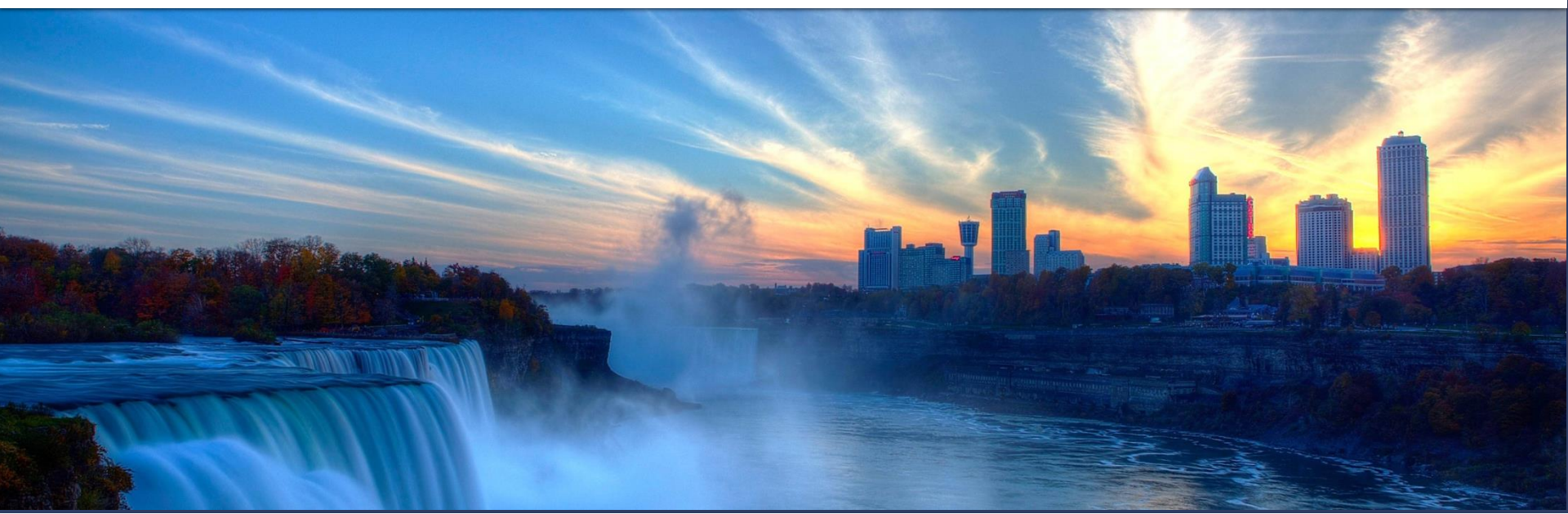


Applying VE and Human Factors Research in the Development of Snow Removal Equipment Safety

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June 2016

OVERVIEW

- *The issue with winter equipment visibility*
- *VE and Human Factors*
- *Study Set-up and Pre-Work*
- *Incorporating Human Factors in the VE Workshop*
- *Workshop Results*
- *Proving Results (Follow-up)*
- *Implementation*

WINTER EQUIPMENT VISIBILITY – THE ISSUE

- 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

UNDERSTANDING - LOSS OF “BRAND IDENTITY”



WHAT IS IT?... WHAT IS HAPPENING?... WHAT SHOULD I DO?



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>

WHY USE VALUE ENGINEERING?

Range of Stakeholders

- 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)

Need solution fast

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

Paradigms need to be broken

Perfect for a VE study!

HOW DOES VE FIT WITH HUMAN FACTORS?

Customer Orientation = Human Orientation

VE and Human Factors actually marry quite well – Translate well into functions

STUDY SET-UP AND PRE-WORK

Decide on team

Plan appropriate venue – Human Factors 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 as Owner-Facilitator

INCORPORATING HUMAN FACTORS

Focused literature review

Human Factors Experts on team

Include “training” in Information Phase

LITERATURE REVIEW CONCLUSIONS

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

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

Recognition: hazard comprehension

- Stronger perception of hazard with **combinations of yellow, blue and red**, than with yellow alone.
- **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

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
- 4-way flashers and rotating single beacon also effective
- Double flash strobes not effective

WHAT WE NEED TO DO?

