TRB 2019 ANNUAL MEETING
CONVENING THE TRANSPORTATION COMMUNITY FOR 98 YEARS
January 13–17, 2019 › Washington, D.C.

How Much Driving Data Do we Need to Assess Driver Behavior?

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#19-02956

Introduction

Some literature facts

- Drivers exhibit variable behavior during driving and per trip
- Availability of high quality real-time data on driving task can lead to the efficient modeling of both individual and total crash risk.
- Monitoring of driver's behavior through technological means → big data for driving safety efficiency

But we cannot wait for BIG DATA for two reasons (among others):

- Big data does not necessarily mean good solutions (Exhaustive modeling is not always the correct modeling path)
- We need to provide useful information to driver as fast as possible

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Scope

We address a very simple question:

What is the required size of the driving data to determine the driving behavior?

Proposed Approach:

- Smartphone based data collection system
- Statistical metrics of convergence and time series analysis

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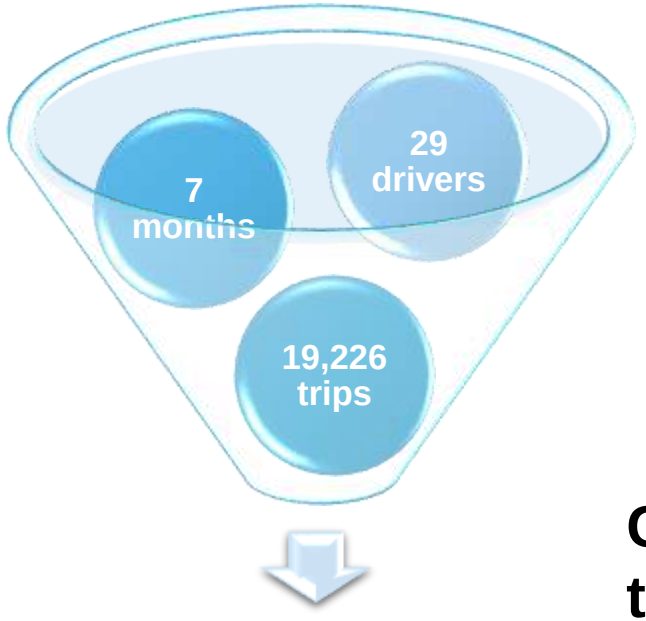
Data Collection

Smartphone app by OSeven Telematics

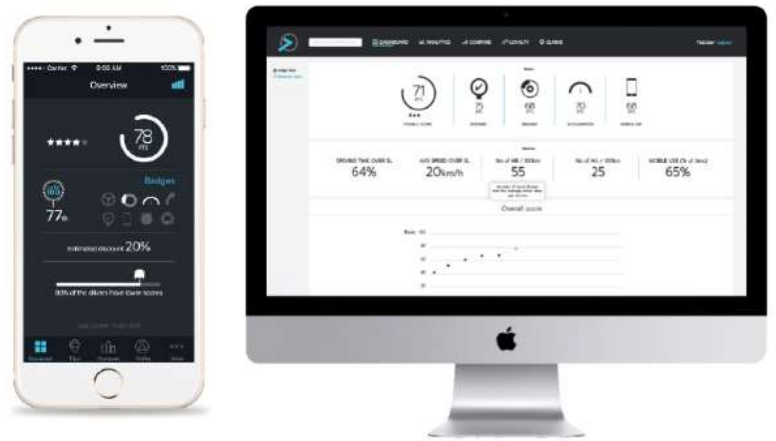
Real-time driving behavior data of 29 drivers using smartphone sensors

