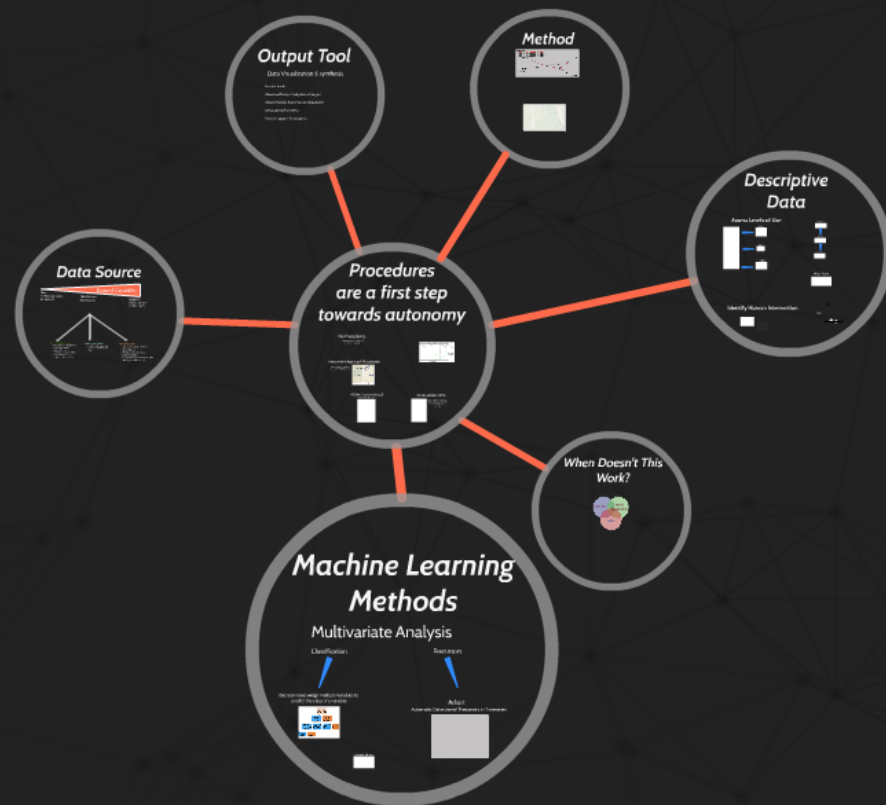
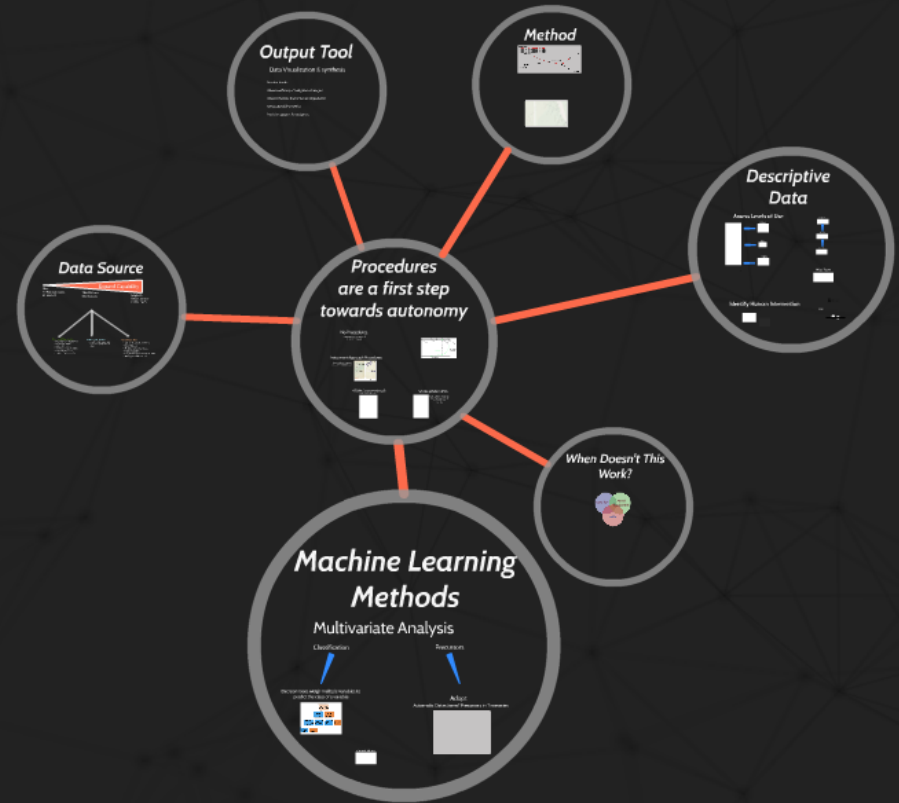


RNAV STAR Procedural Adherence



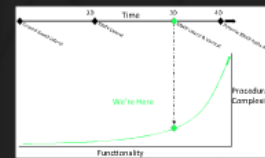
RNAV STAR Procedural Adherence



Procedures are a first step towards autonomy

No Procedures

Flying was dangerous and not standardized



Instrument Approach Procedures

A method to consistently guarantee terrain clearance



STARs (conventional)



STARs (RNAV OPD)



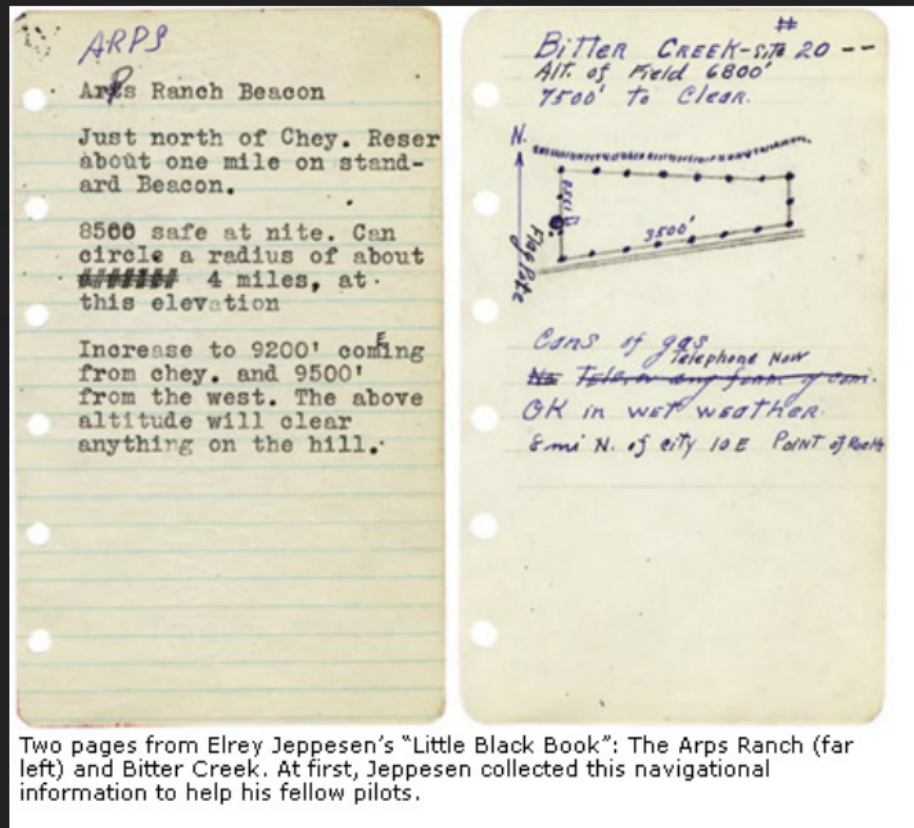
Noise reduction, fuel savings, route standardization, and flow management. (FAA, 2014)

No Procedures

Flying was dangerous and
not standardized

Instrument Approach Procedures

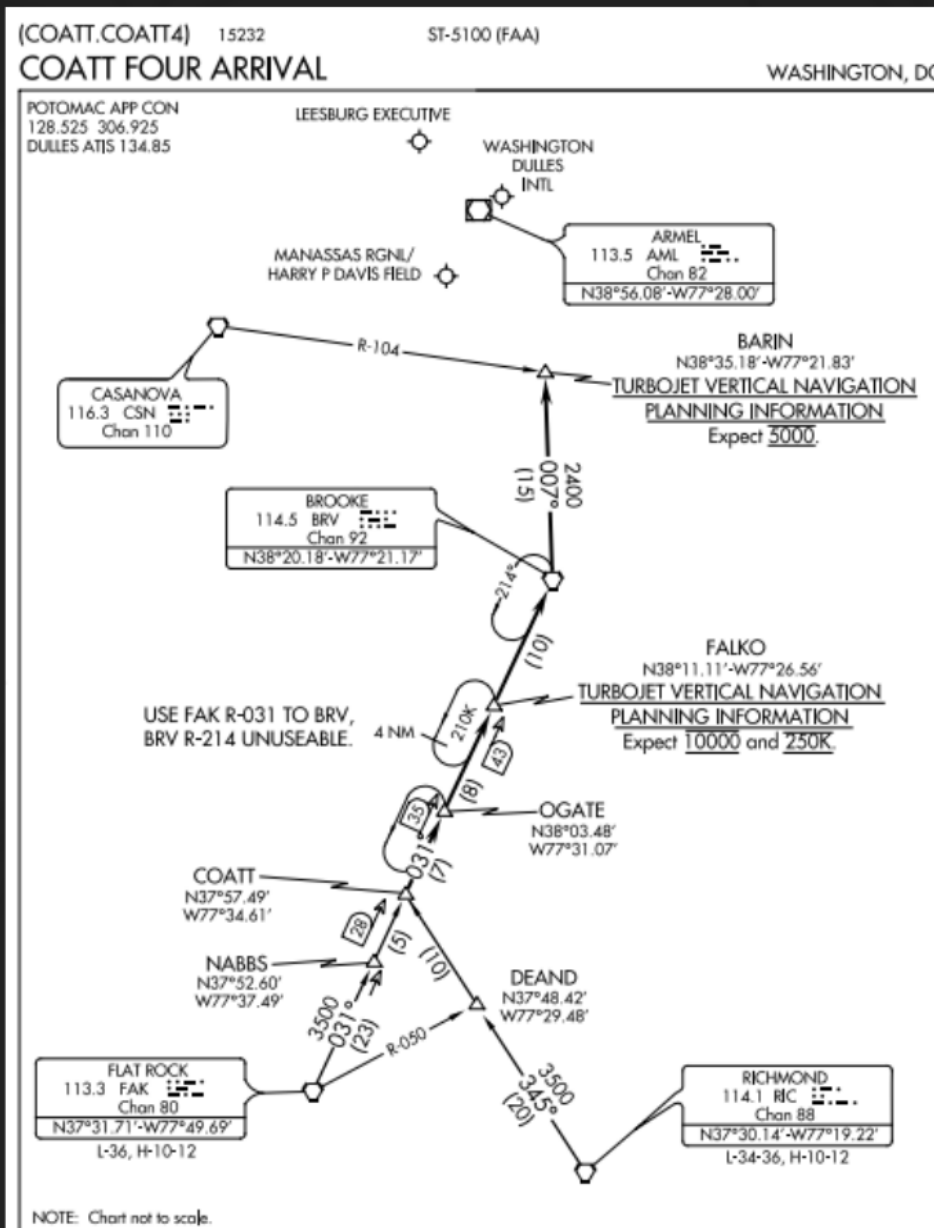
A method to consistently guarantee terrain clearance



Two pages from Elrey Jeppesen's "Little Black Book": The Arps Ranch (far left) and Bitter Creek. At first, Jeppesen collected this navigational information to help his fellow pilots.

