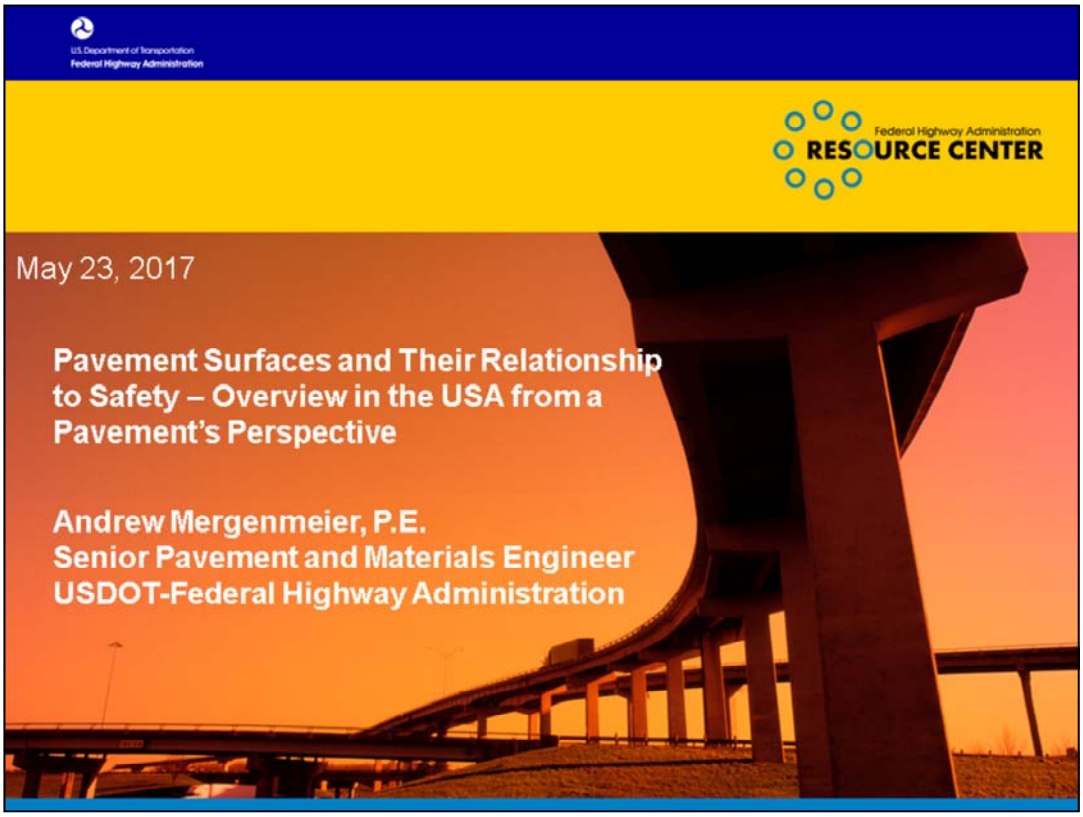
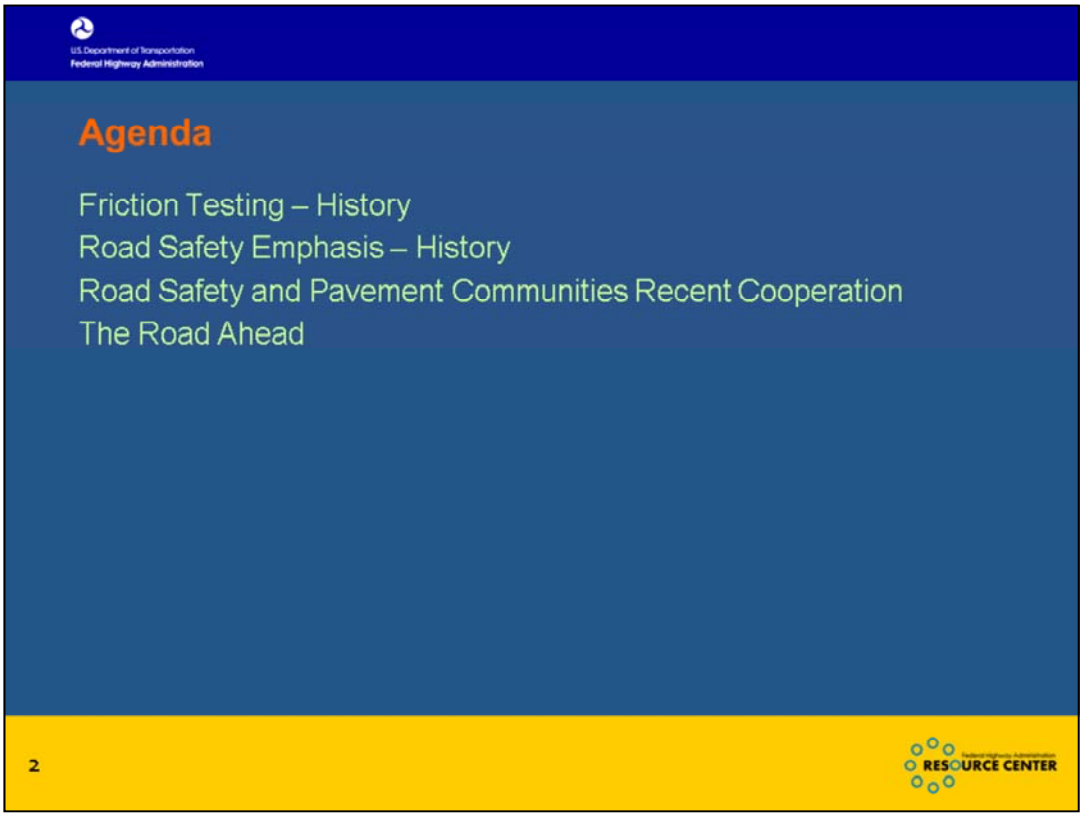
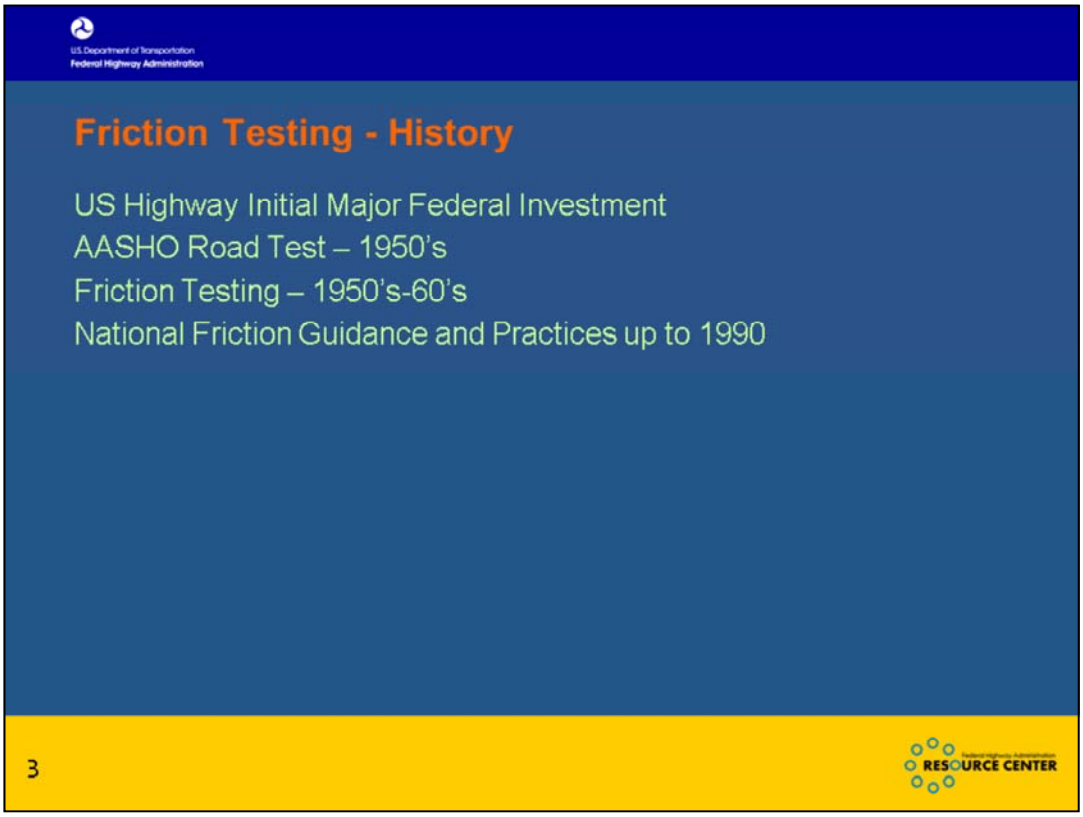


Appreciate opportunity to share with you . . . In the US discussion between pavement personnel and safety does not have a long history. US is learning from information presented in the years at this conference, and trying to apply it within the US. I am honored to be here, give you insight into US practices



History is a great teacher and must know history to move forward. Physics and science do not recognize political boundaries, but culture does and culture drives policies, priorities, and action. Culture changes as a country goes from being young, to middle age, and further into maturity and that is the case with the US and road transport and safety.

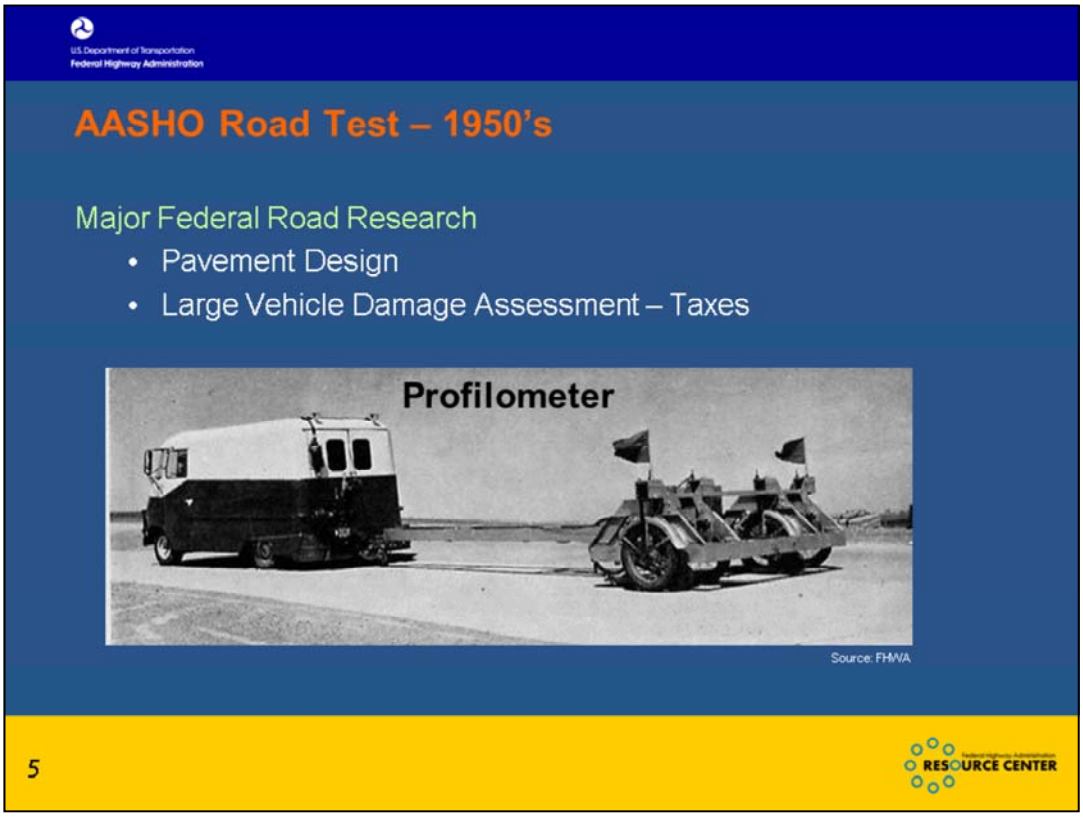


Follow the money trail is a common process in forensic investigations and it is where my discussion starts today - funds were provided to execute the policy of building roads; I will now cover pavement and friction technology and practices up to 1990.