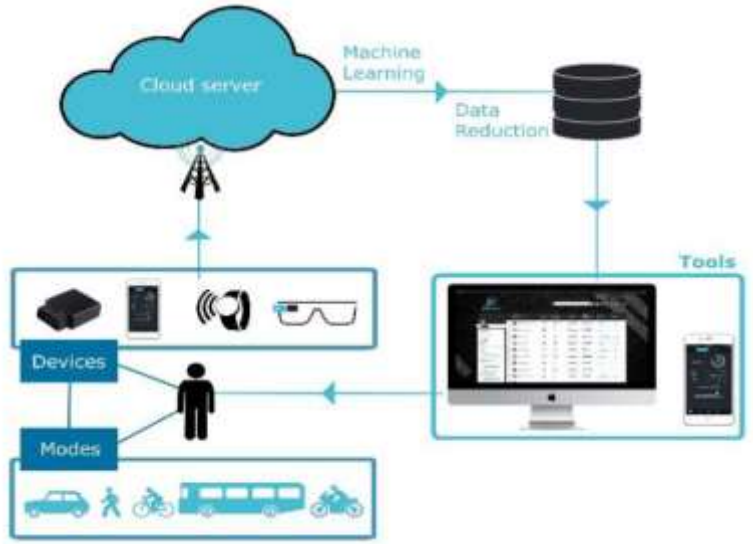


Database

- **Analysis per:**
  - **Aggressiveness level**
  - **Trip duration**
  - **Road types**

Chronological classification of data to observe the changes over time





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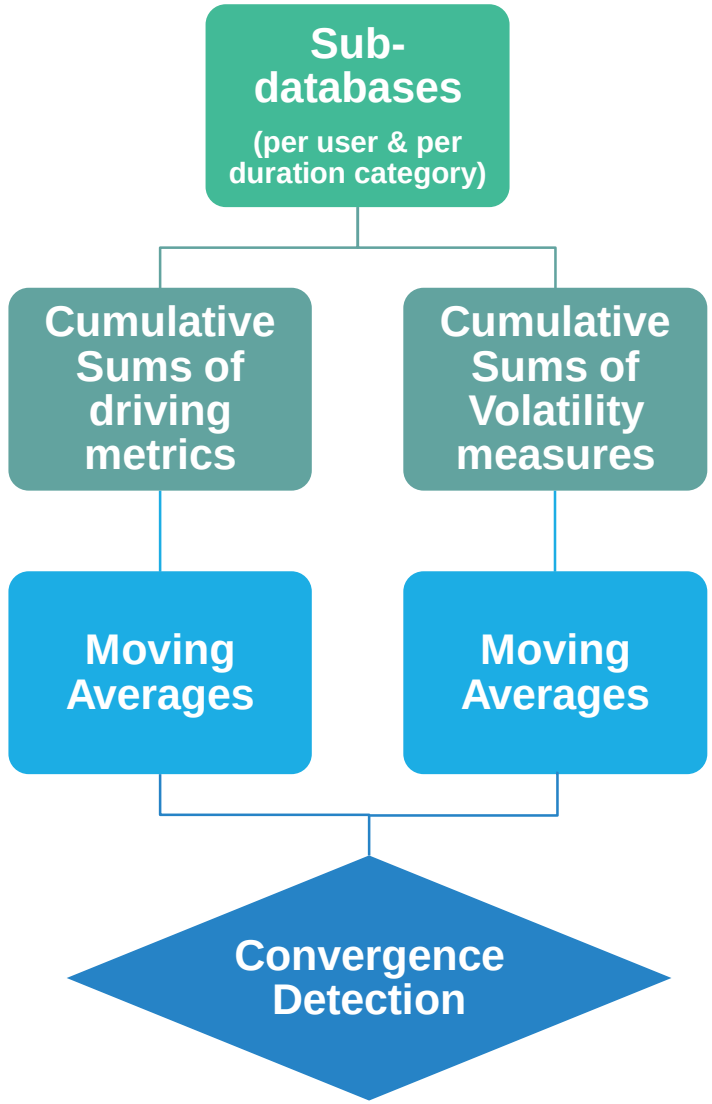
Methodological Approach

Driving metrics – Per driver analysis

- Harsh acceleration events (HA)
- Harsh braking events (HB)
- Time of mobile phone usage (MU)
- Time of speeding (SP)

Cumulative sums → detection of stabilization or fluctuation around a fixed value over time

- Number of HA & HB per kilometer travelled
- Percentage of driving duration for MU & SP



