-destination pair</td>
</tr>
<tr>
<td><strong>ADDITIONAL FEATURES FOR OTHER APPLICATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Trip Distance</td>
<td>Trip distance for a certain origin-destination pair</td>
</tr>
<tr>
<td>Trip Purpose</td>
<td>A breakdown of trips by purpose for each origin-destination pair (e.g. home-based work, home-based other, non-home-based)</td>
</tr>
<tr>
<td>Additional Trip Details</td>
<td>Other trip details such as vehicle classification, demographics of travelers, mode of travel, etc.</td>
</tr>
<tr>
<td>Date Range</td>
<td>Availability of historical data from past years</td>
</tr>
<tr>
<td><strong>LOGISTICAL CRITERIA</strong></td>
<td></td>
</tr>
<tr>
<td>Data Format</td>
<td>Format of data when received from vendor (e.g. excel spreadsheet, graphic visualization, interactive platform, etc.)</td>
</tr>
<tr>
<td>User Interface</td>
<td>Interactive web platform that can be used to either request data or explore and visualize the data after it is received</td>
</tr>
<tr>
<td>Schedule</td>
<td>Length of time and level of effort needed to make a data request and receive the data</td>
</tr>
<tr>
<td>Cost</td>
<td>The least data cost between one-time purchase cost of data and a subscription (cost estimates to be based off data needs for UFCO study)</td>
</tr>
<tr>
<td>Contracting</td>
<td>Level of effort for the contracting process and potential contract limitations</td>
</tr>
</tbody>
</table>
### DATA EVALUATION

The following sections summarize the key evaluation findings for each data source based on the criteria. These key findings include the data source’s level of application for the UFCO study and for future potential RTC applications. Additional notes that address each criteria for individual data providers is included in the full evaluation matrix in the Appendix.

When applying each of the criteria against the six data sources, several of these appear to be more suitable for the UFCO Study over others. Table 3 shows how each data source scored for the evaluation criteria. As noted, three of the data sources have fatal flaws for this project application.

#### TABLE 3. EVALUATION CRITERIA RESULTS

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUTURE USE CASE CRITERIA</strong></td>
<td></td>
</tr>
<tr>
<td>Potential Future Project</td>
<td>Applicable Data Needs</td>
</tr>
<tr>
<td>Model Updates</td>
<td>Origin-destination trip data (larger zones), trip purpose</td>
</tr>
<tr>
<td>Interchange Study</td>
<td>Origin-destination trip data (smaller zones), vehicle classification</td>
</tr>
<tr>
<td>Corridor Study (non-freeway)</td>
<td>Travel times; origin-destination data for trips using the corridor</td>
</tr>
<tr>
<td><strong>Flexibility of Application</strong></td>
<td>Description</td>
</tr>
<tr>
<td>Data Customization</td>
<td>Various combinations of time customizations and origin-destination pairs can be formed from the OD data for the Regional OD study which would be able to support future undefined studies in the same area</td>
</tr>
<tr>
<td>User Accessibility</td>
<td>Data is easily accessible for the user after the Regional OD study is completed for aggregation, download, or visualization purposes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>TECHNICAL CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OD Data Resolution</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Time of Day</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Day Type</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ADDITIONAL FEATURES FOR UFCO</strong></td>
<td></td>
</tr>
<tr>
<td>OD Data Sample Size</td>
<td></td>
</tr>
<tr>
<td>Travel Time</td>
<td></td>
</tr>
<tr>
<td>Routing Details</td>
<td></td>
</tr>
<tr>
<td><strong>ADDITIONAL FEATURES FOR OTHER APPLICATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Trip Distance</td>
<td></td>
</tr>
<tr>
<td>Trip Purpose</td>
<td></td>
</tr>
<tr>
<td>Additional Trip Details</td>
<td></td>
</tr>
<tr>
<td>Date Range (Availability)</td>
<td></td>
</tr>
</tbody>
</table>

ORIGIN DESTINATION DATA COLLECTION METHODOLOGY AND EVALUATION
DATA SOURCE EVALUATION SUMMARIES

The following sections summarize the evaluation for each of the data sources.

