

Categorizing Unintended Acceleration/Pedal Misapplication Collisions from Event Data Recorders



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**Presented By: JASON YOUNG, M.A.Sc., P.Eng.
ADVANTAGE FORENSICS, TORONTO**

**Co-authors: KYLE SERKIES, B.A.Sc., M.A.Sc.
GREG PRENTICE, B.Eng.
REBECCA YOUNG, B.A.Sc.
ALBERTO MARTINEZ, B.Eng., M.A.Sc.**

Advantage Forensics



- Practice Areas

- Collision Reconstruction
- Road/Signage Assessment
- Human Factors
- Biomechanics
- Slips, Trips & Falls
- Product Failure
- Material Failure
- Safety Assessments



About the Author

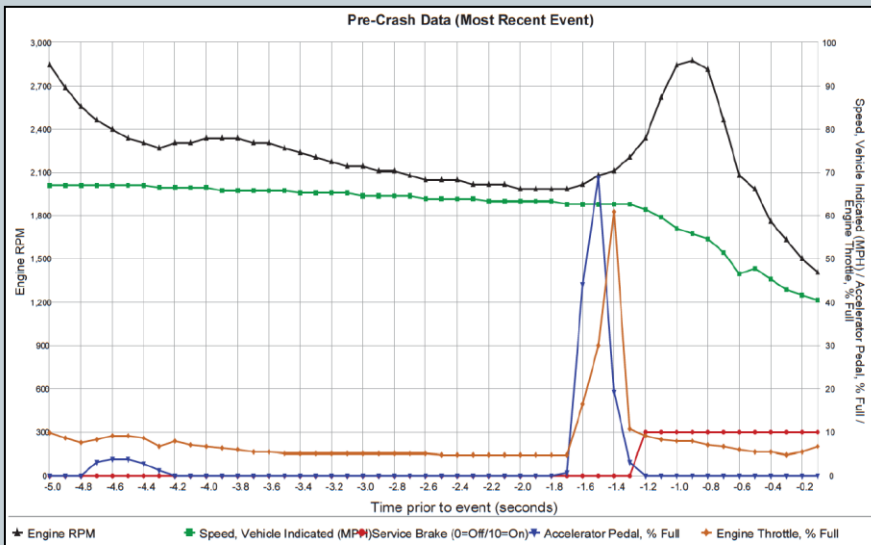


- 17 years of forensic engineering investigations
- 1800+ cases
- 23 trials, including pedal misapplication collision
- Qualified by Superior Court as expert in:
 - Human Factors
 - Collision Reconstruction
 - Collision Avoidance
 - Road Design
 - Signage Assessment
- Human Factors Forensics Professional Program Co-chair
- TV featured expert on collision reconstruction
- Collision reconstruction instructor for Police courses
- Human factors instructor for municipal & university courses

Purpose of the Study



To demonstrate the unique aspects of EDR pre-crash data, particular to each category of unintended acceleration scenario



Potential Benefits



- New tool for collision database analysis
- Categorization of unintended acceleration collisions to determine frequency of each category
- Improved vehicle safety systems, targeted to reduce most frequent categories of unintended acceleration

Definitions



Unintended Acceleration Collision

- Any instance of physical acceleration of the vehicle, for any reason whatsoever, without the driver's intention

Includes:

- Mistaken/confused driver actions
- Secondary driver inputs occurring without knowledge of driver
- No driver inputs at all
- Forward or reverse acceleration
- All speeds and road types



Frequency of UAC's



- Has been a chronic collision safety issue for decades in North America
- Over 16,000 reported unintended acceleration collisions per year in U.S.
- Historically difficult to categorize, since reports of UAC's depend on driver statements
- Frequency and causes of UAC's have been thoroughly studied by:
 - Transport Canada
 - NHTSA
 - NASA

Prevalance of UAC's



- Has occurred at all speed ranges
- Has occurred on all road types
- Has occurred with all vehicle types, including:
 - Passenger vehicles
 - Commercial trucks
 - Municipal buses
 - Motorcycles
 - Boats
 - Golf carts
 - Power wheelchairs/scooters
 - Segways
- Many people in this room have likely been in UAC's

Categories of UAC



- **Category 1: Pedal Misapplication**
 - Driver error
 - Mistaken application of gas pedal, or both pedals
 - Driver initially responds with increased pedal application
 - Panic response follows
 - Driver responds with full pedal application
 - Most common current category of UAC (90-99%??)
 - ~16,000 cases/year in U.S.

Categories of UAC



- **Category 2: Gas Pedal Entrapment**
 - Non-driver related error
 - Physical interference of floor mat or other floor object with gas pedal
 - Driver applies brake pedal only
 - Famous 2009 Toyota floor mat recall
 - 2nd most common current category of UAC (1-10%??)

