J-Band & Sustainability

September 2021

Making a difference today for a better world tomorrow.

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SITUATION

Situation

- 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
  - Greenwashing risk must be managed

	Stakeholder	Sustainability Goals
FEDERAL	DOT SUSTAINS	• Decrease emissions of greenhouse gases (GHGs) and other pollutants • Ensure transportation infrastructure resiliency
FEDERAL	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 raw materials …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 (Environment, Economy, Operations, Community)	• 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?

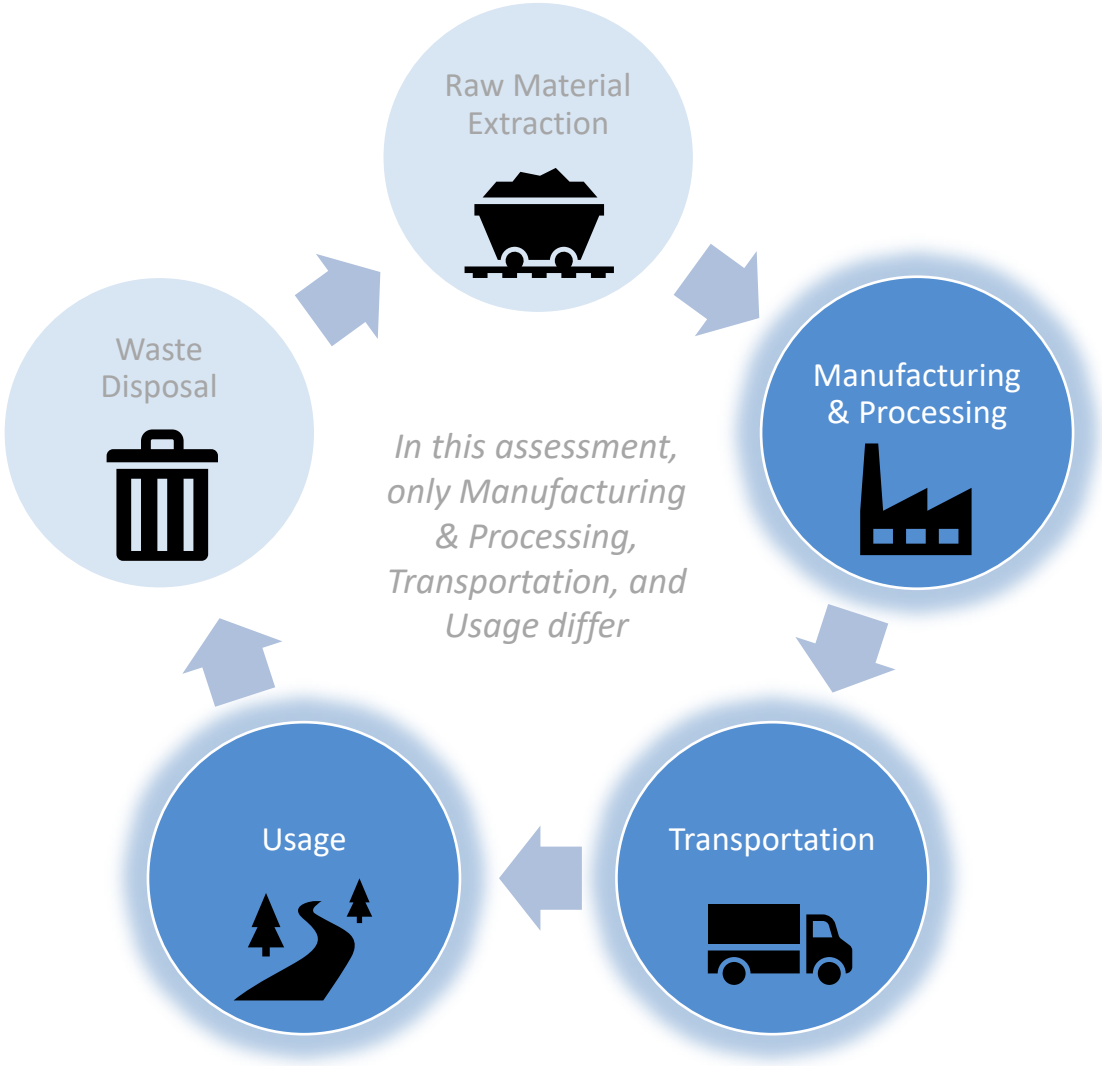
→How will J-Band's sustainability **benefits shift in the future**, due to weather pattern changes, distracted driving, and possible policy developments?

