CALTRANS STOP AND GO INERTIAL PROFILER IMPLEMENTATION

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ATLAS TECHNICAL CONSULTANTS

SENSORS SOFTWARE AND INSTRUMENTS

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AGENDA

1. Inertial Profilers Comparison
2. Why Stop-and-Go Inertial Profilers?
3. Specialized Speed Runs
4. PMPC Ad-hoc Working Group
5. Implementation
6. Results and System Data

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INERTIAL PROFILER COMPARISON

	Conventional Inertial Profilers 	**Stop-and-Go** Inertial Profilers 
 Additional equipment		• Three-axis accelerometers • Additional sensors/lasers • Rate gyroscopes (angular movement rate)
 Survey Speed	> 15 mph	• 0 – 15 mph in Stop-and-Go mode • > 15 mph in Conventional mode
 Traffic convoy	Required to minimize error at low speeds/stops	• Not required

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STOP-AND-GO IP BENEFITS

Improved IP Operator Safety

Decreased Interruption to Travelling Public

Decreased Labor Expenses for IP Surveys

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WHY STOP AND GO INERTIAL PROFILERS?

- An alternative to conventional IPs
- Better efficiency in IP surveys
- Multiple vendors promoting Units

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STOP-AND-GO IP TIMELINE

PAVEMENT & MATERIALS PARTNERING COMMITTEE (PMPC) AD-HOC GROUP

- Created as a collaborative effort Caltrans and Industry
- Forum to coordinate efforts and propose improvements
- PMPC serves to receive stakeholder input and recommend solutions to issues

SSI

UMTRI

Department of Transportation United States of America

METS Caltrans

Pavement Recycling PRS Systems

Collaborate

Division of Construction California Department of Transportation

MD Caltrans Maintenance Division

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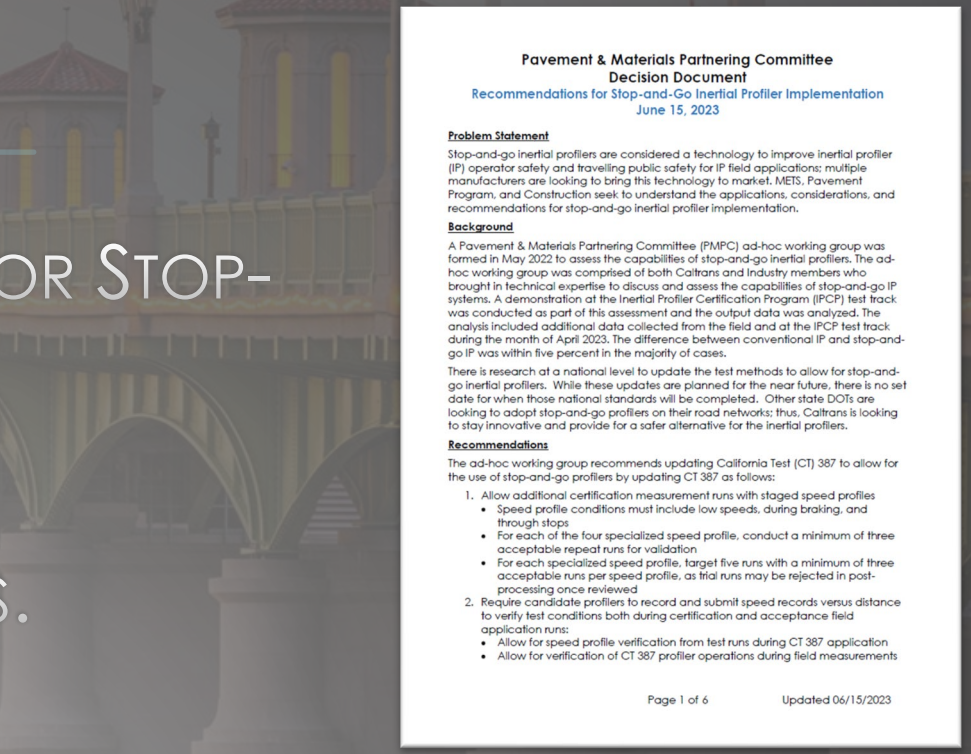
IMPLEMENTATION CONSIDERATIONS

IP SURVEYS < **15 MPH NOT ALLOWED**

NO CURRENT CERTIFICATION METHOD FOR STOP-AND-GO IPS

VALIDITY OF STOP-AND-GO IP DATA VS. CONVENTIONAL IPS



Pavement & Materials Partnering Committee
Decision Document
Recommendations for Stop-and-Go Inertial Profiler Implementation
June 15, 2023

Problem Statement

Stop-and-go inertial profilers are considered a technology to improve inertial profiler (IP) operator safety and travelling public safety for IP field applications; multiple manufacturers are looking to bring this technology to market. METS, Pavement Program, and Construction seek to understand the applications, considerations, and recommendations for stop-and-go inertial profiler implementation.

Background

A Pavement & Materials Partnering Committee (PMPC) ad-hoc working group was formed in May 2022 to assess the capabilities of stop-and-go inertial profilers. The ad-hoc working group was comprised of both Caltrans and Industry members who brought in technical expertise to discuss and assess the capabilities of stop-and-go IP systems. A demonstration at the Inertial Profiler Certification Program (IPCP) test track was conducted as part of this assessment and the output data was analyzed. The analysis included additional data collected from the field and at the IPCP test track during the month of April 2023. The difference between conventional IP and stop-and-go IP was within five percent in the majority of cases.

There is research at a national level to update the test methods to allow for stop-and-go inertial profilers. While these updates are planned for the near future, there is no set date for when those national standards will be completed. Other state DOTs are looking to adopt stop-and-go profilers on their road networks; thus, Caltrans is looking to stay innovative and provide for a safer alternative for the inertial profilers.

Recommendations

The ad-hoc working group recommends updating California Test (CT) 387 to allow for the use of stop-and-go profilers by updating CT 387 as follows:

1. Allow additional certification measurement runs with staged speed profiles
   - Speed profile conditions must include low speeds, during braking, and through stops
   - For each of the four specialized speed profile, conduct a minimum of three acceptable repeat runs for validation
   - For each specialized speed profile, target five runs with a minimum of three acceptable runs per speed profile, as trial runs may be rejected in post-processing once reviewed
2. Require candidate profilers to record and submit speed records versus distance to verify test conditions both during certification and acceptance field application runs:
   - Allow for speed profile verification from test runs during CT 387 application
   - Allow for verification of CT 387 profiler operations during field measurements

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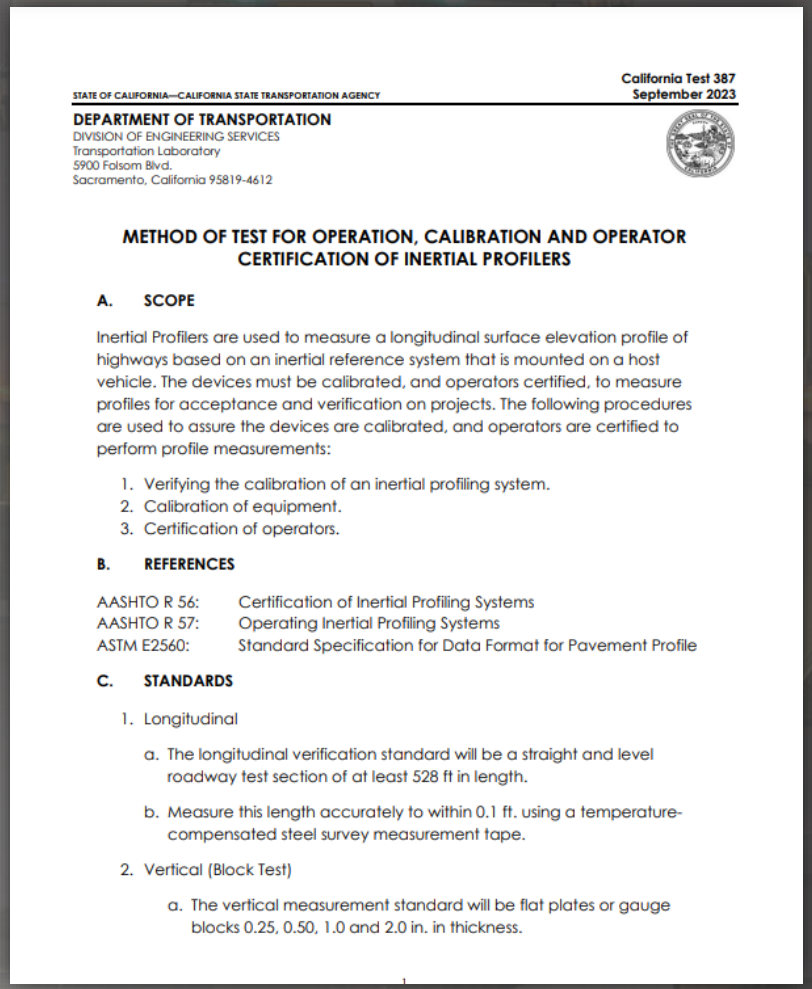
STOP-AND-GO IP CERTIFICATIONS

CT 387 Additions

- Adds a Specialized Runs Section
- Test Section Layout Using Cones
- Additional Four Speed Profiles/Conditions
- Three Compliant Runs of Each Condition



STATE OF CALIFORNIA—CALIFORNIA STATE TRANSPORTATION AGENCY

California Test 387
September 2023

DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Transportation Laboratory
5900 Folsom Blvd.
Sacramento, California 95819-4612

METHOD OF TEST FOR OPERATION, CALIBRATION AND OPERATOR CERTIFICATION OF INERTIAL PROFILERS

A. SCOPE

Inertial Profilers are used to measure a longitudinal surface elevation profile of highways based on an inertial reference system that is mounted on a host vehicle. The devices must be calibrated, and operators certified, to measure profiles for acceptance and verification on projects. The following procedures are used to assure the devices are calibrated, and operators are certified to perform profile measurements:

1. Verifying the calibration of an inertial profiling system.
2. Calibration of equipment.
3. Certification of operators.

