AIRPORT TECHNOLOGY R&D VISUAL GUIDANCE RESEARCH

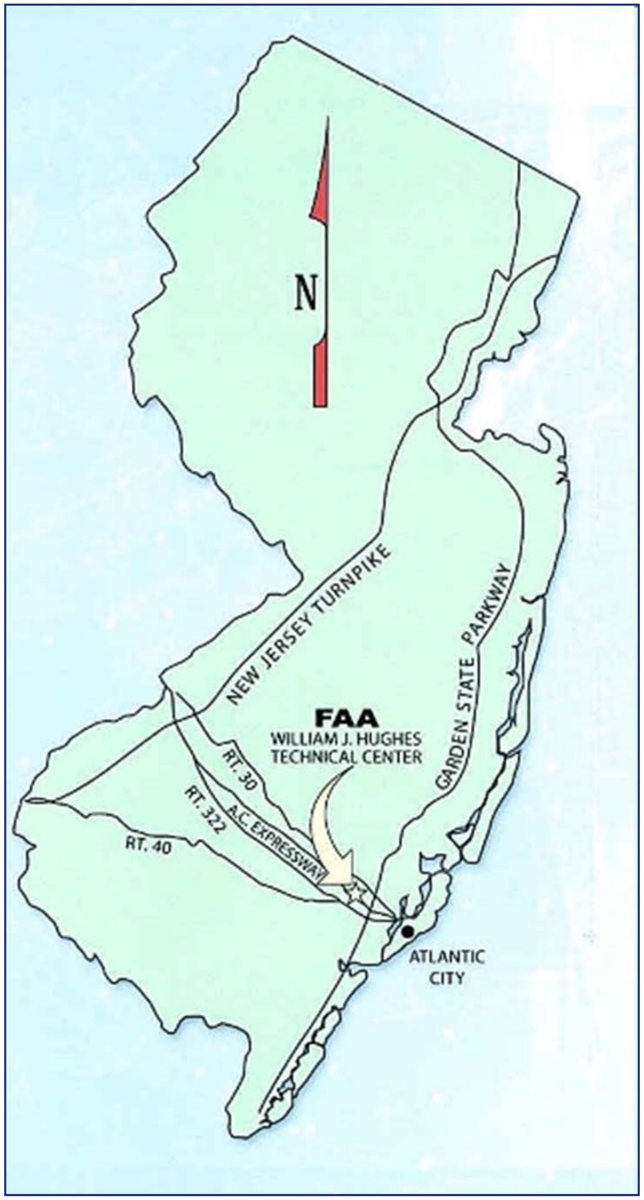
Presented to: IES ALC Government Contacts Mtg.

By: Joseph Breen, P.E.

Date: October 22, 2019

FAA William J. Hughes Technical Center at ACY

3,000 Federal/Contractor Employees
1,000 non-FAA Tenants
Over 5,000 Acres



FAA Technical Center at ACY

Who are we?

FAA Airport Technology R&D Branch (ANG-E26)

Airport Safety R&D Section

Airport Pavement R&D Section

Mission: Conduct the necessary research and development required to enhance the safety of operations at our nation's airports and to ensure the adequacy of engineering specifications and standards in all areas of the airport systems and, where necessary, develop data to support new standards.

http://www.airporttech.tc.faa.gov/

FAA
Airport Technology R&D Branch

<u>Program Sponsors:</u>

- **FAA Office of Airport Safety and Standards**
  - Airport Engineering Division (AAS-100)
  - Airport Safety and Operations Division (AAS-300)
- **FAA Office of Planning and Programming**
  - Planning and Environmental Division (APP-400)
- **FAA Lighting Systems Office**
- **Oher FAA Lines of Business as needed – Air Traffic Organization & Flight Standards**

<u>Research is funded under the Airport Improvement Program (AIP)</u>

FAA Airport Safety Research Program Areas

Visual Guidance
- Lights, Signs, Paint/Markings, LEDs, IR, Other Visual Cues, Incursion Reduction, Electrical Infrastructure, Photometrics, Obstruction Lighting, Lighting Innovations, Heliports, NAS Vis Aides, Special Projects

Airport Planning & Design
- RIM, Trapezoidal Grooves, Rwy/Taxiway Design, Capacity, Spaceports, Design Stds

Runway Surface Operations & Technology
- Rwy Friction, CFMEs, Winter Ops, TALPA RCAM, Deicing, EMAS, FOD Detection

UAS (Drone) Integration at Airports
- Airport Applications and Detection

Wildlife Mitigation
- Avian Surveillance/Deterrence (Radar), Wildlife Strike Data Collection/Analysis, Wildlife Management

Aircraft Braking Friction
- Aircraft braking performance on contaminated surfaces

Airport Safety & Surveillance Sensors
- Low cost surveillance, AeroMACS, Sensor Technology

Airport Noise & Environmental

ARFF
- ARFF Vehicles, Firefighting Systems, FF Agents, Tools, Composites, Technology, New Large Aircraft (NLA) Strategies & Tactics, Agent Methodology, NFPA/ICAO Stds

Over 150 Individual Projects

Airport Technology R&D Visual Guidance Research

- **Technical Evaluation of Electrical Infrastructure for Light Emitting Diodes.**
- **Evaluation of Solar Lighting Systems on Airports**
- **FAA Research Taxiway**
- **Infrared Requirements for Developing an LED HIRL with Infrared Emitter**
- **PAPI Baffling**
- **In-Pavement Light Fixtures**

Evaluation of New Electrical Infrastructure for LED Lighting

Objectives

- Conduct Validation Testing of Draft Fixture-Centric Architecture Performance Requirements to Ensure Full Functionality and Interoperability.
- Update and Finalize Performance Requirements Based on Results of Validation Testing.
- FAA Office of Airports to Initiate Development of an Engineering Brief for Fixture-Centric Architecture Based on Final Performance Requirements.

EIRT Tasks/Schedule

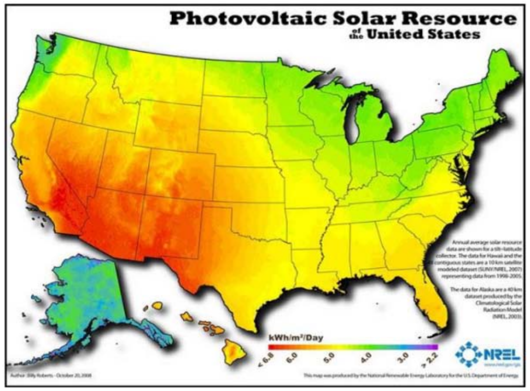
- **Draft Performance Requirements for Fixture-Centric Architecture Were Completed in February, 2019.**
- **Light Fixture Manufacturers Developing and Testing Firmware for Installation in Fixtures at Cape May Airport.**
- **Validation Testing of Fixture-Centric Architecture is Currently Underway at Cape May Airport.**
- **Final Test Report for Fixture-Centric Architecture Validation Testing to be Completed by December 31, 2019.**
- **Final Performance Requirements Completed and Engineering Brief for Fixture-Centric Architecture to be Published By End of FY2020.**

Evaluation of Solar Powered Lighting Systems on Airports

- **Challenges to Photovoltaic (Solar) Powered Lighting Systems have included Limited Geographical Operational Areas, Panel Efficiency Limitations for Recharge, Capacity of Batteries, and Lighting Brightness.**
- **Developments Relating to LED Lighting Systems and Solar Technology Have Made Solar Powered Lighting Systems a Practical Alternative in Certain Airfield Environments.**
- **Solar Technology Advancements Present an Opportunity for Airports to Produce On-Site Electricity and Reduce Long Term Energy Costs.**

Evaluation of Solar Powered Lighting Systems on Airports

- Five Geographic Regions Have Been Selected Around the Country Representing Varied Solar Insolation, Ambient Temperature Range, and Snow Fall.
- Geographic Regions Include Washington State, Central Upstate New York, Central Arizona, Central Oklahoma, and Cape May, NJ.
- Cape May Airport in New Jersey will be the Initial Prototype GA Airport Site for Evaluation.
- Multiple Site Surveys to be Conducted at GA Airports in the Other Four Geographic Regions Selecting One GA Airport from each Region for Solar Powered Lighting Evaluation.
- Evaluations to be Conducted over a Sufficient Period of Time to Allow for Assessment of Seasonal Solar Insolation and Related Battery Charging Capabilities.



Evaluation of Solar Powered Lighting Systems on Airports

- Solar Powered Lighting System Evaluation will Initially Consist of Laboratory Testing at the William J. Hughes Technical Center in Atlantic City, NJ and Field Testing at the Cape May Airport in New Jersey.
- Laboratory Testing Has Been Initiated.
- Field Testing with Data Collection will be Initiated at the Cape May Airport in February, 2020.
- Interim Test Report will be Completed in June, 2020.
- Site Surveys will be Conducted at Selected GA Airports in Early 2020 .

