J-Band® & Sustainability

2022

Making a difference today for a better world tomorrow.

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SITUATION

Situation

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- J-Band® is growing
  - More agencies using on more roadways
  - Project number doubled in 2020
- Financial story is compelling and communicated well
  - Benefit: 3-5x the cost of the material, per IDOT
- Sustainability story can be added
  - Stakeholders are hungry for impact and collaboration

	Stakeholder	Sustainability Goals
FEDERAL	DOT SUSTAINS	• Decrease emissions of greenhouse gases (GHGs) and other pollutants • Ensure transportation infrastructure resiliency
	U.S. Department of Transportation Federal Highway Administration SUSTAINABLE HIGHWAYS INITIATIVE	• For the Federal Highway Administration (FHWA), sustainability encapsulates a diversity of concepts, including efficient use of funding, incentives for construction quality, regional air quality, resilience considerations…
STATE	Oregon Department of Transportation	• ODOT is the first transportation agency to have a comprehensive Sustainability Plan • Careful material selection and management …and lowering demand for new products …can also reduce operating costs while increasing environmental benefits.
CITY	CLIMATE MAYORS; C40 CITIES	• Hundreds of members have signed the Climate Mayors letters committing to the Paris Agreement • C40 is a network of the world's megacities committed to addressing climate change.
OTHER	FEDERAL AVIATION ADMINISTRATION; Sustainable Airport Development	• Over 40 North American airports have received funding from FAA to create sustainability plans, including baseline GHG inventory, reduction targets

Key Questions

→How does J-Band® **compare to alternative joint solutions** in the categories of air quality, greenhouse gas emissions, and safety?

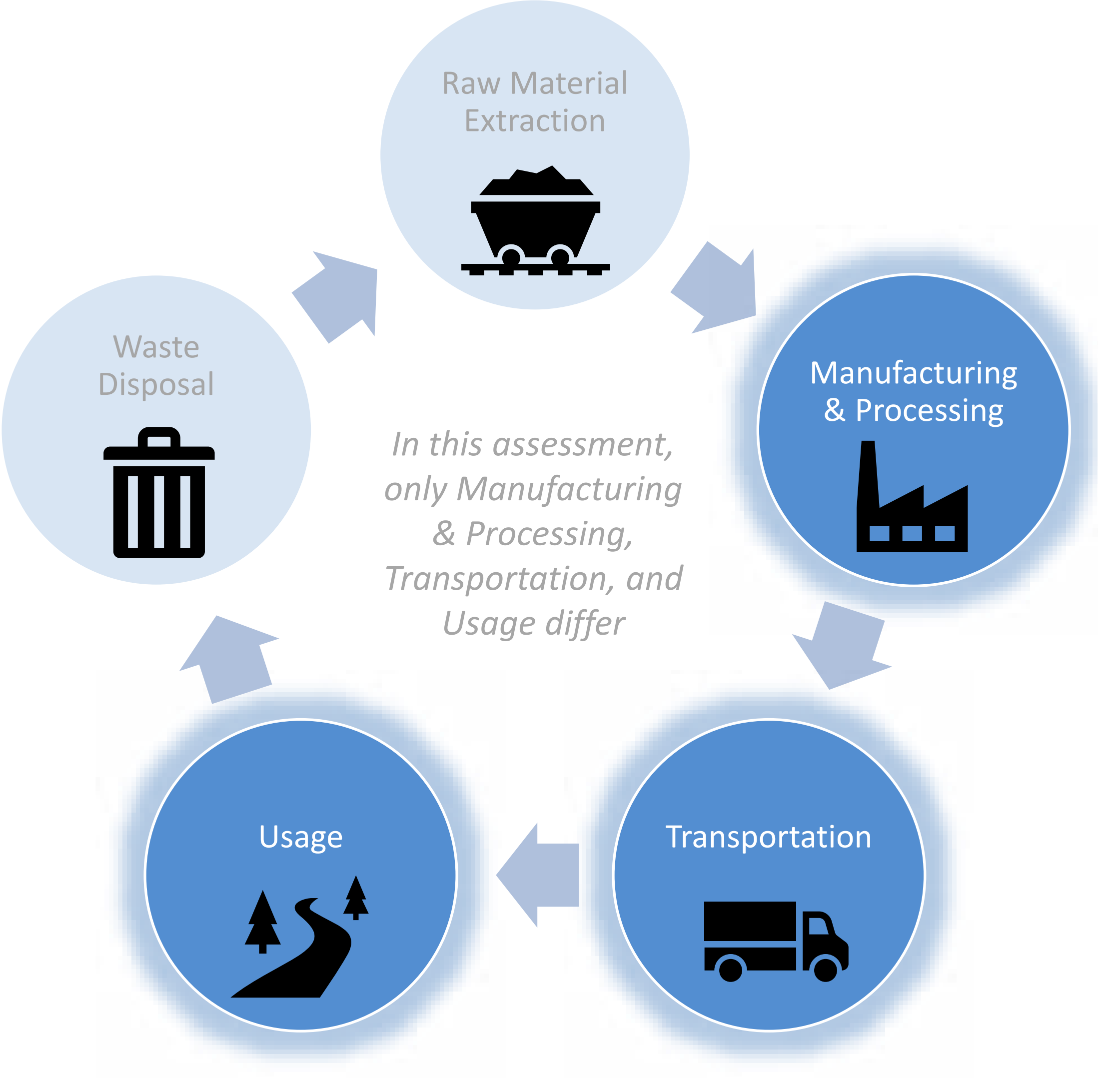
→How will J-Band's sustainability **benefits shift in the future**, due to climate factors, distracted driving, and possible policy developments?