B. REFERENCES

AASHTO R 56: Certification of Inertial Profiling Systems
AASHTO R 57: Operating Inertial Profiling Systems
ASTM E2560: Standard Specification for Data Format for Pavement Profile

C. STANDARDS

1. Longitudinal
   a. The longitudinal verification standard will be a straight and level roadway test section of at least 528 ft in length.
   b. Measure this length accurately to within 0.1 ft. using a temperature-compensated steel survey measurement tape.
2. Vertical (Block Test)
   a. The vertical measurement standard will be flat plates or gauge blocks 0.25, 0.50, 1.0 and 2.0 in. in thickness.

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SPECIALIZED SPEED RUN SETUP

- Stop-and-Go IP Systems Evaluation
  - Ensures Reproducible Data
  - Not Platform-Specific
  - Reasonable Expectation of Quality Data

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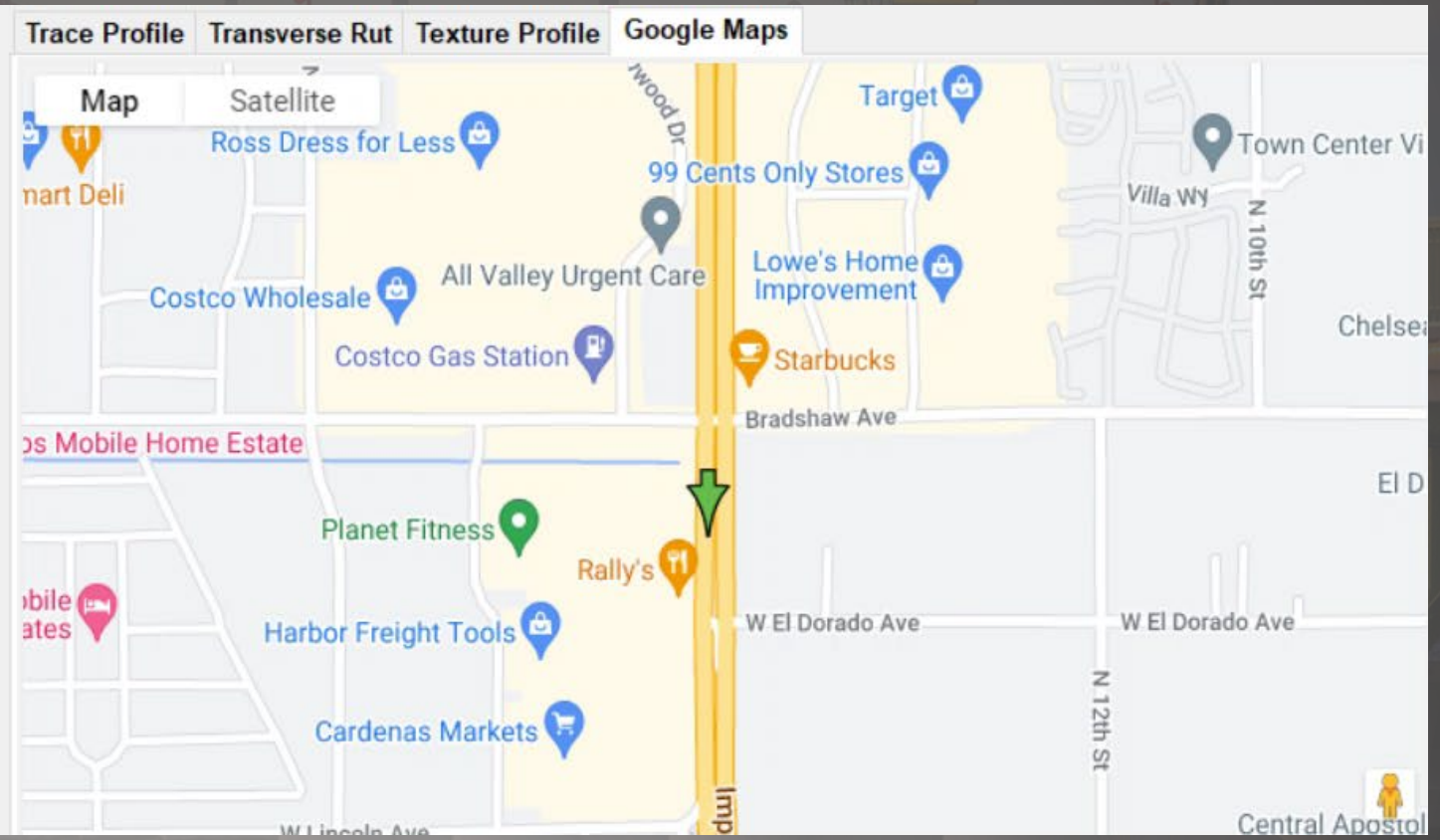
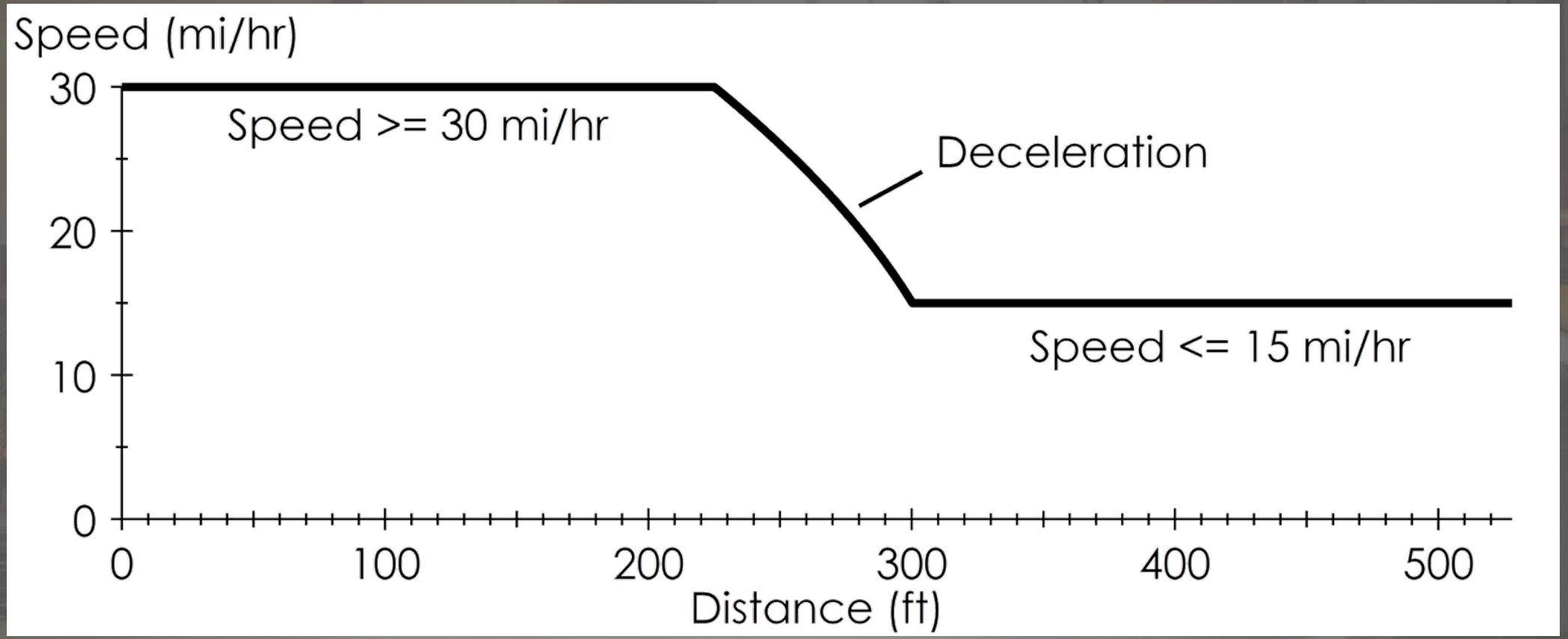
SCENARIO A: SUDDEN DECELERATION



