SYNCHRONIZATION: MINIMIZING CONGESTIONS AND CRASHES

COMPILED RESEARCH

AND *20 QUESTIONS ON CONGESTION & SAFETY*

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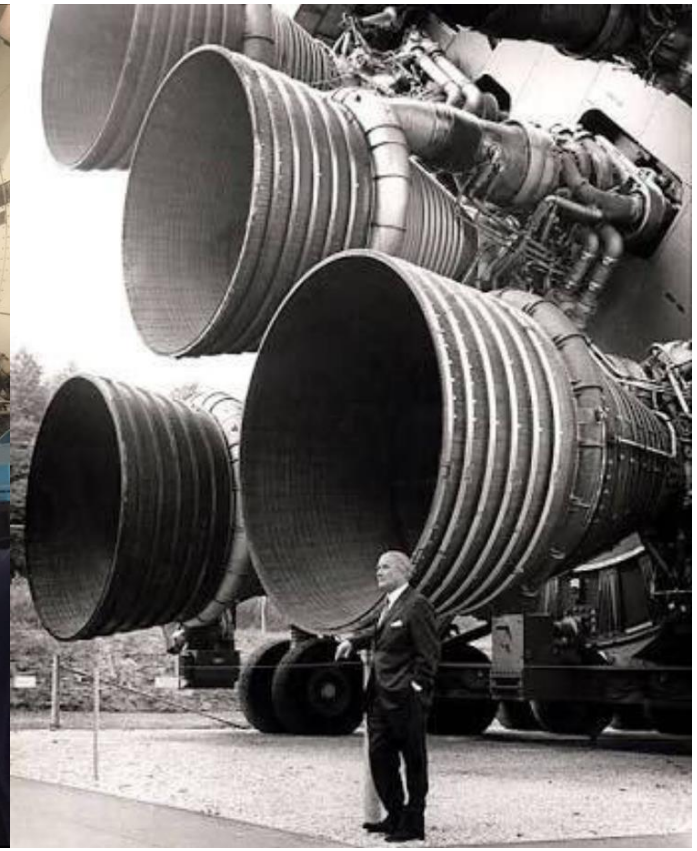

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THE COVID-19 PANDEMIC HAS COMPLETELY ALTERED TRAFFIC CONGESTION IN 2020[1]

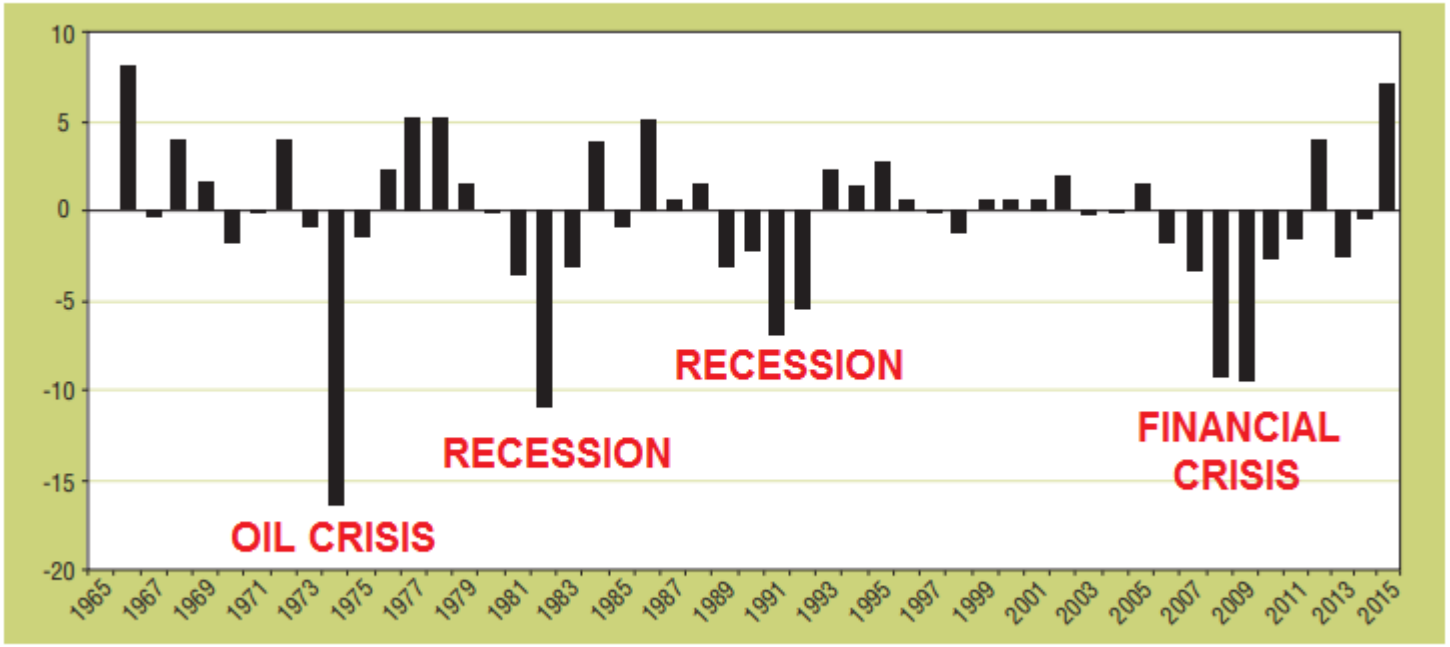
1 - https://www.tomtom.com/en_gb/traffic-index/

DOES RECESSION HELP WITH FATALITIES?

UNDERSTANDING CRISIS

We are currently under a global crisis caused by the pandemic. We are seeing dramatic drops in congestion and crashes, due to lockdowns and restrictions.

Figure 1
Percentage Change in Total Traffic Fatalities, 1965–2015



Sources: 1965–1974: National Center for Health Statistics, HEW, and State Accident Summaries (Adjusted to 30-Day Traffic Deaths by NHTSA); FARS 1975-2014 Final File, 2015 Annual Report File (ARF)

Past crises reduced fatalities without the forced control. How is this effect explained on a micro, traffic scale?

Image: NHTSA - Economic Trends and Cycles

FUTURE OF CONGESTION & SAFETY

Before the COVID-19 pandemic, popular approaches to mend the traffic and transportation ailments in the near future were:

- ►Congestion: Congestion pricing
- ►Congestion: On-demand riding[1]
- ►Crashes: Autonomous driving

1 - https://www.businessinsider.com/no-one-will-own-a-car-in-the-future-2017-5

20 QUESTIONS ON CONGESTION & SAFETY

From these futuristic discussions 20 questions arose, motivating my research:

PART 1 IDENTIFYING THE PROBLEM

CONGESTION PRICING AND AV / TNC RESPONSE

GO 1. Why is Stockholm the model city for congestion pricing when its population is at 1 million?

GO 2. Can NYC congestion pricing be effective, and will autonomous vehicles be counteractive?

GO 3. How could AV proponents, TNCs and their lobbyists work around congestion pricing?

GO **SHORTCOMINGS AND FUNDAMENTALS: ONE-TO-MANY & MANY-TO-MANY CRASHES**

GO 4. Where did one-to-many and many-to-many crashes manifest in Istanbul?

GO 5. How do poor road geometry and design amplify many-to-many crashes?

GO 6. Why did the decommissioning of Ataturk Airport immediately reduce crashes in vicinity?

GO 7. While demand is known to increase congestion, how does it influence crashes?

GO 8. Which property emerges when the crash-vehicle graph is scaled down to city and vehicle?

20 QUESTIONS ON CONGESTION & SAFETY

LIGHT COMMERCIAL VEHICLES / LIGHT TRUCKS – UNIVERSALITY OF AN EMERGENT PATTERN

GO 9. Why are light commercial vehicles & lights trucks the heavy hitters of traffic crashes?

GO 10. From USDOT 2015 Call to Action to 2019, why crash fatality factors vary in importance?

GO 11. When vehicle type sales surpass others, is there a criticality similar to a phase transition?

PART 2: REEXAMINING WHAT WE KNOW

DISTRACTED DRIVING: SYNCHRONIZATION OF DRIVERS AND THE COUNTER ARGUMENT

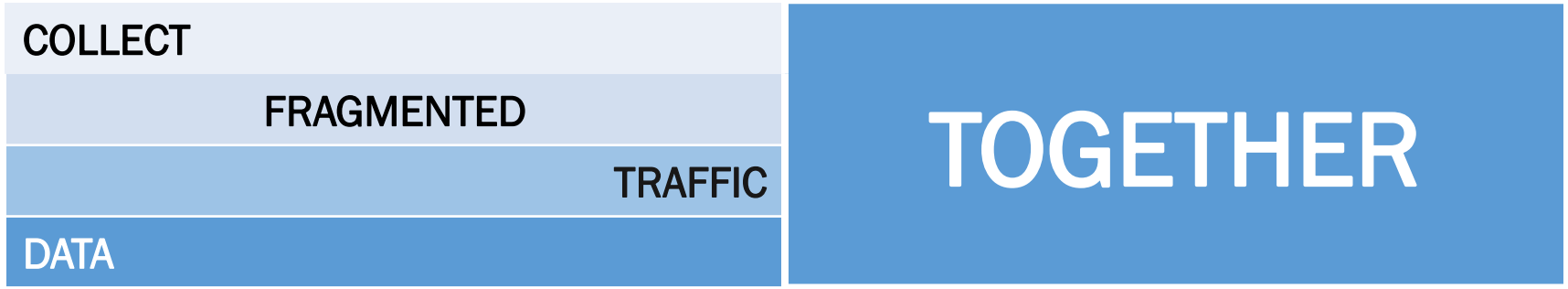
12. If distracted driving is an impairment, shouldn't Virginia Tech study have discrepancies?
13. Is maintaining the synchonization between drivers the key to crashes and congestions?
14. Can risk analysis be applied to crashes, grouping them by their severity and frequence?
15. Why is Ireland's dangerous driving offense a great example of near-misses in crashes?
16. Can a link between occupational accidents and traffic crashes explain distracted driving?
17. Which external factors impair drivers? A study of Turkey's abandoned daylight saving time

20 QUESTIONS ON CONGESTION & SAFETY

PART 3: PROPOSED SOLUTION

FUTURE OF VEHICLE INSURANCE COMPANIES - TRAFFIC BROKERAGE

18. Why are insurance companies losing money against the rising premium rates?
19. How do insurance companies envision their sustainability against an AV future?
20. A transformative business model for vehicular insurance: What is traffic brokerage?



PART 1

IDENTIFYING THE PROBLEM

1. STOCKHOLM CONGESTION TAX

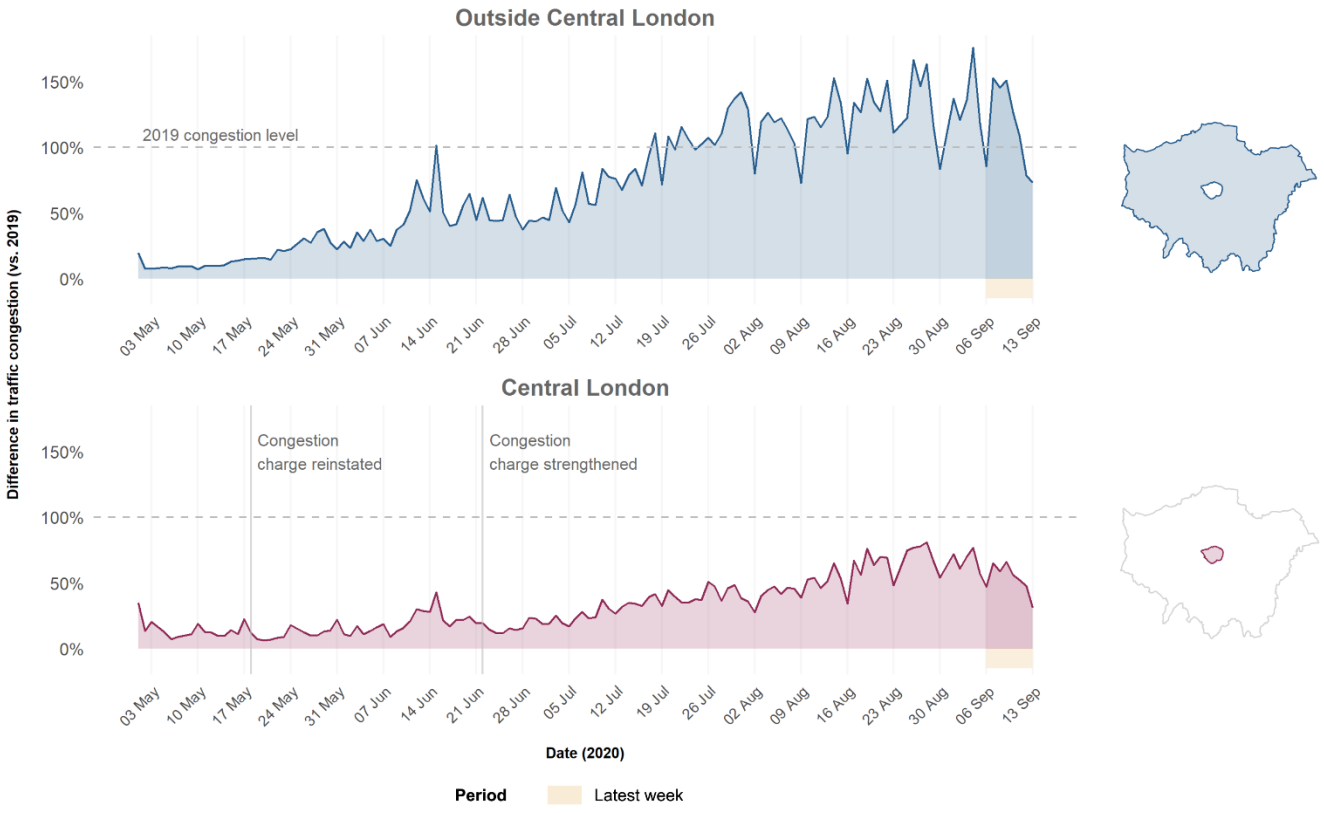
On congestion road pricing: 'the streets were never free' (link). 'The government has heavily subsidized driving, or hidden the reality of who pays for it in places no one sees. Local laws require off-street parking from businesses and housing developers, who pass on the construction cost of it to tenants and customers who may not drive at all.' Related: when Stockholm introduced a congestion tax, pollution levels dropped by between 5-10% and the rate of asthma attacks among local children decreased by nearly 50% (link).

Stockholm is the model city for congestion pricing, achieving positive returns in many areas.

Question: A quick search lists Stockholm's population at 1 million, and 1.6 million in its urban area. Are these results reproducible in a megacity, 10x-20x larger in size?

Image - No Free Lunch Argument Behind Congestion Pricing : Trucks|Future of Transportation Weekly Mail Dispatch of Trucks Venture Capital

1. LONDON CONGESTION CHARGE



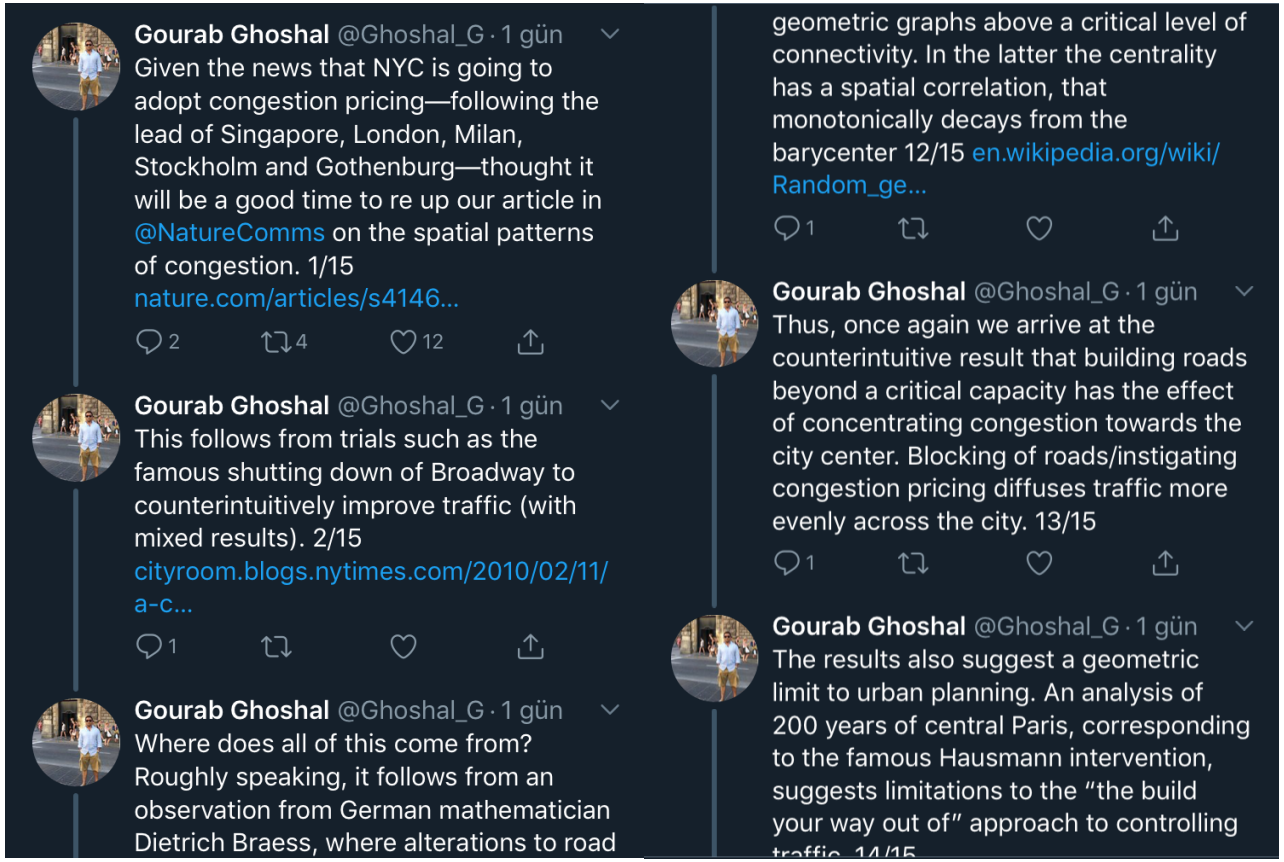
London is a megacity that has implemented congestion pricing policies under Ken Livingstone.

Results: In London, congestion levels are close to pre-pricing levels[1], while in Stockholm they rose[2] after a brief drop. Without pricing, consensus is congestion would have been worse.

Image - Rising London Congestion 2020: https://www.edfeurope.org/news/2020/15/09/traffic-congestion-increasing-london-above-2019-levels-outside-city-centre

1. https://en.wikipedia.org/wiki/London_congestion_charge#Traffic_speeds
2. https://en.wikipedia.org/wiki/Stockholm_congestion_tax#Effects

2. NYC PLANNED CONGESTION PRICING



New York City is another megacity that has congestion pricing plans. There are merits to the argument.

