



# Snow Removal Equipment Visibility

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National Equipment Fleet Management Conference

June 2016

# Overview

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- *The issue with winter equipment visibility*
- *Factors Affecting the Study*
- *Study Set-up*
- *Pre-Work and Literature Review*
- *The VA Workshop*
- *Workshop Results*
- *Proving Results (Follow-up Study)*
- *Implementation*

# Winter Equipment Visibility – the issue

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- Snow removal equipment often operates under the most adverse conditions when conspicuity is most important



- Changes in delivery methods and equipment types have affected previous “brand identity” (yellow and black)
- Drivers are not always aware that they are approaching snow plows
- Inappropriate driver reactions can lead to collisions

# Winter Equipment Visibility – business need

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- A new lighting standard was needed for winter equipment and real progress had to be demonstrated within 6 months



- Our current service providers needed to be fully involved in the process – mutual agreement necessary
- Previous attempts had failed

# Understanding - Loss of “brand identity”



# What is it?... And what is happening?

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# Alternative Techniques to Solve the Problem

<p>Form committee to develop the standard</p>	<p>Takes too much time. Need wide range of people from different industries. Participants reluctant to travel long-distances for multiple short meetings. Competing priorities.</p>
<p>Owner develops standard and issues it</p>	<p>Internally do not have knowledge of current equipment, highway safety science and new lighting technology. Will face resistance from industry to implement.</p>
<p>VE/VA Study followed by proof of concept</p>	<p>Successfully used in other areas. Works well with multiple stakeholders. Structured process with quick timelines. Encourages innovation. Builds consensus.</p>

# Factors Affecting the Study

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- LED vs incandescent lighting concerns – both ways
  - This had been a long-standing controversy
  - Heat, light array... many myths
  - This is really what triggered the study
- Blue light controversy and pressure from police
  - Police desires and recent changes in their equipment
  - Long history dating to 1948
- How to get people to agree and resolve quickly?
  - Needed quick but accurate results to help stakeholder relationship



# Study Set-up and Organization

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- Perfect for a VE study even though outside our normal realm
- Need full range of stakeholders
  - Use of trade show contacts to get suppliers – “free”
  - If service providers are part of the solution they will buy-in
  - Select key staff – keep numbers low, but need skill/knowledge
  - Supplement team with the right “experts” (human factors/research)
- What is appropriate scope?

# Winter Equipment Visibility – the response

- Agreed with industry to investigate and develop alternatives
- Held initial workshop in July to get the process started (less than 2-months after concept)
- 4 of 5 AMC contractors participated and provided valuable input in generating ideas

# Pre-Work

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- Decide on team
- Plan appropriate venue – human factors important here too!
  - Location (easy to get to, avoid distractions)
  - Space (not too cramped)
  - Catering (keep them happy)
- Literature Review
  - 800 Pages – need to read it all

# Literature Review Conclusions

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- Detection
  - LEDs recommended
    - brighter
    - need more frequent cleaning
  - Increasing intensity
    - does not always improve detection
    - can result in glare
  - Optimum detection requires different levels of intensity for day vs. night
  - **Blue most conspicuous colour day and night, and needs least intensity, thereby reducing glare**

# Literature Review Conclusions

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- Detection
  - Short, intense flash (i.e. strobes)
    - good detection
    - fail to convey closure rate
  - Second set of elevated stop-tail-turn and backup lights beneficial
  - Reflective tape to outline back of the snow plow box

# Literature Review Conclusions

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- Recognition: hazard comprehension
  - Stronger perception of hazard with **combinations of yellow, blue and red**, than with yellow alone.
  - Suggested responses to red alone (78% indicated braking) were more dramatic than to yellow (42%) and blue (42%)
  - **Connecting dots** is important (lights + outline)
  - **Brand** (distinctive pattern) is helpful
- Recognition: perception of closing speed
  - **Widely separated lights** will give strongest cue
  - **Retro-reflective contour markings** assist at night
  - **Longer duration lights** (steady or incandescent) are better than short duration lights (strobe)

