

Overview of Density Profiling System (DPS)

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FHWA Workshop
(March 31, 2021)



Mn/DOT

Office of Materials and Road Research

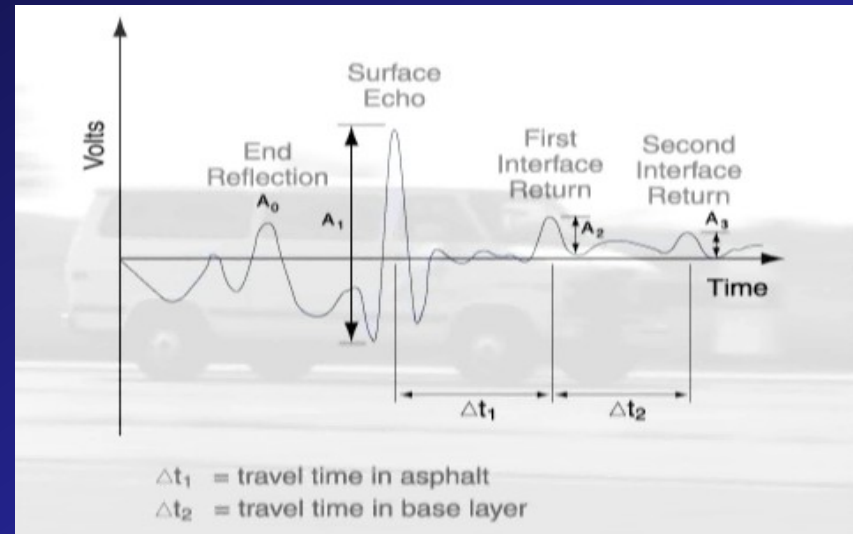
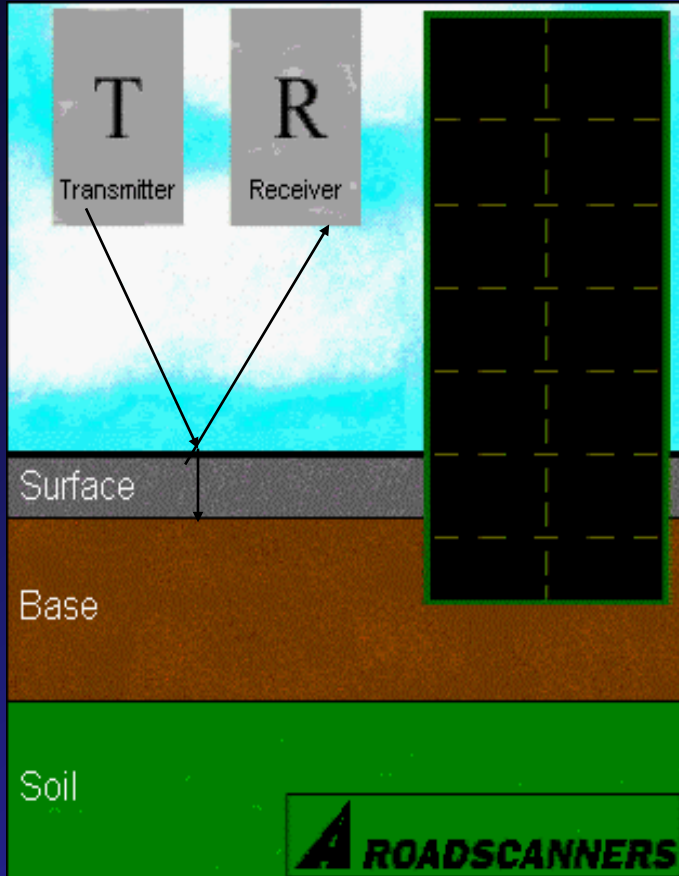


Density Profiling System (DPS)

