AIRPORT TECHNOLOGY R&D VISUAL GUIDANCE RESEARCH

Presented to: IES ALC Government Contacts Mtg.

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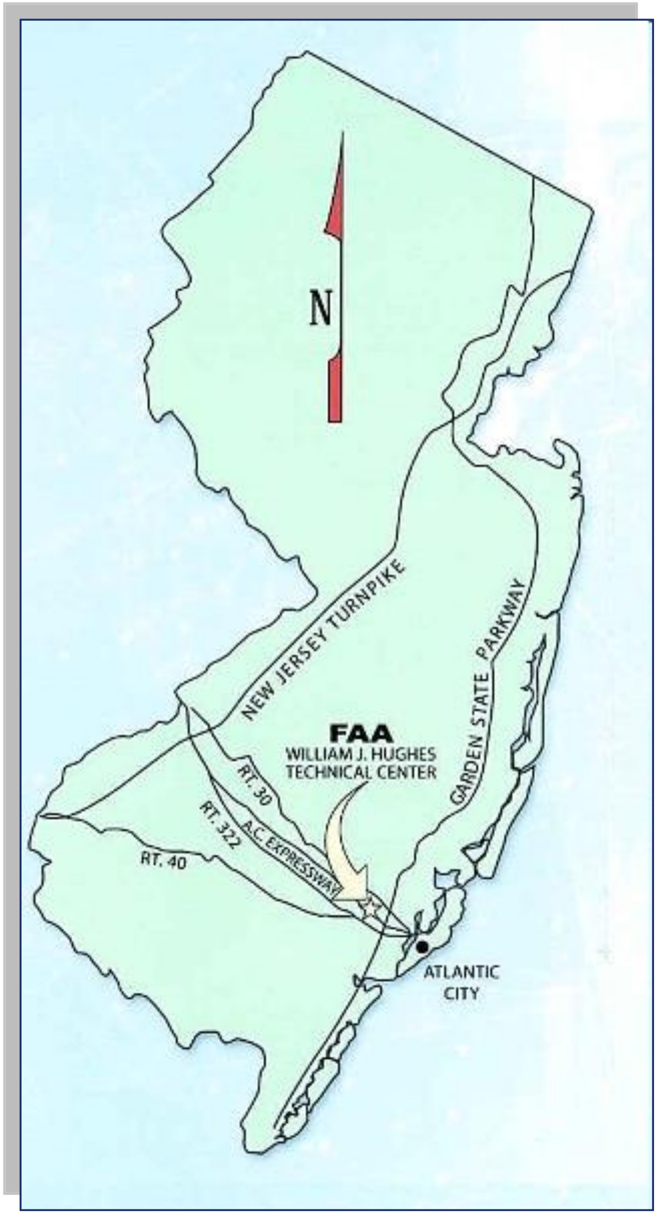
Date: April 18, 2019

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

Program Sponsors:

- **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**

Research is funded under the Airport Improvement Program (AIP)

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 and New Bedford Panoramex (NBP) LED PAPI
- In-Pavement Light Fixtures

Evaluation of New Electrical Infrastructure for LED Lighting

Electrical Infrastructure Research Team (EIRT) Background

- **The EIRT developed a three phase strategy:**
  - Phase 1: Investigate candidate LED infrastructures to test, characterize, and evaluate/identify optimal characteristics of the systems.
  - Phase 2: Optimize on results from Phase 1, and resolve and test prototypes to answer remaining questions.
  - Phase 3: Draft Performance Requirements and Conduct Validation Testing for Selected Architecture(s).
  - Performance Requirements to be Finalized and Incorporated into an Engineering Brief.

Fixture-Centric LED Architecture

- **Phase 2 Testing at Cape May Has Proven that the Fixture-Centric Architecture is Sufficiently Developed for Deployment in Airport Environments.**
- **"Fixture-Centric Architecture" consists of each light fixture controlling its intensity level after digital intensity information is conveyed to it.**
- **The FAA has Worked with Light Fixture Manufacturers to Draft Performance Requirements for the Fixture-Centric Architecture to define and standardize the Core Technical Elements of the Architecture.**
- **These elements include the following:**
  - Message encoding protocol
  - Fixture behavior
  - Power source behavior
- **The FAA is Currently Working with the Light Fixture Manufacturer's to Prepare for Validation Testing at Cape May Airport.**

Fixture-Centric Architecture Validation Testing

- **136 LED fixtures, supplied by three manufacturers, installed on 3 respective sign pads along FAA Research Taxiway.**
- **Light fixtures mounted on each sign pad are connected in series consistent with current airport circuits.**

Fixture-Centric Architecture Validation Testing (Cont.)

- **Three additional light fixtures instrumented with current probes to measure fixture current and count occurrences of successful intensity commands.**
- **Each instrumented light fixture was mounted in an orange electrical panel located adjacent to one of the groups of fixtures.**

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 Airport Engineering Division (AAS-100) to Initiate Development of an Engineering Brief for Fixture-Centric Architecture Based on Final Performance Requirements.

EIRT Tasks/Schedule

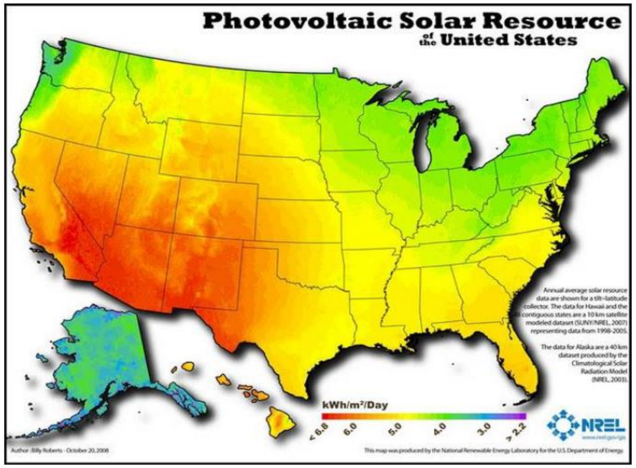
- **Draft Performance Requirements for Fixture-Centric Architecture Were Completed in February, 2019.**
- **Light Fixture Manufacturers to Develop and Test Firmware for Installation in Fixtures at Cape May Airport by July 1, 2019.**
- **FAA to Update Labview Environment, Test Instrumentation, and Develop Test Plan by July 1, 2019.**
- **FAA and Light Fixture Manufacturers Make Final Instrumentation and Firmware Updates at Cape May Airport by July 15, 2019.**
- **Validation Testing of Fixture-Centric Architecture to be Completed by July 31, 2019.**
- **Final Performance Requirements for Fixture-Centric Architecture to be Completed by September 30, 2019.**
- **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 to be Selected Around the Country Representing Varied Solar Irradiance Availability.**
- **Multiple Site Surveys to be Conducted at GA Airports in each Geographic Region Selecting One GA Airport from each Region for Solar Powered Lighting Evaluation.**
- **Cape May Airport in New Jersey will be the Initial Prototype GA Airport Site for Evaluation.**
- **Evaluations to be Conducted over a Sufficient Period of Time to Allow for Assessment of Seasonal Solar Irradiance and Related Battery Charging Capabilities.**