REPLICA, SIDEWALK LABS
Since Replica, from Sidewalk Labs, is an existing conditions model that covers the entire roadway network of a city or region it is not primarily an OD data product and does not meet the basic requirements for the UFCO study. Replica does not provide a data archive with filterable queries of raw data, and the calibration time (several months or more) exceeds the UFCO schedule needs. Since these models usually cover an entire region, cost is likely to be prohibitive. In terms of OD data providers, Replica is among the newest. However, the Portland region’s potential procurement of Replica may allow for its use in future potential regional transportation analyses.

BLUETOOTH DATA
While manual collection methods through Bluetooth data meet the minimum criteria for the UFCO study, cost and schedule issues make it an impractical option. Bluetooth data is able to provide the proper OD resolution to capture freeway ramp movements, but the day type and depth of data is limited to the one to two week period when data is collected. Travel time information from device to device is available, but detailed routing information is not. Manual collection of OD data yields fairly limited metrics besides the OD data, so additional features such as trip distance, trip purpose, and demographics are not provided.
Logistics of schedule and cost renders Bluetooth data collection infeasible for regional-sized projects such as UFCO or travel model updates. A third party company is required to collect the data, and these companies often do not have enough physical devices to cover the entire study area in one collection time period. This leads to increased time for collection (one to two months), increased costs, data covering different dates, and limitations for OD pairs (that may not include all potential combinations of locations if data was collected on separate days). Due to these limitations, Bluetooth data and manual collection is not recommended for the UFCO study as the primary collection method. However, this data could be used (in a limited basis) to verify or supplement other data collection methods.

TERALYTICS
The Teralytics OD data product is user friendly and cost-efficient for large scale studies. Teralytics product includes trip distance, trip purpose, and vehicle type. Once the user interface is set up, there are several filters and visualizations available to help visualize trends and understand the data. However since it uses only less-precise cell tower data to determine location, it is not adequate for the UFCO study needs. No routing data is available and it requires a third party to query the data. A web-based visualization platform is available, but users cannot initiate queries. Based on the offered features and magnitude of cost, this product is well suited for regional studies or travel demand model updates, where locational precision of trips on roadways is less critical. It does not meet all the needs of the UFCO Study.

TRIPMATRIX, AIRSAGE
AirSage’s OD data product, TripMatrix, meets the basic requirements of providing freeway ramp to ramp OD summaries for this study, however additional metrics are limited and no online platform is provided for querying and visualizing the data. No travel time or routing details are available with this data set, which are desirable secondary features for the UFCO study and future RTC applications. The OD data set is delivered in spreadsheet format, requires third party (AirSage) fulfillment of the data request (two to four weeks), and cannot be easily used in other applications. Though this source provides the minimum features needed for the UFCO study, it fails to meet many other criteria needed to be considered the best choice for this application.

DB4IOT, INRIX
INRIX data involves more than just OD data products, and its strengths lie in the raw data it provides (i.e., disaggregated waypoint information). This raw data requires effort to process and may be unmanageable for some regional studies such as UFCO (due to effort and time required to prepare a custom data analysis tool). However, one of INRIX’s partners, Moonshadow Mobile, provides a DB4IoT platform which is able to visualize and analyze this vast waypoint dataset.

DISCLOSURE NOTE: Similar to other big data analysis and storage providers, DKS Associates has previously coordinated with Moonshadow to provide industry perspective for transportation data analysis in order to enhance data analysis options for future application and improve the state of the industry. DKS does not have a formal agreement with Moonshadow, nor does DKS have a commercial interest in Moonshadow. DKS Associates employee Adrian Pearmine serves on Moonshadow’s Board of Directors. The consideration for Moonshadow’s services through the Regional OD Study would have no financial or other impact for DKS Associates.