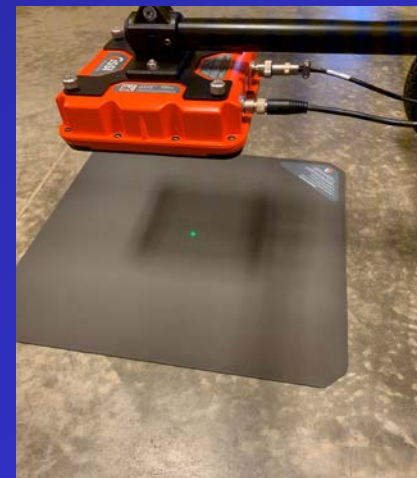
- **What is DPS?**
 - **A Ground Penetrating Radar (GPR) device.**
 - **Not directly measure density; measure dielectric constant.**
 - **GPR: is a noninvasive, nondestructive testing tool for mapping subsurface conditions.**
 - **Archaeology**
 - **Similar to X-ray**
 - **Radio waves to detect features in pavement**



➤ Wave propagation in solids

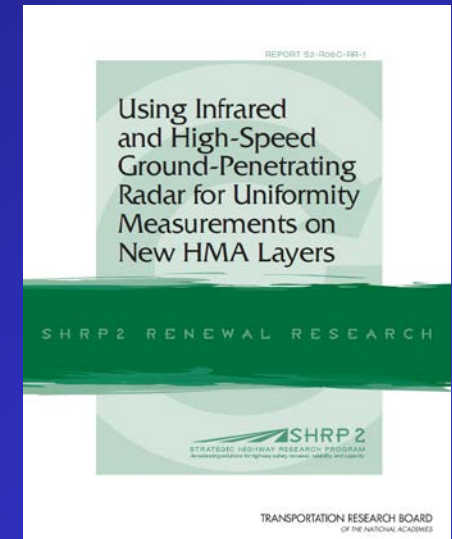


$$\epsilon_{HMA} = \left(\frac{1 + \frac{A_0}{A_P}}{1 - \frac{A_0}{A_P}} \right)^2$$



Density Profiling System (DPS)

- **DPS**
 - One channel or multi-channels
 - Specific designed to measure HMA compaction density
- **SHRP2 R06C Research Product (2013)**
 - Dielectric values related to air voids.



SHRP2 Implementation Assistance (2015)

➤ Objective:

- Provide financial and technical assistances to states to further evaluate and implement DPS.

➤ Partnership

- FHWA, AASHTO, CH2M Hill
- University of Minnesota
- Maine DOT
- Nebraska DOT
- MnDOT



Motivation

- **Pavement density has great effects on performance.**
 - Lack of density --- localized failure
 - **1989 – “Effect of Compaction on Asphalt Concrete Performance” (Wash.DOT)**
Each 1% increase in air voids (over 7 percent) tends to produce ~10 percent loss in pavement life.