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.
- Instrumentation to be Installed to Remotely Monitor Component Key Performance Parameters Including Voltage/Current Output from Solar Panels, Voltage/Current Downstream of Charge Controllers, and Lighting Output.

Evaluation of Solar Lighting Systems on Airports

- Selection of GA Airports for Evaluation to Begin in Spring, 2019.
- Design, Installation, and Evaluation of Photovoltaic (PV) Lighting Systems Scheduled at GA Airports to Begin in Spring, 2019.
- Evaluations to be Conducted over a Sufficient Period of Time to Allow for Assessment of Seasonal Solar Irradiance and Related Battery Charging Capabilities.
- FAA Research Taxiway at Cape May Airport will be the first GA Airport Selected for System Installation and Evaluation.
- Photovoltaic (PV) Lighting System Including Instrumentation/Data Acquisition System Installed and Data Collection Initiated at Cape May Airport in Fall, 2019.
- System Installation and Evaluation at Other Selected GA Airports will begin After Installation at Cape May Airport is Successfully Completed and Operational.

FAA Research Taxiway:
Cape May County Airport (WWD)

FAA Research Taxiway

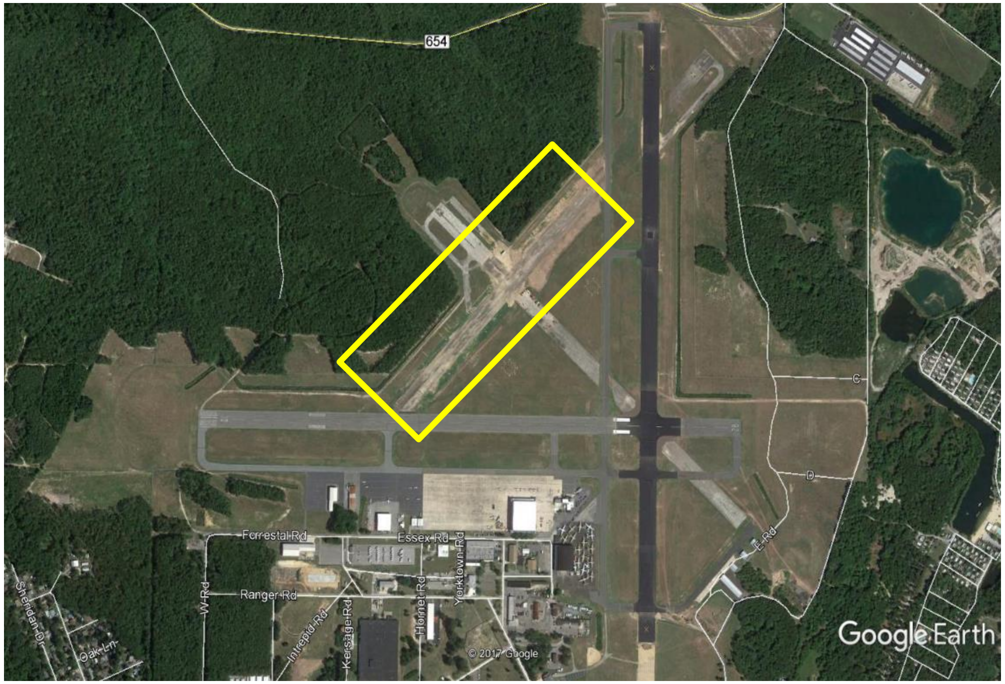
- **Single site to design, test, evaluate, monitor, and report on the performance of state-of-the-art airport safety and pavement technologies.**

- **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

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

- 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

- <u>Location</u>: An evaluation site was established at Otis AFB in Cape Cod, MA
- <u>Objective</u>: 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