# Literature Review Conclusions

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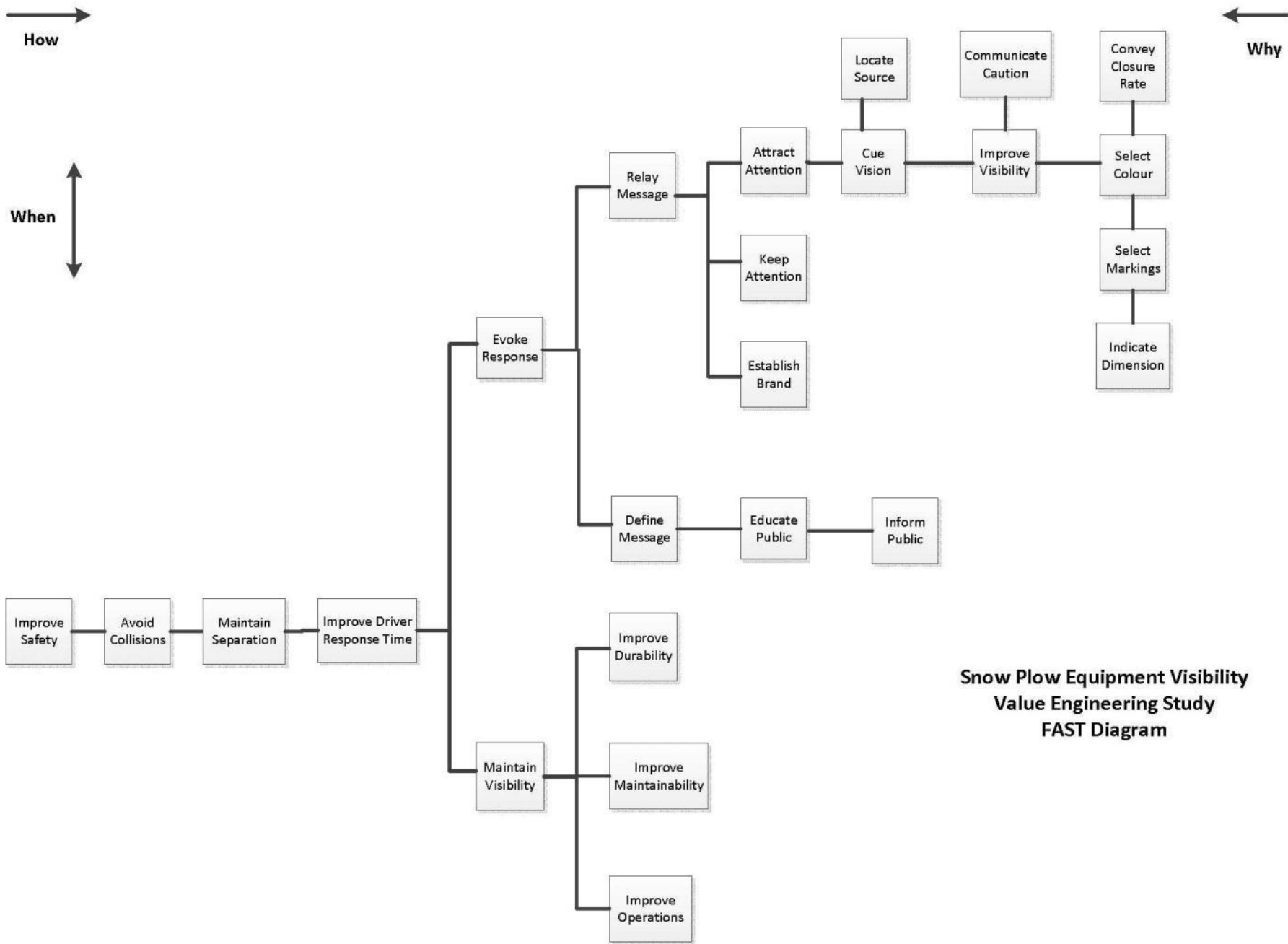
- Decision
  - Slow/pass – dependent on driver awareness
- Response: speed, lane choice, lane changes
  - Some evidence that:
    - speed slower for yellow/blue combination than for yellow alone
    - yellow/blue/red is associated with greater brake activations than yellow alone
  - Light bar with 6 sequential flashers more effective than 4-way flashers with regard to closing speed assessment
  - Rotating single beacon also effective
  - Double flash strobes not effective

# What We Need to Do?

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- Grab the driver's attention (Detection)
- Allow the driver to locate the source (Recognition)
- Relay a message to the driver (Decision)
- Obtain the appropriate response (Response)





Scope of Value Engineering Study

Snow Plow Equipment Visibility  
Value Engineering Study  
FAST Diagram

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# **VALUE ENGINEERING STUDY RECOMMENDATIONS**

# Summary of Creative Ideas

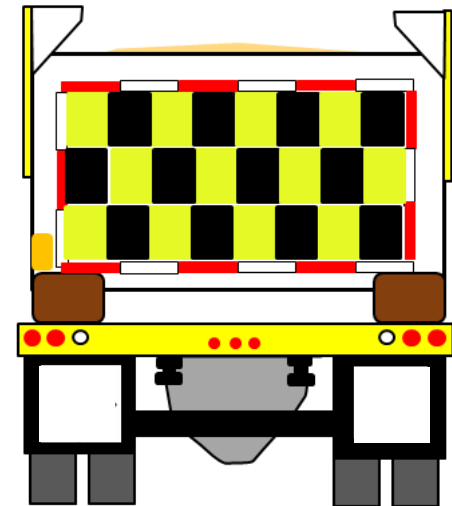
<b>Value Target Areas</b>	<b>No. of Creative Ideas</b>	<b>No. of Ideas Developed</b>	<b>No. of Ideas Developed with Others</b>
<b>Improve Visibility (IV)</b>	72	7	34
<b>Maintain Safe Separation (MSS)</b>	11	1	1
<b>Educate Public (E)</b>	31	8	15
<b>Develop Standards (DS)</b>	30	5	16
<b>TOTAL</b>	144	21	66