There are infinite elements that are related to safety, and developing standards is a well respected initial start. With these standards we can now do analysis on what the impacts of the standards are for safety, performance . . . Implementing standards are a significant challenge in the US, agencies do not want to lose control, know their system needs better than others from afar.

For pavement folks – our original pavement structural design was focused on 20 years as a result of this law. The 20 year time horizon I believe is a good indication of the culture and priorities at the time – let's get it built now and to meet today's needs.

Pre 1956 Federal level involvement in design/construction fairly low. This law provided funds for research and construction.



The AASHO road test is the foundation for the pavement design of most roads constructed in the US and much of this research is included in our current pavement design methods.

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Friction Testing – 1950's-60's

- 1st International Skid Prevention Conference held in the USA, 1959
  - Correlation study of locked wheel skid trailers in 1962
- American Society for Testing and Materials (ASTM) committee E-17 on Skid Resistance formed in 1960

Source: Virginia Tech Transportation Institute

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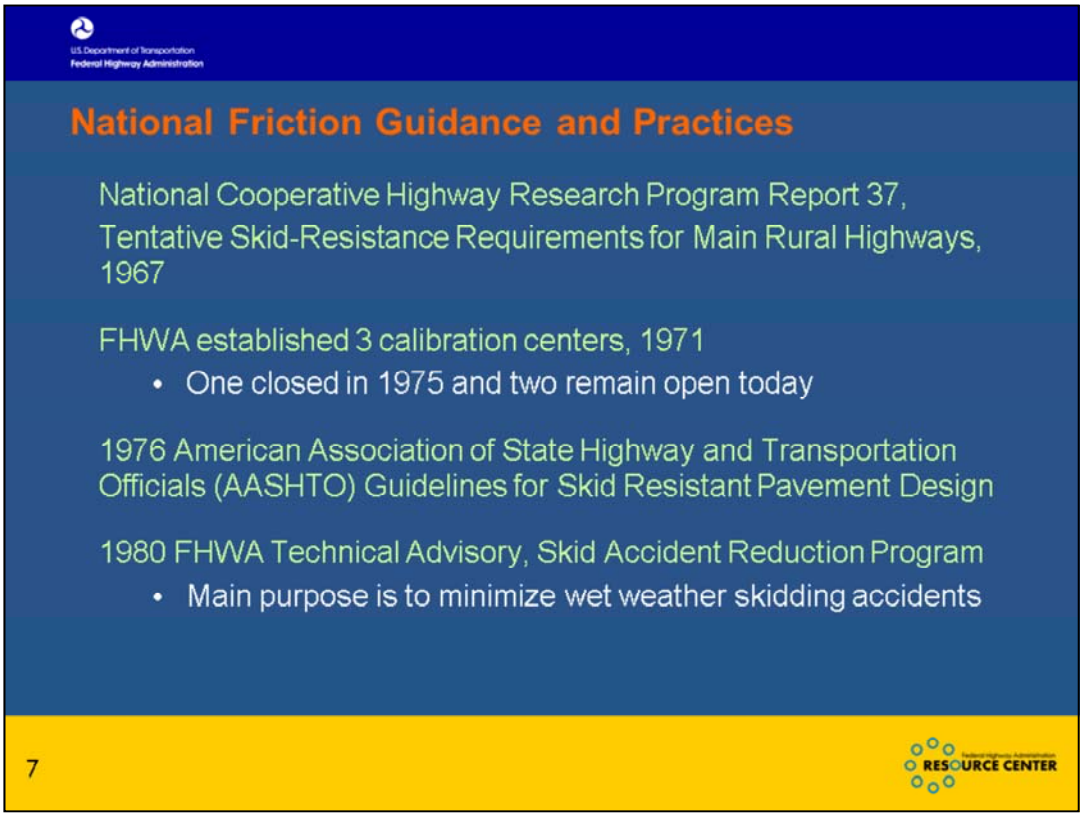
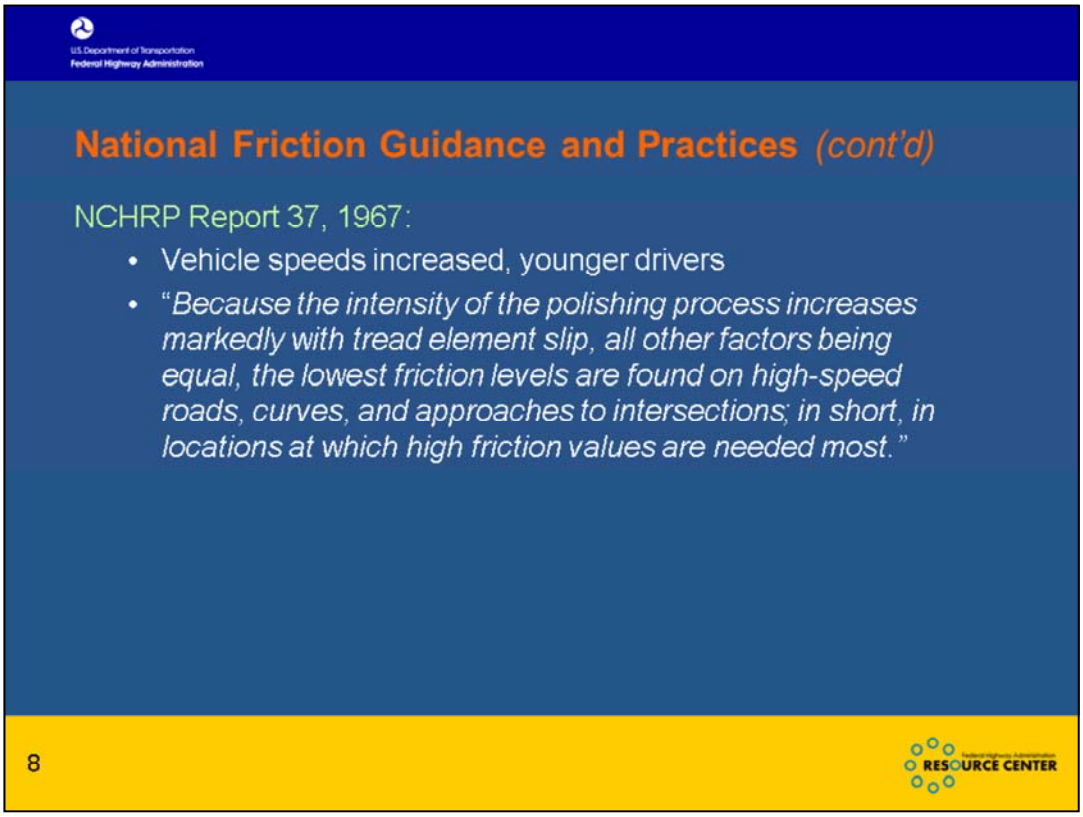
Significant fundamental rubber friction research was occurring in the US in this time frame. The fundamental research was then applied to pavements. That research led to these activities



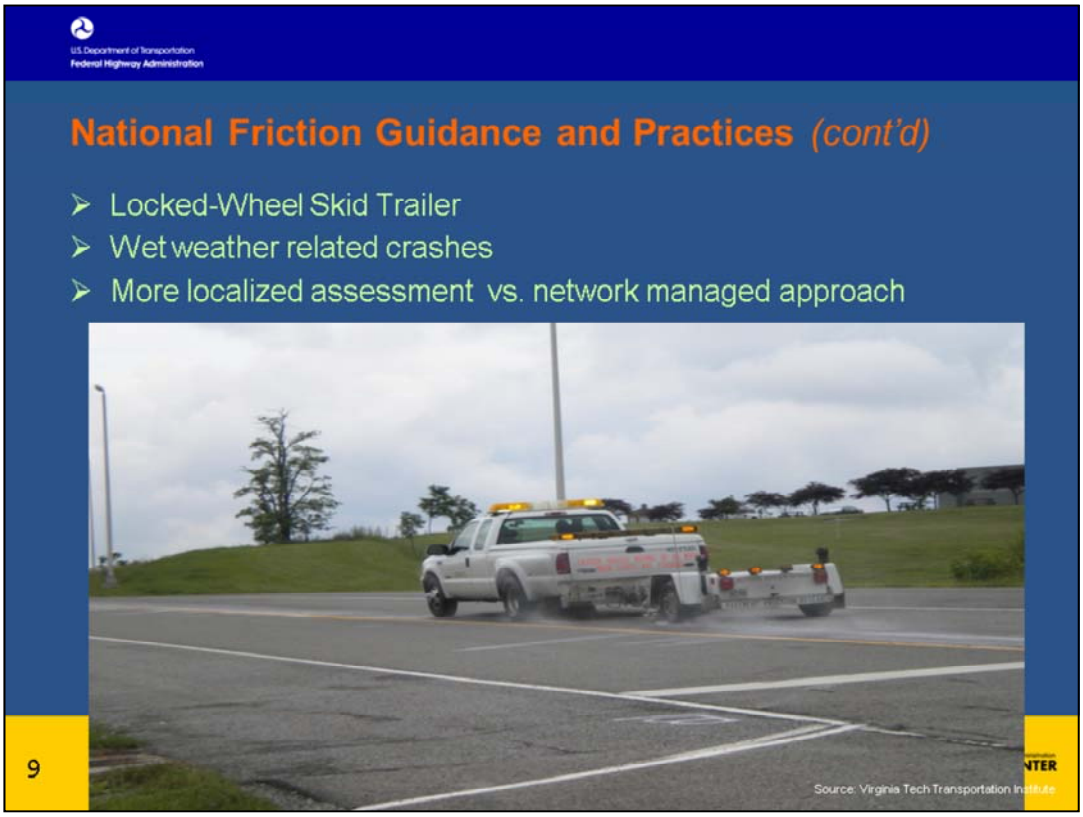
Additional key milestones: NCHRP 1967 compiled research

The main purpose of a skid accident reduction program is to minimize wet weather skidding accidents by ensuring that new surfaces have adequate and durable skid resistance properties, identifying and correcting sections of roadway with high skid accident incidence, and utilizing resources available for accident reduction in a cost-effective manner. Did NOT require program, advisory/suggested;

AASHTO does not established requirements – it is the state agencies cooperating in developing guidance



Recognized in 1967, but not formally addressed; Pavement friction not regarded as great concern prior to 1950. Perceived skidding accident rate increase, thus increase in interest of pavement friction. Similar concept as we face many times today, 50 years later, – was it an increase in skidding accident rate or improved accident reporting? No question that vehicle speeds increased, younger drivers, increase vehicle density (increase in pavement wear).



Conventional US skid test: A locked wheel skid tester consists of a trailer with one test wheels in the left wheelpath. The trailer is towed at a given speed, and then water is applied in front of the test wheel when the test wheel is locked. The friction force between the tire and the pavement is then measured for a specific time interval (usually 2 to 3 seconds, test result is the average over a 1 second interval (59ft) of fully locked wheel). Either a ribbed tire or a smooth tire can be used for testing. Twenty four out of the 39 State highway agencies that responded to the survey by Henry(1) indicated they perform skid testing of their highway network at regular intervals. The testing frequency varied among the agencies. The testing frequency of the interstates was: entire network annually – 12 agencies; half of the network annually – 9 agencies; a third of the network annually – 3 agencies. The testing frequency of the primary road network was: entire network annually – 3 agencies; half of the network annually – 14 agencies; a third of the network annually – 2 agencies; and a quarter or a fifth of the network annually – 5 agencies.

Network – testing was still spot testing – 59' feet measured/recorded and 1 test every mile or so – probably not at high friction demand locations. Many believe skid test represents a certain pavement section vs. a spot test.