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Methodological Approach

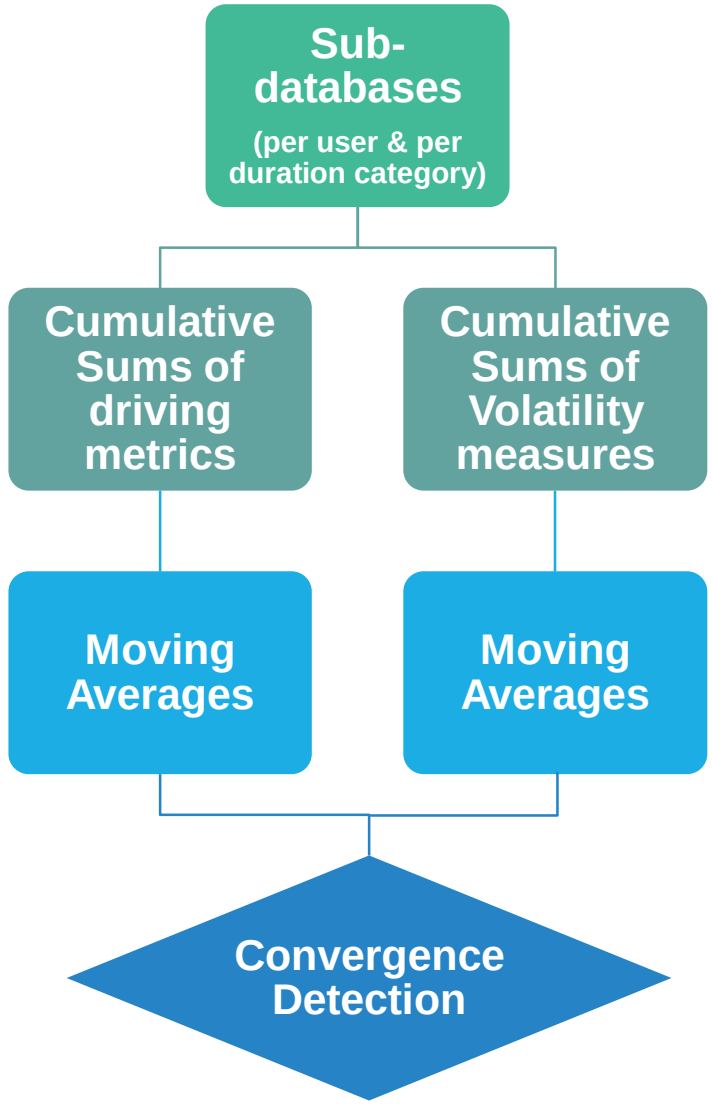
Per user analysis

Three distinct trip duration categories

- 5, 10 and 20 minutes trips

Variability of metrics is examined to observe driving behavior evolution over time.

- Moving averages, Shewhart control charts principles, driving behavior volatility



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Methodological Approach

Convergence criteria:

- The moving average is within the range Mean ± one Standard Deviation.
- The percentage change (in absolute terms) between successive values of the moving average is less than or equal to 1.5% for five consecutive trips.
- The value of the moving average in the corresponding trip is a local extreme

Separately applied to the cumulative sum of each metric and to their volatility measures

→ Convergence detection (time point and values of metric and volatility)

