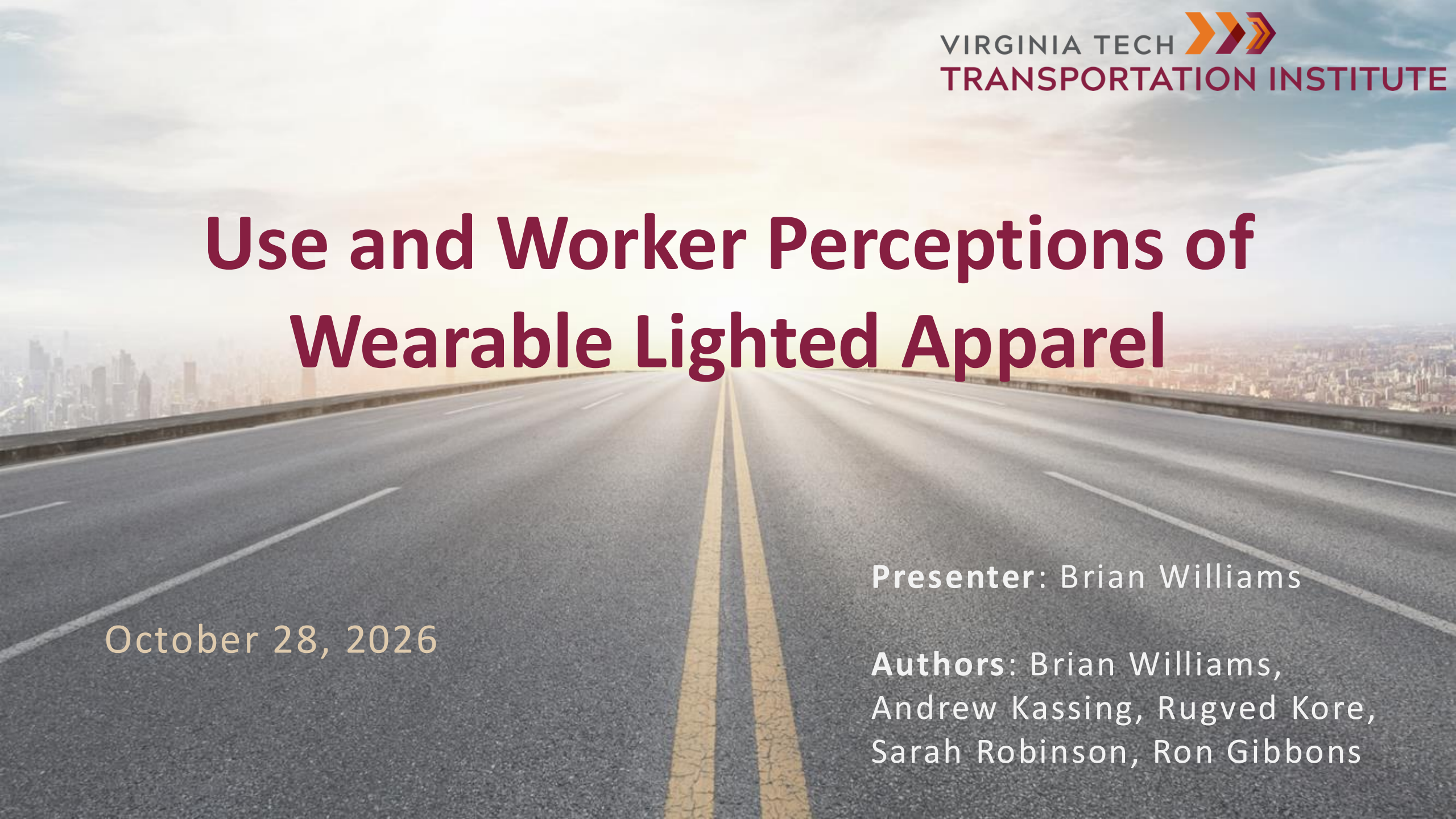
Nighttime Work Zone Safety



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Use and Worker Perceptions of Wearable Lighted Apparel

October 28, 2026

Presenter: Brian Williams

Authors: Brian Williams, Andrew Kassing, Rugved Kore, Sarah Robinson, Ron Gibbons

Purpose

- Evaluate the impact of wearable lighted apparel on the nighttime visibility of work zone personnel with the goal of providing recommendations to VDOT.

- **Human-factors study on VA Smart Roads**
  - 48 participants
  - 3 simulated work zones
  - 14 ensembles
  - Detection Distance
- **Field Test**
  - 4 ensembles
  - User feedback
  - Online survey & focus group


Retro
Vest
White Helmet
White Shoulder
White Shoulder x 2
White Shoulder Vest
White Helmet Vest
White Shoulder MAX
Green Shoulder
Green Shoulder x 2
Amber Shoulder
Red Shoulder
Red Helmet
Red Helmet Flashing