→Which agencies and organizations that have **control over the adoption** and expansion of J-Band also have **interest 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 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** can be 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

- 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 tend to be in the initial phases of their sustainability journeys, though Granite Construction and CRH were noted exceptions.
- 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 are more focused on the **big picture** of sustainability, raising **awareness** and offering **support**, instead of dealing with in-depth details and target setting.
- They are looking to advance energy efficiency and reduce 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 change **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 and 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 frequency of this was reported to be greater in 2021 than over the previous 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 J-BAND'S BENEFITS

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 of Consumed Product	Electricity consumption, heat	Electricity consumption, heat	*See below	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 + Trim 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

*The manufacturing of propane is not included here due to the nature of the EPA emission factors applied to the propane accounted for and burned during the construction process. The addition of propane to the manufacturing process would double count some of the propane emissions.

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 of Consumed Product	Electricity consumption, heat	Electricity consumption, heat	*See below	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 +~~ Trim off additional 6”
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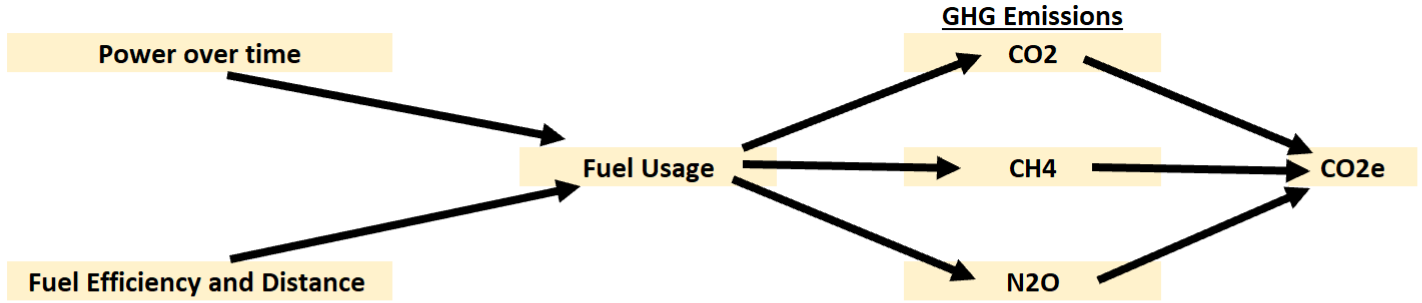
Methods

- 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



Emissions are calculated from vehicles, generators, heaters, etc.	*Total fuel used, seperated by fuel type*	*Each fuel type has associated GHG emissions*	*GHGs are normalised to CO2equivalent based on their Global Warming Potential (GWP)*

Example

30 miles travelled in a 5.26 mpg truck → *Total fuel usage = 5.67 gallons of gasoline* → *1 gallon of gasoline emits 8.78 kg of CO2, 0.38 g of CH4, and 0.08 g of N2O* → *For 5.67 gallons of gasoline, 72.5 kg of CO2, .074 kg of CH4, and 0.18 kg N2O are emitted* → *Emissions are multiplied by their GWP. GWP for CH4 is 25, and 298 for N2O, giving a final emission factor of 72.78 kgCO2e*

Assumptions

- This comparative life cycle analysis is focused on the singular life cycle of a joint. Modelling 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 likely 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 slow vehicle speeds during application, fuel usage is based on highway and city fuel usage values.

Greenhouse Gas

- 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 PWTB, **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 pavement results in **fewer** averaged per year emissions.