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# **DEVELOPED PROPOSALS**

# Rear-End Markings

- Yellow-green on black checkerboard or similar to uniquely brand snow removal equipment
- Checkerboard can be attached by brackets to rear tailgate, and should fill the area of the tailgate or equivalent on the V-hopper or grader, with the exception of a border of red and white retro-reflective tape fully outlining the rear tailgate
- Need to verify colour combination



N.T.S.

# Airfoils to Keep Snow off Back/Lights

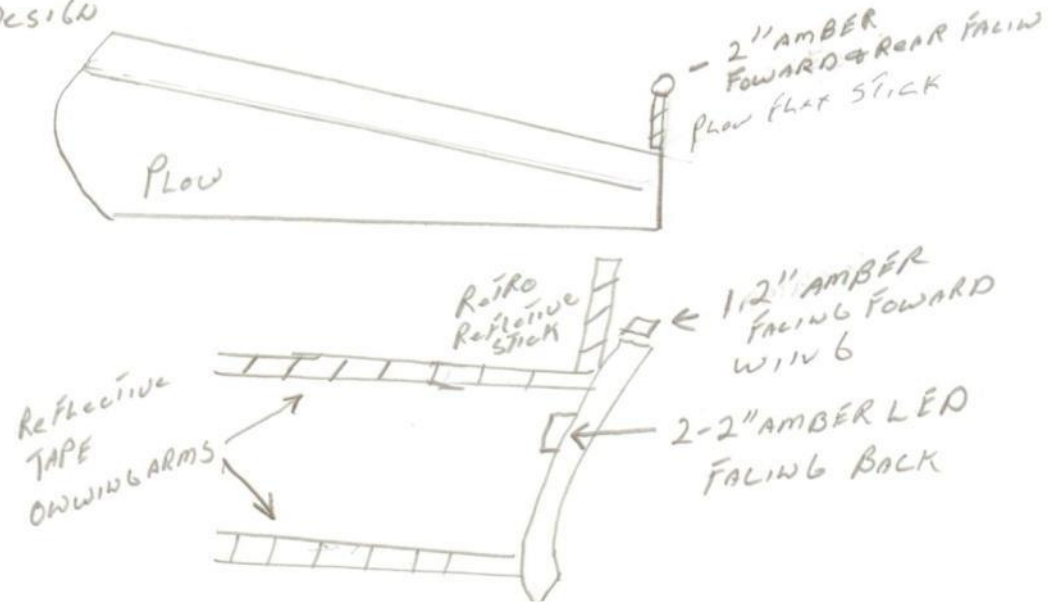
- This would give more visibility by helping keep lights and signs clear
- Alberta design is starting point