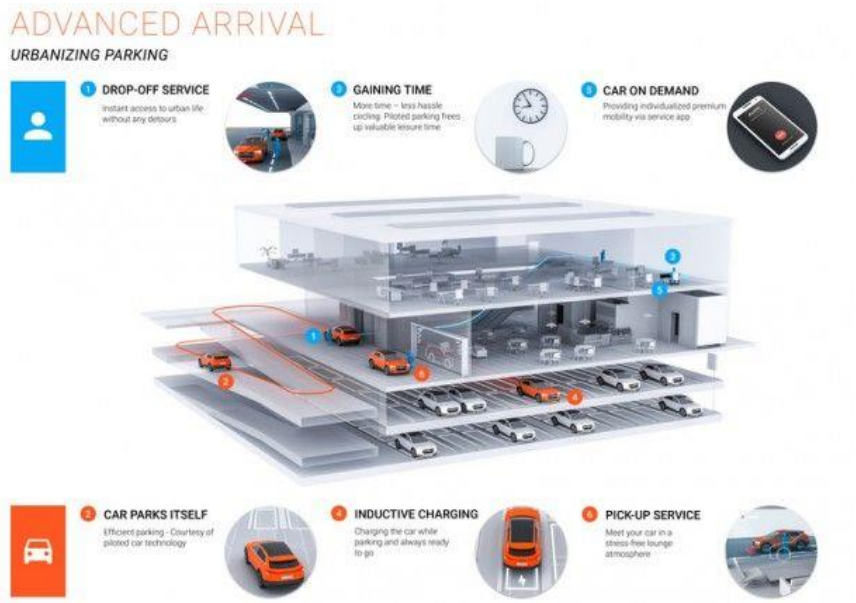
History: Under the helm of Robert Moses, New York City undertook massive infrastructure projects and highways[1]. This induced a rapid demand for cars, and congestion.

Image - Twitter Thread: Counterintuitive Rise of Traffic Congestion After Road Construction, see https://en.wikipedia.org/wiki/Induced_demand

1. https://en.wikipedia.org/wiki/Robert_Moses

2. AUTONOMOUS VEHICLE PRICING

This paper in Transport Journal points out that without congestion pricing, empty AVs are incentivized to drive around in circles for free rather than to pay for parking (link). Unsaid here is that this has always been true for vehicles of all types in the US, regardless of human or robot operation, and already contributes to high congestion in cities. Our friend Mike Granoff of Maniv famously points out this paradox of America's free road space: within Manhattan, parking can be as high as $40/hour, making it much cheaper to hire a NYU student at $20/hour to drive the car around the block over and over again. Without congestion pricing of all vehicles, not just AVs, the same paradox will continue.



US megacities are further affected by the introduction of autonomous vehicles, which has its own caveats.

Question: Will the AV championing self-styled TNCs (Transportation Network Companies), with their immense lobbying power, try to bend the law to their incentives?

Image 1 - Empty Autonomous Vehicles vs Congestion Pricing : Trucks|Future of Transportation Weekly Mail Dispatch of Trucks Venture Capital
Image 2 - Audi: Car on Demand Scheme https://www.automobil-industrie.vogel.de/umleitung-gal-511941/?p=5

3. FIRST-MILE INVESTMENT OF UBER: LIME

Uber settles driver classification lawsuit for $20 million

The ride-hail company gets to continue not paying for traditional benefits like paid sick time and workers' compensation

- **Uber must face a class action lawsuit from 4,800 drivers in California, a court ruled Tuesday.**
- **Drivers sued over Uber's refusal to pay employment benefits under AB-5 before Prop 22 passed.**
- **The ruling lets them sue together over expenses and pay statements, but only separately on pay amounts, overtime, and sick leave.**

Uber's scooter business Jump was absorbed by Lime, with Lime getting $170M investment from Uber.

Potential Issues: While scooters are a solution to the first-mile problem, they may be used by TNCs to offset congestion away from priced roads, rendering the practice useless.

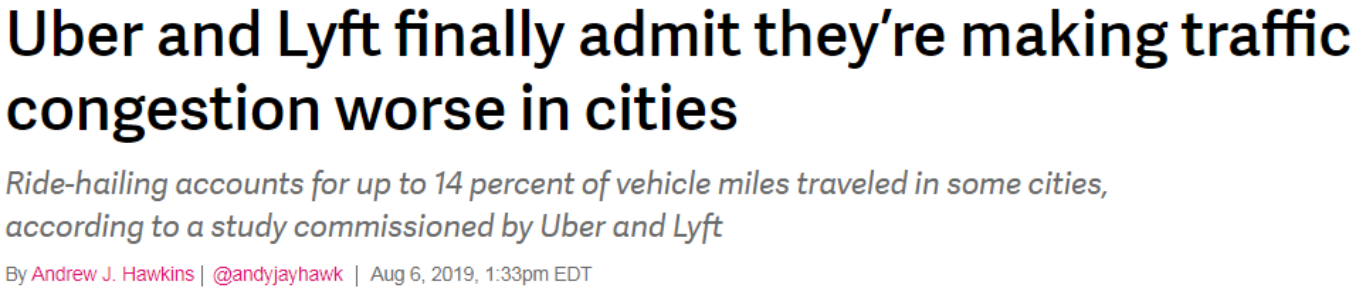
Uber: repeated refusal to acknowledge drivers as employees, and pressuring drivers to vote legislations against their own rights

Image 1 - https://www.theverge.com/2019/3/12/18261755/uber-driver-classification-lawsuit-settlement-20-million

Image 2 - https://www.businessinsider.com/uber-class-action-lawsuit-california-prop-22-ab5-driver-pay-2021-1

Anti-employment initiative messaging - https://www.washingtonpost.com/technology/2020/10/22/uber-prop22-suit/

3. TNCs WORSENING CONGESTION IN SF



Uber and Lyft finally admit they're making traffic congestion worse in cities

Ride-hailing accounts for up to 14 percent of vehicle miles traveled in some cities, according to a study commissioned by Uber and Lyft

By Andrew J. Hawkins | @andyjayhawk | Aug 6, 2019, 1:33pm EDT

Safety driver of fatal self-driving Uber crash was reportedly watching Hulu at time of accident

Police report deems accident 'entirely avoidable'

By Chaim Gartenberg | @cgartenberg | Jun 22, 2018, 9:54am EDT

Uber suspends self-driving cars after Arizona crash

26 March 2017

Ride-sharing was the answer to congestion. Ironically, ride-hailing only made matters worse.

Question: Given that ride-hailing companies are looking to cut costs by working around laws and making congestion knowingly worse, will an AV future comply with regulations?

Image 1 - https://www.theverge.com/2019/8/6/20756945/uber-lyft-tnc-vmt-traffic-congestion-study-fehr-peers
Image 2 - https://www.theverge.com/2018/6/22/17492320/safety-driver-self-driving-uber-crash-hulu-police-report
Image 3 - https://www.bbc.com/news/technology-39397211

SHORTCOMINGS: PROPOSED SOLUTIONS

So far we've covered:

- Congestion pricing temporarily reducing congestion before it eventually returns to pre-pricing levels
- Autonomous vehicles bringing a new aspect to congestion pricing policies
- TNCs, one of the largest owners of AV fleets in the foreseeable future, not being positive contributers to congestion

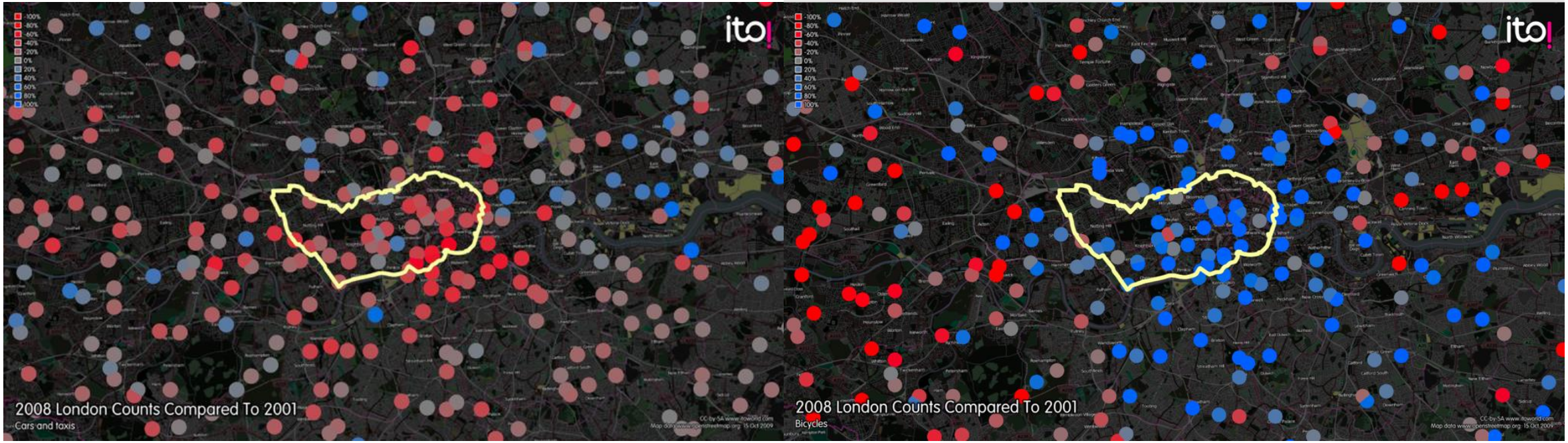
All of the proposed solutions are empirical, try-and-see methods, often imported from other cities.

Fundamentals: These solutions are too layered and complex, or too large businesses which obscure the simplicity. This is often why we are placing the cart before the horse.

FUNDAMENTALS: REPURPOSING ROADS

LONDON: CAR AND TAXI DECREASE OCTOBER 2008 TO OCTOBER 2001

LONDON: BICYCLE COUNT INCREASE OCTOBER 2008 TO OCTOBER 2001



Images - https://en.wikipedia.org/wiki/London_congestion_charge#Traffic_volume

FUNDAMENTALS: COUNTERINTUITION

Hans Monderman:

- A traffic engineer from Netherlands
- Known for his concept of **shared space**
- In a shared space, traffic lights, crosswalks, signs, lane markers and curbs are removed
- At the town Oudeshake, Monderman was appointed road safety investigator on traffic fatalities. He removed the road signs and street furniture. This forced the drivers to be careful and negotiate, cutting vehicle speeds by forty percent[1].

Counterintution is not limited to NYC closing roads in Brooklyn to improve traffic, but applies to crashes too.

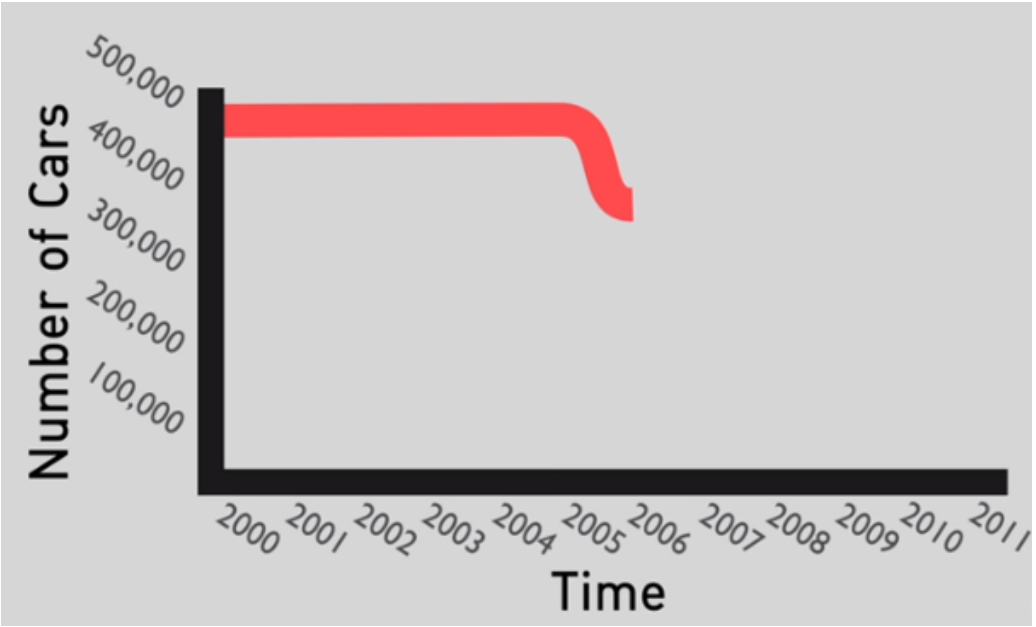
Repurposing: The positive result of London's congestion charge was the increase in bicycle use. For safety, speed limits were introduced, traffic slowing down counterintuivitively[2].

1 - https://www.pps.org/article/hans-monderman
2 - https://en.wikipedia.org/wiki/London_congestion_charge#Traffic_speeds

FUNDAMENTALS: ACHIEVING DROPS

EFFECTIVENESS OF CONGESTION PRICING IN STOCKHOLM IN 1 YEAR

22% DROP[1]



EFFECTIVENESS OF PLASTIC SHOPPING BAG PRICING IN TURKEY IN 1 YEAR

77% DROP[2]

1 - https://www.transportportal.se/swopec/cts2014-7.pdf
2 - https://www.bbc.com/turkce/haberler-turkiye-50799641

FUNDAMENTALS: FEASIBLE ALTERNATIVES

EFFECTIVENESS OF CONGESTION PRICING IN STOCKHOLM IN 1 YEAR

A road user can't bring their own road and often are required to pass from a specific road, whether priced or not.

If there are alternative routes, there may be additional fuel consumption that makes the trip infeasible, and not sustainable, even with a £15 charge.[1]

EFFECTIVENESS OF PLASTIC SHOPPING BAG PRICING IN TURKEY IN 1 YEAR

Following the example of South Korea, Turkey made it mandatory to pricing plastic bags in markets from January 1st 2019, previously freely offered.

Even at the meager price of 0.25₺ (£0.0222), plastic bag pricing was an immediate success, because customers could bring their bags from their homes.

1 – June 2020 Charge https://en.wikipedia.org/wiki/London_congestion_charge

FUNDAMENTALS: SHARED VS OWNED

EFFECTIVENESS OF CONGESTION PRICING IN STOCKHOLM IN 1 YEAR

DRIVERS **SHARE** A ROAD SECTION

CONGESTION PRICING A ROAD IS A **PERSONAL** DISINCENTIVIZATION

EFFECTIVENESS OF PLASTIC SHOPPING BAG PRICING IN TURKEY IN 1 YEAR

CUSTOMERS **OWN** PERSONAL BAGS

SHOPPING BAG PRICING IS A **PERSONAL** DISINCENTIVIZATION

Images – Pokémon

ONE-TO-MANY VS ONE-TO-ONE

EFFECTIVENESS OF CONGESTION PRICING IN STOCKHOLM IN 1 YEAR

ONE-TO-MANY

PERSONAL DISINCENTIVIZATION:

- DIRECTLY AFFECTING MANY DRIVERS PASSING THROUGH THE SAME ROAD
- INDIRECTLY AFFECTING: **MANY?**

EFFECTIVENESS OF PLASTIC SHOPPING BAG PRICING IN TURKEY IN 1 YEAR

ONE-TO-ONE

PERSONAL DISINCENTIVIZATION:

- DIRECTLY AFFECTING ONLY THE CUSTOMER
- INDIRECTLY AFFECTING: ENVIRONMENT

ONE-TO-MANY VS MANY-TO-MANY

COORDINATION BY:
TRANSPORTATION AUTHORITY

►drivers know in that road section, congestion pricing is implemented

ONE-TO-MANY

CONGESTION PREVENTION AT THE CONGESTION PRICED ROAD SECTION

Congestion levels rising back:
Induced demand

COORDINATION BY:
NONE

►currently no way to know in advance, only after congestion through apps

MANY-TO-MANY

CONGESTION PREVENTION AT THE «UPSTREAM» OF THE TRAFFIC FLOW

Congestion (and accidents) at[1]:
Intersections

1 – (3) The state of the roads and driving habits.. https://repositorio.cepal.org/bitstream/handle/11362/37898/1/LCG2199P_en.pdf

Crashes Lead to Congestions:

TRIVIAL KNOWLEDGE

Do Congestions Lead to Crashes?

AIM OF THIS RESEARCH

ONE-TO-MANY CONGESTION

BOTTLENECKS AND ZIPPER MERGE

Usually one-to-many congestions happen at bottlenecks, such as Istanbul's bridges on the right. If **zipper merge** is not maintained, the bottleneck may generate congestions, especially long in rush hours.

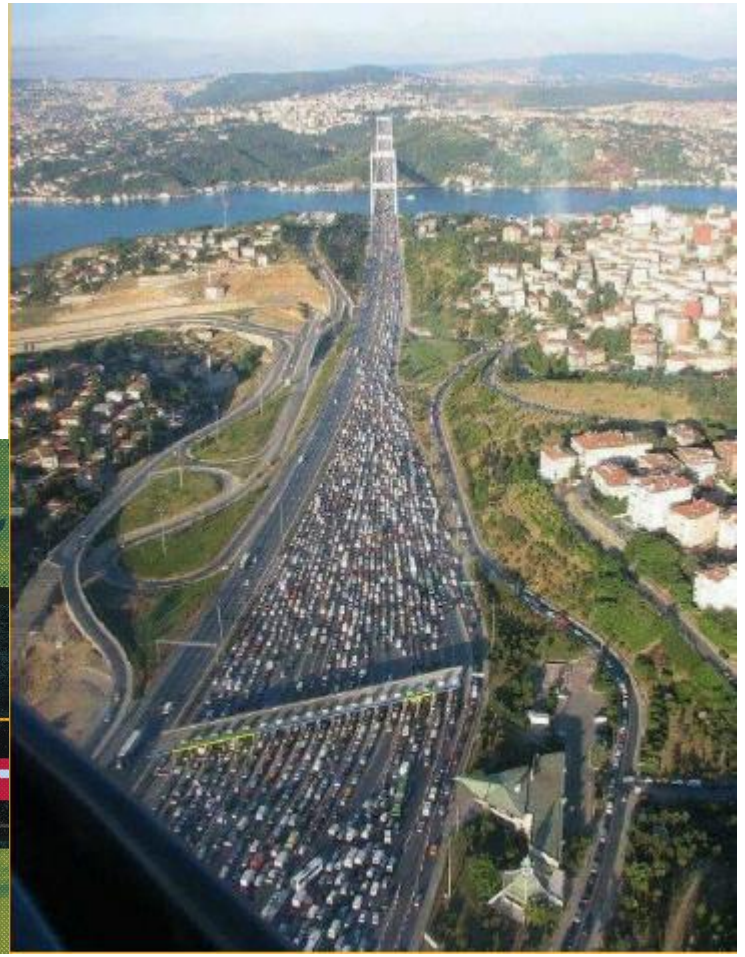


Image 1 - https://twitter.com/erikwest73/status/1031842127918125057
Netherlands Entreprise Agency Report: - https://www.rvo.nl/sites/default/files/2018/08/Who-need-cars-anyway.pdf
Image 2 - https://amainsider.com/zipper-merge/

ONE-TO-MANY CRASHES

REAR-ENDING: SUDDEN BREAKING AND ACCELERATION

Behind bottleneck congestions, if the incoming flow is high speed, read-end collisions are commonplace. On the other end of the congestion, once the road is cleared, the irritated drivers stomp their feet on the gas, causing disruption. Erratic driving of autonomous vehicles is the dominant cause of humans rear-ending them.