→Which agencies and organizations that have **control over the adoption** and expansion of J-Band, also have **interests in sustainability?**

→How can J-Band **communicate** its sustainability benefits to those parties?

Comparative Life Cycle Analysis

A **Life Cycle Analysis** (LCA) is the compilation and evaluation of the inputs, outputs and the potential **environmental impacts of a product system** throughout its five life cycle stages.



When only **certain stages of the LCA differ** between selected alternative scenarios, a **comparative LCA** is used to assess only the differing stages, without performing a full LCA

ASSESSING AUDIENCE FOR SUSTAINABILITY

Selected Audience

→ Which customers want to hear about sustainability?
→ What topics are they most interested in?
→ How can J-Band help them meet their goals?

State or municipal transportation agencies	Minnesota	Illinois	New York	Delaware	Pennsylvania
	Michigan	Texas	California	Washington	NJ/NY Port Authority
Contractors	Tri-State Asphalt	Milestone	Granite Construction	ColasUSA	CRH
Regional or Federal entities	DOT Sustains	Sustainable Highways Initiative (FHWA)	Transportation and Climate Initiative (TCI)	National Asphalt Pavement Association (NAPA)	

A comprehensive table summarizing the audience assessment findings was shared with AMI. Key takeaways are summarized on the following slides.

State or Municipal Agencies

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- DOTs have a role to play in helping states achieve **state-wide emission reduction targets**.
- Energy and GHG emission goals focus on **facility usage** and **electrification** of transportation sector.
- Rise in programs aimed at increasing the use of **'green' products**, sustainable practices, and innovative new techniques and materials. Life Cycle Analyses (**LCA**) and Environmental Product Declarations (**EPDs**) are increasingly common.
- Many agencies have goals to achieve **zero work-zone fatalities**.

Contractors

- As a group, contractors **are beginning to develop** sustainability programs. Many contractors made mention of sustainability, while Granite Construction and CRH appear to be further along the developmental curve.
- There is a focus on **optimizing efficiency** and transitioning to **low-carbon technologies** in order to meet GHG reduction targets.
- Meeting all air emission limits is a priority.
- Companies are looking to use **new technologies and materials** with improved sustainability attributes.
- **Safety** is a core goal or company value for most contractors.

Regional or Federal Entities

- These groups appear to be more focused on the **big picture** of sustainability, raising **awareness** and offering **support**, versus dealing with in-depth details and target setting.
- They are looking to advance energy efficiency and reducing GHG emissions throughout the industry, through **collaboration, technical assistance, and support.**
- There is a focus on improving **community health** and **quality of life** through a reduction in air pollutants.
- Parties are dually focused on sustainable **innovation** and climate **resiliency**.

Interview Insights

- Local DOTs, regional transportation districts, and "super-regionals" (ex. Chicago tollway, Florida tollway, NJ Turnpike, etc.) have the **autonomy and dexterity** to be early adopters of new technologies.
- While not yet widespread, Environmental Product Declarations (**EPDs**) are growing in **use and commonality**, with several states now requiring them.
- **LCAs or EPDs** are beginning to be **gateways** to bidding (i.e. a box to be checked) and will likely evolve to become determinants in bid selection (i.e. your performance demonstrated on the LCA/EPD will factor into bid decisions, similar to cost). The movement on this topic in 2021 was reported to be greater than movement over the past five years combined.
- There has been movement towards developing a framework for a **LEED-type system** for infrastructure. Greenroads and ENVISION were mentioned as ones to watch.
- The **Federal Aviation Administration** is working with the asphalt industry to accelerate longitudinal joint solutions.

Audience Leaders

- State leaders include WA, CA, NY/NJ PA, MN
  - Other states not included in the analysis but referenced as leaders during industry interviews: OR, CO, AZ
- Leading contractors include Granite and CRH

QUANTIFYING THE COMPARATIVE EFFECTIVENESS OF J-BAND TO MAINTAIN THE LONGITUDINAL JOINT

Alternative Scenarios Analyzed

Lifecycle Stage		J-Band	Joint Adhesive + Sealant	Infrared Joint Heaters	Pave Wide and Trim Back Alternative
Creation of Product(s)	Upstream	Traditional HMA + Material inputs	Traditional HMA + Material inputs	Traditional HMA	Traditional HMA + Additional 6” of HMA
	Manufacturing	Electricity consumption, heat	Electricity consumption, heat	-	Additional electricity consumption, heat
	Transportation of Product	Heated trucks, pick-up	Pick-up pulling heated kettle, asphalt emulsion distributor	Transported with paver	Additional dump trucks for excess waste
	Product End of Life	Traditional HMA/RAP	Traditional HMA/RAP	Traditional HMA/RAP	Traditional HMA/RAP
Road Lifetime	Road Construction	Traditional HMA + J-Band Application	Traditional HMA + Application of Adhesive, Sealant	Traditional HMA (Smaller volume) with pass of heater	Traditional HMA + Mill off additional 6”
	Road Maintenance	Minor crack sealing 3 years	Crack sealing/filling every 3 years May use routers	Crack sealing/filling every 3 years	Crack sealing/filling every 3 years
	Road End of Life	Year 18 (conservative)	Year 15	Year 16	Year 15

Alternative Scenarios - Impacts Quantified

In this **comparative LCA,** impacts are only quantified for lifecycle stages **where the alternatives differ.** The elements excluded from the quantitative analysis are crossed out in the table below.