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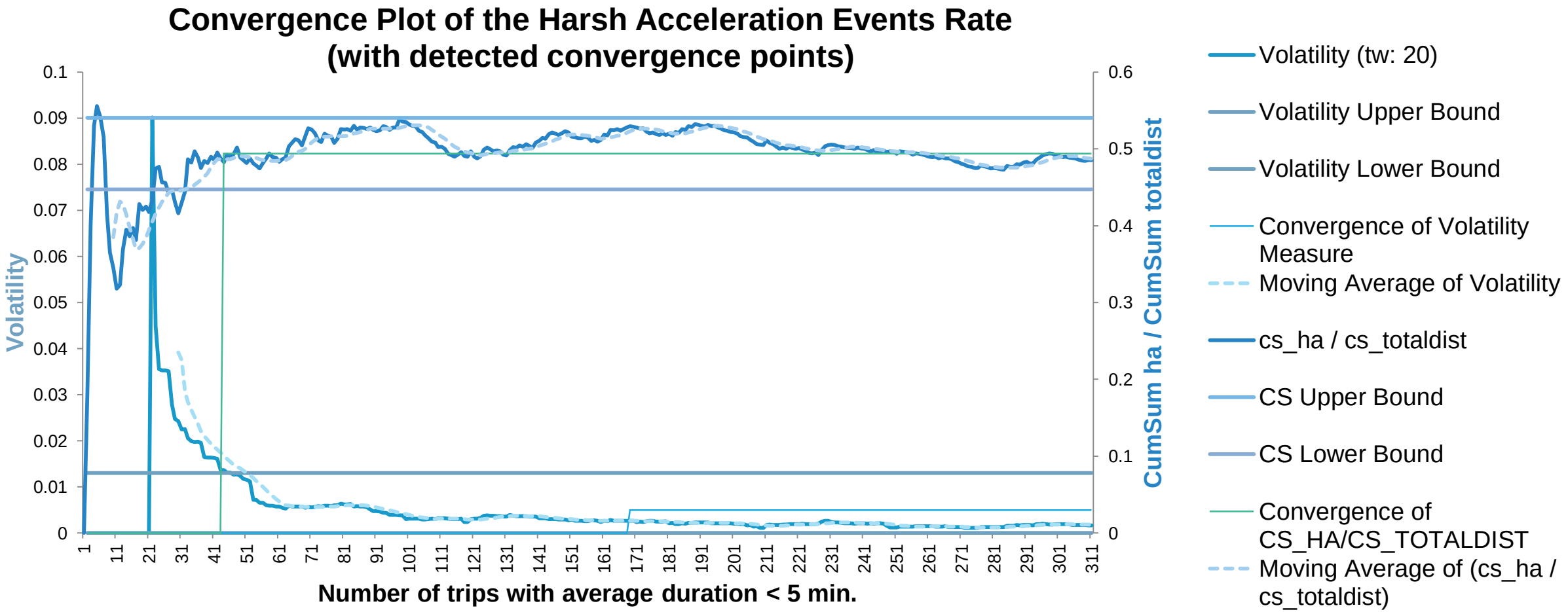
Methodological Approach



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Key Findings

The time point at which driving behavior stabilizes is not common for all drivers and/or all driving behavior metrics

Aggressive (higher convergence value) drivers tend to converge faster than cautious (lower convergence value) drivers

The critical driving characteristic that determines the necessary driving data amount that should be collected is the driving behavior metric that converges later for each driver