Categories of UAC



- Category 3: Cruise Control Driver Activation Error
 - Driver error
 - Driver unknowingly activates 'resume' or 'accelerate' button with cruise control system active
 - Activation by hand, or theoretically by voice
 - Driver applies brake pedal only
 - Immediately deactivates 'resume' or 'accelerate' function
 - Collision can result if insufficient braking distance
 - Would likely be reported by driver as electronic failure
 - Very rare category of UAC (<<1%??)

Categories of UAC



- **Category 4: Mechanical Failure**
 - Non-driver related error
 - Mechanical failure of throttle cable (older vehicles only) or ‘stuck’ gas pedal without floor mat interference
 - Gas pedal locked in depressed position
 - Driver applies brake pedal only
 - Typically reported as an observed ‘stuck’ gas pedal
 - Rare category of UAC (<1%??)

Categories of UAC



- **Category 5: Electronic Failure**
 - Non-driver related error
 - Electronic/computer malfunction of ETC or cruise control
 - Driver applies brake pedal only
 - Collision can result if insufficient braking distance
 - Most commonly claimed cause by drivers (Toyota cases, etc.)
 - NASA unable to create this failure (system redundancies)
 - Theoretical category with no documented cases, until:
 - May 2018 Fiat Chrysler recall
 - 4.8M vehicles: 2014-19 Chryslers, Dodges, Jeeps & Rams
 - Short circuit of cruise control redundancy: unable to deactivate

Event Data Recorders



- Integral part of the air bag control system since '90's
- Record collision-related data in event of an airbag deployment, or near-deployment event
- 2012 US Regulation: EDRs in new passenger vehicles must be commercially downloadable
- EDRs are now present in over 99% of new passenger vehicles sold in Canada and US

Data Recorded by EDRs



- Varies in amount & format by make & model of EDR module
- Continually increasing amount of data stored
- Typical minimum data includes:
 - Frontal delta-v of collision
 - Driver seatbelt status
 - 2.5 to 5 s pre-impact data (speed, throttle, braking, RPM)
- Often, much more available (lateral delta-v, rollover g's, cruise control status, secondary impacts, etc.)