STARs (conventional)

Standardized Routing & Terrain Clearance

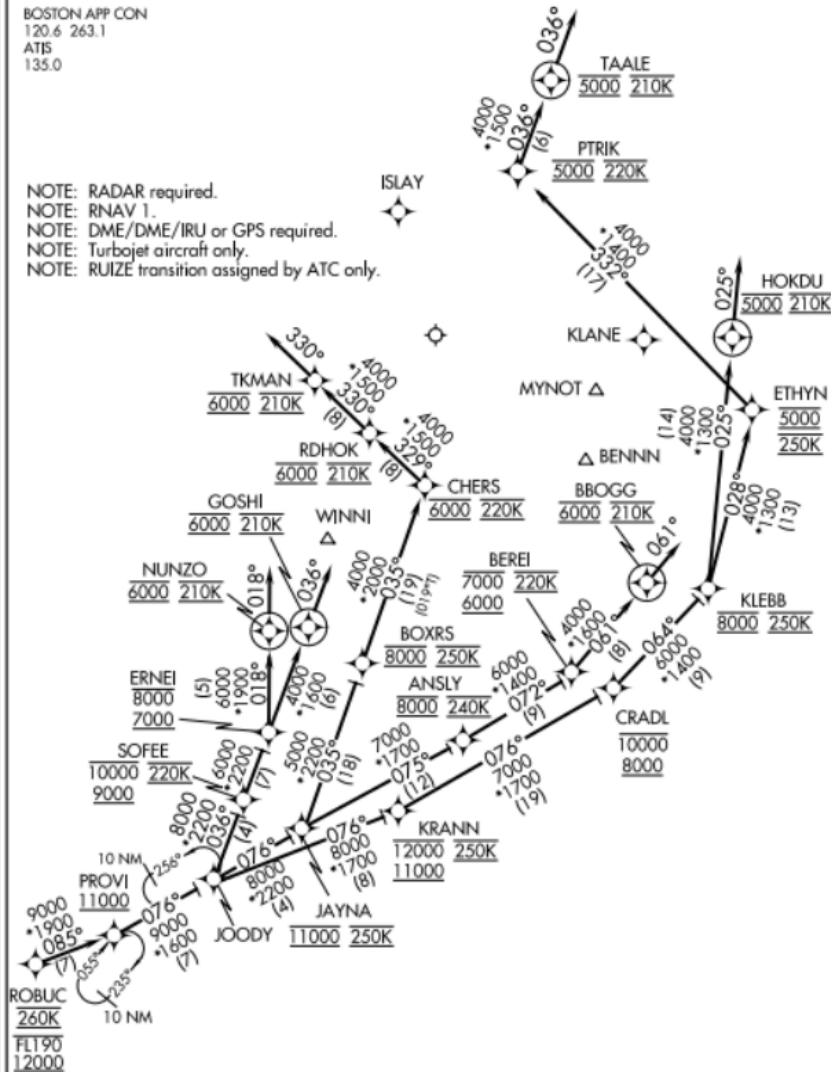


STARs (RNAV OPD)

(ROBUC.ROBUC2) 16147 ST-58 (FAA)
GENERAL EDWARD LAWRENCE LOGAN INTL (BOS)
ROBUC TWO ARRIVAL (RNAV) Arrival Routes BOSTON, MASSACHUSETTS

BOSTON APP CON
120.6 263.1
ATIS
135.0

NOTE: RADAR required.
NOTE: RNAV 1.
NOTE: DME/DME/IRU or GPS required.
NOTE: Turbojet aircraft only.
NOTE: RUIZE transition assigned by ATC only.

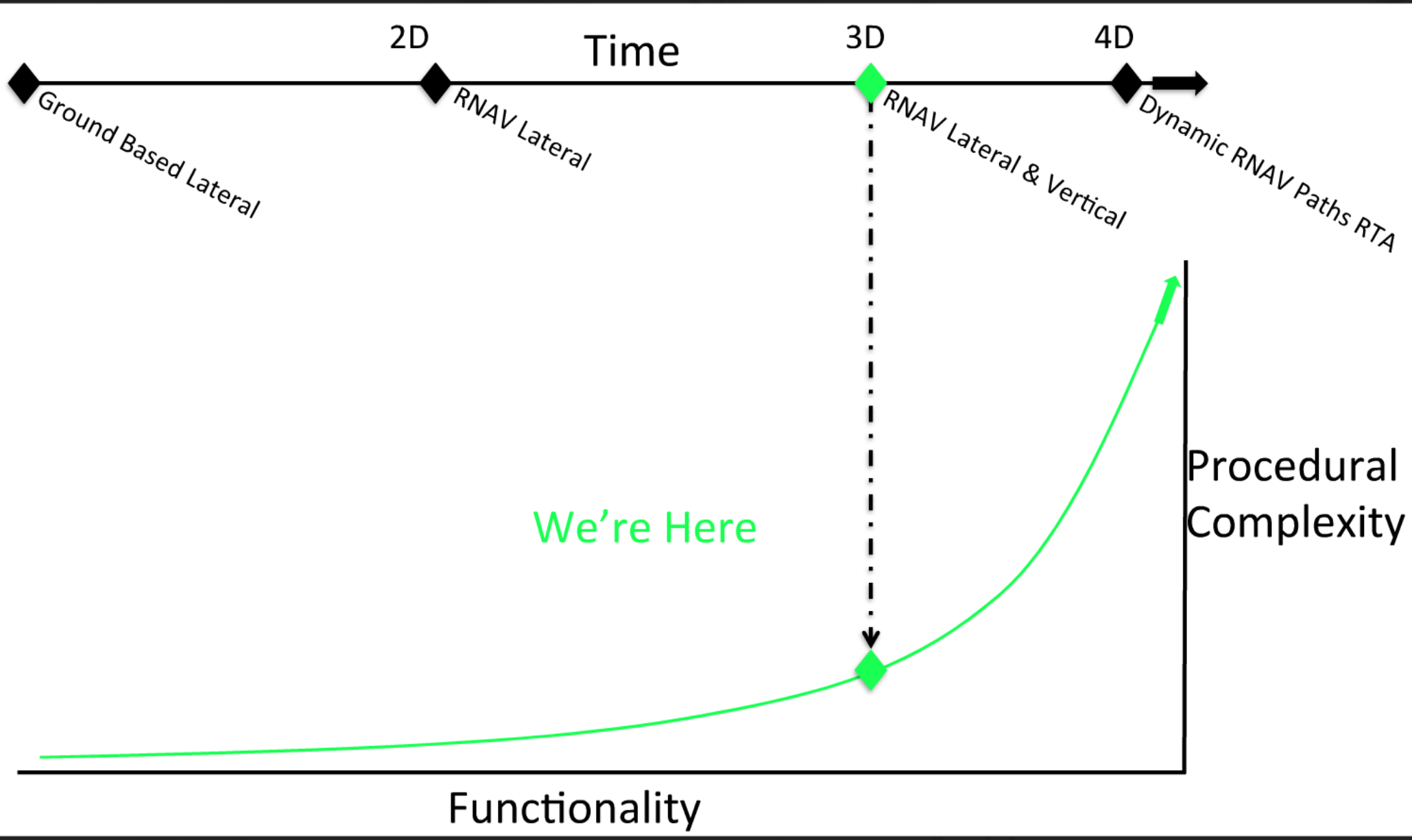


NOTE: Chart not to scale.

(NARRATIVE ON FOLLOWING PAGE)

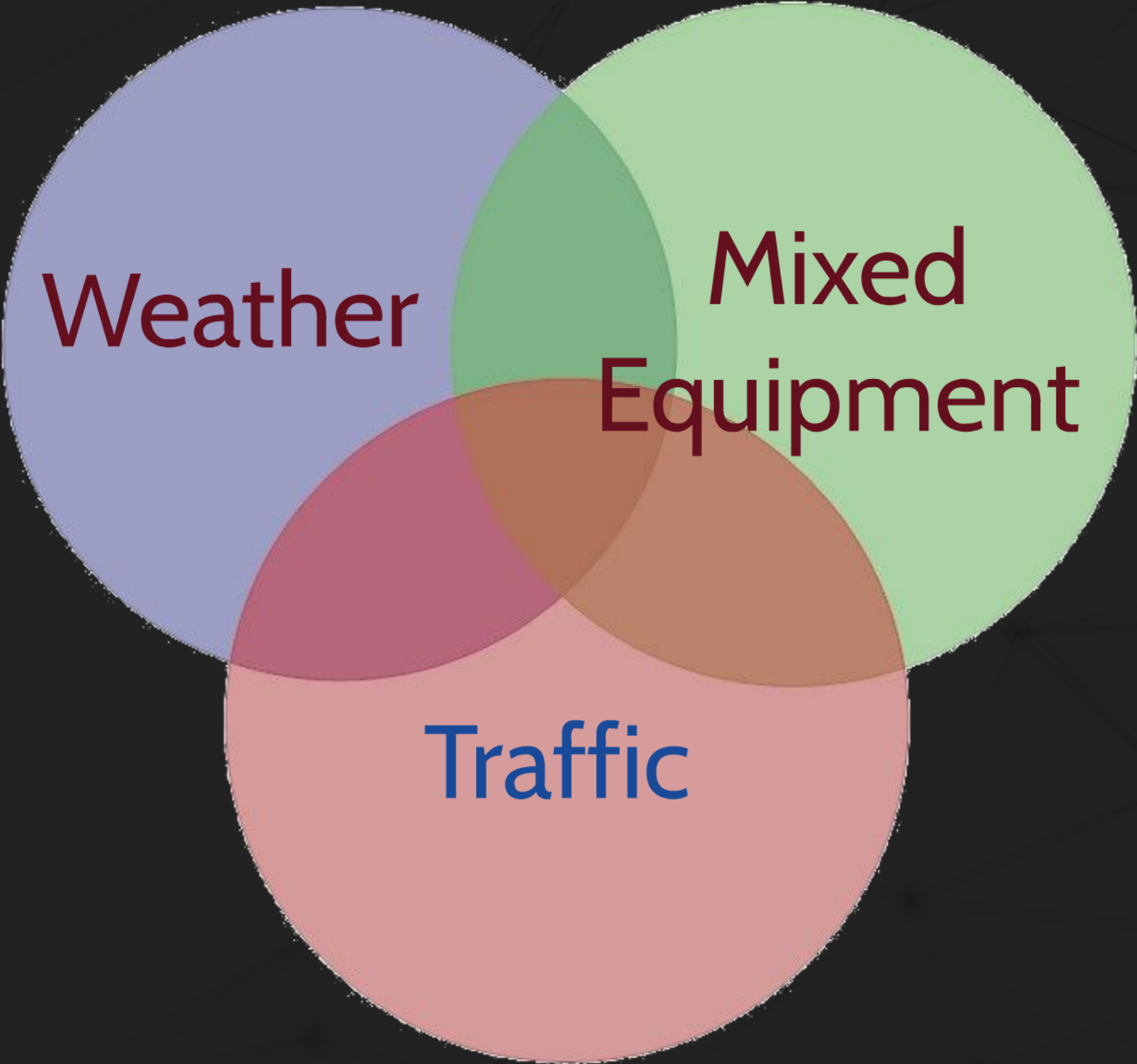
Noise reduction, fuel savings,
route standardization, and
flow management.