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Road Safety Emphasis – History

Emphasis before the Interstate Era (pre-1956)
Interstate Era (1956-2000)

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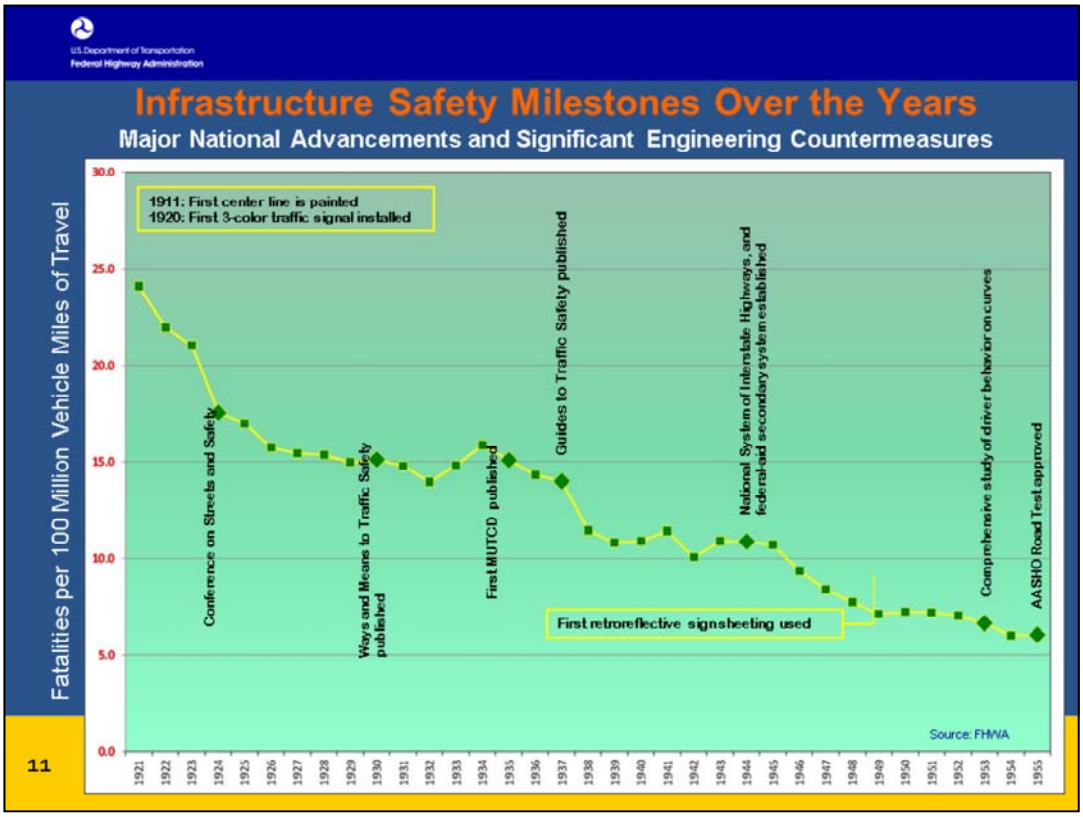

Standards and uniformity have certainly played a part in driving down fatality rates. We got the basic downs, such as communicating uniformly to drivers and providing fairly consistent lane and shoulder widths appropriate for the specific class of highways and continued to improve on those standards. Then we moved on to using data to determine where the biggest crash problems were and set out making spot improvements. Another big change came as we started considering how we could improve the consequences when motorists ran off the roads – prior to this the prevailing attitude of highway designers was that if the driver got off the road it was their own fault and nothing we should be too concerned about. Each of these shifts made improvements in highway safety. However, the attitude still prevailed that if we follow the standards we are building a “safe” highway… (go to next slide), (Safetea-lu was 2005)

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Emphasis before the Interstate Era (pre-1956)

Driver Expectations of Road Environment

- Traffic Control
  - Signs
  - Pavement markings
  - Intersections
- Geometric
  - Lane and shoulder widths
  - Curvature

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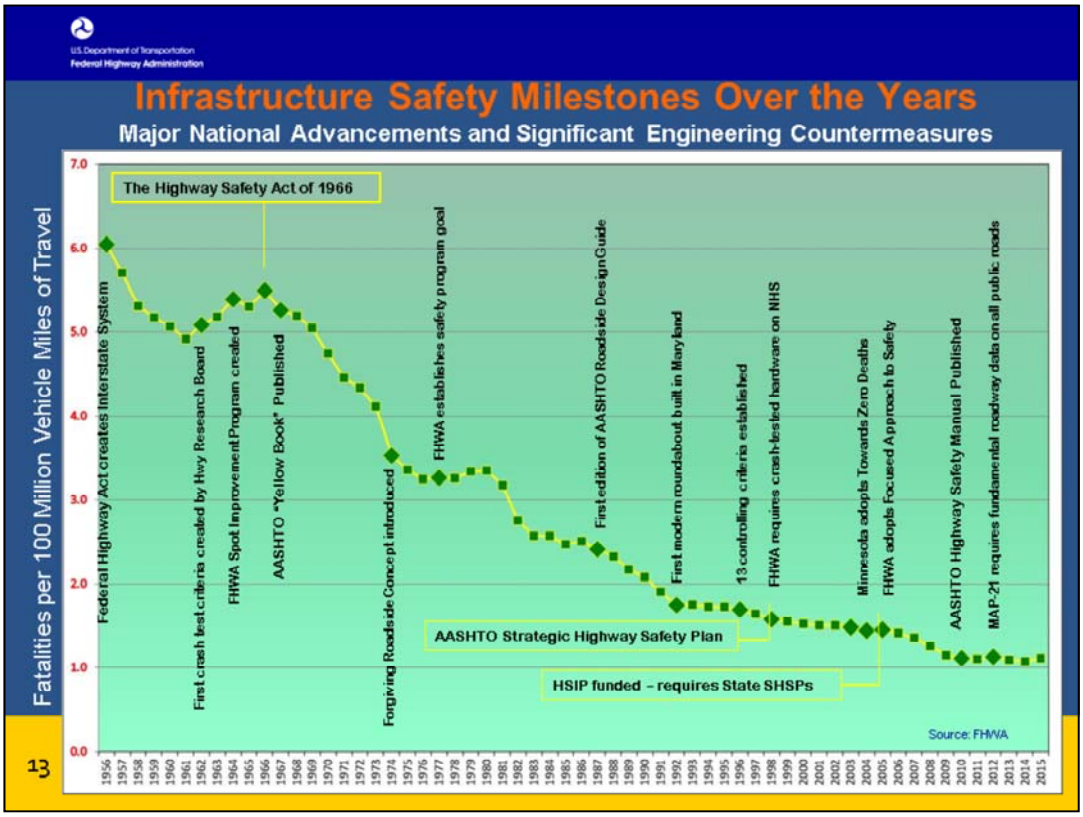

Note, the vertical axis scale has changed, much lower rate than pre 1956

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Interstate Era (1956-2000)

Standards and uniformity for the specific class of highways
FHWA Spot Improvement Program, 1964
Roadside Safety

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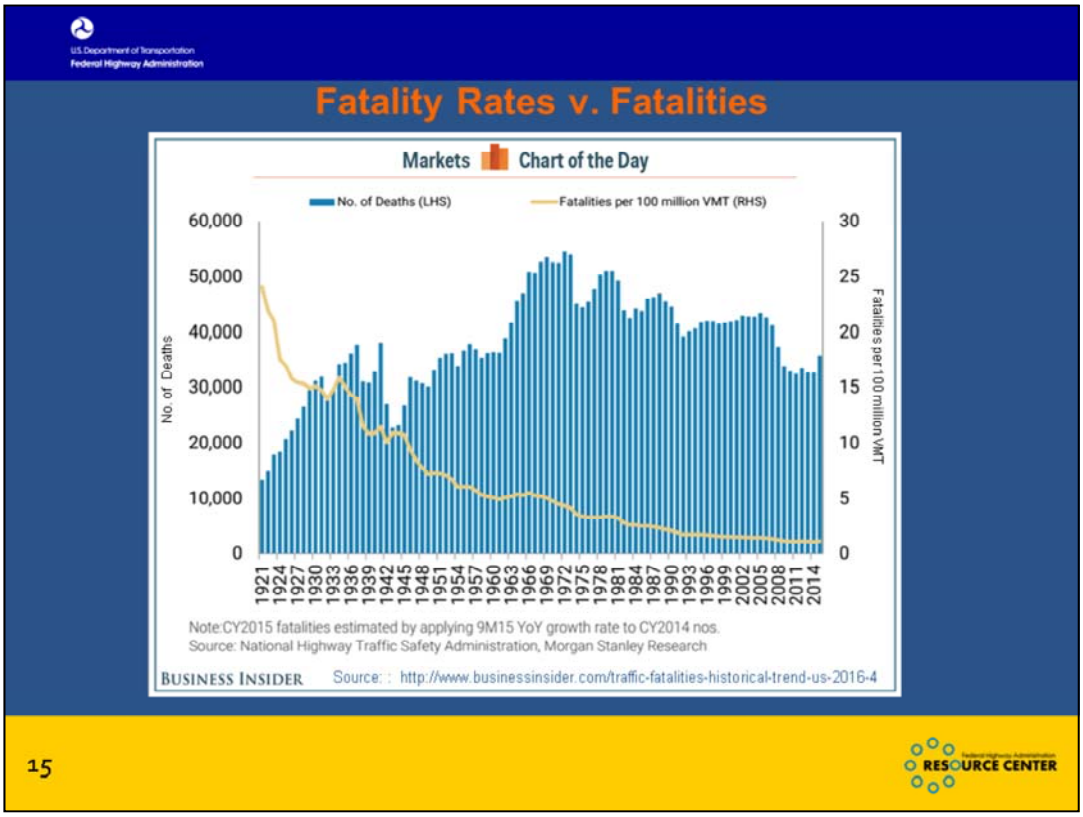
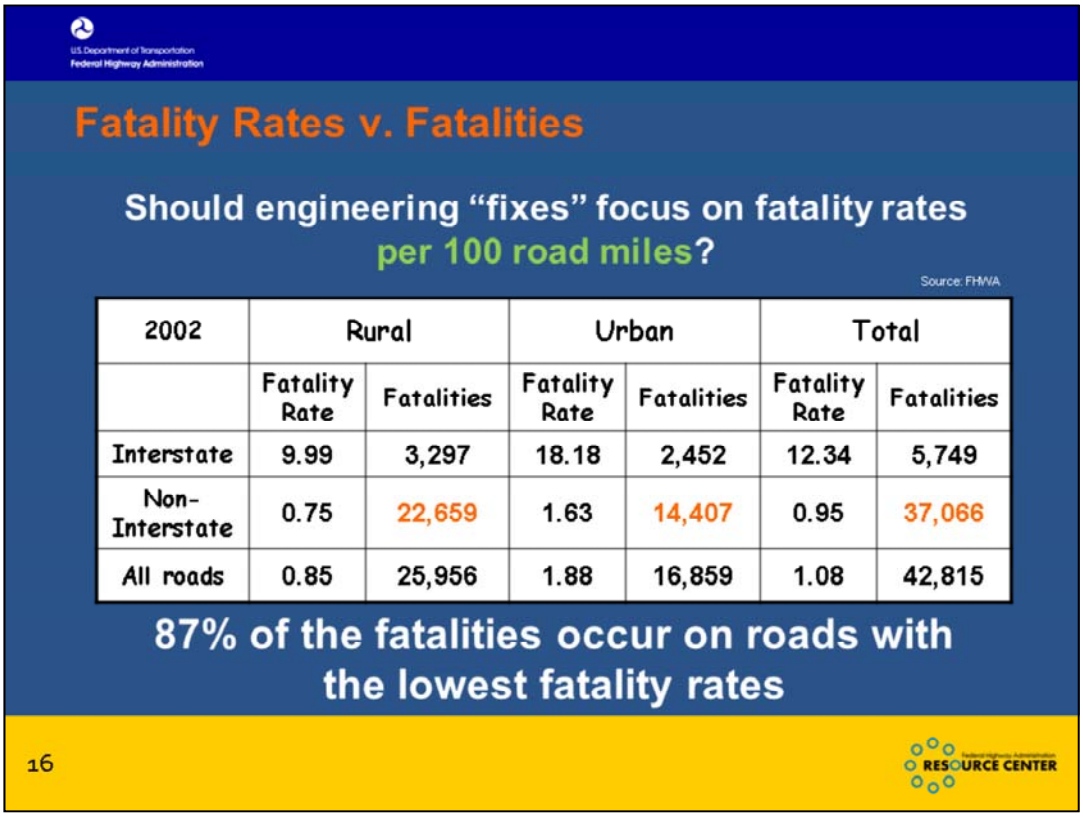
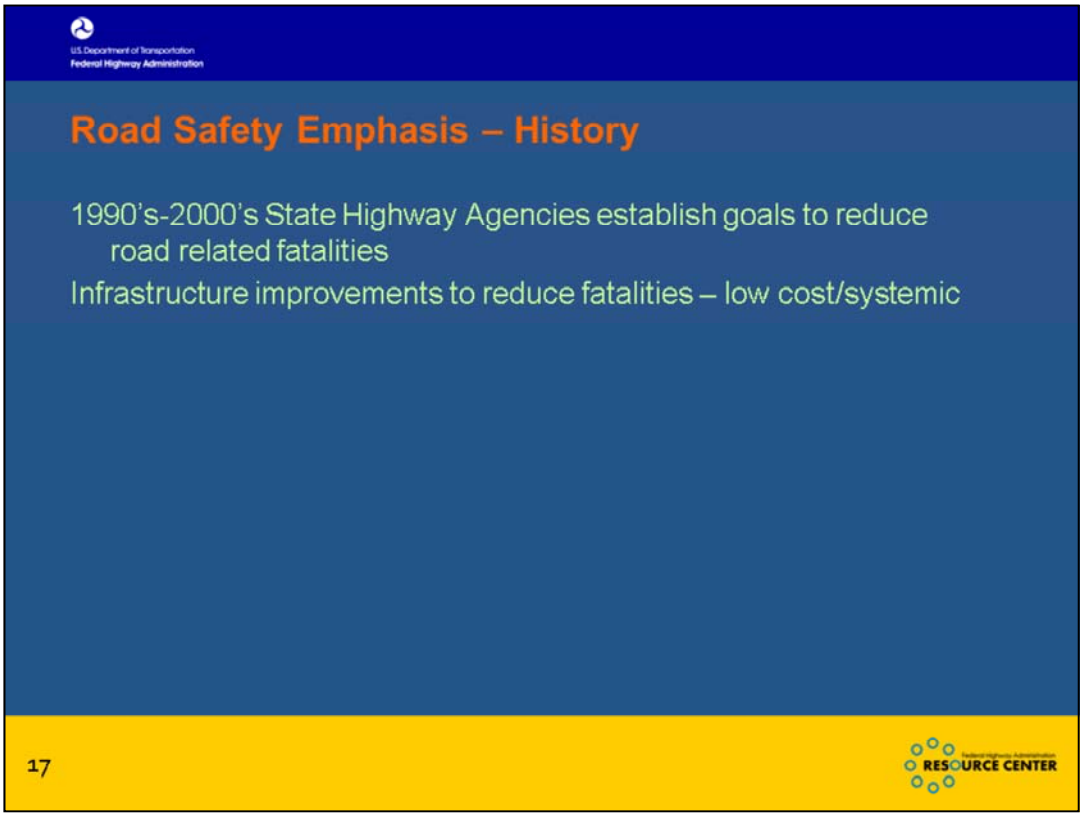