Lifecycle Stage		J-Band	Joint Adhesive + Sealant	Infrared Joint Heaters	Pave Wide and TRIM Back Alternative
Creation of Product(s)	**Upstream**	~~Traditional HMA +~~ Material inputs	~~Traditional HMA +~~ Material inputs	~~Traditional HMA~~	~~Traditional HMA +~~ Additional 6” of HMA
	Manufacturing	Electricity consumption, heat	Electricity consumption, heat	-	Additional electricity consumption, heat
	Transportation of Product	Heated trucks, pick-up	Pick-up pulling heated kettle, asphalt emulsion distributor	Transported with paver	Additional dump trucks for excess waste
	Product End of Life	~~Traditional HMA/RAP~~	~~Traditional HMA/RAP~~	~~Traditional HMA/RAP~~	~~Traditional HMA/RAP~~
Road Lifetime	**Road Construction**	~~Traditional HMA +~~ J-Band Application	~~Traditional HMA +~~ Application of Adhesive, Sealant	~~Traditional HMA~~ (Smaller volume) with pass of heater	~~Traditional HMA +~~ Mill off additional 6”
	Road Maintenance	Minor crack sealing 3 years	Crack sealing/filling every 3 years May use routers	Crack sealing/filling every 3 years	Crack sealing/filling every 3 years
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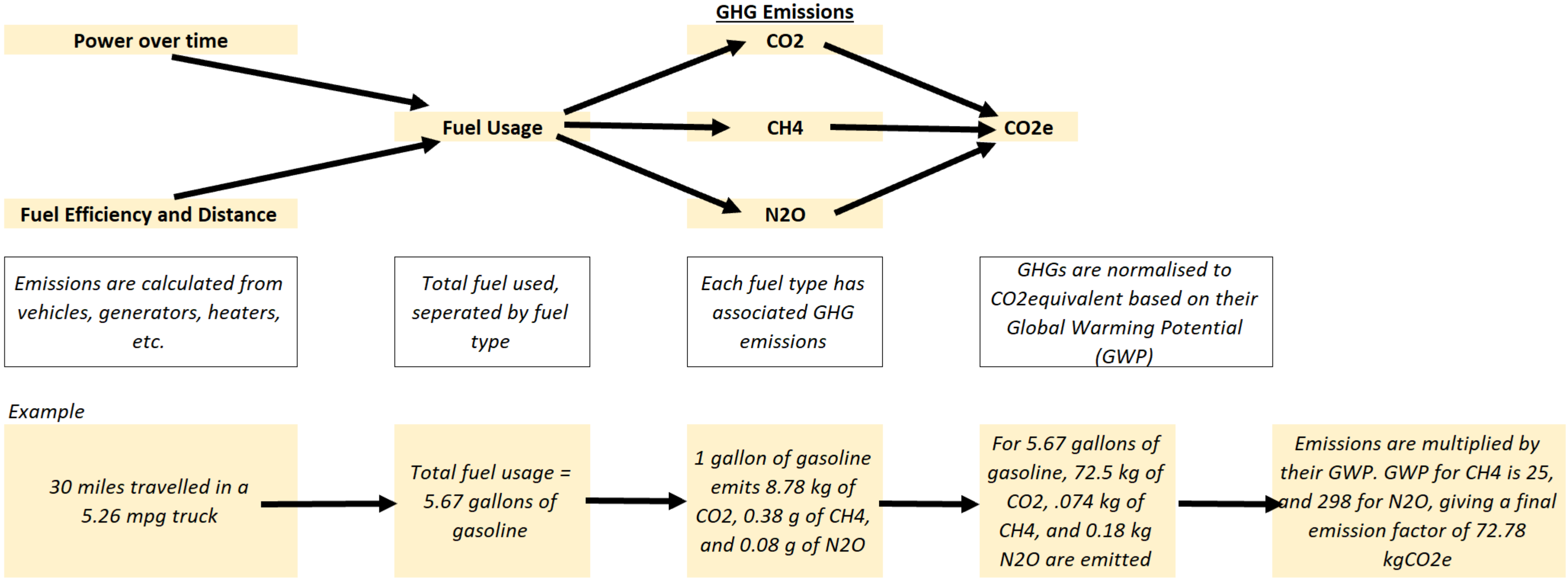
Methods

- Interviews with Industry Experts
- Equipment specific information
  - Reference manuals for trucks, generators, pavers, etc.

