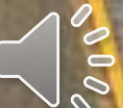# Reidentification of Previously Anonymized Connected Vehicles

Is the Industry Keeping Its Promise on Privacy?

Research Project Proposal by
Steve Johnson, MSc Cybersecurity Candidate
University of Essex, 2022 Cohort

Source: USDOT

Abstract:

- Connected Vehicle (CV) technology offers a large leap forward in reaching "Vision Zero", a goal of eliminating all traffic deaths attributable to distracted driving.
- There are inherent risks to privacy in the deployment of CV technology
- The Industry has in place many standards, specifications, and regulations aimed at protecting individual privacy. Regulating bodies include:

  - Society of Automotive Engineers (SAE)
  - Institute of Electrical and Electronics Engineers (IEEE)
  - United States Department of Transportation (USDOT)
  - National Highway Traffic Safety Administration (NHTSA)
  - OmniAir Consortium, an industry council which certifies CV devices against the standards

This research will investigate:

- **Whether the currently implemented safeguards provide an acceptable efficacy, and;**
- **Critically examine if the next generation of safeguards under proposal by the industry will add any substantial improvement?**
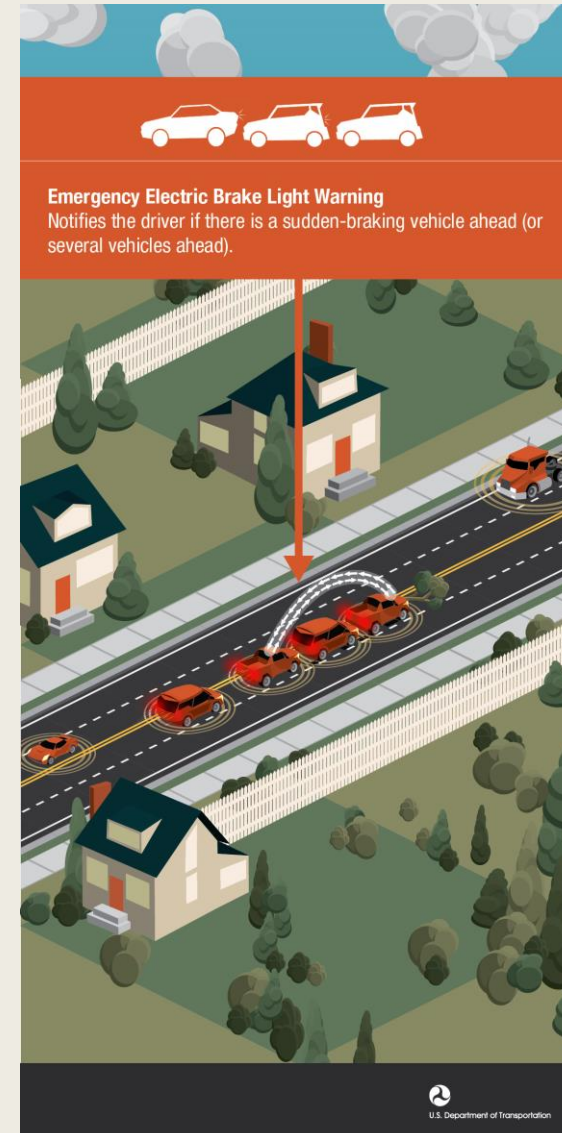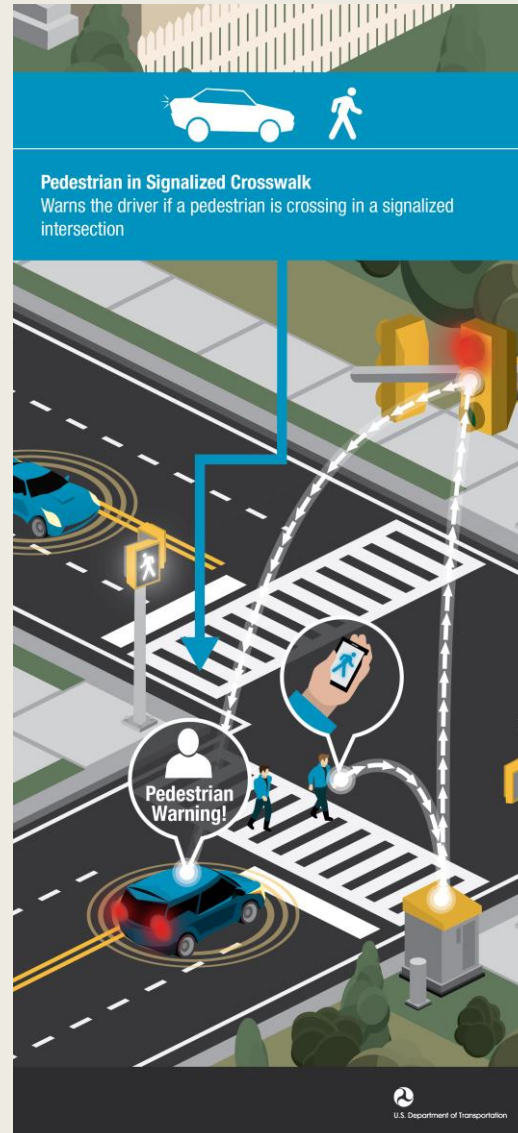
Proposed Aims and Objectives.