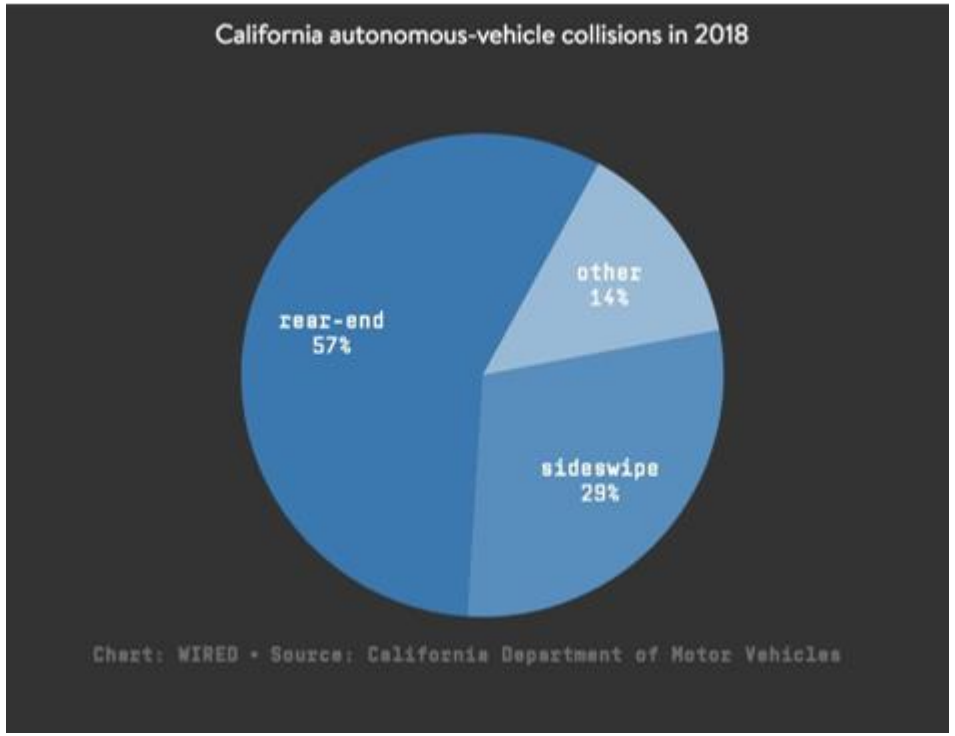
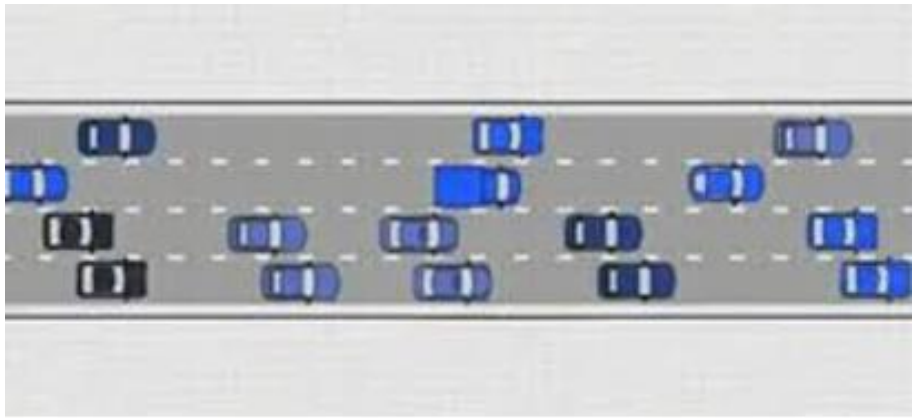


Image - https://www.wired.com/story/self-driving-car-crashes-rear-endings-why-charts-statistics/

MANY-TO-MANY CONGESTION

CONGESTION (in my terms)

When in one time frame, if two vehicles attempt to pass through a road section able to accommodate one vehicle at that one time frame, congestion occurs if one of the vehicles **fall in queue**. This queue may extend backwards depending on other vehicles joining the road.



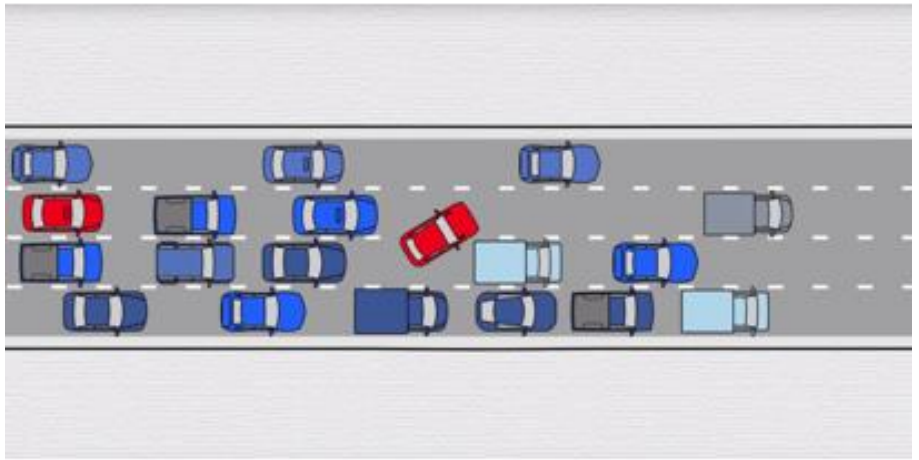
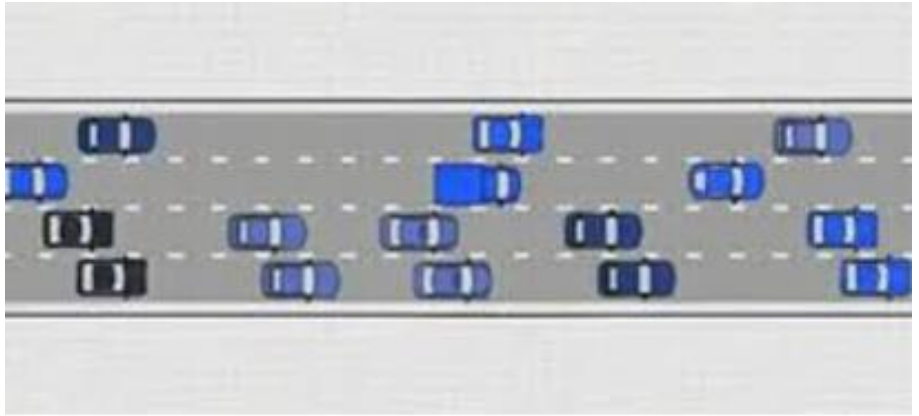


Image: Traffic jams created by merging – https://www.youtube.com/watch?v=2Loi9YyOz4k

MANY-TO-MANY CRASHES

CRASHES (between two vehicles)

When in one time frame, if two vehicles attempt to pass through a road section able to accommodate one vehicle at that one time frame, a crash occurs if one of the vehicles **end up on sharing the same road space at the same time,** stopping, blocking the road passage.



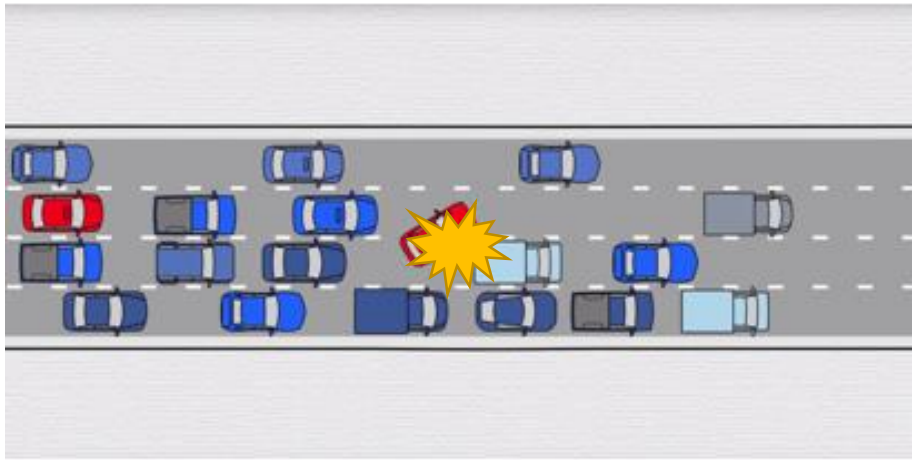


Image: Traffic jams created by merging – https://www.youtube.com/watch?v=2Loi9YyOz4k

FUNDAMENTALS: MANY-TO-MANY CRASH

WHEN THERE IS HEAVY CONGESTION: **NO SPACE FOR COLLISION**

WHEN THE ROAD IS EMPTY: **NO VEHICLE TO COLLIDE WITH**

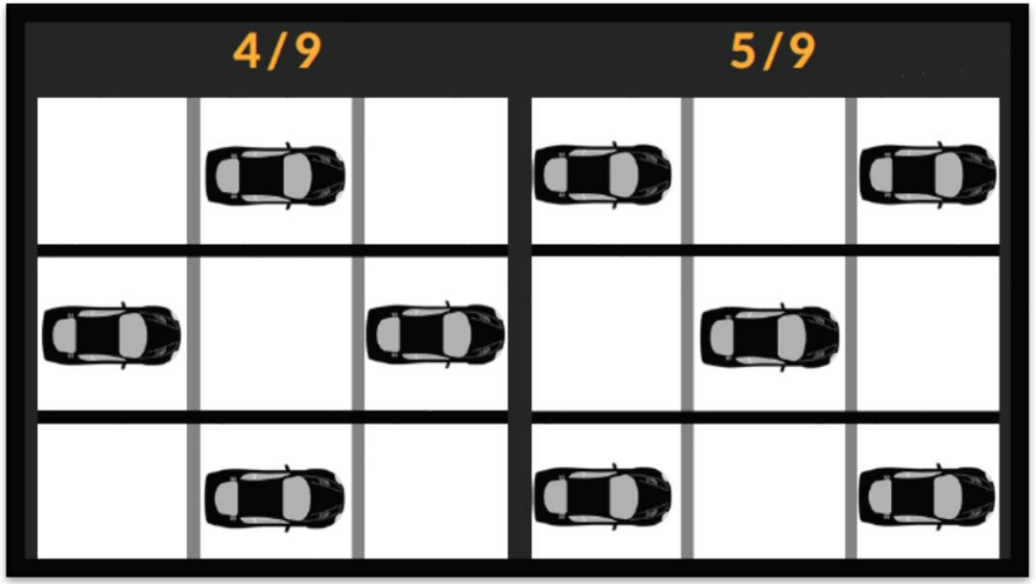
THUS, NON-BOTTLENECK COLLISIONS MUST HAPPEN IN BETWEEN

WHAT MAKES A FLOW CRASH-PRONE, OR ELSE, CRASH-SAFE?

METHODOLOGY: ITS TURKEY SUMMIT 2019

Hypothetical optimal traffic formation: **continuous zipper merge or, checkerboard**

Allowing vehicles to move forward and merge sideways, causing no disruption to the traffic flow.



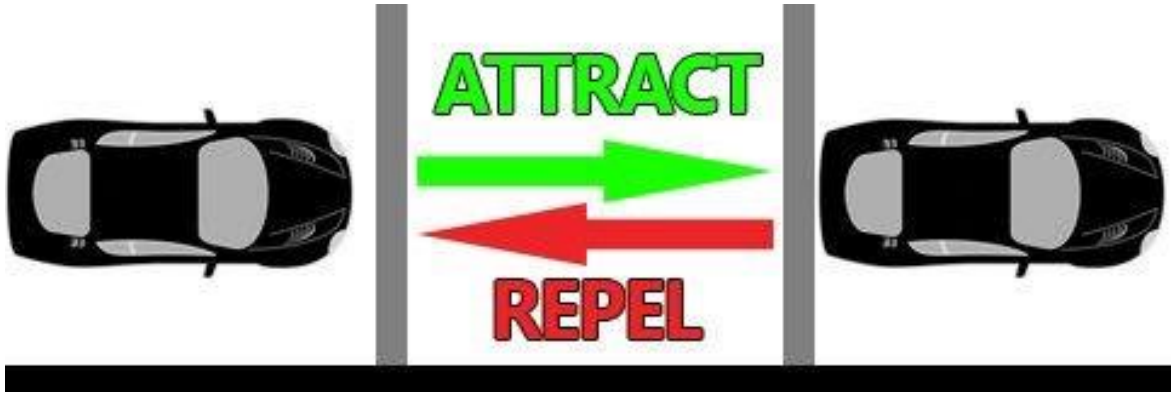
Physics of formation is presented at NECSI ICCS 2020[1], NERCCS 2021[2] [3] conferences on complex systems.

1 - https://www.researchgate.net/publication/348521157_A_2D_Ising_Model_Cellular_Automaton_Mapped_Onto_Catenary_Involute
2 - https://github.com/goktu/ADama
3 - https://goktu.github.io/ADama/pdf/GoktugIslamoglu_NERCCS2021_Presentation.pdf

METHODOLOGY: ZIPPER FLEXIBILITY

Continuous zipper merging can form one empty lane on demand.

This use is reserved for emergency vehicles. Vehicles in side demagnetize the flow: physics in the previous slide.



1 - https://www.reddit.com/r/videos/comments/5zx8ar/drivers_in_germany_form_an_emergency_corridor_on/

COUNTERINTUITIVELY,
CONGESTION AND **CRASHES**
ARE *INTIMATELY*
CORRELATED AND
INTERCONNECTED

- Speeding?
- Rule violations?
- Impaired driving?
- Mechanical failures?
- Road geometry/design?

INFORMS 2018 *PHOENIX, AZ*

Institute for Operations Research and the Management Sciences

SESSION CHAIR

4. ONE-TO-MANY, MANY-TO-MANY IN CITY

Crash focus Istanbul D100 Roadway:

- Spans from European to Asian side, connected by 1st Bridge of Istanbul
- Surrounded by very dense population
- Formerly E-5 highway, lost highway status :
  - Bus-Rapid Transit (Metrobüs) protected road built in 2011, both shrunk the lane width and occupied one lane on each direction
  - Entry into highway not managed exclusively through access roads, especially near airport
  - Highway travel speeds not maintained

Dataset: Istanbul Municipality's Transport Management Center Twitter: Dec 2016 - Mar 2017[1]

Outdated Data: In the above time period, Istanbul Ataturk Airport was still operational. On April 2019, the decommissioning of Ataturk Airport greatly altered the traffic conditions.

1 - https://twitter.com/4444154, Twitter API

4. ONE-TO-MANY MONDAY MORNING CRASH

D100 KUCUKCEKMECE BOTTLENECK CRASHES ON MONDAY MORNINGS

Hour Range	Mon
3	1
5	2
7	4
8	4
10	1
11	1
12	4
13	2
14	1
15	1
16	1
18	2
19	2
20	1

Insurance Information and Monitoring Center (SBM): In 2014, highest number crashes happened on Mondays in Istanbul[1].

REST OF ISTANBUL PROPER CRASHES ON MONDAY MORNINGS

3	2
4	4
5	7
6	9
7	13
8	5
9	6
10	7
11	3
12	5
13	9
14	1
15	4
16	3
17	5
18	3
19	1
20	1

D100 Küçükçekmece crashes on **Monday** **08.00** and **12.00** are **disproportionately high** compared to the rest of three-months dataset.

1 - https://www.wsj.com/articles/trafikte-pazartesi-sendromu-1405253239

D100 ROADWAY
MORNING CRASHES
08:00-12:00
CONCENTRIC

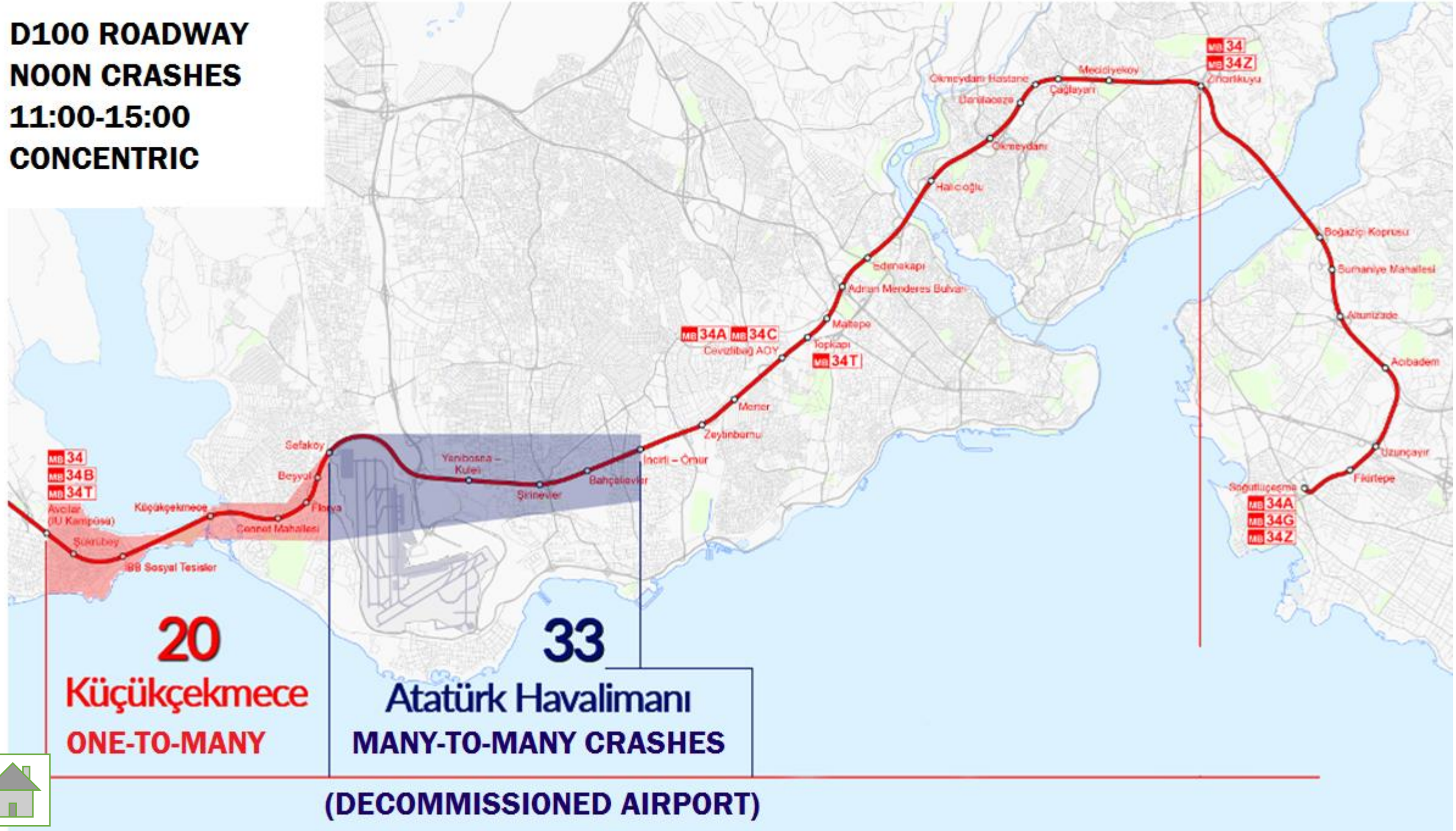
20

Küçükçekmece

ONE-TO-MANY CRASHES

(LAKE BOTTLENECK)