- Agency Data
  - Safety data: FHWA, BLS
  - Energy and Fuel data: Dept. Of Energy, EPA
  - Pollutant and Air Quality Data: EPA, Federal Regulations, NC DEQ



Assumptions

- This comparative life cycle analysis is focused on the singular life cycle of a joint. Modeling the full life cycle of a road, including additional asphalt and maintenance trips necessary on parts of the road not along the centerline joint, is out of scope for this analysis. In addition, the highly varied methods and needs for roads across different regions and road types would reduce the accuracy of the analysis.
- The model parameters presented in this deck are for a 1-mile stretch of paving that is located 50 miles away from the manufacturing site for J-Band and Joint Adhesive, and 30 miles away for IR Heater and Pave Wide/Trim Back.
- Emissions originating from vehicles idling in traffic slowdowns caused by road work are not included in the accounting. The social benefits of reduced congestion for the traveling public have not been accounted for, either. Both of these factors, had they been accounted for, would tip the scales further in favor of J-Band.
- With a lack of detailed manufacturing data and with the difference in composition between J-Band and Joint Adhesive materials being deemed insignificant, Joint Adhesive manufacturing emissions are estimated as a fraction of J-Band manufacturing emissions.
- Due to lack of data on fuel usage at the very slow vehicle speeds during application, fuel usage is based on highway and city fuel usage values.

Comparative effect on: Greenhouse Gas

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- GHG emissions were analyzed **for 4 stages across the life cycle** of a road: Manufacturing, transport, application, and maintenance. Not all stages are applicable to every alternative.
- In the base case of a 1-mile project 50 miles from manufacturing to job site for J-Band and Joint Adhesive, and 30 miles away from IR Heater and PW/TB, **J-Band emits 48.5 kg of CO2 equivalents/yr**, which is less than all the other alternatives. This is largely due to the significantly **reduced need for maintenance**, as well as a **quicker application** process.
- Although J-Band's **total** lifetime emissions are higher than some alternatives, the increased **longevity** of the road results in **fewer** averaged per year emissions.

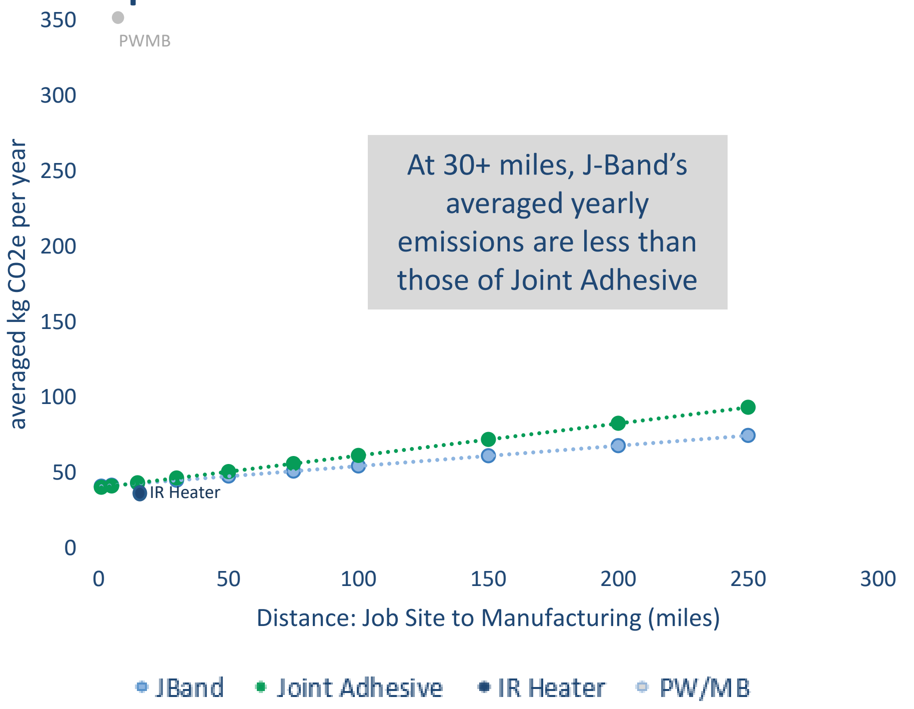
	GHG Emissions (kgCO2e)			
	J-Band	Joint Adhesive	IR Heater	PW/TB
Manufacture	458.6	35.6	-	3,042.4
Transport	136.3	160.0	-	58.1
Application	2.7	119.5	400.0	1,834.1
Maintenance trips	274.7	444.2	444.2	444.2
Total over lifetime	**872.3**	**759.3**	**844.2**	**5,378.8**
Averaged per year emissions	**48.5**	**50.6**	**52.8**	**358.6**

*Greenhouse Gas Emissions, in kilograms of CO2 equivalents, broken down by segments of the construction process. This is for a 1-mile project distance, 50 miles away from manufacturing site**