(FAA, 2014)



When Doesn't This Work?





Weather

**Mixed
Equipment**

Traffic

Data Source

Expand Capability

Now

ARTCC radar tracks
(CTAS data)

TRACON data
(Sherlock2.0)

Longterm

Aircraft sensors
(FOQA-type)

Procedural Characteristics

- Waypoint type, window size
- Speed Restrictions
- Altitude Restrictions
- Route name (e.g., transition)
- Slope-degree angles
- Leg type (e.g., track to fix)

Environmental Variables

- Wind (tailwind component)
- Temperature (Rapid Refresh NOAA)

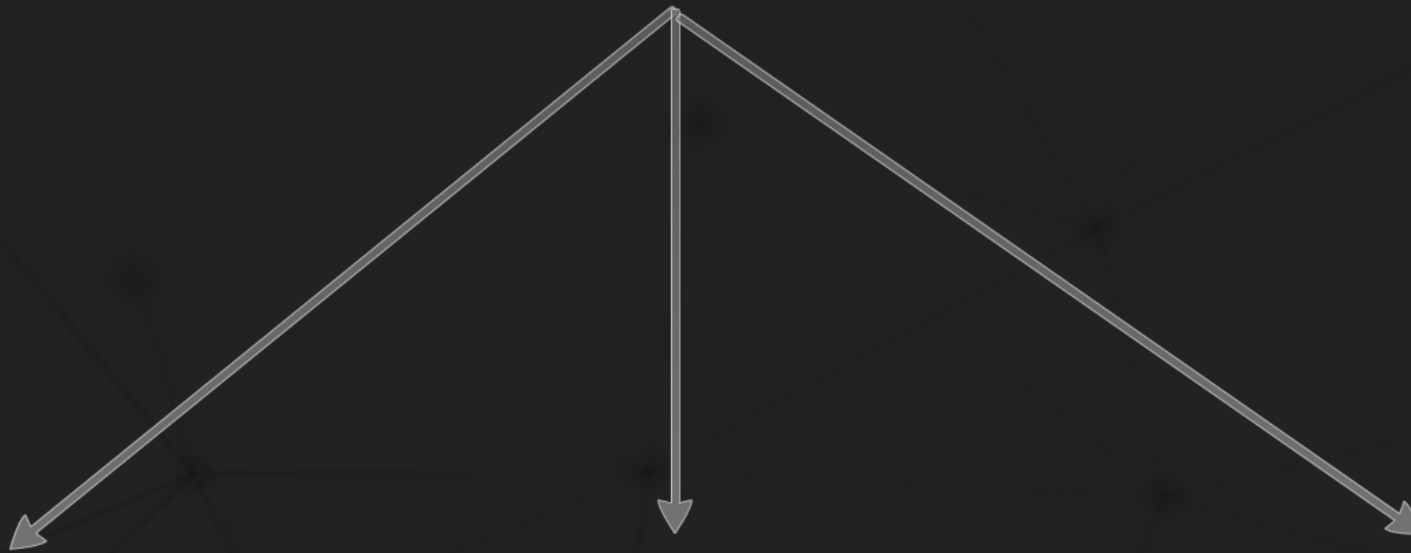
Aircraft Variables

- Type and equipment suffix
- Groundspeed
- Altitude (several samples)
- Rate of descent
- Required slope to next restriction
- #of flights on the arrival

ata)

(Sherlock2.0)

Longterm
Aircraft sensors
(FOQA-type)



Procedural Characteristics

- Waypoint type, window size
- Speed Restrictions
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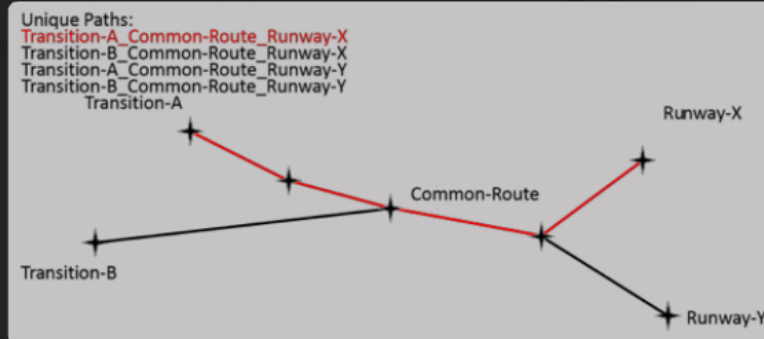
Environmental Variables

- Wind (tailwind component)
- Temperature (Rapid Refresh NOAA)

Aircraft Variables

- Type and equipment suffix
- Groundspeed
- Altitude (several samples)
- Rate of descent
- Required slope to next restriction
- #of flights on the arrival

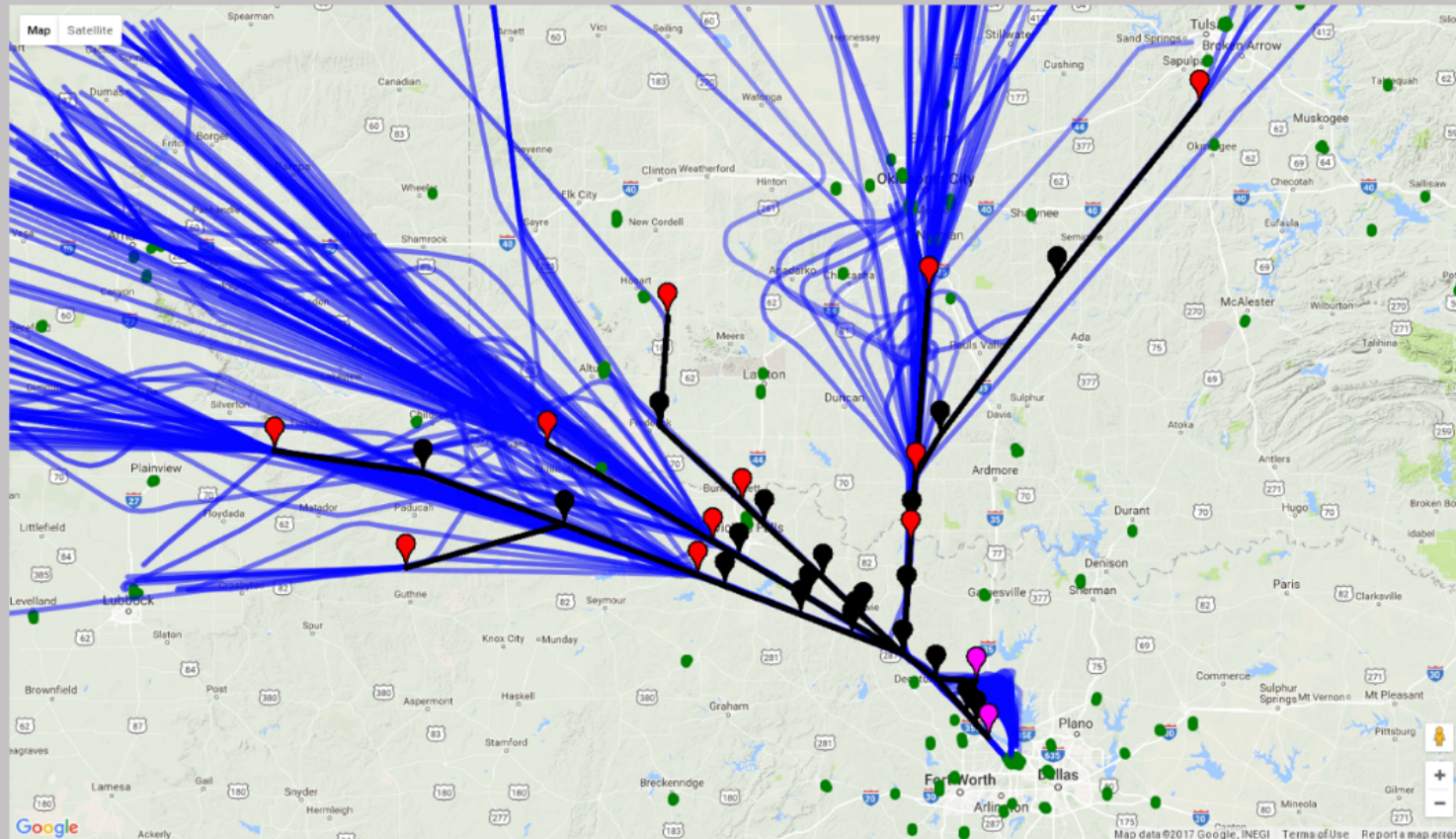
Method



Overlay Flights on Routes

- 📍 Entry Waypoint
- 📍 Waypoint in route
- 📍 Exit Waypoint

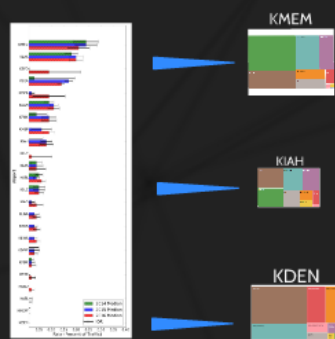
- Identify route flow
- Determine adherence of lateral flight trajectory with waypoint restrictions
- Characterize lateral adherence (join late/skip/ early exit)



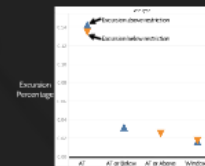
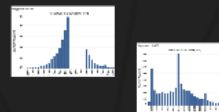
Full Lateral Adherence of VKTRY2 into KDFW

Descriptive Data

Assess Levels of Use

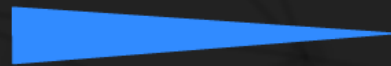
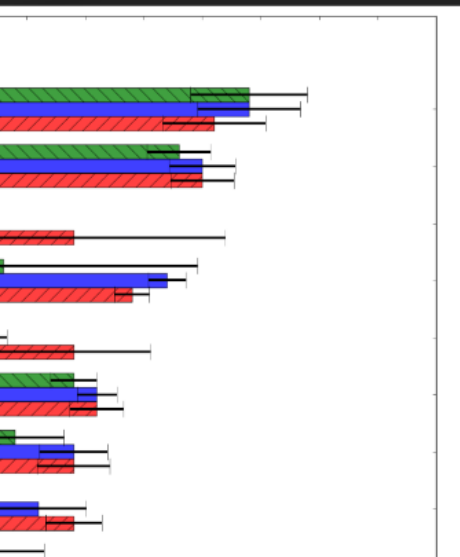