System Evaluations

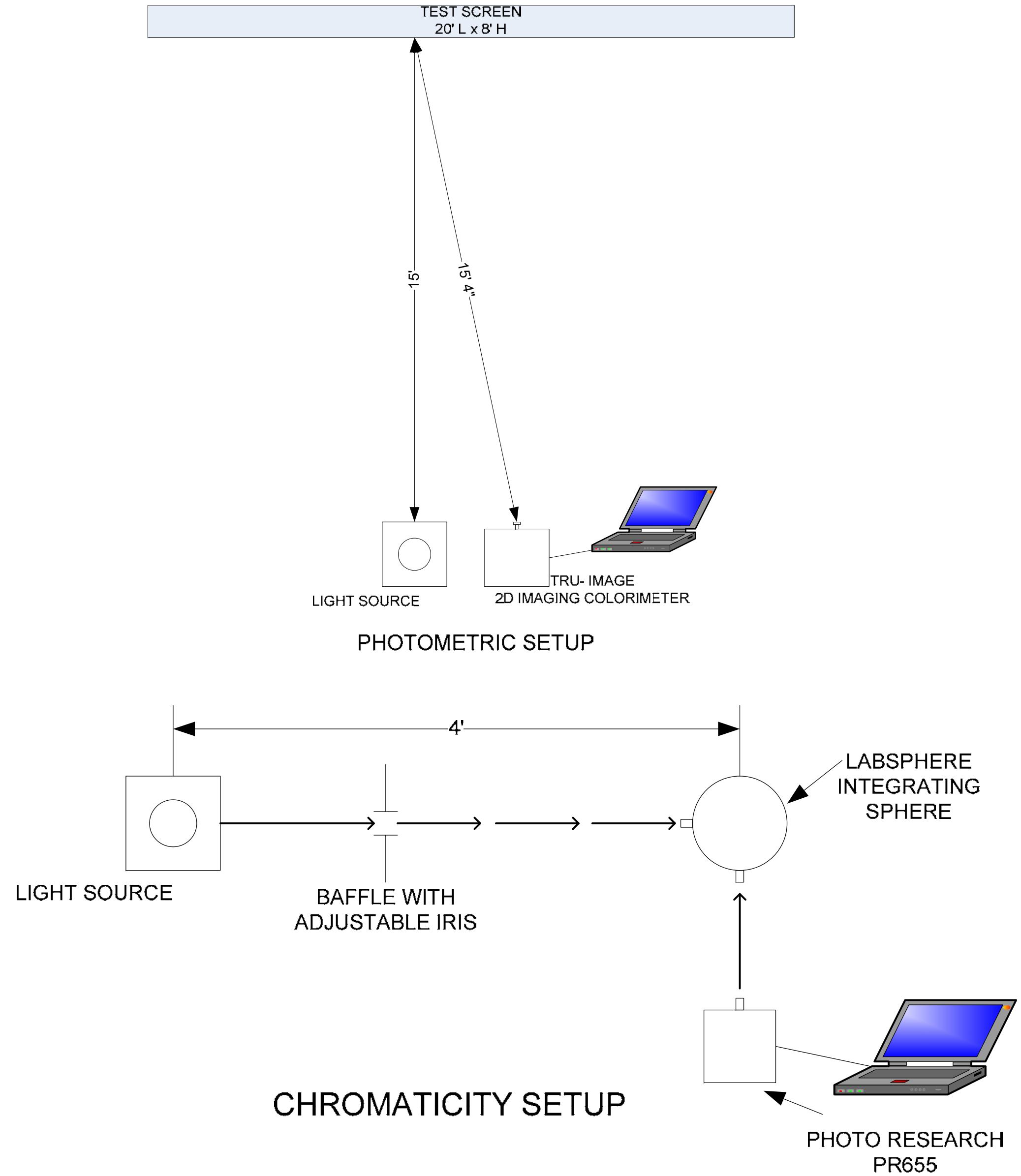
- Evaluations will be Conducted on the Following Airfield Components:
  - Runway Edge/Threshold Lights
  - Taxiway Edge Lights
  - Obstruction Lights
  - Elevated Runway Guard Lights
  - Wind Cones
  - Airfield Guidance Signs
- Component Selections will be Based on Compliance with FAA Requirements for Intensity and Chromaticity and will be Obtained from Three Manufacturers.
- A Wireless Controller will be Obtained from Each Manufacturer.
- Components will be Decentralized Type with Each Having its Own Solar Panel and Battery/Charging System.

System Evaluations

- **Evaluations Shall Consist of Laboratory Testing and Field Testing.**
  - **Laboratory Evaluations will Consist of Both Photometric Testing and Autonomy Testing.**
  - **Field Testing will Assess the Functionality and Durability of the Solar Powered Devices at Selected GA Airports Under Varying Environmental Conditions.**

Laboratory Testing

- **Testing to Measure the Luminous Intensity (Candela) and Chromaticity for All Steady Burning Solar-Powered Devices.**
- **Measurements will be Taken and Evaluated Based on Applicable FAA Advisory Circular Criteria.**
  - **Obstruction Light (L-810) Photometric Measurements Tested in Accordance with FAA AC 150/5345-43, "Specification for Obstruction Lighting Equipment".**
  - **Airport Light Fixtures (L-861, L-861T, and L-804) Tested in Accordance with FAA AC 150/5345-46, "Specification for Runway and Taxiway Light Fixtures".**


TEST SCREEN
20' L x 8' H
15'
15' 4"
LIGHT SOURCE
TRU- IMAGE
2D IMAGING COLORIMETER
PHOTOMETRIC SETUP
4'
LABSPHERE
INTEGRATING
SPHERE
LIGHT SOURCE
BAFFLE WITH
ADJUSTABLE IRIS
CHROMATICITY SETUP
PHOTO RESEARCH
PR655

Laboratory Testing

- **Autonomy Testing will be Conducted to Determine Solar Powered Device Operating Times from a Full Battery Charge.**
- **Solar Powered Devices will be set up with Batteries Charged in accordance with Manufacturer's Criteria.**
- **Operating Times will be Evaluated Based on FAA EB 76, "Using Solar Power for Airport Obstruction Lighting".**
- **FAA EB 76 Criteria Requires Batteries to Have Sufficient Capacity to Power Obstruction Lights from Dusk to Dawn for at Least Seven Consecutive 12-Hour Nights with Little or No Sunshine During the Day.**

Field Testing

- **Field Testing will be Conducted with Solar Powered Devices Installed on FAA Research Taxiway at Cape May Airport.**
- **Temporary Foundations (Test Bed) to be Installed to Support all Solar Powered Devices.**

Field Testing

- **Ethernet Cameras and Instrumentation with Data Acquisition System (DAQ) will Allow for Remote Monitoring of All Solar Powered Devices.**
- **DAQ Will Record Performance Parameters Including: Voltage/Current Output From Solar Panels and Downstream of Charge Controllers, Battery Charge, and Lighting Output.**

Evaluation of Solar Lighting Systems on Airports

- **Photovoltaic (PV) Lighting System Including Instrumentation/Data Acquisition System Installed and Data Collection Initiated at Cape May Airport in February, 2020.**
- **Site Surveys of GA Airports in Each Geographic Region to Begin in 2020.**
- **System Installation and Evaluation at Other Selected GA Airports will begin After Installation at Cape May Airport is Successfully Completed and Operational.**
- **Evaluations to be Conducted over a Sufficient Period of Time to Allow for Assessment of Seasonal Solar Insolation, Ambient Temperature, and Related Battery Charging Capabilities.**

FAA Research Taxiway: Cape May County Airport (WWD)

FAA Research Taxiway

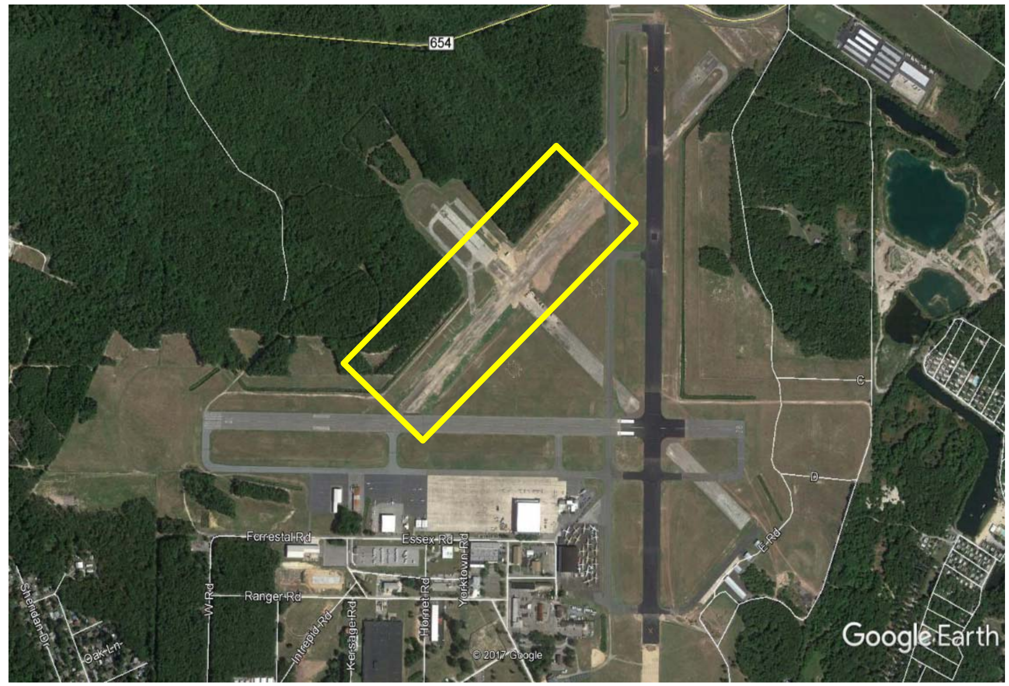
- **Single site to design, test, evaluate, monitor, and report on the performance of state-of-the-art airport safety and pavement technologies.**

- **Memorandum of Agreement (MOA) between FAA and Delaware River and Bay Authority (DRBA).**
  - November 15, 2010 through September 30, 2030.
  - Grants the FAA the "right to construct, operate and maintain Research Infrastructure" at Cape May County Airport (WWD) in Erma, NJ