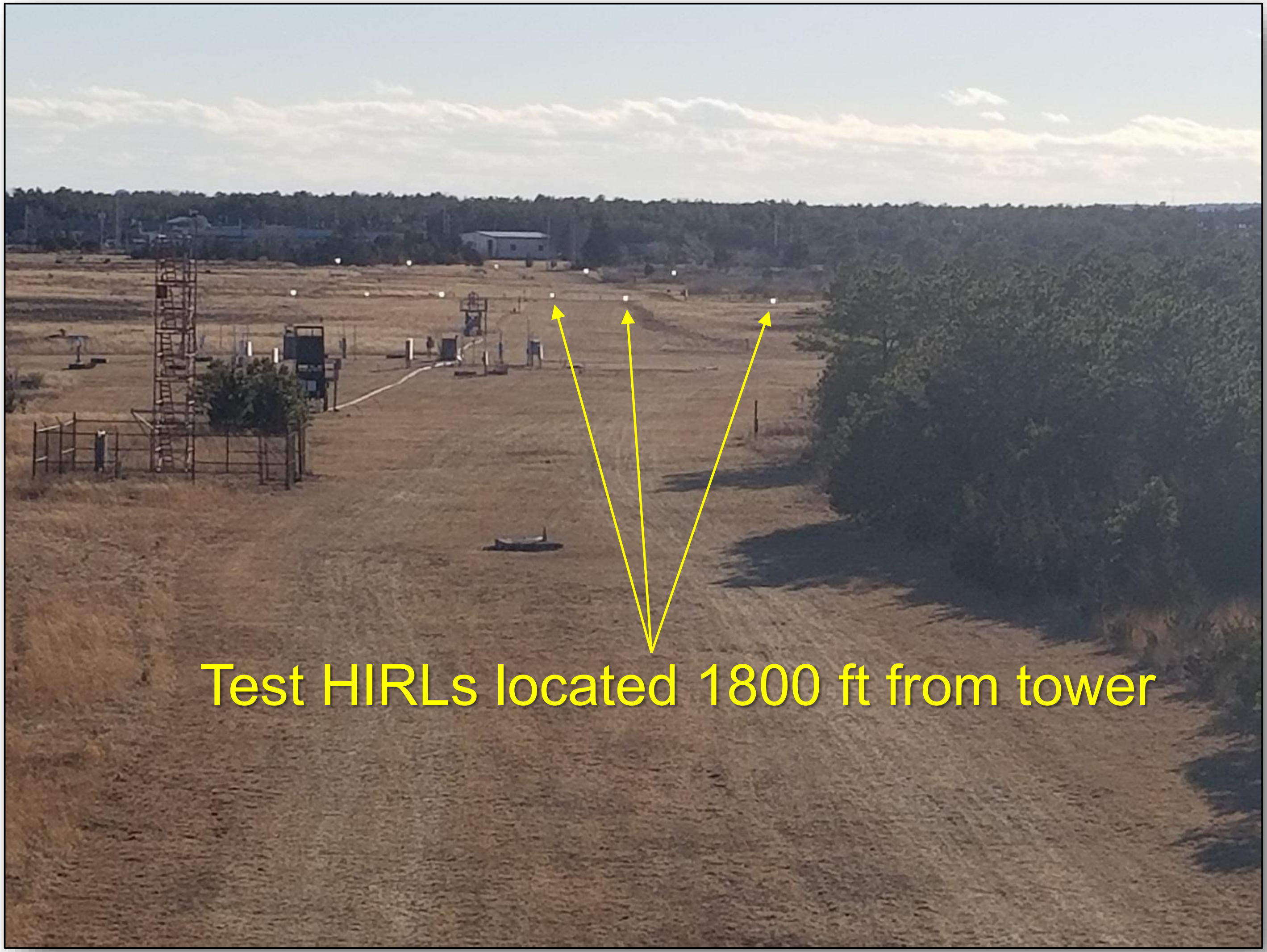
Standard

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

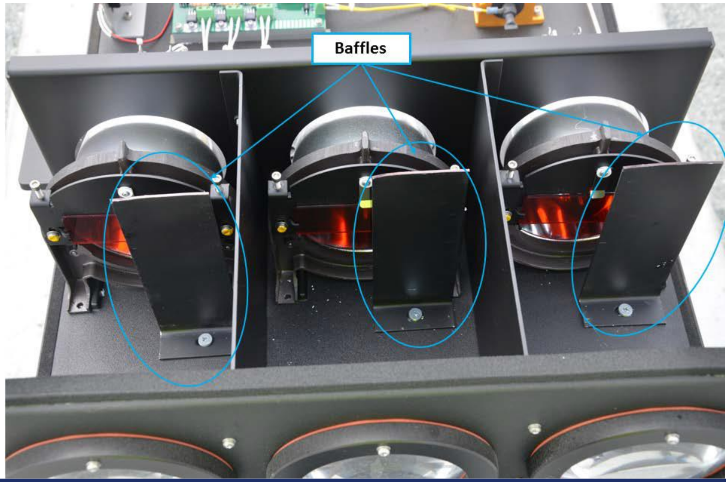


FAA R&D
PAPI Baffling &
New Bedford Panoramex (NBP)
LED PAPI

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 potential fly into a obstacle.
- FAA R&D +50 airports in 8 years
- Why?



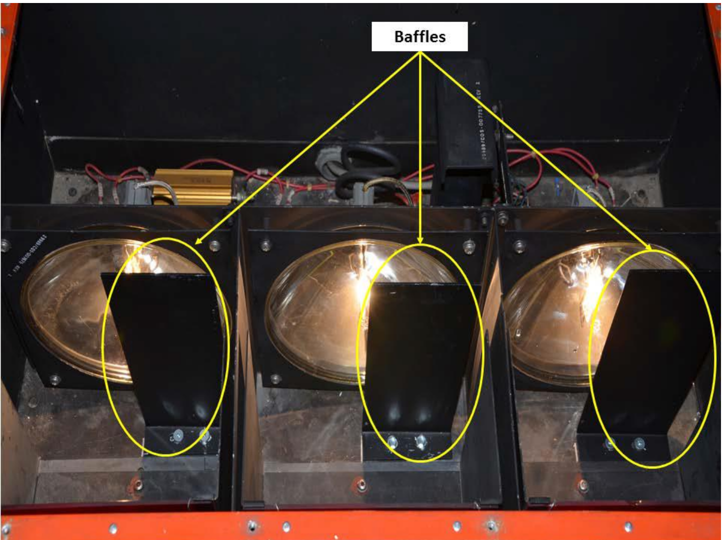
Why?