Method

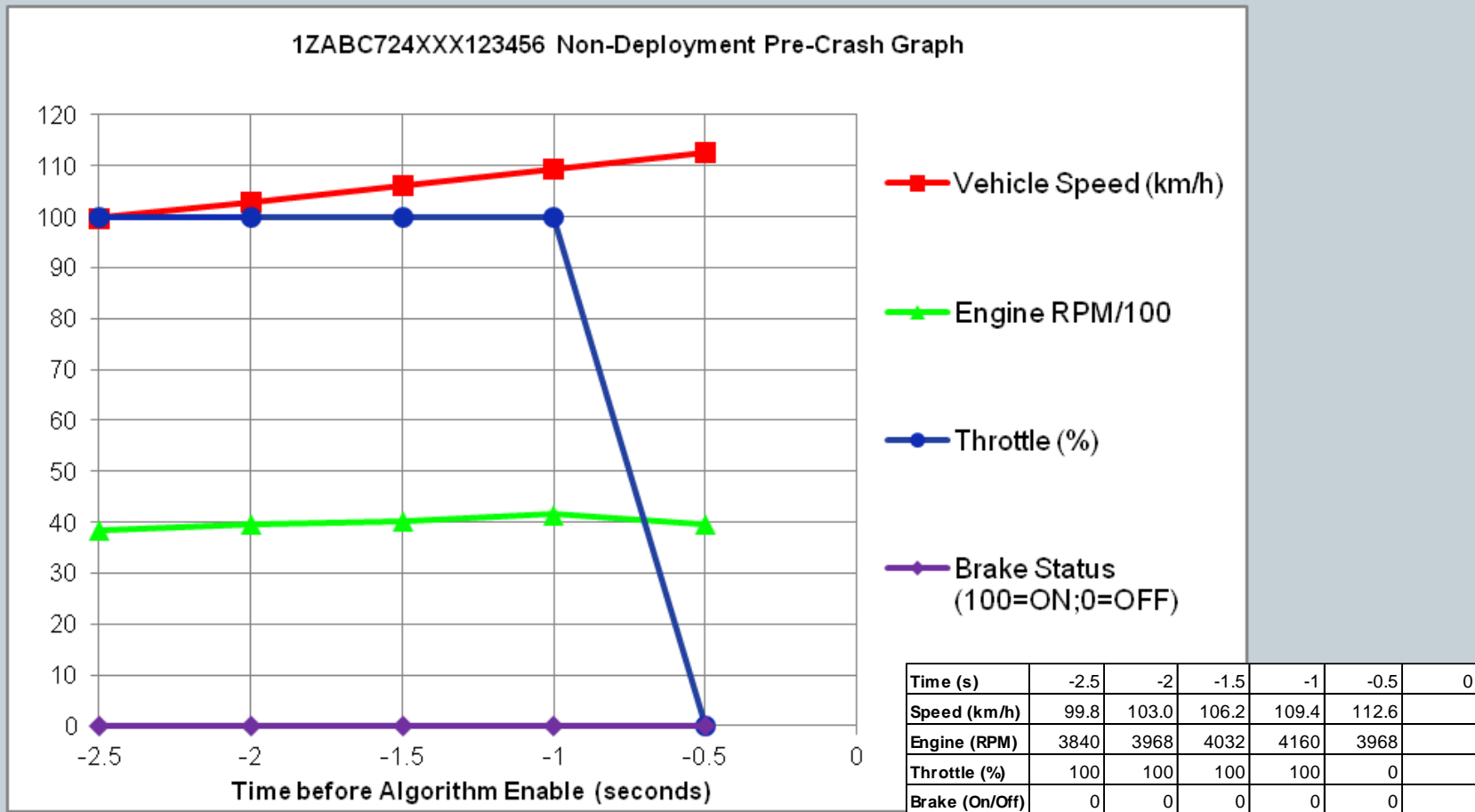


- Actual case studies used from databases of EDR downloads from unintended acceleration collisions:
 - NHTSA (58 UAC collisions from 2010)
 - Transport Canada (22 UAC collisions from 2010 to 2012)
 - Authors (investigation of 1400+ collisions from 1995 to 2017)
- Only EDR data verified as being from incident collisions were considered
- All EDR data copied into identical format for ease of visual comparison

Results



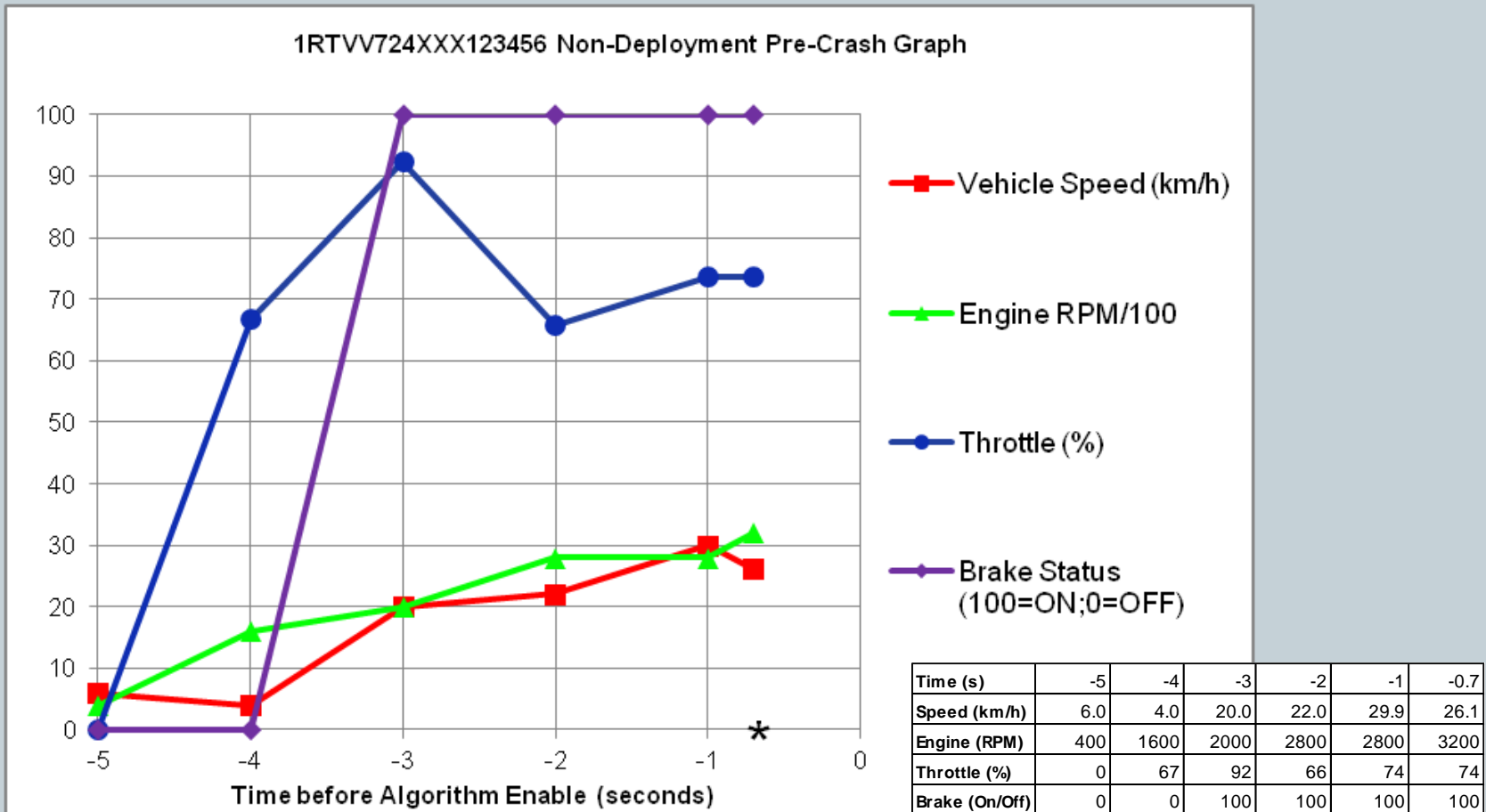
Pedal Misapplication Category - Gas pedal only:



Results



Pedal Misapplication Category - Both pedals:

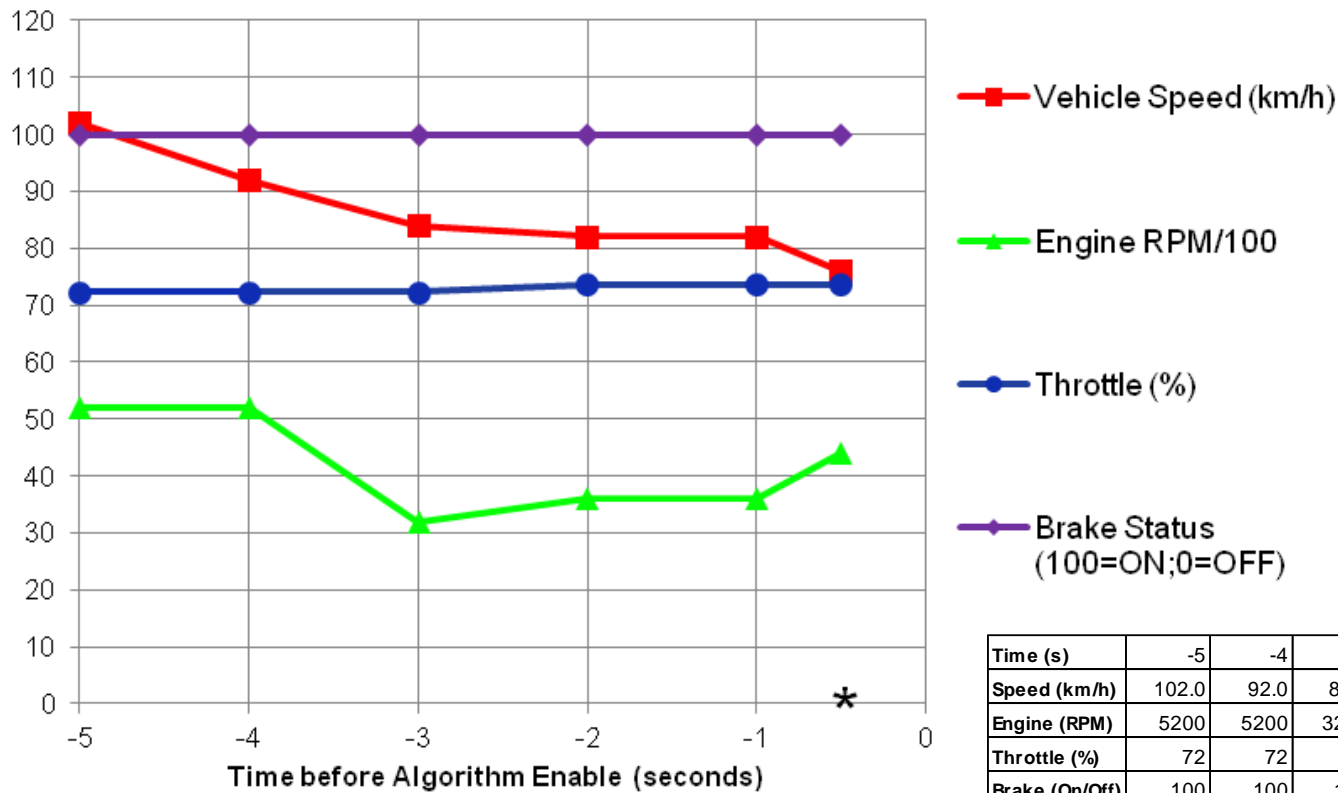


Results



Gas Pedal Entrapment Category:

1ZDEF712XXX123456 Non-Deployment Pre-Crash Graph



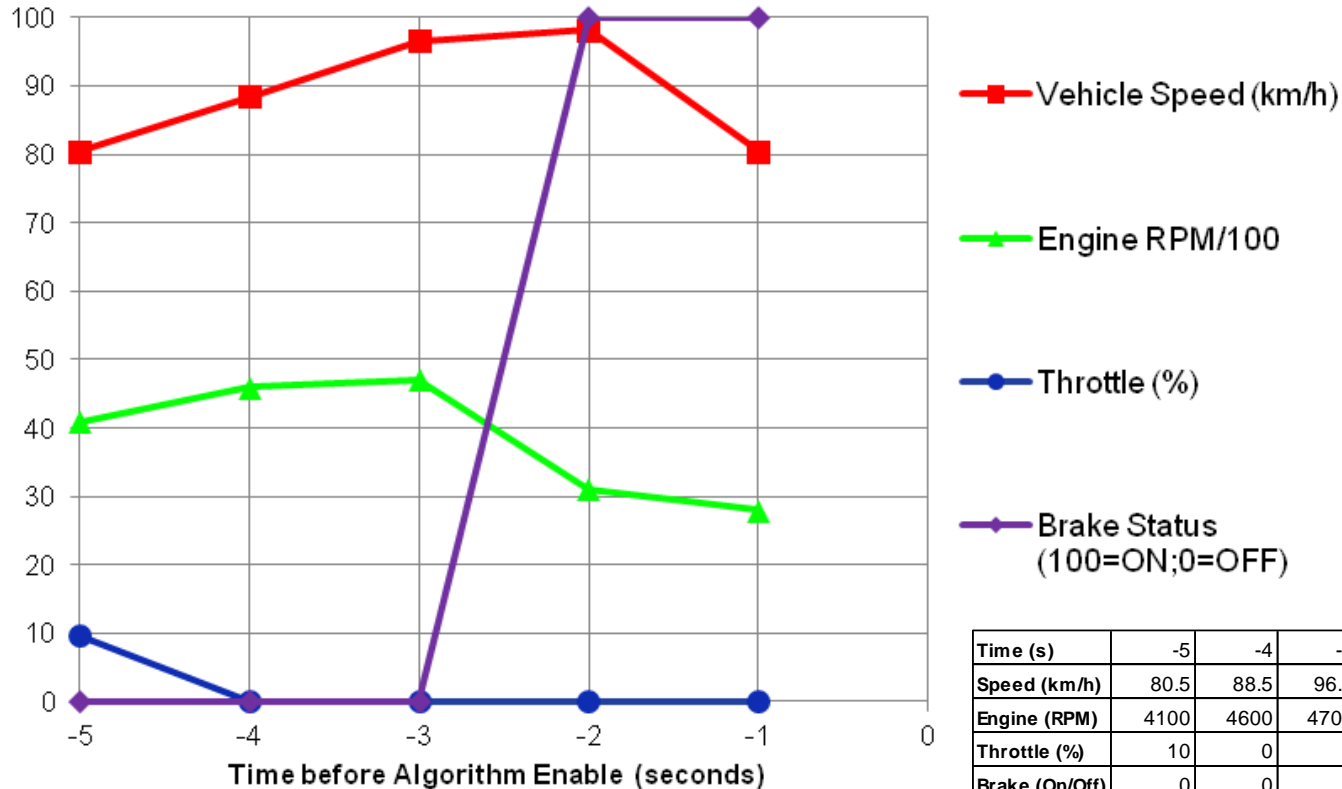
Time (s)	-5	-4	-3	-2	-1	-0.5
Speed (km/h)	102.0	92.0	84.0	82.1	82.1	75.9
Engine (RPM)	5200	5200	3200	3600	3600	4400
Throttle (%)	72	72	72	74	74	74
Brake (On/Off)	100	100	100	100	100	100

Results



Cruise Control Driver Activation Category:

1RGHK800XXX123456 Deployment Pre-Crash Graph



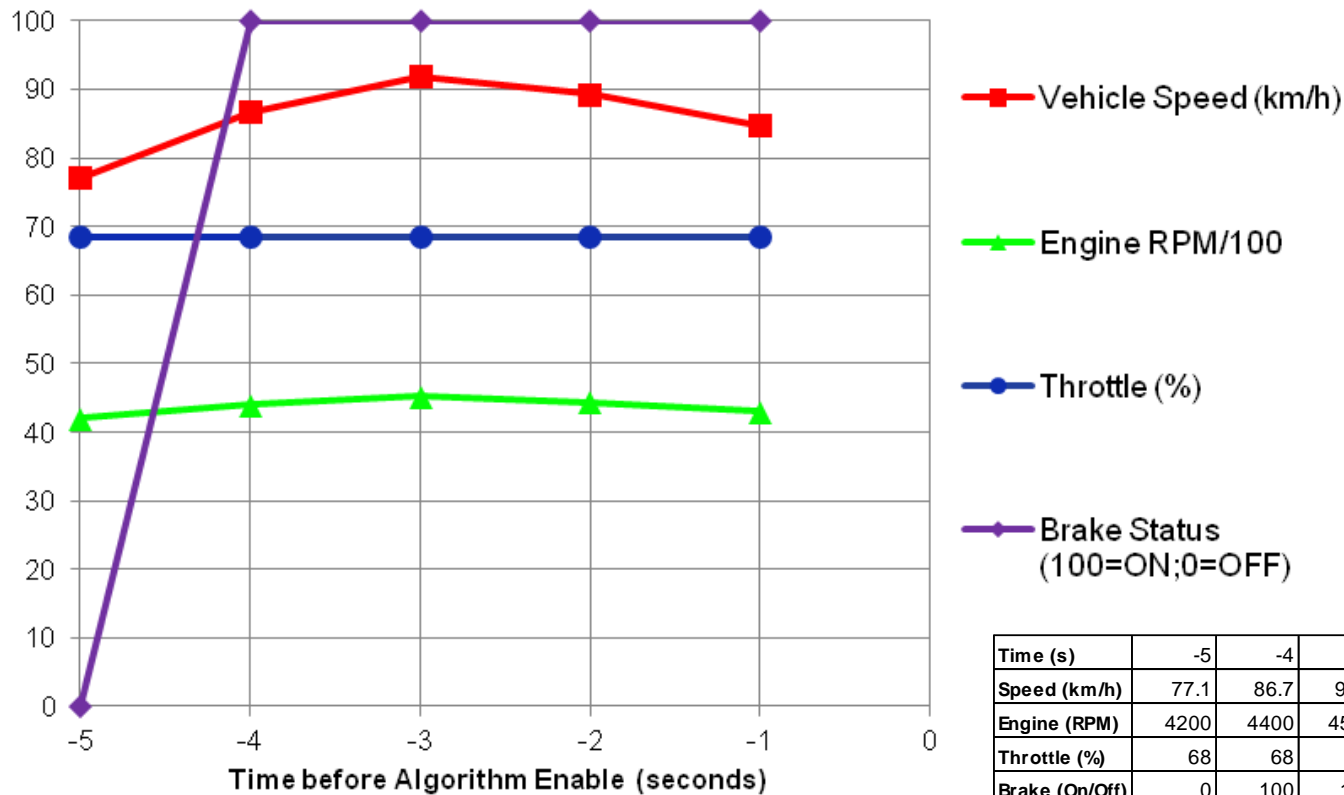
Time (s)	-5	-4	-3	-2	-1	0
Speed (km/h)	80.5	88.5	96.5	98.1	80.5	
Engine (RPM)	4100	4600	4700	3100	2800	
Throttle (%)	10	0	0	0	0	
Brake (On/Off)	0	0	0	100	100	