D100 ROADWAY
NOON CRASHES
11:00-15:00
CONCENTRIC



D100 ROADWAY
DAY-LONG CRASHES
11:00-22:00
SPREAD-OUT

20
Küçükçekmece
ONE-TO-MANY

33
Atatürk Havalimanı
MANY-TO-MANY (AIRPORT)

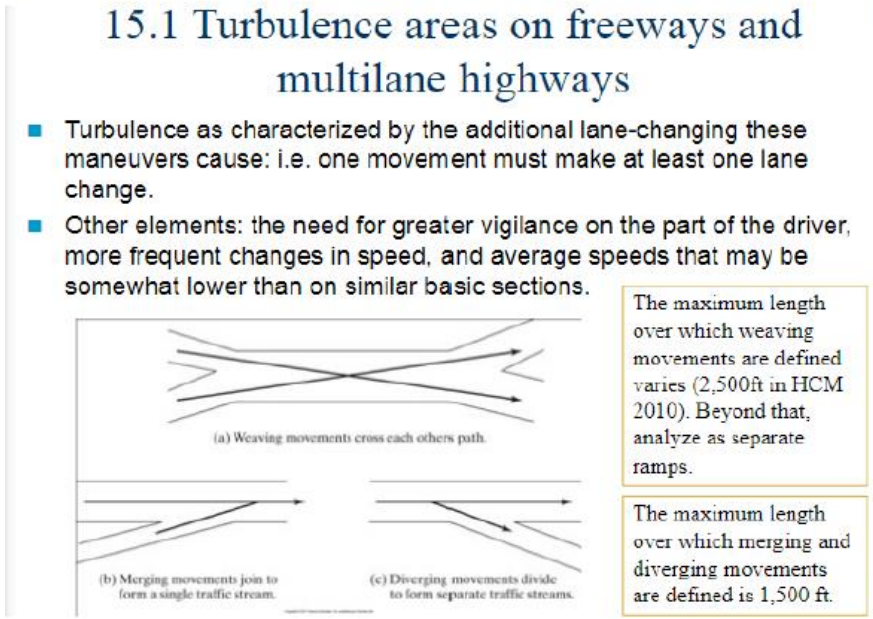
29
15 Temmuz Şehitler Köprüsü
ONE-TO-MANY (BOTTLENECK)

MANY-TO-MANY (BRIDGE DEMAND)

5. FAULTY DESIGN AMPLIFYING CRASHES

D100 roadway in the now decommissioned Ataturk Airport area:

- Squeezed by BRT road on one side
- Squeezed by side road on the other side
- No access road to former highway D100, weave lane



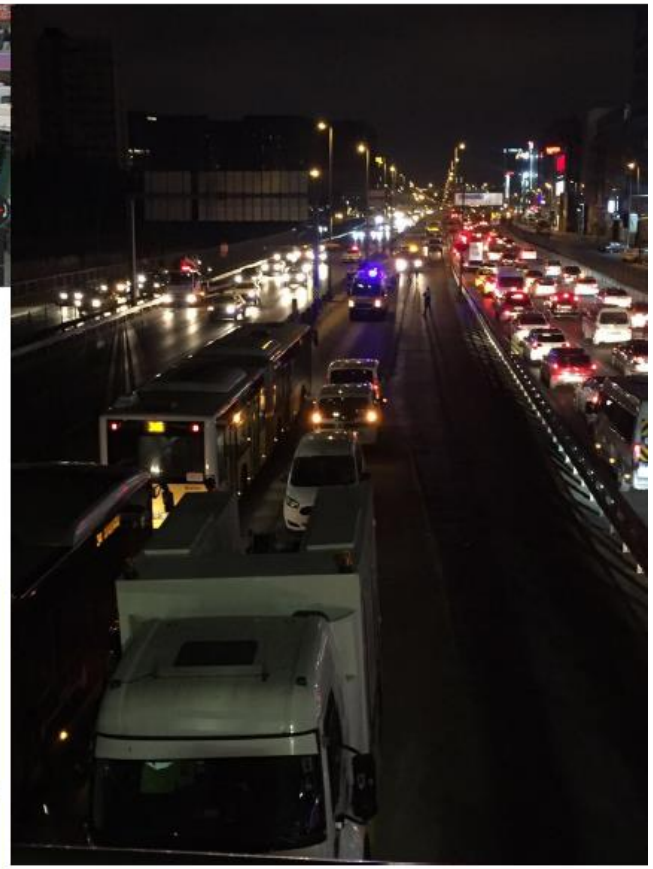
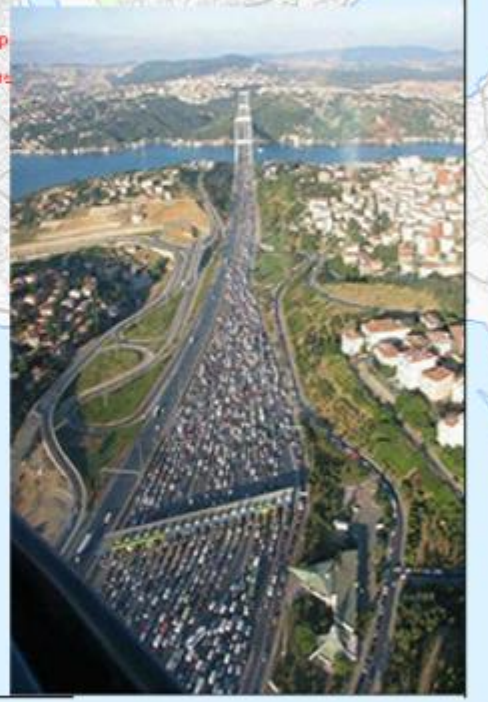


Photo 1 - Google Maps Street View – Şirinevler D100 Roadway and Side Road, Joining Ahead Without Access Road
Photo 2 – Goktug Islamoglu, Taken en Route to Airport, Şirinevler Metrobüs Stop. BRT Operations Stopped Due to Car Entering Protected Road
Image 1 - Traffic Engineering, Roger P. Roess / Elena S. Prassas / William R. McShane, Prentice Hall, Pearson .

PERSONALLY WITNESSED
CRASH: 30.05.2017 03:00

2017 - 6/7 ENTRIES OF VEHICLES INTO BRT ROAD
MERTER-SEFAKÖY AREA



MB 34 MB 34B MB 34T
Avcılar (İÜ Kampüsü)
Şükrübey
BB Sosyal Tesisler
Küçükçekmece
Cennet Mahallesi
Florya
Beşyol
Sefaköy
1
Yenibosna – Kuleli
Şirinevler
2
3
Bahçelievler
İncirli – Çınar
4
Merter
Zeytinburnu
5
MB 34A MB 34C
Cevizlibağ AOY
Topkapı
MB 34T
Maltepe
Edirnekapı
Adnan Menderes
Halıcıoğlu
Ökmeydanı
Ökmeydanı Hastane
Darülaceze
Çağlayan
Mecidiyeköy
MB 34 MB 34Z
Zincirlikuyu
Boğaziçi Köprüsü
Sarıyer
Sarıyer Mahallesi
Altunizade
Acıbadem
Uzunçayır
Fikirtepe
Söğütlüçeşme
MB 34A MB 34G MB 34Z

20
Küçükçekmece
ONE-TO-MANY

33
Atatürk Havalimanı
MANY-TO-MANY (AIRPORT)

29
15 Temmuz Şehitler Köprüsü
ONE-TO-MANY & MANY-TO-MANY

5. BRT CRASH – VEHICLE ENTRY INTO ROAD

Kadıköy accident is the lone outlier, which was a cement truck crashing into BRT road barriers.

DURAK	1	8	13	17	22	Total
Atakoy	1					1
Bahçelievler					1	1
Cevizlibağ Sefaköy	1					1
Incirli	1					1
Kadıköy		1				1
Küçükçekmece Sefaköy			1			1
Merter				1		1
Total	**2**	**1**	**1**	**1**	**1**	**7**

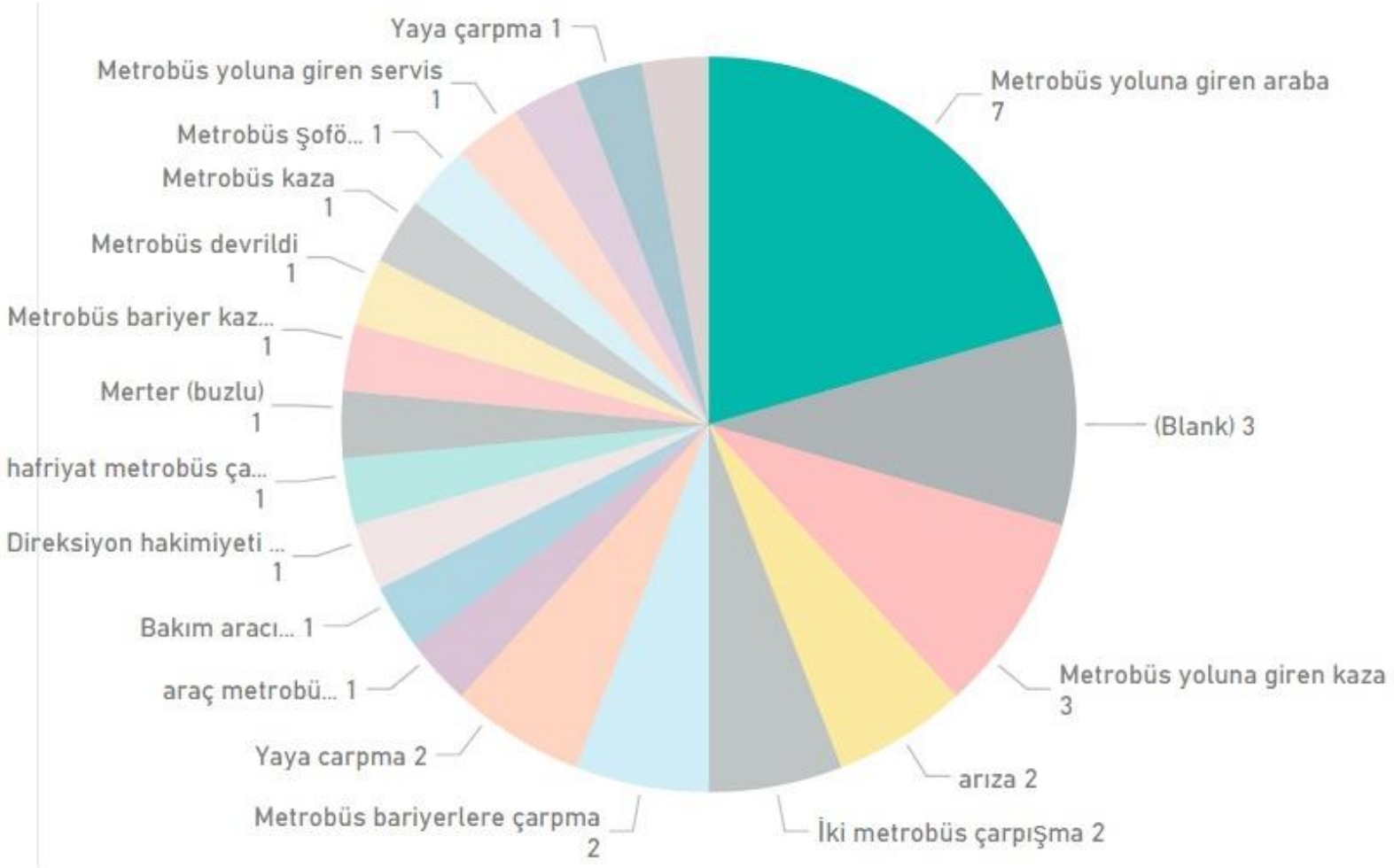


Image 1, 2 – Twitter Search Results for Istanbul Metrobus Line Accidents, 2017

5. MANY-TO-MANY FRIDAY EVENING CRASHES

İncirli lies within Merter-Sefaköy section of D100 roadway. In the 3 month dataset, Friday evening crashes concentrated in D100 İncirli, almost as dense as the rest of the city roads combined.

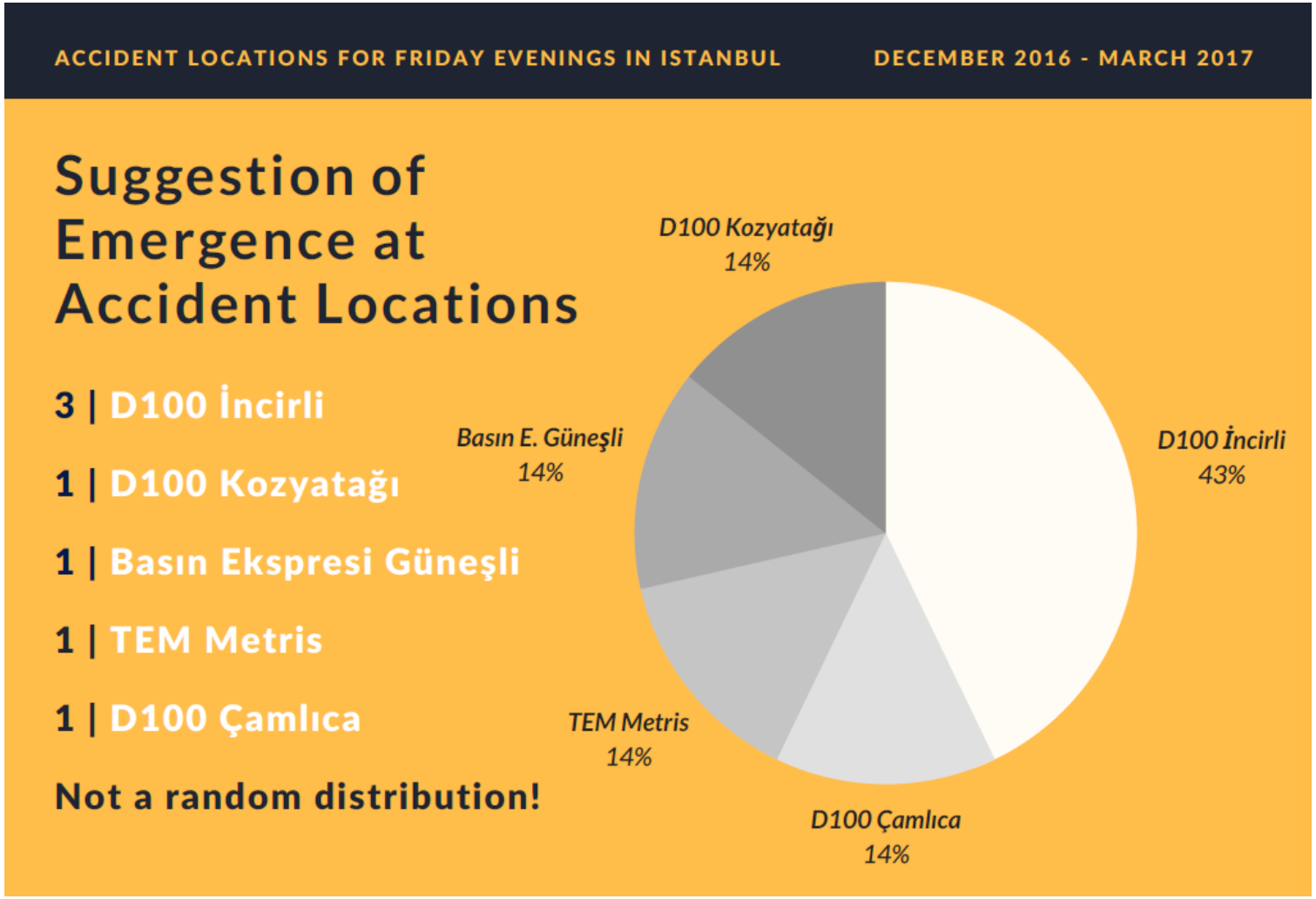


Image 1 – Istanbul Municipality Transportation Management Center Twitter Announcement, Twitter API, December 2016 - March 2017

5. FRIDAY EVENING CRASH PREDICTIONS

Repeating crashes in retrospect, predictions were successfully made 7/9 times, 2 misses due to road repairs & congestion. İETT, Istanbul's public transit firm, held an hackathon 03.11.2017 Friday. There, I predicted a crash for that night in D100 İncirli; two occured.

Image 1 - Twitter Account @Pamirsk, Crash Predictions on Many-to-Many Critical Region in Istanbul

6. DEMAND BASED CRASH PERSPECTIVE

At this point, we've shown that:

- D100 İncirli – Ataturk Airport roadway was an hotspot for many-to-many crashes
- There have been repeating crash types unique to this roadway
- Bottlenecks, both geographical and those created by poor design, funnel vehicles causing rear-ending crashes at either by breaking, or accelerating too rapidly.

After establishing crash types, I will identify the suspect behind these crashes, both locally and globally.

Demand: Following slides will show the dramatic drop in congestion and crashes, by the decommissioning of Ataturk Airport, and the 2019 crisis. Traffic is a product of demand.