Identify Human Intervention

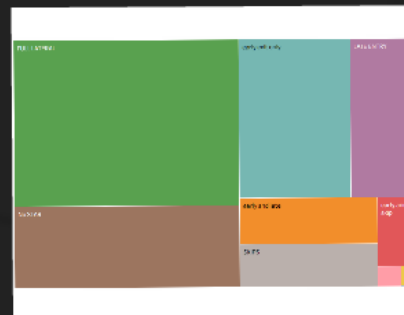


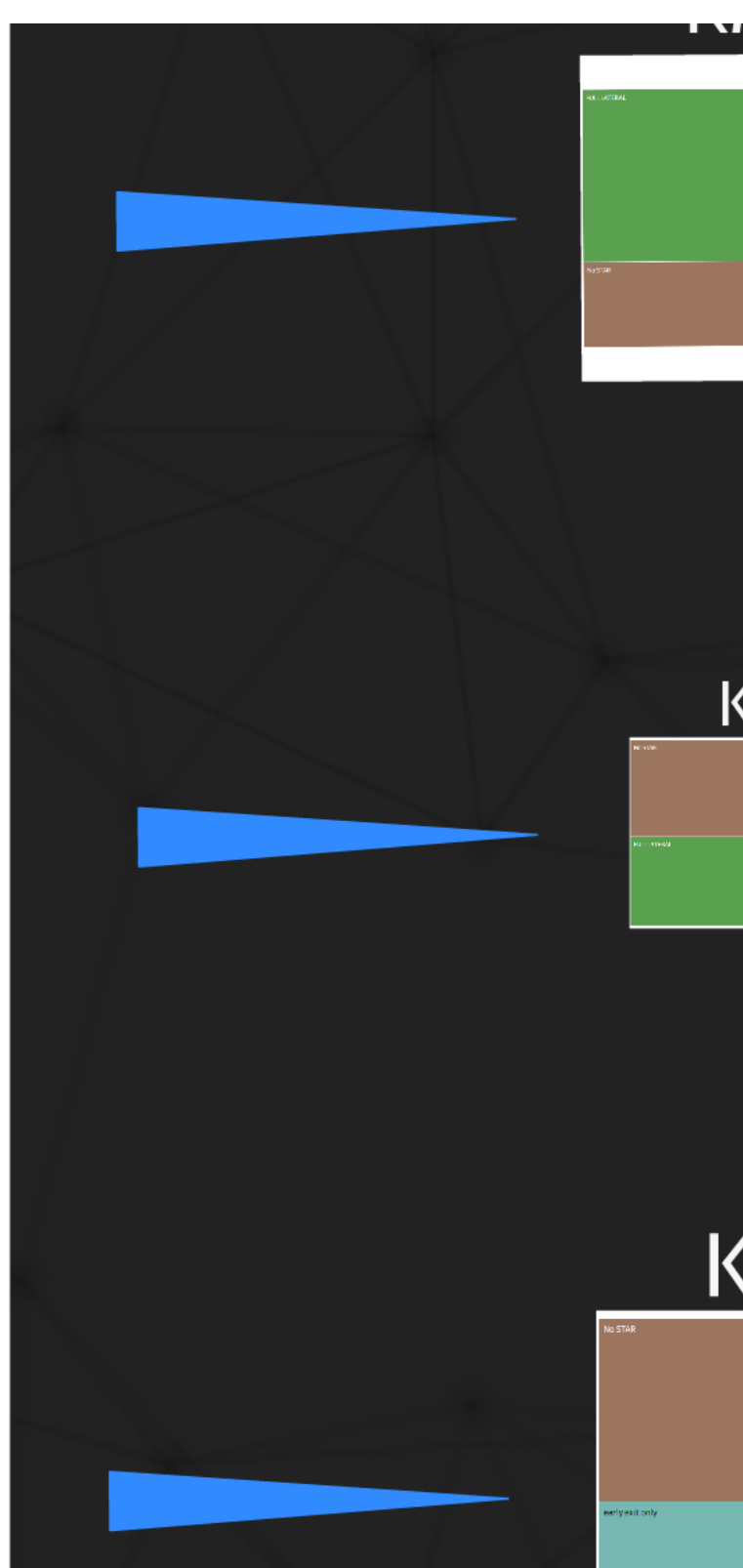
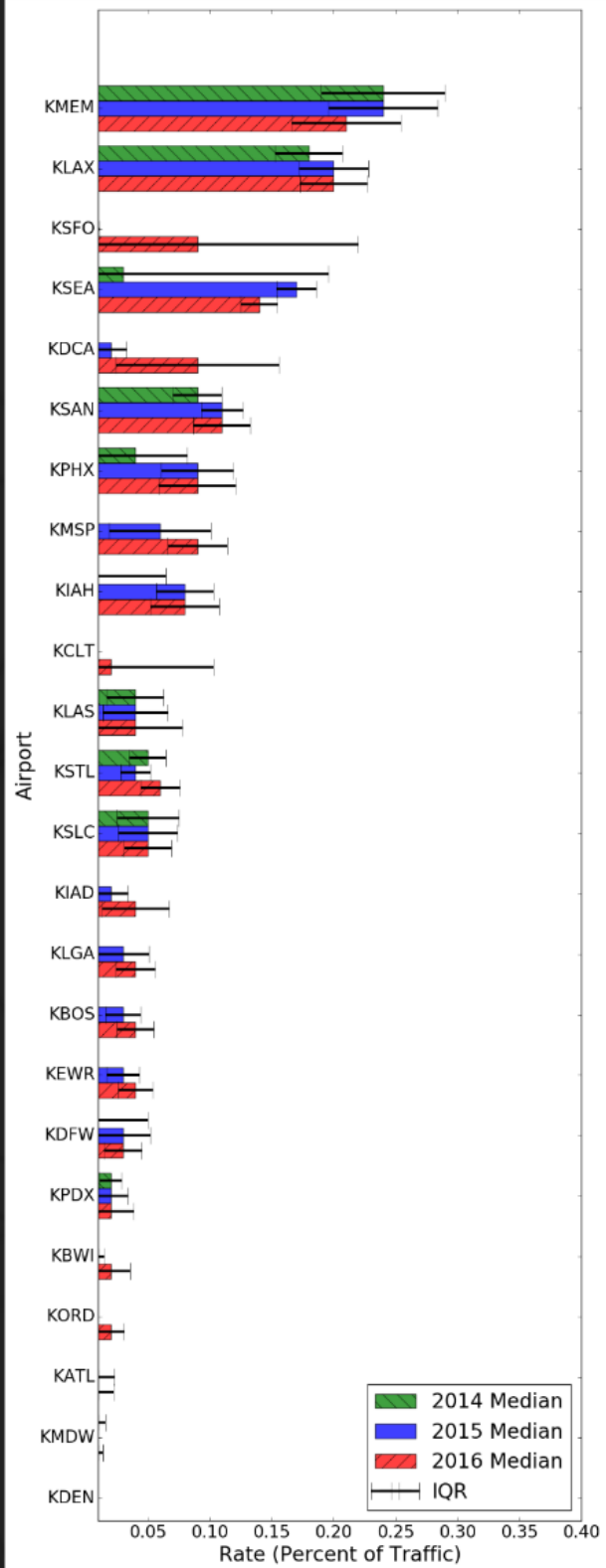
Da