Results



Mechanical Failure Category:

1QTRB707XXX123456 Deployment Pre-Crash Graph



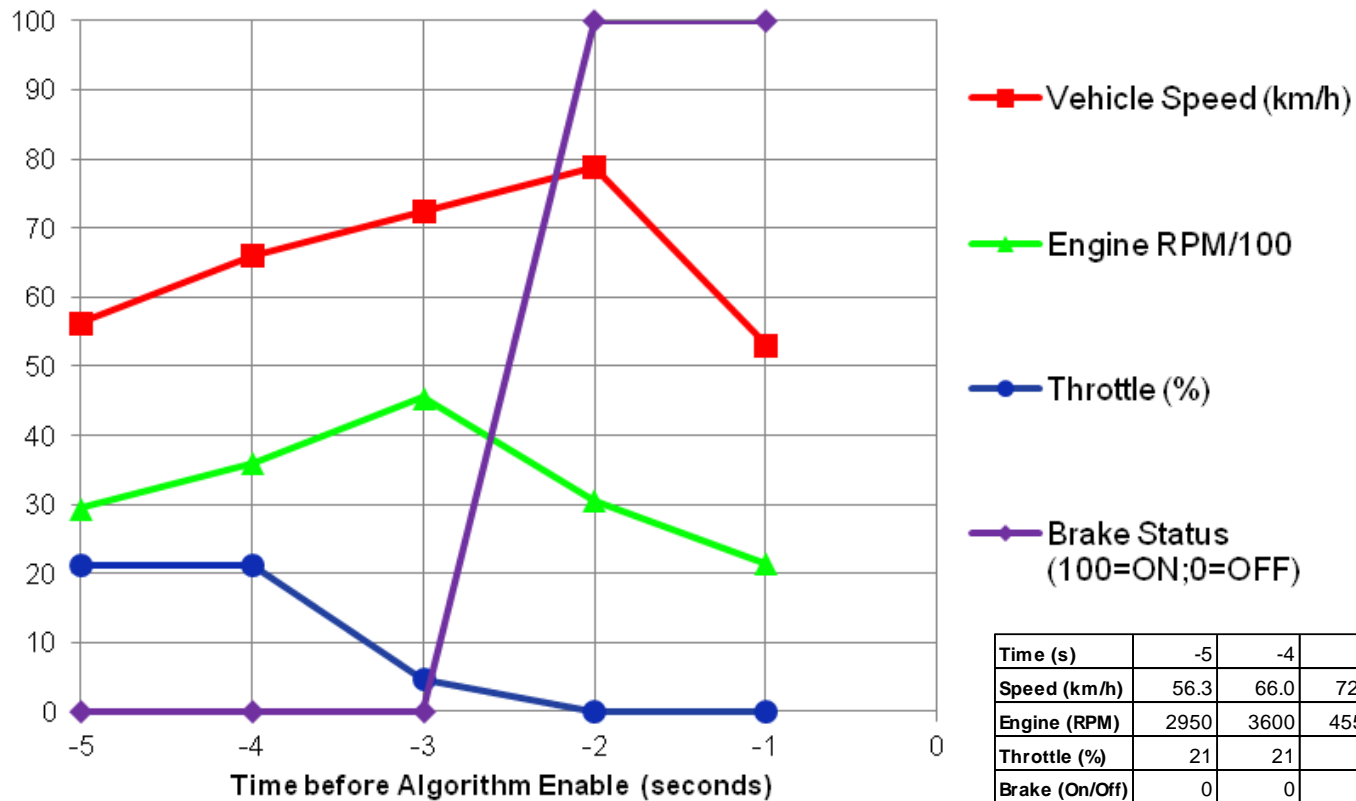
Time (s)	-5	-4	-3	-2	-1	0
Speed (km/h)	77.1	86.7	91.9	89.3	84.8	
Engine (RPM)	4200	4400	4520	4440	4300	
Throttle (%)	68	68	68	68	68	
Brake (On/Off)	0	100	100	100	100	