SCENARIO A: SUDDEN DECELERATION



SCENARIO B: STOP AND GO DRIVING

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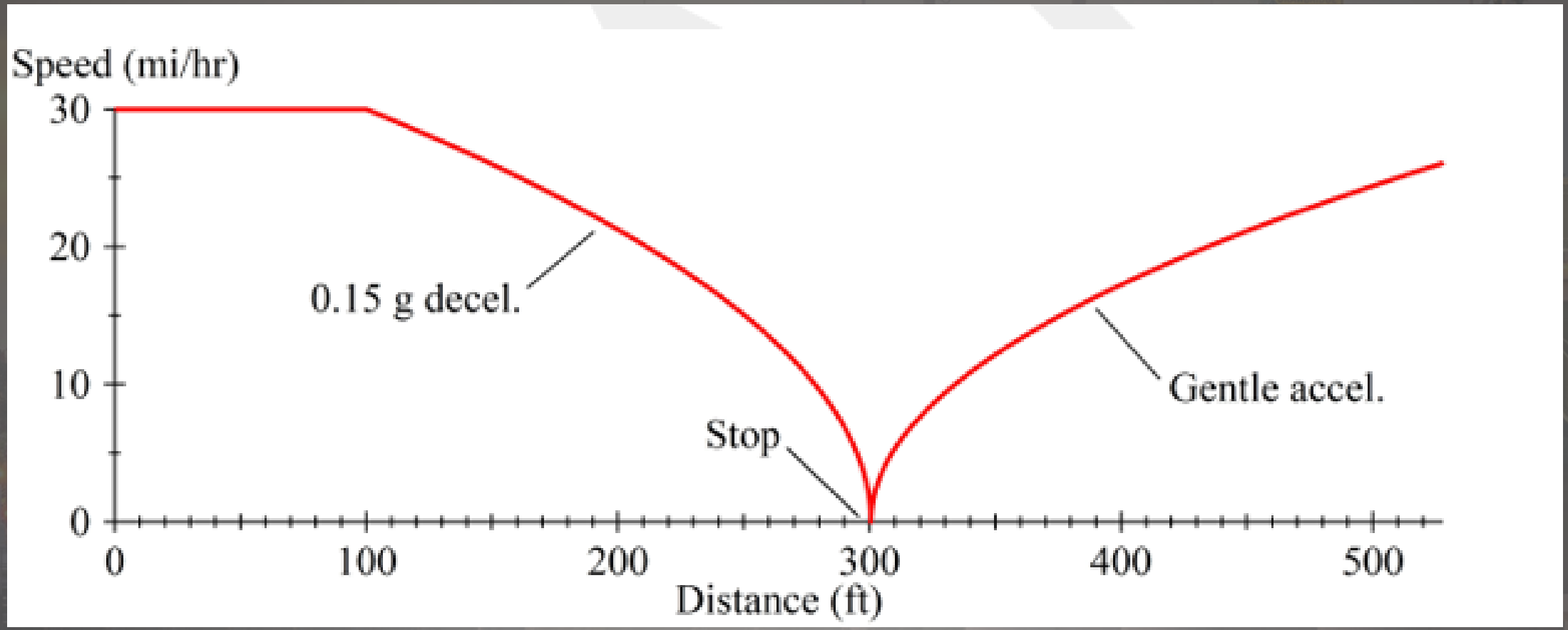
SCENARIO B: STOP AND GO DRIVING



SCENARIO C: MIXED MODE DRIVING

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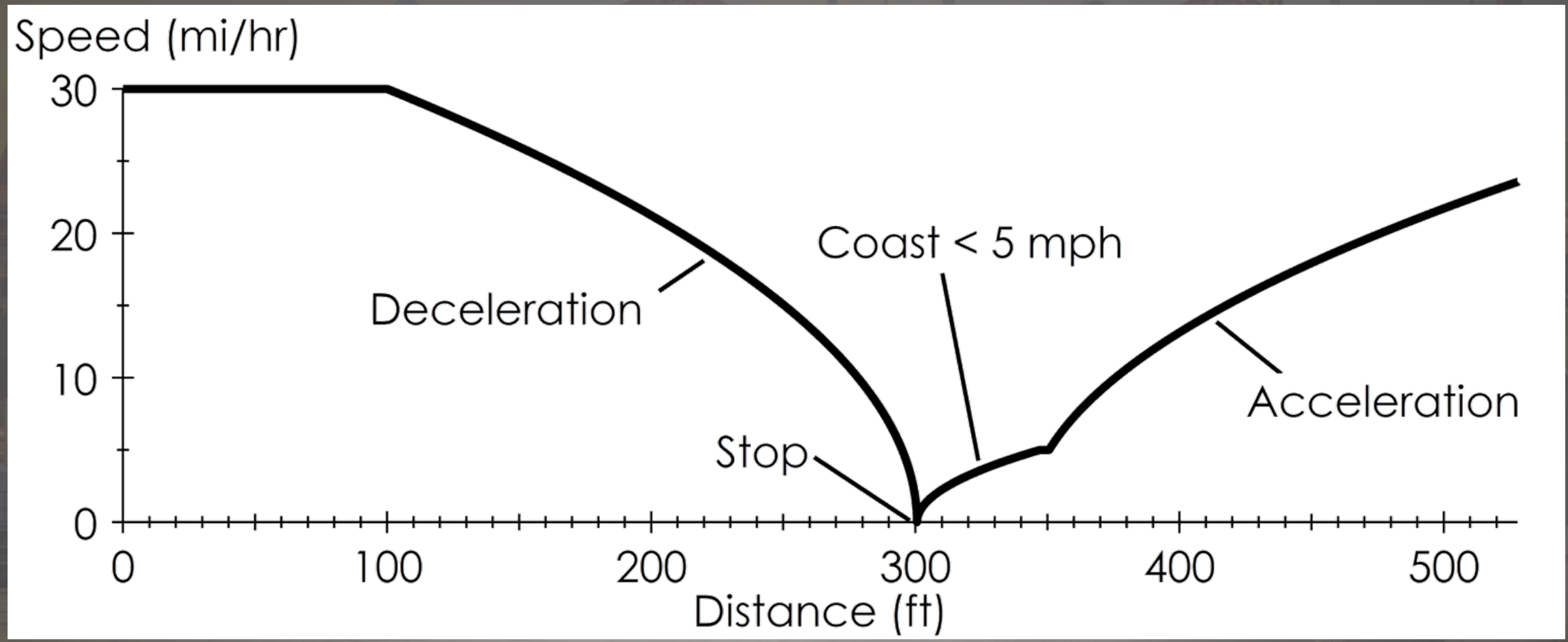

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SCENARIO D: LOW SPEED DRIVING

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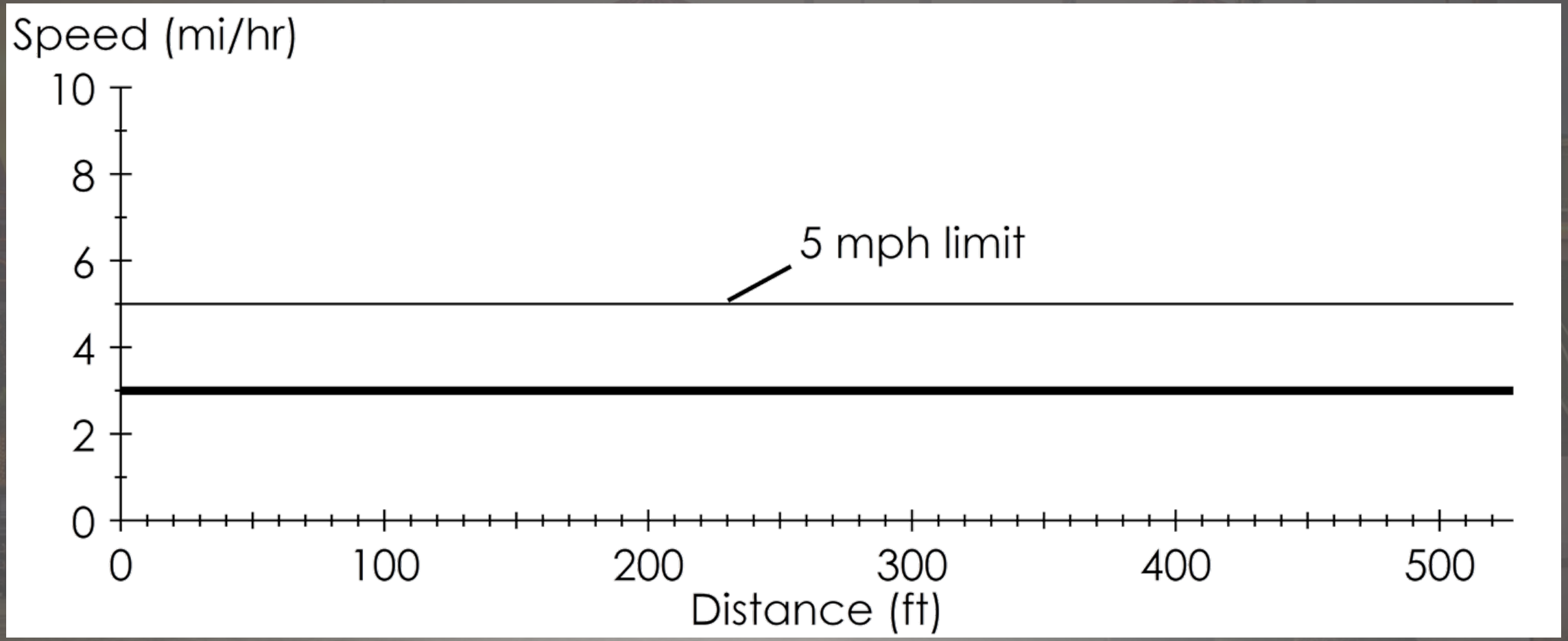
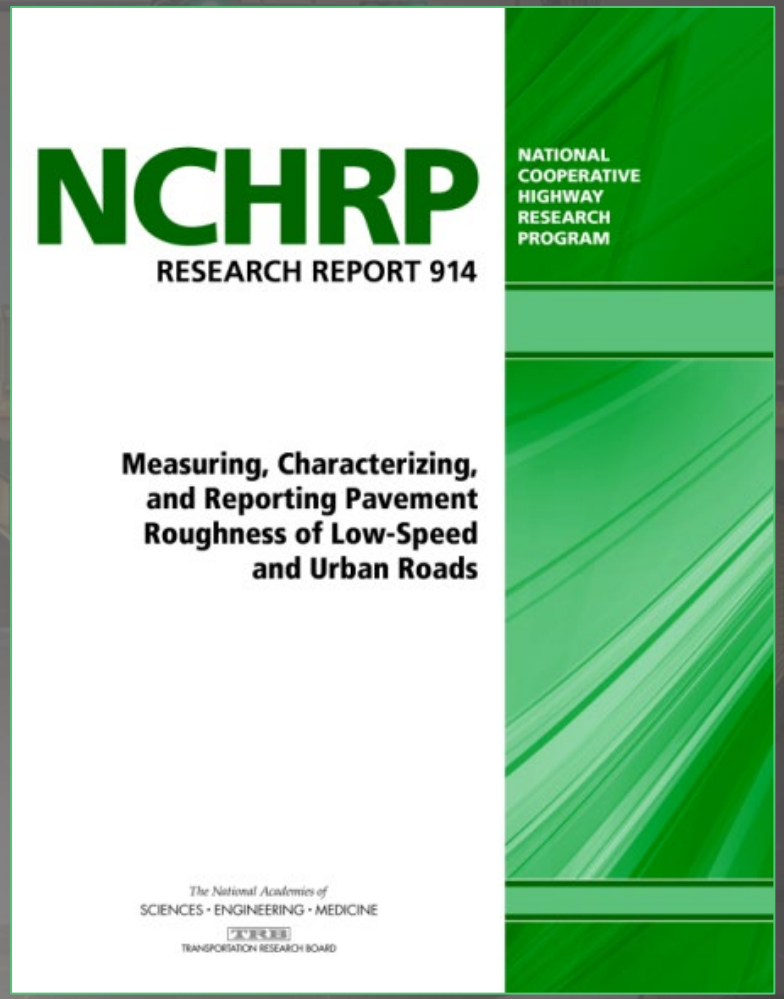
SCENARIO D: LOW SPEED DRIVING