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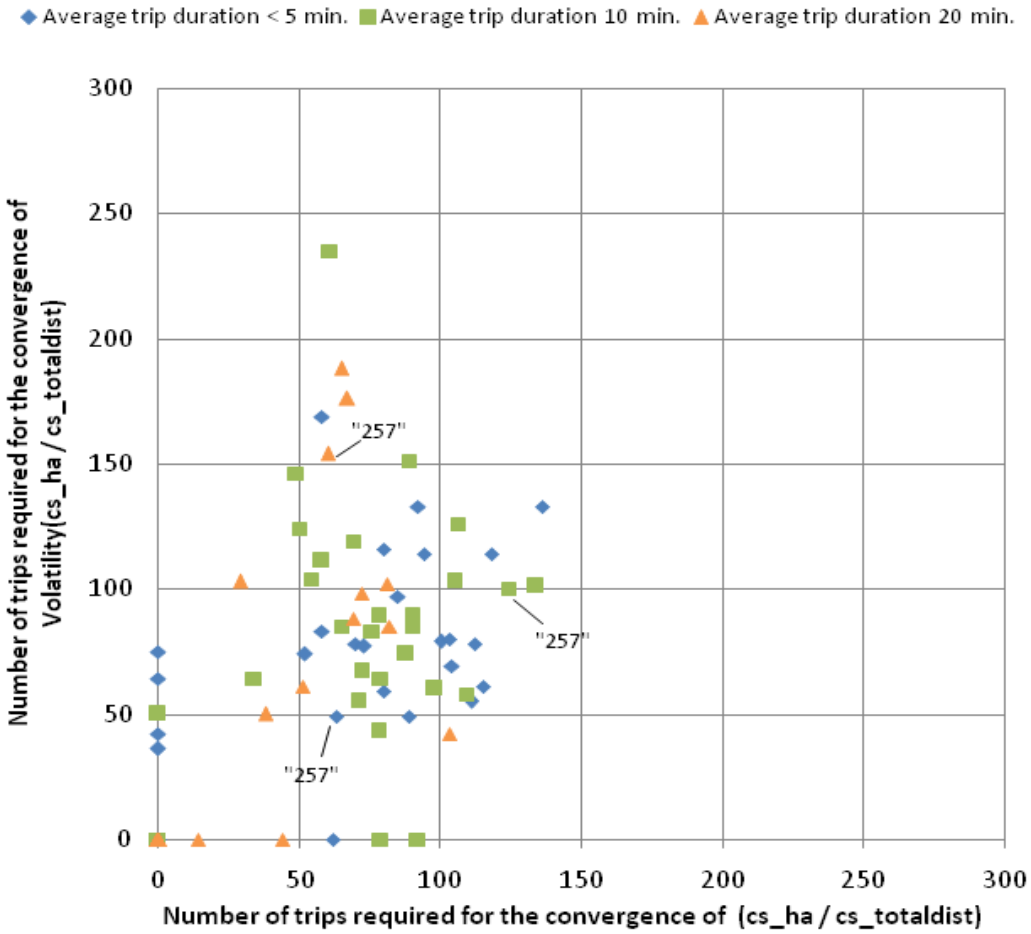
Key Findings

- The number of trips that each driver should be monitored for varies in terms of the *average duration* of the trips being studied.
- Even for the same driver, the convergence point of a specific characteristic (and its volatility) varies considerably, depending on the average duration of the trips studied.
- Apparently, the relative position of the same driver on the chart might be different even for the same characteristic.
- Driver *"257"* is highlighted in the Figure for the three different trip durations studied.

Minimum Number of Trips Required for the number of Harsh Acceleration Events per Km Rate to Converge



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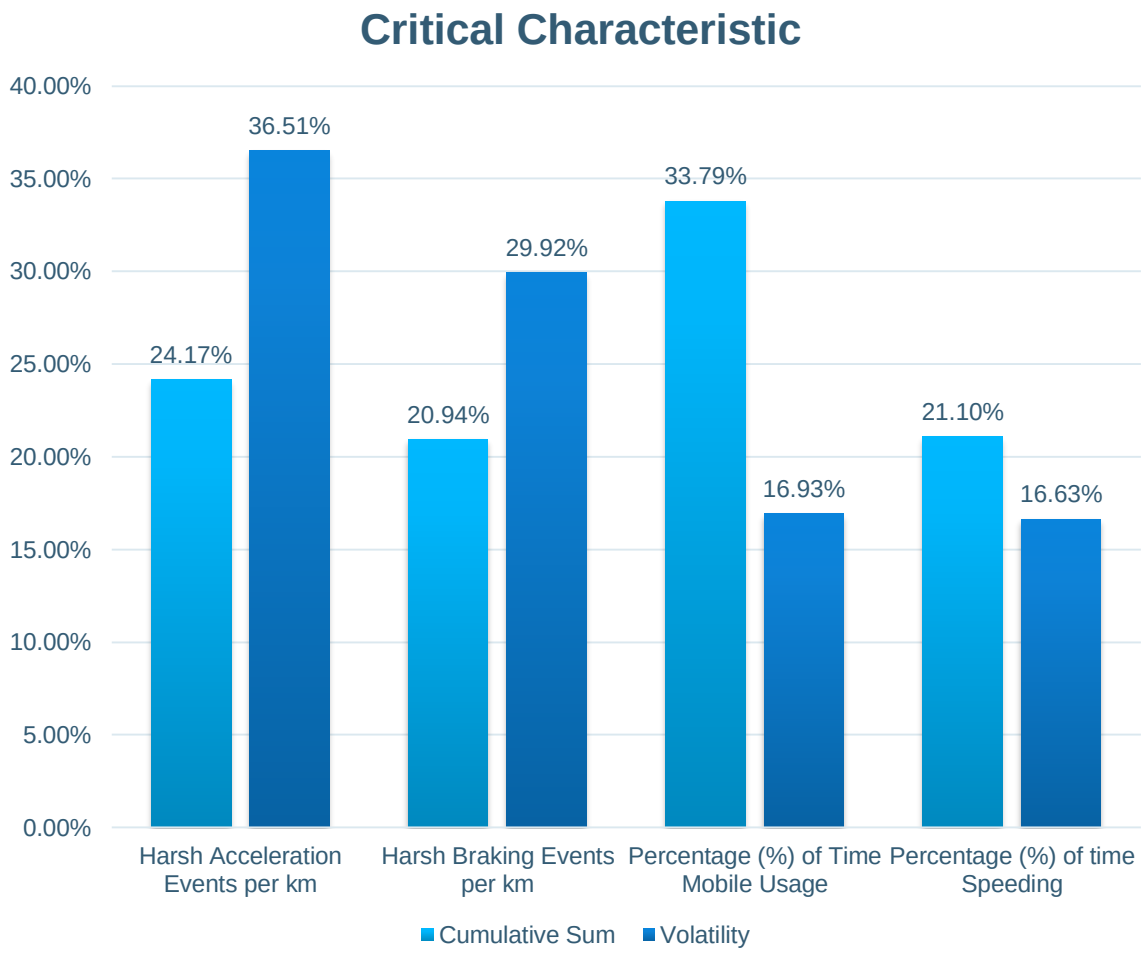
Key Findings