- **Taxiway opened in April 2017**

FAA Research Taxiway

- **Taxiway C**
  - Length – 3250 ft.
  - Width – 50 ft.
  - Pavement Width – 150 ft.
- **Full array of Taxiway <u>and</u> Runway Lights**
- **State-of-the-art Lighting Vault**
- **Six Pavement Test Strips**



FAA Research Taxiway

FAA Research Taxiway Lighting Vault

FAA Research Taxiway: Research Plans

- **Safety Projects**
  - Obstruction lights with IR testing
  - Electrical infrastructure testing – EIRT Test Team
  - Runway surface friction
  - UAS integration at airports
  - Future lighting research efforts

- **Pavement Projects**
  - Nondestructive Testing
  - Field and Laboratory Characterization of Pavement Materials
  - Long Term Aging Study of Various Paving Mixes

Infrared Requirements for Developing an LED High Intensity Runway Edge Light (HIRL) with Infrared (IR) Emitter

LED HIRL with IR: Objectives

<u>Conduct research to develop an efficient and effective LED HIRL fixture with an IR signature compatible with Enhanced Flight Vision Systems (EFVS).</u>

- Develop IR requirement based on legacy L-862 incandescent fixture measurement..
- Perform IR measurements (IR power output in watts per steradian, and IR beam pattern) on the legacy tungsten-halogen FAA L-862 (HIRL), which current EFVS system's utilizes, to determine current IR output
- Develop prototype fixtures.
- Conduct field evaluations using prototype and standard lights

Field Evaluations

- Location: An evaluation site was established at Otis AFB in Cape Cod, MA
- Objective: Determine if prototype lamps are discernable during operationally significant low visibility conditions at various ranges of interest

Field Evaluations: Lights

- **Two prototype LED HIRLs with IR**
- **Two standard incandescent HIRLs**

Prototype 1

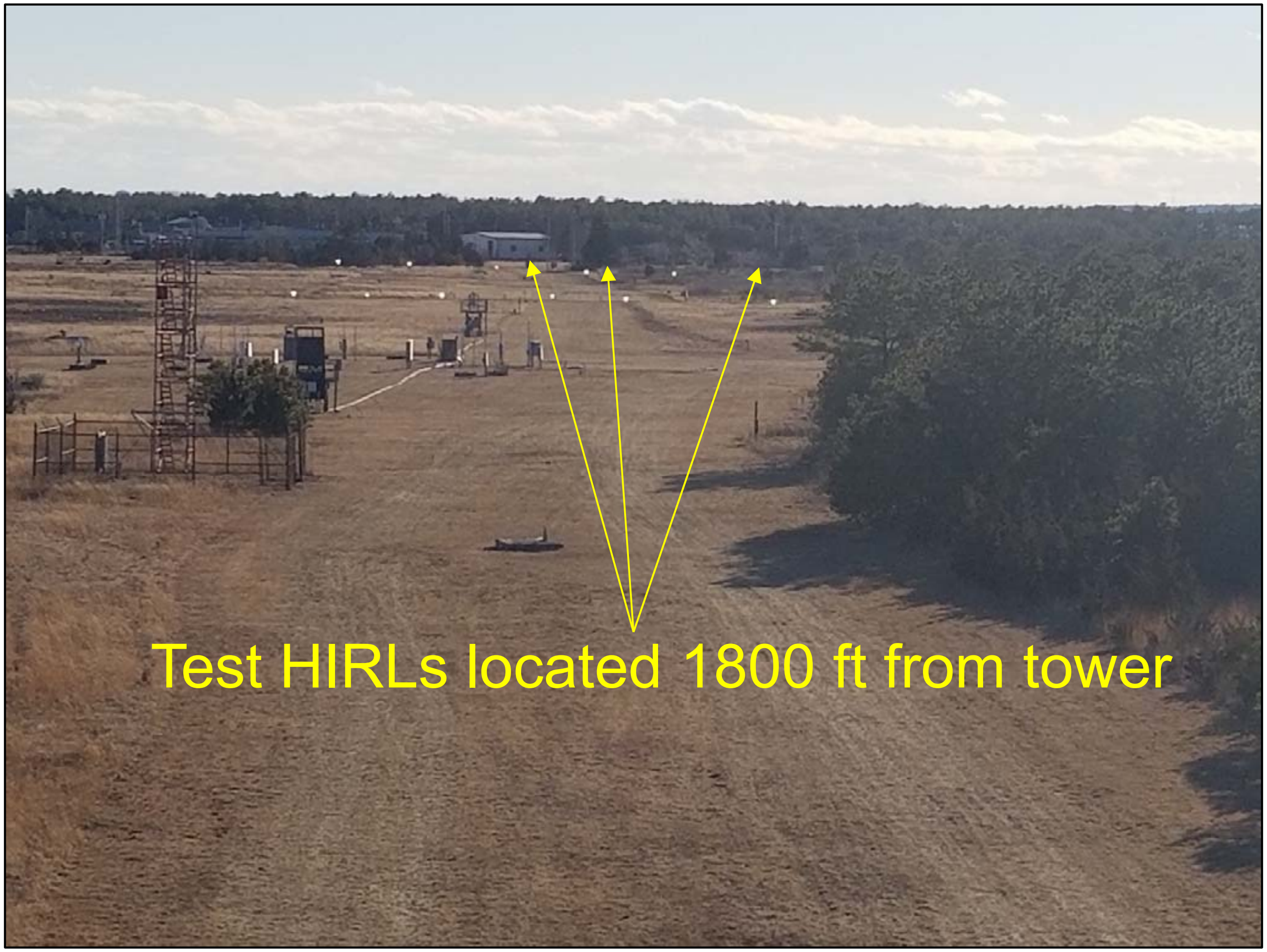
Standard

Prototype 2

Field Evaluations

- **A 30 ft. tower was installed to provide the required viewing angle for data collection cameras**
- **Visible Spectrum Camera**
- **EFVS Camera**

Field Evaluations: Tower View

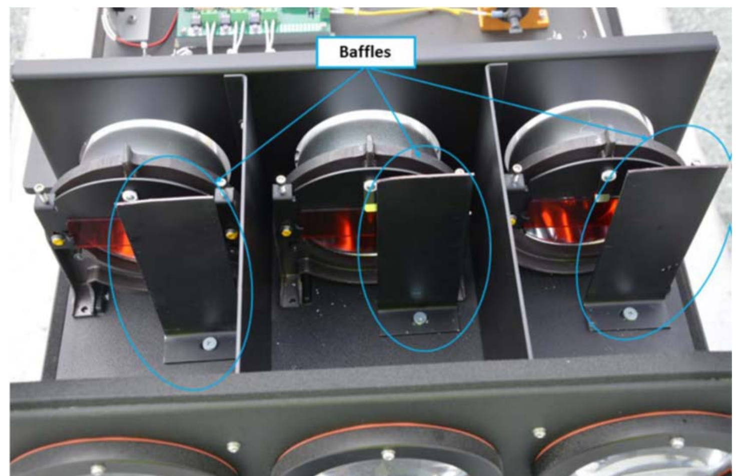


FAA R&D
PAPI Baffling &
New Bedford Panoramex (NBP)
LED PAPI

Precision Approach Path Indicator (PAPI)

What the is PAPI “Baffling”

- Retrofitting the PAPI by adding metal shields called “Baffles” to…
- Reduce the PAPI light signal lateral coverage to satisfy FAA Flight Inspection criteria.
- So pilots DO NOT see PAPI light signal and potentially fly into a obstacle.
- FAA R&D +50 airports in 8 years
- Why?



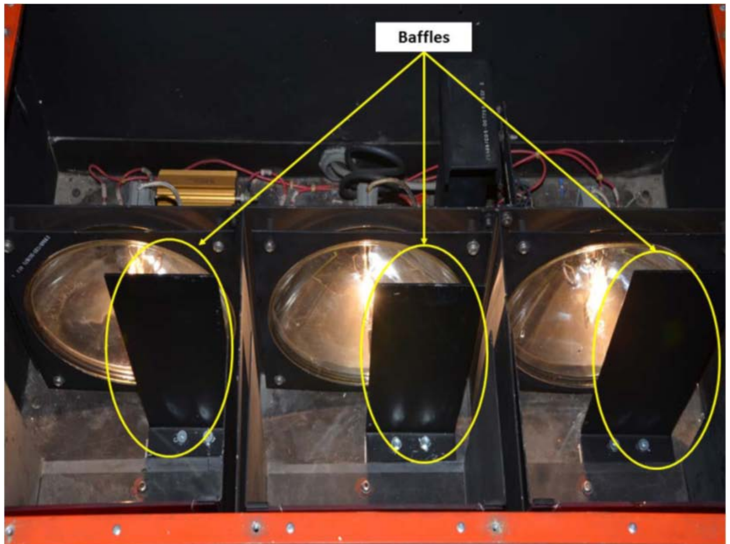
Why?