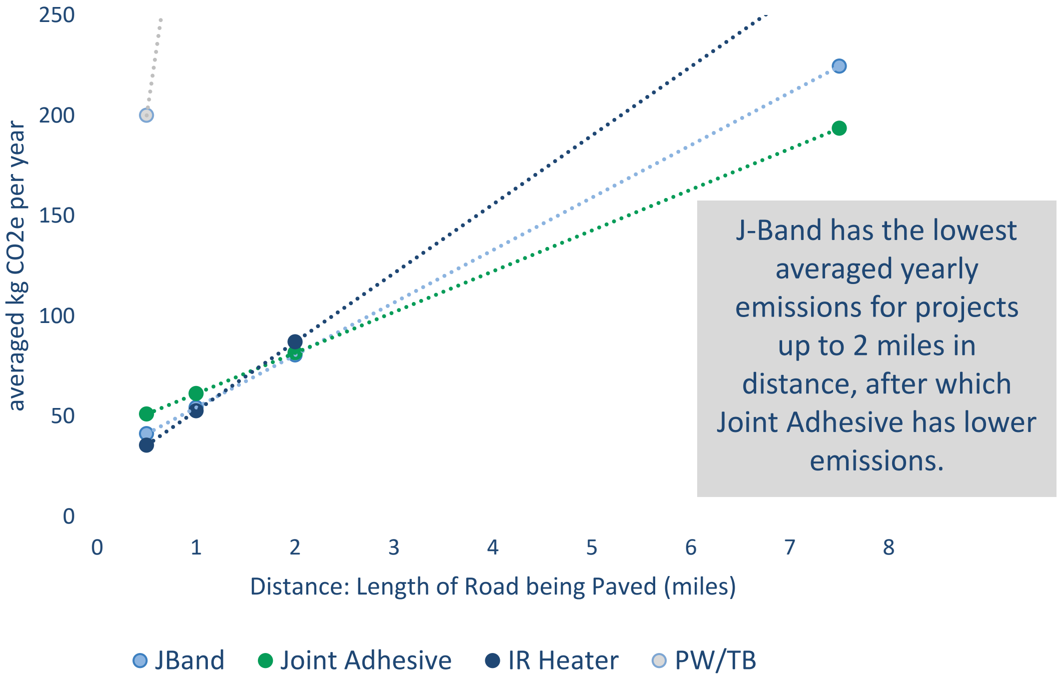
**Distance only applies to J-Band and Joint Adhesive. Distance between the home base and project site for IR heater and PW/TB is always 30 miles.*

Sensitivity Analysis of Alternative Methods

- GHG emissions **vary** based on different paving distances and transportation distances. A sensitivity analysis was performed to evaluate J-Band's performance over **different model parameters**



Sensitivity to Distance: Job Site to Manufacturing*
(keeping constant 1 mi paved)



Sensitivity to Distance: Miles Paved
(keeping constant 100 mi between Manufacturing and Job Site)

* As IR Heater and PWMB are far more localized, Distance from manufacturing to job site is assumed a constant 30 miles

Comparative effect on: Air Quality

- Road construction and repair results in **emissions of harmful compounds** impacting local human health and environment
- Project emissions of regulated criteria air pollutants were comparatively assessed and included volatile organic compounds (**VOCs**), **carbon monoxide**, nitrogen oxides (**NOx**), and **fine particulate matter** (2.5μ diameter and smaller)
- All four compounds were **combined** as a pounds of pollutant metric

	Lb Pollutant (VOC/CO/NOx/PM2.5)			
	JBand	Joint Adhesive	IR Heater	PW/TB
Manufacture	0.00072	0.00004	-	12.60
Transport	1.8	3.7	-	1.6
Application	0.061	1.5	1.5	122.7
Maintenance trips	1.8	26.7	26.7	26.7
Total over lifetime	**3.7**	**31.8**	**28.2**	**163.6**
Averaged per year emissions	**0.2**	**2.1**	**1.8**	**10.9**

*Pounds of pollutants emitted during all phases (manufacture through maintenance) for a 1-mile project distance, 50 miles away from manufacturing site**

**Distance only applies to J-Band and Joint Adhesive. Distance between the home base and project site for IR heater and PW/TB is always 30 miles.*

Comparative effect on: Safety

- Application and maintenance work on J-Band is expected to result in far **fewer injuries and fatalities** compared to the alternatives
- The **reduction in required maintenance** in the largest contributor to the reduced safety incidents of J-Band
- Safety metrics were calculated based on expected man-hours for each phase of work, combined with BLS and FHWA safety data

	Injuries per million miles				Fatalities per million miles			
	JBand	Joint Adhesive	IR Heater	PW/TB	JBand	Joint Adhesive	IR Heater	PW/TB
Application	21	32	189	284	0.7	1.1	6.3	9.5
Maintenance Trips	44	837	837	837	1.5	28.0	28.0	28.0
Total over lifetime	**65**	**868**	**1026**	**1120**	**2.2**	**29.1**	**34.4**	**37.5**
Average per year	**4**	**58**	**64**	**75**	**0.1**	**1.9**	**2.1**	**2.5**

Number of worker safety incidents. Safety metrics have been normalized to one million miles for ease of comprehension.

Sustainability Calculator

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Based on the cost comparison calculator previously used by J-Band, a calculator incorporating sustainability metrics was designed for AMI. These include safety incidents, GHG emissions, and Air Pollutant emissions.