…yet 40,000 – 50,000 people were dying in traffic crashes every year on our "safe" roads, it was clear we needed a new way to look at safety. Is it okay to have all this carnage on our highways and defend that we are still making them safer based on the fatality rate because the number of miles traveled keeps going up? US fatal casualties in Viet Nam war – 58,220 (1960's-1970's)

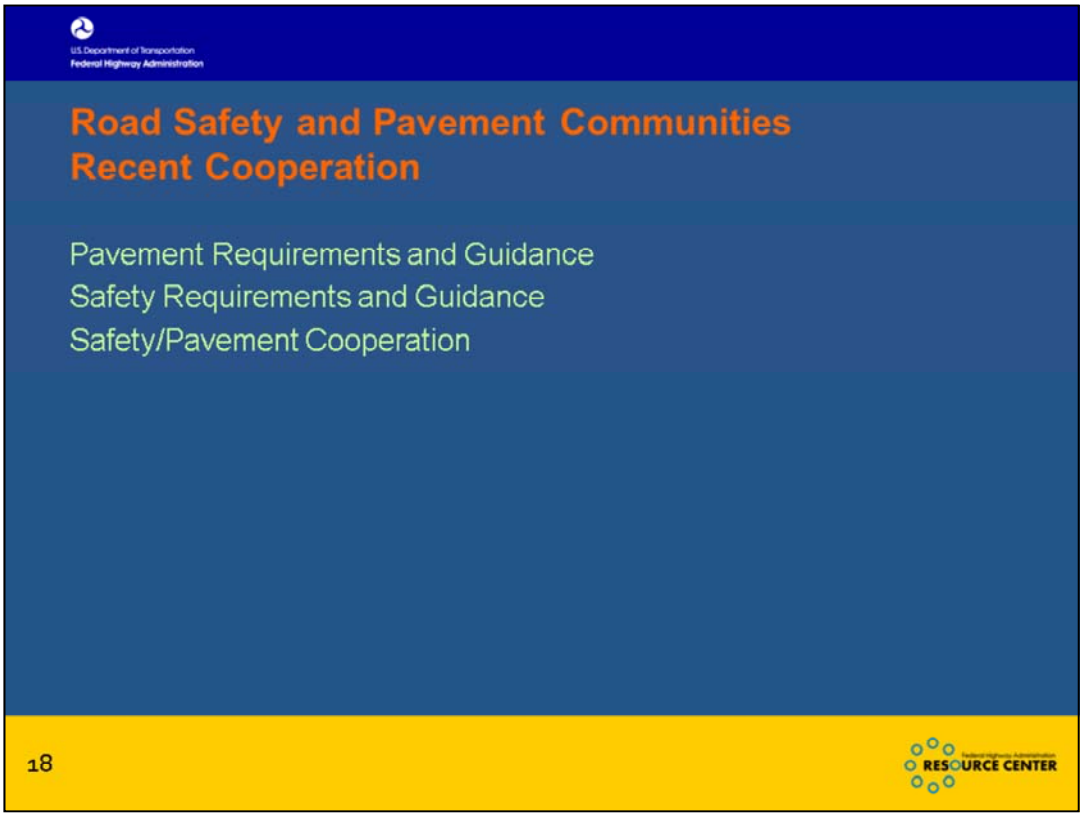
Good example of performance measures – rate goes down while # of fatalities goes up – which is better perf measure?



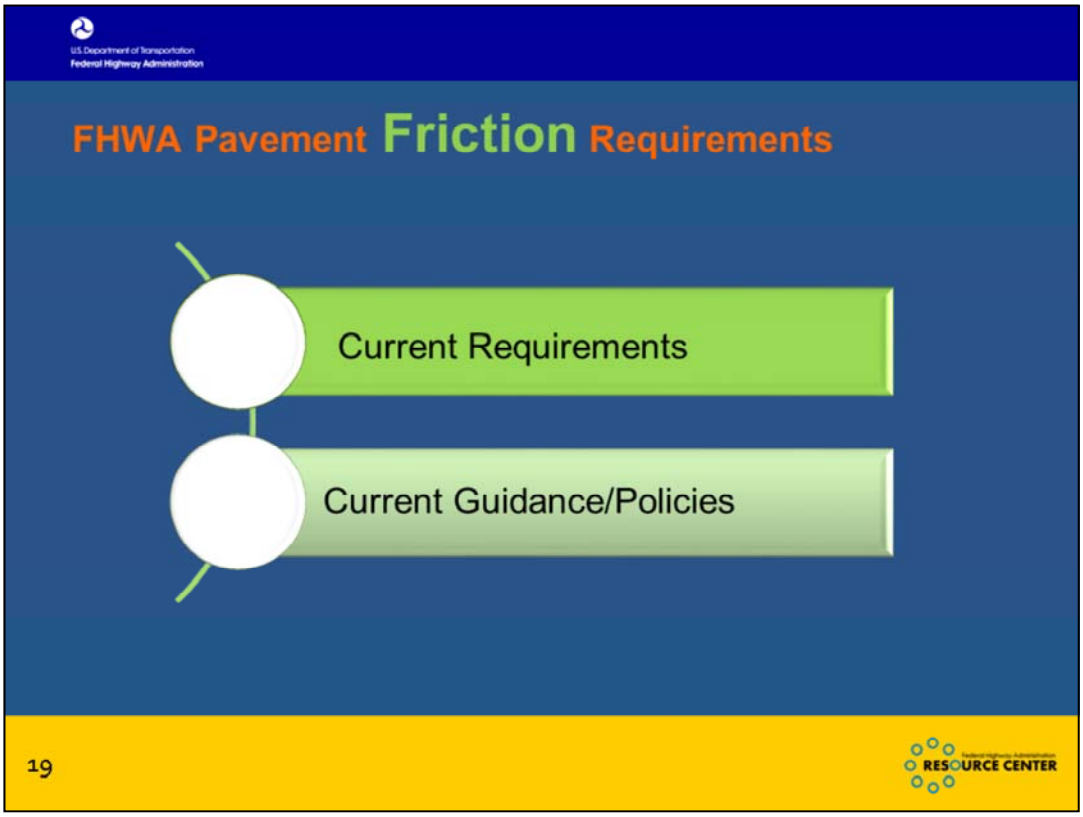
In the late 90's safety professionals and others started asking some hard questions. Where should we focus our efforts was one of those questions.



Not just reduce crashes but focus on fatalities



In the early 2000's Safety/Pavement more cooperation;



Requirements are mandates/minimums from the Fed govt

Policies/Guidance - encourage

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Present National REQUIREMENTS For Friction Measurement

THERE ARE NONE

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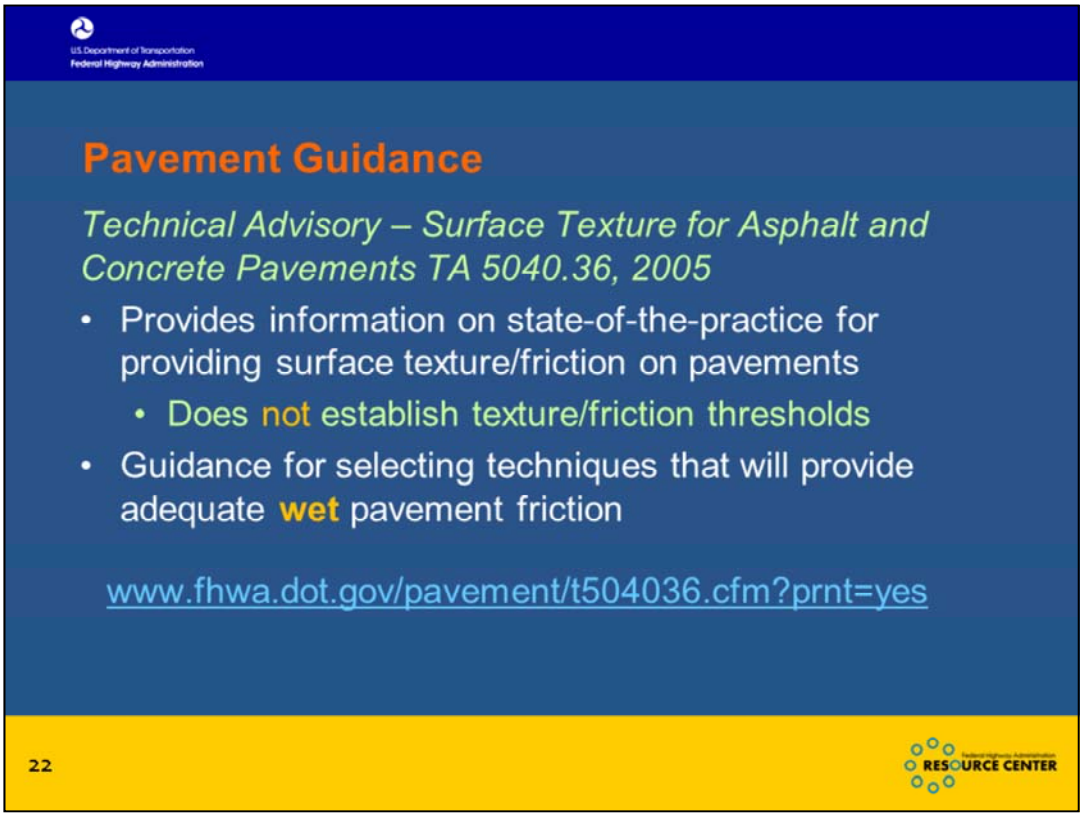
Pavement Policies