The DB4IoT platform provided at an additional cost and combined with the waypoint dataset meets the minimum criteria for the UFCO study. The platform has the ability to identify routing information for OD pairs and to filter the OD data directly based on time, date, and location based filters. This platform and dataset would be accessible following the 12 months of purchase. In addition to visualization within the platform, it provides the ability to export data for additional report, visualization, and mapping needs. Data could be procured for the entirety of Clark County, which would include waypoint data for all trips.
traveling through, to/from, or within the County.

This source is best suited for larger regional studies, including travel model updates. Although this waypoint data and DB4IoT platform combination is more costly than the other sources, it provides an excellent level of detail and good user interface to facilitate regional OD analyses.

**INSIGHT, STREETLIGHT**

StreetLight’s InSight platform is one of the few products available where data queries and visualization do not require a third party interface. OD data can be queried by the user at any time in the platform as long as the total number of zones are not exceeded for a project. StreetLight data meets the minimum OD data requirements for the UFCO study and also provides details on OD zone travel time, trip purpose, and demographics. Routing information can also be compiled using StreetLight’s middle filter capability, which identifies trips that pass through a user-defined zone on their way to their destination. Based on technical and logistical criteria, StreetLight data is well suited for smaller corridor studies and interchange studies, but due to cost, is not well suited for travel model updates. StreetLight’s easy to use platform, data analysis flexibility, and reasonable cost for this scale of project makes it one of the top choices for the UFCO study.

**EVALUATION SUMMARY**

The evaluation indicated that three datasets have one or more fatal flaw(s) for the specific application needs of the regional OD Study:

- Replica from Sidewalk Labs – no historical data query, not available within project schedule
- Bluetooth data – data cost and schedule do not scale for project need
- Teralytics – resolution of data does not offer precision for road network

However, these datasets each provide useful data for broad application and may be useful for future studies. TripMatrix from Airsage addresses the minimum requirements of the regional OD study, but does not provide the same level of benefit as INRIX or Streetlight. Both INRIX and Streetlight meet the requirements of the regional OD study and provide additional application benefit and flexibility. Table 4 summarizes the key findings from the evaluations of the six data sources.

**TABLE 4. SUMMARY EVALUATION OF DATA SOURCE TECHNOLOGIES**

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>ALIGNMENT WITH KEY UFCO CONSIDERATIONS</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replica, Sidewalk Labs</td>
<td>• Existing conditions model  &lt;br&gt; • Schedule challenges  &lt;br&gt; • No historical data</td>
<td>Does not meet minimum technical criteria and is not recommended for UFCO</td>
</tr>
<tr>
<td>Bluetooth Data</td>
<td>• Long schedule  &lt;br&gt; • Limited collection dates  &lt;br&gt; • Higher cost</td>
<td>Meets minimum technical criteria, but schedule and cost make it infeasible for UFCO</td>
</tr>
<tr>
<td>Teralytics</td>
<td>• Cell tower data is less precise  &lt;br&gt; • Visualization platform  &lt;br&gt; • Cost-effective for regional studies</td>
<td>Well suited for regional studies with larger zones, but not recommended for UFCO due to data precision</td>
</tr>
</tbody>
</table>
**THE ROUTING DIFFERENCE**

While both INRIX and Streetlight meet the needs of the OD Study, a key difference between the two datasets and visualization platforms is how vehicle routing is displayed. The portion of trips passing through a given location can be identified in Streetlight by selecting the origin, destination, and a pass through (“middle filter”) location on the street network. As shown in Figure 1, this selection could be performed to determine how much traffic passes between two zones (Vancouver Mall and Downtown Portland) via one of two routes (I-5 bridge or I-205 bridge).

**FIGURE 1. STREETLIGHT ROUTING SELECTION EXAMPLE**

[Map of O-M-D Traffic]

Colors indicate the O-M-D Traffic to each destination Zone during the selected time period.
The results (Figure 2) report the amount of traffic that meets the filtered criteria – including that traffic has passed through a specific routing point (in this case one of the Columbia River bridges) between the origin and destination. This query can be repeated for several midpoints to determine the share of traffic that uses each route. However, the full set of possible routes and individual street segments contained within those routes are not directly identified. While this routing information is useful in comparing two distinct route points, it does not allow for the direct identification of diversion in a redundant transportation network.