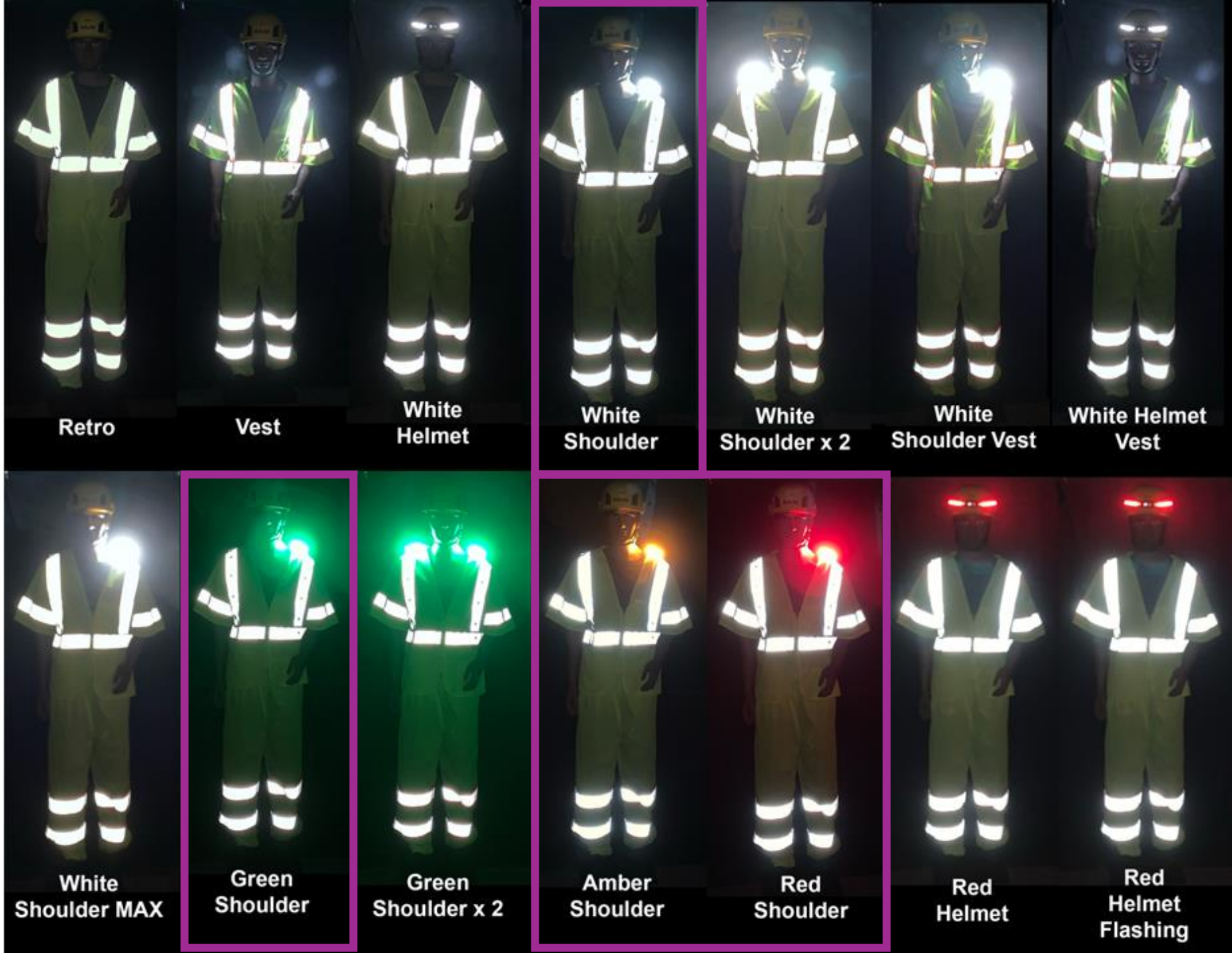
Baseline


Retro
Vest
White Helmet
White Shoulder
White Shoulder x 2
White Shoulder Vest
White Helmet Vest
White Shoulder MAX
Green Shoulder
Green Shoulder x 2
Amber Shoulder
Red Shoulder
Red Helmet
Red Helmet Flashing

Lighting Design



Color


Retro
Vest
White Helmet
White Shoulder
White Shoulder x 2
White Shoulder Vest
White Helmet Vest
White Shoulder MAX
Green Shoulder
Green Shoulder x 2
Amber Shoulder
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Red Helmet Flashing

Intensity


Retro
Vest
White Helmet
White Shoulder
White Shoulder x 2
White Shoulder Vest
White Helmet Vest
White Shoulder MAX
Green Shoulder
Green Shoulder x 2
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Red Helmet Flashing

Light Behavior



Low Complexity Work Zone

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Medium Complexity Work Zone

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High Complexity Work Zone

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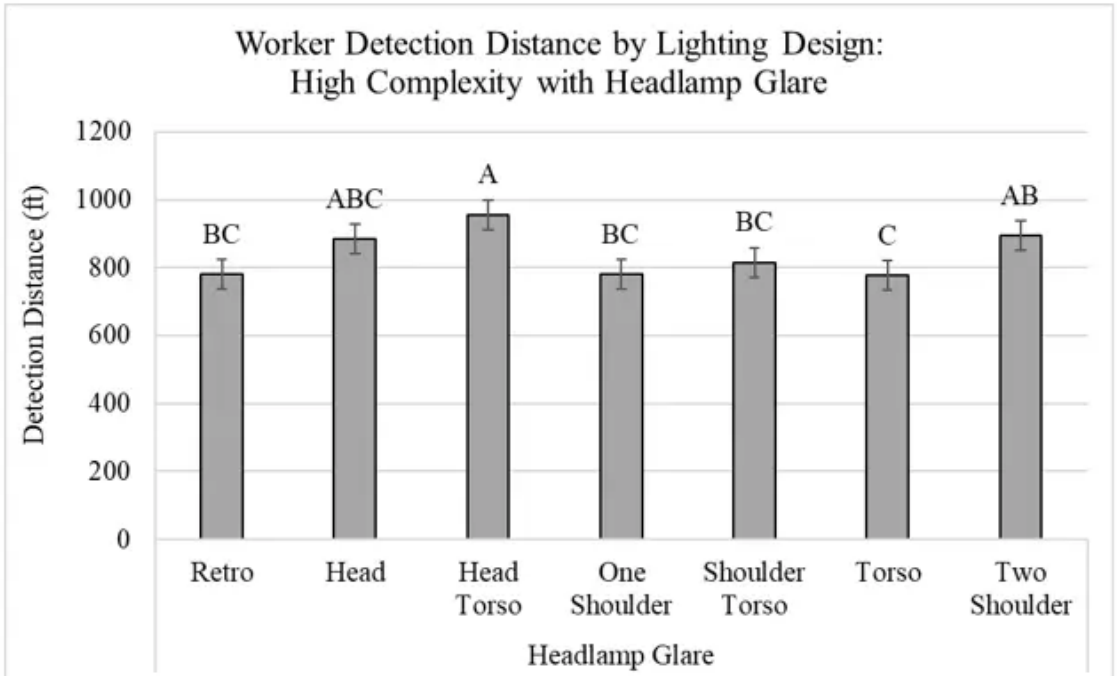