# Lighting on End of Tow Plow and Wing



ALTERNATE DESIGN

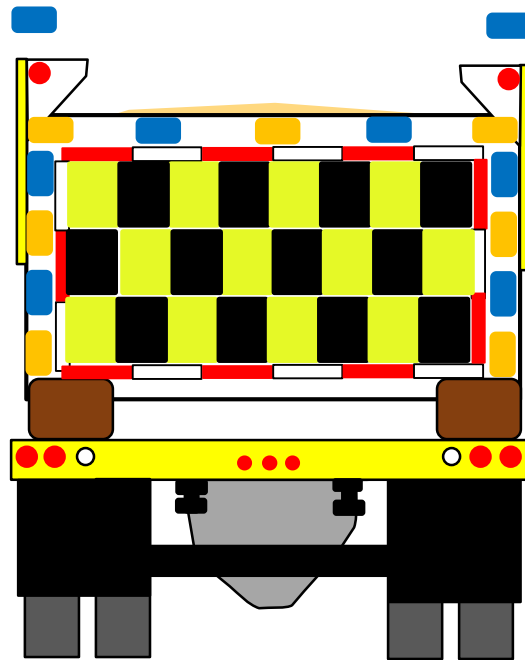


## Improved Lighting Conspicuity/Visibility on Rear of Snow Plow(s)/Spreader(s)

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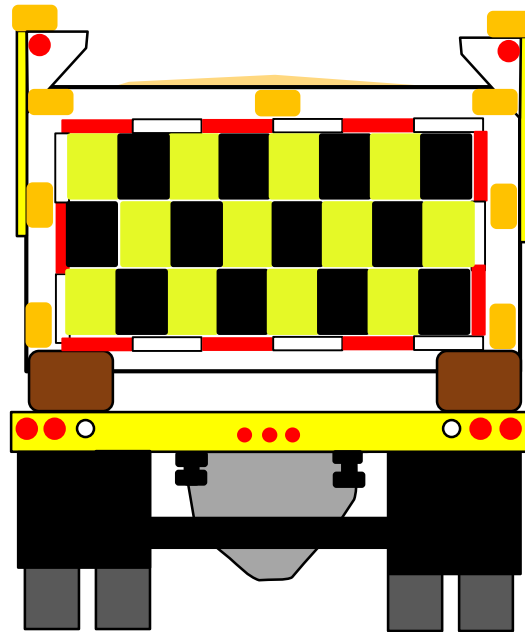
- Amber & blue L.E.D. lighting embodied in an “H” pattern on the rear of the unit
- Upper blue/amber beacons would flash alternately between the two colours at 1 Hz
- All other blue lights would cycle in conjunction with these “upper” beacons while the amber would remain constantly lit
- An increased strategic placement of retro reflective red & white tape around the outer perimeter of the unit and a checkerboard pattern to cover the bulk of the tailgate





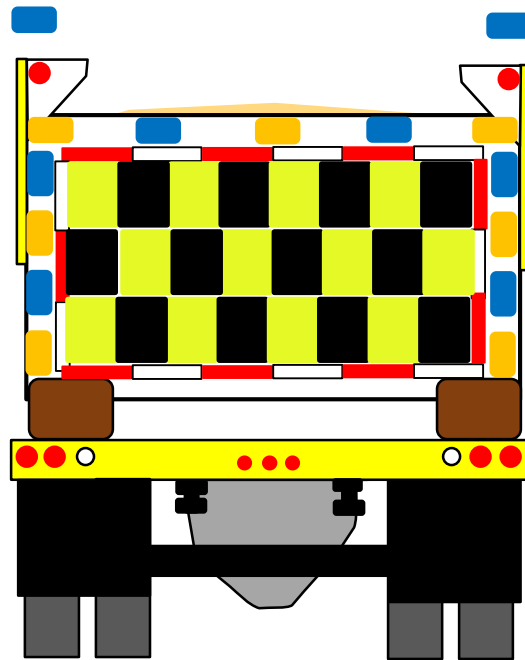
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July 10, 2013