**FIGURE 2. STREETLIGHT REPORT SHOWING PORTION OF TRAFFIC SAMPLE THAT MEET ROUTE CRITERIA**

INRIX waypoint data in Moonshadow’s DB4IoT visualization identifies the routes used by trips. While filterable criteria can be applied similar to Streetlight, the difference is that all portions of routes (via individual waypoint pings) can be identified. As shown in Figure 3, this allows a visual trace of routing to identify route choice used by travelers as well as potential diversion causes by congestion. This tool greatly enhances the ability to understand routing differences through the transportation system.

**FIGURE 3. DB4IOT VISUALIZES INRIX WAYPOINT DATA ALONG EACH ROUTE**
Based on the analysis of available data sources, several potential options for RTC’s regional OD data collection were developed. While both INRIX + DB4IoT and Streetlight would address the base requirements of the OD Study, INRIX + DB4IoT provides additional coverage and routing detail that will provide additional benefit. Therefore, Option 1 (INRIX + DB4IoT) is the preferred strategy for the UFCO study. Table 5 lists cost and other details of this option compared with the other options.

**OPTION 1 (RECOMMENDED) – INRIX + DB4IoT**

This package combines the strengths of the waypoint data provided by INRIX and the processing and visualizing platform of INRIX partner, DB4IoT. This option would allow for analyzing routing details on the freeway system (as well as waypoint data for any other segment or route in the County). This provides a powerful visualization tool and meets the critical technical criteria for UFCO. One disadvantage of this option is the higher cost to provide broader county-wide coverage. However, the cost could be accommodated within the project budget for the Regional OD Study. While this would provide the broadest dataset (including both Countywide coverage and detailed routing visualizations) the dataset would have the following limitations:

- Trip purpose and/or demographic data are not provided.
- Vehicle type data (including commercial vehicle classification) may be limited.
- Limited travel time metrics (average zone to zone directly provided).
- Data is raw and not pre-processed.

**OPTION 2 – STREETLIGHT DATA**

This option offers an all-in-one OD product, including the ability to run data queries on demand, determine routing information, and create visualizations. This option meets the critical technical criteria for UFCO and excels in several additional criteria. This product is only limited by the number of zones purchased, but can cover any location on or off the freeway. For the minimum number of zones needed for the UFCO study, cost is within the budget (see Table 5), though the cost required to cover all the zones for the full regional travel demand model would exceed the available data budget. Streetlight data would address trip purpose and vehicle type (noted limitations of DB4IoT +INRIX), however such data would be provided at a limited (freeway network) scale based on cost limitations. The travel time metric limitations are similar to INRIX’s. Relative to Option 1, the dataset would have the following limitations:

- Limited zone/area coverage (maximum number increases cost).
- Individual trip details and routing not available.
- Limited travel time metrics (average zone to zone directly provided).
- Limited ability to identify detour routes.

**OPTION 3 – OD DATA PRODUCT PLUS INRIX SPEED PROFILE**

This option is a combination of either Option 1 or Option 2 and a separate purchase of INRIX’s historical speed and travel time data. Since neither StreetLight data nor INRIX waypoints have automated and efficient methods to obtain statistical segment-level travel times in the UFCO study area, this additional, cost-efficient data-set could provide supplemental operational data to either option, as listed in Table 5.
### TABLE 5. RECOMMENDED OPTIONS

<table>
<thead>
<tr>
<th>OPTION</th>
<th>KEY FEATURES</th>
<th>COST</th>
</tr>
</thead>
</table>
| 1: INRIX with DB4IoT | • Detailed waypoint data  
• Powerful visualization platform  
• Clark County coverage | ~$53k (INRIX) + ~$27k (DB4IoT)  
Total: ~$80k  
Assumes: 12 months of platform access |
| 2: InSight, StreetLight Data | • Run data queries on demand  
• Freeway locational coverage  
• Limited zones | ~$25k for 100 zones  
~$55k for 250 zones  
Assumes: advanced analytics package, 12 months of access |
| 3a: INRIX with DB4IoT and INRIX Speed Profile | • Same as option 1  
• Historical speed and travel time for freeway segments | ~$80k (Option 1) + ~$3k (Speed)  
Total: ~$83k  
Assumes: 12 months of access |
| 3b: InSight, StreetLight Data and INRIX Speed Profile | • Same as option 2  
• Historical speed and travel time for freeway segments | ~$55k (Option 1) + ~$3k (Speed)  
Total: ~$58k  
Assumes: 12 months of access |