- **Core used to determine density**

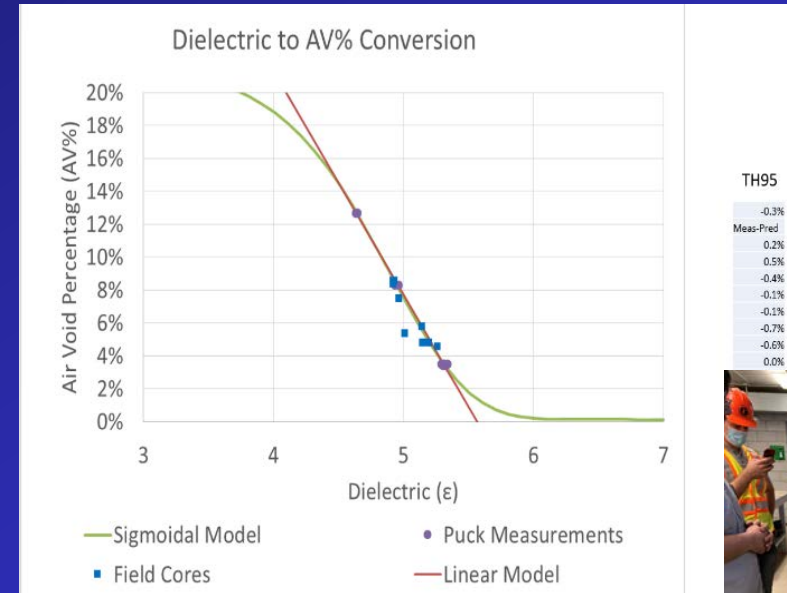
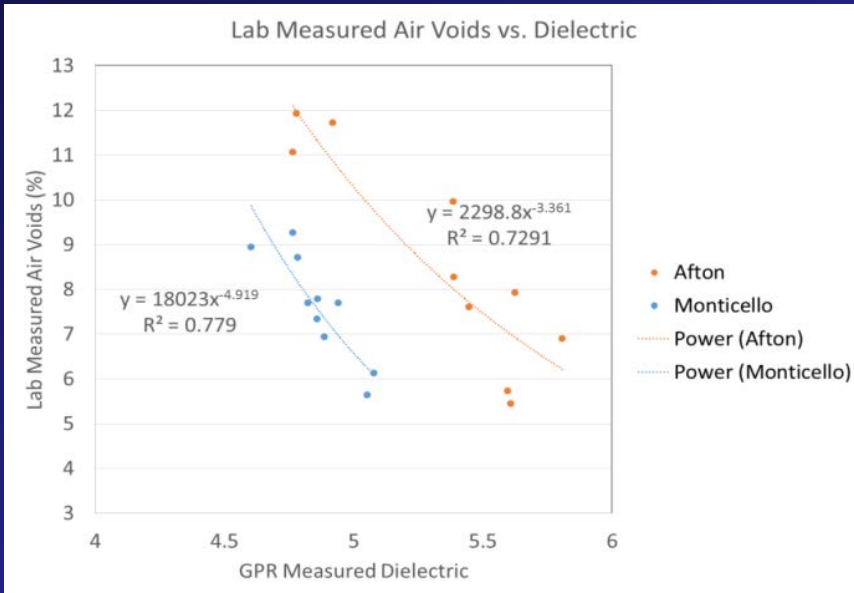
- At a particular location, does not represent the entire pavement density
- Need a way to obtain full coverage of the surface
 - GPR is a good tool: Continuous profile



Photo 1

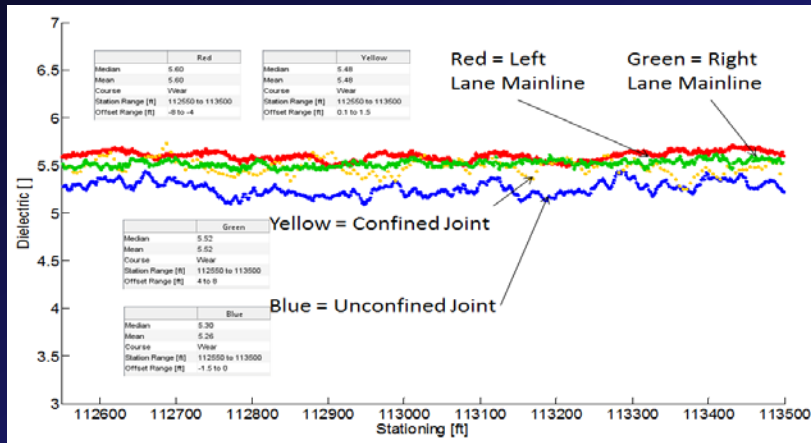
General Concept

- How to relate dielectric to density?
 - Calibration between dielectric constant and density
 - Previously: Used cores
 - Currently: Gyrotory pucks