J-Band

Treatment Number	Year of Treatment	Treatment	GHG Emissions	Air Quality Emissions	Injury Rates	Fatality Rates*
1	0	Manufacturing	459	0.0007	-	-
2	0	Transport	73	1.8	-	-
3	0	Full-Depth Pavement 13" HMA	-	-	-	-
4	0	J-Band Application	2	0.1	0.000021	0.000001
5	3	Maintenance	31	0.2	0.000011	0.000000
6	6	Maintenance	61	0.4	0.000011	0.000000
7	9	Maintenance	61	0.4	0.000011	0.000000
8	12	Maintenance	61	0.4	0.000011	0.000000
9	15	Maintenance	61	0.4	0.000011	0.000000
10	18	Major Mill & Fill (2 lifts- 4")	-	-	-	-

Joint Adhesive

Treatment Number	Year of Treatment	Treatment	GHG Emissions	Air Quality Emissions	Injury Rates	Fatality Rates
1	0	Manufacturing	34	0.00004	-	-
2	0	Transport	96	3.70	-	-
3	0	Full-Depth Pavement 13" HMA	-	-	-	-
4	0	Joint Adhesive Surface	119	1.46	0.000032	0.000001
5	0	Joint Adhesive Intermediate				
6	0	Liquid Asphalt Sealant Surface				
7	3	Joint Seal	40	1.34	0.000054	0.000002
8	6	Joint Seal	40	1.34	0.000054	0.000002
9	9	Joint Seal	40	1.34	0.000054	0.000002
10	12	Joint Seal	40	1.34	0.000054	0.000002
11	15	Major Mill & Fill (2 lifts- 4")	-	-	-	-

Infrared

Treatment Number	Year of Treatment	Treatment	GHG Emissions	Air Quality Emissions	Injury Rates	Fatality Rates
1	0	Manufacturing	-	-	-	-
2	0	Transport	-	-	-	-
3	0	Full-Depth Pavement 13" HMA	-	-	-	-
4	0	IR Heater	399	1.5	0.000189	0.000006
5	4	Joint Seal	40	5.4	0.000054	0.000002
6	7	Joint Seal	40	5.4	0.000054	0.000002
7	10	Joint Seal	40	5.4	0.000054	0.000002
8	13	Joint Seal	40	5.4	0.000054	0.000002
9	16	Major Mill & Fill (2 lifts- 4")	-	-	-	-

PWTB

Treatment Number	Year of Treatment	Treatment	GHG Emissions	Air Quality Emissions	Injury Rates	Fatality Rates
1	0	Manufacturing	-	-	-	-
2	0	Transport	58	1.6	-	-
3	0	Full-Depth Pavement 13" HMA	-	-	-	-
4	0	Milling 6"	1834	122.7	0.000284	0.000010
5	0	Joint Seal	40	5.4	0.000054	0.000002
6	3	Joint Seal	40	5.4	0.000054	0.000002
7	6	Joint Seal	40	5.4	0.000054	0.000002
8	9	Joint Seal	40	5.4	0.000054	0.000002
9	15	Major Mill & Fill (2 lifts- 4")	-	-	-	-

These results represent values for a 1-mile project distance, 50 miles away from manufacturing site for J-Band and Joint Adhesive, and 30 miles away for IR Heater and PW/TB.

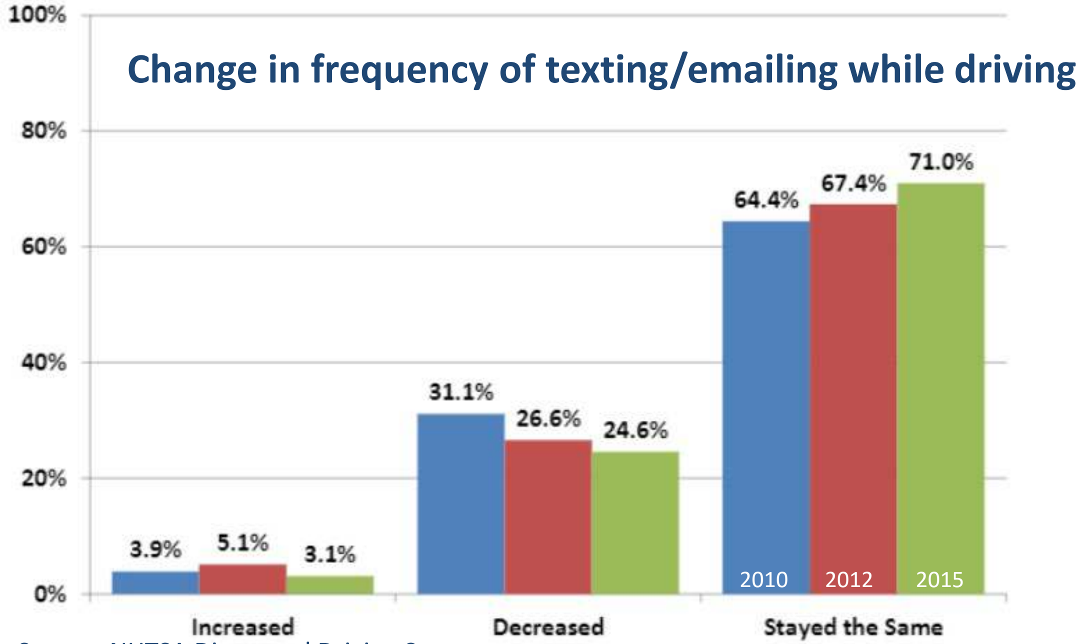
***Units:** GHG Emissions in kg of CO2e; Air quality emissions in lb of pollutant;*
Injury and fatality rates are expected number of injury/fatality per project distance.