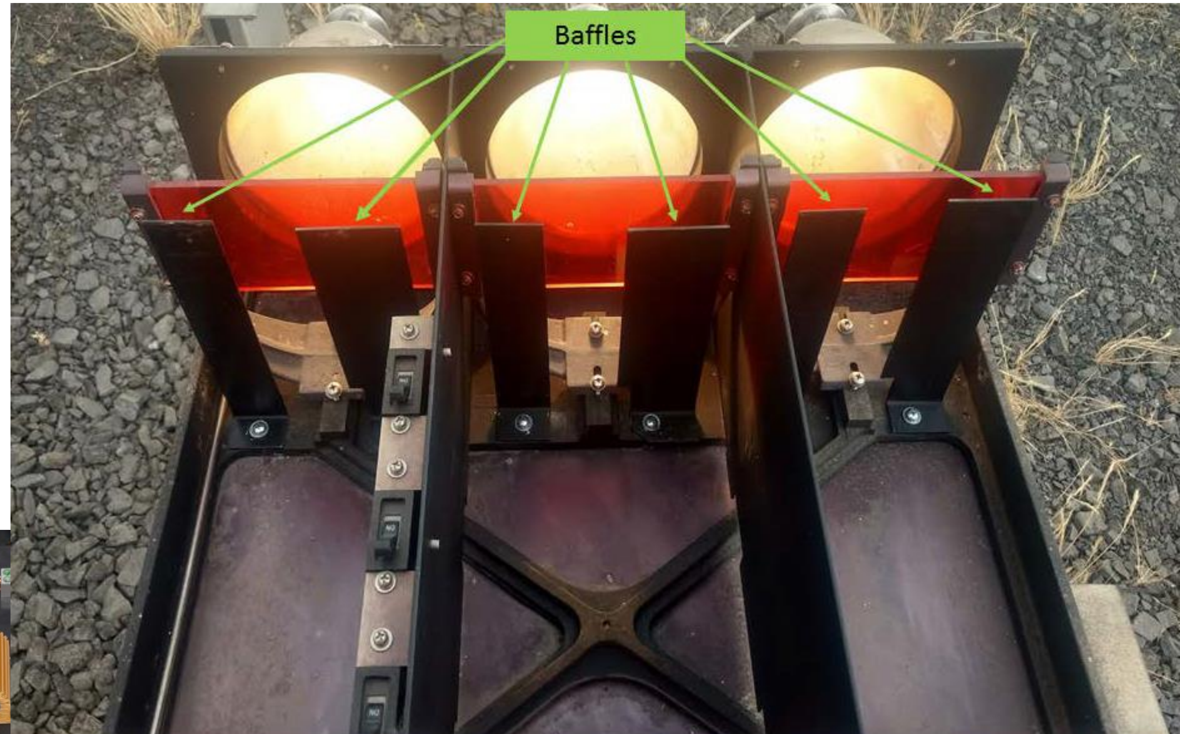
- **Combination of:**
  - Airport geometry with surrounding environment
    - Terrain, Mountains, Trees, Buildings, Towers, etc. in approach path
  - PAPI performance specs – lab vs actuality
    - -10°/+10° Light Distribution in lab vs -13°/+13° can seen by Flight Inspection
  - PAPI installation criteria (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."

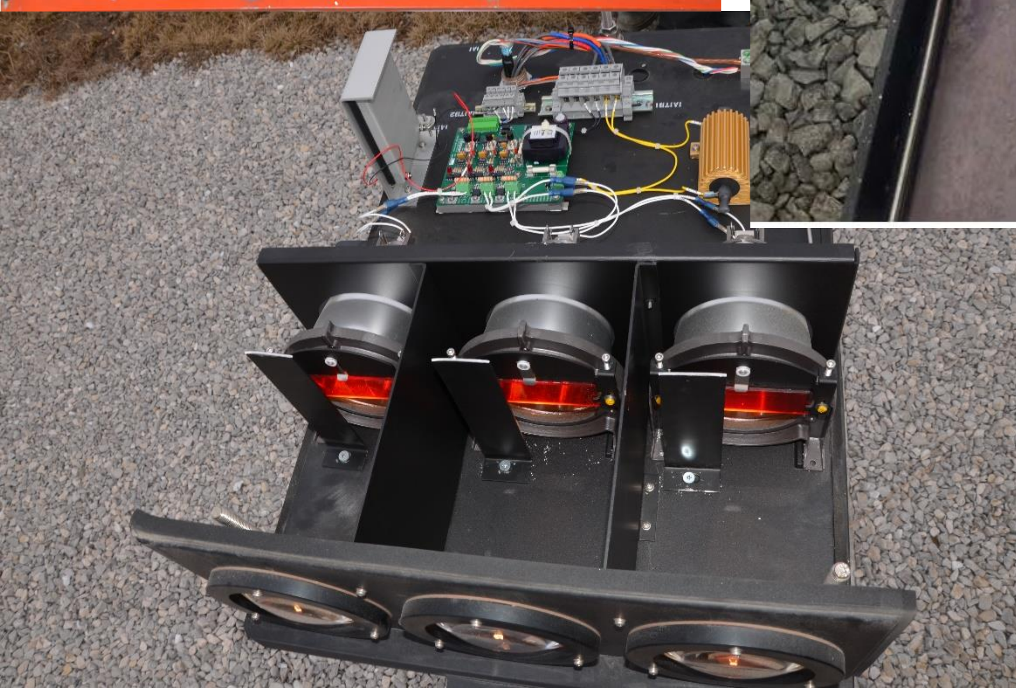
Baffle Effect

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



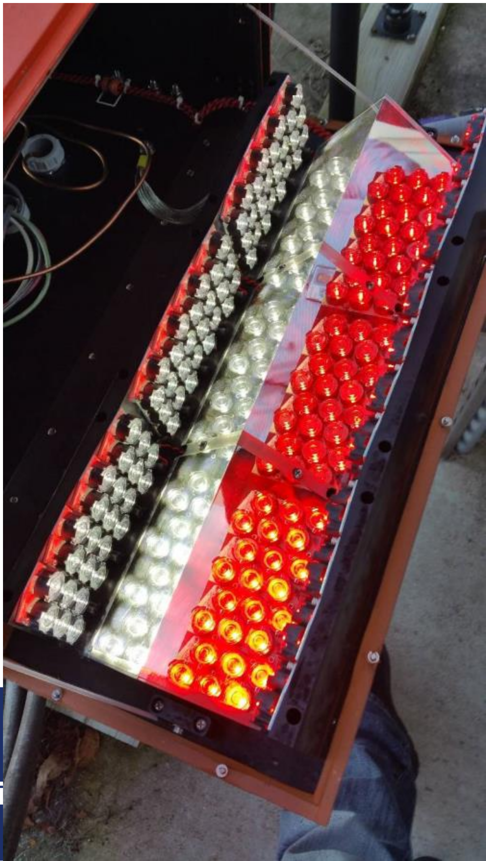




NBP LED PAPI = New Challenge

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

How do you baffle NBP LED PAPI?