Assess Levels of Use

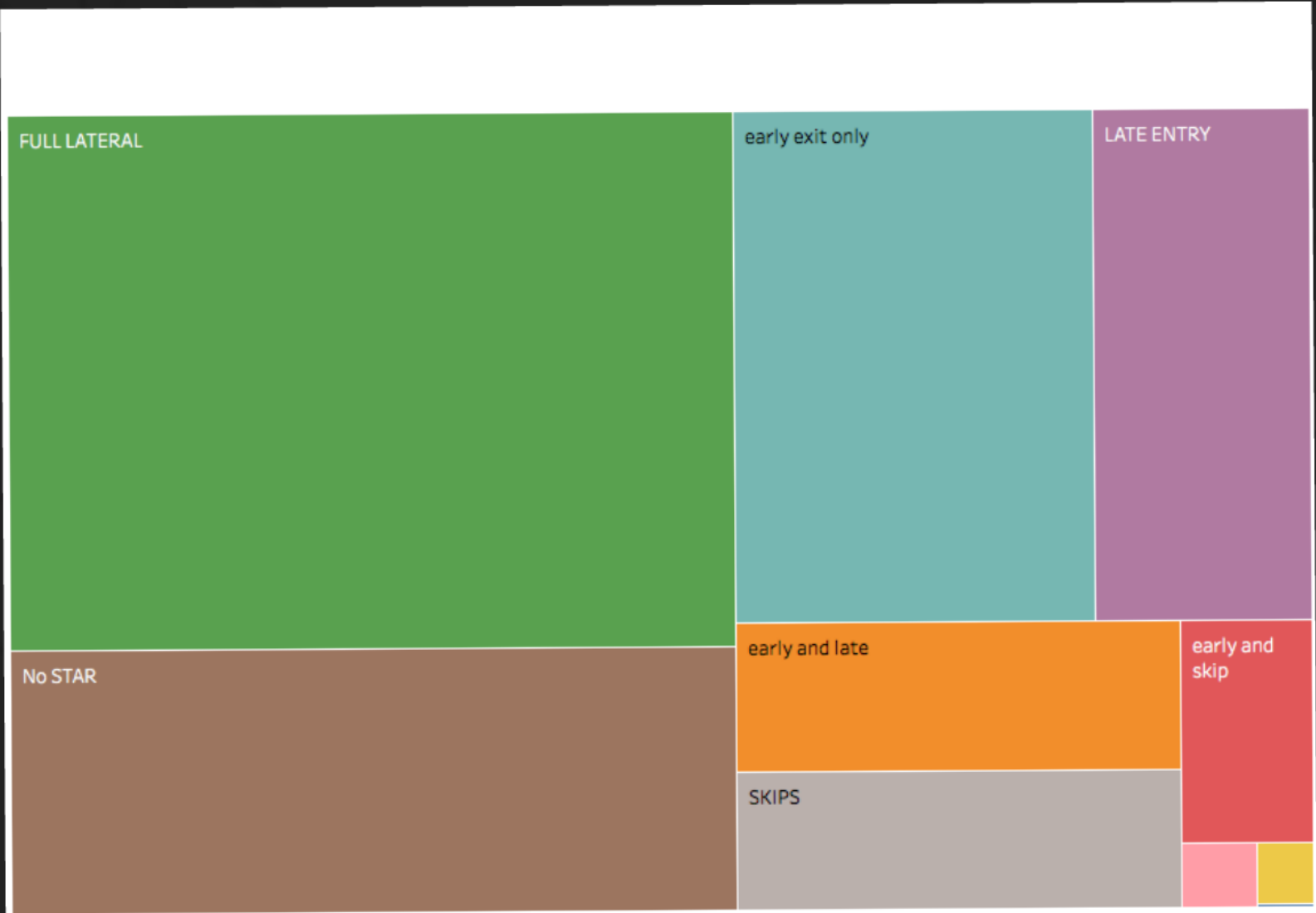


KMEM

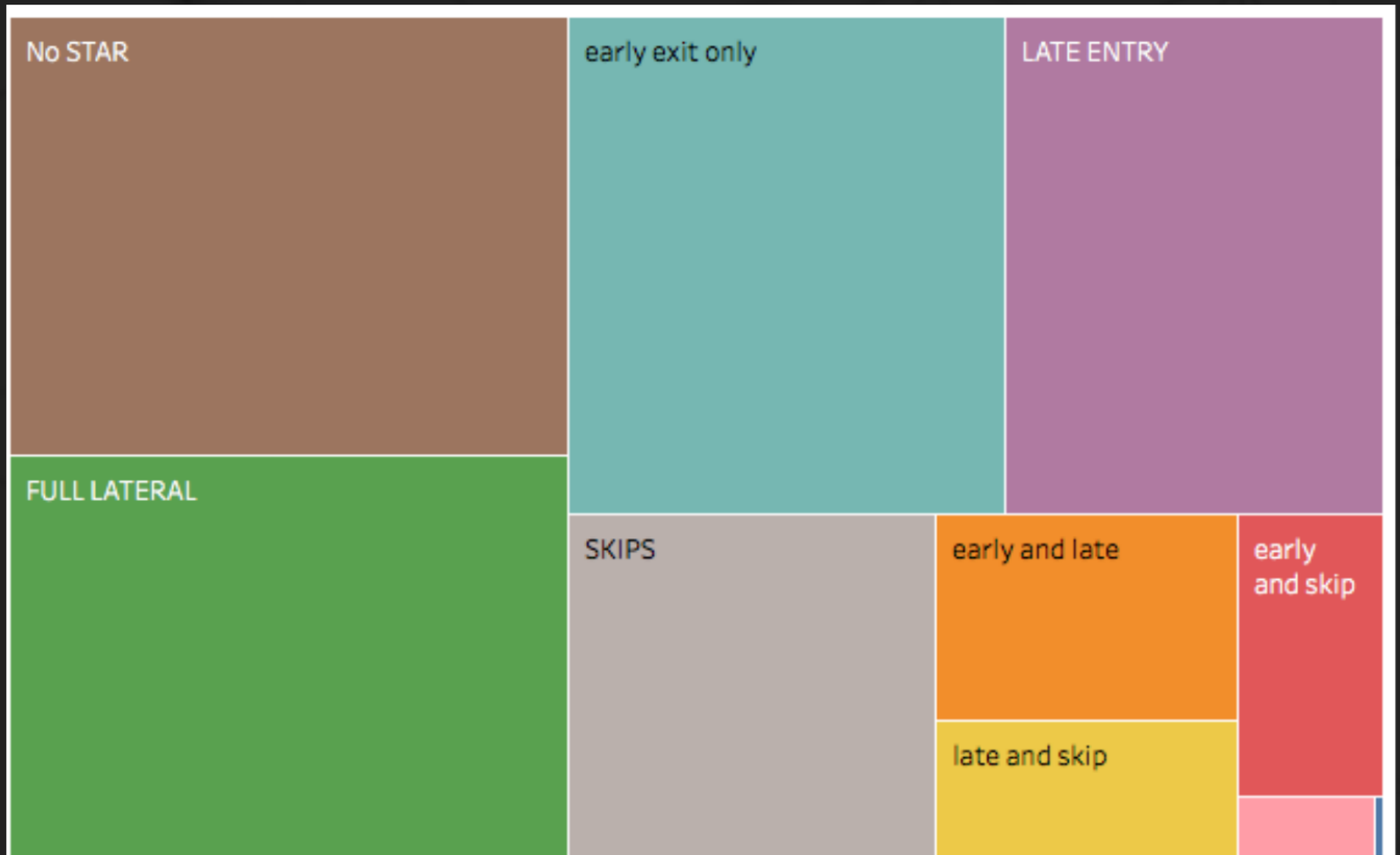




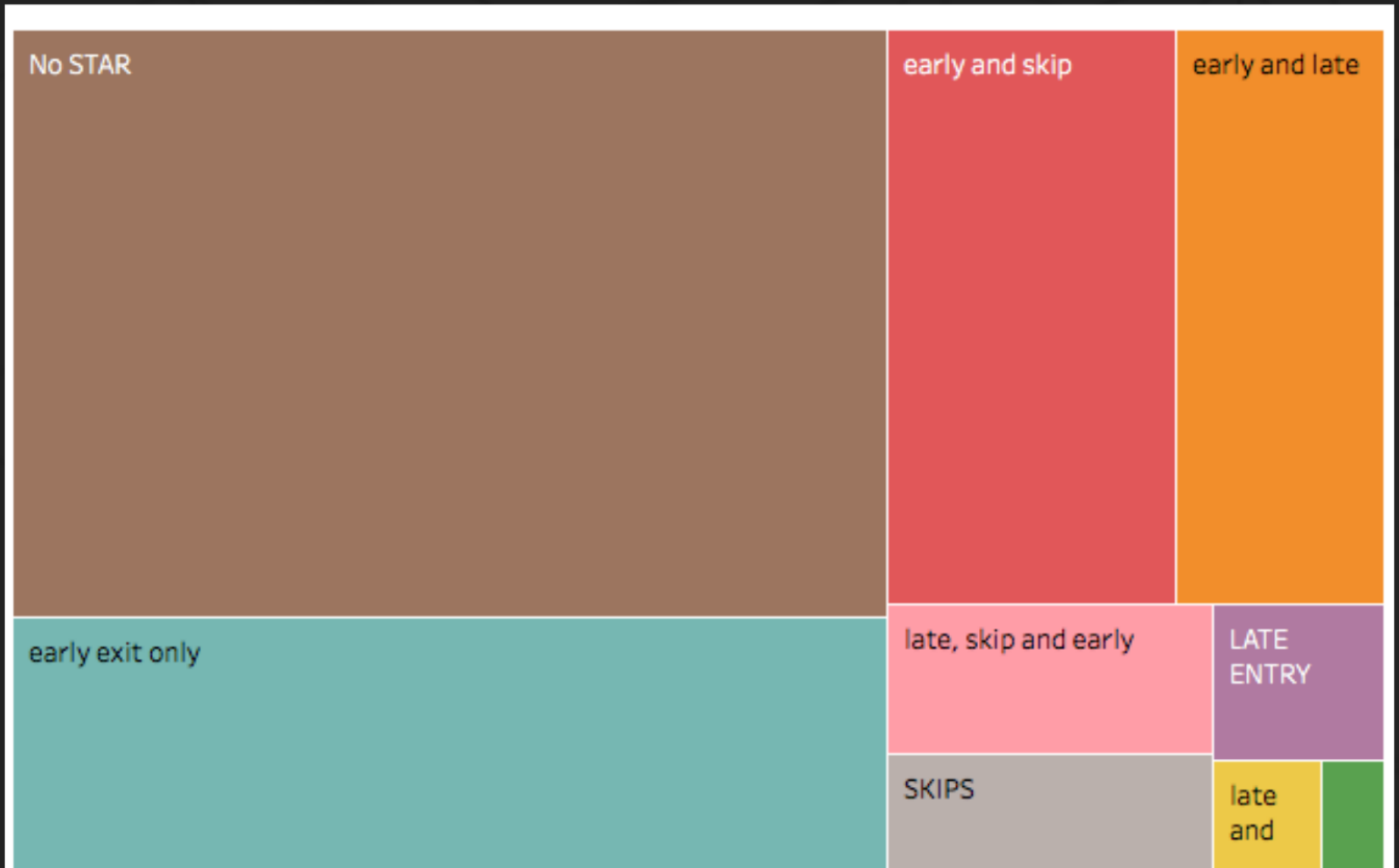
KMEM



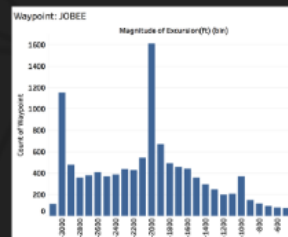
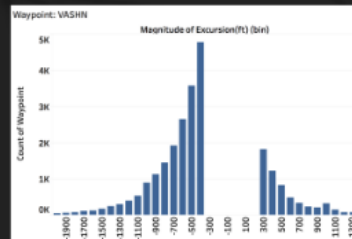
KIAAH