Field Testing

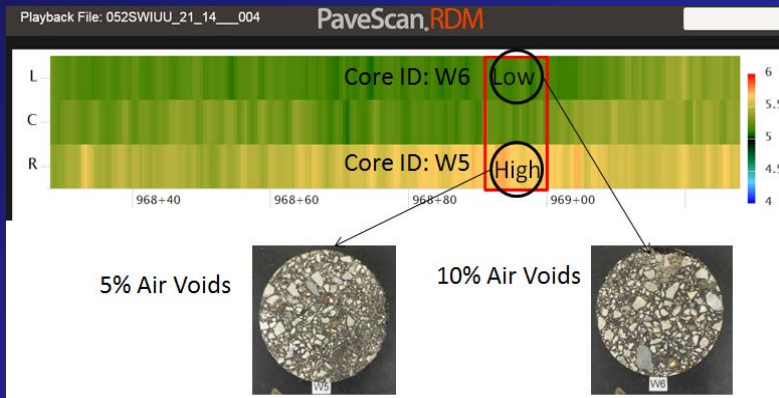
➤ On-Site Identification



➤ Mainline Survey: multiple passes



➤ Joint Survey: one antenna close to joint



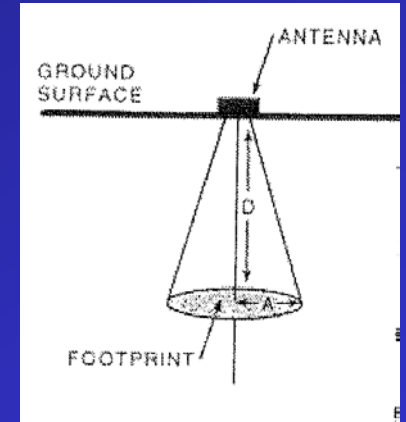
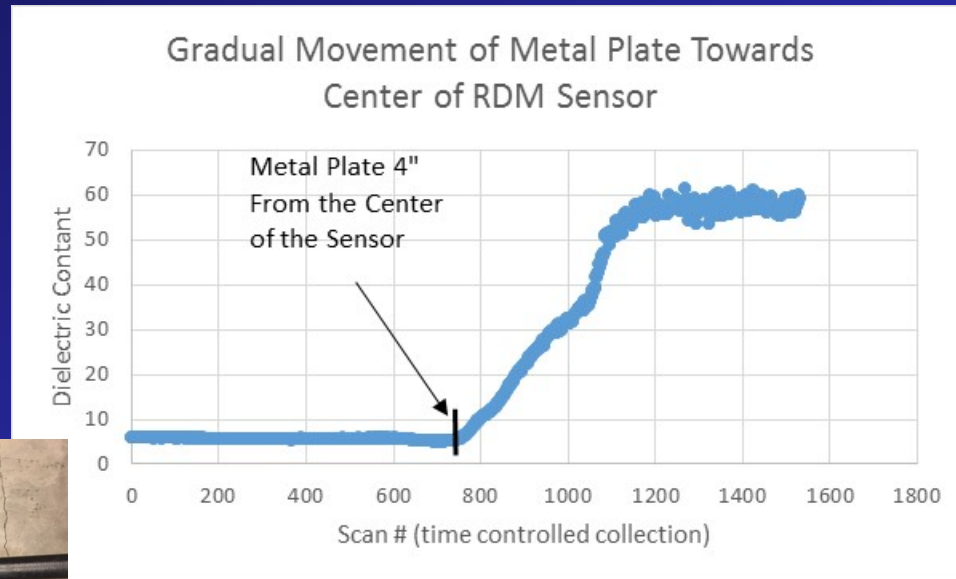
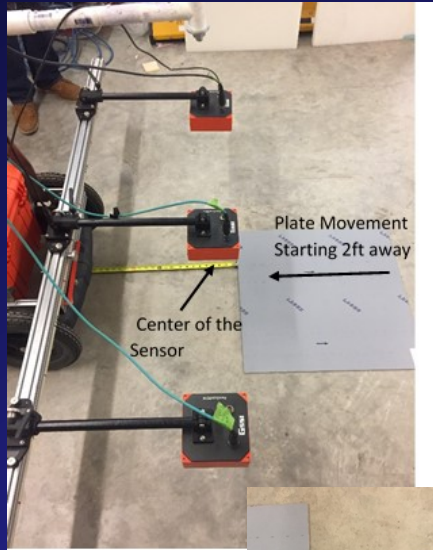
Challenges

- Footprint area of an antenna (Fresnel Zone)?