SPEED RUN JUSTIFICATION

- TARGETS URBAN AND LOW SPEED IP CHALLENGES
- INCLUDES KNOWN ERROR SOURCES
- PROTECTS AGAINST PASSING UNDER SELECT RUNS
- VETTED IN AND BASED NCHRP PROJECTS
  - NCHRP PROJECT 10-93
  - NCHRP PROJECT 20-05



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FIELD DATA VALIDATION

UNCERTAINTY BETWEEN CONVENTIONAL AND STOP-AND-GO IP DATA

ADDITIONAL COMPARISON TESTING ON ACTIVE PROJECTS

BOTH IP DATASETS WERE WITHIN 5%

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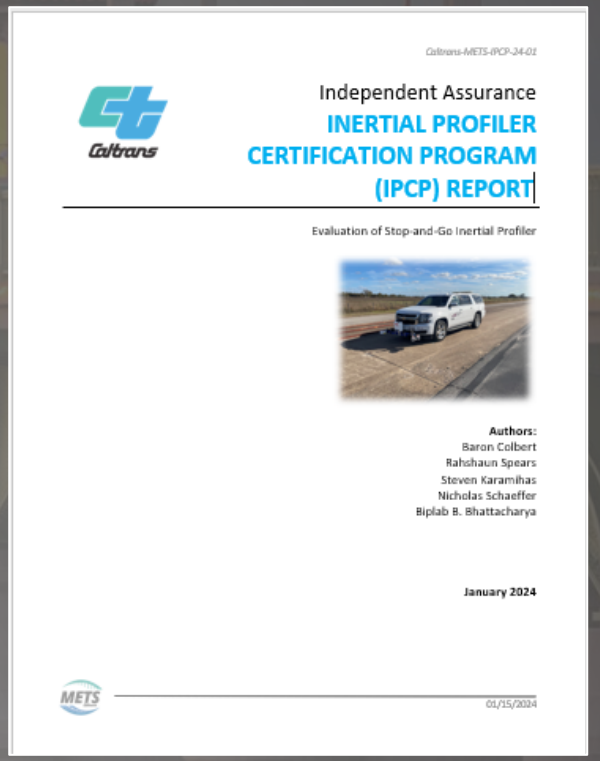
METS TECHNOLOGY REPORT

- Joint METS/Industry Effort
- Assessed Stop-and-go IP Implementation
- Recommendations
  - Submit a Decision Document to the PMPC
  - Update CT 387 to Allow Stop-and-Go IPs
  - Develop a Construction Procedure Directive (CPD) for optional Stop-and-Go IPs


Caltrans-METS-IPCP-24-01

Caltrans

Independent Assurance
INERTIAL PROFILER CERTIFICATION PROGRAM (IPCP) REPORT

Evaluation of Stop-and-Go Inertial Profiler

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January 2024

METS

01/15/2024

Communicate

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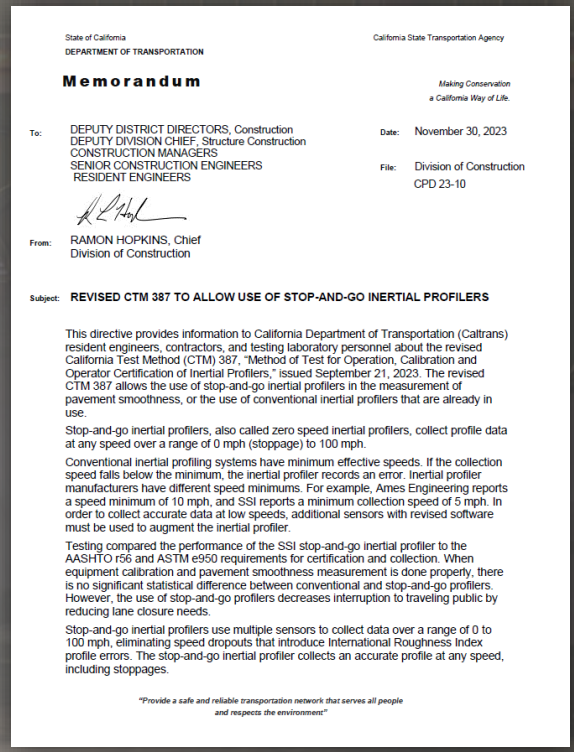
IMPLEMENTATION

- PMPC Decision Document Approved – Jul. 2023
- The CT 387 Updated – Sept. 2023
- Construction CPD Issued – Nov. 2023
- Stop-and-Go IP Certifications – Feb. 2024
- District Equipment Purchases – In Progress



State of California
DEPARTMENT OF TRANSPORTATION

California State Transportation Agency

Memorandum

Making Conservation a California Way of Life.

To: DEPUTY DISTRICT DIRECTORS, Construction
DEPUTY DIVISION CHIEF, Structure Construction
CONSTRUCTION MANAGERS
SENIOR CONSTRUCTION ENGINEERS
RESIDENT ENGINEERS

Date: November 30, 2023

File: Division of Construction
CPD 23-10

From: RAMON HOPKINS, Chief
Division of Construction

Subject: **REVISED CTM 387 TO ALLOW USE OF STOP-AND-GO INERTIAL PROFILERS**

This directive provides information to California Department of Transportation (Caltrans) resident engineers, contractors, and testing laboratory personnel about the revised California Test Method (CTM) 387, "Method of Test for Operation, Calibration and Operator Certification of Inertial Profilers," issued September 21, 2023. The revised CTM 387 allows the use of stop-and-go inertial profilers in the measurement of pavement smoothness, or the use of conventional inertial profilers that are already in use.

Stop-and-go inertial profilers, also called zero speed inertial profilers, collect profile data at any speed over a range of 0 mph (stoppage) to 100 mph.

Conventional inertial profiling systems have minimum effective speeds. If the collection speed falls below the minimum, the inertial profiler records an error. Inertial profiler manufacturers have different speed minimums. For example, Ames Engineering reports a speed minimum of 10 mph, and SSI reports a minimum collection speed of 5 mph. In order to collect accurate data at low speeds, additional sensors with revised software must be used to augment the inertial profiler.

Testing compared the performance of the SSI stop-and-go inertial profiler to the AASHTO r56 and ASTM e950 requirements for certification and collection. When equipment calibration and pavement smoothness measurement is done properly, there is no significant statistical difference between conventional and stop-and-go profilers. However, the use of stop-and-go profilers decreases interruption to traveling public by reducing lane closure needs.

Stop-and-go inertial profilers use multiple sensors to collect data over a range of 0 to 100 mph, eliminating speed dropouts that introduce International Roughness Index profile errors. The stop-and-go inertial profiler collects an accurate profile at any speed, including stoppages.