Federal Regulation - Policy

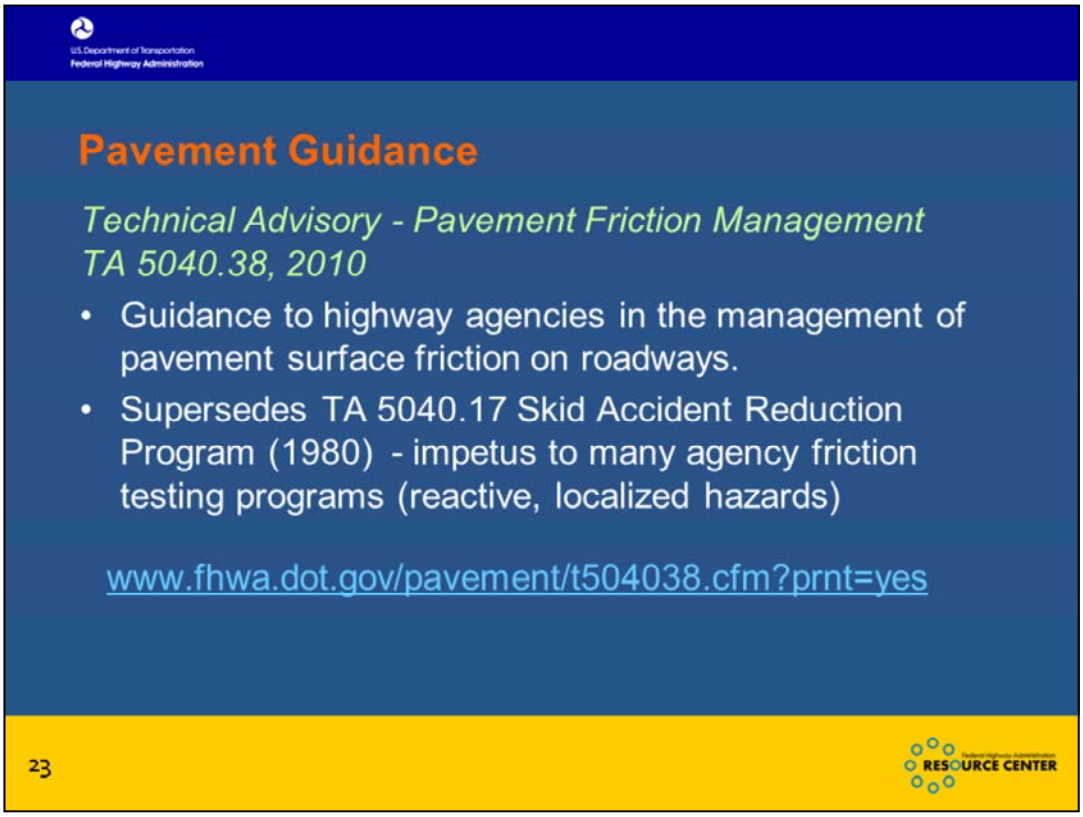
- "Pavement shall be designed to accommodate current and predicted traffic needs in a **safe**, durable, and cost effective manner."



FHWA will issue Technical Advisories to assist with understanding and clarification for specific topics. This TA can be found at:

http://www.fhwa.dot.gov/pavement/t504038.cfm?prnt=yes

The general purpose is described in this slide.



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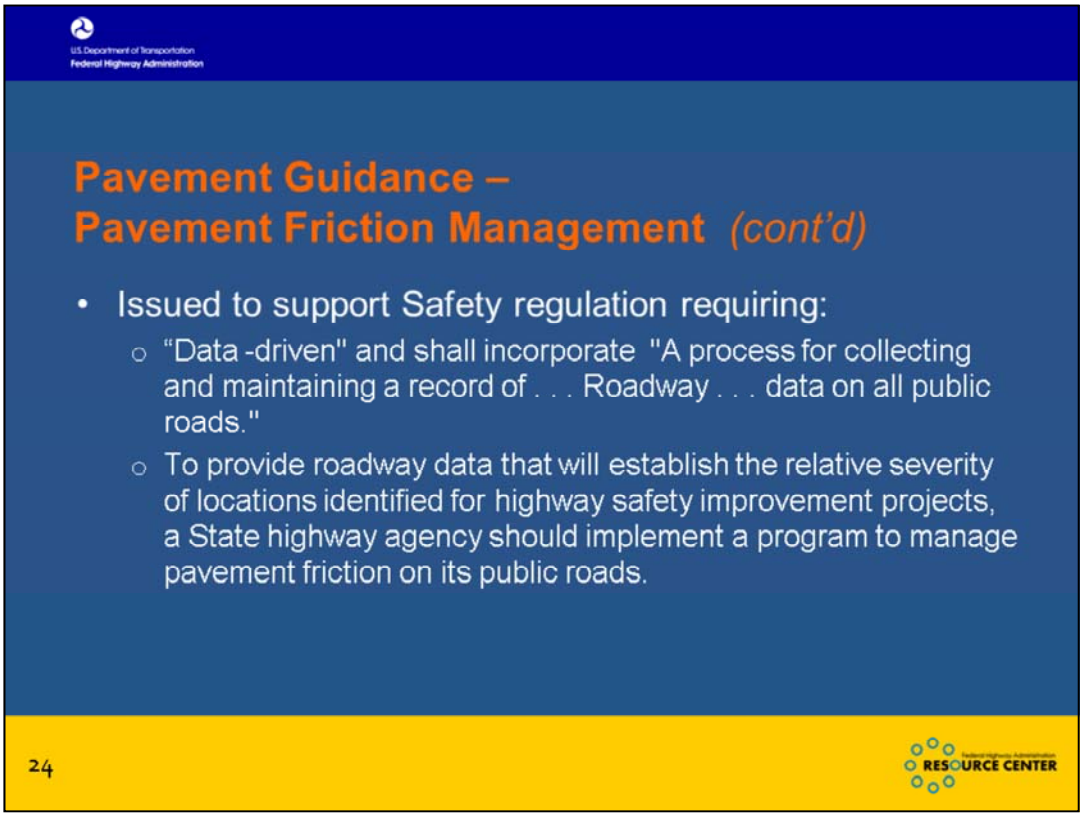

The Safety regulation made items such as friction testing, eligible for Federal funding.
FHWA will issue Technical Advisories to assist with understanding and clarification for specific topics. This TA can be found at:

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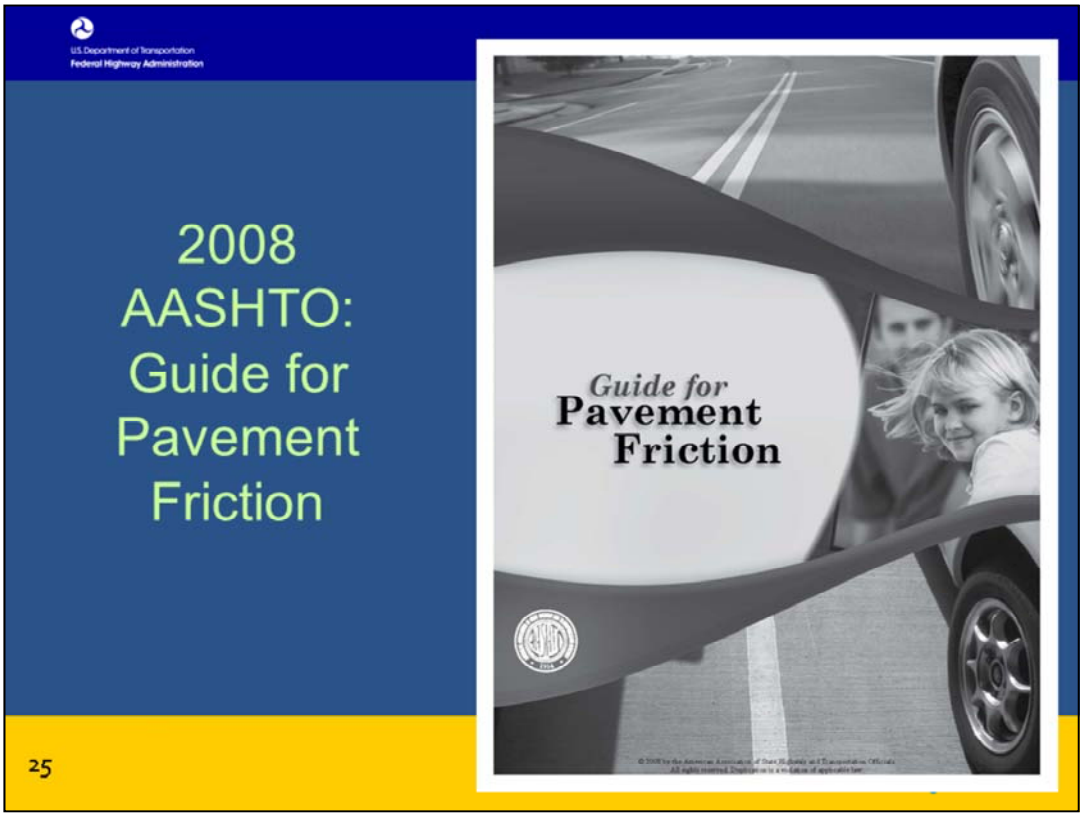
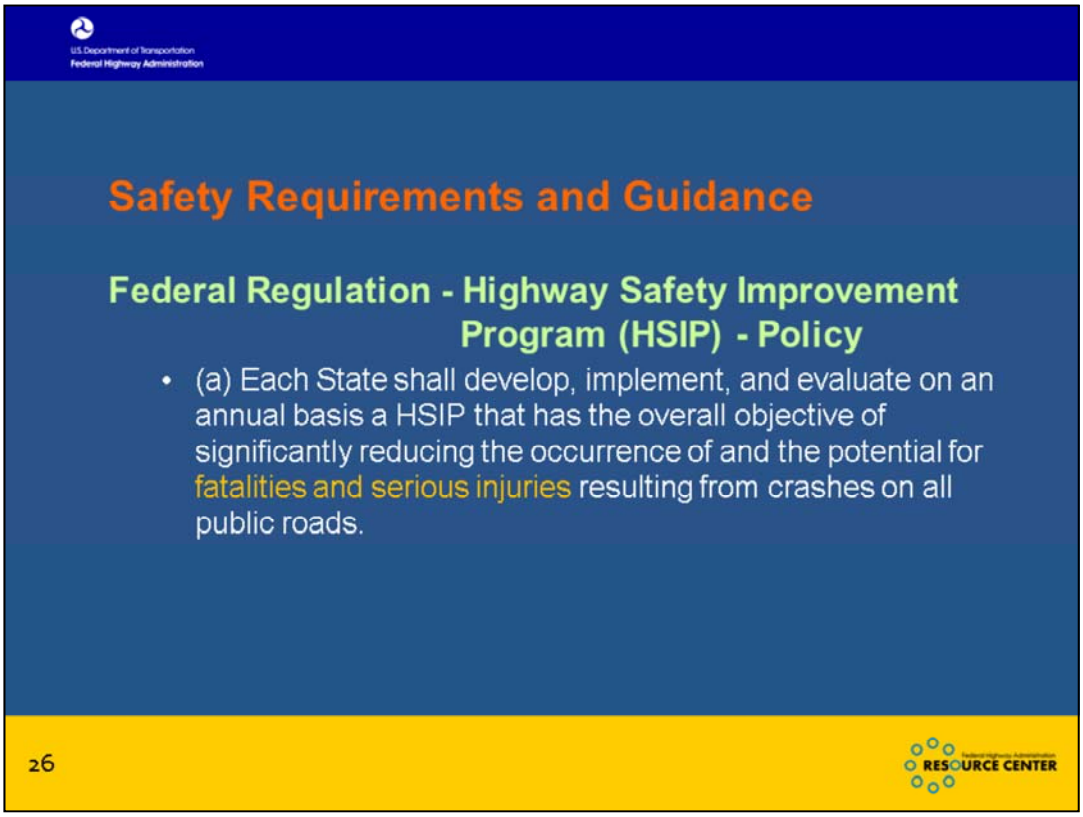
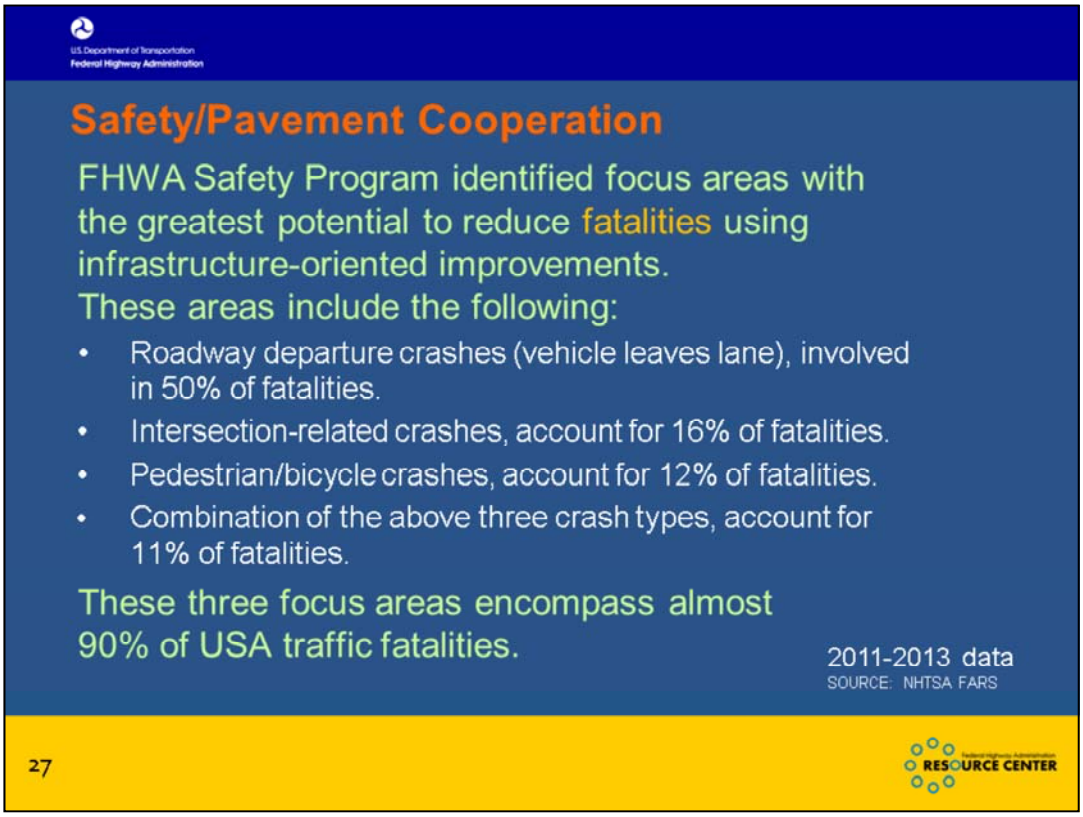