6. CRASHES PRODUCT OF AIRPORT DEMAND

D100 İNCİRLİ PRE-DECOMMISSIONING CRASHES AND CONGESTION ALERTS

Three weeks before:

29 traffic congestion alerts

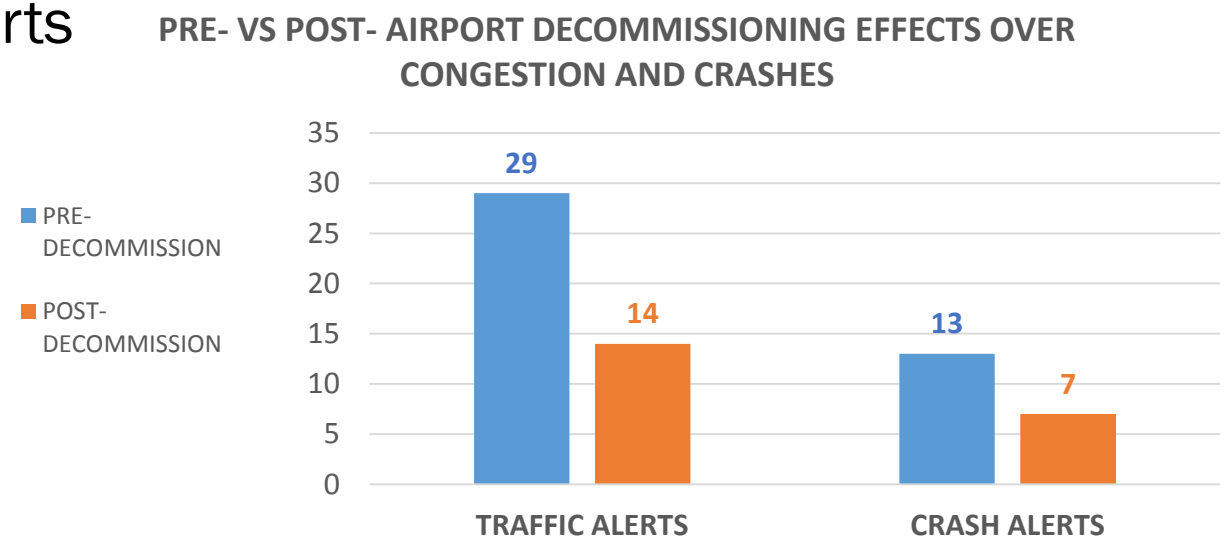
13 crash alerts

D100 İNCİRLİ POST-DECOMMISSIONING CRASHES AND CONGESTION ALERTS

Three weeks after:

14 traffic congestion alerts (**-52%**)

7 crash alerts (**-46%**)

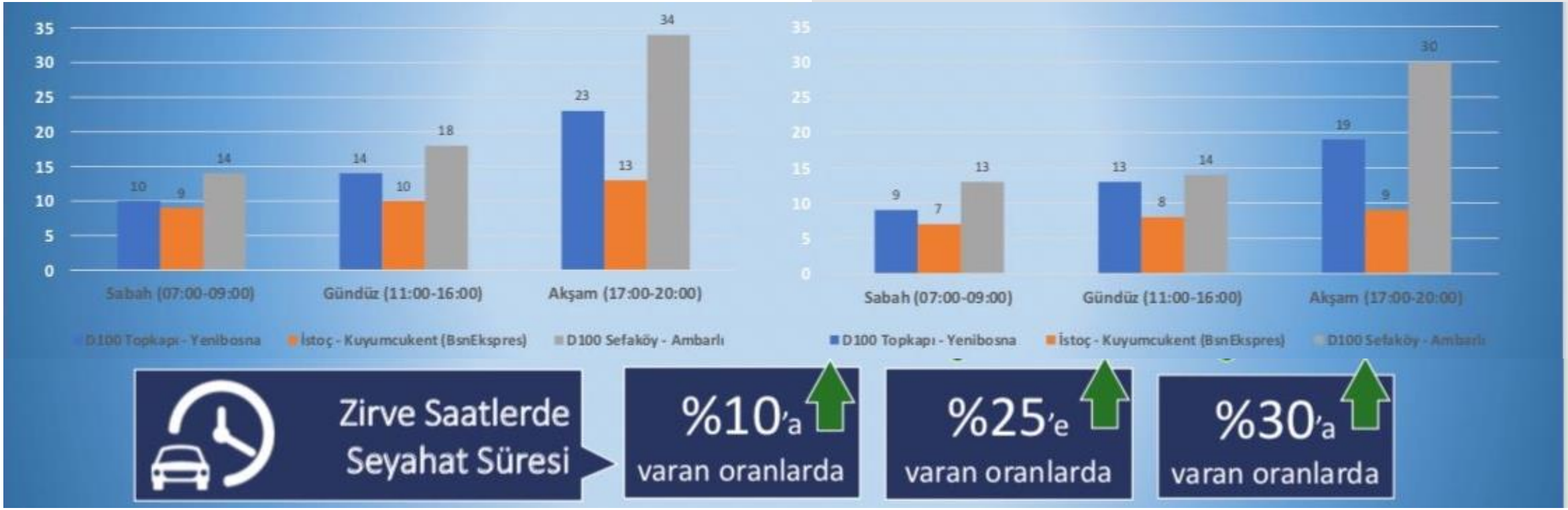


Alerts – Istanbul Municipality Transportation Management Center Twitter Announcement, Twitter Search, March 2019 - April 2019

6. AIRPORT CONGESTION IMPROVEMENTS

AIRPORT PRE-DECOMMISSIONING PEAK HOURS TRAVEL TIME REPORT

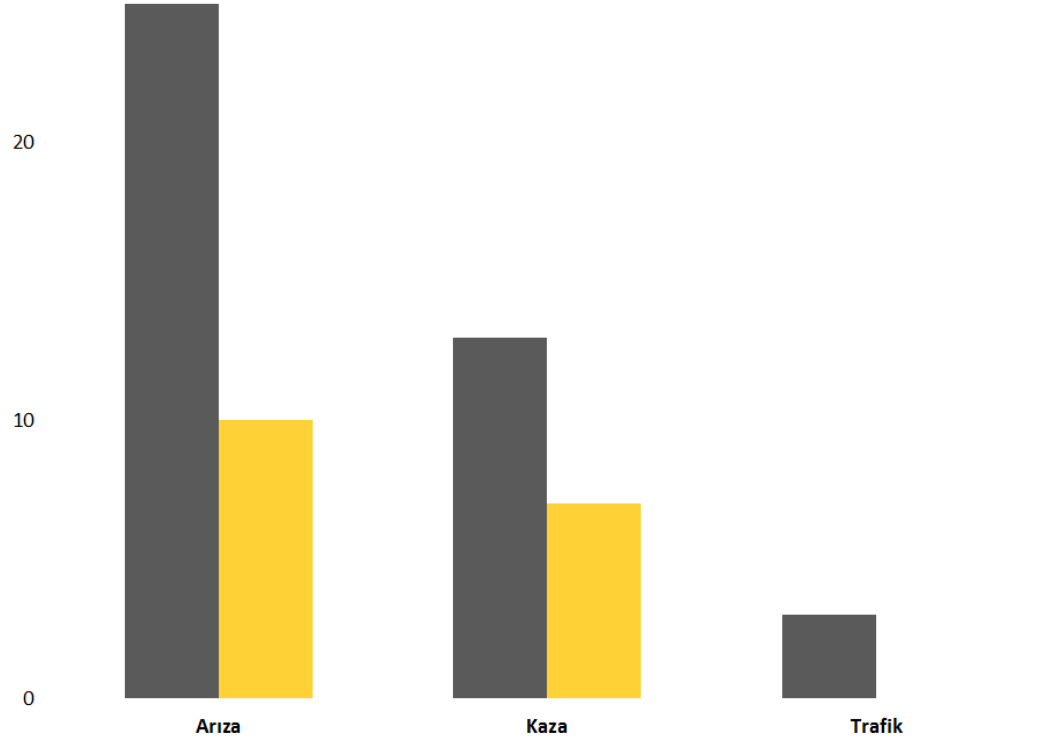
AIRPORT POST-DECOMMISSIONING PEAK HOURS TRAVEL TIME REPORT



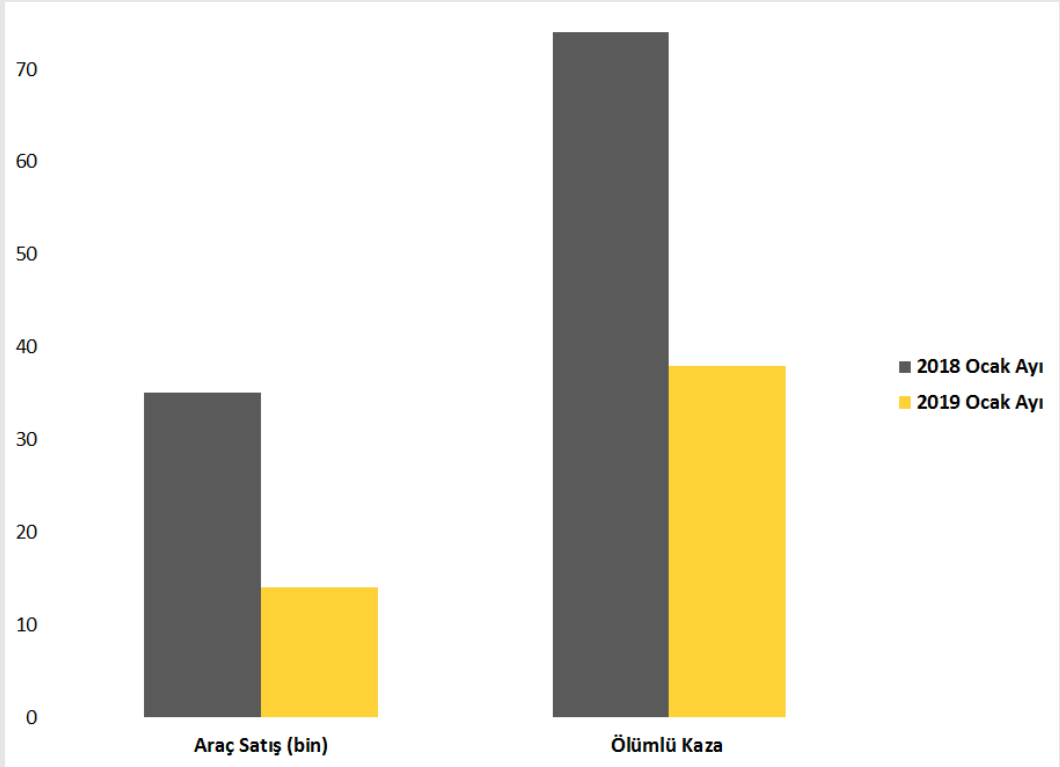
Report – Istanbul Metropolitan Municipality, 10% Morning Improvements, 25% Noon Improvements, 30% Evening Improvements

7. DEMAND-CRASH LINEAR RELATIONSHIP

2018-19 JANUARY VEHICLE SALES DROPS IN CRASHES AND BREAKDOWNS



2018-2019 JANUARY VEHICLE SALES DROPS IN SALES AND FATALITIES

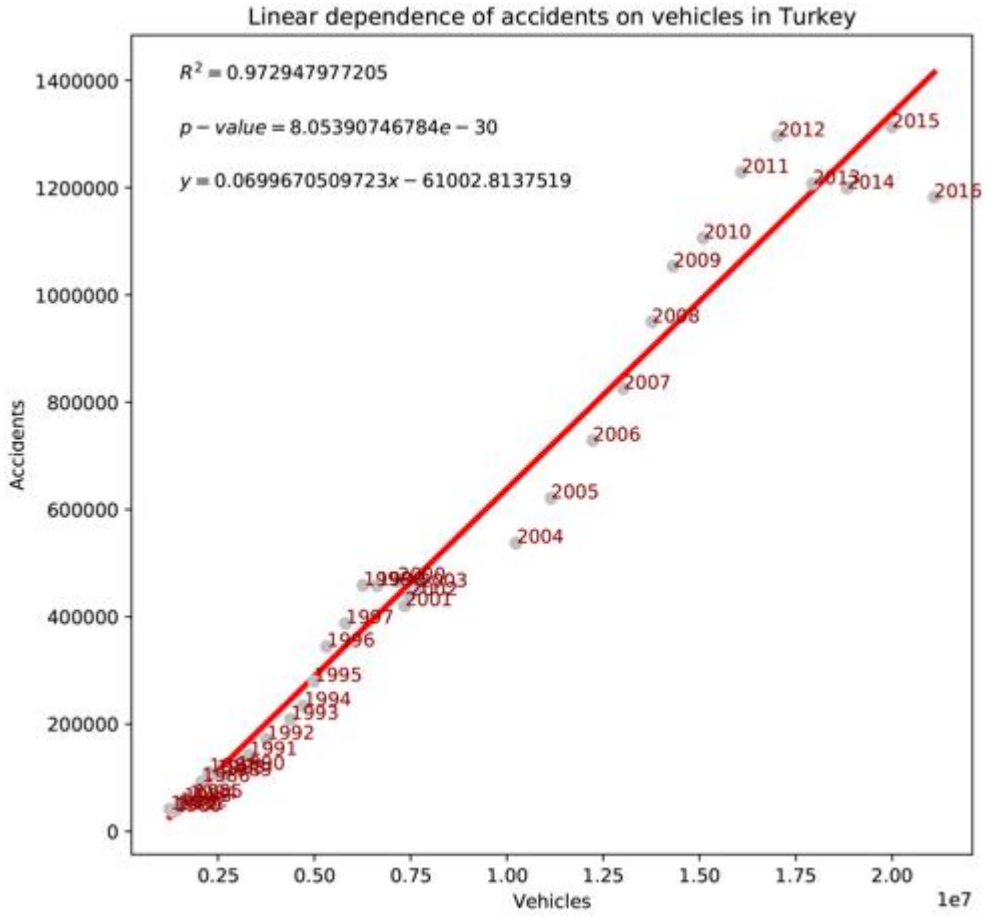


Alerts – Istanbul Municipality Transportation Management Center Twitter Announcement, Twitter Search, January 2018; January 2019
Drops in Automobile Sales in January 2019 - https://alemicihan.com/post/182556630096/2019-ocak-ayi-otomobil-satislarinda-buyuk-dusus-yasandi

7. TURKEY VEHICLES VS CRASHES GRAPH

As registered vehicles have risen annually in Turkey, crashes have also risen proportionally. The 0.97 R^2 value is the indicator of this linearity.

However, there is also an expanding spiral that shows there is an additional property beyond linearity.



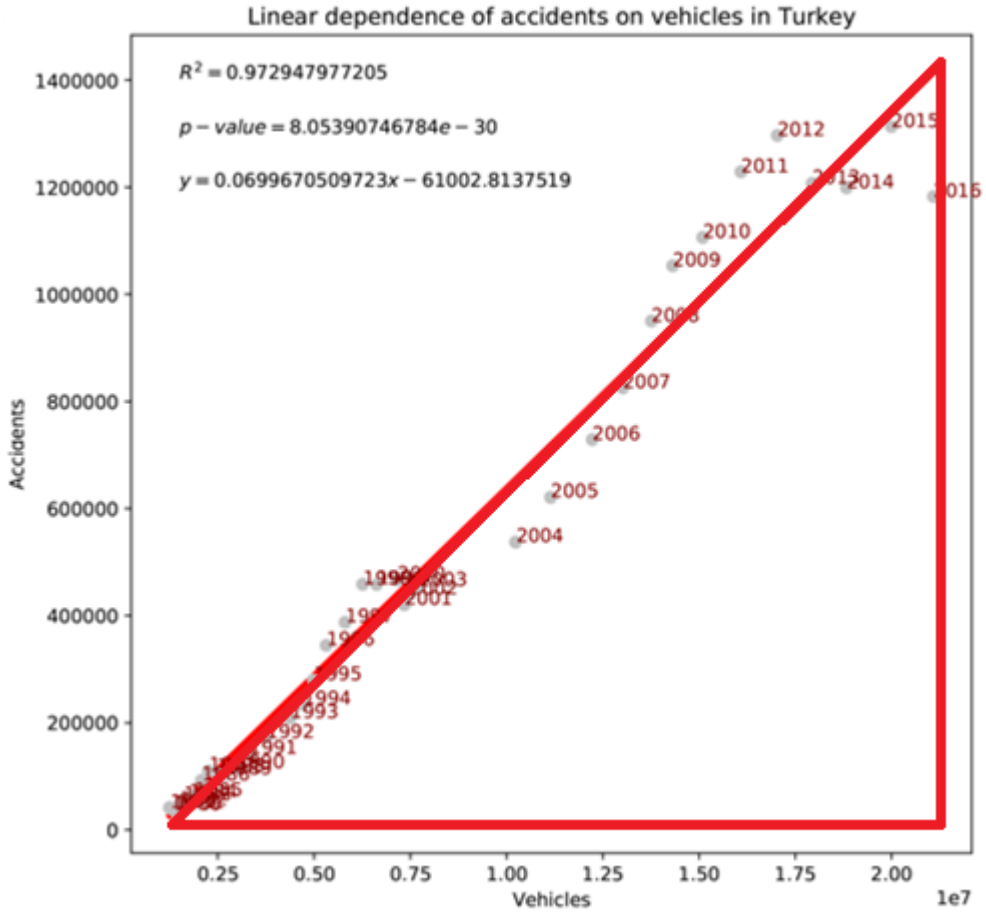
Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1988 - 2016

7. TURKEY ONE-TO-MANY CRASHES GRAPH

LINEAR CRASHES

More vehicles causing more crashes is a counterintuitive property of traffic flow. More vehicles should lead to congestion, which should decrease crashes. Yet, as explained before, the opposite is the case.

One-to-many corresponds with linearity. Early morning crashes at bottlenecks is a clear indicator of heavy traffic demand.



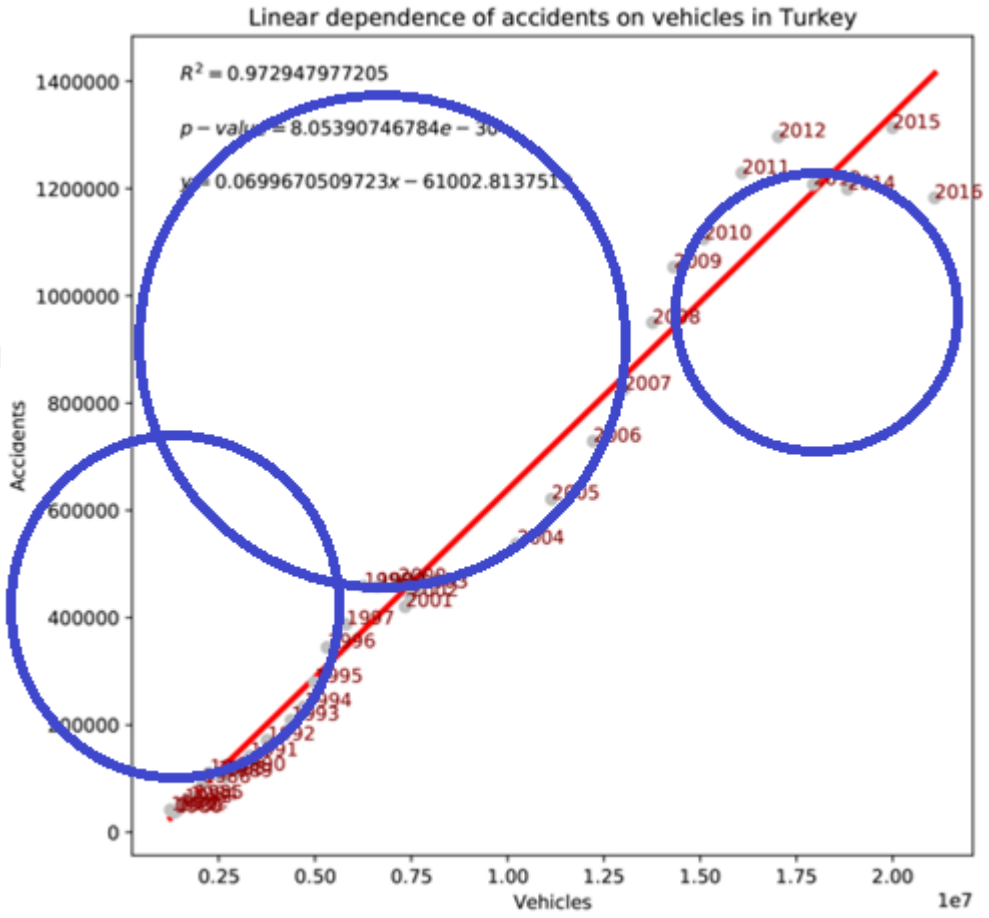
Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1988 - 2016

7. TURKEY MANY-TO-MANY CRASHES GRAPH

NONLINEAR CRASHES

The spiraling distribution of accidents is not very easy to quantifiably explain. Although certain economic downturns can be pinpointed (2001 economic crisis), the overall behavior of the graph is at the first glance not clearly visible.