"Provide a safe and reliable transportation network that serves all people and respects the environment"

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CERTIFICATION RUNS: FEBRUARY 2024

First Revised CTM 387 Certification Procedure

- Five inertial profilers with Zero-Speed upgrades
- Ten runs for standard inertial certification
- Four scenarios with three passing runs
  - 90% accuracy
  - 92% repeatability
- Two systems retested the next day

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GOALS

- Replicate field speed conditions
- Same requirements as constant speed runs
- Report profiler dynamics – speed [and acceleration]
- Operator competence - More settings with stop-and-go
  - IMUs and GPS
  - Lasers
  - Measurement offsets

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RESULTS

- Repeatability isn't the failing criteria, typically
- Vehicle tracking is crucial
- Operator Opinion:
  - Scenario A from 30 to 15mph is most difficult
  - Scenario B "Creep" is hard to go slow enough
- Focus on speed **and** obstacles **and** tracking

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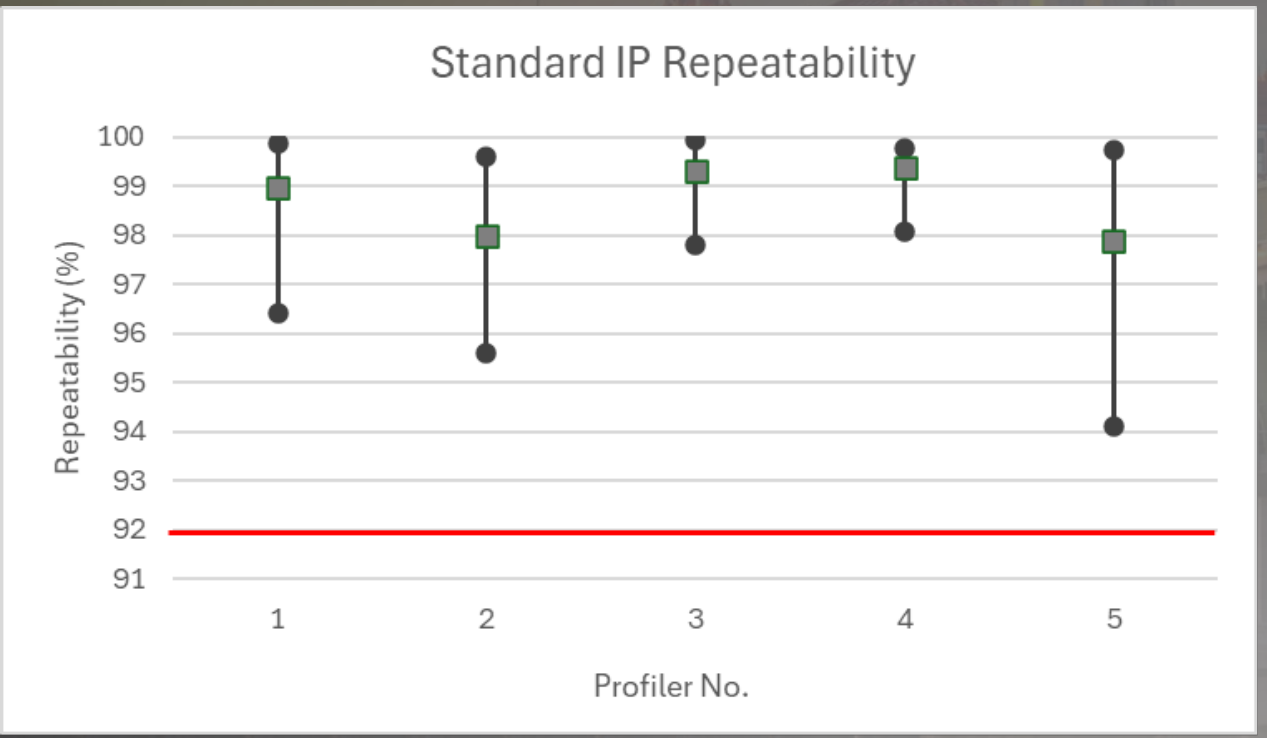
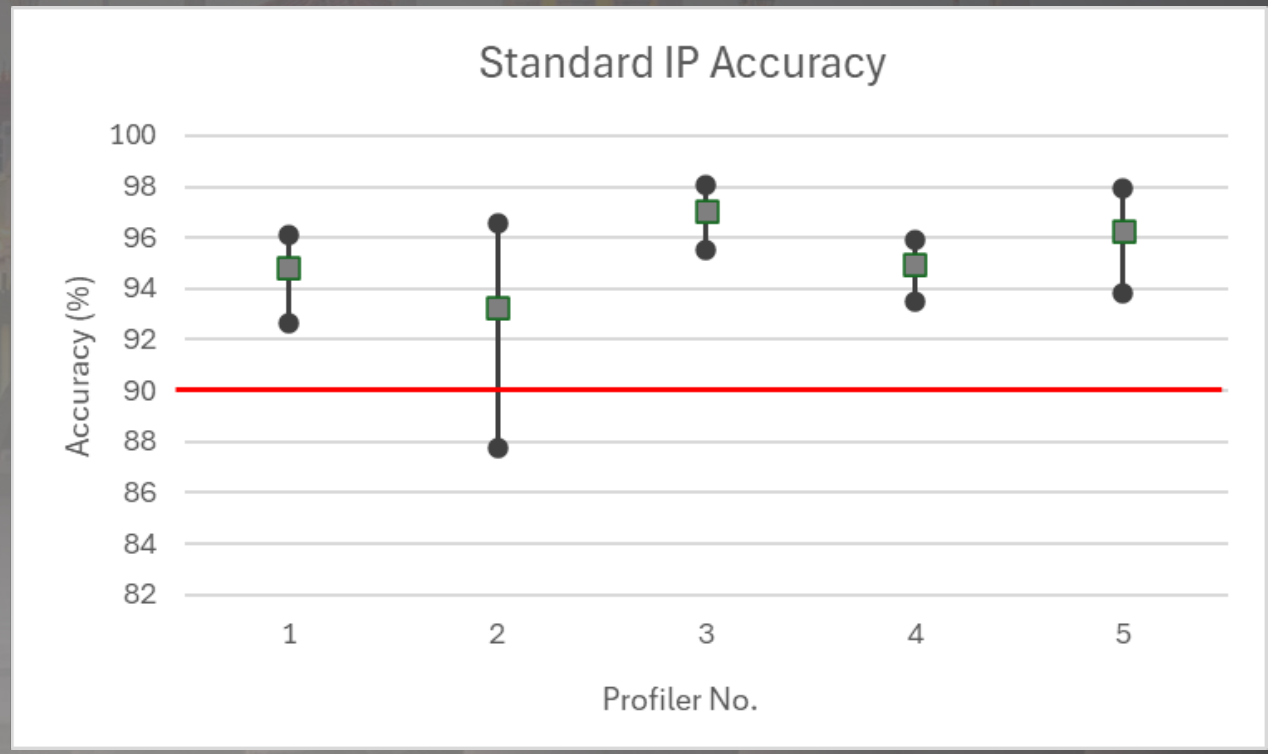
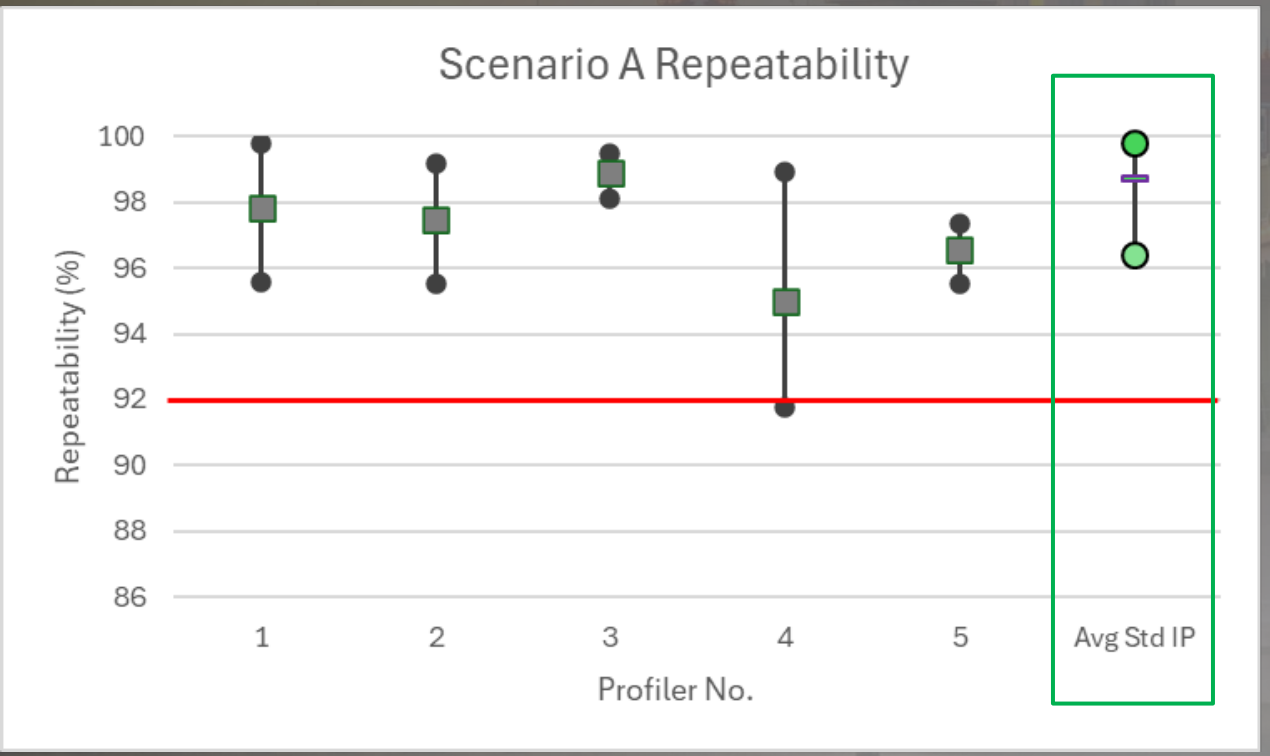
RESULTS – 2/28/24 STANDARD IP