Results



Electrical Failure Category:

1XBBC411XXX123456 Deployment Pre-Crash Graph

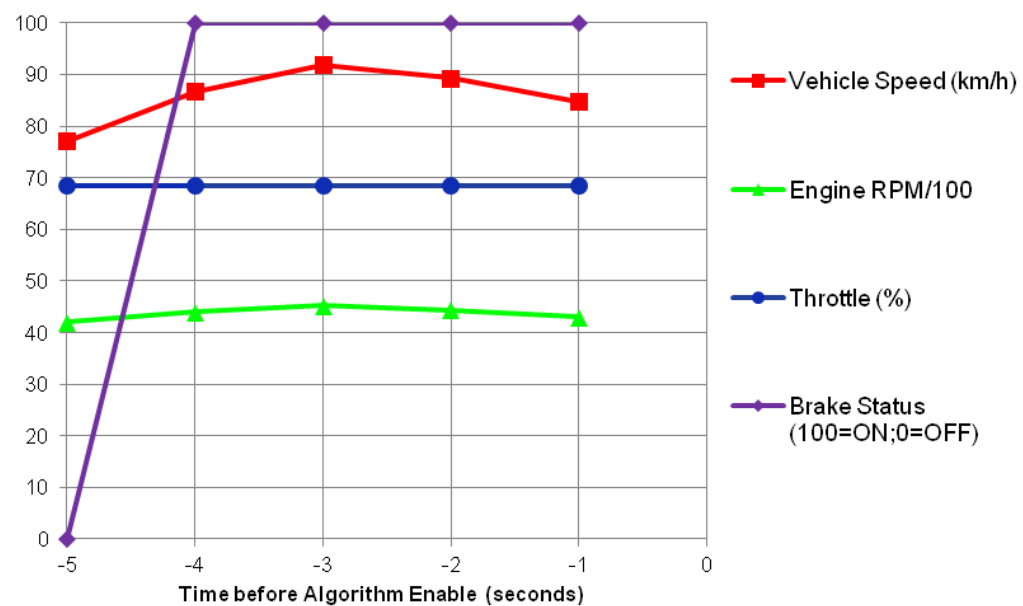
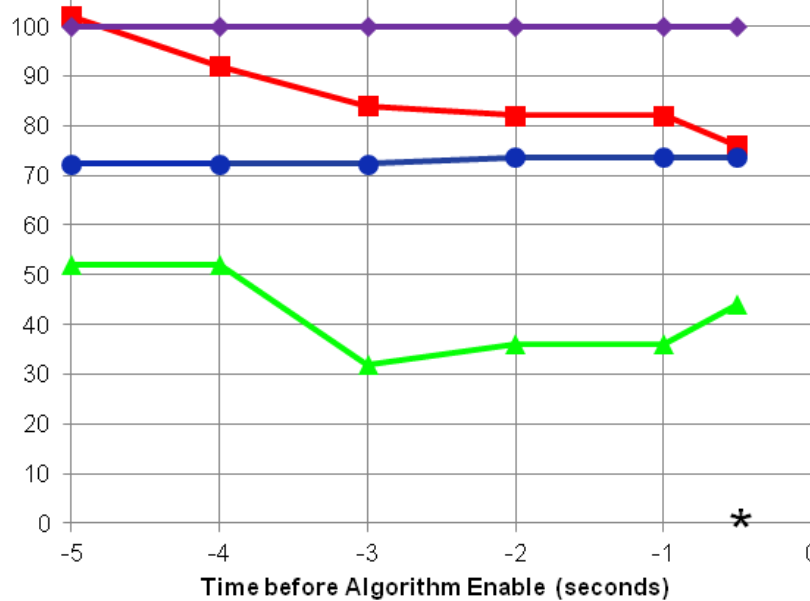


Time (s)	-5	-4	-3	-2	-1	0
Speed (km/h)	56.3	66.0	72.4	78.8	53.1	
Engine (RPM)	2950	3600	4550	3050	2150	
Throttle (%)	21	21	5	0	0	
Brake (On/Off)	0	0	0	100	100	