Both the AASHTO 2008 Guide and FHWA TA on Friction Management – were mostly compilation of past practices and information and suggestions on approaches to move forward with a more managed approach. The managed approaches had not been validated by practical experience in the US.



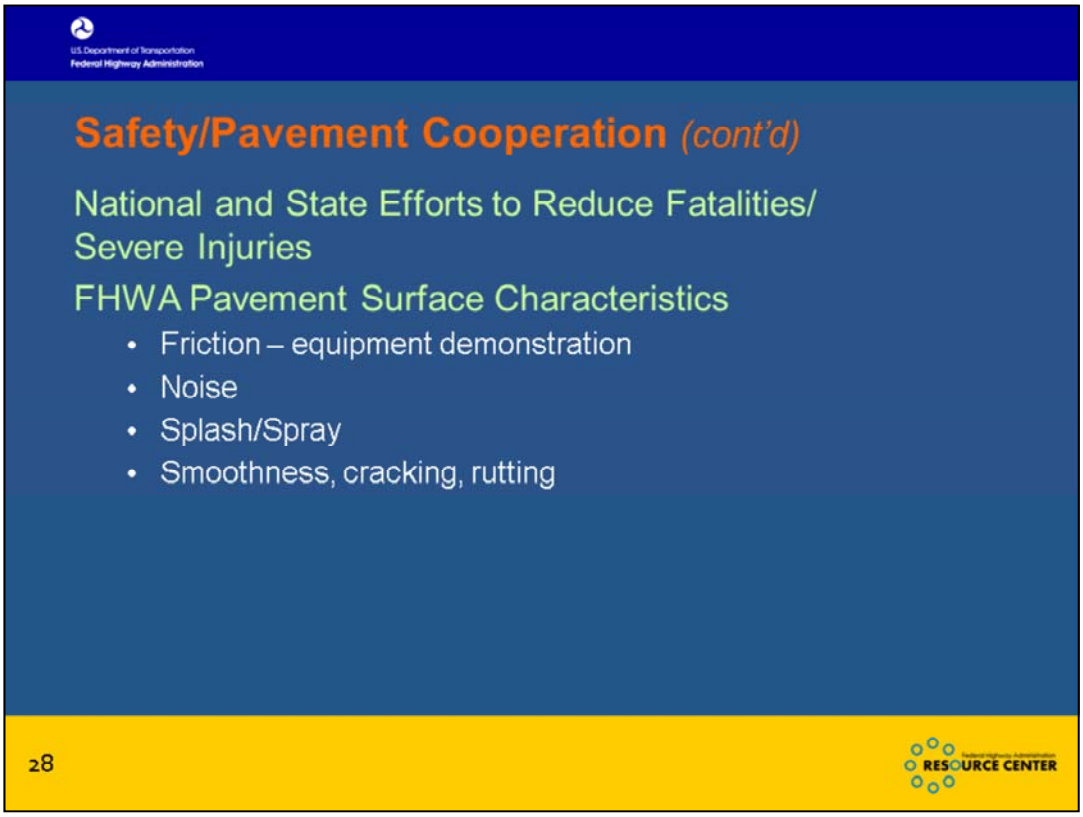
This is the Safety regulation I referenced earlier.

Focus on fatalities and severe injuries



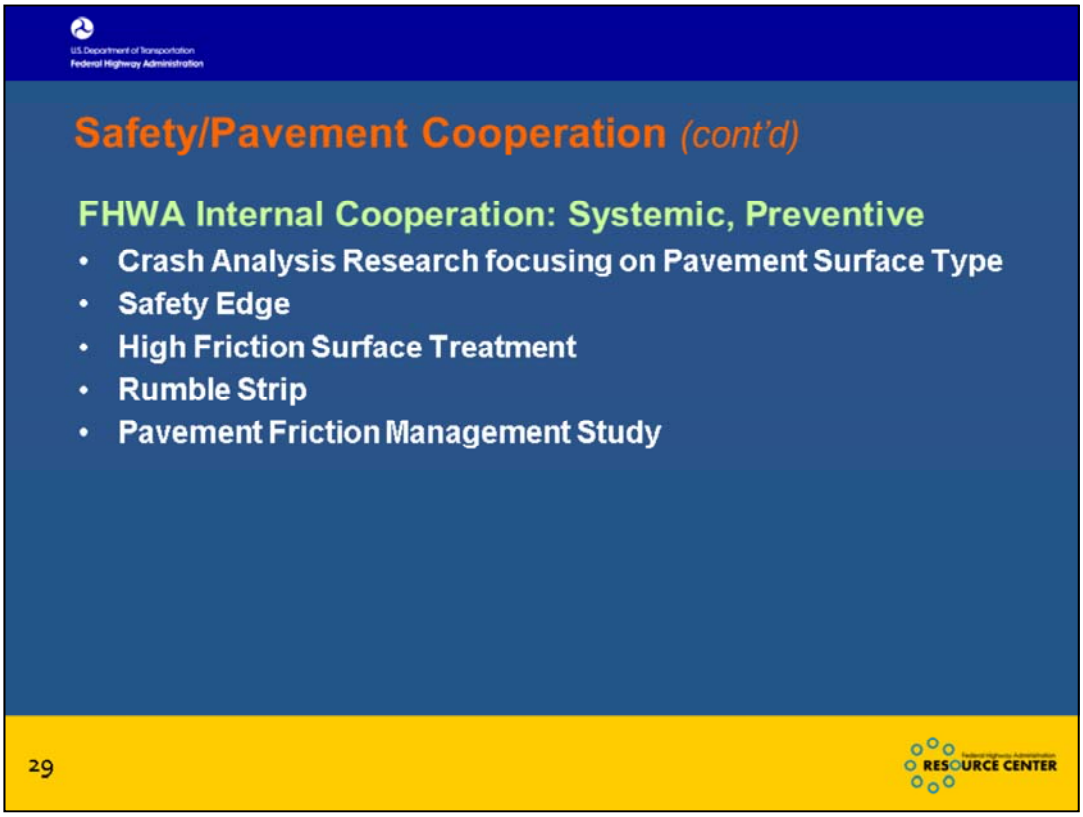
Focus on what highway engineers can do, not law enforcement. Setting the stage – what we are faced with in current condition

Roadway departure – leaving the lane (left or right); This highlights the NCHRP Report 37 discussion of locations that have highest need for friction, many times will have lower friction due to rubber tire polishing the aggregate.



To assist in meeting the crash goals, Safety/Pvt increased cooperation.

Many projects are safety driven – reduce fatalities. Cooperation between FHWA Safety and Pvt/Mat Units. Most safety focus on roadsides, barriers, . . . significant investment (ROW) and cost; now digging deeper into the data to be more focused and efficient on resource expenditures. Pvt friction – new frontier; Refining our highway system – systemic, preventive approach;



Many projects are safety driven – reduce fatalities. Cooperation between FHWA Safety and Pvt/Mat Units. Most safety focus on roadsides, barriers, . . . significant investment (ROW) and cost; now digging deeper into the data to be more focused and efficient on resource expenditures. Pvt friction – new frontier; Refining our highway system – systemic, preventive approach;

Add EDC emblem
The Safety Edge

The purpose of this overview is to introduce the purpose and need for the Safety Edge; the practical solution the Safety Edge provides; and the features and benefits. This presentation also is an opportunity to answer questions and discuss the advantages of the Safety Edge.

Three messages are key to communicating the benefits of the Safety Edge. The Safety Edge—

- Saves lives.
- Is low cost.
- Improves durability.

This Safety Edge Technical Overview contains the following:

- Purpose and Need
- A Practical Solution
- Conclusion

This is your elevator speech to all your partners. The Safety Edge-

· Reduces crashes and saves lives by mitigating pavement edge drop-off

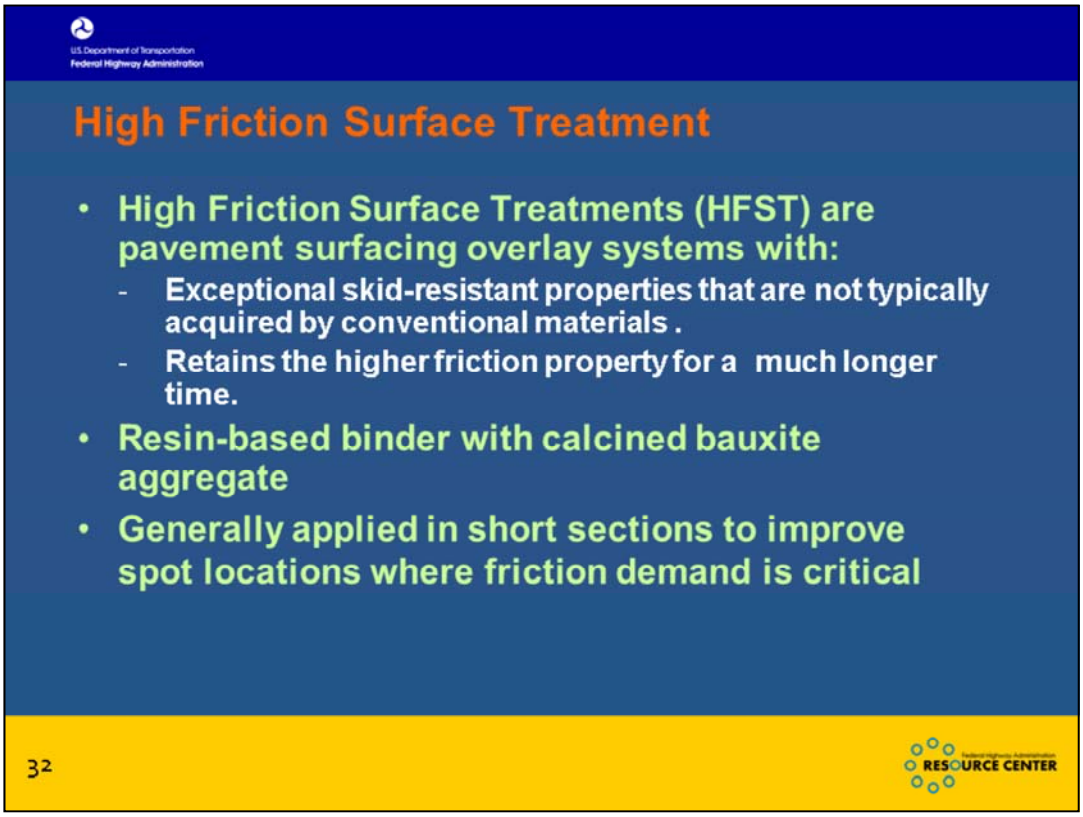
· Is a low cost, systematic improvement applied during paving

· Improves durability by reducing edge raveling

Communicate that the Safety Edge is a simple but extremely effective solution that can help save lives by allowing drivers who drift off highways to return to the road safely. The FHWA's goal is to accelerate the use of the Safety Edge technology, working with States to develop specifications and adopt this pavement edge treatment as a standard practice on all new and resurfacing pavement projects.