**Note:** During the February 6, 2019 Technical Advisory Committee (TAC) Meeting the recommended Option 1: INRIX with DB4IoT was selected by the TAC.
### Table 6. Regional OD Dataset Evaluation Details

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>DESCRIPTION</th>
<th>MANUAL DATA (BLUETOOTH)</th>
<th>TRIP MATRIX, AIRSAGE</th>
<th>INRIX WAYPOINT + MOONSHADOW</th>
<th>INSIGHT, STREETLIGHT</th>
<th>TERALYTICS</th>
<th>REPLICA, SIDEWALK LABS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CRITERION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GENERAL CRITERIA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OD Data Resolution</td>
<td>The smallest division of geographic area for determination of origins and destinations or the type of geographic area used (e.g., zip code, census tract, user-defined)</td>
<td>User defined gateways based on device locations</td>
<td>User defined zones, predefined zones including zip and census</td>
<td>User defined by shapefile</td>
<td>User defined zones, predefined zones including zip and census</td>
<td>User defined zones shapefile, predefined down to census block group (depending on cell tower coverage)</td>
<td>zone size dependent on model parameters</td>
</tr>
<tr>
<td>Time of Day</td>
<td>Minimum day part (time slice) available for origin-destination data (e.g. 15 minutes, hour, peak period)</td>
<td>1 hour or larger is standard (can go smaller)</td>
<td>1 hour and larger</td>
<td>1 hour and larger</td>
<td>1 hour and larger</td>
<td>1 hour and larger</td>
<td>1 hour and larger</td>
</tr>
<tr>
<td>Day Type</td>
<td>ability to specify day of week, weekday vs weekend, or specific dates</td>
<td>Depends on days data is collected; can specify DOW</td>
<td>Specify DOW, and dates</td>
<td>Specify DOW, and dates</td>
<td>Specify DOW, and dates</td>
<td>Specify DOW, and dates</td>
<td>Typical existing weekday and weekend, no dates</td>
</tr>
<tr>
<td><strong>ADDITIONAL FEATURES FOR UFCO</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OD Data Sample Size</td>
<td>sample size of data reported as a percentage of total population or total trips</td>
<td>~ 3-10% of trips</td>
<td>~ 15% of population (gps on mobile devices)</td>
<td>3-5% personal, 12% freight</td>
<td>Lbs = 25% us adults, gps = 1-3%, gps comm = 10-12%</td>
<td>10-20% of total trips</td>
<td>Depends on specific model</td>
</tr>
<tr>
<td>Travel Time</td>
<td>Duration of trips for a certain origin-destination pair (either at the link level or for the entire origin-destination trip)</td>
<td>Yes (zone to zone)</td>
<td>No</td>
<td>Yes, from waypoint data (requires processing) or additional product</td>
<td>Yes, (zone to zone, reported as average and histogram) for manually queried individual segments (count as extra zones)</td>
<td>Yes, but would have to request buckets smaller than 30 min</td>
<td>Yes, on all links in network</td>
</tr>
<tr>
<td>CRITERION</td>
<td>DESCRIPTION</td>
<td>MANUAL DATA (BLUETOOTH)</td>
<td>TRIP MATRIX, AIRSAGE</td>
<td>INRIX WAYPOINT + MOONSHADOW</td>
<td>INSIGHT, STREETLIGHT</td>
<td>TERA LYRICS</td>
<td>REPLICA, SIDEWALK LABS</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>----------------------</td>
<td>-----------------------------</td>
<td>----------------------</td>
<td>-------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Routing Details</td>
<td>specific information on which routes used for each origin-destination pair</td>
<td>No</td>
<td>No</td>
<td>Yes, route details from raw waypoint data (requires processing)</td>
<td>Yes, middle filter (manually identify individual routes based on one mid-point); does not auto-identify routes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Trip Distance</td>
<td>Trip distance for a certain origin-destination pair</td>
<td>No</td>
<td>No</td>
<td>Yes, in online portal (limited) and from raw waypoint data (requires processing)</td>