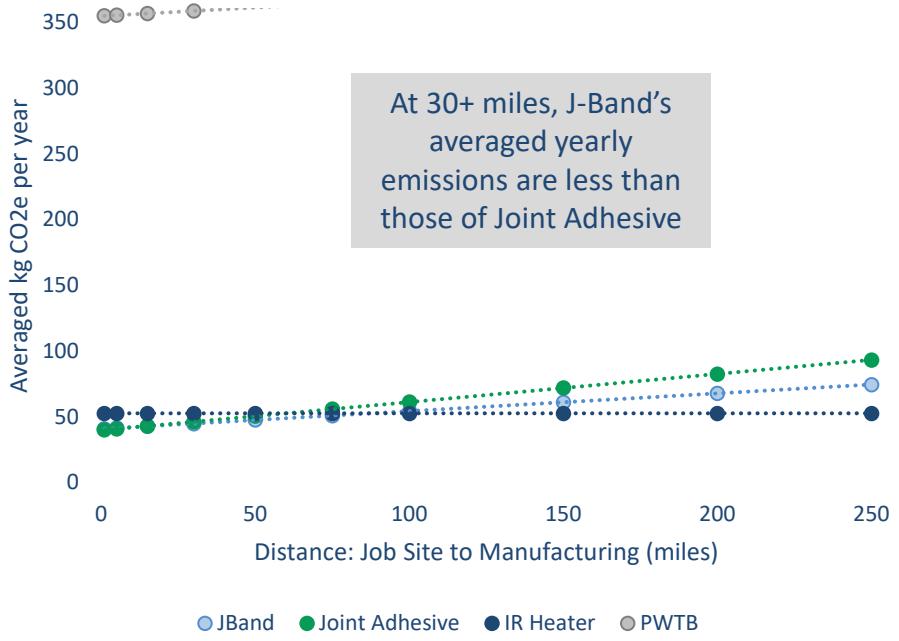
	GHG Emissions (kgCO2e)			
	JBand	Joint Adhesive	IR Heater	PWTB
Manufacture	458.6	35.6	-	3,042.4
Transport	136.3	160.0	-	58.1
Application	2.7	119.5	400.0	1,834.1
Maintenance trips	274.7	444.2	444.2	444.2
Total over lifetime	**872.3**	**759.3**	**844.2**	**5,378.8**
Averaged per year emissions	**48.5**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

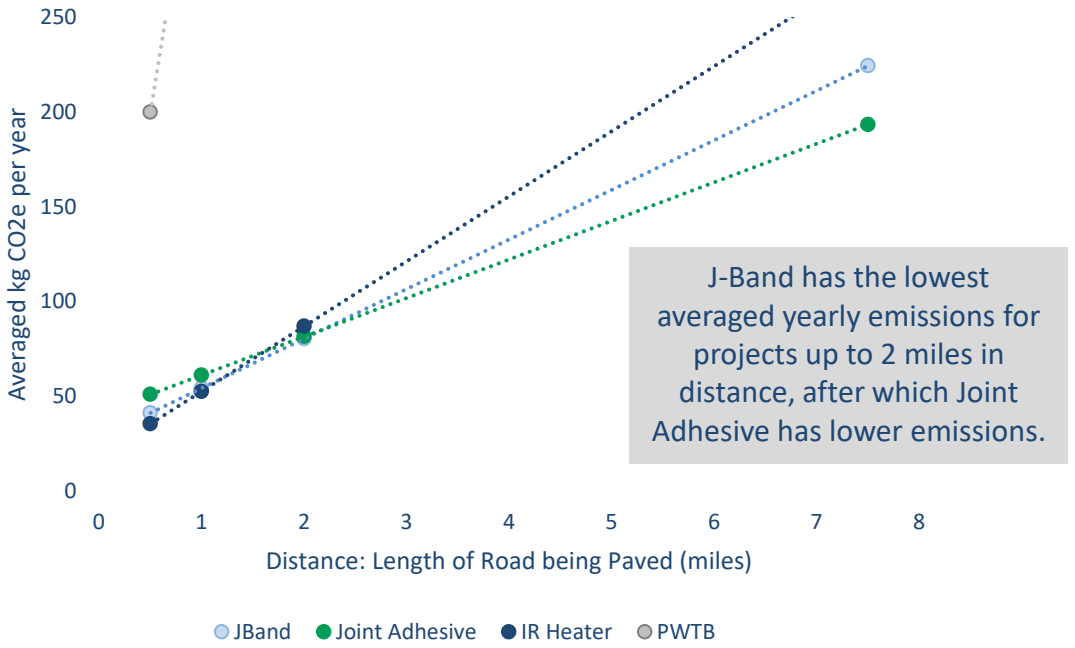
**Distance only applies to J-Band and Joint Adhesive. Distance between the home base and project site for IR heater and PWTB is assumed to be 30 miles.*