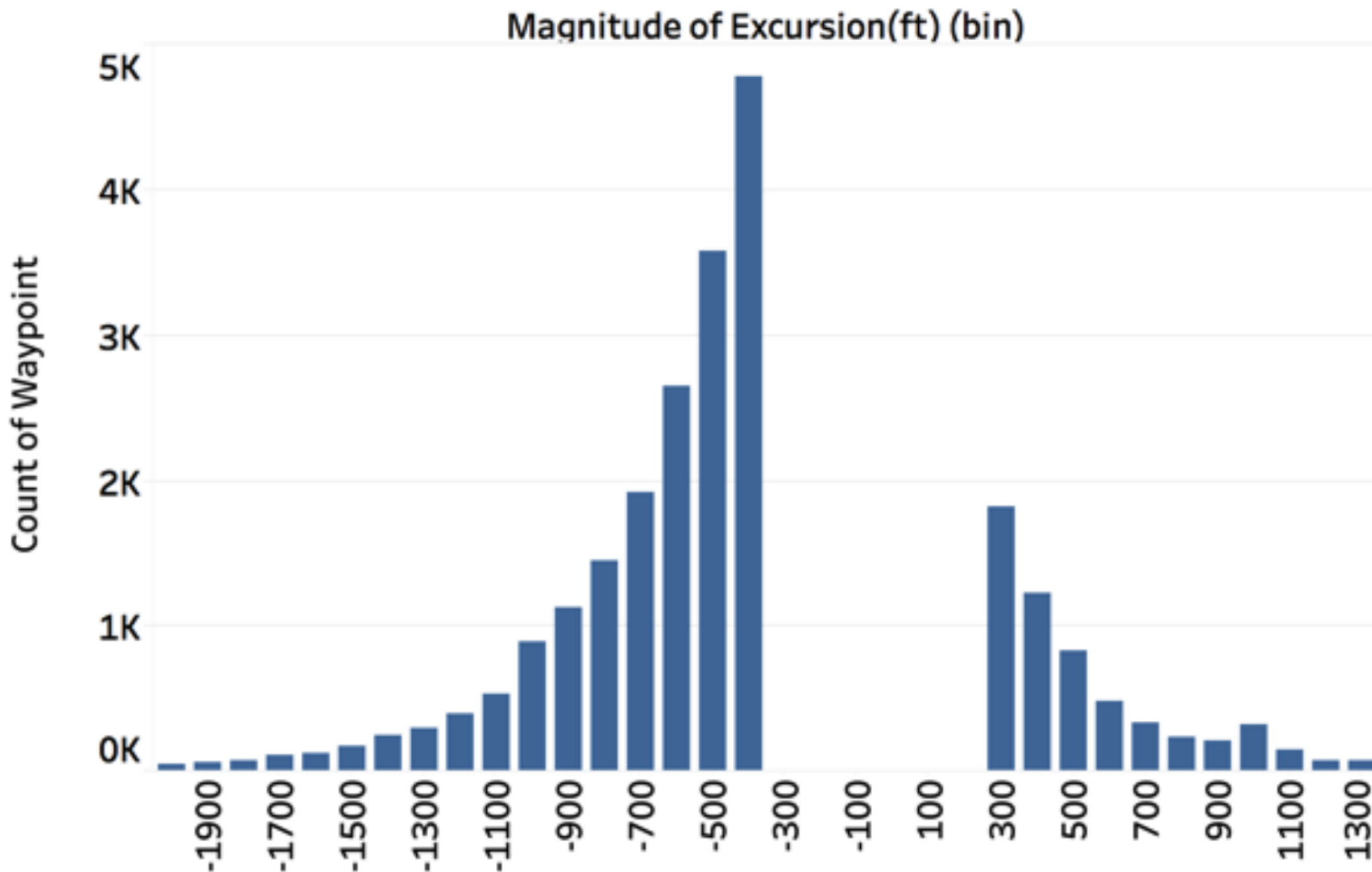
KDEN



Identify Human Intervention

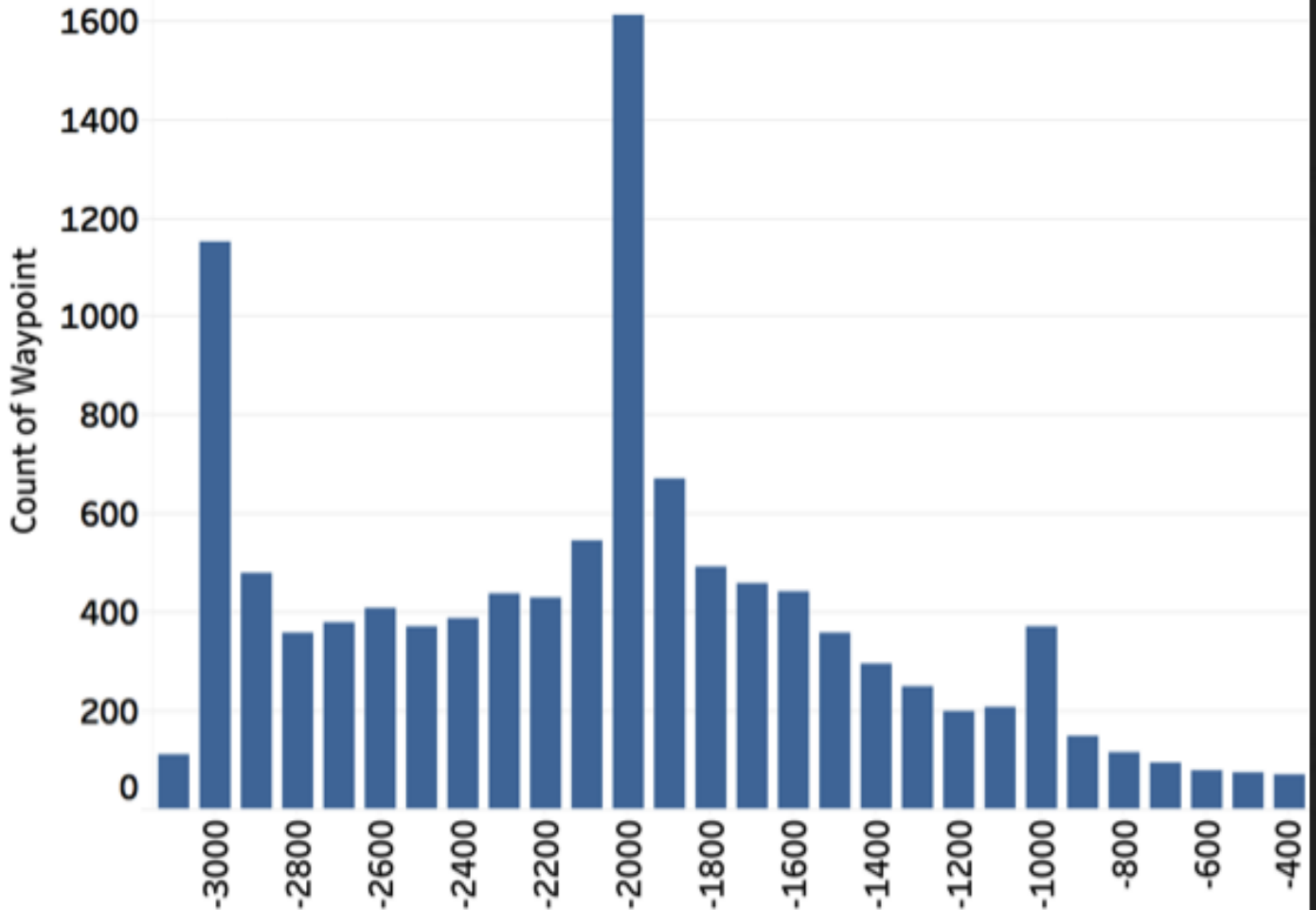


Waypoint: VASHN



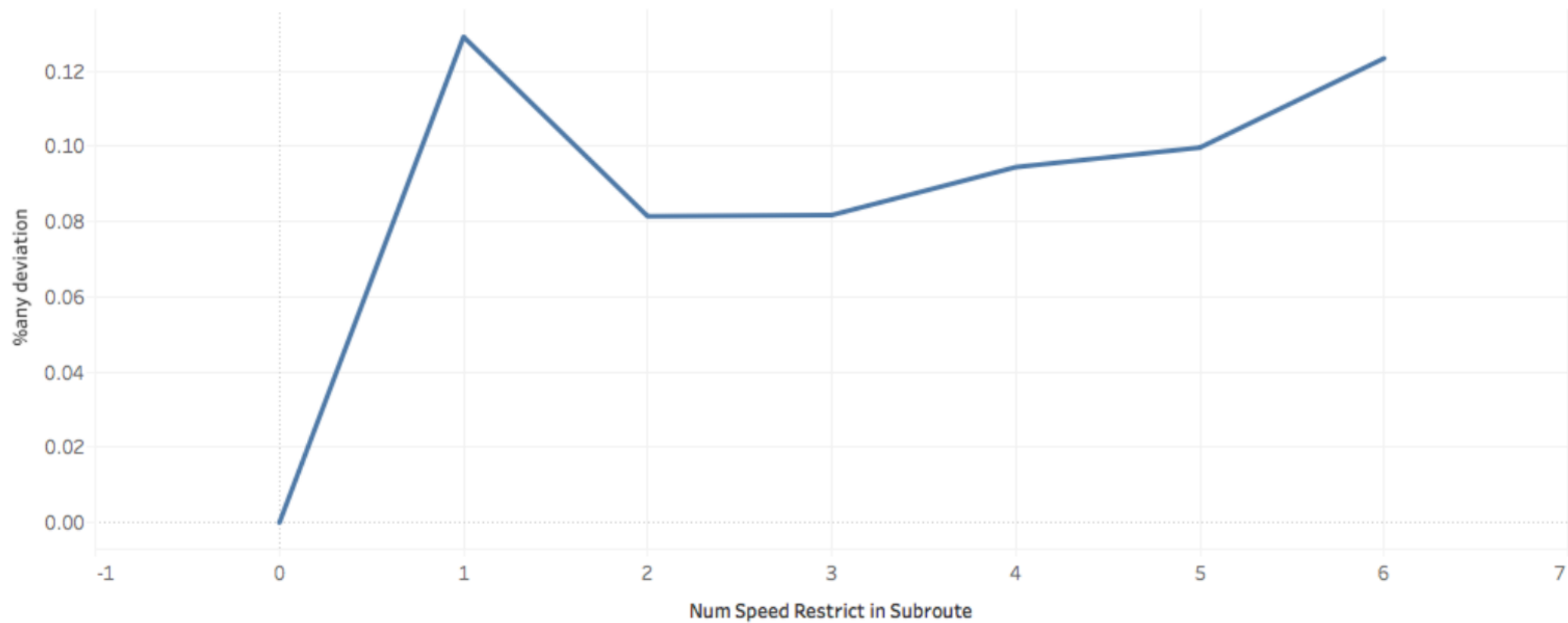
Waypoint: JOBEE

Magnitude of Excursion(ft) (bin)