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)

BUILDING FUNCTIONS FROM HUMAN FACTORS

Detection

- Attract Attention
- Cue Vision

Recognition

- Locate Source
- Establish Brand

Decision

- Define Message
- Educate Public

Response: speed, lane choice, lane changes

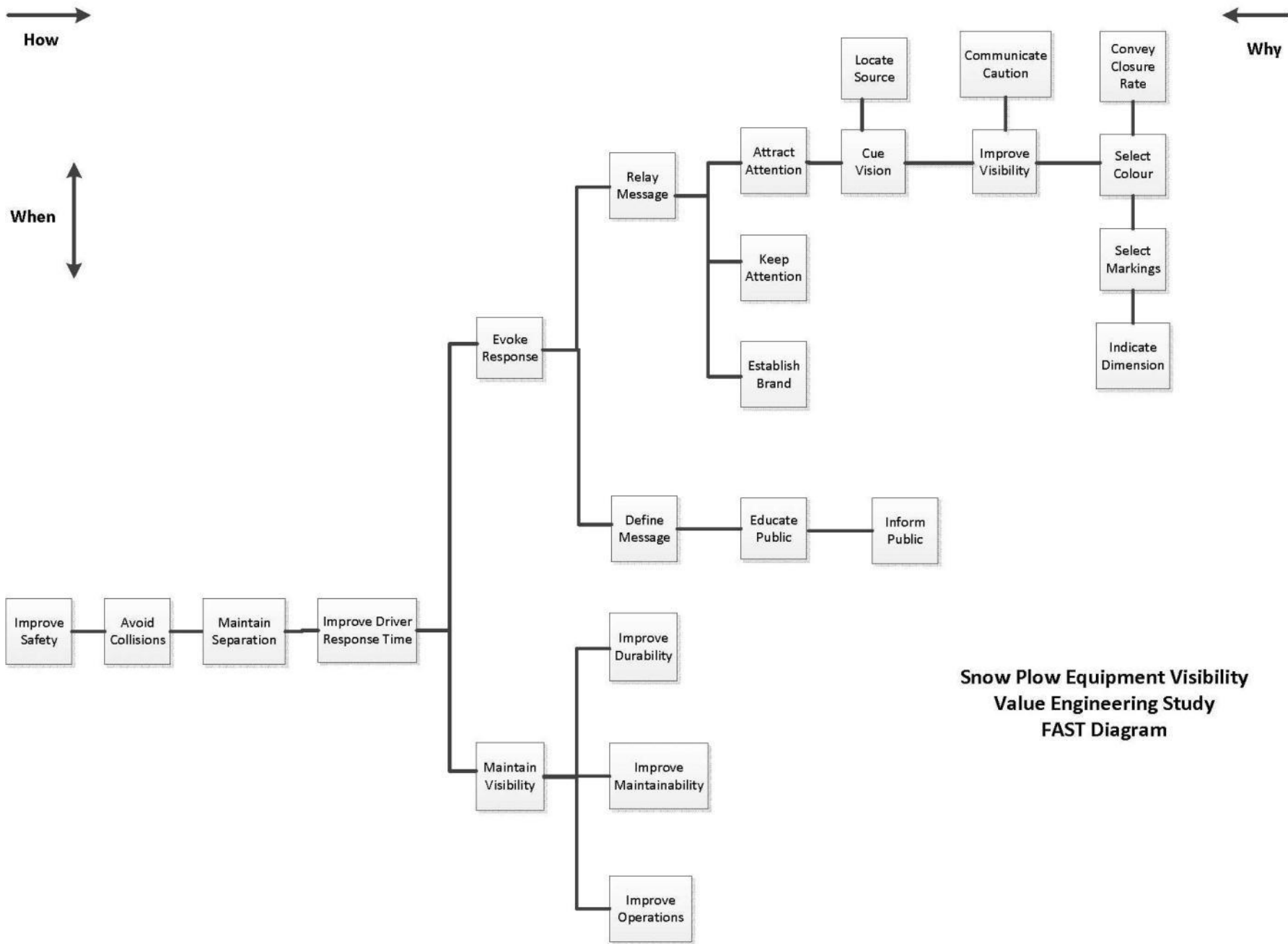
- Avoid Collisions
- Maintain Separation

BUILD THE FAST DIAGRAM

Use information team has gathered

Think more along the lines of Customer
FAST than Technical FAST

Good idea to have 'back-pocket' start



**Snow Plow Equipment Visibility
Value Engineering Study
FAST Diagram**

Scope of Value Engineering Study

SUMMARY OF CREATIVE IDEAS

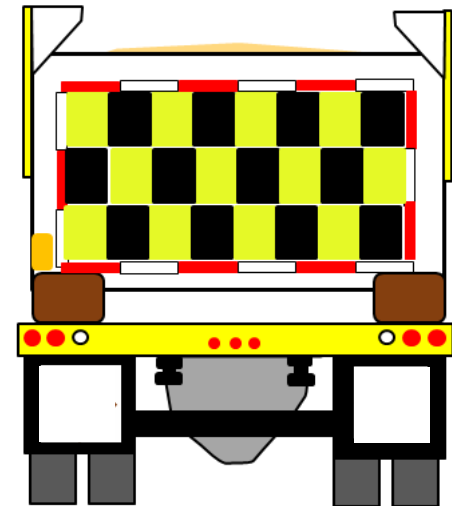
Value Target Areas	No. of Creative Ideas	No. of Ideas Developed	No. of Ideas Developed with Others
Improve Visibility (IV)	72	7	34
Maintain Safe Separation (MSS)	11	1	1
Educate Public (E)	31	8	15
Develop Standards (DS)	30	5	16
TOTAL	144	21	66