Critical characteristics:

- **The critical characteristic for the majority of drivers (~ 37%) is the volatility of the number of HA per km as well as the MU (~ 34%)**
- **The number of HB per km and its volatility follow (~ 30%) while for a few drivers it seems that critical characteristic is the SP and its volatility (~ 17%).**

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Key Findings

Aggressiveness, Volatility Limits and Convergence Rate of Driving Behavioral Characteristics

	Minimum Required Number of trips		Average Convergence Rate of Driving Characteristics and Volatility			
	Fast Convergence	Slow Convergence	Cautious	Aggressive	Stable	Volatile
Harsh Acceleration events per km	< 50 (24.14%)	> 120 (10.34%)	< 0.11 (33.33%)	> 0.23 (17.24%)	-	-
Harsh Braking events per km	< 60 (13.79%)	> 140 (20.69%)	< 0.01 (5.75%)	> 0.12 (9.20%)	-	-
Percentage (%) of Time Mobile Usage	< 50 (17.24%)	> 120 (27.59%)	< 0.04 (32.18%)	> 0.16 (21.84%)	-	-
Percentage (%) of time Speeding	< 50 (24.14%)	> 120 (24.14%)	< 0.02 (12.64%)	> 0.14 (9.20%)	-	-
Volatility	< 60 (42.24%)	> 120 (21.55%)	-	-	< 0.005 (35.63%)	> 0.05 (23.75%)

- **42.24% of the drivers were found to have *fast* convergence rates regarding their volatility measure**
- **27.59% of the drivers were found to have *slow* convergence rates regarding the percentage of MU**
- **Over 35% of the drivers exhibited a rather *stable* behavior**