The safety edge is a:

- 30 degree beveled pavement edge
- shaped during the paving process
- it can be asphalt or concrete
- and it is located where the pavement interfaces with a graded material. This can be the edge of the travel lane and a graded shoulder or the edge of a paved shoulder and a front slope
- but in either case it allows a vehicle to re-enter the pavement with better stability and less loss of control resulting in reduced crashes on the roadways
- The Safety Edge when used on asphalt pavement extrudes the shape and can improve pavement edge durable.

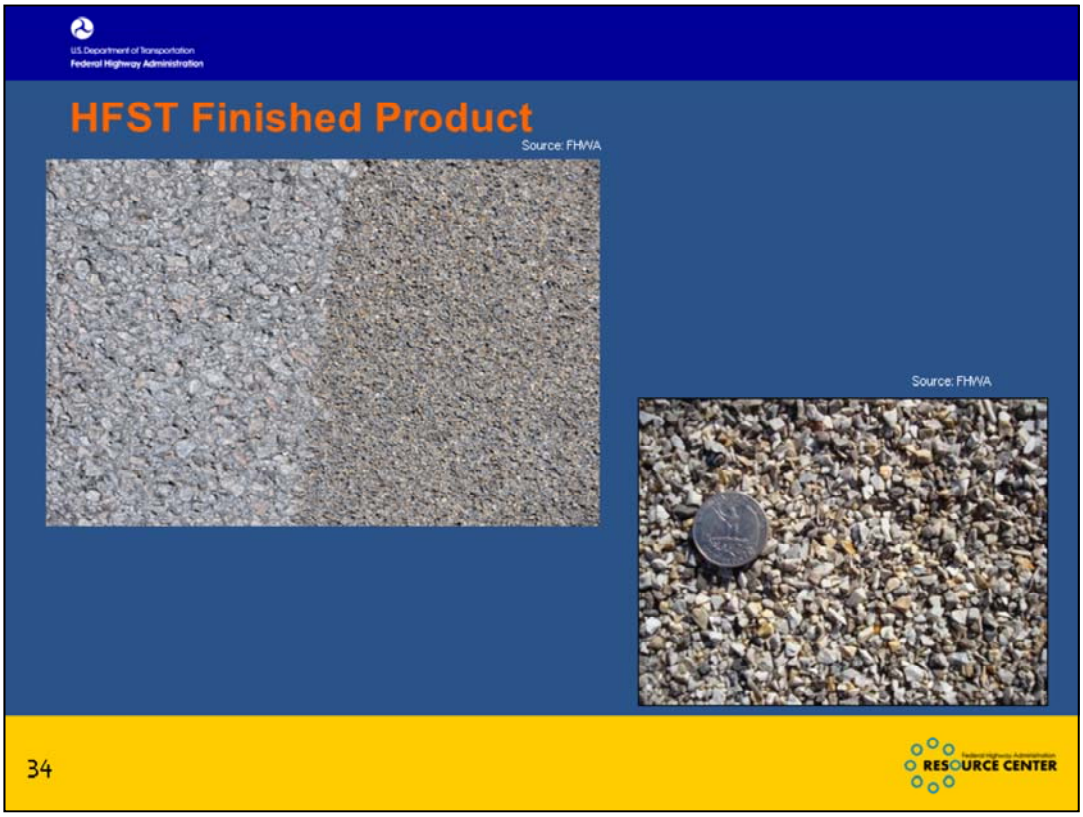


HFST has been around for a while! It first started in the US in the 50's and then exported to UK. They have been installing in since the 60's and their experience is more mature than the USA.
HFST are pavement surfacing systems with **exceptional** skid-resistant properties. These properties are the application of durable aggregates bonded to the existing pavement by a layer of polymer resin.
HFST is not used for pavement maintenance or continuous resurfacing, it is for spot treatment for problem (high crashes) locations.

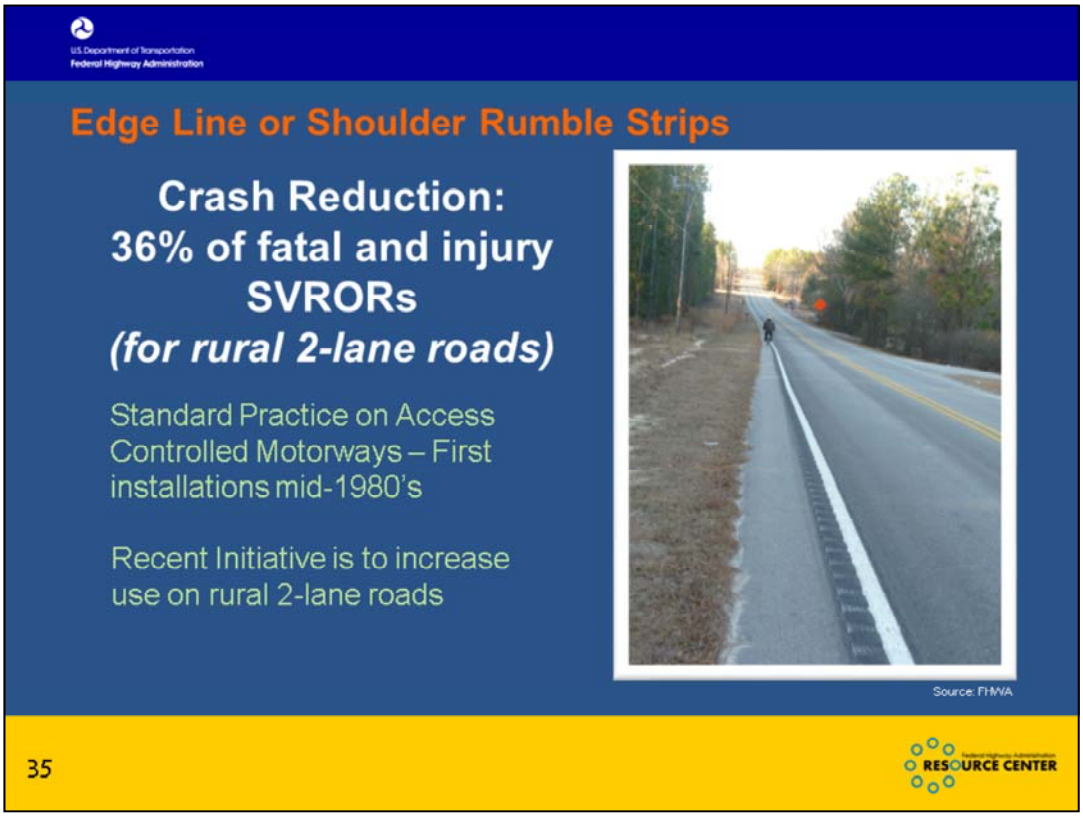
Acceptable methods of installation:

In the past, mostly manual method. Recently, machine application is available. For smaller projects, manual installation is may be more cost effective but you can also group small projects for machine application to get better unit prices.

Bidding directly with the HFST installers can also help reduce cost since General Contractors don't add much to the specialty work except cost.



Comparison of the two surface: the one on the right is HFST using Calcined Bauxite. The one on the left is the before condition. The size of the coin illustrate the size of the aggregate.



SVROR-single vehicle run-off-the-road; Edge line or shoulder rumble strips help drivers avoid crash events in two of the three primary RwD emphasis areas and at least one secondary area. Shoulder rumble strips reduce rollovers by alerting the driver so they can recover before they get on a slope and the vehicle becomes unstable. They also reduce the potential for collisions with trees, utility poles, signs and other fixed objects by either keeping the vehicles on the road, or making the drivers more alert so they have a chance to recover or steer clear of the roadside objects.

NCHRP Report 641 also analyzed this type of rumble strips, using approximately 130 miles of 2-lane rural roads in three states with crash data from 3-5 years before and after the installation with the same rigorous statistical method. What they found was that edge line or shoulder rumble strips are VERY effective on 2-lane rural roads, they reduce fatal + injury SVROR crashes by 36.4% with a standard error of 9.7%. These rumble strips were also milled rumble strips, although there was more variation in the dimensions. (MN, MO, PA)

They also did a smaller analysis on rural freeways in two states that showed a reduction of 17.1% with a standard error of 7.3%. (MO and PA)

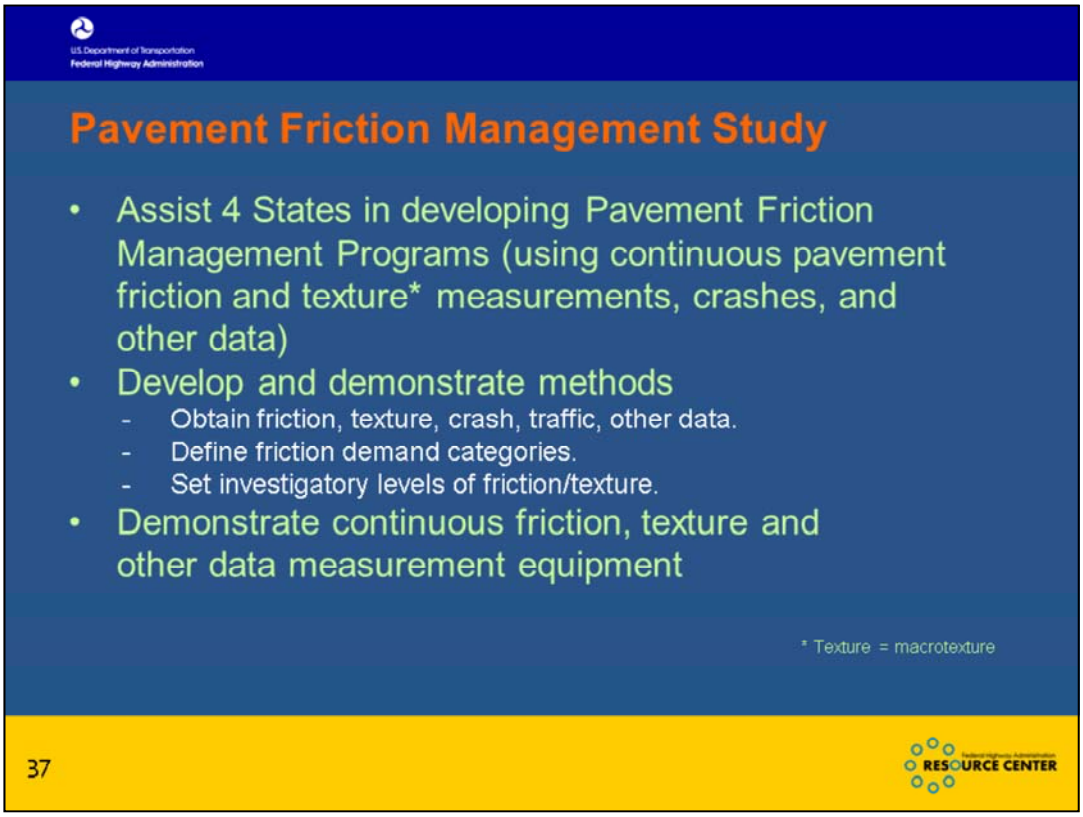
Center line rumble strips are one of very few countermeasures available to address the RwD primary emphasis area of opposing direction collisions by reducing the number of cross center line crashes on undivided roads. This is critical because 80% of this slice of the pie are undivided roads.