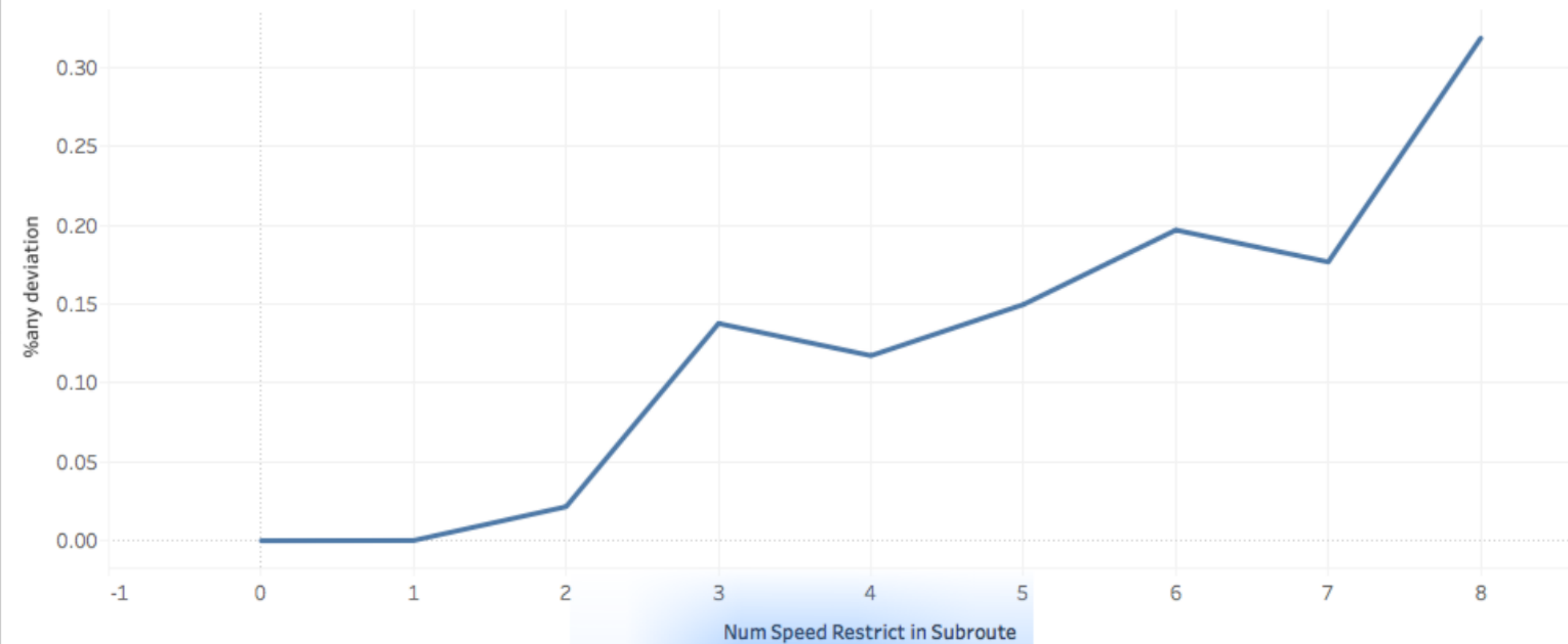
KMEM

Sheet 9



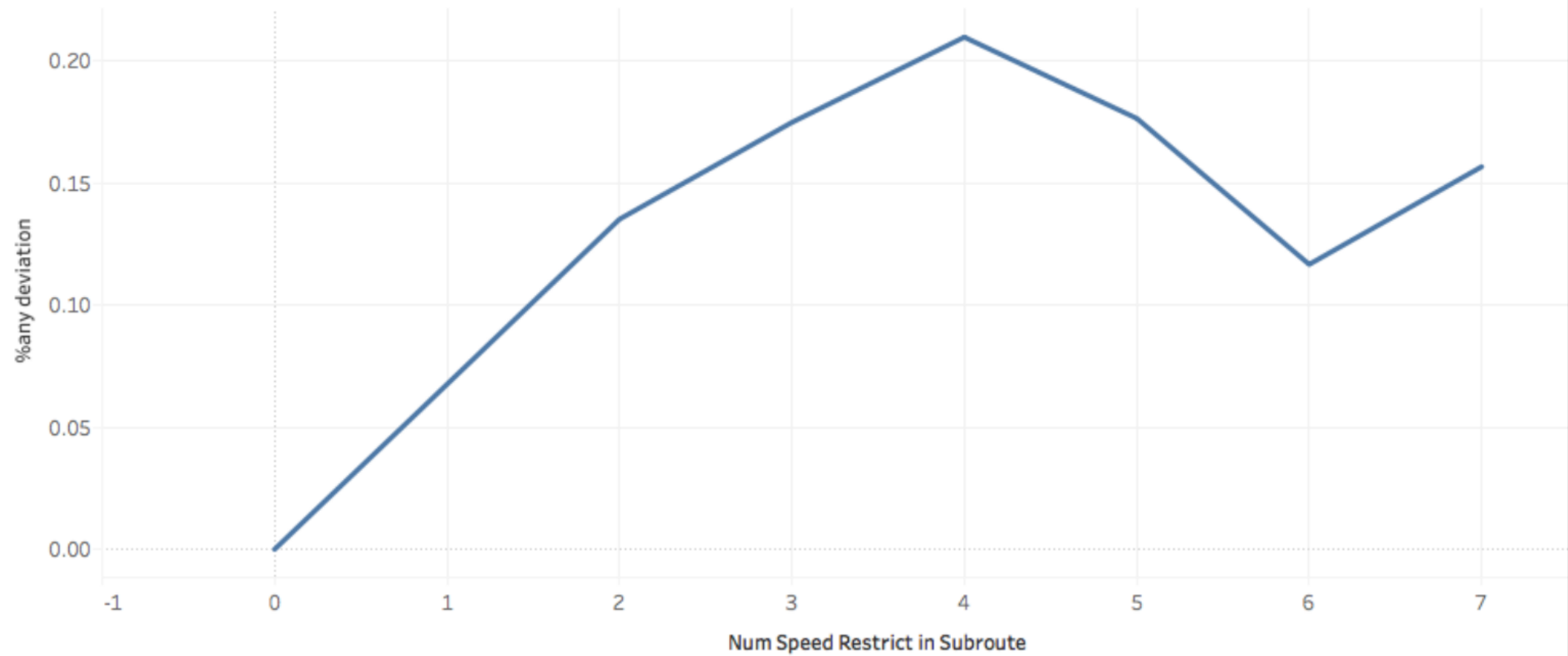
KIAAH

Sheet 9



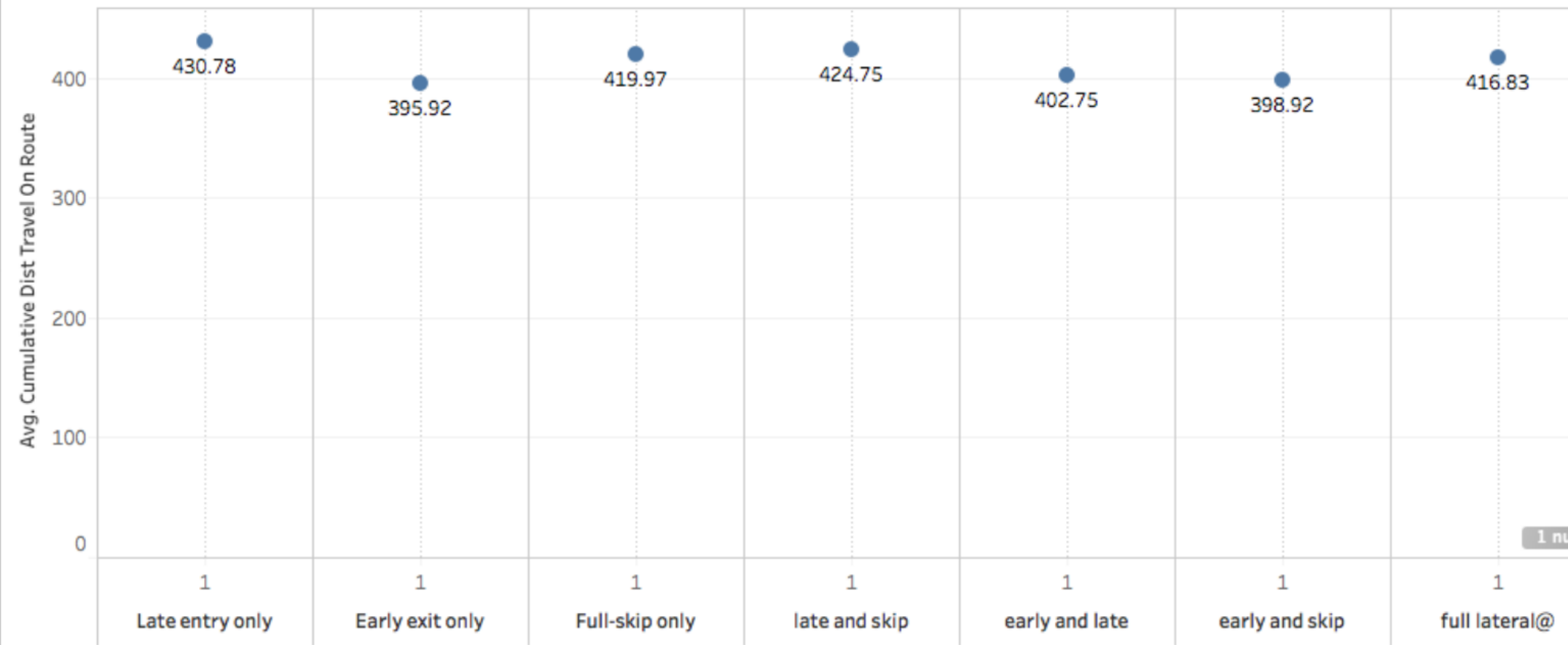
KDEN

Sheet 9

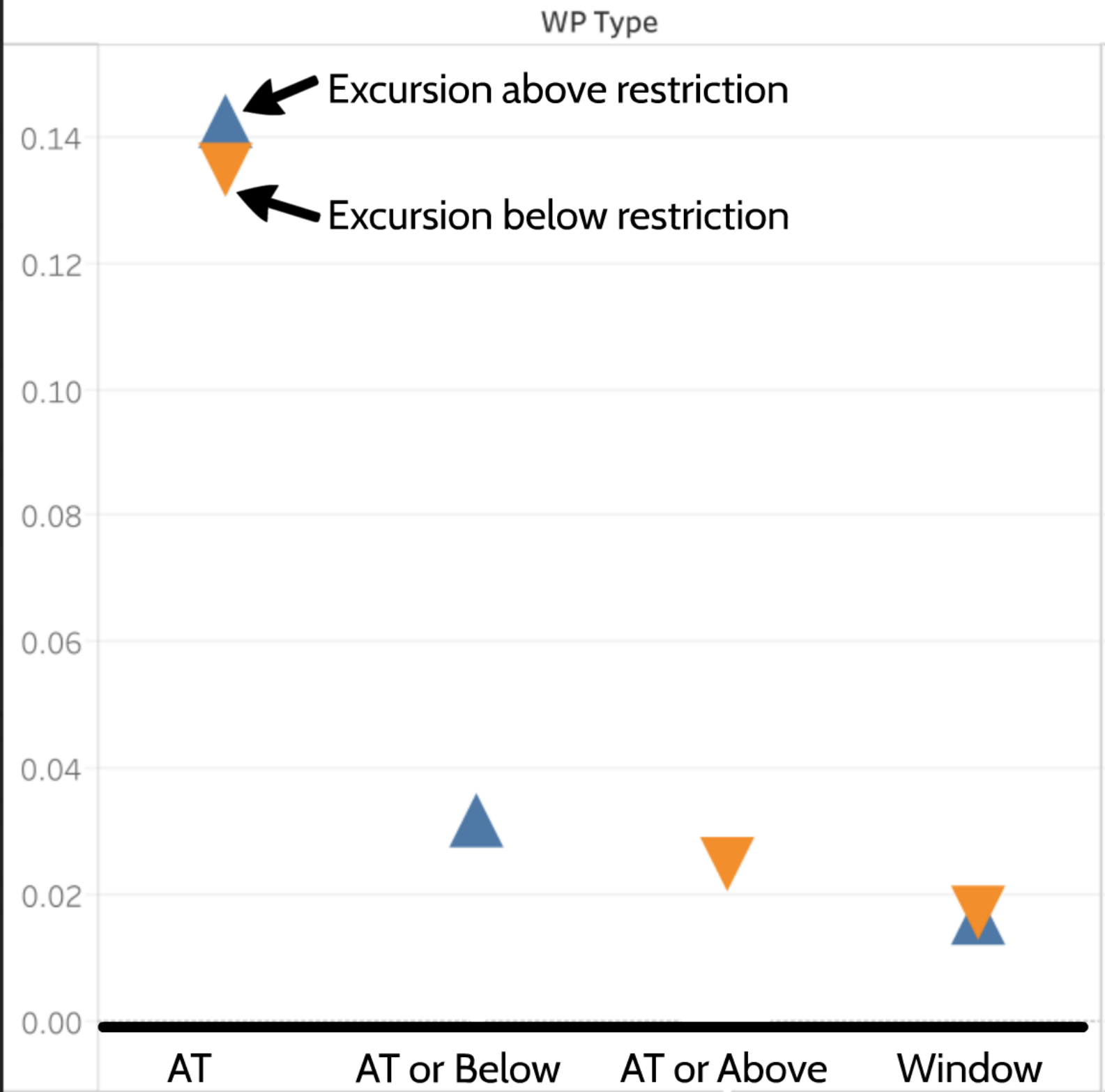


Miles Flown

Sheet 1



Excursion
Percentage

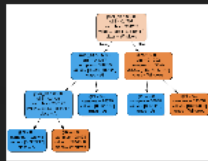


Machine Learning Methods

Multivariate Analysis

Classification

Decision trees weigh multiple variables to predict the class of a variable



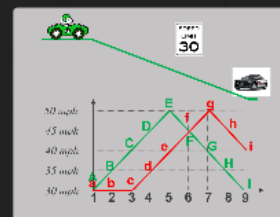
Change in Behavior



Precursors

Adopt

Automatic Detection of Precursors in Timeseries



Methods

Multivariate Analysis

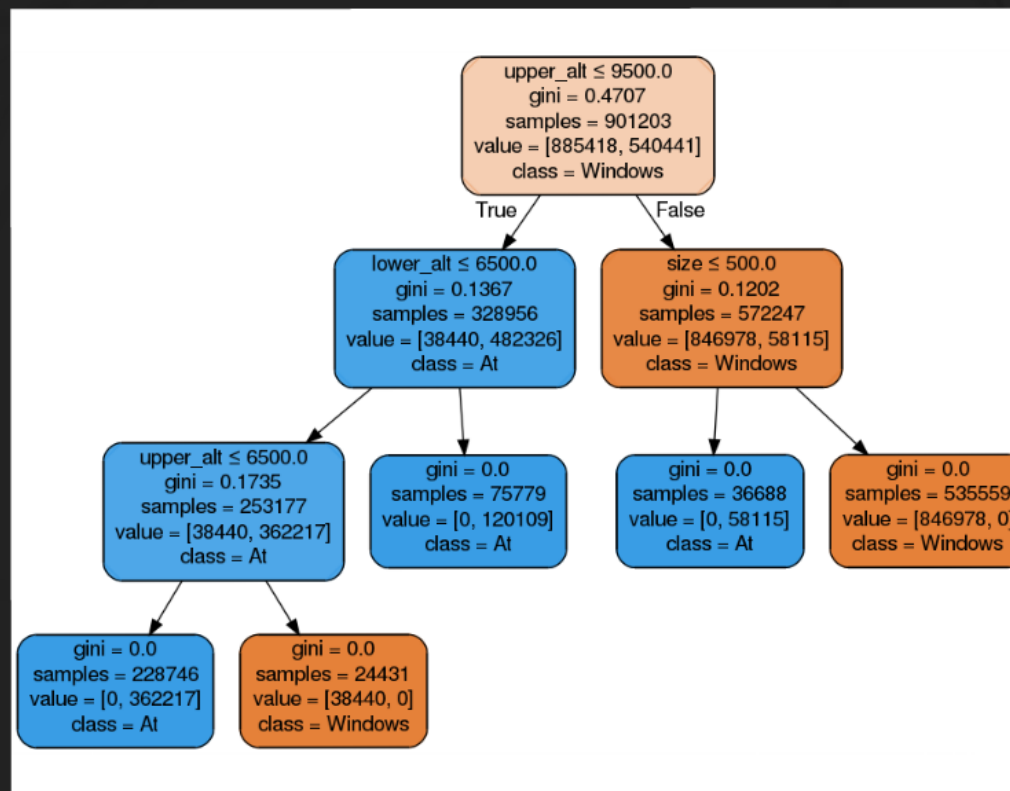
Classification