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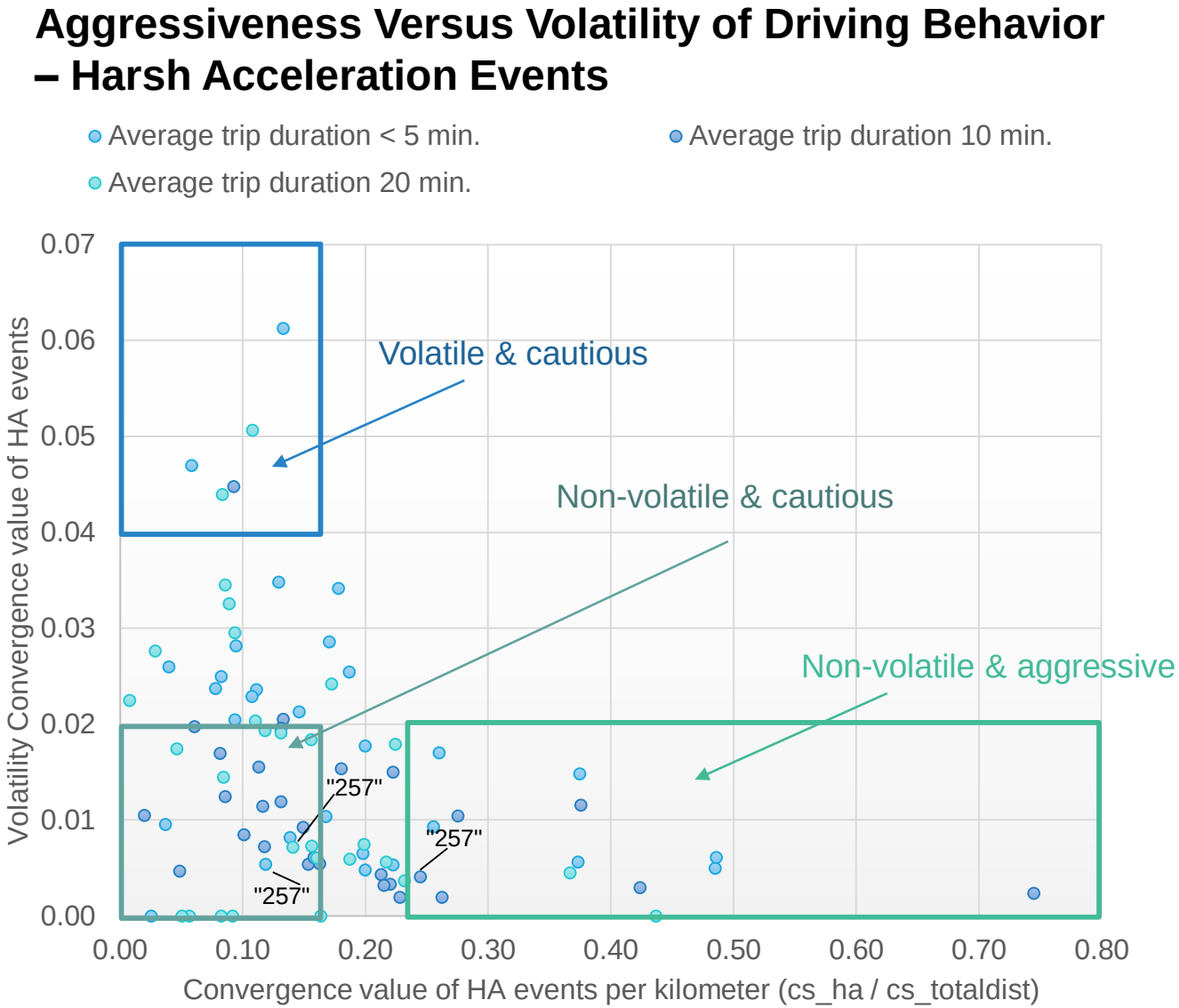
Key Findings

- **A driver may be cautious regarding the feature being studied, but at the same time exhibiting significant variations/fluctuations in his travel-related behavior, and vice versa**



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Conclusions

How much data do we need for understanding your driver behavior?

Depends on the aggressiveness and stability of the overall driver's behavior as well as the average duration of the trips being studied

Knowledge of drivers' behavioral volatility is of paramount importance when studying driving behavior

Smartphones can contribute significantly to the exploration-monitoring of driving behavior & distracted driving

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Future Research

Drivers' profiling

Better results could be obtained by observing the same variables on a larger sample of drivers

Or by using demographic characteristics of drivers, different traffic conditions and road environments as well as various groups of drivers (professional drivers, motorcyclists, etc.).

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