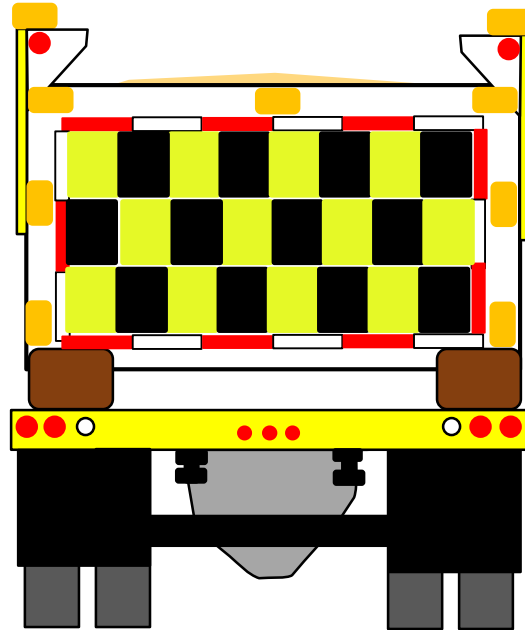
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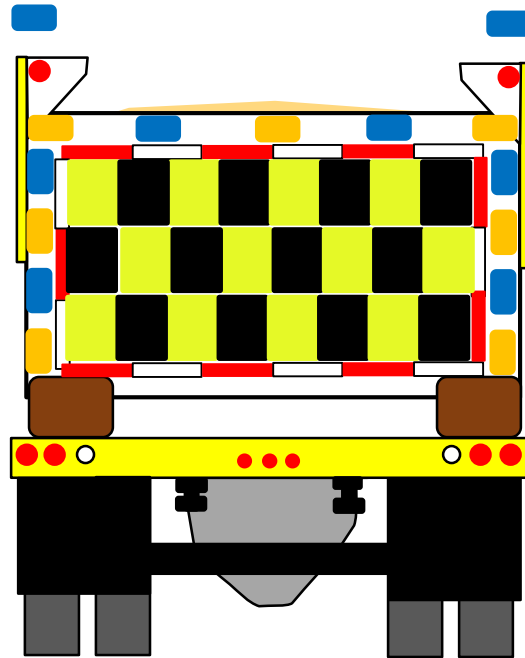
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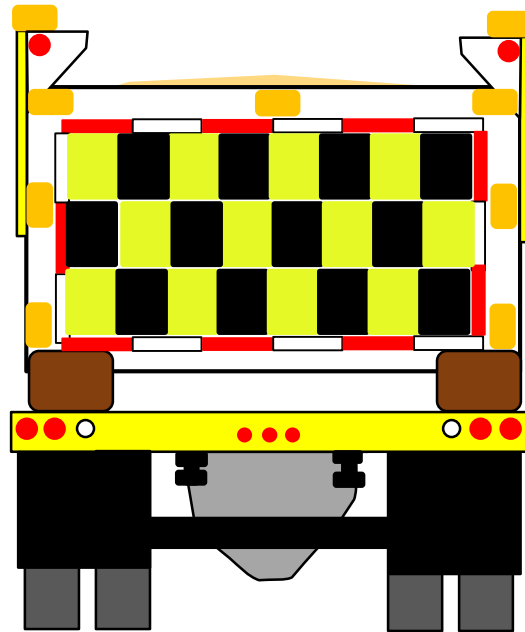
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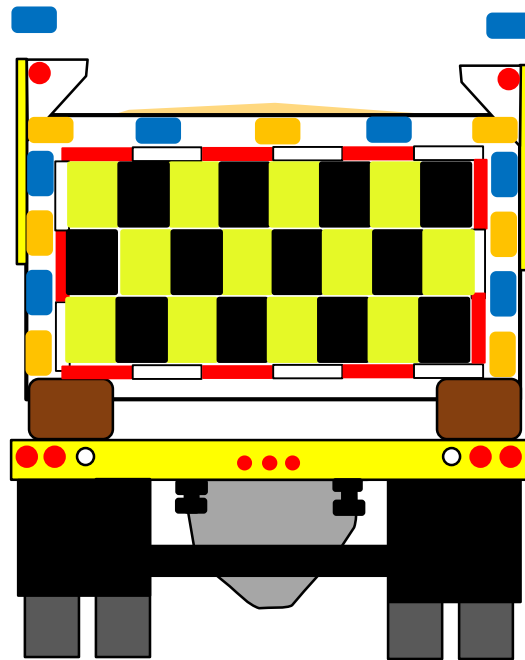
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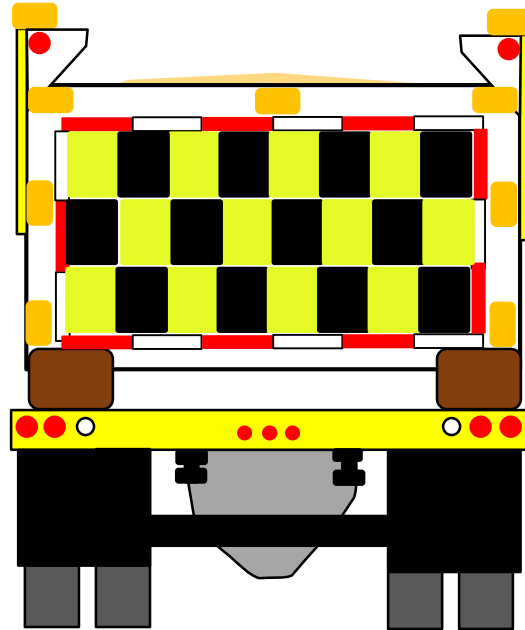
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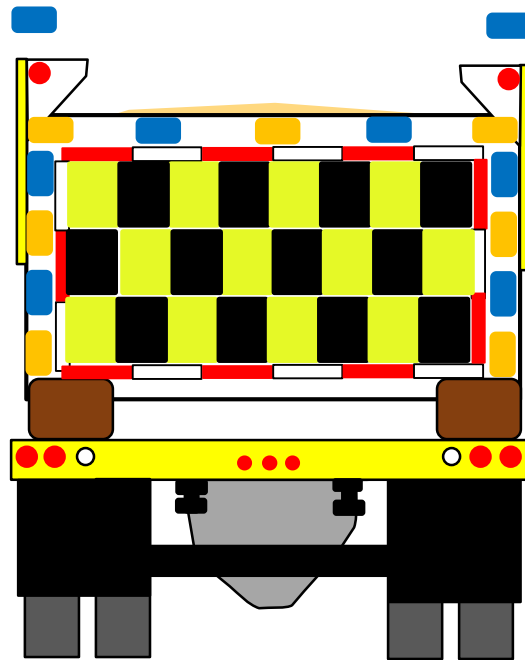
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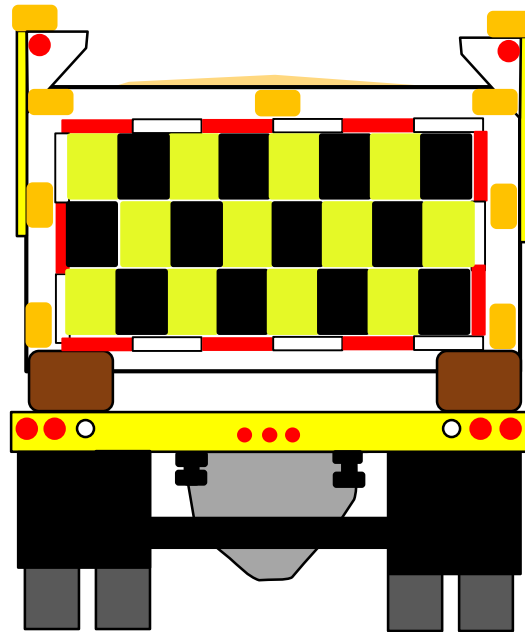