I mentioned that rumble strips are one of our proven safety countermeasures. We don't decide that arbitrarily, based on what we think will happen when a driver hears the noise from the rumble strip – it is based on rigorous statistical studies comparing roadways that have been treated with rumble strips to similar ones that do not have rumble strips. The before and after data from the reference roadways (those that did not have rumbles installed) are used with the before data for the treated roadways to predict how many crashes should be expected in the after period on the roads with the rumble strips. If there are less crashes than expected on the treated roads (those with rumble strips), and it is statistically significant, we then feel confident that the rumble strips are effective in reducing crashes.

Obtaining statistically significant results requires many installations of a safety treatment over several years. For example, in NCHRP Report 641, there were over 400 miles of 2-lane rural roads in three states in the analysis of the center line rumble strips and the crash data from 3-5 years before and after the installation was considered in determining the outcome.

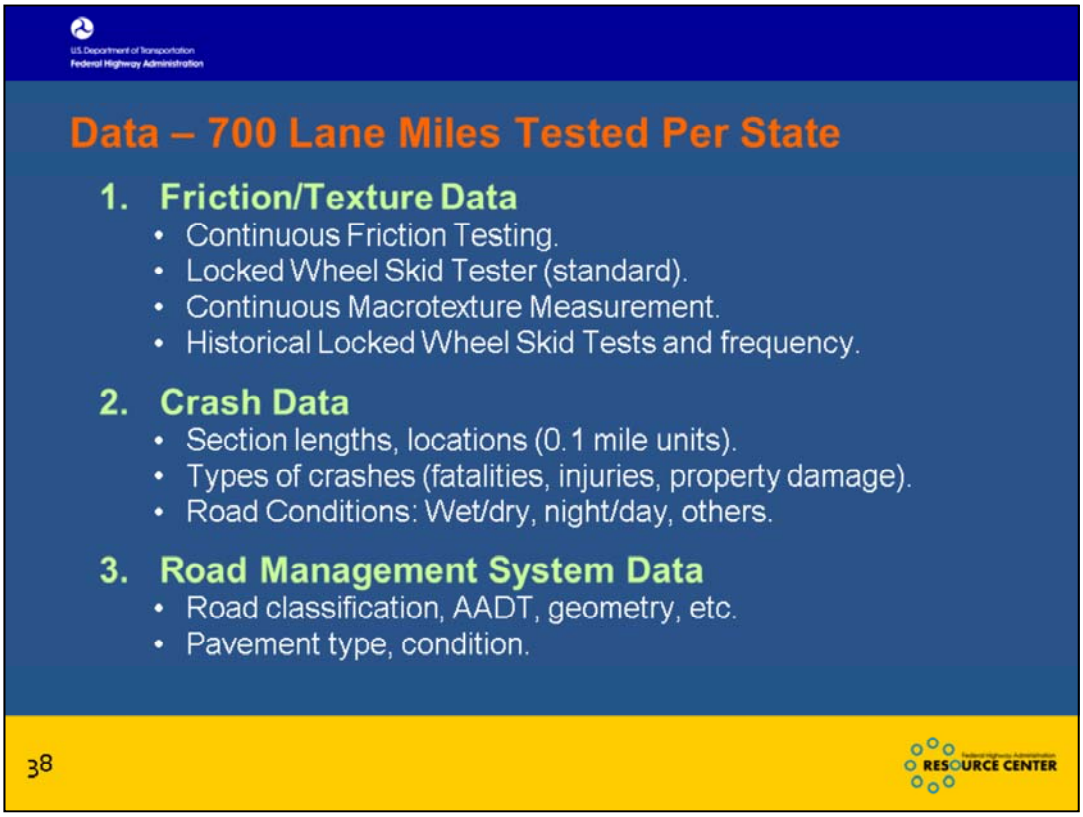
According to that study, we can expect TRADITIONAL MILLED RUMBLE STRIPS to reduce fatal + injury opposing direction collisions by 44.5% with a standard error of 6.4%. It should be noted that the states included in this study use milled rumbles that are primarily 16x7inches and half an inch deep. (MN, MO, WA)

Center line rumble strips are very effective at reducing these severe crashes because the driver is alerted to the fact that he has moved into the opposing lane, giving them the opportunity to recover before a collision occurs. While every driver may not recover before colliding with another vehicle, MANY WILL! And if there is no on-coming traffic, it gives 10-12 extra feet of pavement to safely get back in the correct lane before encountering a shoulder or the roadside where they could potentially rollover or hit a tree or become one of the other statistics in the gray part of this chart.

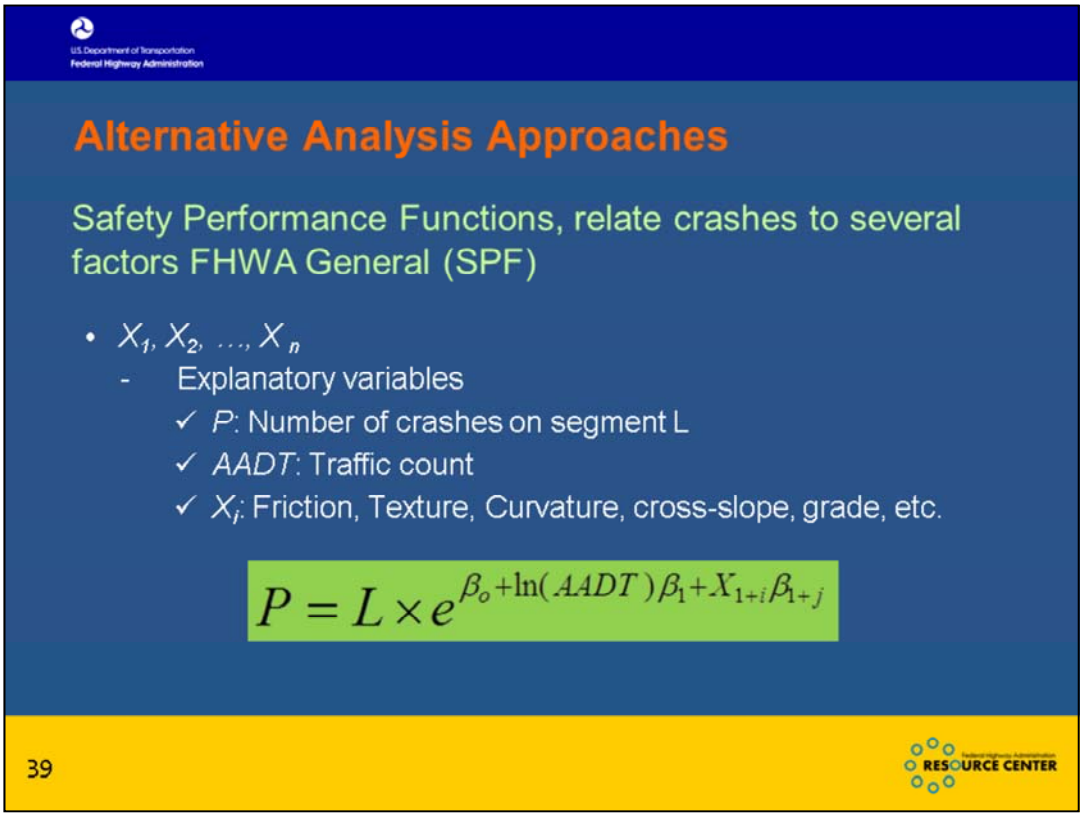


Information provided by Dr. deLeon-Izzeppi yesterday; Heavily based off experiences in UK, New Zealand, Australia

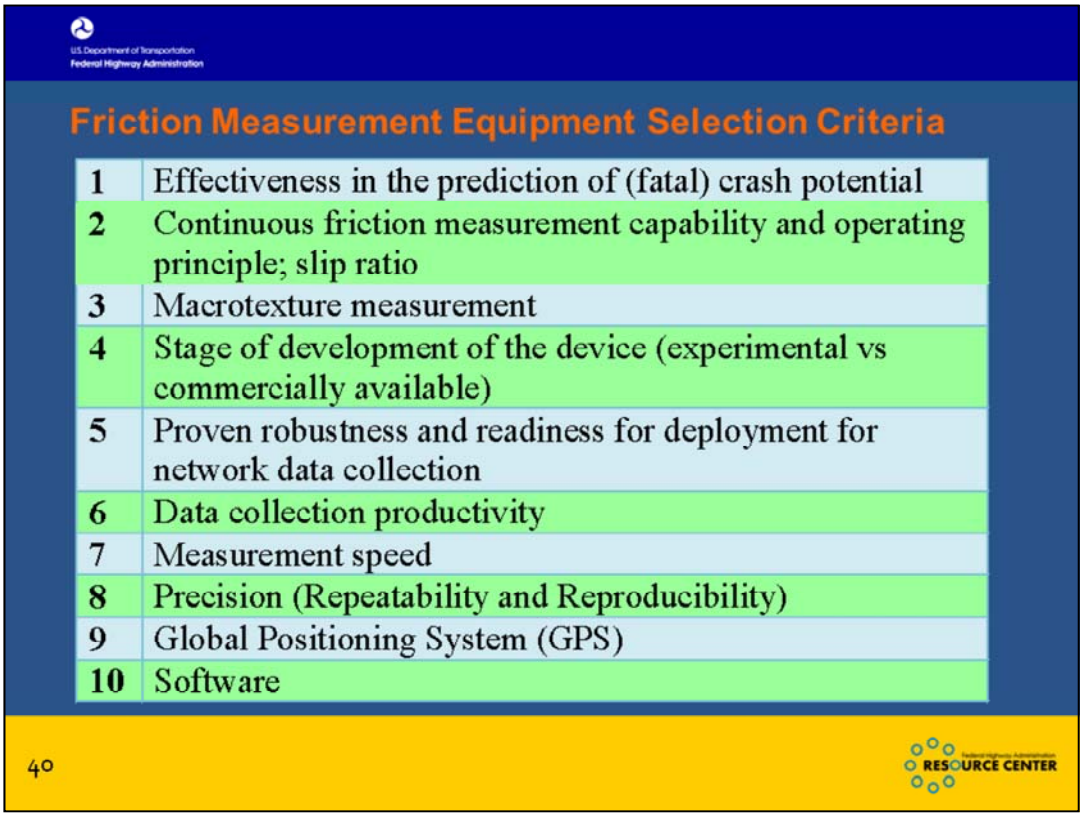
Several states have Frict Management Programs at different levels of complexity and scope. This focus is on what they do not have – continuous measurement; Pavements and Safety engineers cooperating



This is a major effort, largest of its kind ever in the US.



Current and emerging Safety analysis methods are being assessed; – it is commonly used now in the Safety Analysis field; Negative Binomial equation; Trying to assess crash risk



For the study it is not just friction – other road geometrics; need system with proven performance – this is not a research effort of equipment it is demonstration – the research is the analysis; the system that met these criteria at the highest level was the SCRIM.

SCRIM system – the reason it is the size it is – project required 2000 gallon water tank to meet daily testing requirements to test 150 miles/tank; So I am excited to learn of your long term experiences.

Implementation is a challenge in the US – change is a challenge – so when engineers saw this vehicle compared with their conventional trucks, they were initially taken a back

Continuous side force friction measurement system. The slide mentions all the data that will be collected by the system. So we will have the roadway geometrics collected during testing so we have good data on curves to develop friction demand categories. The last slide on the bullet is an indication of the number of SCRIM units running (total of 32 of which 17 are in the UK);

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Pavement Friction Management Study - *status*

Field Data Collection completed in all 4 States

Data Analysis ongoing

Draft Reports to States underdevelopment

Crash Data:

- Roadway Characteristics: horizontal curve, vertical curve, super-elevation.
- Develop Friction Demand Categories.
- Pavement Surface Type.
- Current Safety Analysis Methodologies.

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Remember regulations are requirements, so the focus on reducing fatalities and severe injuries will continue

U.S. Department of Transportation
Federal Highway Administration

Thank You

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Senior Pavement and Materials Engineer
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