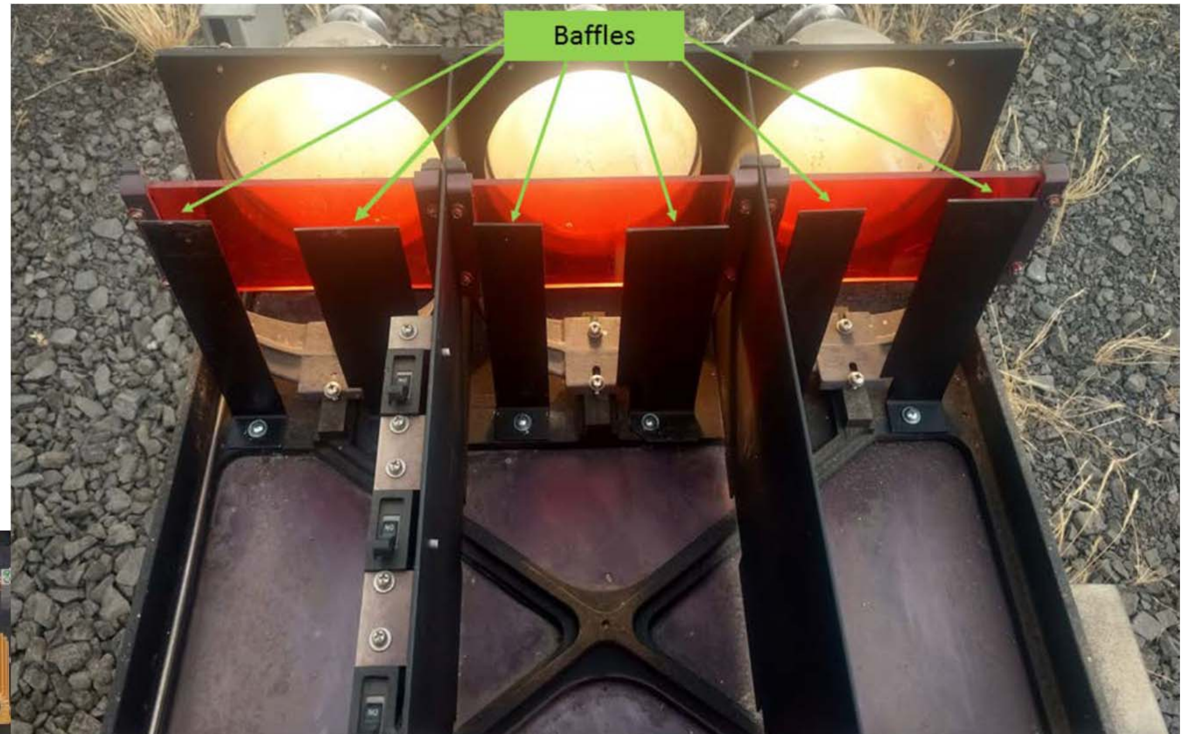
- **Combination of:**
  - Airport geometry with surrounding environment
    - Terrain, Mountains, Trees, Buildings, Towers, etc. in approach path
  - PAPI performance specs – lab vs actuality
    - -10°/+10° Light Distribution in lab vs -13°/+13° can seen by Flight Inspection
  - PAPI installation criteria (Order 6850.2B or AC 150/5340-30H & Engineering Brief 95)
    - Engineered around center of runway Obstacle Clearance Surface, but PAPI is located on side of runway
  - Flight Inspection procedures (8200.1D) [started in 2013, TFIG]
    - "…evaluation of the obstacle clearance within the lateral limits of the visible light beam, even if it means going outside the standard 10-degree to 10-degree obstacle protection area centered on the runway."

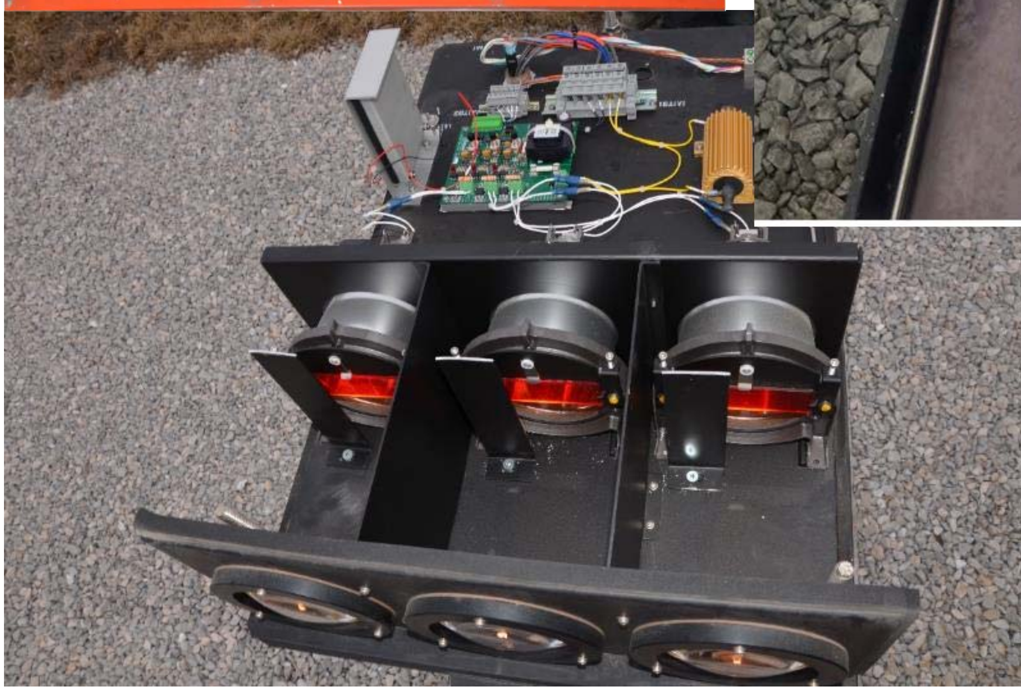
Baffle Effect

Forces the pilot to fly closer to extended runway centerline (away from an obstacle) to see the PAPI light signal

Can Baffle Any Legacy PAPI LHA







NBP LED PAPI = New Challenge

- **Traditional baffle methods DO NOT WORK.**

How do you baffle NBP LED PAPI?

Solution!!

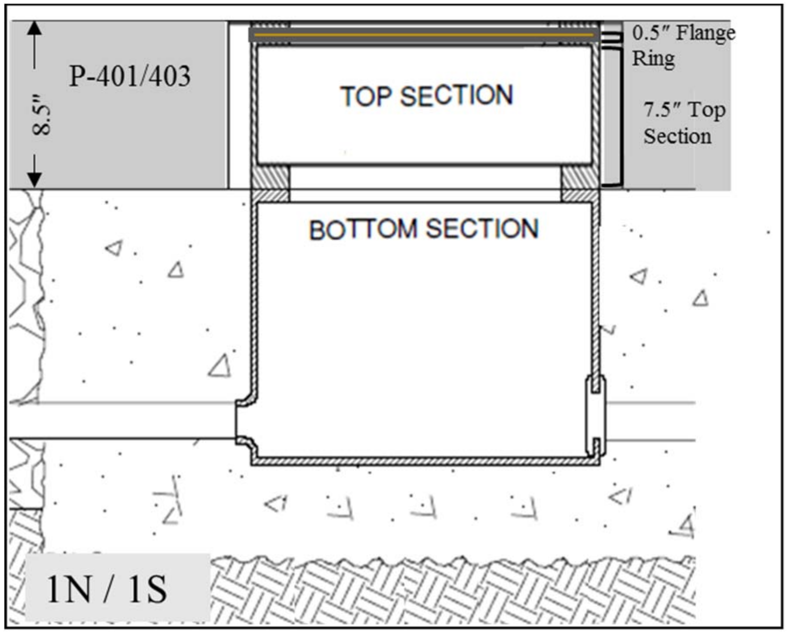
- **FAA R&D Team at FAA Technical Center**
  - Developed a method to install custom baffles
    - Fabricated baffles at Tech Center
    - No physical alterations to the LHA needed
    - Can be installed/removed as needed for maintenance
    - **First installation complete and Flight Inspected at Waterbury-Oxford Airport (OXC), CT.**
  - **Baffle design & installation are patent pending**

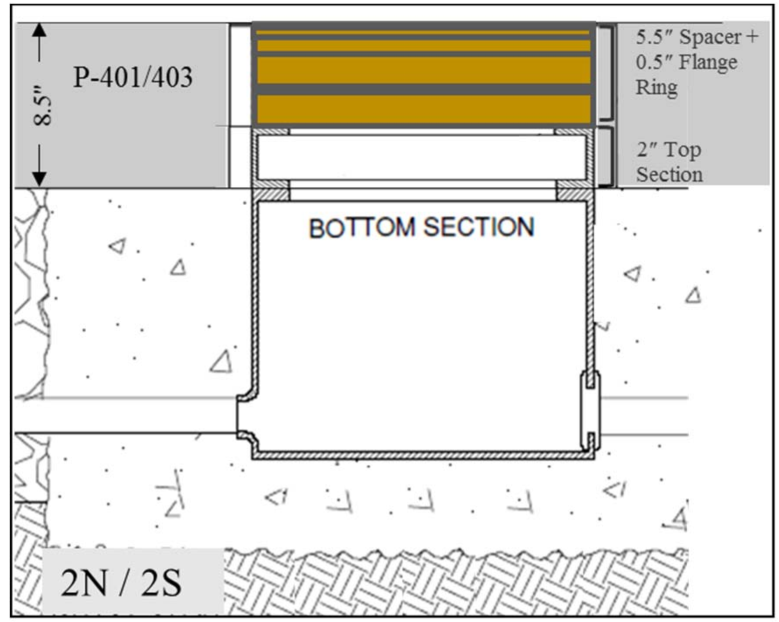
In-Pavement Light Fixture Testing and Evaluation

Testing of In-Pavement Light Fixtures

- **Incidents have occurred at US Airports where In-pavement Light Fixture bolted connections have failed, resulting in L-850A light fixtures completely separating from their associated L-868 light bases.**
  - Subject instrumented light fixtures to controlled trafficking, utilizing the NAPTV, with incrementally increasing levels of wheel loading.
  - Assess the effects of incrementally increasing levels of wheel loading on the test items with respect to the ultimate failure of the In-Pavement Light Fixture Assemblies.
- **Four test item configurations identified and constructed.**