Challenge, but possible solution

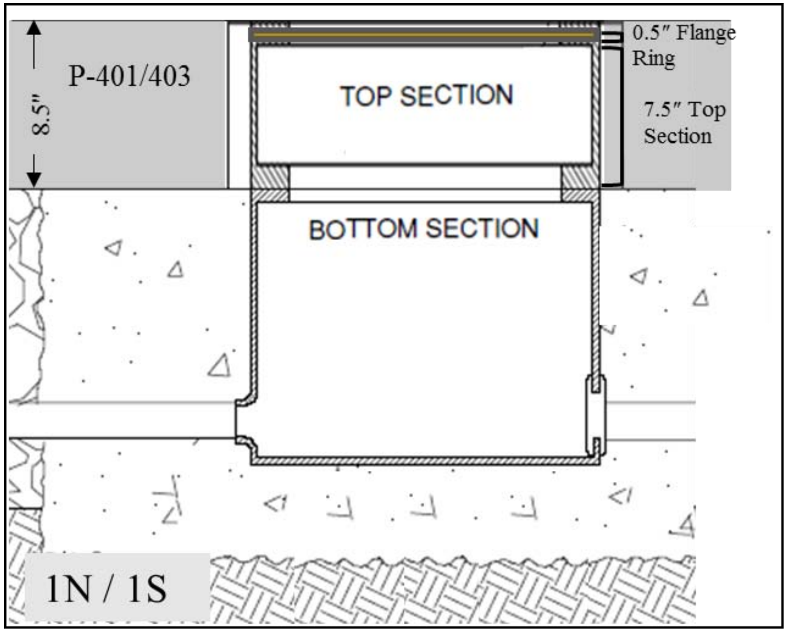
- **FAA R&D Team at FAA Technical Center**
  - Tried several varying methods through trial/error
  - Possible solution using a custom baffle design
    - Fabricated baffles at Tech Center
    - No physical alterations to the LHA needed
    - Determined method to install/remove as needed for maintenance
    - Verified method works on ground and can be aligned as needed
    - Last step will be to install LED Baffles on PAPI and perform R&D Flight Evaluations.
    - Then ready for FAA Flight Inspection

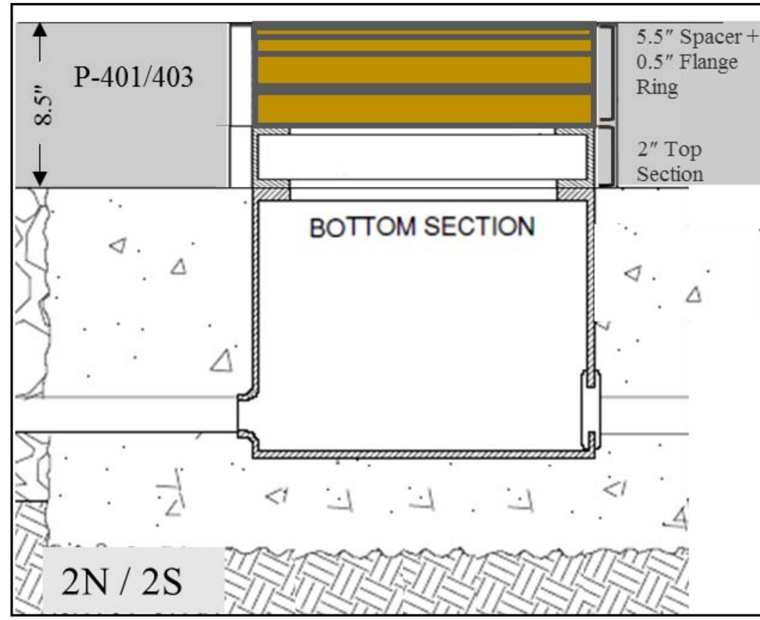
In-Pavement Light Fixture Testing and Evaluation