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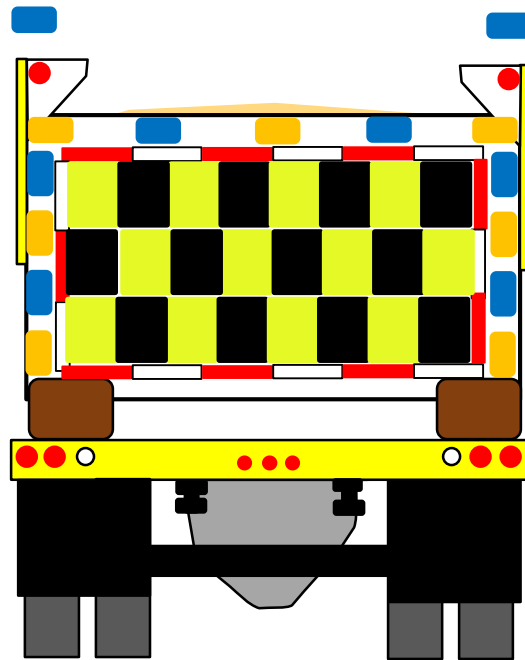
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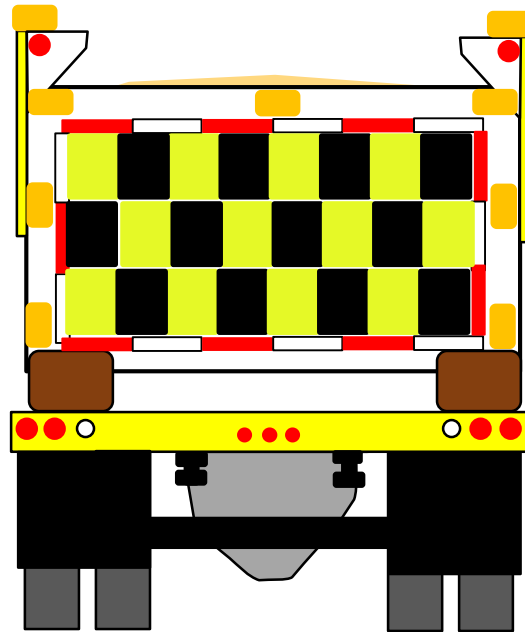
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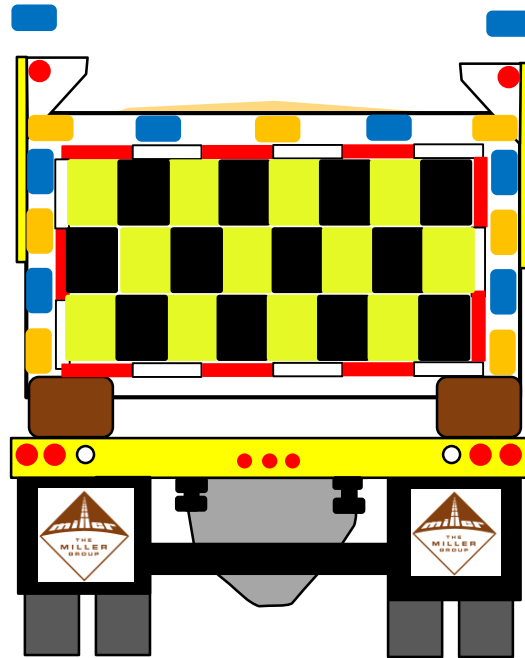
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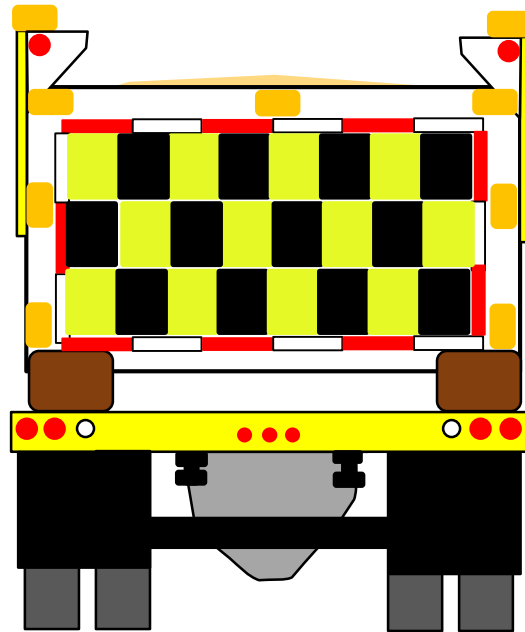
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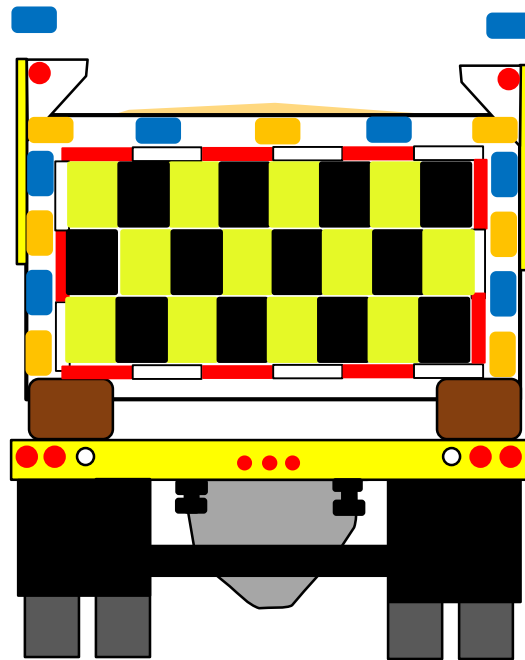
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## Improved Lighting Conspicuity/Visibility on Rear of Snow Plow(s)/Spreader(s)