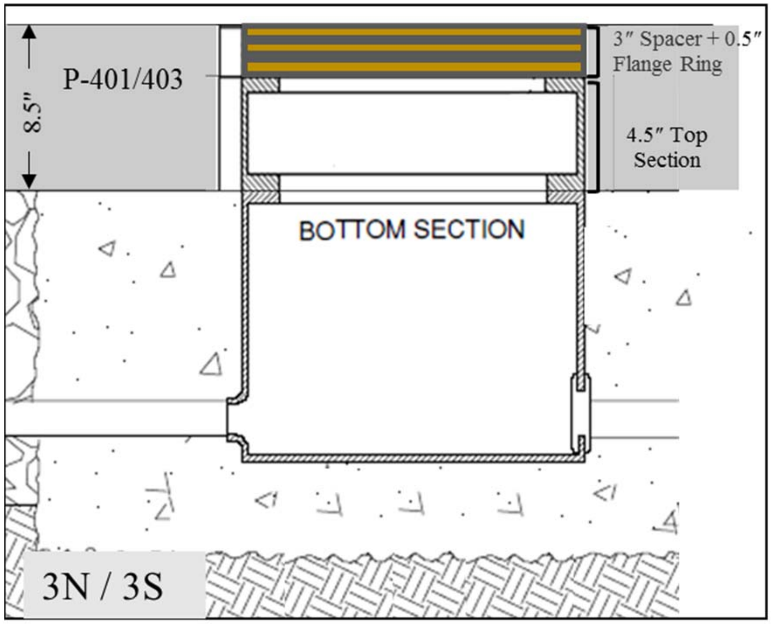
Test Configurations 1 and 2

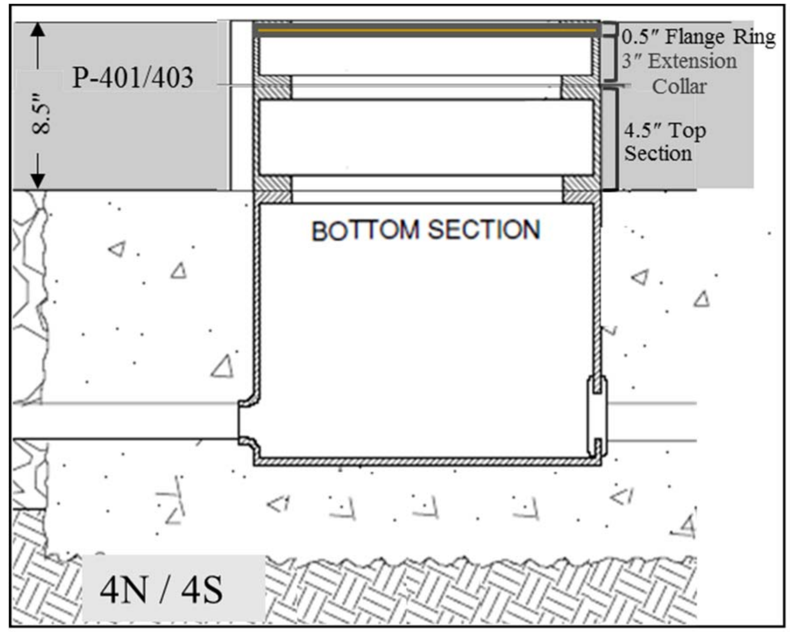




Fixtures	Surface Adjustment Spacer Ring	L-868 Top Section	Extension	Top Spacer Rings	Flange Ring with Pavement Dam	Stud Type
1N, 1S	0 – 1″	Single 7.5″	None	None	0.5″	3/8″ fluoropolymer coated Grade 5 carbon steel
2N, 2S	0 – 1″	Single 2″	None	2″ + 2″ + 1.5″	0.5″	

Test Configurations 3 and 4



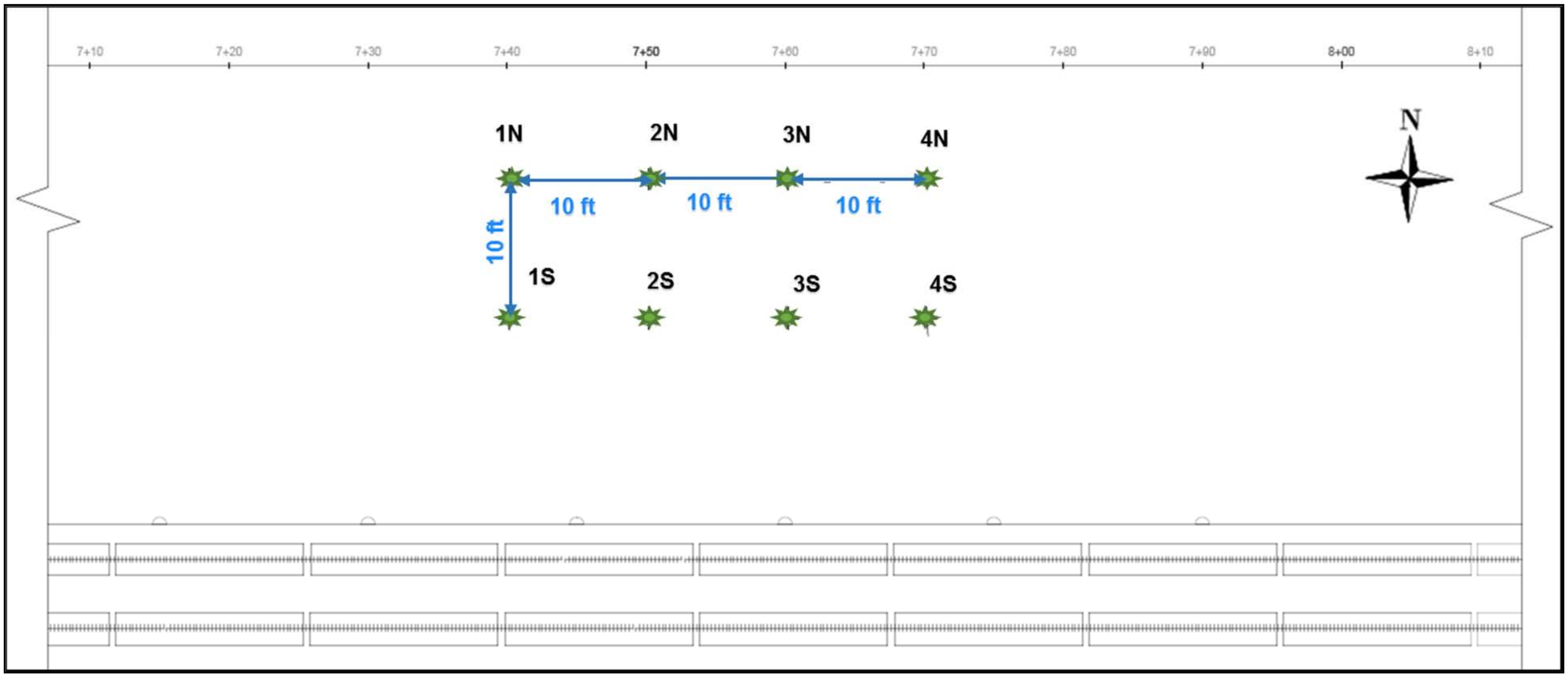


Fixtures	Surface Adjustment Spacer Ring	L-868 Top Section	Extension	Top Spacer Rings	Flange Ring with Pavement Dam	Stud Type
3N, 3S	0 – 1″	Single 4.5″	None	1″ + 1″ + 1″	0.5″	3/8″ fluoropolymer coated Grade 5 carbon steel
4N, 4S	0 – 1″	Single 4.5″	3″	None	0.5″	

Calibration/Installation of Mounting Studs

- **Mounting Studs are Coated 3/8 Inch Diameter SAE J429 Grade 5 Bolts with Heads Removed.**
- **Mounting Studs Have 1.6 mm Diameter Holes Drilled Through Longitudinal Centerline for Installation of Strain Gauges.**
- **Laboratory Tensile Machine Used to Calibrate Strain Levels in Studs Based on Target Clamping Forces.**
- **Studs Threaded Into Top Flanges of Light Base Upper Sections with Loctite.**
- **SAE J995 Grade 5 Nuts with Two Part Locking Washers Installed Onto Top Of Studs and Torqued to Achieve Required Incremental Clamping Force for Securing Light Fixtures.**