❑ Summarize the CV technology, benefits to society, and challenges of secure implementation.

❑ Critically examine the evolution of the privacy threat surface and implemented mitigations.

❑ Critically examine existing research literature covering privacy and security of connected vehicles.

❑ Develop an experimental project upon which to test/validate author's thesis on CV's remaining privacy weaknesses.

❑ Propose areas for further research and development for CV to close identified privacy protection gaps.

Representative CV Applications

Intersection Movement Assist
Warns the driver if it is not safe to enter an intersection - for example, if another vehicle is running a red light or making a sudden turn.

U.S. Department of Transportation

Pedestrian in Signalized Crosswalk
Warns the driver if a pedestrian is crossing in a signalized intersection

Pedestrian Warning!

U.S. Department of Transportation

Emergency Electric Brake Light Warning
Notifies the driver if there is a sudden-braking vehicle ahead (or several vehicles ahead).

U.S. Department of Transportation

70+ Additional Apps

Safety
➢ Wrong Way Entry
➢ Wrong Way Driver
➢ Forward Collision Warning
➢ Curve Speed Warning
➢ Emergency Vehicle Preemption

Environment
➢ Traffic Progression
➢ Transit Vehicle Priority
➢ Speed Harmonization

Mobility
➢ Travel Time Data

CV Deployments in the U.S.

➢ **Infrastructure**

❖ As of July 2021:
- ❖ 69 Active Deployments
- ❖ 102 Planned

❖ Early 2022 Estimates:
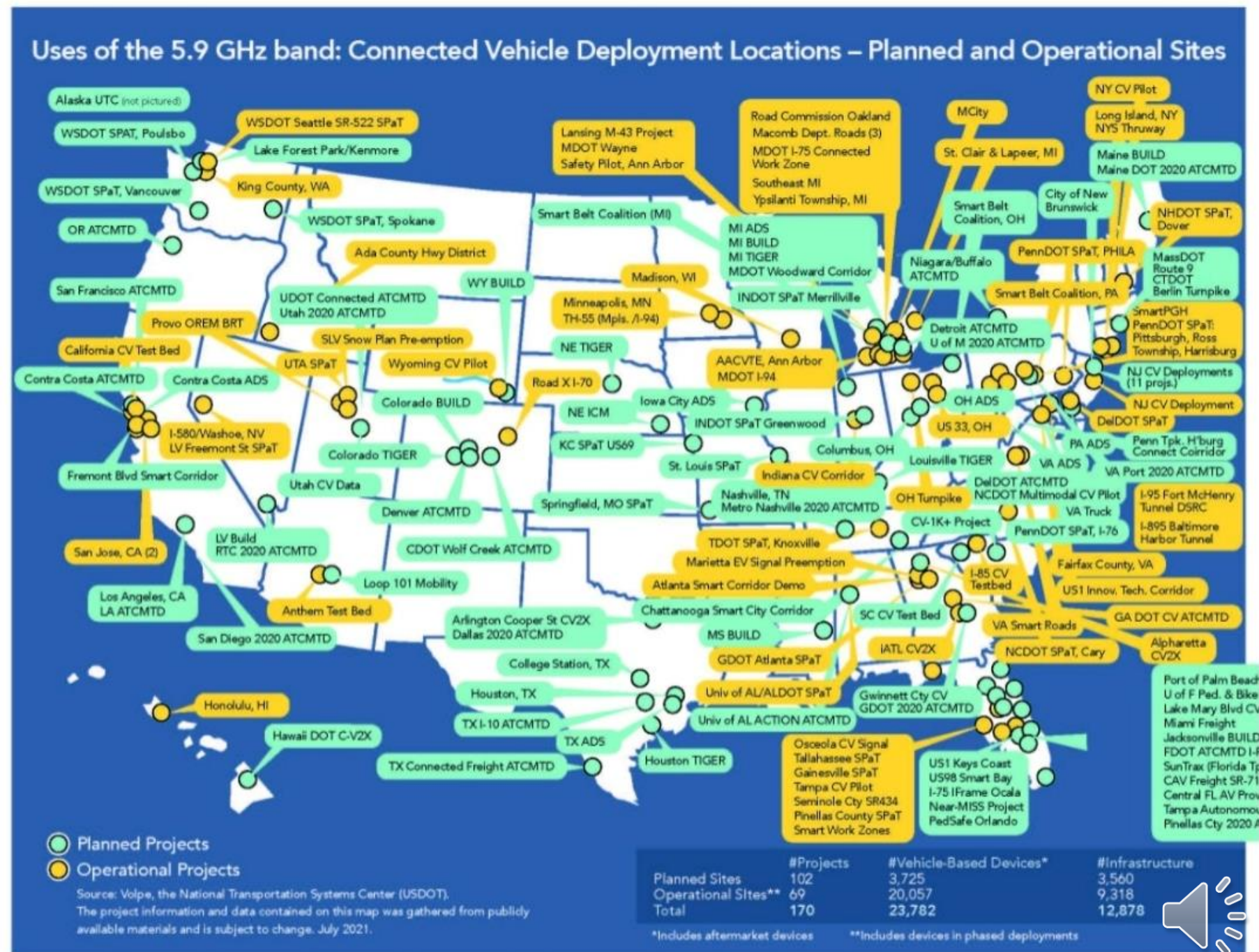- ❖ 80+ Active Projects
- ❖ 200+ Planned Projects