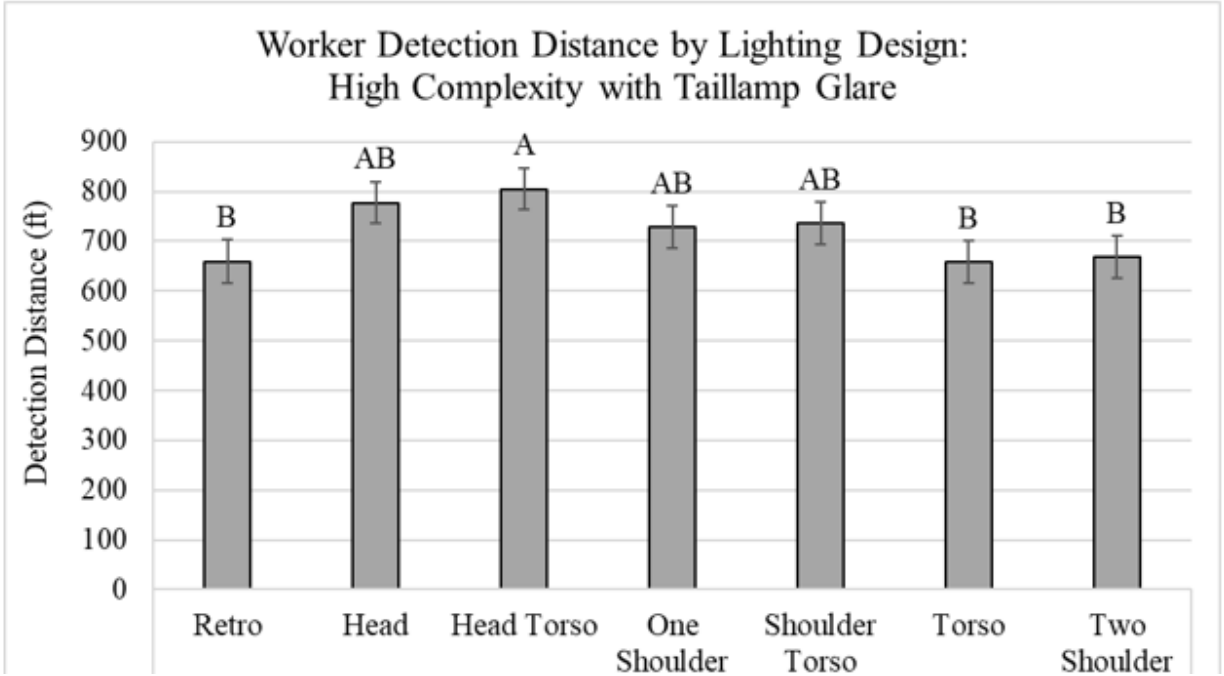
Lighting Design

- Head + torso combination improved detection in medium and high complexity work zones.
- Most other designs no different from standard retro apparel.

Performance Comparison to Control Condition by Lighting Design

Design	Low Complexity		Medium Complexity		High Complexity	
	Headlamp	Taillamp	Headlamp	Taillamp	Headlamp	Taillamp
Head	No Diff	No Diff	No Diff	NA	No Diff	No Diff
Head Torso	No Diff	No Diff	Better	NA	Better	Better
One Shoulder	No Diff	No Diff	No Diff	NA	No Diff	No Diff
Shoulder Torso	No Diff	No Diff	No Diff	NA	No Diff	No Diff
Torso	No Diff	No Diff	No Diff	NA	No Diff	No Diff
Two Shoulder	Better	No Diff	No Diff	NA	No Diff	No Diff



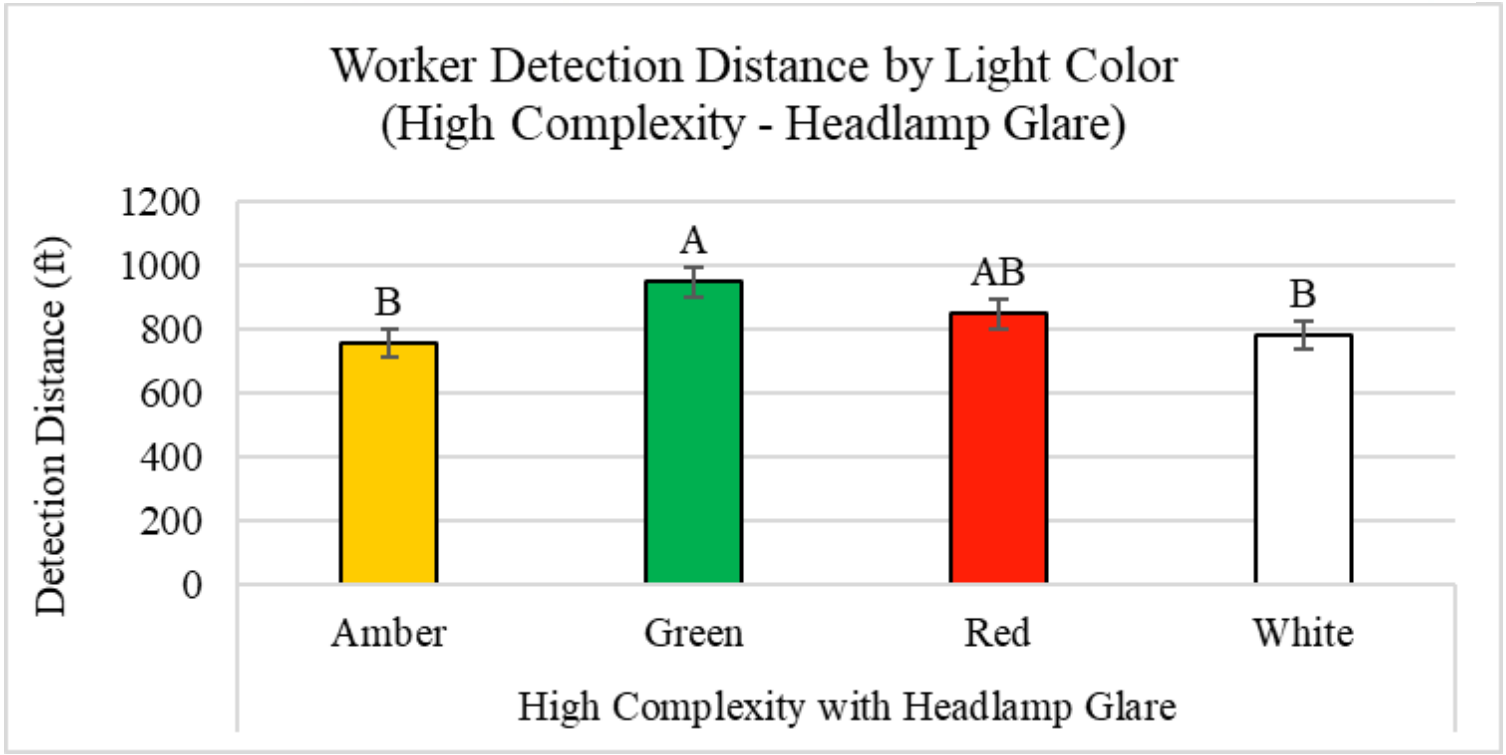


Light Color

- Green significantly improved worker detection across all tested scenarios compared to white lights.