Light Fixture Test Bed Layout



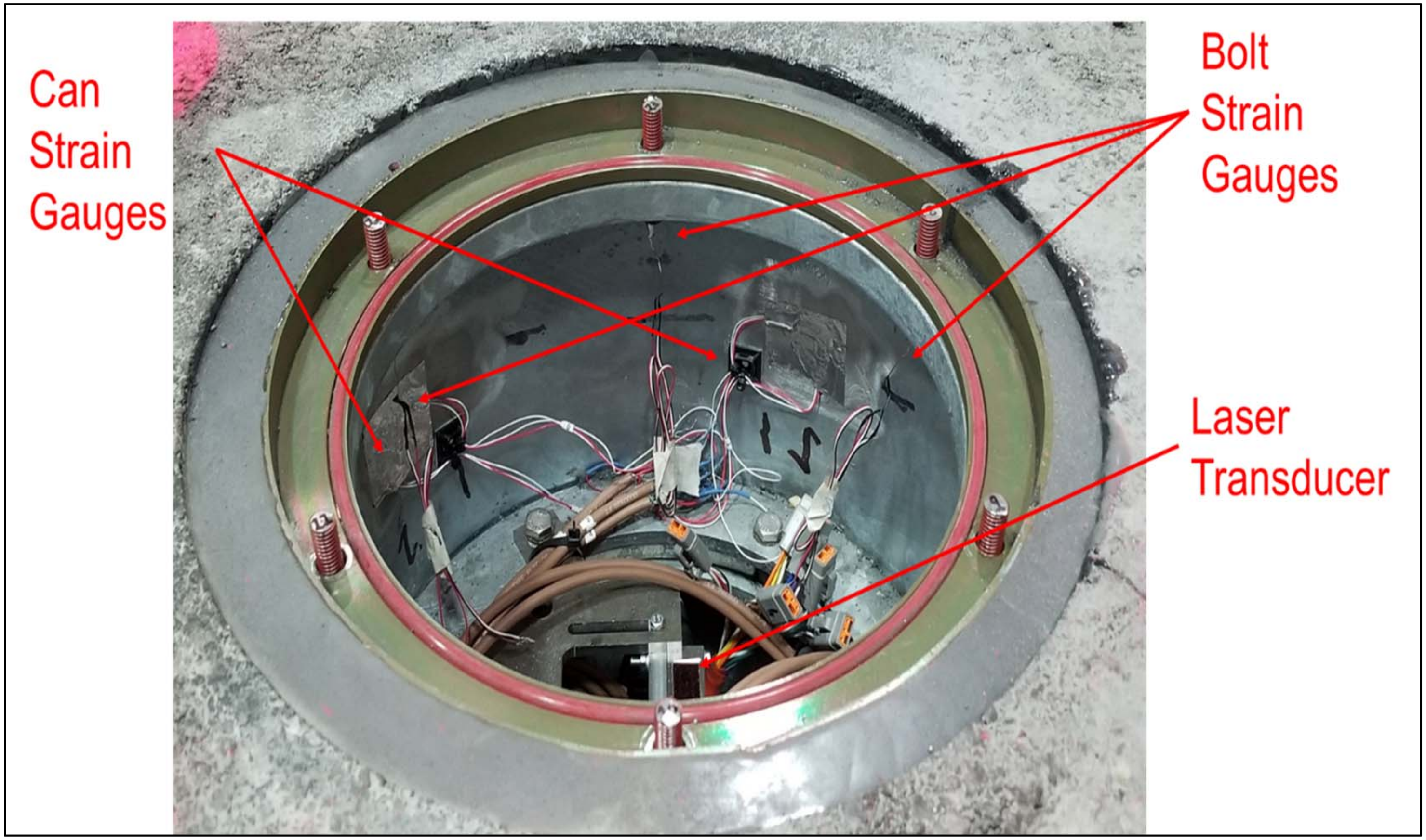
Instrumentation: 27 Channels per Item

- **Fixture**
  - 1 triaxial accelerometer
  - 4 strain gauges
- **Bolts**
  - 6 strain gauges
- **Fixture Base**
  - 8 strain gauges
    - 4 horizontal
    - 4 vertical
  - 2 laser displacement meters
    - 1 horizontal
    - 1 vertical

- **Pavement**
  - 4 strain gauges
    - Located at bottom of HMA layer
    - 2 transverse
    - 2 longitudinal

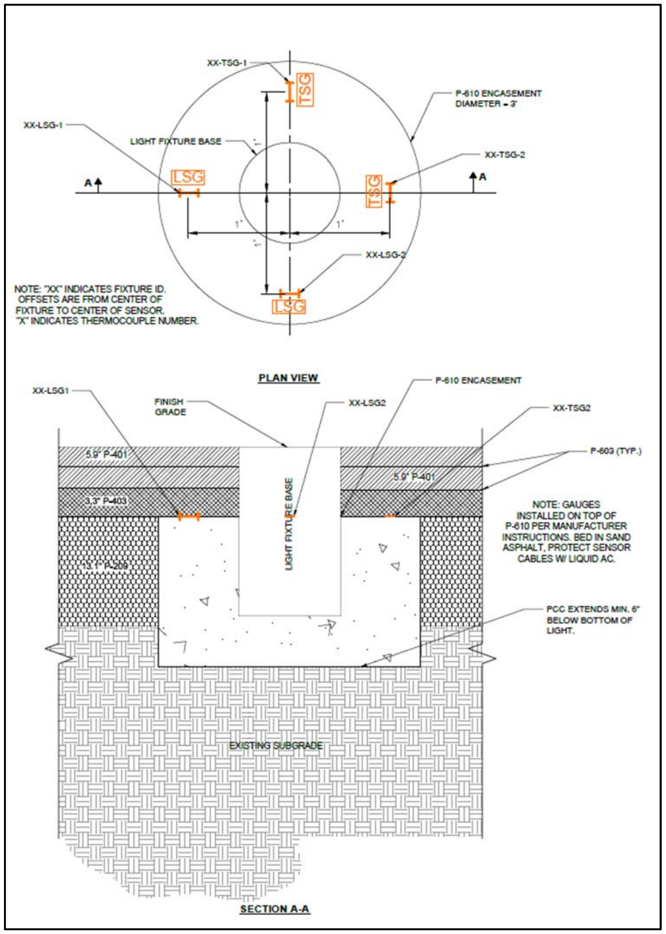
- **Additionally, 6 thermocouples for the entire test section**

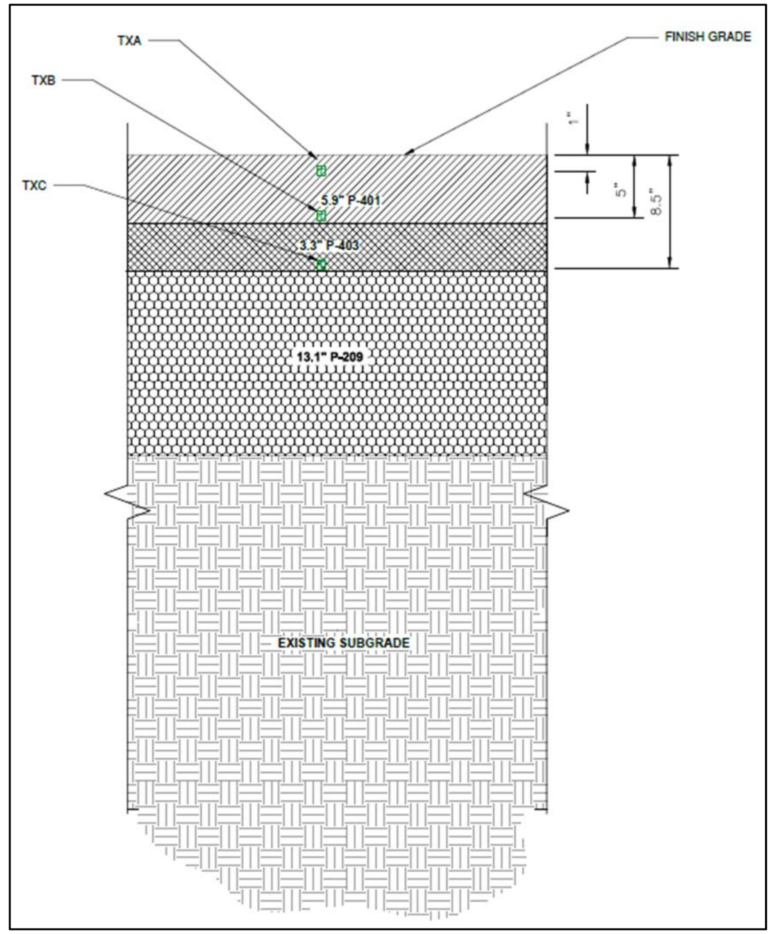
Fixture Base Instrumentation



Pavement Strain Gauges

Pavement Strain Gauges and Thermocouples



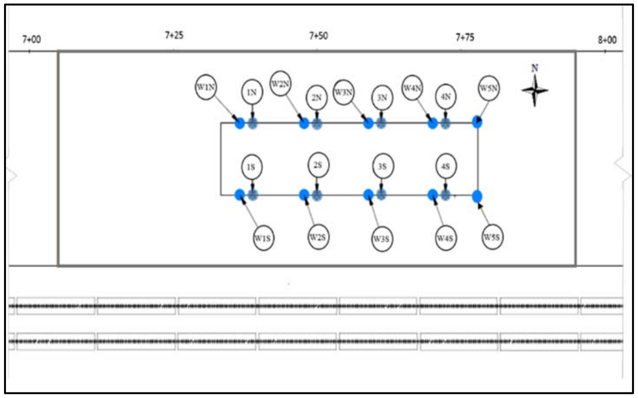


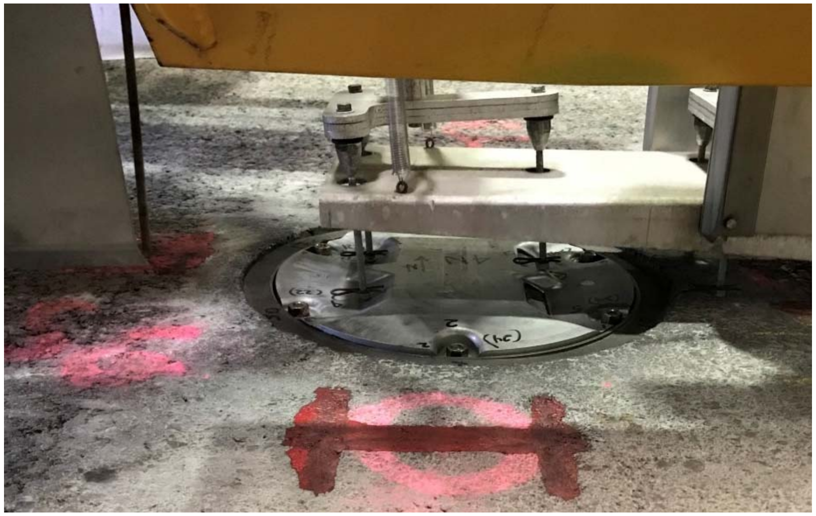
In-Pavement Light Fixture Testing

- Heavy Weight Deflectometer (HWD) Testing
- Static Loading
- In-Motion (Trafficking) Loading
- National Airport Pavement Test Vehicle Used to Apply Static Loading and In-Motion (Trafficking) Loading