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.**

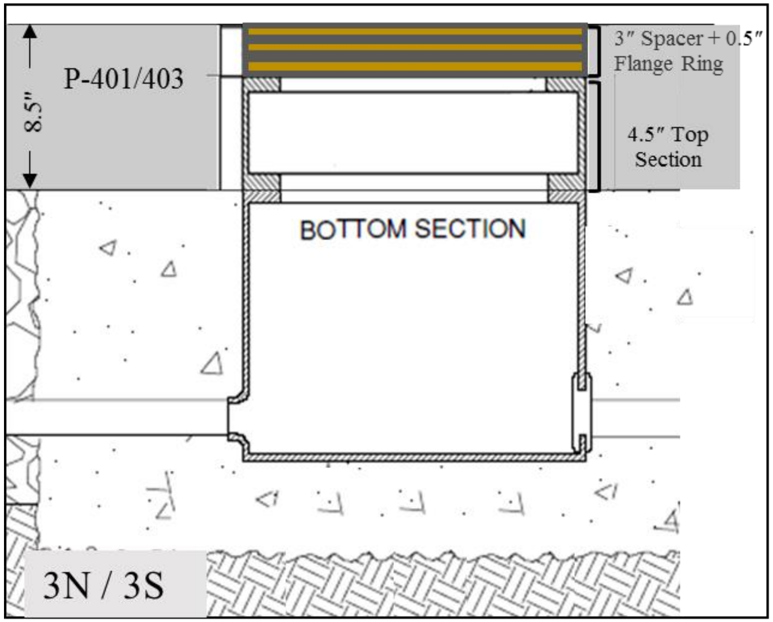
Test Configurations 1 and 2

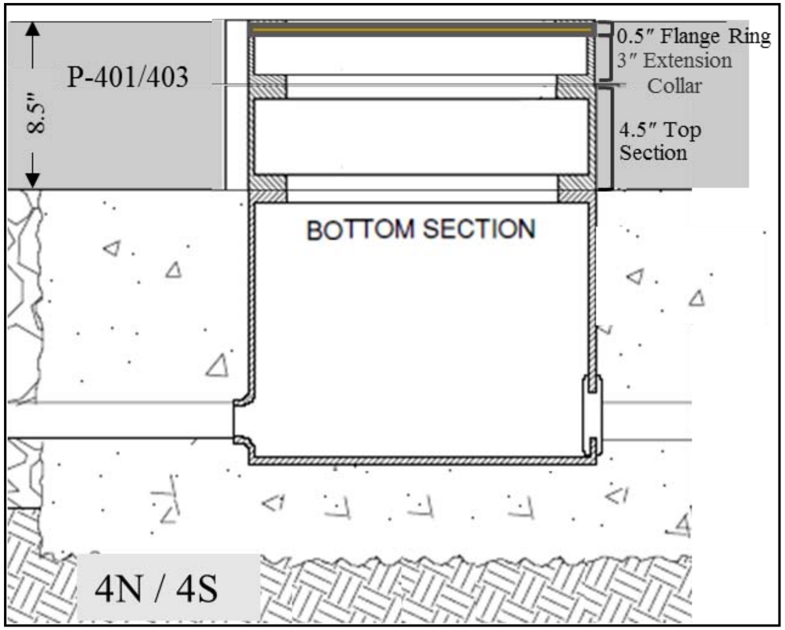




Fixtures	Surface Adjustment Spacer Ring	L-868 Top Section	Extension	Top Spacer Rings	Flange Ring with Pavement Dam	Stud Type
1N, 1S	0 – 1″	Single 7.5″	None	None	0.5″	3/8″ fluoropolymer coated Grade 5 carbon steel
2N, 2S	0 – 1″	Single 2″	None	2″ + 2″ + 1.5″	0.5″	

Test Configurations 3 and 4



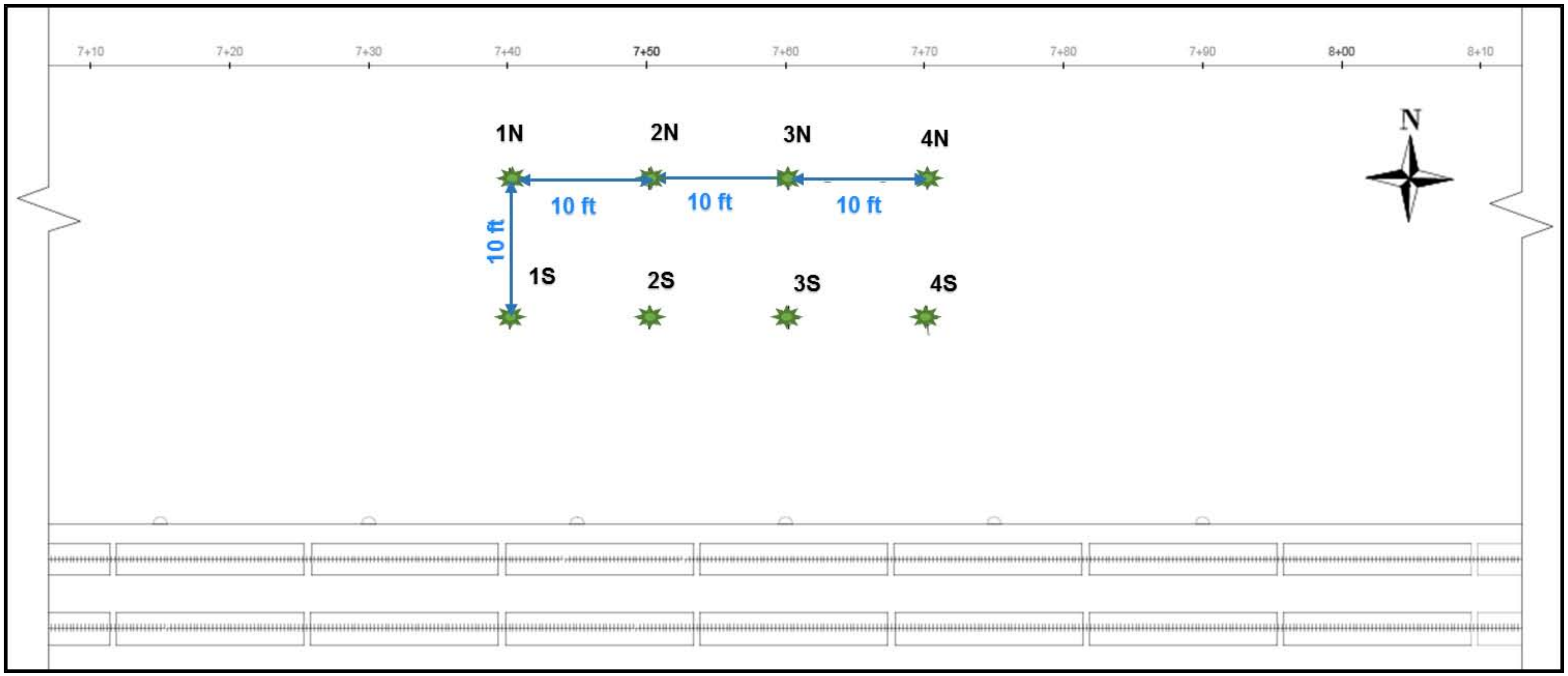


Fixtures	Surface Adjustment Spacer Ring	L-868 Top Section	Extension	Top Spacer Rings	Flange Ring with Pavement Dam	Stud Type
3N, 3S	0 – 1″	Single 4.5″	None	1″ + 1″ + 1″	0.5″	3/8″ fluoropolymer coated Grade 5 carbon steel
4N, 4S	0 – 1″	Single 4.5″	3″	None	0.5″	

Calibration/Installation of Mounting Studs

- Mounting Studs are Fluoropolymer 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 Clamping Force for Securing Light Fixtures.