TRENDS AFFECTING J-BAND’S SUSTAINABILITY EDGE

Distracted Driving

*A potential increase in distracted driving could result in an increase in **wear and tear** on the centerline joint, leading to an **increased need for maintenance** on roads. In this case, an increase in maintenance requirements would give J-Band a further advantage over its competitors.*

Causing Increase	Causing Decrease
Cell phone use	Autonomous vehicles
Complex in-vehicle information system	Regulation



Source: NHTSA Distracted Driving Survey

Distracted driving deaths

Source: NHTSA Survey Data via The Zebra

Joint failure
Joint reflection cracking not generally load initiated
Inconclusive impacts of centerline rumble strips

Worker Safety

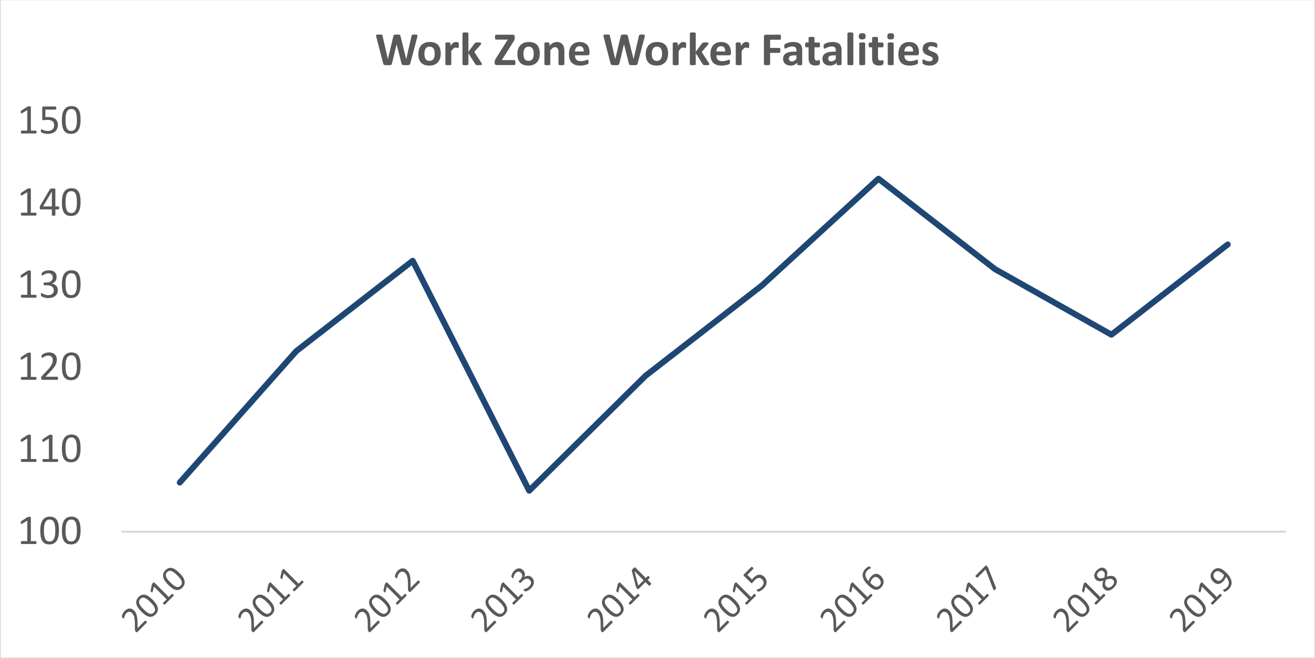
Work zone safety incidences are on the rise, leading to ***an increasing number of injuries and deaths*** *among roadway construction workers. As J-Band reduces the need for maintenance, maintenance crews spend significantly* ***less time exposed to dangerous work zones*** *compared to alternative solutions.*

Worker Fatalities in Road Construction Sites[8]