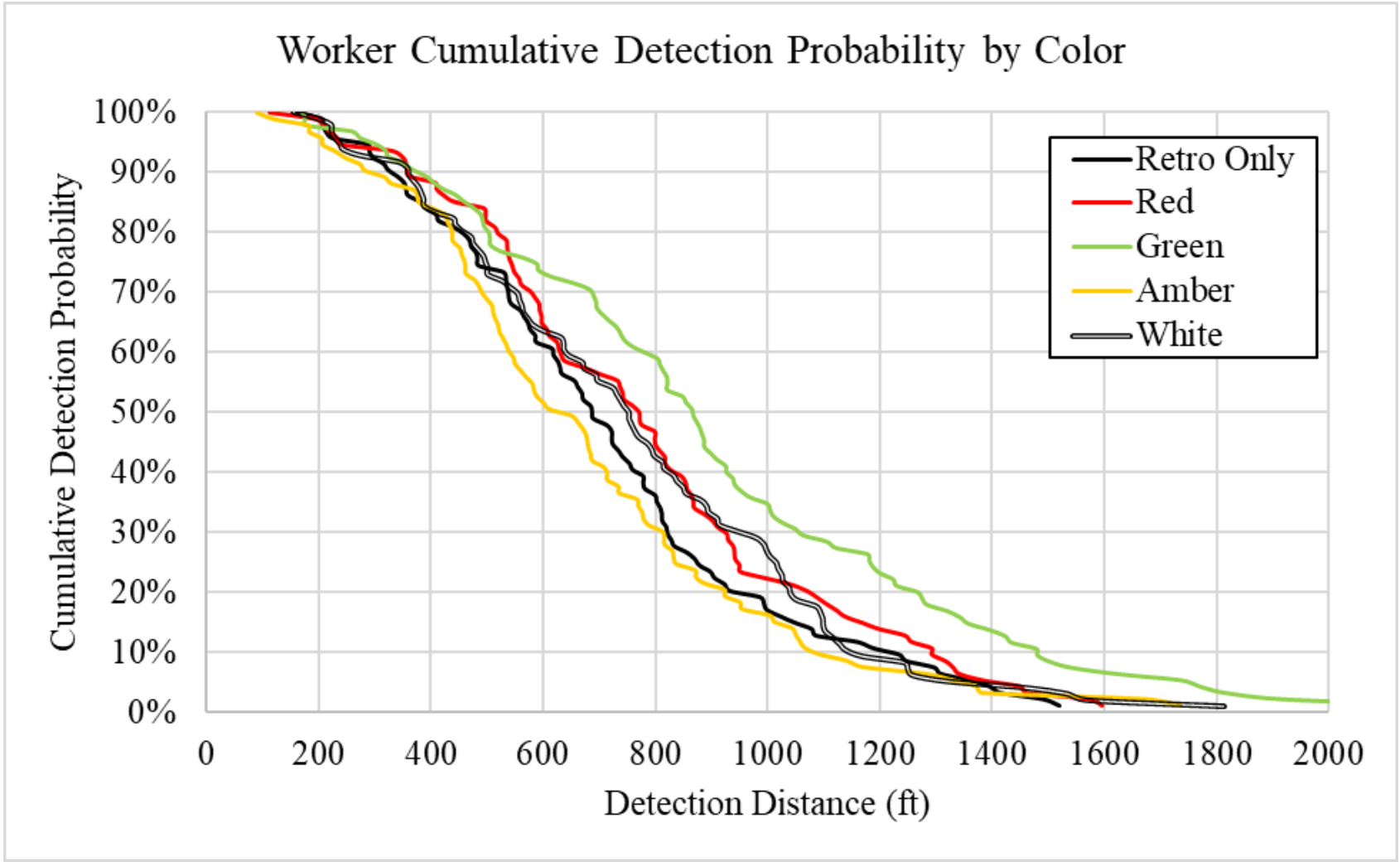
Performance Comparison to White by Lighting Color

Color	Low Complexity		Medium Complexity		High Complexity	
	Headlamp	Taillamp	Headlamp	Taillamp	Headlamp	Taillamp
Amber	No Diff	No Diff	No Diff	NA	No Diff	No Diff
Green	Better	Better	Better	NA	Better	Better
Red	No Diff	No Diff	No Diff	NA	No Diff	No Diff



Detection Probability by Color (High Complexity)

- Green had significantly larger proportion of detections more than 600 ft from the worker.
- Red and white were consistently associated with a larger proportion of detections than the retro only condition.