Sensitivity Analysis

- 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 PWTB are far more localized, Distance from manufacturing to job site is assumed a constant 30 miles

Air Quality

- Road construction and repair typically 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** into a pounds of pollutant metric

	Lb Pollutant (VOC/CO/NOx/PM2.5)			
	JBand	Joint Adhesive	IR Heater	PWTB
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 PWTB is assumed to be 30 miles.*

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** is 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	PWTB	JBand	Joint Adhesive	IR Heater	PWTB
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**

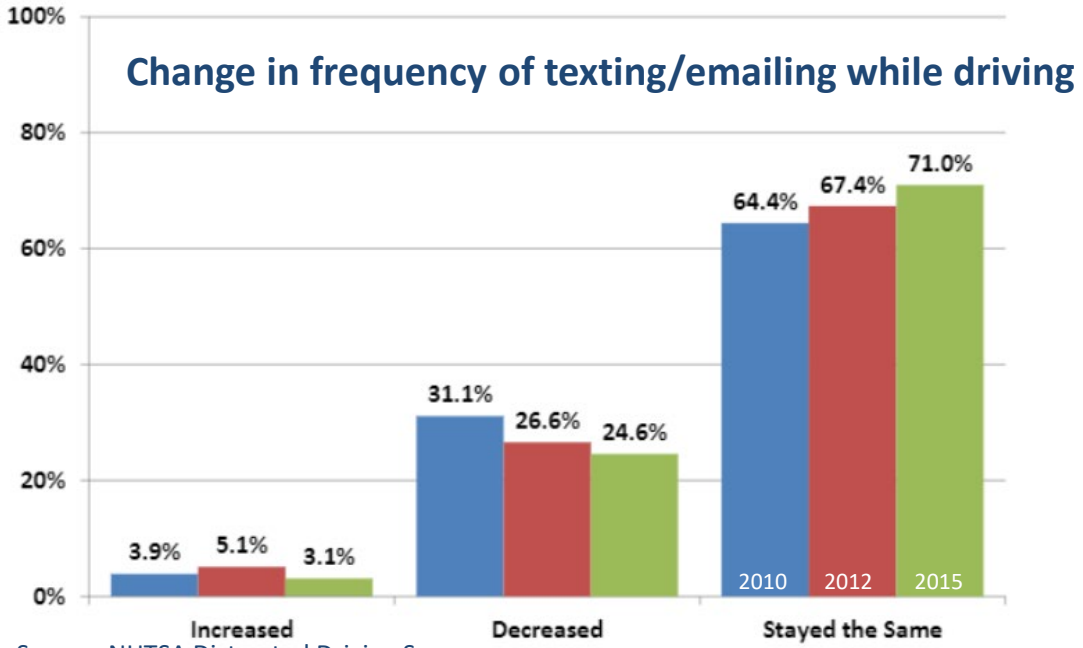
Number of worker safety incidents. Safety metrics have been normalized to one million miles for ease of comprehension.

TRENDS AFFECTING J-BAND'S SUSTAINABILITY EDGE

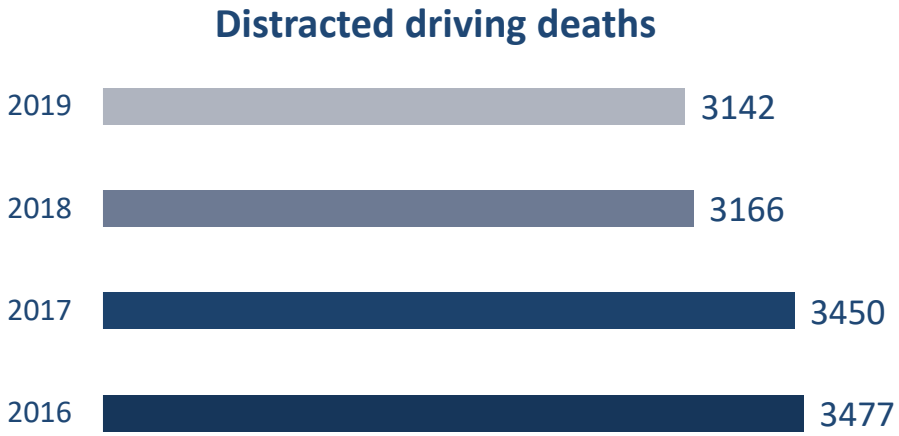
Distracted Driving

*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



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]