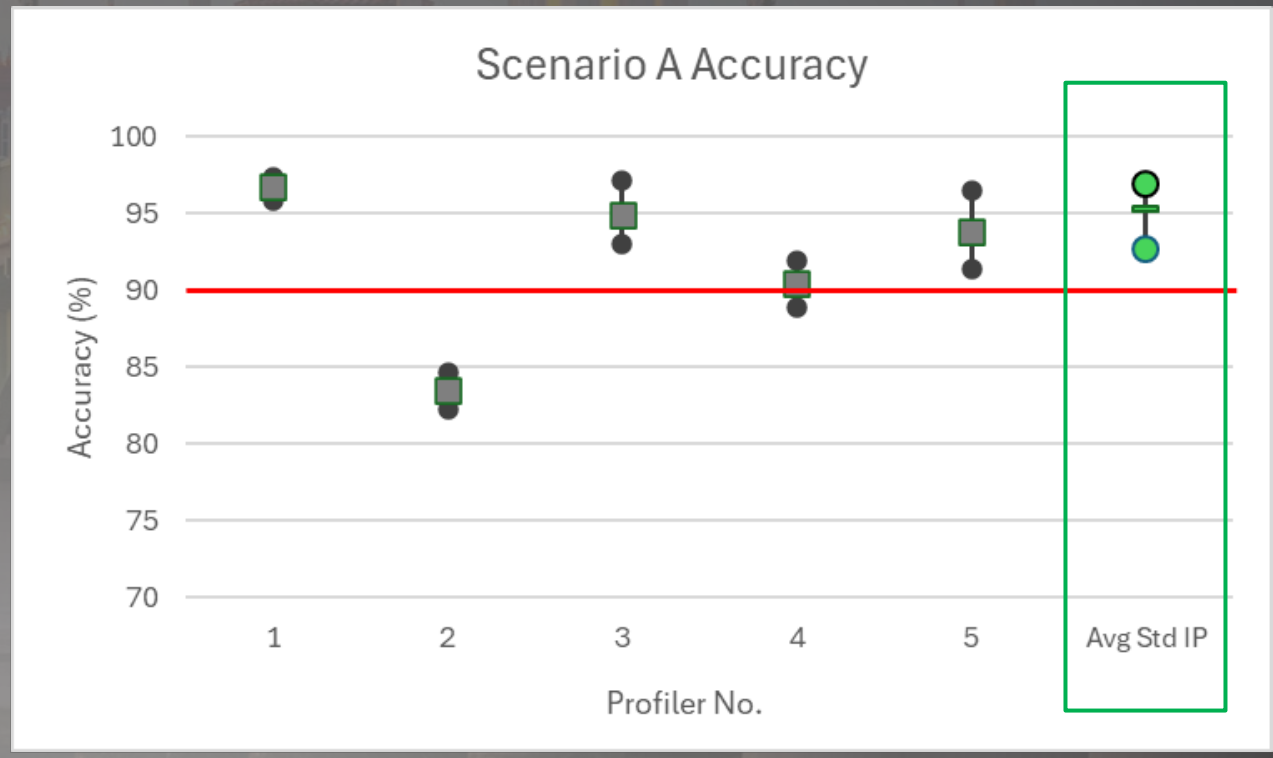
Standard Inertial Profiler



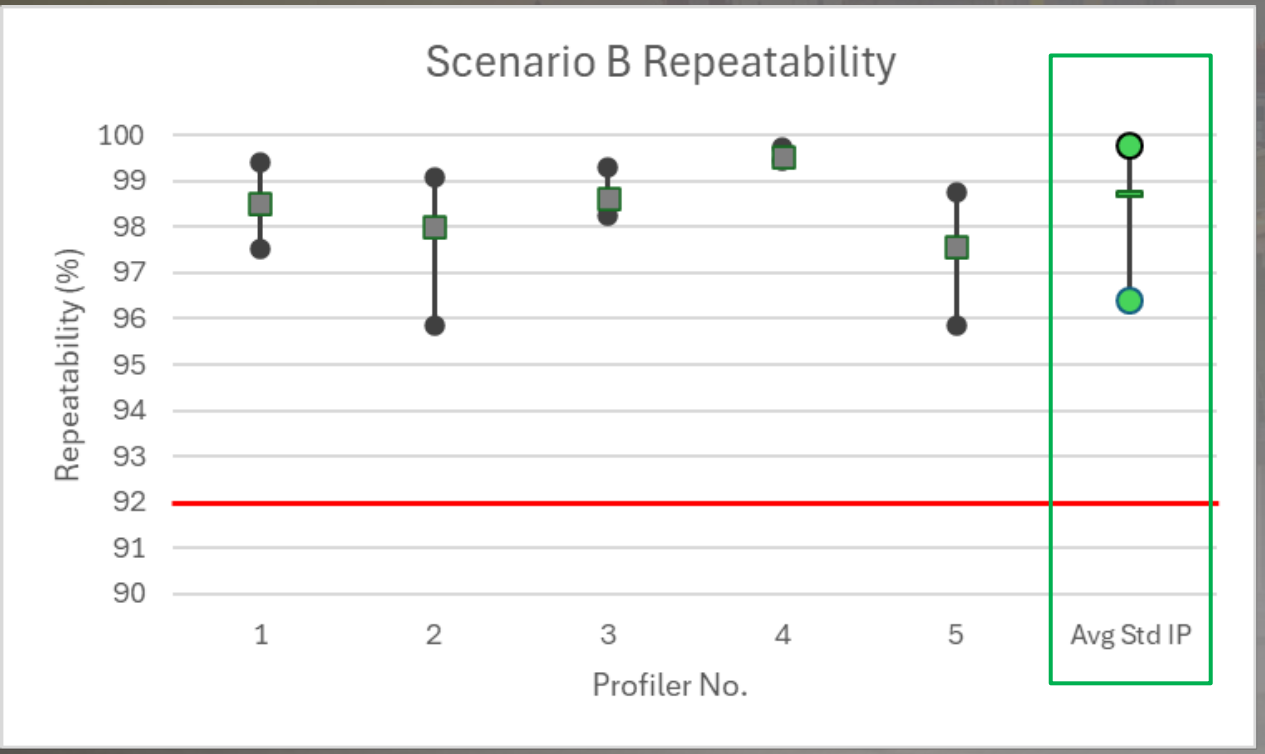


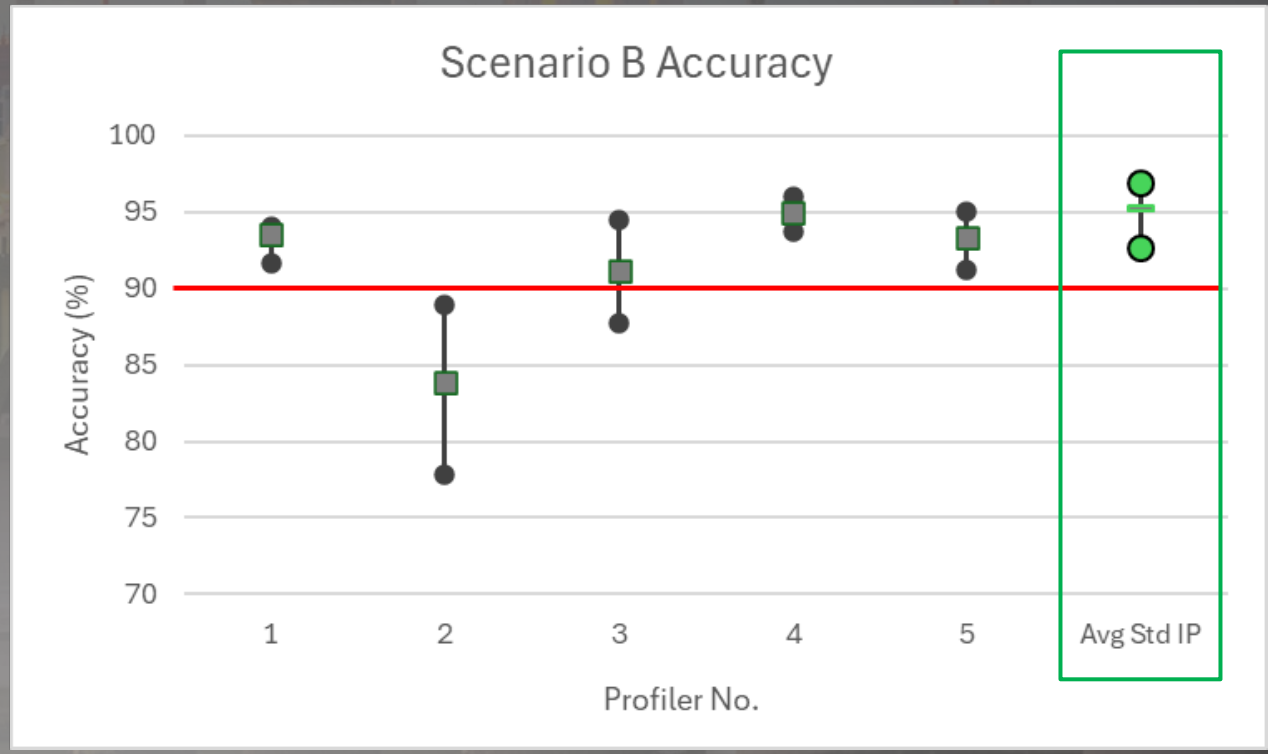
RESULTS: SCENARIO A 30MPH – 15 MPH