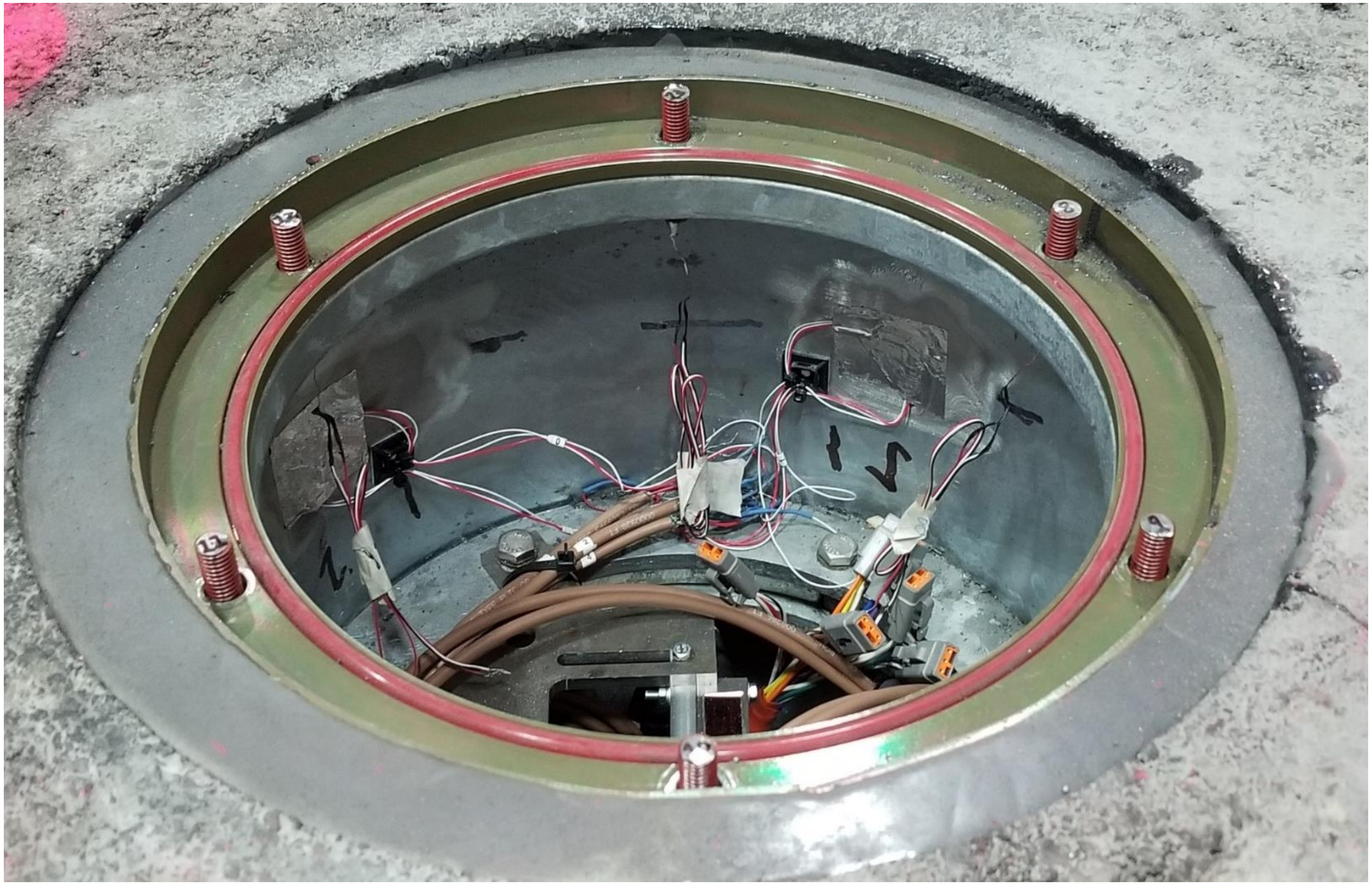
Light Fixture Test Bed Layout



Instrumentation: 27 Channels per Item

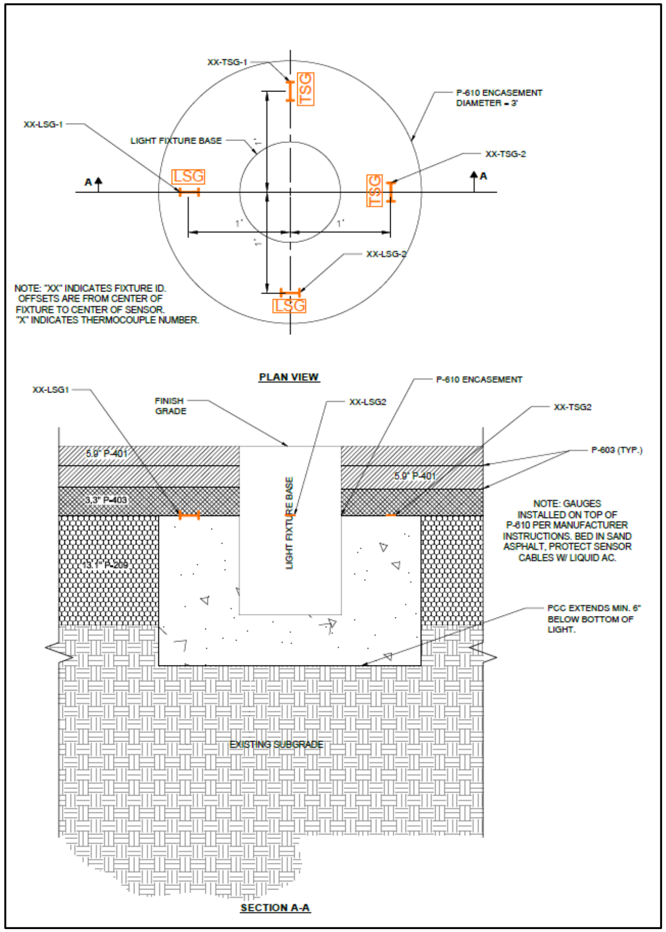
- **Fixture**
  - 1 triaxial accelerometer
  - 4 strain gauges
- **Bolts**
  - 6 strain gauges
- **Fixture Base**
  - 8 strain gauges
    - 4 horizontal
    - 4 vertical
  - 2 laser displacement meters
    - 1 horizontal
    - 1 vertical
- **Pavement**
  - 4 strain gauges
    - Located at bottom of HMA layer
    - 2 transverse
    - 2 longitudinal
- **Additionally, 6 thermocouples for the entire test section**