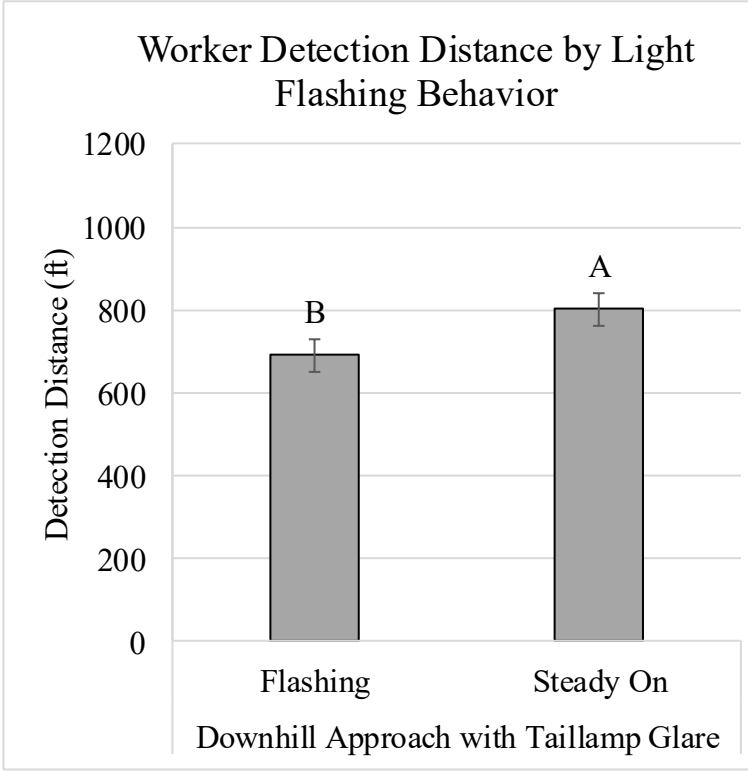


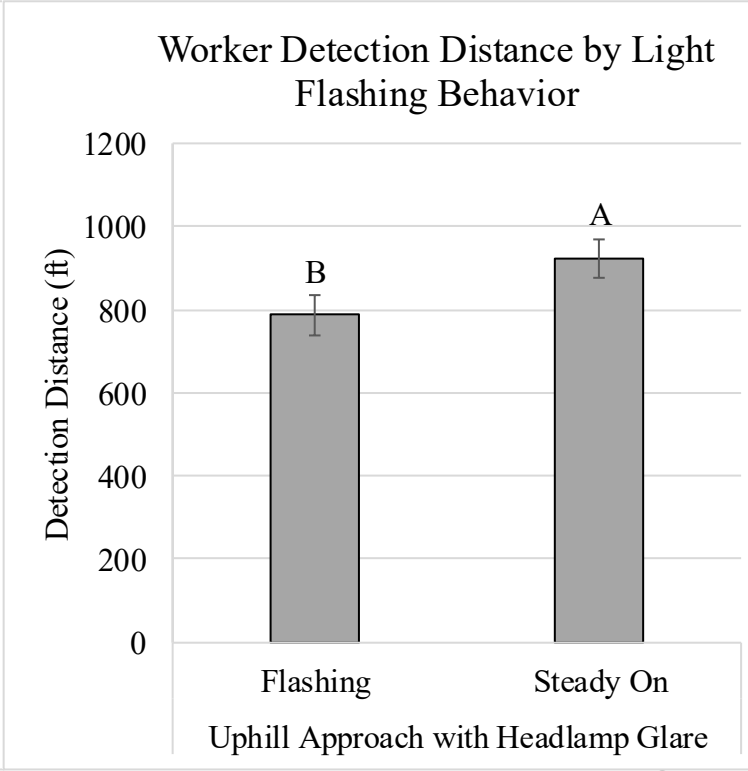
Light Behavior

- Steady-on lights improved worker detection in high complexity work zones with several other flashing lights. (+110 to 138 ft)
- Only tested 1 flash pattern (1Hz) on one device (head).

Table 29. Performance Comparison by Light Behavior

Behavior	Low Complexity		Medium Complexity		High Complexity	
	Headlamp	Taillamp	Headlamp	Taillamp	Headlamp	Taillamp
Flashing	No Diff	No Diff	No Diff	NA	Worse	Worse
Steady-on	No Diff	No Diff	No Diff	NA	Better	Better





Intensity

- High intensity aided detection when the worker was viewed against the work vehicle's headlamps, **but not** when viewed against the taillamps.
- Only 2 intensity levels on one device (shoulder).

Table 31. Performance Comparison by Light Intensity

	Low Complexity		Medium Complexity		High Complexity	
Intensity	**Headlamp**	**Taillamp**	**Headlamp**	**Taillamp**	**Headlamp**	**Taillamp**
High	No Diff	No Diff	No Diff	NA	Better	Worse
Low	No Diff	No Diff	No Diff	NA	Worse	Better

Conclusions

Lighting Design

- Combination of lights on the head and torso led to significantly longer detection distances than the standard Class 3 vest and hi-vis pants in most scenarios.

Light Color

- Green lights resulted in significantly longer detection distances.
- Amber lights performed worse than the control condition in some scenarios.
- **Based on novelty?**

Flash Pattern

- Steady-on lights resulted in significantly longer detection distances within the high complexity work zone, but no difference between steady-on and flashing lights in any other scenario.

Light Intensity

- Higher intensity did not increase detection distance.
- Glare was a concern for workers.


Title
Thank You!

Field Test, Survey, and Focus Groups

- Distributed to SSP, IMC, Contractor groups
- Asked users to complete online survey
- Invited users to focus group



Focus Group Discussion

- 5 Attendees (3 SSP, 2 Contractor)

Lighted Vest

- Did not increase visibility/safety.
- Battery was bulky and in the way.
- White light negatively affected night vision.
- One person called it "garbage".

Light Color

- White and amber are ineffective.
- Red is effective and does not impair night vision/dark adaptation.
- Green is the most visible color.
- Open to other unique colors, but unsure of effectiveness.

Shoulder Beacon

- Green color was most visible.
- Green color enhanced safety.
- Would have preferred flashing.
- Shoulder location was distracting.
- Helmet-mounted option might reduce glare.

General Comments

- Lighted apparel is most effective (and needed) for workers in temporary, unlit work zones.
- Desire flashing to increase visibility.
- Lighted apparel is unnecessary in well-lite work zones and should not be required.

Red Halo

- The preferred device but would prefer a more durable product.
- Encouraged drivers to move over.
- Red color was attention-grabbing.
- Red color maintained night vision.
- Glare not an issue since light was out of sight.
- The work light was useful.

Ideal Device

- A rigid halo device with a flashing green halo.
- Forward facing work light with separate bright/dim beams to improve work visibility and reduce user-to-user glare.

Vermont Agency Of Transportation Engineering Standards for Temporary Nighttime Traffic Control

Presented by Nancy L. Avery , PE

Work Zone Safety & Mobility Policy and Guidance

- VTrans uses night work to balance worker and public safety, as well as aide accelerated bridge projects to provide minimal disruptions to traffic flow by shifting operations to overnight hours.
- The Work Zone Safety and Mobility policy and guidance references strict national and state standards (such as the MUTCD, ATSSA, and OSHA) for all high-visibility apparel worn by personnel and reflective materials used on channelizing devices, barriers, and portable changeable message signs (PCMS) to maximize nighttime retroreflectivity
- The policy ensures adequate illumination for nighttime work zones taking into consideration the risks of higher travel speeds, and the potential for compromised drivers (drowsy, impaired) that may be encountered at night. Additionally, local ordinances are checked before proceeding with this strategy to determine if night work can occur.