RESULTS: SCENARIO B < 5MPH CREEP





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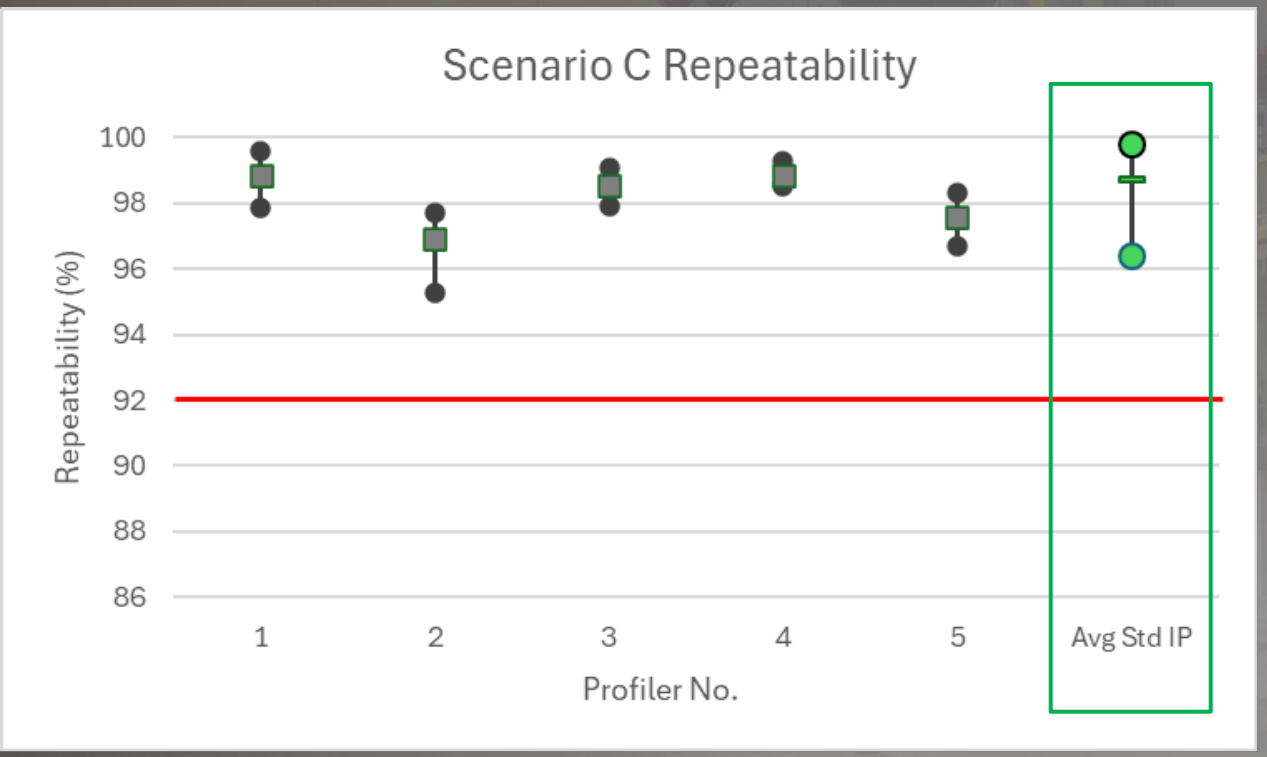
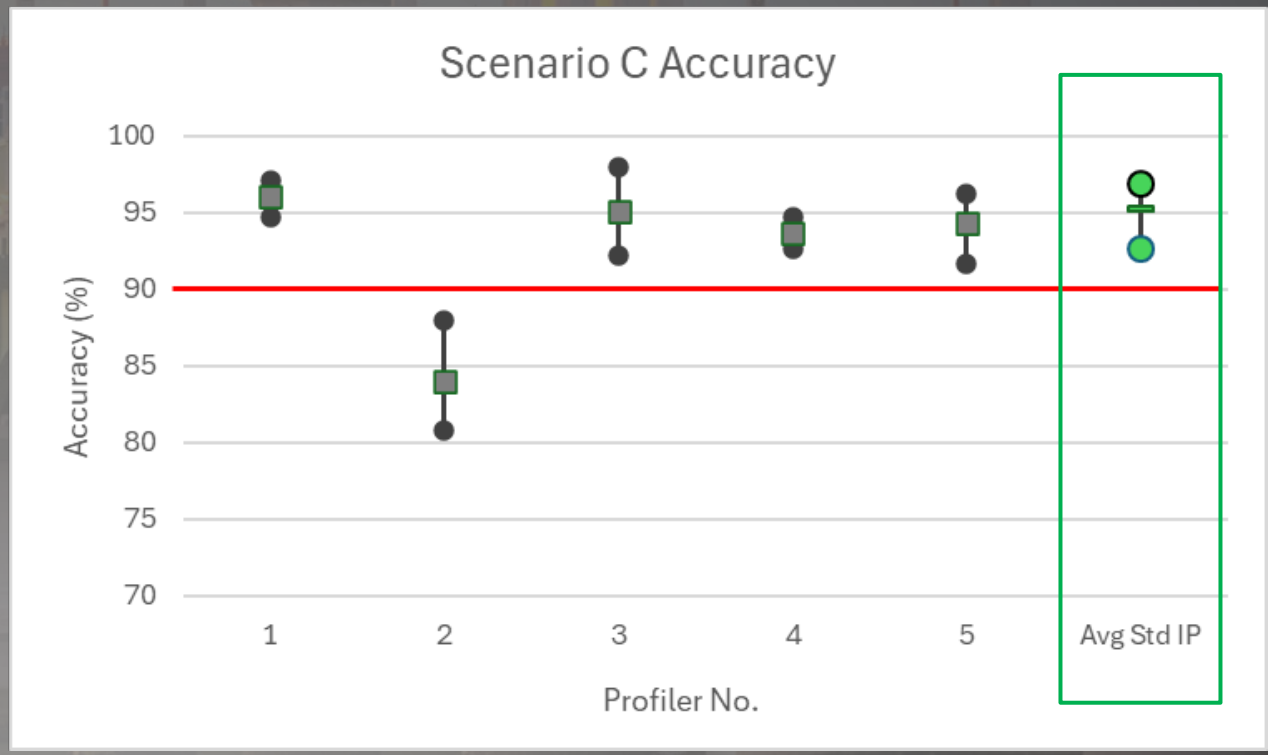
RESULTS: SCENARIO C 30 MPH, STOP, CREEP, ACCELERATE