HWD Testing

- **Seating drop plus 12k, 24k, 36k, and 48k drops at each location**
- **Test locations:**
  - On each fixture
  - 2ft offset from each fixture
  - Two control locations

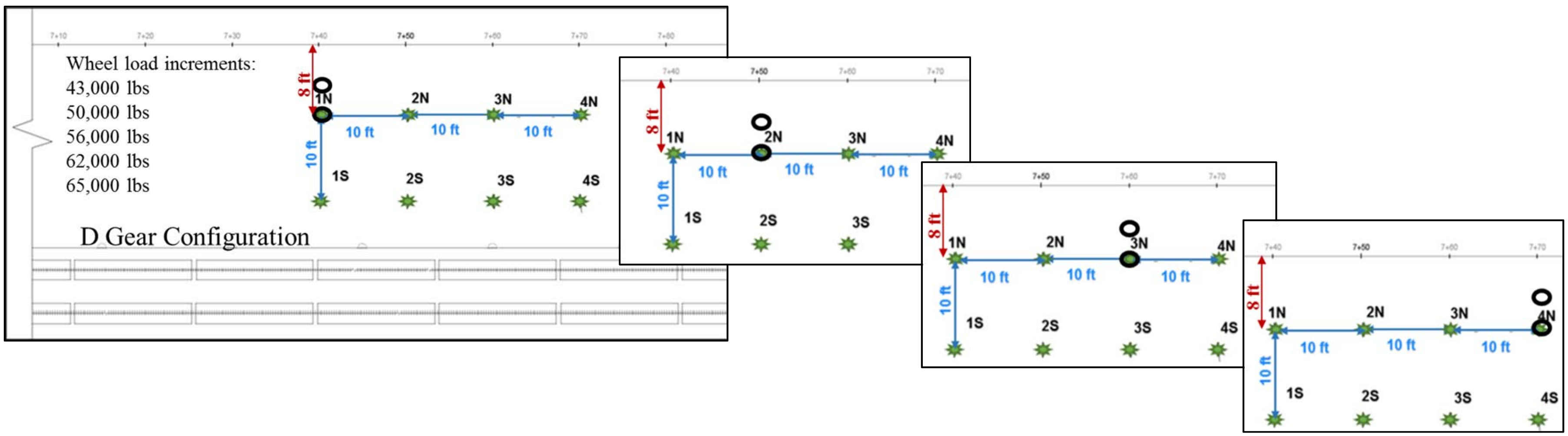




HWD Testing

Static Loading

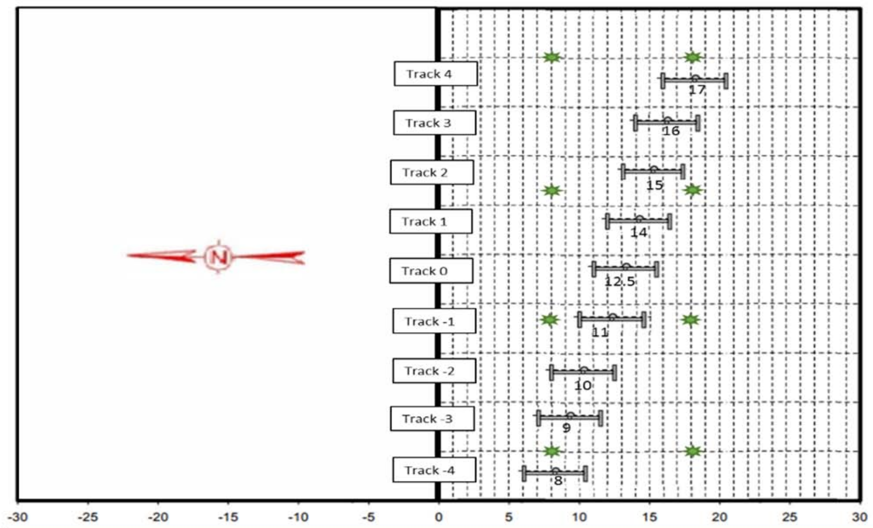
- D, 2D and 3D gear configurations
- Same per-tire loads
- Right front tire placed directly on fixture



Static 3D Wheel Loading

In-Motion Trafficking Loading

- 3D Gear Load Increments
  - 50,000 Pounds/Wheel
  - 54,000 Pounds/Wheel
  - 59,000 Pounds/Wheel
  - 63,000 Pounds/wheel
  - 65,000 Pounds/Wheel
- Total 3D Gear Loading Equals Wheel Load x 6
- Two Passes Conducted at Each Load Increment at Each of Nine Lateral Gear Locations



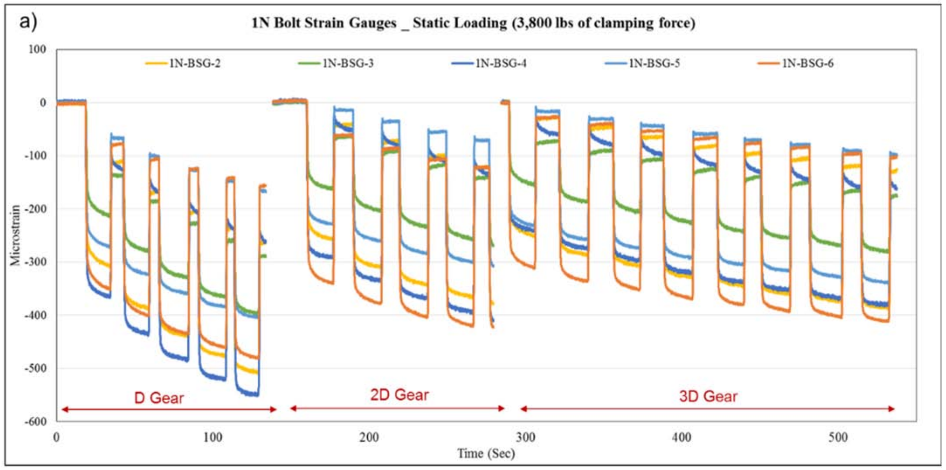
Trafficking Loading

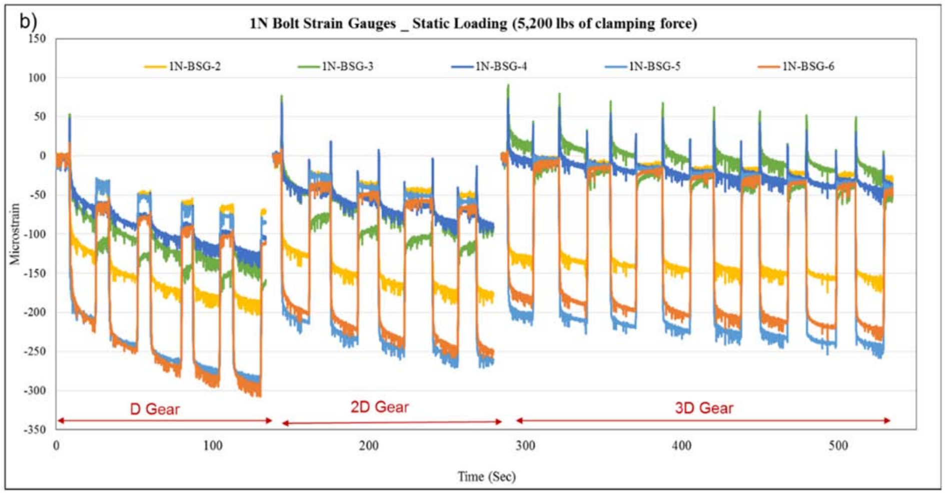
Testing Sequence

- **3,800 lbs. Bolt Clamping Force (75% of Yield Load for Grade 304 SS Bolt)**
  - Torque Studs
  - HWD Testing
  - Check Torque
  - Static Loading with NAPTV
  - Check Torque
  - Trafficking with NAPTV
  - Check Torque
  - HWD Testing