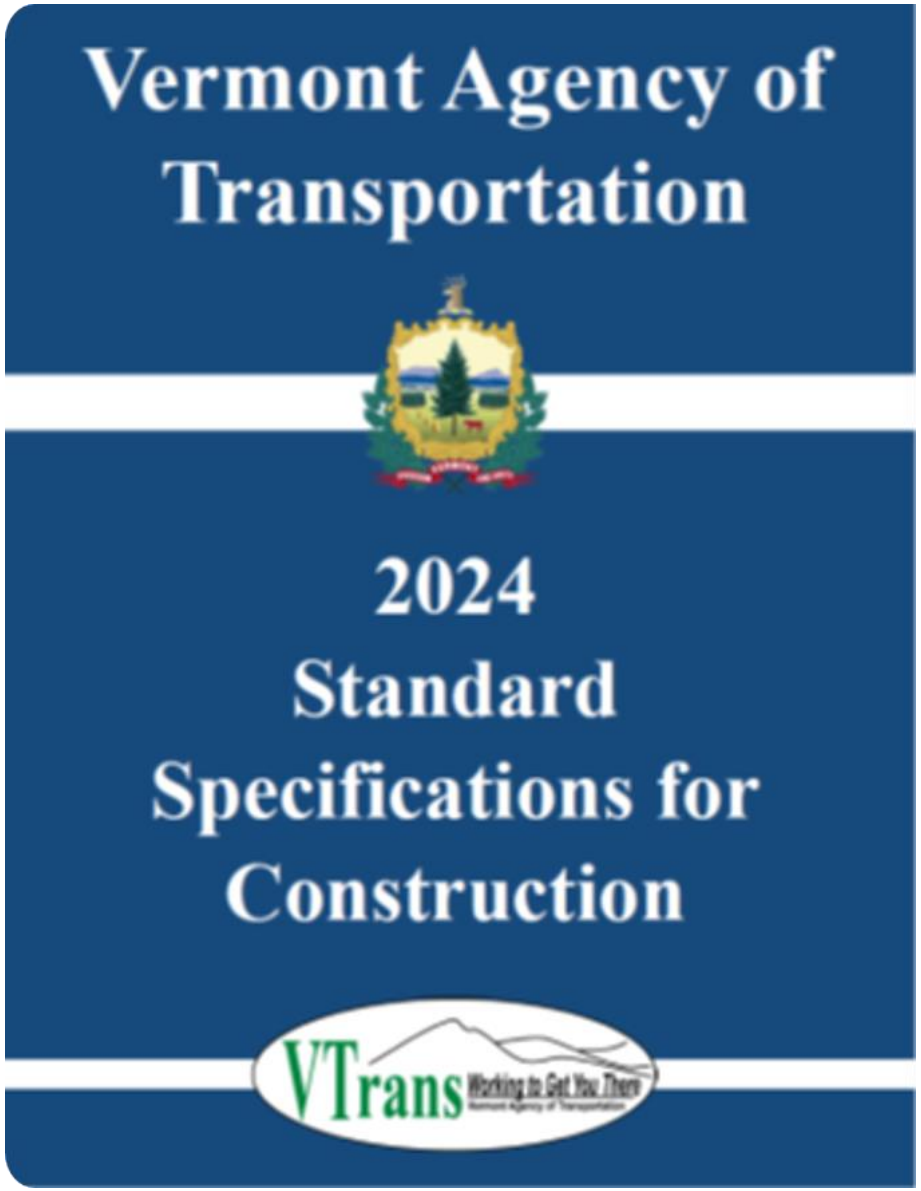
Work Zone Safety & Mobility Policy and Guidance

PREPARED FOR

Vermont Agency of Transportation

VTrans Working to Get You There

JANUARY 1, 2026



VTrans- 2024 Standard Specification for Construction

Section 105.14

(d) Night Work. Work performed at night, as defined in Subsection 101.02, will require a lighting plan in accordance with Section 641.

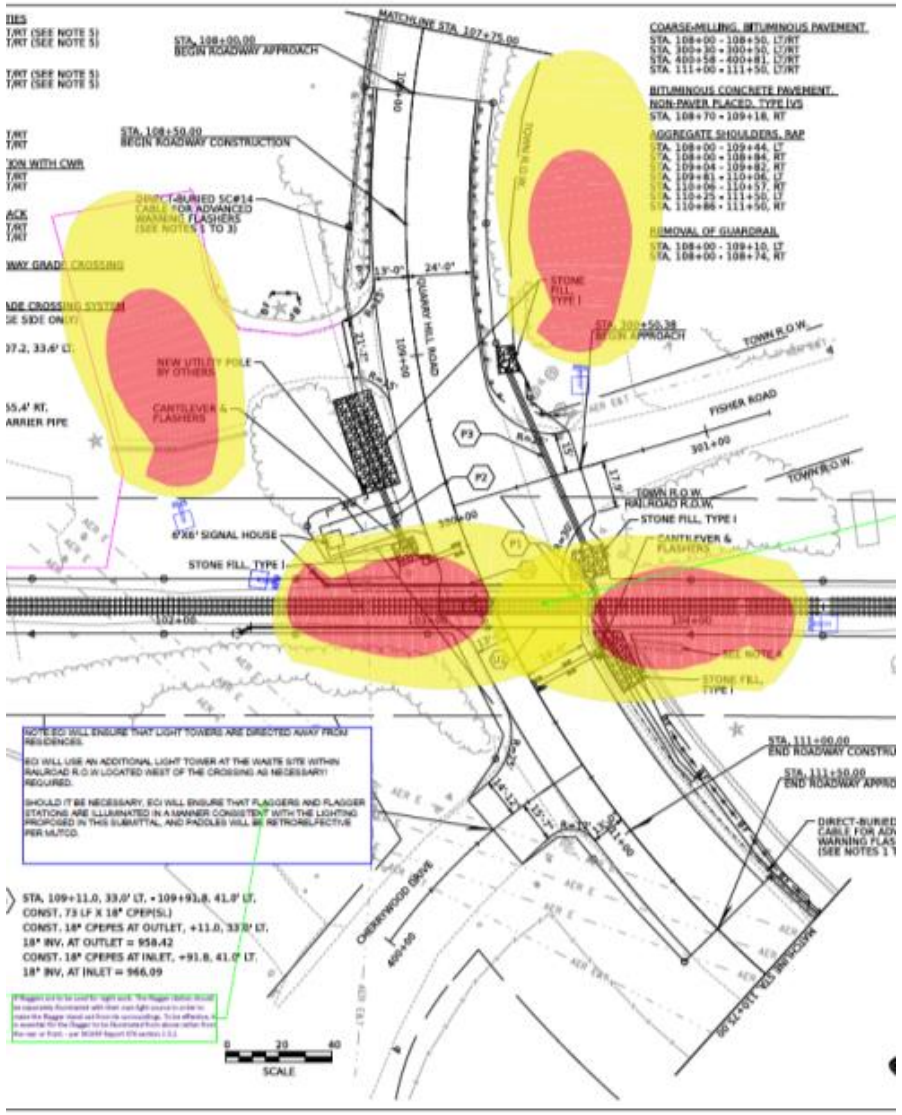
Definition of Night

From Section 101.14 NIGHT – The period from sunset until sunrise of the following day, as determined by the National Oceanic and Atmospheric Administration (NOAA) Solar Calculator for the location of the project.