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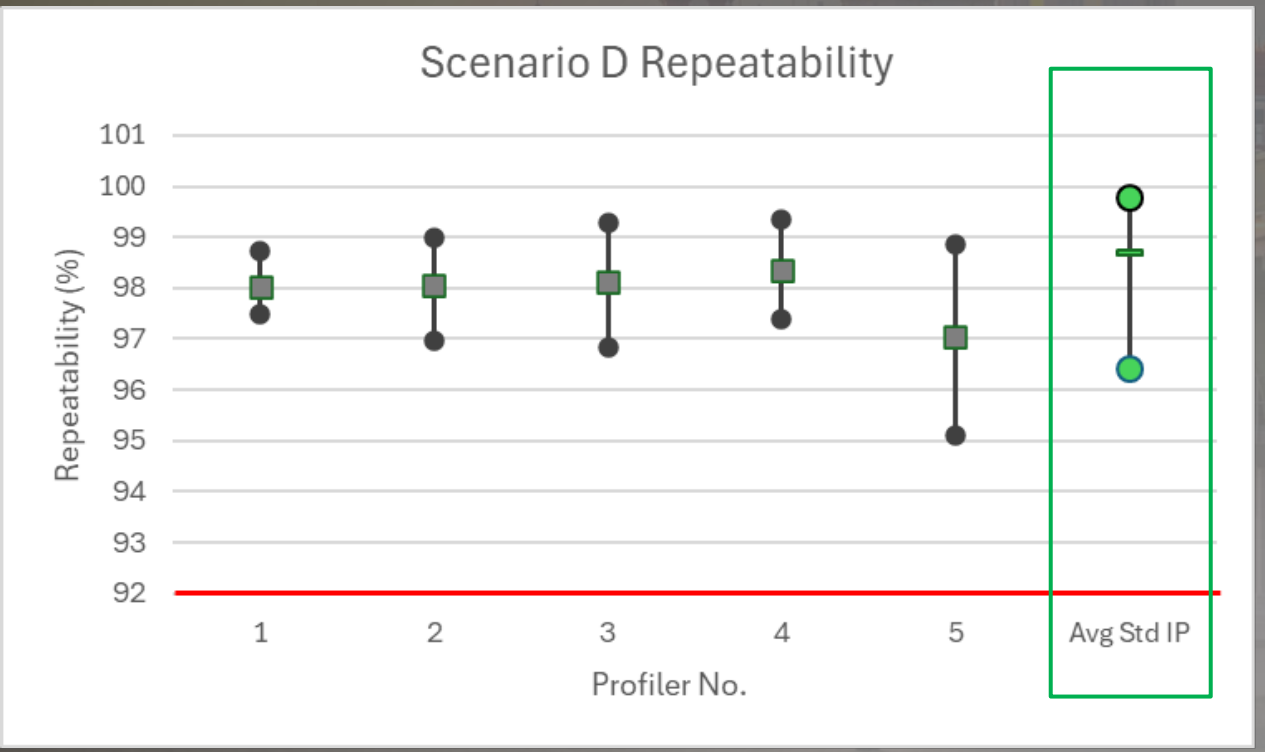
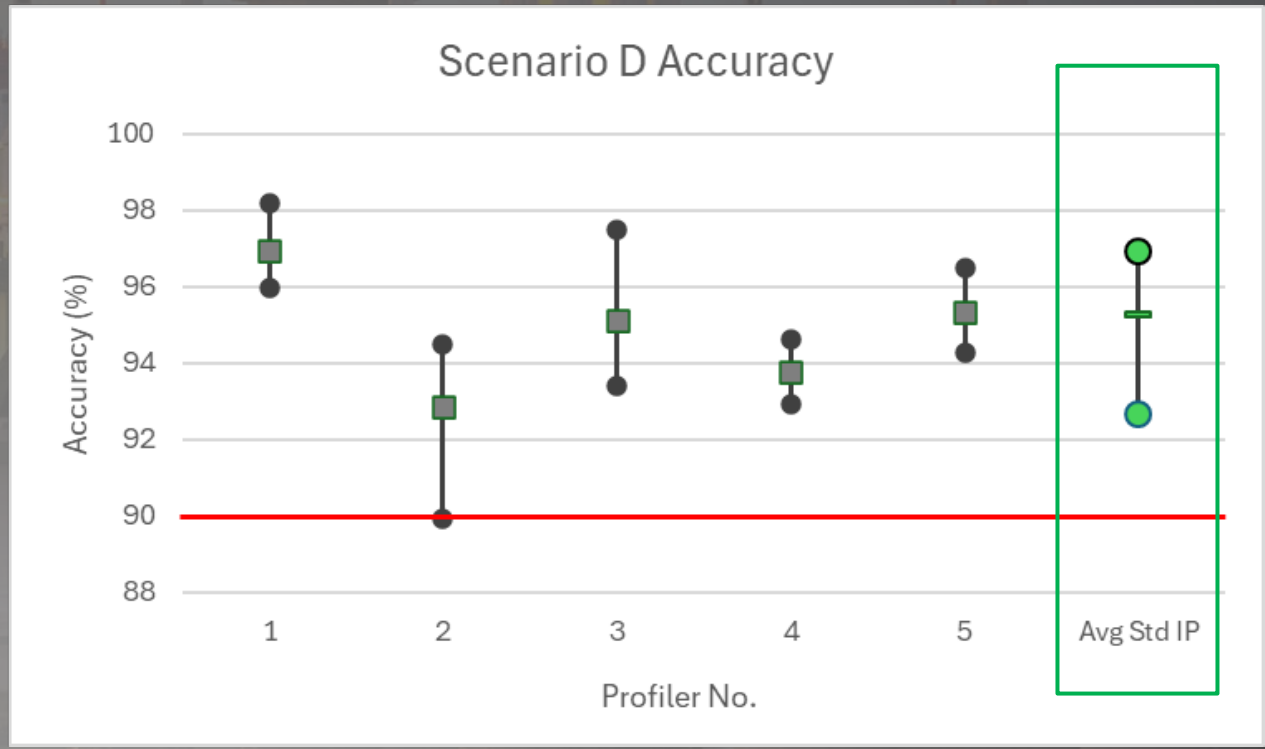
RESULTS: SCENARIO D 30 MPH, STOP, ACCELERATE





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EXPORT OPTIONS

1. Export speed at higher resolution
2. View
3. New acceleration
   - Ne

DavBAHB04 Run 1 Raw Profile Heights.txt - Notepad

File Edit Format View Help

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Station (ft), Track 1 Elevation (in), Track 2 Elevation (in), Speed (mph)
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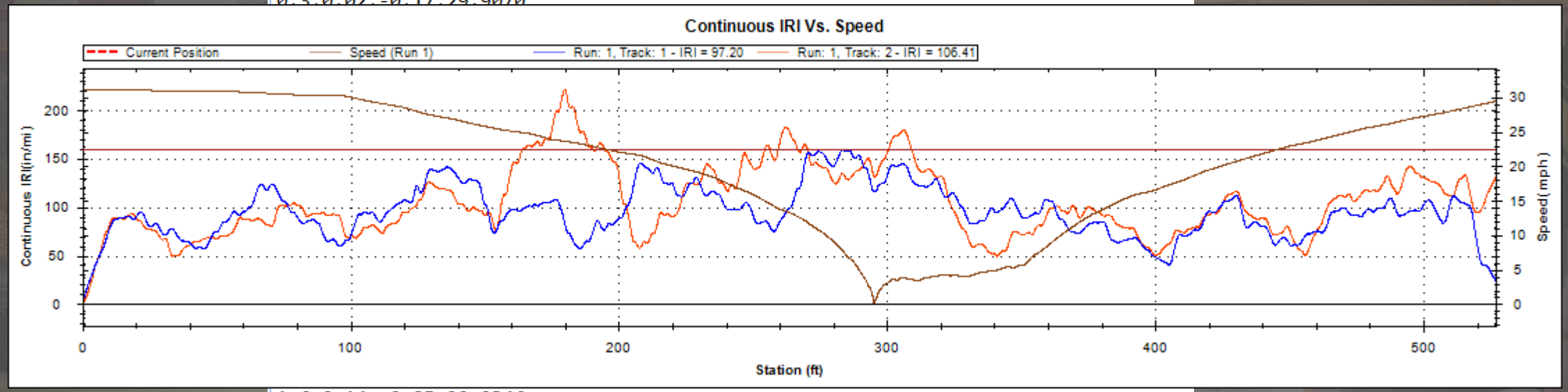

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MOVING FORWARD

- Faster verifications and exports for speed
- Better way to set and maintain speed by operator
  - Define speed tolerance in tests
- Field conditions not to exceed certification condition
- GPS-DMI
  - Improvement over wheel mounted encoders

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MOVING FORWARD

- EXPORT SPEED OVER TIME (FOR STOPS)

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DavNAHB04 Run 1 Raw Profile Heights Track 1.txt - Notepad

File Edit Format View Help

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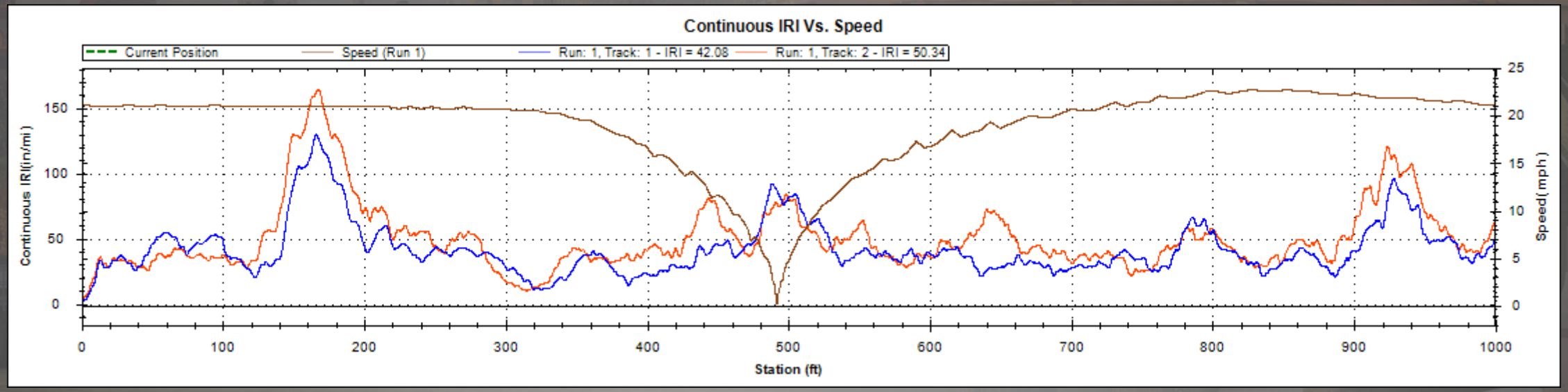
OTHER SITES

NEVADA DOT AND ICART

- SINGLE SCENARIO STOP AND GO



ACKNOWLEDGEMENTS

- Caltrans
- FHWA
- University of Michigan Transportation Research Institute
- Sensors Software & Instruments
- Pavement Recycling Systems
- Atlas Technical Consultants

THANK YOU!

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