To capture the driving force, a breakdown will be applied on city and vehicle scales.



Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1988 - 2016

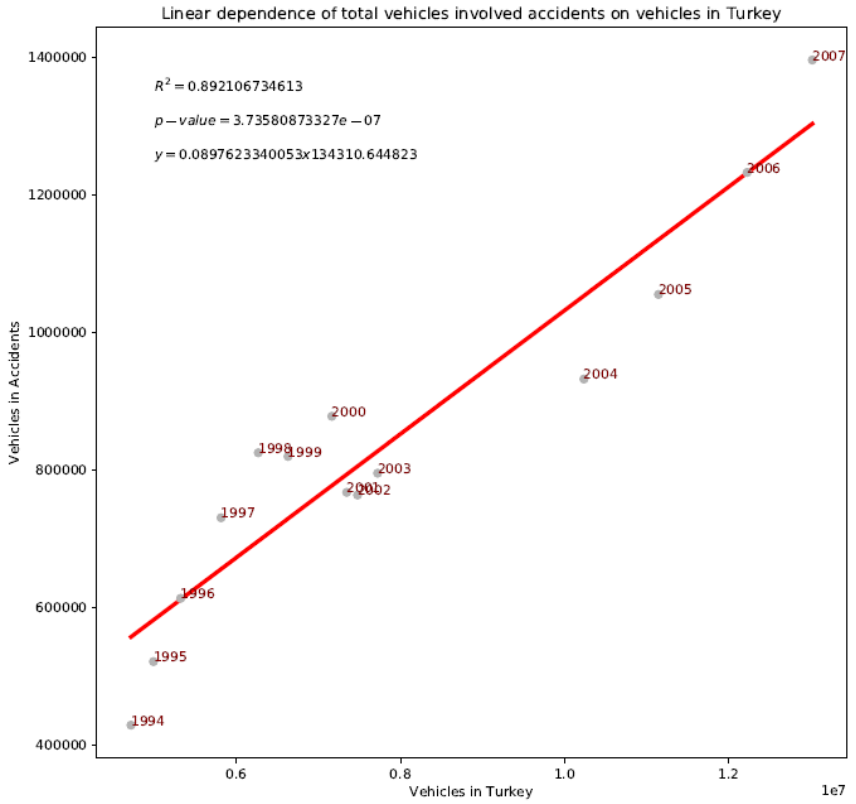
8. NONLINEAR CRASHES PER VEHICLE TYPE

CITY AND VEHICLE SCALE DOWN

Turkish Statistical Institute's crash data per vehicle type and city is limited to 1994-2007. For total crashes, graph on the right is given.

I have first scaled down crashes by municipal metropolitan cities, then by vehicle types.

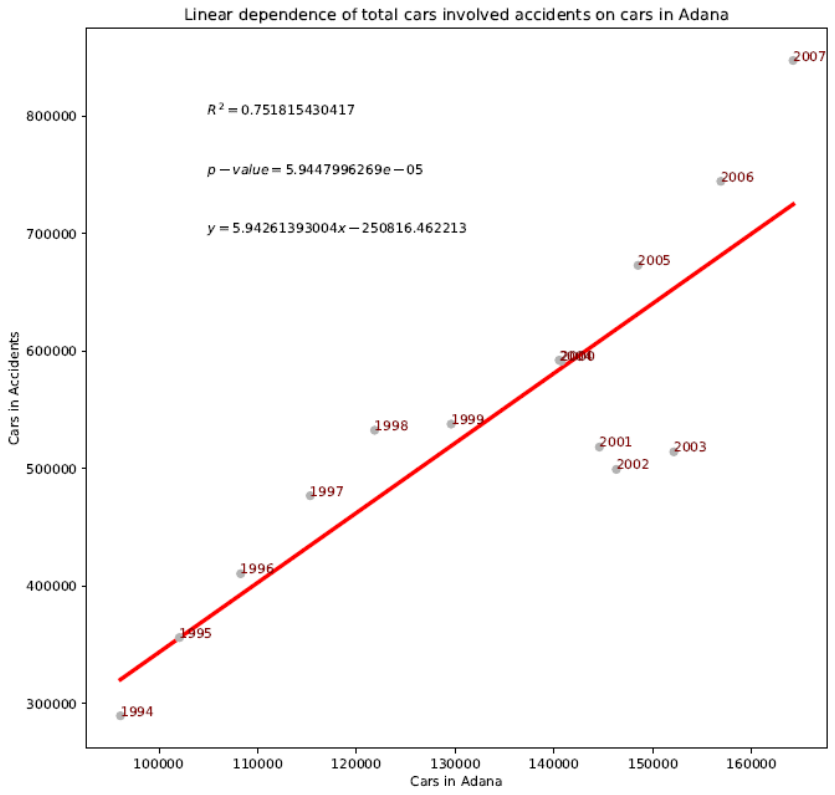
Only vehicle type to maintain this symmetry must be the driving force behind crashes.



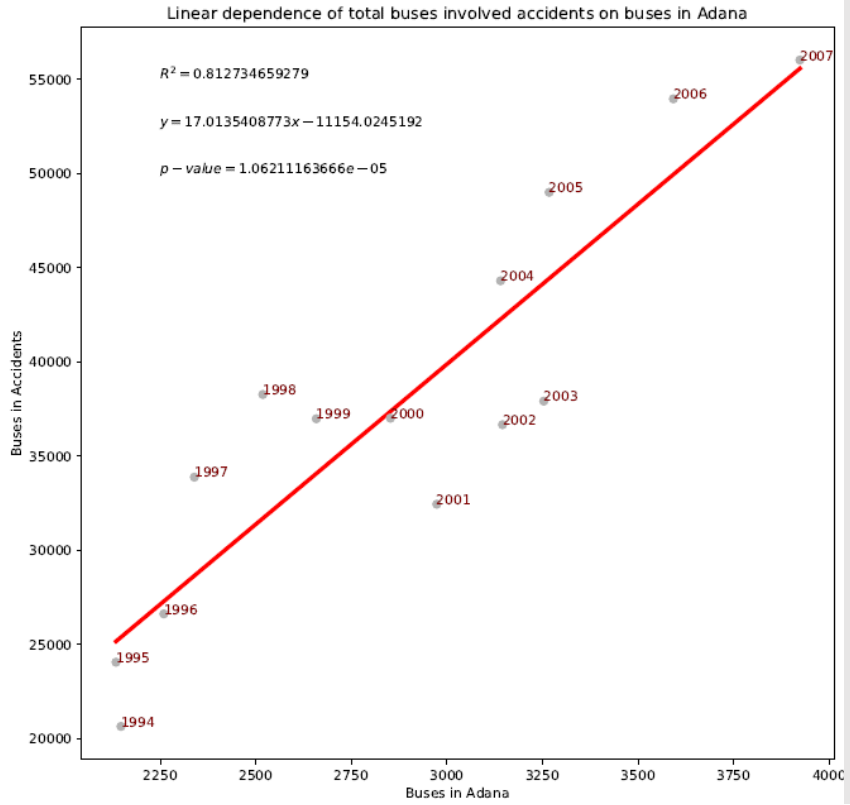
Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1994 - 2007

8. SYMMETRY BREAKDOWN: CAR & BUSES

CAR SYMMETRY BREAKDOWN



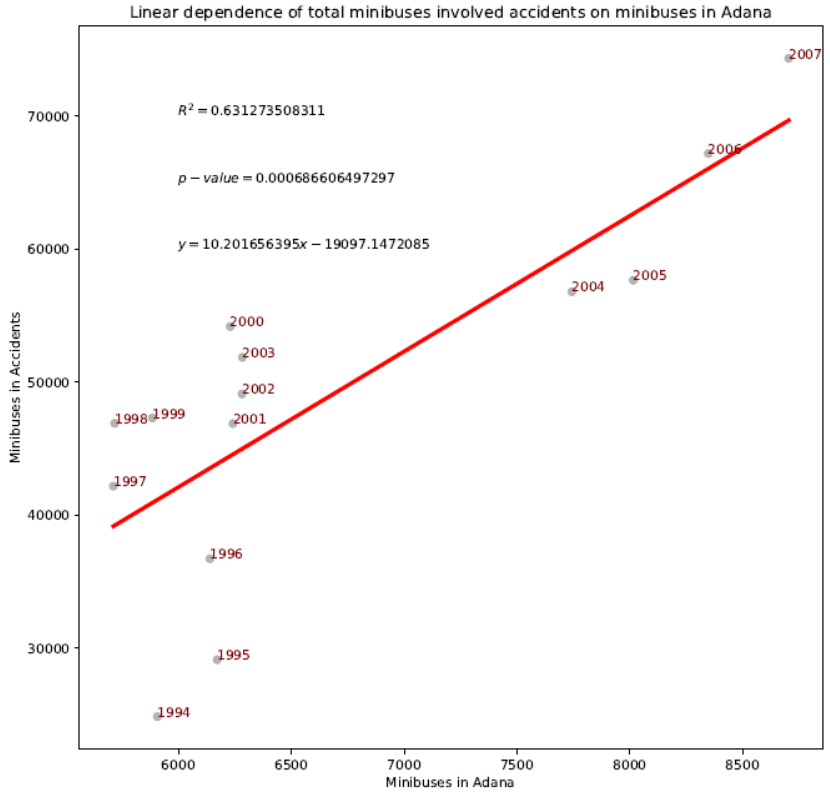
BUS SYMMETRY BREAKDOWN



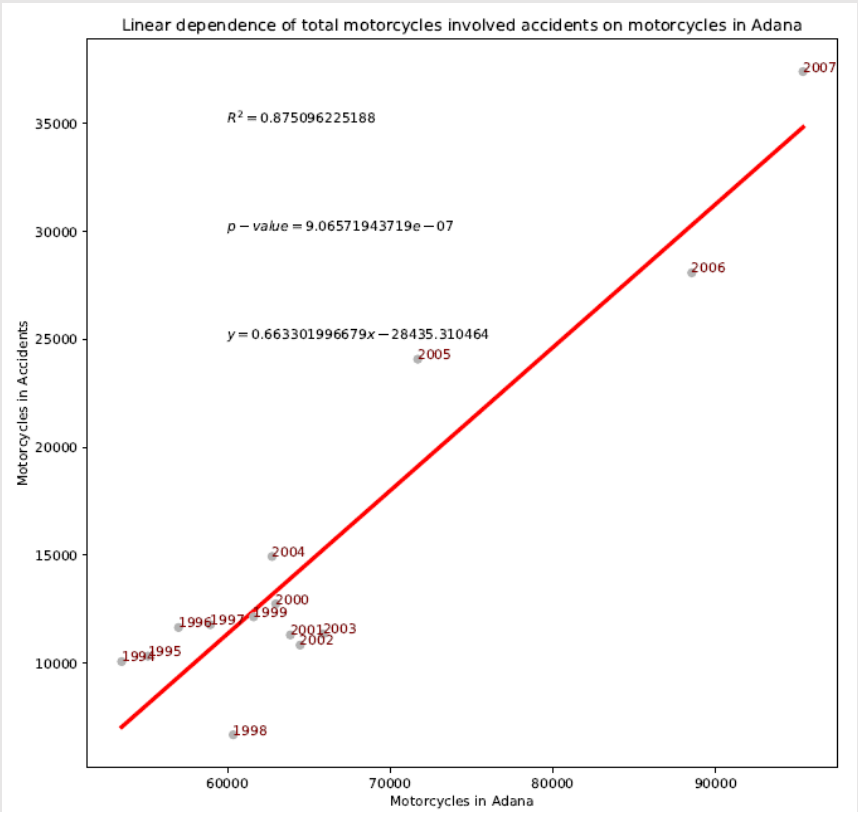
Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1994 - 2007

8. MINIBUSES & MOTORCYCLES

MINIBUS SYMMETRY BREAKDOWN



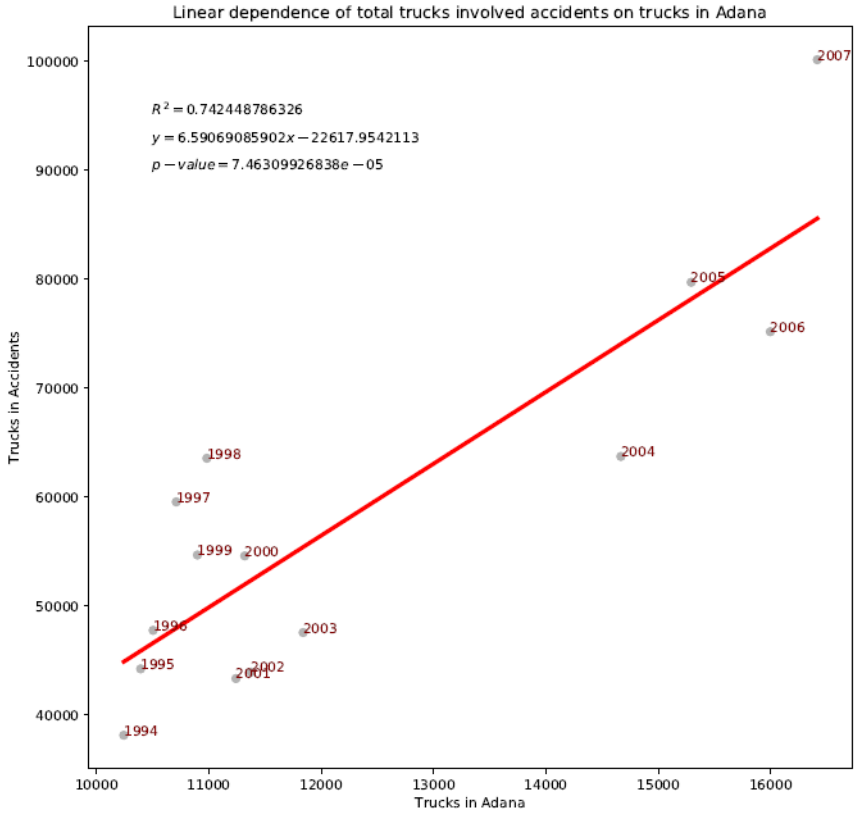
MOTORCYCLE SYMMETRY BREAKDOWN



Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1994 - 2007

8. TRUCKS & EMERGENT PATTERNS

TRUCK SYMMETRY BREAKDOWN



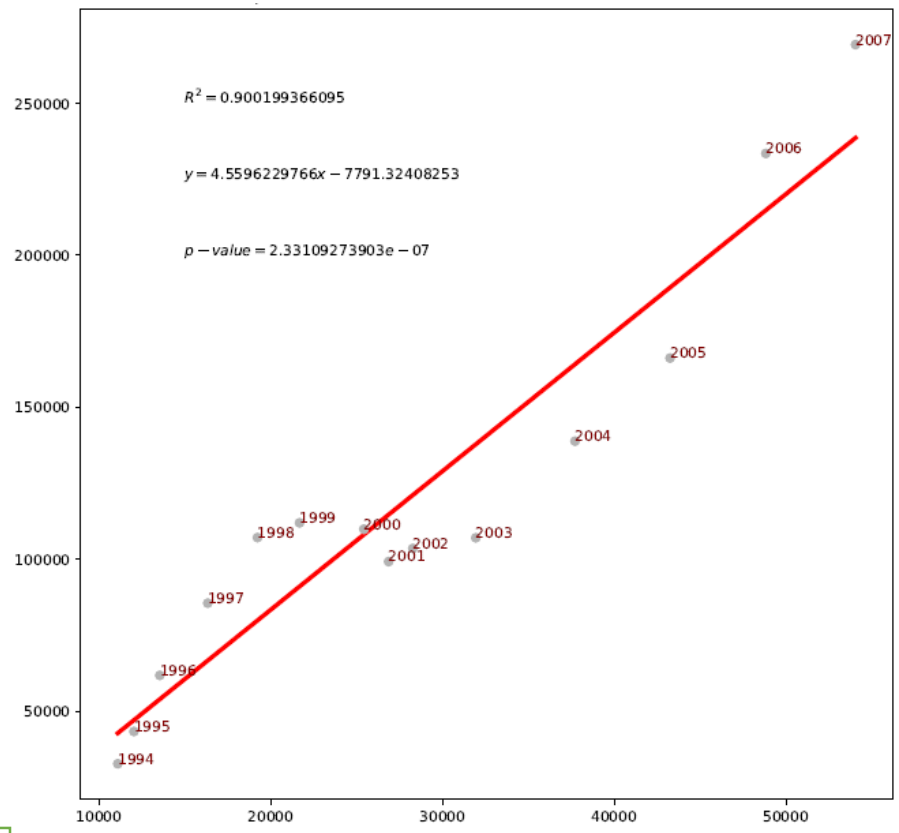
Cars, buses, minibuses, motorcycles and trucks immediately lose the crash symmetry even only in Adana.

Emergence: There is one vehicle type that maintains the underlying crash symmetry for each city. That vehicle has a higher proponence to cause crashes than nominality.