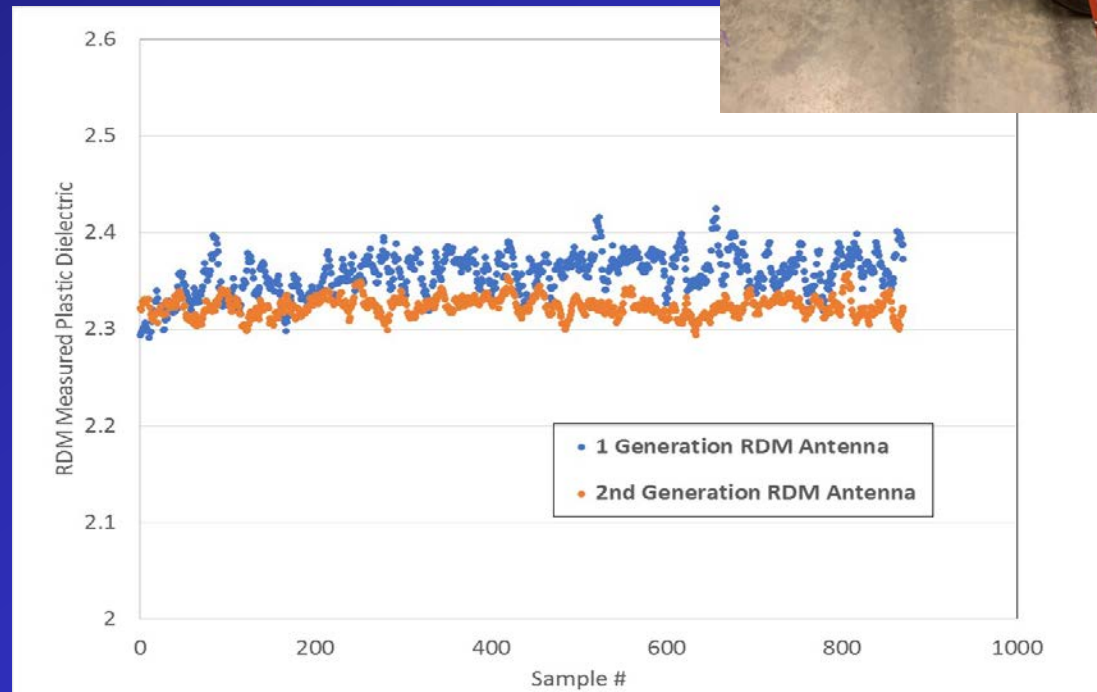
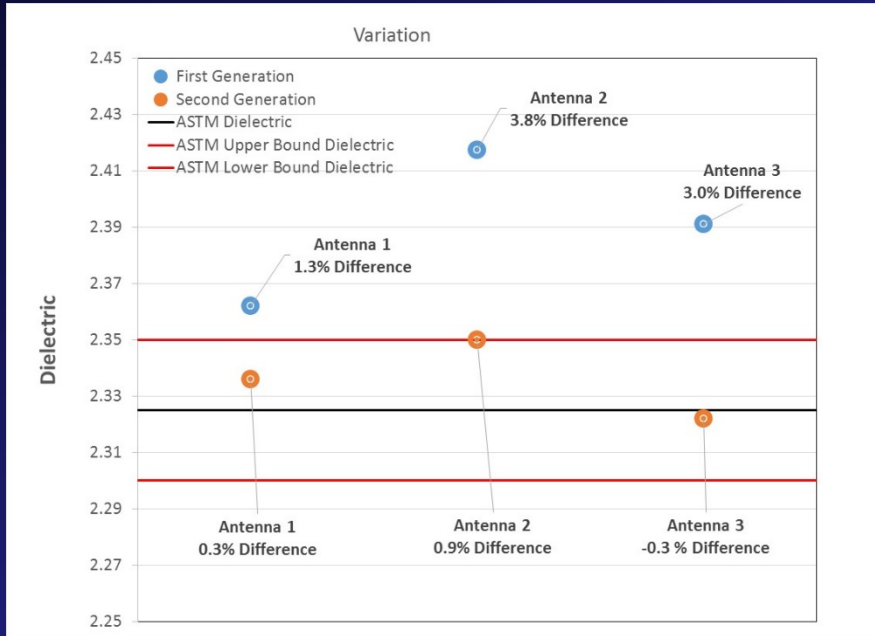
$$F_r \sim 0.5 \sqrt{t_r/f_c}^{1/2}$$