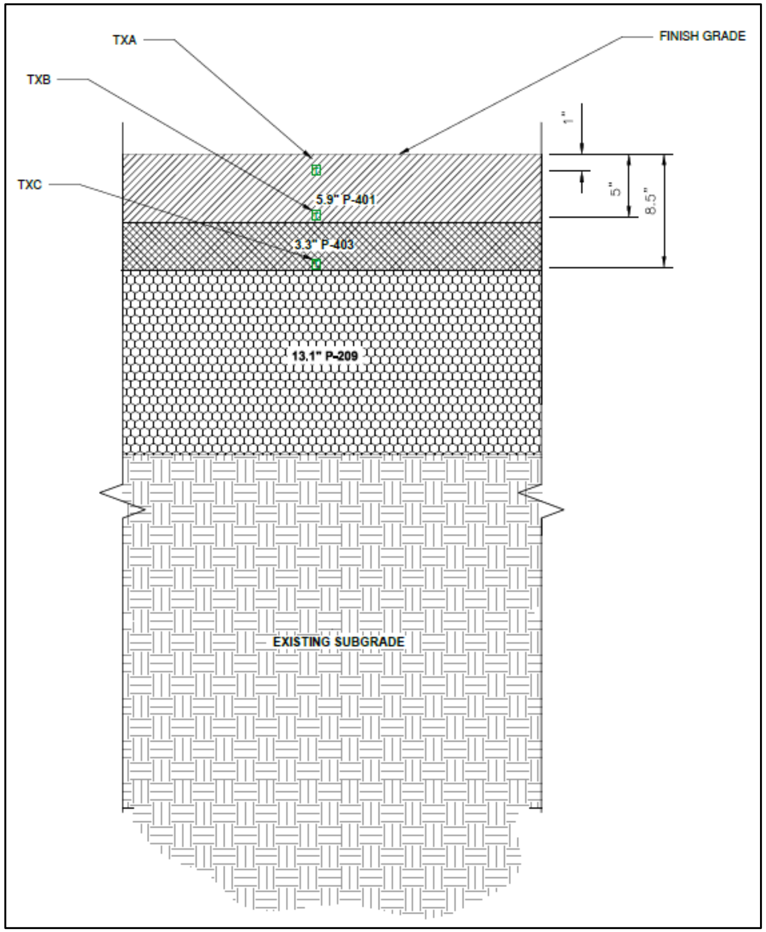
Fixture Base Instrumentation



Pavement Strain Gauges

Pavement Strain Gauges and Thermocouples



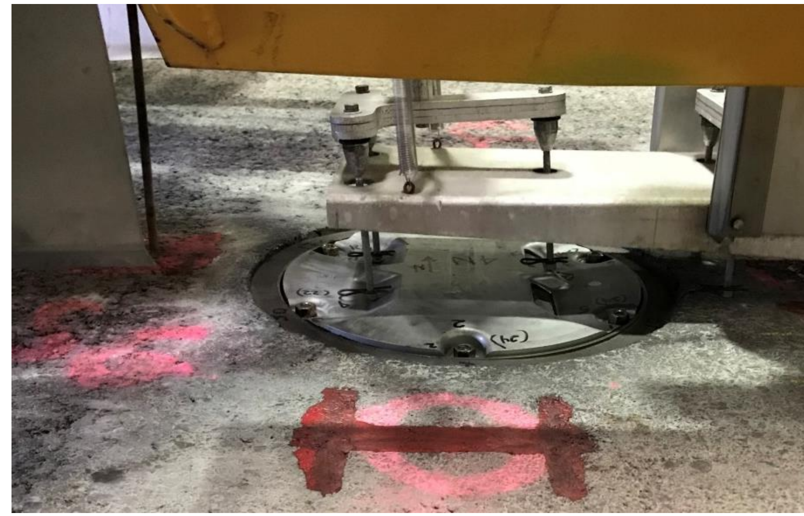


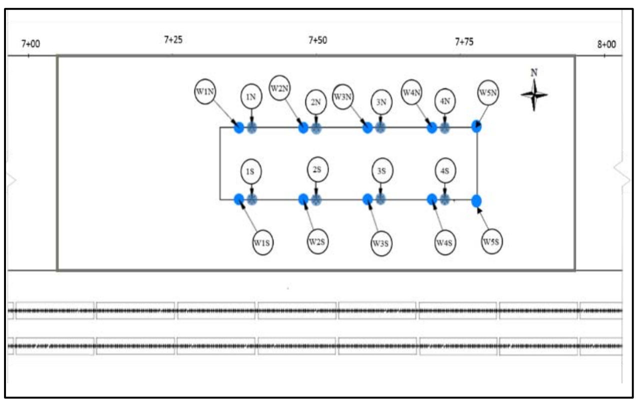
In-Pavement Light Fixture Testing

- 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



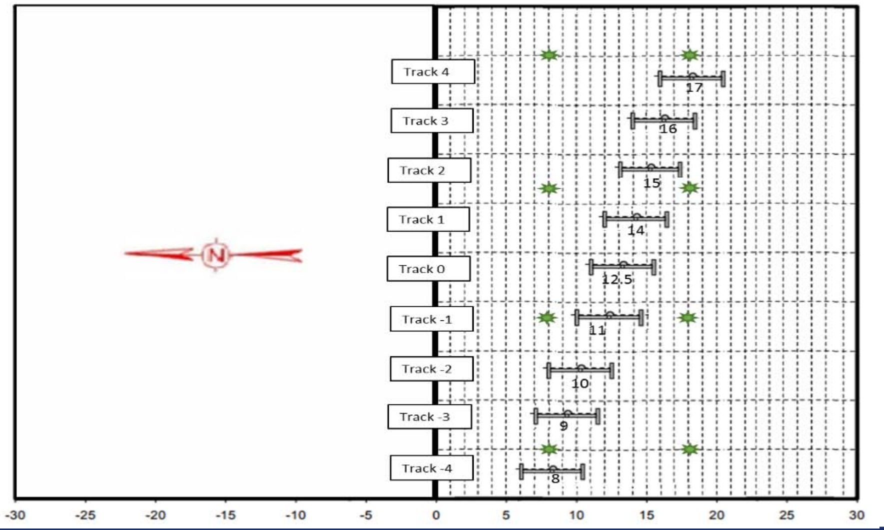


Static Loading

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

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



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

Next Steps

- Preliminary analysis of all test items and all sensors (strain gauges, laser transducers, and accelerometers).
- Evaluation of responses with respect to load and load distance.
- Evaluation of responses with respect to light fixture configuration, and clamping force used in preloading the studs and the failure of bolts.
- Assessment of the nature of pavement/light fixture interaction.
- Comparison between the strain levels using models and actual values recorded by strain gauges for future model calibrations.
- Report on Testing and Analysis to be Completed June, 2019.

Questions?