<td>Yes (zone to zone, reported as average and histogram)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Trip Purpose</td>
<td>A breakdown of trips by purpose for each origin-destination pair (e.g. home-based work, home-based other, non-home-based)</td>
<td>No</td>
<td>Yes (up to 6 categories)</td>
<td>Not provided in waypoint data (other product visits includes from lbs)</td>
<td>Yes (3 categories)</td>
<td>Yes (includes resident/visitor distinction)</td>
<td>Yes</td>
</tr>
<tr>
<td>Additional Trip Details</td>
<td>Other trip details such as vehicle classification, demographics of travelers, mode of travel, etc.</td>
<td>No</td>
<td>Yes, demographics, freight fleet (but not truck size)</td>
<td>Not provided in waypoint data (other product visits includes)</td>
<td>Yes, commercial vehicles (med/heavy) for gps (ped/bike included for higher fee), demographics from lbs</td>
<td>Yes (demographics, personal vs commercial vehicles)</td>
<td>Yes (demographics and mode (including transit))</td>
</tr>
<tr>
<td>Date Range (Availability)</td>
<td>availability of historical data from past years</td>
<td>Availability limited to data collection period (typically 2 weeks)</td>
<td>From Jan 2017 (gps), cell data previously</td>
<td>Best data is from 2017 onward, older data available</td>
<td>Gps since 2014, lbs since 2016; recent data available within 8 weeks (some low/unusable data in early 2014, summer 2015)</td>
<td>From early 2016</td>
<td>Average existing conditions only, updated quarterly</td>
</tr>
<tr>
<td>CRITERION</td>
<td>DESCRIPTION</td>
<td>MANUAL DATA (BLUETOOTH)</td>
<td>TRIP MATRIX, AIRSAGE</td>
<td>INRIX WAYPOINT + MOONSHADOW</td>
<td>INSIGHT, STREETLIGHT</td>
<td>TERALYTICS</td>
<td>REPLICA, SIDEWALK LABS</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------</td>
<td>----------------------</td>
<td>-----------------------------</td>
<td>----------------------</td>
<td>-------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>LOGISTICAL CRITERIA FOR UFCO STUDY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Format</td>
<td>Format of data when received from vendor (e.g. excel spreadsheet, graphic visualization, interactive platform, etc.)</td>
<td>Online platform and downloadable</td>
<td>Spreadsheet only</td>
<td>Online platform and downloadable (raw waypoints)</td>
<td>Online platform and downloadable</td>
<td>Online platform and downloadable</td>
<td>Online platform and downloadable</td>
</tr>
<tr>
<td>User Interface</td>
<td>Interactive web platform that can be used to either request data or explore and visualize the data after it is received</td>
<td>Limited platform to visualize data</td>
<td>None</td>
<td>Interactive platform to query and visualize data including dynamic animations</td>
<td>Interactive platform to query and visualize data,</td>
<td>Visualization platform (map with filters)</td>
<td>Platform to view model</td>
</tr>
<tr>
<td>Schedule</td>
<td>length of time and level of effort needed to make a data request and receive the data</td>
<td>requires third party fulfillment (1-2 months)</td>
<td>requires third party fulfillment (2 weeks-1 month)</td>
<td>Initial setup less than one week. Subsequent queries on-demand</td>
<td>on-demand (no third party)</td>
<td>requires third party fulfillment</td>
<td>requires third party, initial startup time to calibrate model</td>
</tr>
<tr>
<td>Cost</td>
<td>The least data cost between one-time purchase cost of data and a subscription (cost estimates to be based off data needs for UFCO study)</td>
<td>$60k for 80 devices ($750 per device)</td>
<td>$30-35k for 100 zones (10 time parts, one month average), $40-45k with additional long distance trips flag</td>
<td>waypoint data and Moonshadow platform (12 mo) for Clark County coverage ~ $80k</td>
<td>depends on number of zones and package; $25,800 for 100 zones, $55k for 250 zones, full TAZ system not cost feasible</td>
<td>$37k for 100 zones with all features; $68k for regional zones (census tract level)</td>