➢ **Connected Vehicles**

❖ Implemented by CV Pilots
- ❖ 4,500 comprising
  - ❖ 1000 private vehicles (Tampa)
  - ❖ 400 commercial trucks (Wyoming)
  - ❖ 3000+ mix of commercial and agency fleet (NYC)

❖ Manufactured by GM, Ford, BMW, Audi, VW, Toyota, Honda, Hyundai, *et al.*
- ❖ *100's of thousands with a projected CAGR of 24% through 2027*

Source: USDOT

Proposed Research Design.

❖ Critical evaluation via literature review, surveys, interviews, et al; of the current efficacy of privacy protections available to CV users.

❖ Present a theory of one way in which previously anonymized CV vehicles may be trivially reidentified.

✓ Using live captured, published, anonymized CV Data.

❖ Validate by data visualization/mapping that theorized method of reidentification is possible.

❖ Discuss potential additional mitigation processes for consideration, experimentation.

❖ Discuss the ethical issues raised and the potential conflicts between diverse ethical models. IE:

▪ Is the moral imperative to save lives greater than the ethical mandate to protect privacy?

▪ How does the ACM code of ethics apply to the development of CV with known privacy issues?

▪ How does the ACM code of ethics apply to Government agencies or private firms that publish CV data for open use with known privacy risks?

▪ How does GDPR apply and to whom?

Validate by data visualization/mapping that theorized method of reidentification is possible.

$$\frac{\alpha\beta\left\{3\eta / \pi\right\}}{\alpha\gamma * \eta} = NI$$

Experimental Design

Anonymized CV Data (ACVD), Live Captured, Published

Timestamp	RSUID	VID	Latitude	Longitude	Elevation	Heading	Velocity	Accelleration	position
7.34.00.9	27	1082	84.27+38	27.44+16	53	320	46.23	4.9823476	={D2+E2}
7.34.00.10	34	1082	84.27+39	27.44+17	51	298	45.27	-2.568	={D2+E2}
7.34.00.11	16	1082	84.27+40	27.44+18	48	312	40.43	8.1345457	={D2+E2}
7.34.00.12	22	1082	84.27+41	27.44+19	50	309	23.7	3.875	={D2+E2}
7.34.00.13	11	1082	84.27+42	27.44+20	56	299	11.03	6.239476	={D2+E2}
7.34.00.14	9	1082	84.27+43	27.44+21	42	296	0.46	12.98476	={D2+E2}
7.34.00.15	6	1082	84.27+44	27.44+22	94	284	37.2	-14.987234	={D2+E2}
7.34.00.16	7	1082	84.27+45	27.44+23	86	281	38	1.987	={D2+E2}
7.34.00.17	8	1082	84.27+46	27.44+24	71	288	58.3	6.1963	={D2+E2}
7.34.00.18	27	163	84.27+47	27.44+25	53	320	46.23	4.9823476	={D2+E2}
7.34.00.19	34	163	84.27+48	27.44+26	51	298	45.27	-2.568	={D2+E2}
7.34.00.20	16	163	84.27+49	27.44+27	48	312	40.43	8.1345457	={D2+E2}
7.34.00.21	22	163	84.27+50	27.44+28	50	309	23.7	3.875	={D2+E2}
7.34.00.22	11	163	84.27+51	27.44+29	56	299	11.03	6.239476	={D2+E2}
7.34.00.23	9	163	84.27+52	27.44+30	42	296	0.46	12.98476	={D2+E2}
7.34.00.24	6	163	84.27+53	27.44+31	94	284	37.2	-14.987234	={D2+E2}
7.34.00.25	7	163	84.27+54	27.44+32	86	281	38	1.987	={D2+E2}
7.34.00.26	8	163	84.27+55	27.44+33	71	288	58.3	6.1963	={D2+E2}
7.34.00.27	27	416	84.27+56	27.44+34	53	320	46.23	4.9823476	={D2+E2}
7.34.00.28	34	416	84.27+57	27.44+35	51	298	45.27	-2.568	={D2+E2}