- The new proposed design incorporates several added advantages
  - L.E.D. lighting to increase life cycle/decrease maintenance, automatic adjustment of light intensity via photocell based on ambient lighting, lower amperage draw, more controlled light spectrum, increased vibration resistance
  - Effective communication of plow location and closure rate to following drivers
  - Increased ability to estimate size/dimension via use of additional retro-reflective tape and strategic light placement
  - Standardization of all lighting packages for all snow plows/sanders
  - Uniquely identifies snow plow/sander equipment



# VMS and PVMS Messaging

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- Use VMS and PVMS messaging to warn drivers of slow snow removal equipment ahead, that they should slow down and not pass
  - **Advantages**
    - Provide education to the very drivers who need it and at the time they need it (i.e. to drivers approaching snow removal equipment, that they should slow down and not pass)
  - **Disadvantages**
    - Various VMS warning of snow removal equipment, including snowplows ahead, snow plows do not pass, but tested bilingual sign not yet available.
    - Producing a bilingual version of the message that fits on one sign will be challenging and should have a human factors evaluation to ensure drivers understand it.



# Educate Public

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- Media Campaign
  - Help establish public “brand recognition” of snow removal equipment
  - Greatly increase driver awareness of how to behave around snow removal equipment
- Drivers Handbook
- Social Media
  - Facebook and Twitter
- Stakeholder Involvement
  - Sessions at OnRoute Centres

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# **PROVING RESULTS / PROOF OF CONCEPT**

# Improved Lighting Conspicuity / Visibility

- Upper blue/amber beacons flash alternately at 1 Hz.
- Amber and blue LEDs on side and top of rear box
  - Amber stays on
  - Blue turns on and off
- Red and white tape outline rear box
- Light intensity adjustment for day / night
- Air foils to keep LEDs clear

# Sample

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# Testing Considerations

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- Started with a model
- Scientific Process
  - Must be defensible
  - Control variables
- Independent
- Different Age Groups
  - >25
  - 25-55
  - 55+

# 1. Rear Panel Colour and Pattern

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- Tested nine (9) different colour and sheeting combinations
  - Daytime and nighttime conditions (November)
  - Closed road
  - 12 test subjects



## 2. Light Patterns / Configuration

- Confirm light patterns and compare to common emergency vehicles on highway to show unique conspicuity
  - Stop/turn lights as well as old and new configurations
  - Daytime and nighttime conditions (December)
  - Closed road – 12 test subjects
  - 12 test subjects





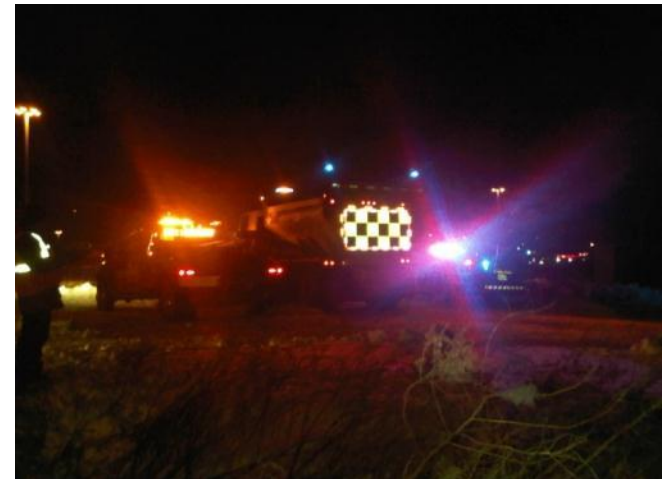
# 3. Monitored On-Road Testing

- Compared existing to new lighting
  - Daytime and nighttime (February)
  - Winter conditions (Huntsville)
  - 6 test subjects



# Results

- Testing in November confirmed conspicuity panel should be fluorescent yellow-green and black. III/IV sheeting.
- Testing in December confirmed optimal light pattern amber solid and blue 1Hz flash. Also unique conspicuity compared to common emergency vehicles on highway.