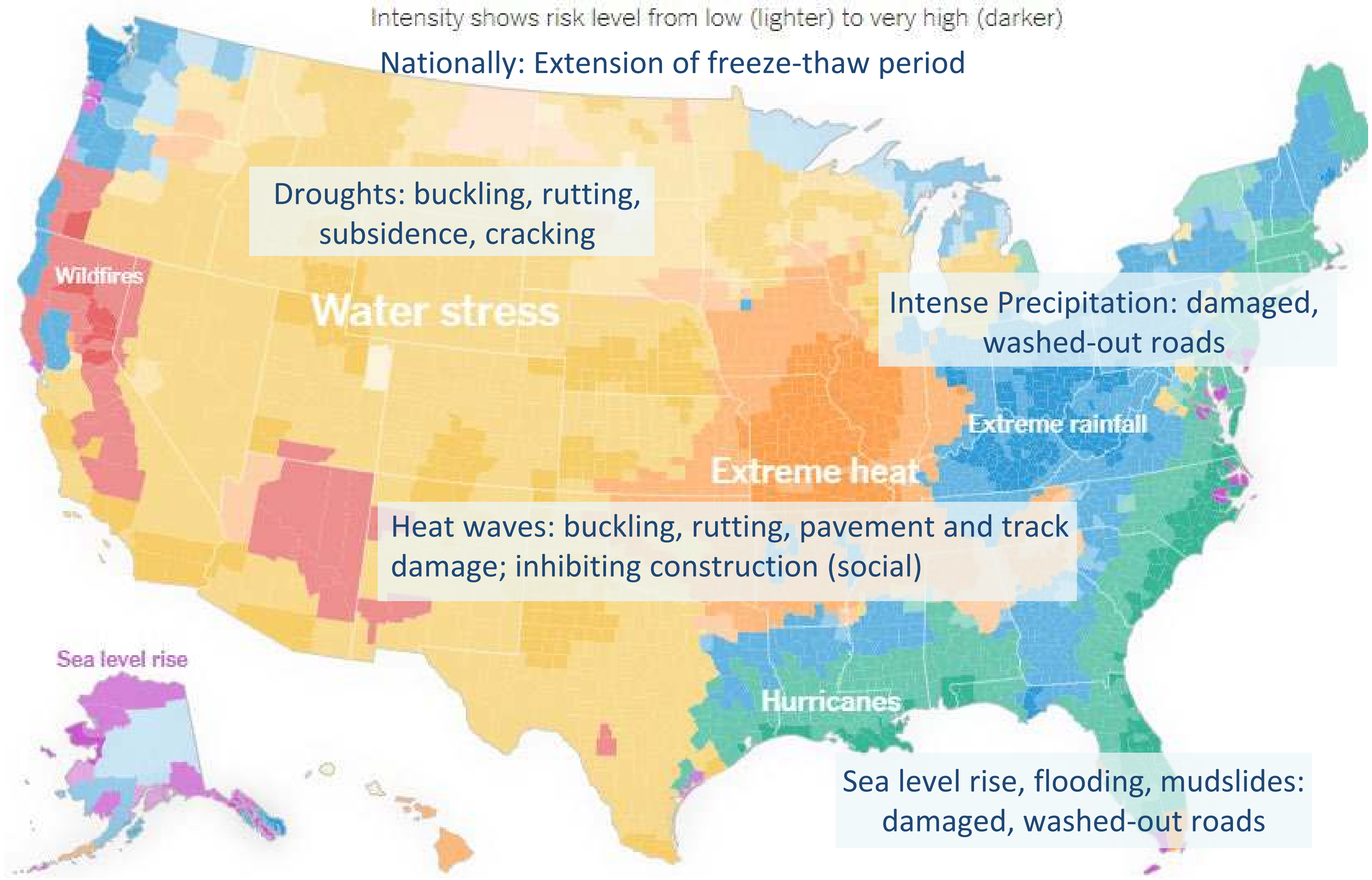
The following types of fatal work zone crashes increased from 2018 to 2019:	2018	2019
• Involving a Rear-End Collision	141 **21%**	182 **24%**
• Involving a CMV	215 **35%**	250 **33%**
• Where Speeding Was a Factor	172 **26%**	239 **31%**
Worker fatalities in road construction sites	**124**	**135**

Source: FHWA Work Zone Facts and Statistics

Worker safety trends
Slight upward trend in deaths
Previous 3-yr average: 133 deaths



Potential Climate Impact



*Dominant climate impacts on roads will **vary regionally**, however, a multitude of factors will affect and eventually **reduce the integrity of centerline joints**.*

J-Band helps a road withstand these stresses better than a road with no joint solution, and results in more resilient roads.

With its lower impact than other joint solutions, J-Band also contributes the least to the issue of climate change.

Source: Climate Threats - The New York Times

CONCLUSIONS

Key Questions Answered

→How does J-Band compare to alternative joint solutions in the categories of air quality, greenhouse gas emissions, and safety?	Under the base conditions of the model, **J-Band outperforms all the analyzed joint solutions**
→How will J-Band's sustainability benefits shift in the future, due to climate change, distracted driving, and possible policy developments?	With worker deaths trending upwards over the last few years, climate change impacting roadways in a variety of detrimental ways, J-Band has the potential to be **more resilient to climate change impacts and stresses brought about by distracted driving**, as well as reducing the amount of time crews will be performing maintenance.
→Which agencies and organizations that have control over the adoption and expansion of J-Band, also have interests in sustainability?	Most states DOTs and agencies acknowledge the **role** that they have in helping to achieving state, region, etc. greenhouse gas emission **reduction targets**. Similarly, for contractors that have shown an interest in sustainability, their focus on implementing sustainable solutions and reduction targets is growing.
→How can J-Band communicate its sustainability benefits to those parties?	Stakeholders in the interviews recommended **transparency** again and again. The findings are only as valuable as peoples' trust in them. Sharing openly is essential to building that trust. We recommend disclosing results alongside data sources, assumptions, gaps filled, etc.

Conclusions

- J-Band's benefits largely come from the **reduced need for maintenance**. With minimal repairs needed over the years, maintenance crews can make **fewer and shorter trips**, preventing greenhouse gas emissions and reducing the number of safety incidences for both workers and drivers.
- J-Band **extends the lifetime** of a pavement beyond the 15 years typical of traditional pavement. Over the long term, there are fewer pavement rehabilitations and replacements required with the use of J-Band.

  In addition to the air quality and greenhouse gas benefits seen in this analysis, the reduced maintenance comes with a significant **reduction in emissions from the manufacture of the asphalt** compared to alternative joint solutions.

J-Band’s benefits go beyond the financial. Its safety benefits and reduced greenhouse gas and pollutant emissions have much to offer customers looking to build a more sustainable future.

We believe these results should be recognized, and the role that J-Band can play in the decarbonization of the transportation sector should be emphasized.

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