641.03 NIGHT WORK- General Requirements.

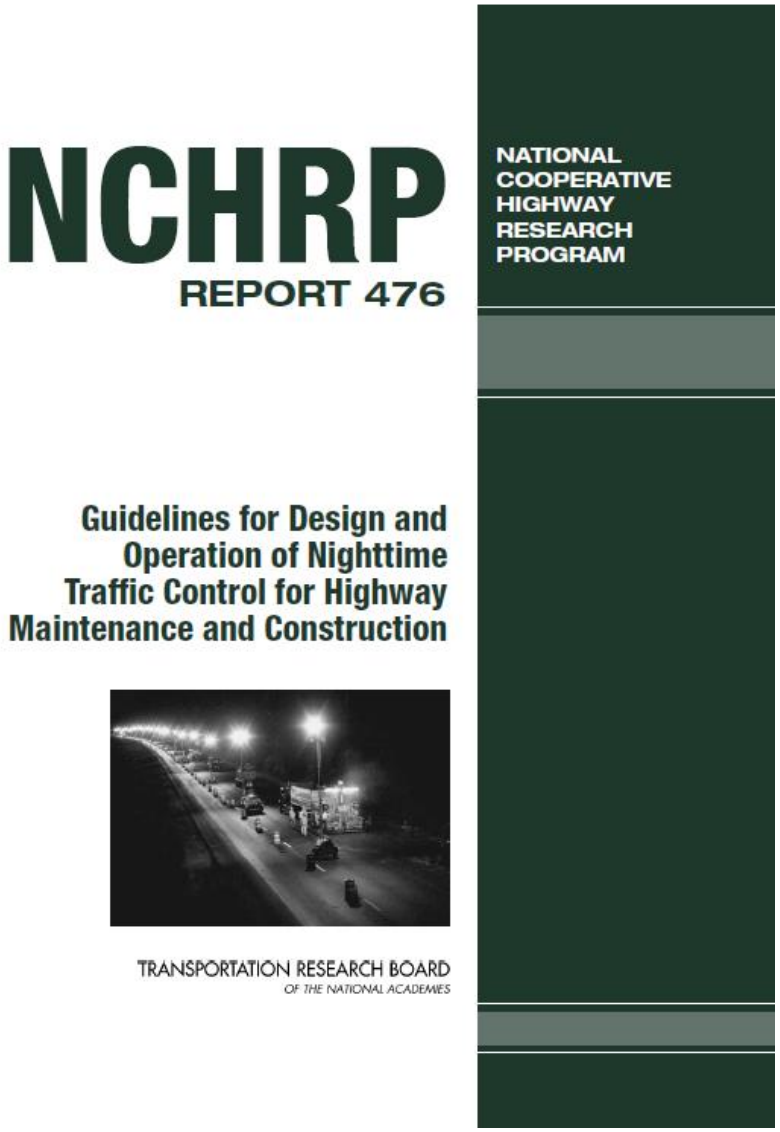
- If the Contractor intends to perform work at night, they shall submit:
  - A request a request to the Engineer, unless night work is explicitly allowed or required by the Contract.
  - The Contractor shall justify the request and detail the enhanced safety procedures they propose to protect the safety of the traveling public and project personnel.
  - The request shall be submitted at least 21 calendar days prior to the date the Contractor plans to begin night work.





The Lighting Plan

- Contractor shall submit a site-specific lighting plan stamped by a licensed Professional Engineer as part of the traffic control plan. No night work can begin until the plan is approved and the traffic control measures are fully installed.
- The plan shall specify the types of lights used and outline clear methods to minimize glare, excessive shadows, and disruptive light patterns.
- The lighting system shall be portable and illuminate the entire work zone to the recommended minimum levels of illumination for the highway tasks being performed.
- The Contractor shall provide a light meter to the Engineer to confirm that on-site lighting conditions meet the approved lighting plan requirements.