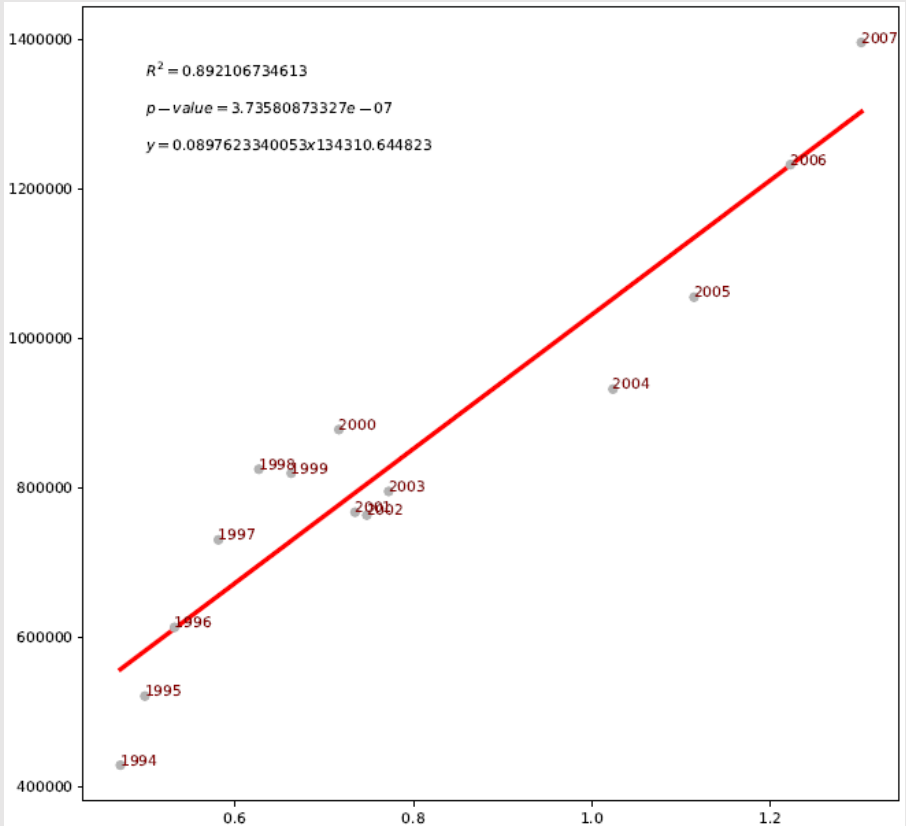
Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1994 - 2007

8. EMERGENCE: LIGHT TRUCKS / LCVs

LCV SYMMETRY IN ADANA



TOTAL VEHICLES SYMMETRY IN TURKEY



Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1994 - 2007

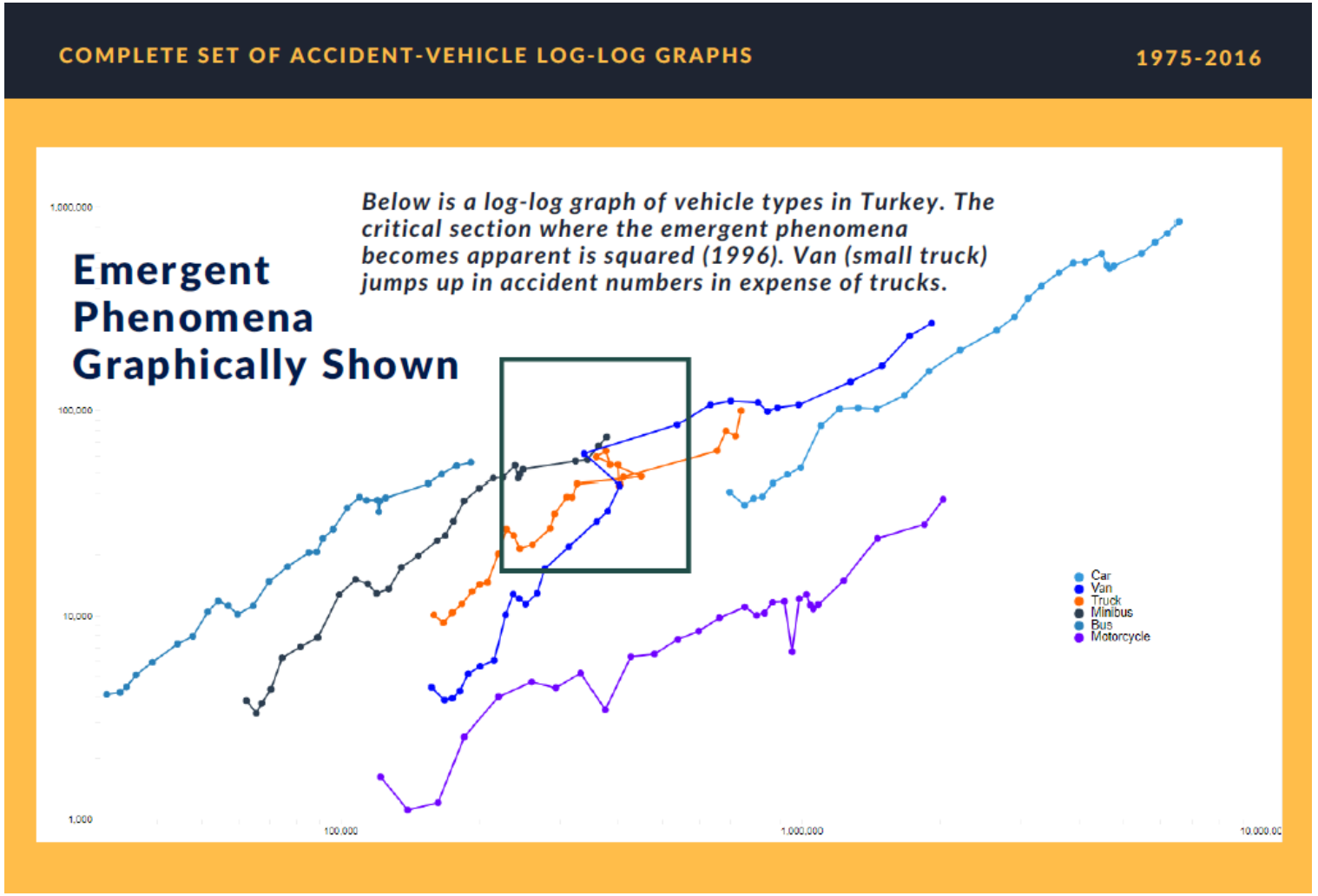
ITS SUMMIT 2019 *ANKARA, TURKEY*

Association of Intelligent Transportation Systems

AUSDER

9. INCREASED CRASH WEIGHT OF LCVs

On the log-log graph of all vehicle types in Turkey, vans (LCVs) appear to take over the trucks in the year 1996. This is in fact in the narrow streets of Turkish cities, LCVs are more maneuverable and better suited for the SME dominant Turkish market.



Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1994 - 2007

9. SCHOOL SHUTTLE PHENOMENON

Crash multiplier effect of LCV and shuttles may not be apparent, but school shuttle role in travel delays is notorious for Istanbulites.

Right: jams start 10 mins earlier

Personal: my late shuttle driver had the habit of cheating into a queue, sizing over smaller cars and blocking the lane behind.

Shuttles and LCVs

Shuttles are the dominant mode for commute. School shuttles are notorious for worsening Istanbul's traffic once the school term begins.

Beylerbeyi Winter Morning Traffic 2017 (Side Road to 1st Bridge):

SCHOOL DAY CONGESTION	06:57 MON
SCHOOL DAY FREE FLOW	06:47 MON
SCHOOL BREAK FREE FLOW	06:57 MON

Data: Goktug Islamoglu, Public Transportation Travel Time Collection en Route to Shuttle Boarding, 2017

9. LIGHT, COMMERCIAL: FAST AND BIG

Shuttles and LCVs have a wide coverage of the city, with their smaller size compared to trucks, yet still towering over cars, while being as nimble as them.
This leads to more crashes than expected, considering LCVs and cars are the two most commonly owned vehicle types in Turkey.

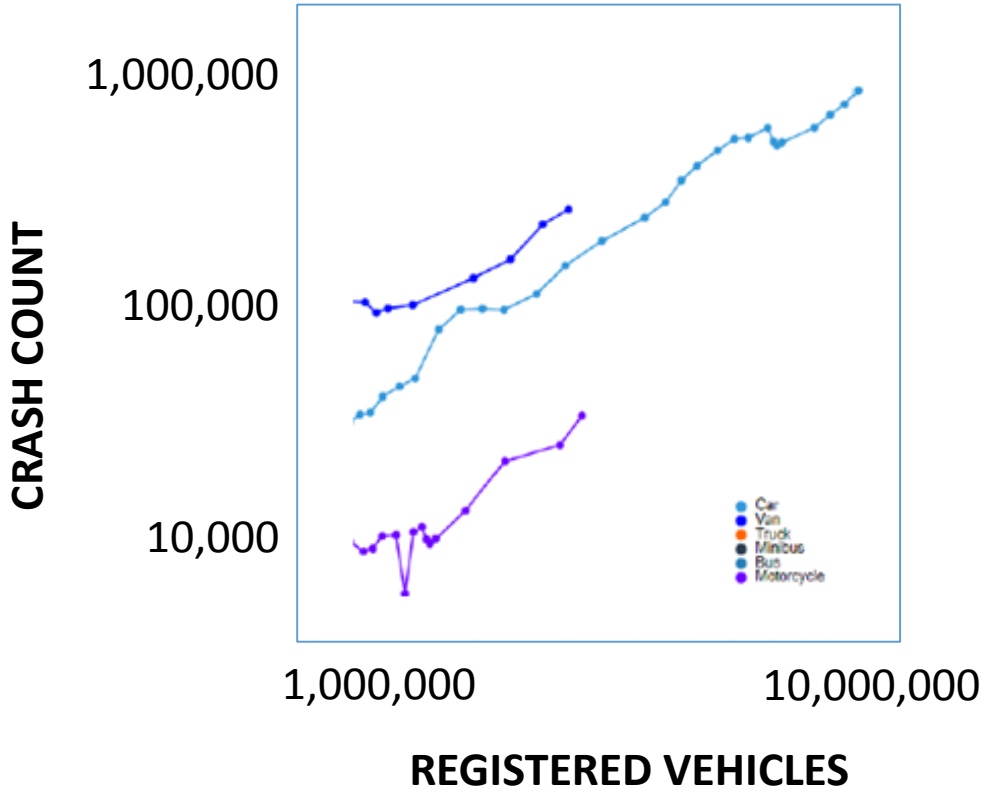


Figure: Snapshot of Accident-Vehicle Log-Log Graph
Top Corner Highlights Most Popular Vehicles and Highest Crashes

Snapshot of Accident-Vehicle Log-Log Graph. Data: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1994 - 2007

TRUCKS: A CONCERN FOR CAR DRIVERS

Light-Commercial and Heavy Vehicles: **HIGHER CRASH %**

In Küçükçekmece Bottleneck: **21% OF THE ROAD USERS**[1]

REMEMBER, TRAFFIC IS COUNTERINTUITIVE.

ROAD SHARED WITH HEAVY VEHICLES: CAR DRIVERS OFTEN OVERTAKE

LESS MANY-TO-MANY CRASHES

1 - General Directorate of Highways (KGM): Annual Report

LCVs: CAR DRIVERS BECOME RELAXED

In Ataturk Airport-D100 İncirli Roadway: **7% OF THE ROAD USERS**[1]

ROAD SHARED WITH LCVs: NOT EASY TO OVERTAKE LCVs

MORE MANY-TO-MANY CRASHES AT BUSINESS HOURS

BUSINESS HOURS = PEAK LCV OPERATIONAL HOURS

SBM[2] **ISTANBUL MOST FREQUENT CRASH HOURS IN 2014: 12.00-13.00**

1 - General Directorate of Highways (KGM): Annual Report
2 - https://www.wsj.com/articles/trafikte-pazartesi-sendromu-1405253239

CAR AND LCV-ONLY BRIDGE ADMISSION

BOSPHORUS BRIDGE: **7% HEAVY VEHICLES**[1]

Cars, LCVs, Public Transit only

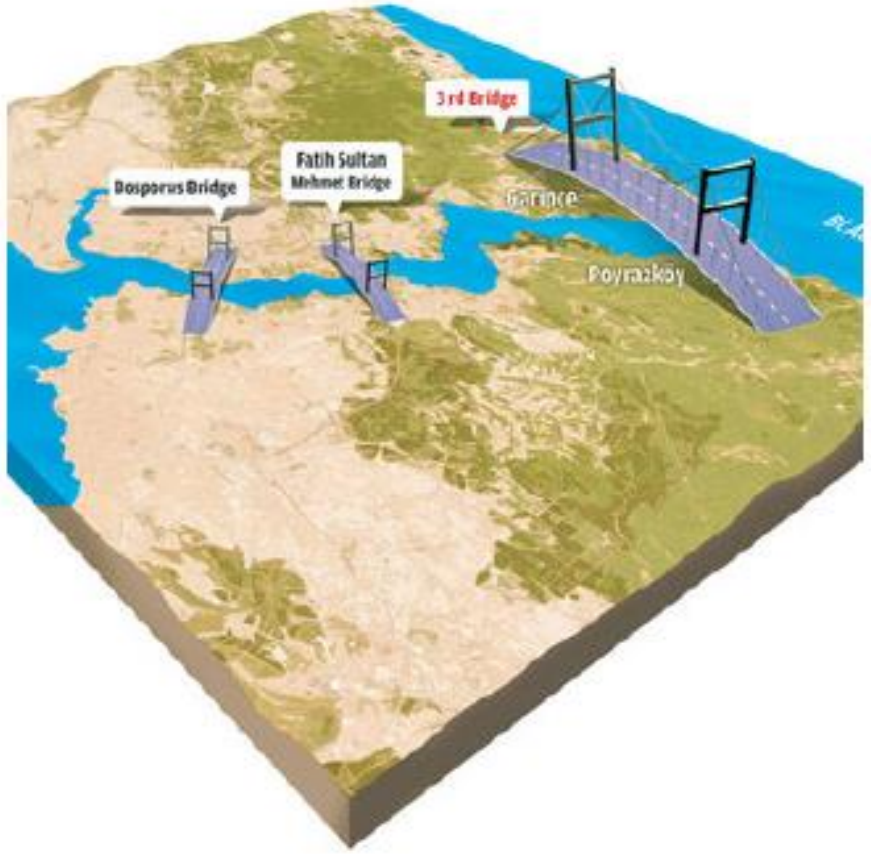
FATIH SULTAN MEHMET BRIDGE:

Vans and Small Trucks + Above

NEW 3RD BRIDGE (YAVUZ SULTAN SELIM):

Long Chassis Vehicles + Above

[1] THE REASON WHY MANY-TO-MANY CRASHES HAPPEN AT BOSPHORUS BRIDGE BOTTLENECK



1 - General Directorate of Highways (KGM): Annual Report

COUNTERINTUITIVELY,
AS **HANS MONDERMAN** STATED,
UNCOMFORTABLE DRIVERS
ARE *ATTENTIVE TO ROAD*
AND *MAKE LESS CRASHES*

9. LIGHT TRUCKS: US VERSION OF LCVs

Being the *New World,* US city planners had less restrictions in city development compared to ancient cities like Istanbul. One from Europe would find US roads, lanes, and thus the vehicles much wider.

With the ample space, it is not surprising that light truck sales have been on top of the US auto sales market since 2015[1].

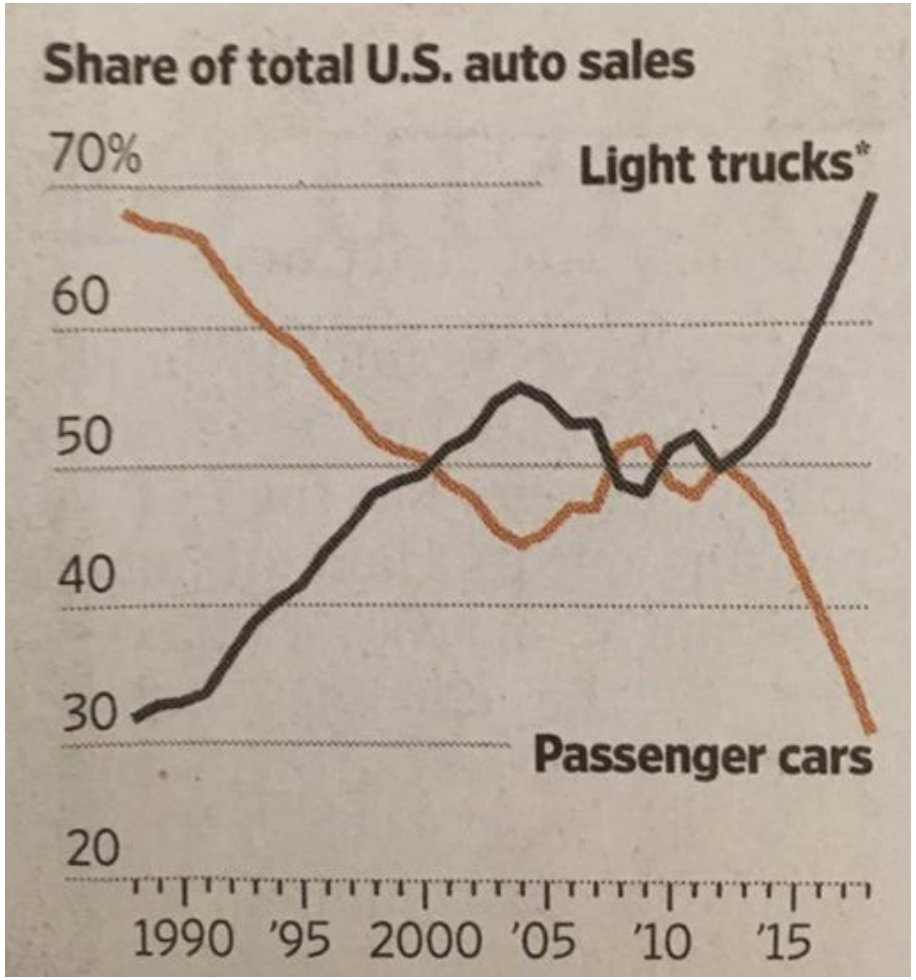


Image - Light trucks: (pickups, SUVs, and vans), source unknown

1 - 2020 graph for light trucks only available at https://twitter.com/Mark_J_Perry/status/1340351782145433600

9. 2016 USDOT FATALITIES CALL TO ACTION

2015 TRAFFIC CRASH FATALITIES RISE

The sudden rise in 2015 traffic crash fatalities were drawn to public attention with Department of Transportation's Call to Action for citizen scientists[1].

Initial result put the blame on apps and smartphones[2]. This strayed away from previous theories: increased vehicle miles, seat belts and driver impairment[1] .