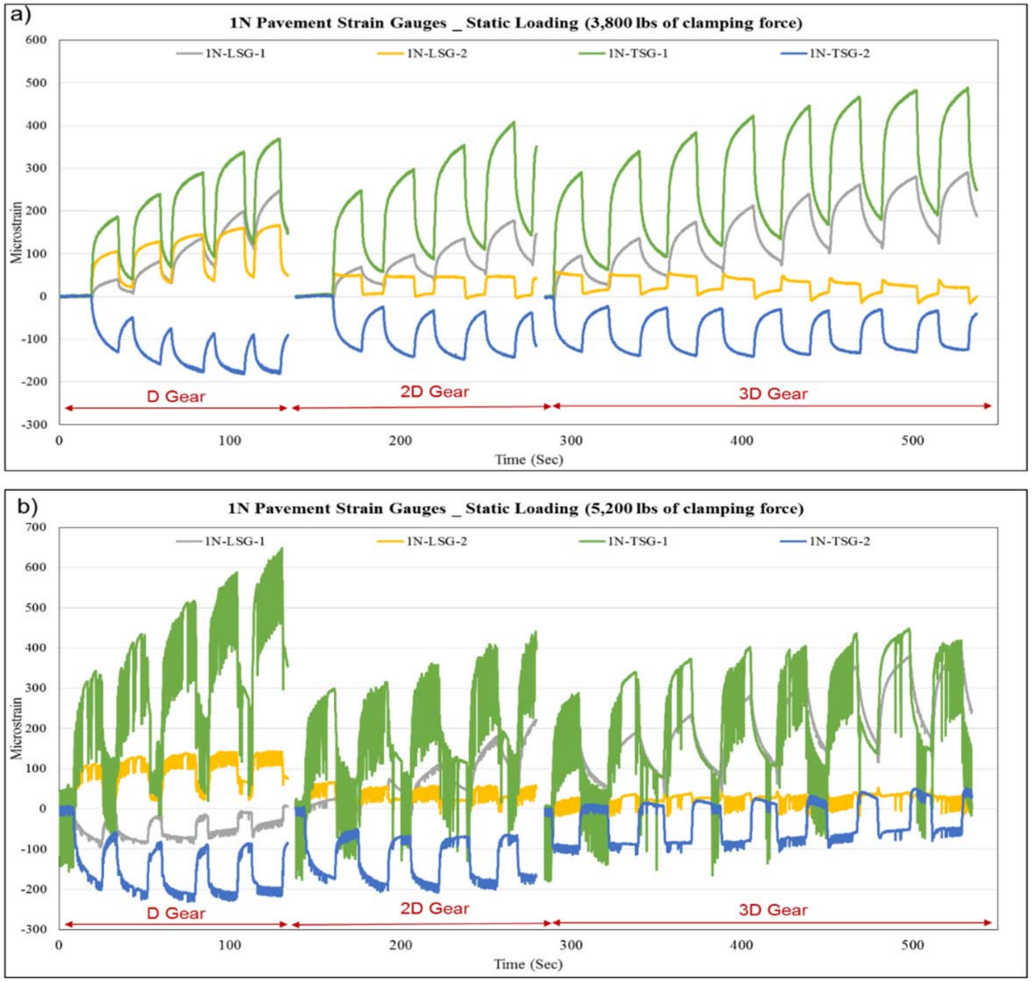
- **5,200 lbs. Bolt Clamping Force (75% of Yield Load for Grade 410 SS Bolt)**
  - Torque Studs
  - HWD Testing
  - Check Torque
  - Static Loading with NAPTV
  - Check Torque
  - Trafficking with NAPTV
  - Check Torque
  - HWD Testing

Bolt Strain Gauge Plot – Static Loading

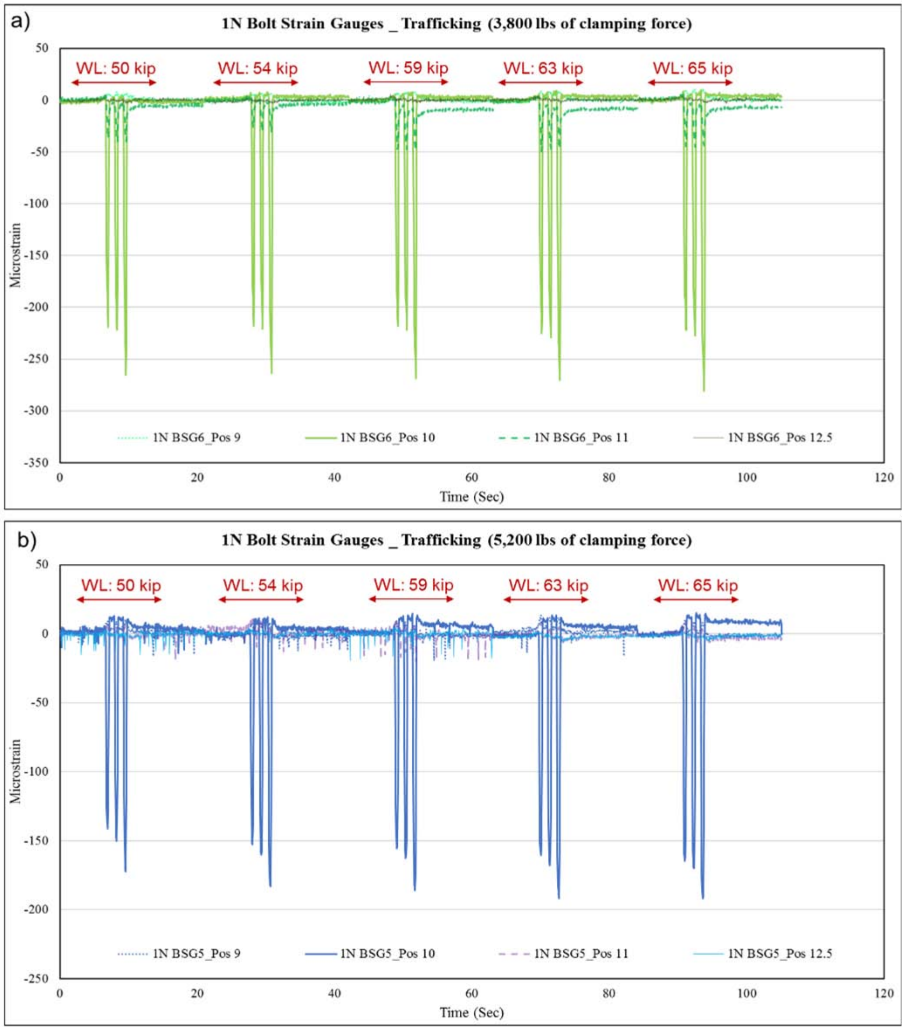




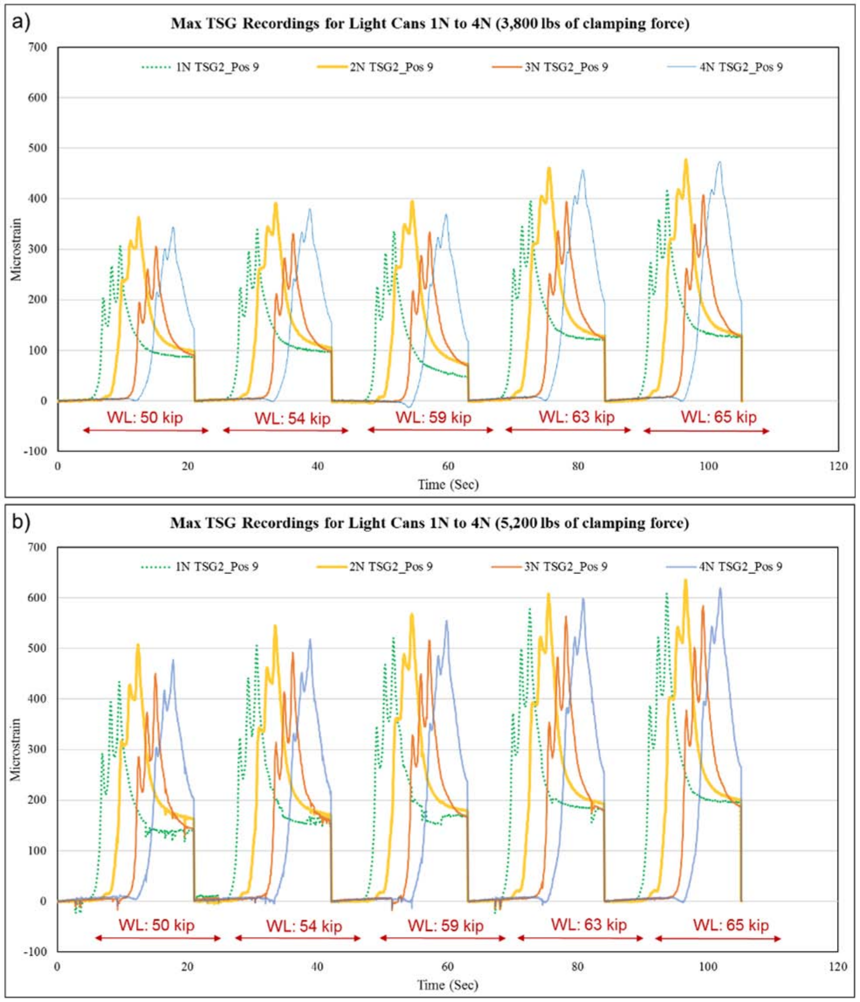
Pavement Strain Gauge Plot – Static Loading



Bolt Strain Gauge Plot – Trafficking



Pavement Strain Gauge Plot – Trafficking



Status of Testing

- Report on Testing and Analysis is Currently Being Finalized.
- Preliminary Observations Include the Following:
  - Higher Installation Clamping Force of Studs Results in Significantly Reduced Relaxation Under Static and Dynamic Loading.
  - Stud Relaxation was Influenced More By Shorter Length Studs Than Configuration of Spacer Rings and Extensions.
  - Effect of Wheel Load on Light Fixture Assembly Strain Gauges Generally Negligible When Wheel Load Was More Than 2 feet Away From Assembly.

Next Steps

- **Conduct Horizontal Shear Force Testing on In-Pavement Light Fixture Assemblies per FAA AC 150/5345-46 with Friction Coatings Applied to Spacer Rings.**
- **Coatings to be Selected Based on Review of Industry Standards Relatable to Light Fixture/Base Applications.**
- **AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts", Identifies 3 Classes of Coatings for Slip Critical Bolted Joints (A,B, and C).**
- **Testing Objective will be to Assess the Influence of Various Coatings on the Static Friction Coefficient Generated Between the Light Fixtures and Bases.**

Questions?