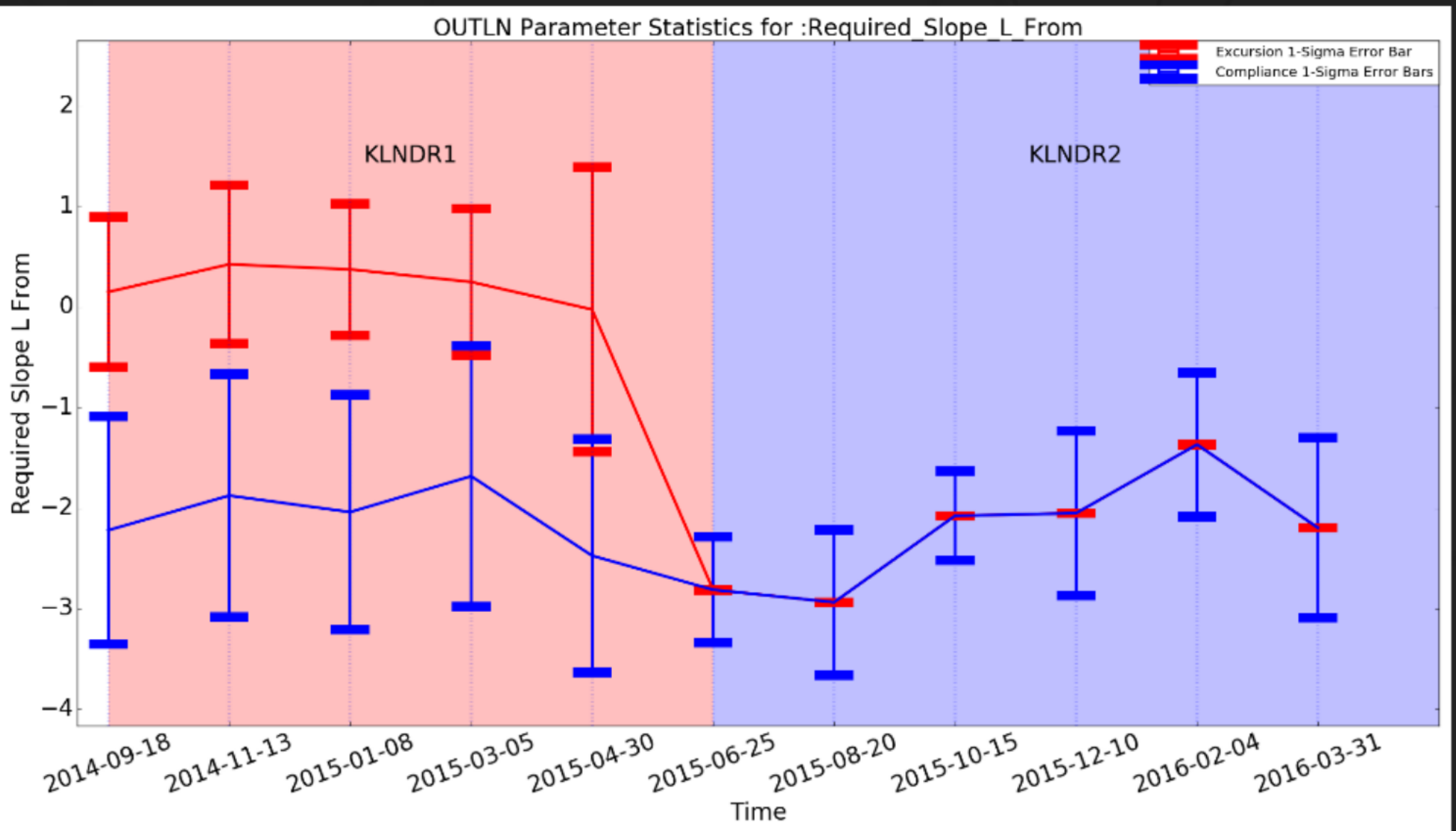
Precursors



Decision trees weigh multiple variables to predict the class of a variable

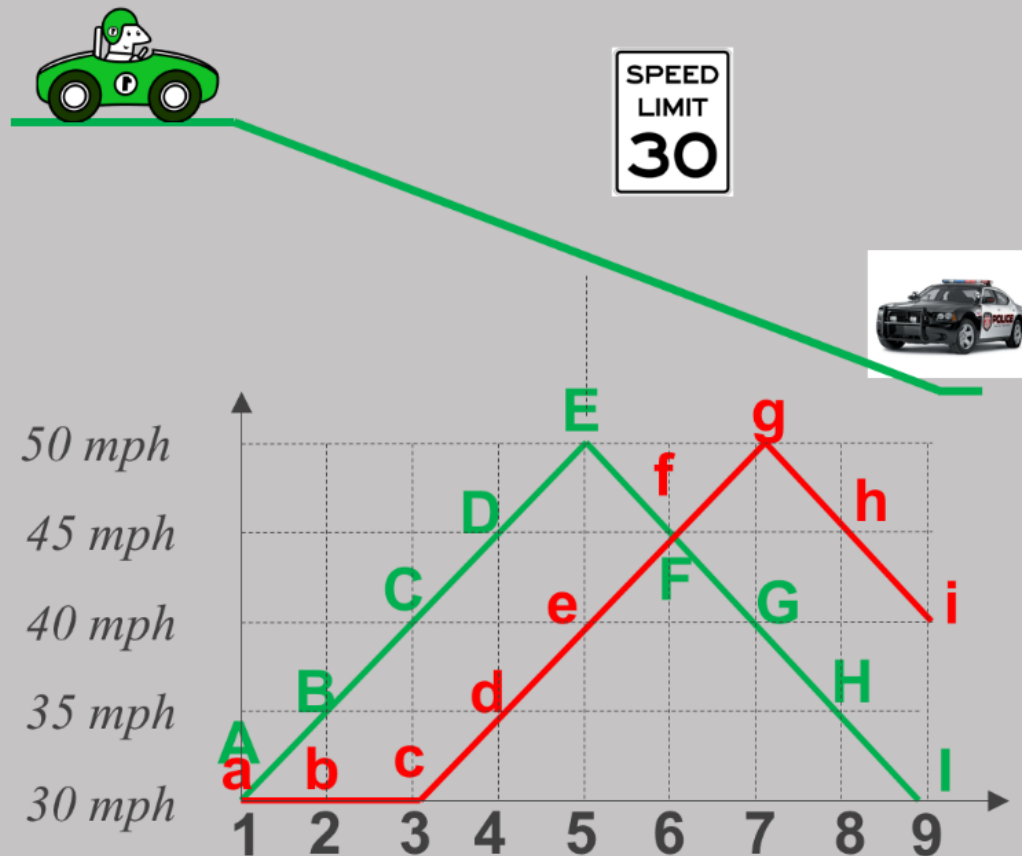


Change in Behavior



Adopt

Automatic Detection of Precursors in Timeseries



Output Tool

Data Visualization & synthesis

Monitor trends

Observe efficacy of mitigation strategies

Observe factors that influence degradation

Set acceptability metrics

Decision support for designers

Monitor trends

Observe efficacy of mitigation strategies

Observe factors that influence degradation

Set acceptability metrics

Decision support for designers

RNAV STAR Procedural Adherence