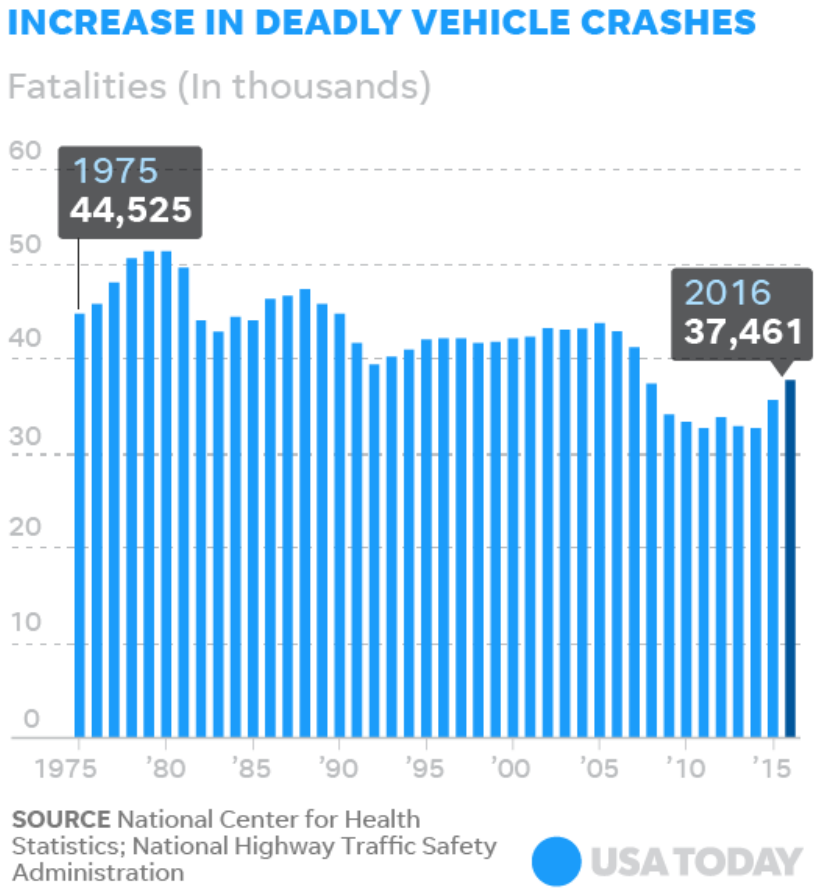


Image – https://www.usatoday.com/story/money/cars/2017/10/06/nhtsa-2016-deadly-crashes/739842001/

1 - https://www.transportation.gov/briefing-room/traffic-fatalities-sharply-2015

2 - https://www.nytimes.com/2016/11/16/business/tech-distractions-blamed-for-rise-in-traffic-fatalities.html

9. SALES DECREASE =? FATALITY DECREASE

2019 TRAFFIC CRASH FATALITIES DROP

Daily smartphone use are at its highest[1].

Despite this, 2019 US crash fatalities have dropped, even with **VMT up 0.8%**[2].

NHTSA cited preventing drunk driving as the primary improvement[2]. Shifting back and forth is a form of statistical bias:

if fatalities are rising, blame the apps; if dropping, praise the law enforcement.

Vehicle sales appear as the key indicator, LE's hardwork notwithstanding.

Image: Twitter, @gregormacdonald

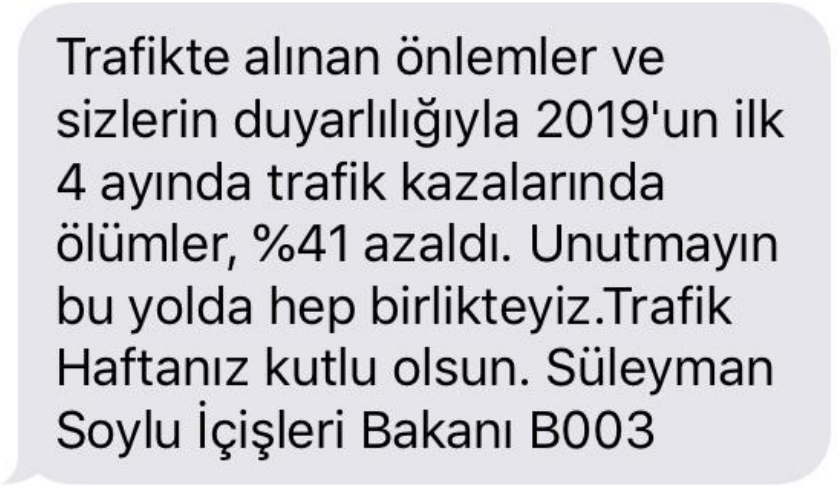
1 - https://www.emarketer.com/content/us-mobile-time-spent-2020

2 – VMT:Vehicle Miles Travelled https://www.nhtsa.gov/press-releases/roadway-fatalities-2019-fars

10. 2019 GLOBAL VEHICLE SALES DROP

COMMON THEMES OF US & TURKEY ROADS

Vehicle sales drop and the subsequent decrease in crashes were a common theme in 2019, as I explained the case for Turkey.



Right: Praise of law enforcement as a reflex. Traffic SMS alert sent by the Turkish Interior Ministry in 2019 (image).

-41% change in Turkish fatalities correlate to the much sharper drop in Turkish auto sales: **-59%** in passenger cars and **-60%** in light commercial vehicles[1].

1 - https://alemicihan.com/post/182556630096/2019-ocak-ayi-otomobil-satislarinda-buyuk-dusus-yasandi

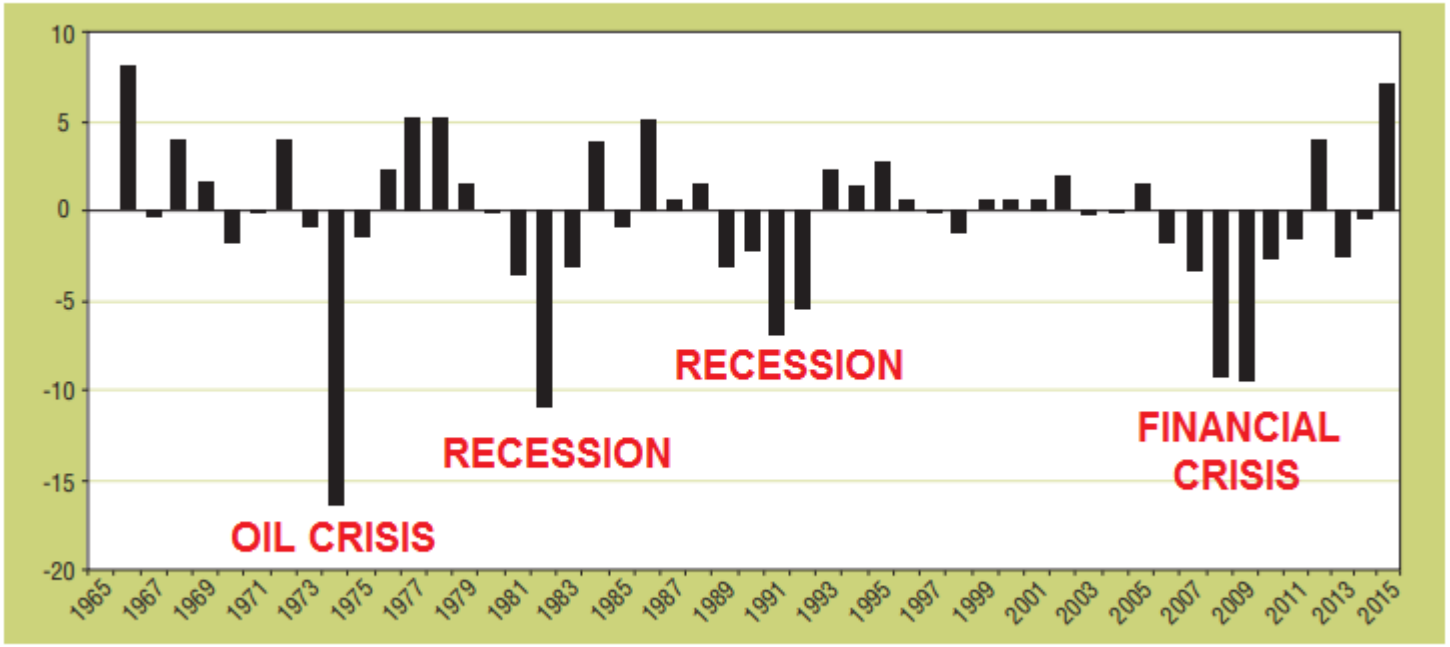
Image: Traffic Safety SMS Alerts, Turkish Interior Ministry

10. GOING BACK TO THE START: RECESSION?

UNDERSTANDING CRISIS

We are currently under a global crisis caused by the pandemic. We are seeing dramatic drops in congestion and crashes, due to lockdowns and restrictions.

Figure 1
Percentage Change in Total Traffic Fatalities, 1965–2015



Sources: 1965–1974: National Center for Health Statistics, HEW, and State Accident Summaries (Adjusted to 30-Day Traffic Deaths by NHTSA); FARS 1975-2014 Final File, 2015 Annual Report File (ARF)

Past crises reduced fatalities without the forced control. How is this effect explained on a micro, traffic scale?

Image: NHTSA - Economic Trends and Cycles

11. VMT vs SALES: KEY INDICATORS?

VEHICLE MILES TRAVELLED (VMT)

Meaningful explanation in terms of traffic flow, though limited correlation

Fatalities drop despite VMT increased

SHOULDN'T THE ROAD COVERAGE BE RELATED TO CRASHES ON THE ROAD?

Congestion levels independent of VMT:
Emergent crashes at black spots

VEHICLE SALES

Best trend that correlated with fatalities, in US and in Turkey.

Sales drop do not offer explanation

CONGESTION PREVENTION AT THE «UPSTREAM» OF THE TRAFFIC FLOW

Vehicle sales influencing crashes:
Changes in mode of transport

11. CURRENCY CRISIS: CAR IMPORTS HALT

CURRENCY CRISIS OF TURKEY

USD/TRY parity skyrocketed from 2.8 in 2016, to 8.1 in 2021, called **2018 Turkish currency and debt crisis**[1]. Majority of vehicles are imports, and the currency rates crashed sales in 2018 and 2019.

TURKISH LIRA CRASH: DROP IN VEHICLE SALES 2018-2019

2016	1.214.610
2017	1.247.449
2018	903.274
2019	671.131
2020	1.038.905

2020: Government stimulus packages

METRO ISTANBUL NEW LINES: SURGE TO PUBLIC TRANSIT IN 2018 AND 2019

TOTAL DAILY TRANSIT RIDES:

2017: 12,939,000[2]

2018: 13,898,470[3] **+7%**

2019: 15,148,333[4] **+9%**

2020 not included due to pandemic lockdowns and travel restrictions.

More Istanbulites turned to public transit as their primary mode for commute.

Image 1: Turkish Statistical Institute (TÜİK) Biruni Central Distribution System https://biruni.tuik.gov.tr/

1 - https://en.wikipedia.org/wiki/2018_Turkish_currency_and_debt_crisis

2 - https://www.gzt.com/jurnalist/istanbulda-toplu-tasimanin-sayisal-verileri-2798866

3 - https://www.ibb.istanbul/News/Detail/36320

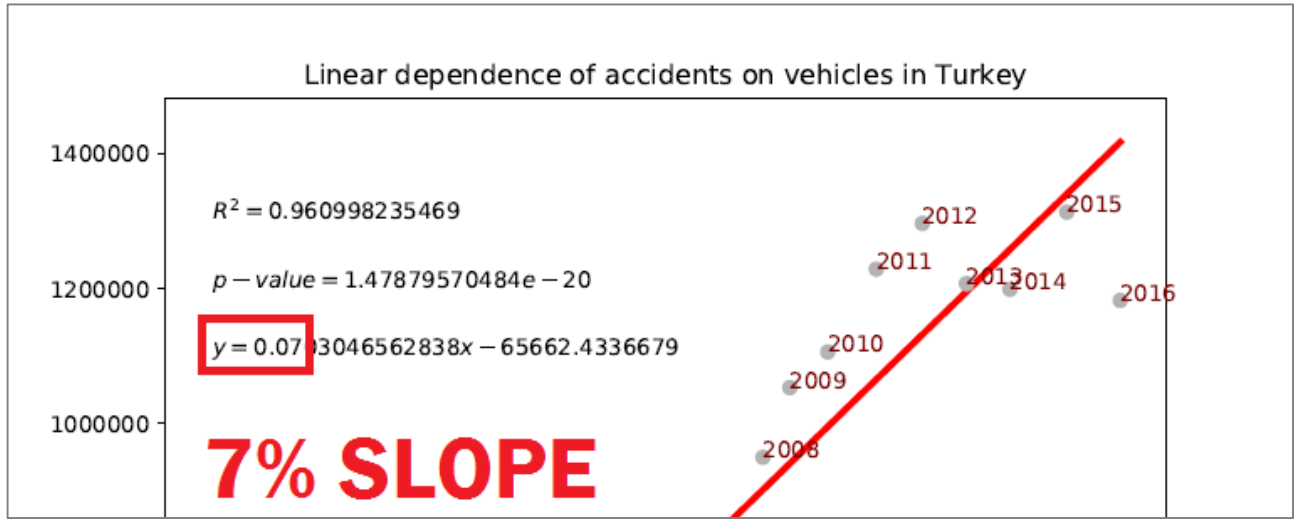
4 - https://www.iett.istanbul/tr/main/pages/istanbulda-toplu-ulasim/95

11. UNIVERSALITY: LADDERING OF SCALES

7% CRITICAL SYMMETRY

7% HEAVY VEHICLES IN D100 İNCİRLİ

7% HOURLY TRAFFIC IN D100 İNCİRLİ

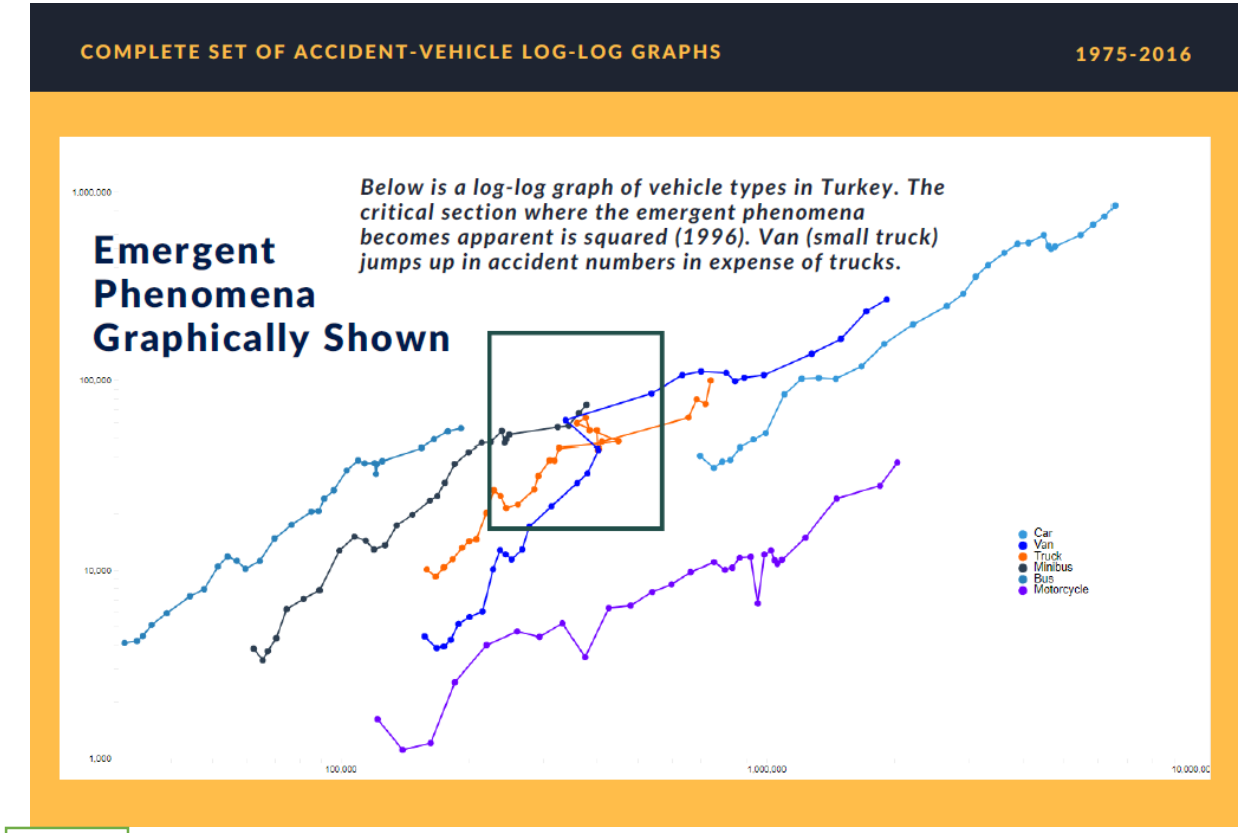


Sales dictate on macro scale, black spots on micro. Critical micro-macro laddering is: **scale-free behavior**

Universality: The emergence of 7% in the **crash-vehicle graph's slope**, the **many-to-many black spot heavy vehicles distribution** and its **hourly traffic ratio** is a universal pattern.

11. CRITICALITY: VEHICLE TRANSITIONS

LCVs SURPASS TRUCKS IN TURKEY



LIGHT TRUCK SALES PASS CARS IN USA

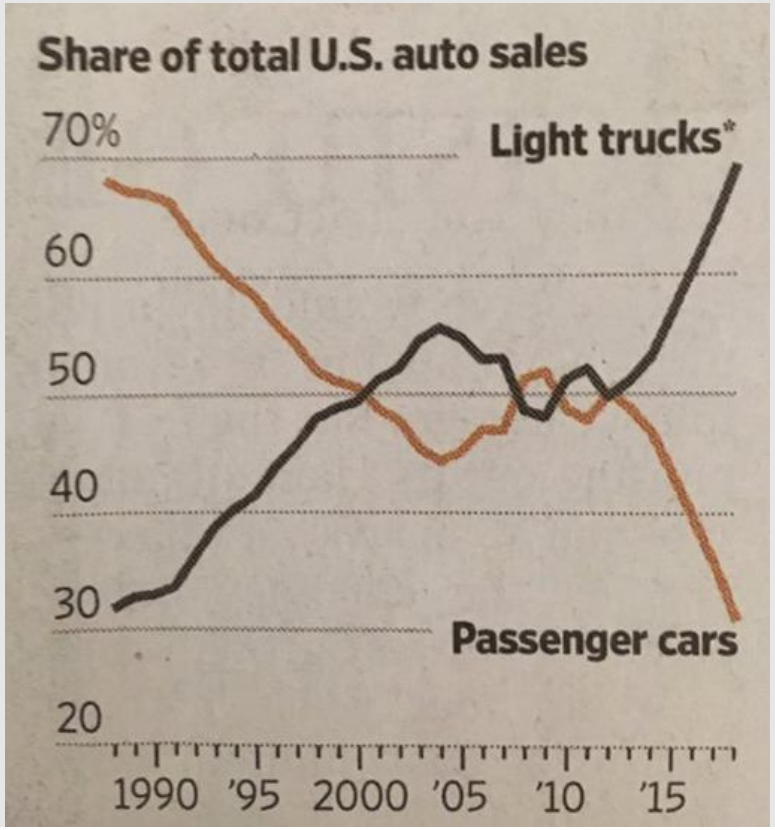


Image 1: Turkish Statistical Institute (TÜİK) - Annual Traffic Crash Report, 1994 – 2016
Image 2: Light trucks: (pickups, SUVs, and vans), source unknown

IF:

LIGHT VEHICLE CRASHES AT **BLACK SPOTS** EMERGE AS A SCALE-FREE BEHAVIOR OF **DAILY** AND **YEARLY CRASH CRITICALITY**

THEN:

- Speeding?
- Rule violations?
- Impaired driving?
- Distracted driving?
- Mechanical failures?
- Road geometry/design faults?

COMING UP NEXT: **PARTS 2 & 3**

FOR MORE INFORMATION:

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