Discussion



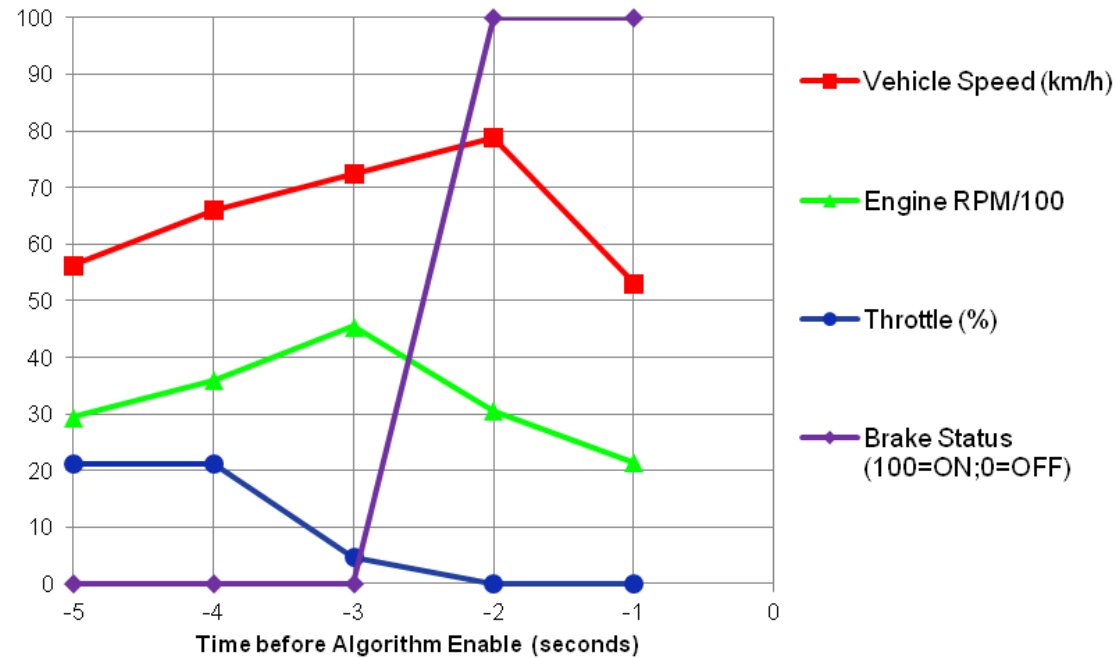
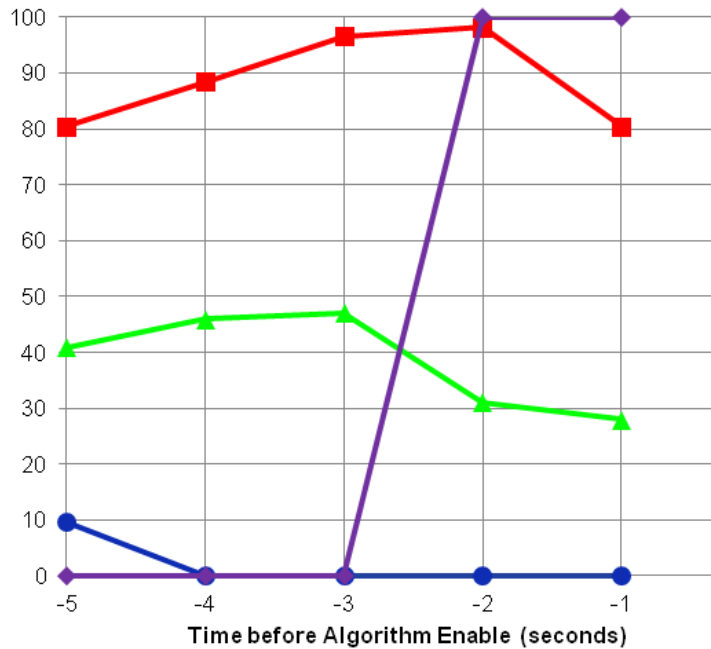
Gas Pedal Entrapment vs. Mechanical Failure:



Discussion



Cruise Control Driver Activation vs. Electrical Failure:



Conclusions



EDR data presented as 1 of 3 easily distinguishable UAC groups:

- **Pedal Misapplication category**
 - distinct from all other categories
 - can be identified quickly by visual examination
- **Pedal Entrapment & Mechanical Failure categories**
 - similar profiles to each other, but distinct from all other categories
 - mechanical inspection will confirm presence of mechanical failure, if any
- **Cruise Control Driver Activation & Electrical Failure categories**
 - similar profiles to each other, but distinct from all other categories
 - check initial gas pedal position or cruise control data to distinguish

Limitations of Study



- Case study date from documented mechanical failure category cases but no actual EDR data
- No documented cases of cruise control driver activation category to date
- No EDR data yet from recently documented electrical failure category recall

Areas for Future Work



- Inclusion of autonomous vehicle mode
- Recommend systematic collection of EDR data by Police from all reported UAC's
- Recommend systematic categorization of all reported UAC's using EDR data in collision databases
- Consider feasibility of customizable pedal positions
- Consider feasibility of UA 'engine kill switch'

References



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Questions