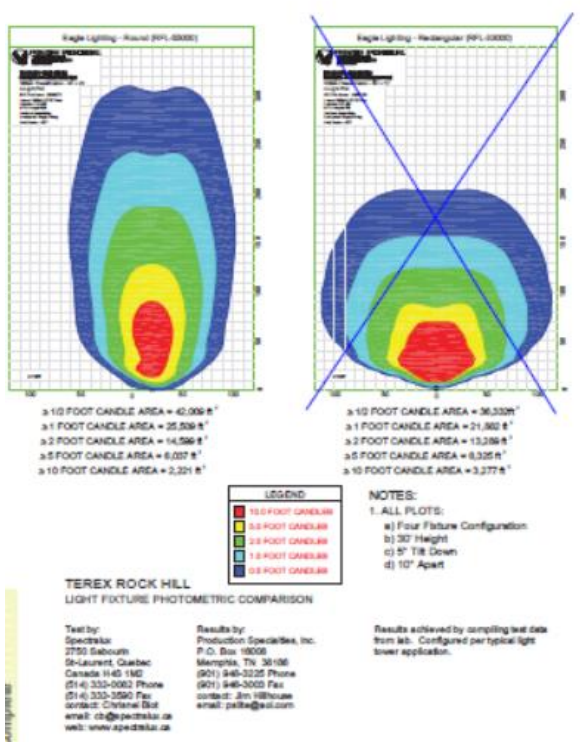


Lighting Plan Requirements

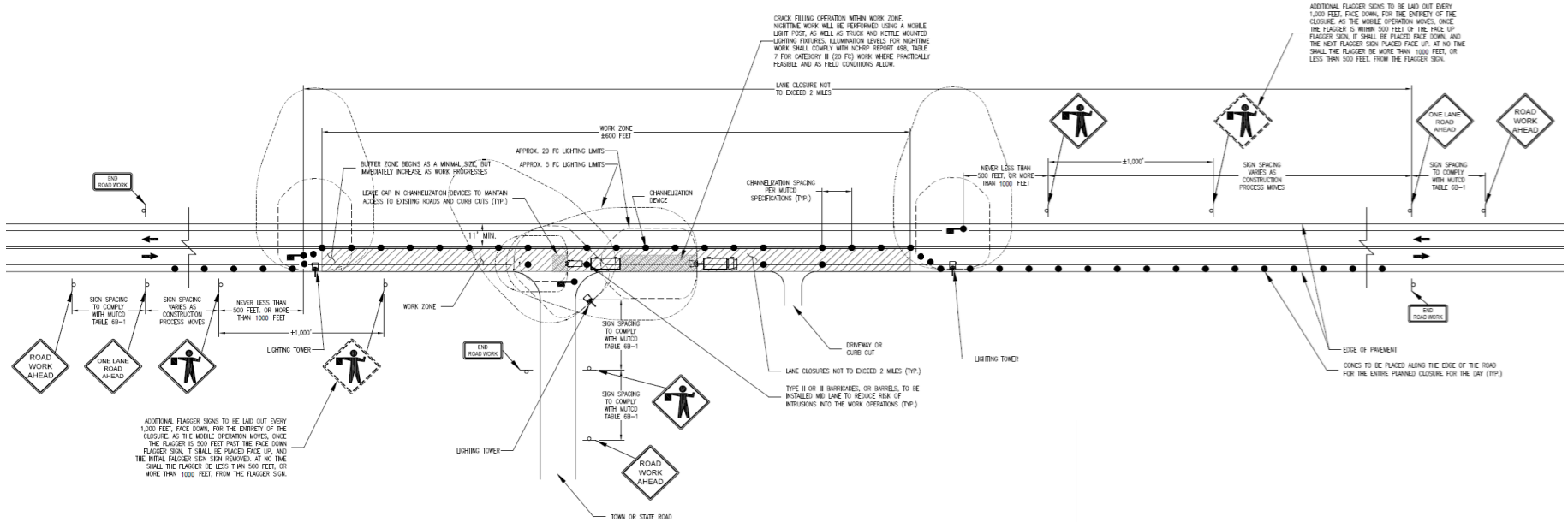
- The submitted lighting plan shall include
- A narrative description of the light fixtures and towers to be used, including
  - Number
  - Spacing, wattage, and
  - Lamp configuration
- Light fixture and light tower specifications sheets providing photometric data and the minimum illumination intensities in foot-candle for the various work tsks being conducted.
- The lighting plan shall take into consideration the guidelines provided in NCHRP Report.

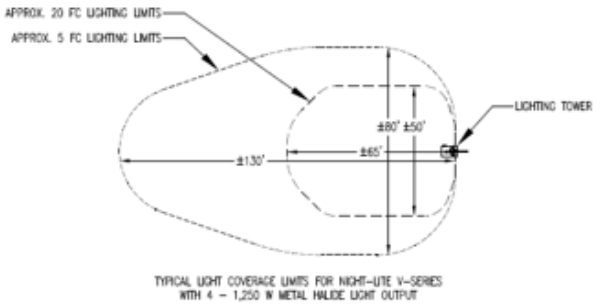
Stationary Work Zone

- A work zone is considered stationary when the traffic control package remains fixed or moves periodically (e.g., bridge construction, paving).
- The lighting plan for this type of work are to include:
  - Fixture Details: a description including count, spacing, wattage, and lamp configuration of each type of fixture used.
  - Technical Data: Specification sheets with photometric data required for each type of Luminar unit used.
  - Illuminance: Minimum intensities measured in foot-candles for each specific work situations.
  - Shall adhere to NCHRP Report 476 and 498 guidelines.

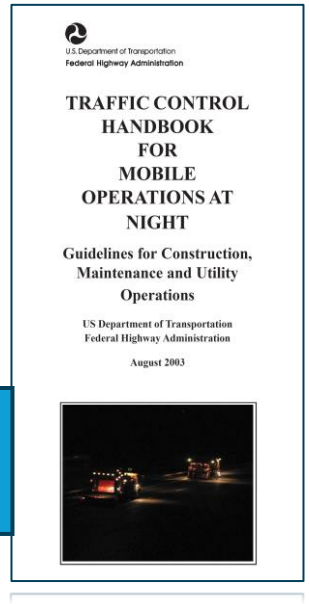








TYPICAL LIGHT COVERAGE LIMITS FOR NIGHT-LITE V-SERIES WITH 4 – 1,250 W METAL HALIDE LIGHT OUTPUT


U.S. Department of Transportation
Federal Highway Administration

TRAFFIC CONTROL HANDBOOK FOR MOBILE OPERATIONS AT NIGHT

Guidelines for Construction, Maintenance and Utility Operations

US Department of Transportation
Federal Highway Administration

August 2003

Mobile Work Zones

- Work zones are considered mobile when the traffic control package moves intermittently or continuously (e.g. line striping and crack sealing).
-
- In Vermont mobile nighttime work shall be performed in accordance with the ***FHWA Traffic Control Handbook for Mobile Operations at Night*.**
- All shadow and work vehicles within the work zone shall display high intensity rotating, flashing, oscillating, or strobe lights.
- Mobile work zones may have lights mounted to vehicles to achieve the recommended footcandles for the work activity that is to occur following tables and figures provided in NCHRP 476 and 498.



PPE General Requirements

- Traffic control personnel shall wear safety apparel in accordance with part 6 of the MUTCD.
- Traffic control personnel and workers deemed to have unsuitable safety apparel shall be considered ineffective and shall be notified to be removed from the construction site by the Engineer .
- When operating during nighttime hours, between sunset and sunrise, all workers within the highway right-of-way shall wear safety apparel meeting or exceeding performance Class 3 requirements of ANSI/ISEA 107, including Class E trousers or gaiters allowing workers to be visible for a full range of body motions and positions.



Challenges

- Despite the presence of approved, PE-stamped traffic control plans and robust field inspections, translating plans into compliant field setups remains a persistent Agency challenge. Contractors frequently take shortcuts or fail to review their accepted traffic control plan before deployment. This gap highlights a critical need for proactive, on-site coaching to ensure field personnel align with engineering expectations.

- To ensure safety compliance, the VTrans Work Zone Safety Engineer performs field evaluations across all active day and night construction zones. Following these site visits, a written report detailing observations and required corrective actions is sent directly to the project engineer and the contractor.



Q & A

Panel discussion session

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Lake Champlain bridge arch –at Crown Point - August 26, 2011