<td>depends on model location and coverage</td>
</tr>
<tr>
<td>Contracting</td>
<td>level of effort for the contracting process and details on potential contract limitations</td>
<td>standard agreement</td>
<td>standard agreement</td>
<td>contract with INRIX can include their partner, Moonshadow</td>
<td>all platform users must sign agreement, standard agreement</td>
<td>standard agreement</td>
<td>higher level of effort due to model specifications</td>
</tr>
<tr>
<td>CRITERION</td>
<td>DESCRIPTION</td>
<td>MANUAL DATA (BLUETOOTH)</td>
<td>TRIP MATRIX, AIRSAGE</td>
<td>INRIX WAYPOINT + MOONSHADOW</td>
<td>INSIGHT, STREETLIGHT</td>
<td>TERALYTICS</td>
<td>REPLICA, SIDEWALK LABS</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>----------------------</td>
<td>-----------------------------</td>
<td>----------------------</td>
<td>-------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>FUTURE USE CASE CRITERIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential Future Project</td>
<td>Applicable Data Needs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model Updates</td>
<td>origin-destination trip data (larger zones), trip purpose</td>
<td>no trip purpose, difficult to get enough devices to cover entire region</td>
<td>some demand data (OD and purpose), but no calibration skims or other data</td>
<td>provides broad (TAZ + more) zone coverage, limited demographics</td>
<td>Provides demographic data, but not at the County scale (based on zone cost)</td>
<td>easily handle large number of TAZs, has trip purpose</td>
<td>limited to using existing conditions model</td>
</tr>
<tr>
<td>Interchange Study</td>
<td>origin-destination trip data (smaller zones), vehicle classification</td>
<td>can do smaller zones, but no vehicle class</td>
<td>limited to OD data (no vehicle class or travel time)</td>
<td>provides routing details and flexible zone definitions</td>
<td>can do smaller zones, vehicle class, segment specific travel time</td>
<td>limited precision due to cell tower location</td>
<td>limited to using existing conditions model</td>
</tr>
<tr>
<td>Corridor Study (non-freeway)</td>
<td>travel times; origin-destination data for trips using the corridor</td>
<td>can do travel times, but no vehicle class</td>
<td>limited to OD data (no vehicle class or travel time)</td>
<td>Can define smaller zones and provide travel time</td>
<td>can do smaller zones, vehicle class, segment specific travel time</td>
<td>limited precision due to cell tower location</td>
<td>can provide travel times and basic OD data</td>
</tr>
<tr>
<td>Flexibility of Application</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Customization</td>
<td>various combinations of time customizations and origin-destination pairs can be formed from the OD data for the regional OD study which would be able to support various future undefined studies in the same area</td>
<td>can be reused as is</td>
<td>can be reused as is</td>
<td>Platform is available for 12 months for the single regional OD study. Reports from the study can provide static summaries for future applications</td>
<td>Platform is available for 12 months. Data can be reused and additional queries performed as long as max zones not exceeded</td>
<td>can be reused as is</td>
<td>limited to using existing conditions model</td>
</tr>
<tr>
<td>User Accessibility</td>
<td>Data is easily accessible for the user after the Regional OD study is completed for aggregation, download, or visualization purposes</td>
<td>data is limited to initial locations and time periods</td>
<td>limited to initial data query and spreadsheet</td>
<td>limited to initial request/product</td>
<td>platform and support is accessible for one year, can be renewed</td>
<td>platform and support is accessible for one year, can be renewed</td>
<td>only most current model available, may require third party</td>
</tr>
</tbody>
</table>