Visualization of ACVD on Googlemaps with path plotting

Provides means to "witness" ID change in real time = "Reidentification"

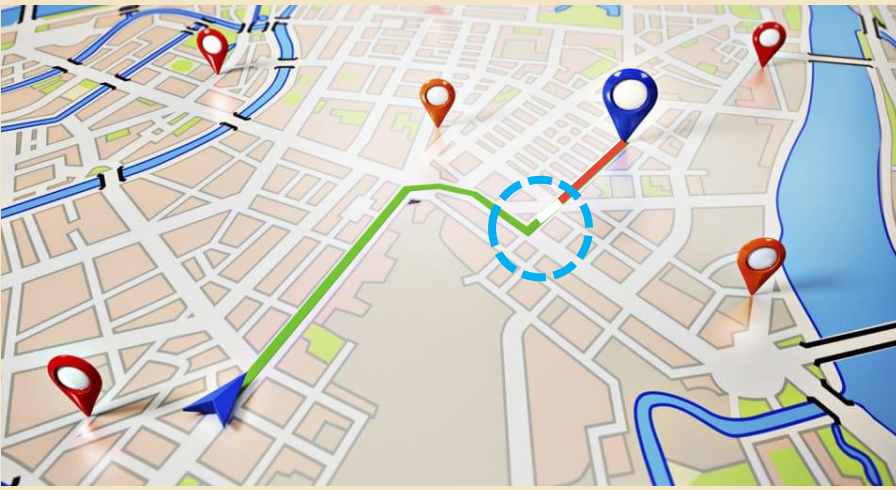**Experiment 1: Plot full range of data as recorded live**

Validate by data visualization/mapping that theorized method of reidentification is possible.

Experiment 2: Plot revised range of data as recorded live, but with 5 seconds of data silence imposed before ID Change

Anonymized CV Data (ACVD),
Live Captured, Published

Timestamp	RSUID	VID	Latitude	Longitude	Elevation	Heading	Velocity	Accelleration	position
7.34.00.9	27	1082	84.27+38	27.44+16	53	320	46.23	4.9823476	={D2+E2}
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7.34.00.16	7	1082	84.27+45	27.44+23	86	281	38	1.987	={D2+E2}
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7.34.00.18	27	163	84.27+47	27.44+25	53	320	46.23	4.9823476	={D2+E2}
7.34.00.19	34	163	84.27+48	27.44+26	51	298	45.27	-2.568	={D2+E2}
7.34.00.20	16	163	84.27+49	27.44+27	48	312	40.43	8.1345457	={D2+E2}
7.34.00.26	8	163	84.27+55	27.44+33	71	288	58.3	6.1963	={D2+E2}
7.34.00.27	27	416	84.27+56	27.44+34	53	320	46.23	4.9823476	={D2+E2}
7.34.00.28	34	416	84.27+57	27.44+35	51	298	45.27	-2.568	={D2+E2}

Visualization of ACVD on Googlemaps with path plotting

Provides means to "witness" ID change in real time = "Reidentification"

Source: Author

Research Project Artifacts

- ❖ Raw CV Data – full scope, unedited
- ❖ CV Data, parsed for experiments
- ❖ Maps, with CV data path tracing by Vehicle ID
- ❖ Recommendations for future study and potential solutions
- ❖ Technical Paper submission for publishing by Society of Automotive Engineers
- ❖ Submittal to Transportation Research Board as a technical paper presentation at annual meeting.