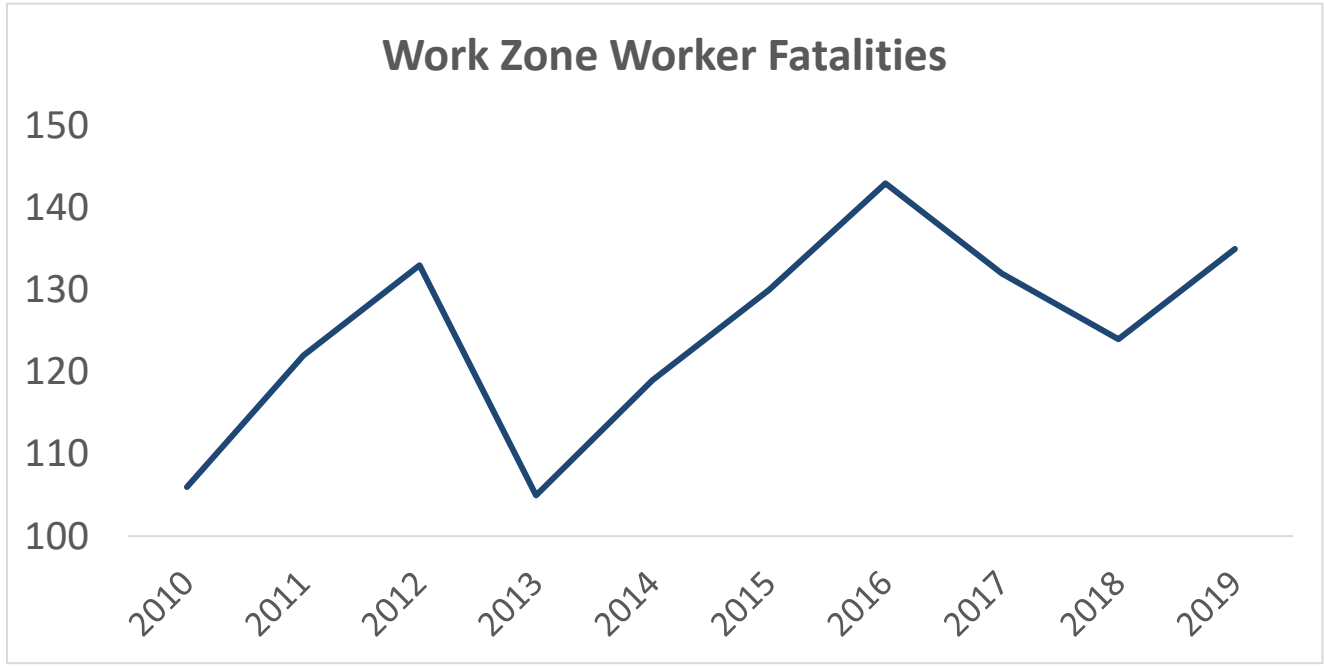
The following types of fatal work zone crashes increased from 2018 to 2019:	2018	2019
• Involving a Rear-End Collision	141 21%	182 24%
• Involving a CMV	215 35%	250 33%
• Where Speeding Was a Factor	172 26%	239 31%
Worker fatalities in road construction sites	124	135

Source: FHWA Work Zone Facts and Statistics

Worker safety trends

Slight upward trend in deaths

Previous 3-yr average: 133 deaths



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**
→Will J-Band's safety benefits become even more important in the future due to distracted driving and future policy developments?	Due to **distracted driving**, centerline rumble strips are becoming increasingly common. Future policy developments are expected to increase their usage. They **can reduce head-on collisions** and can be installed without compromising road life when J-Band is applied. With worker deaths trending upwards over the last few years, longer-lasting roads **decrease the amount of time workers are exposed to dangerous work zones** in the middle of the road.
→Which agencies and organizations that have control over the adoption and expansion of J-Band, also have interest in sustainability?	Most state DOTs and agencies acknowledge the **role** that they have in helping to achieve state, regional, 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 stakeholders?	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, including data sources, assumptions, calculations, and findings.

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, resulting in a **reduced use of asphalt**. In addition to the air quality and greenhouse gas benefits seen in this analysis, the reduced asphalt usage 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 for 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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