at $D=18''$, F_r (Radius) $\sim 6''$ (for 1.5Ghz)

$D=12''$, F_r (Radius) $\sim 3.8''$ (for 2.5Ghz-DPS)



➤ Calibration



MnDOT History

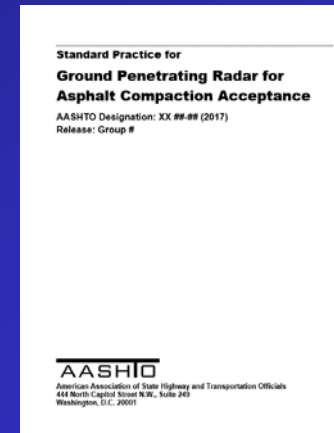
- Obtained the equipment (DSP) in 2015
- Data Collection Equipment:
 - Push-cart → Vehicle → Gator → Robot



MnDOT History

➤ Field Evaluation:

- 2016 -2020: over 20 projects
 - Collect data; get experience; find issues for improvements
- 2018-2021
 - Start to education contractor
 - Hire contractors to collect data for us
 - AASHTO Spec. (AASHTO PP98-19)
 - 2021: Pilot a rental/buy program



Pooled Fund: Continuous Asphalt Mixture Compaction Assessment using Density Profiling System (DPS) - TPF 5(443)

- 3 year project, started in January 2020
- Continuation of SHRP2 Effort
 - SHRP2 identified GPR is promising tool
 - But a lot of work still remain for implementation: user friendly system, data collection and analysis methods, etc.
- Financial Contribution Agencies
FHWA, Idaho, Maryland, Mississippi, Missouri, Maine, New York,
Ohio, Pennsylvania, Washington, North Dakota, Utah, Minnesota



DPS Pooled Fund - TPF 5(443)

➤ Technical Contribution Agencies

- A lot of experience, knows issues and needs
- Alaska; Florida and Nebraska (we can add as needed)

➤ Objective

- A) Further advance and improve DPS system
- B) Support communication
- C) Provide training and technical assistance to states and others
- D) Promote DPS to other vendors, contractors, consultants and DOTs and local government, etc.





Project Tasks

Task 1: Software and Hardware Improvements

- Contract to GSSI to further improve the system.

Task 2: Development of AASHTO Data Collection and Analysis Specification

- Laboratory puck calibration procedure
- Field data collection procedure

Task 3: Precision and Bias Statement

- ASTM E691
- Repeatability and Reproductivity

Task 4: Equipment and Operator Certification

Task 5: Support Communication

Task 6: Provide Training and Technical Assistance

Task 7: Promote the technology

<http://www.dot.state.mn.us/materials/dps/index.html>



Thank you