# Results (continued)

- Testing in February confirmed conspicuity is improved in both urban and rural conditions.
- Perception of closing velocity is improved in order of 10%.



# Additional Findings

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- Need automatic light dimmers (day, night)
- Supplier differences: visibility and durability
- Air foils worked well – Alberta model
- Strobe lights worst



# Other Patterns / Configuration

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- Amber / green reviewed
  - Conflicts with Ontario Highway Traffic Act, volunteer firefighters and traffic signals
  - Visibility less than amber / blue



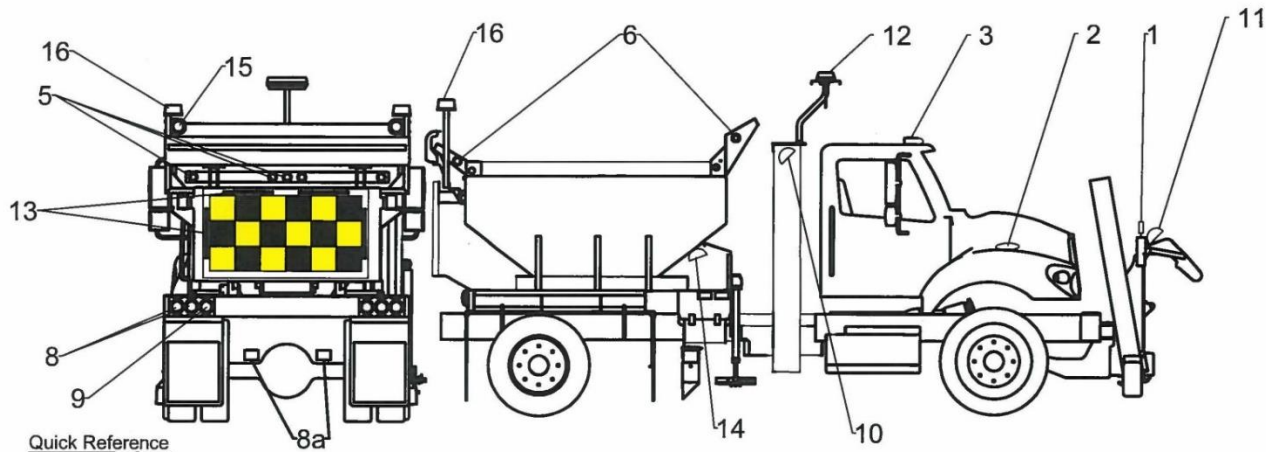
# Project Status

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- Formal testing completed
- Report finalized
- Updated standards have been published
- **Transportation Association of Canada has accepted as a National Guideline**



# New Equipment Standards Issued in 2014



Quick Reference

1. Headlights
2. Directional Turn Lights
3. Identification Lights
5. Red Identification Lights
6. Side Marker Lights
- 8,8a. Stop, Turn and Tail Lights
9. Back-up Lights
10. Wing Light
11. Plow Light
12. Rotating Pattern Blue/Amber Mini-bar
13. Blue/Amber Warning Lights
14. Spinner Light
15. Red Upper Stop and Turn Lights
16. Rotating Pattern Blue/Amber Beacons

FOR A FULL DESCRIPTION OF "QUICK REFERENCE" LIGHTS, SEE STANDARD ES2200012

MINISTRY OF TRANSPORTATION ONTARIO - Contract Management Office

**LIGHTING REQUIREMENTS FOR  
SINGLE AXLE  
PLOW, SPREADER, COMBINATION  
SNOWPLOW SPREADER TRUCKS**

**ES - 2030012**

INITIATED: JUN/2014

REVISED: NOV/2014

APPROVED: Mike Pearsall

# Canadian National Guideline



- **Snow Removal Equipment Visibility Guide**

- PTM-SREVG-E  
\$39 TAC Members  
\$49 Non-Members

**Available in print and ebook format**

The *Snow Removal Equipment Visibility Guide*, now [available in the TAC Bookstore](#), provides information, analysis and testing to assist road authorities and winter maintenance service providers to make their snow removal equipment as visible as possible. It is hoped that establishing guidelines for this purpose will provide increased consistency in the appearance of snowplows and other snow removal equipment across Canada. Increased visibility of and consistency in the appearance of this equipment will enhance motorists' ability to detect, recognize and respond to snowplows which will, in turn, increase road safety.

[WWW.TAC-ATC.CA](http://WWW.TAC-ATC.CA)

- **Publication Catalogue**





# Thank you for attending!

Brendan Thompson, SWS

National Equipment Fleet Management Conference

June 2016