KEY 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 aid visibility by helping to keep lights and signs clear



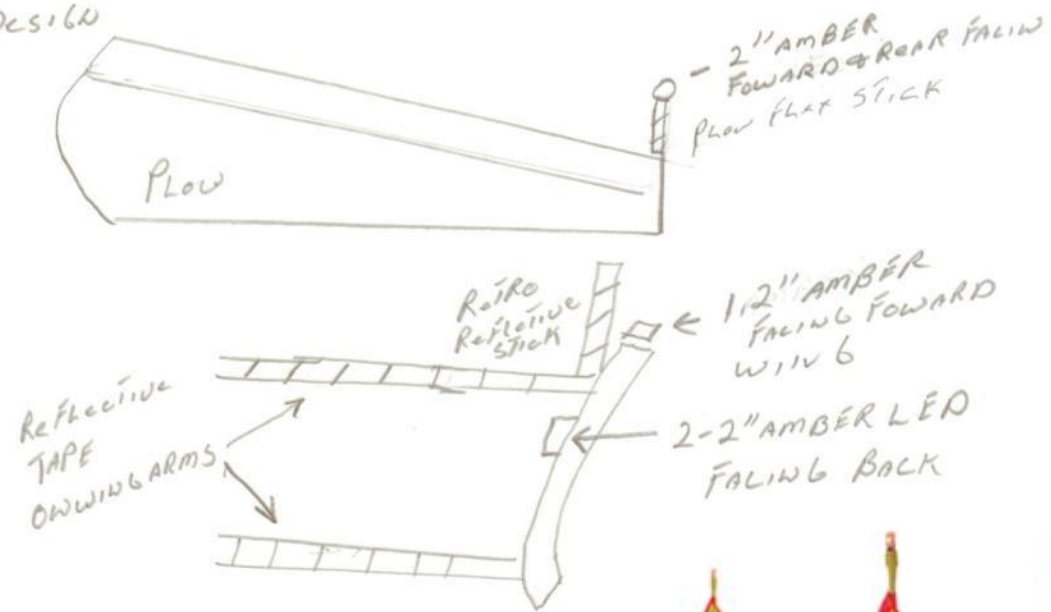
IMPROVE LIGHTING CONSPICUITY / VISIBILITY

- 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
- Add lighting to plow wing

LIGHTING ON END OF TOW PLOW AND WING



ALTERNATE DESIGN



HOW DO THESE RELATE TO HUMAN FACTORS?

- 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 – Branding
- Uniquely identifies snow removal equipment

EDUCATE PUBLIC

- Media Campaign
- Drivers Handbook
- Social Media
- Stakeholder Involvement



PROVING RESULTS / PROOF OF CONCEPT

SAMPLE



TESTING CONSIDERATIONS

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

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

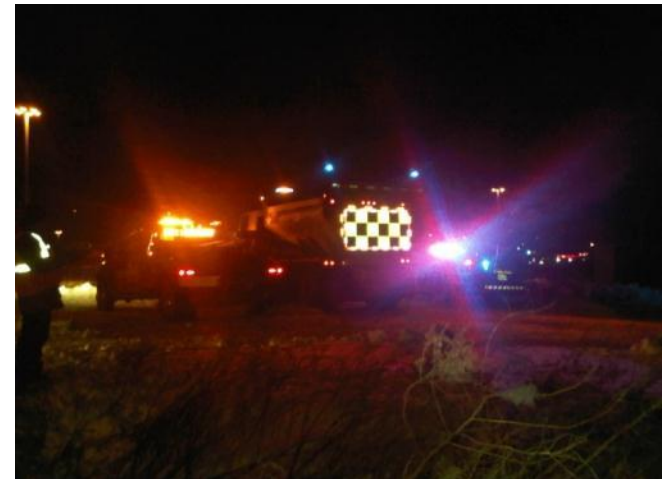
Compared existing to new lighting

- Daytime and nighttime (February)
- Winter conditions (Huntsville)
- 6 test subjects



RESULTS

- Testing in November confirmed conspicuity panel should be fluorescent yellow-green and black.
- 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

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

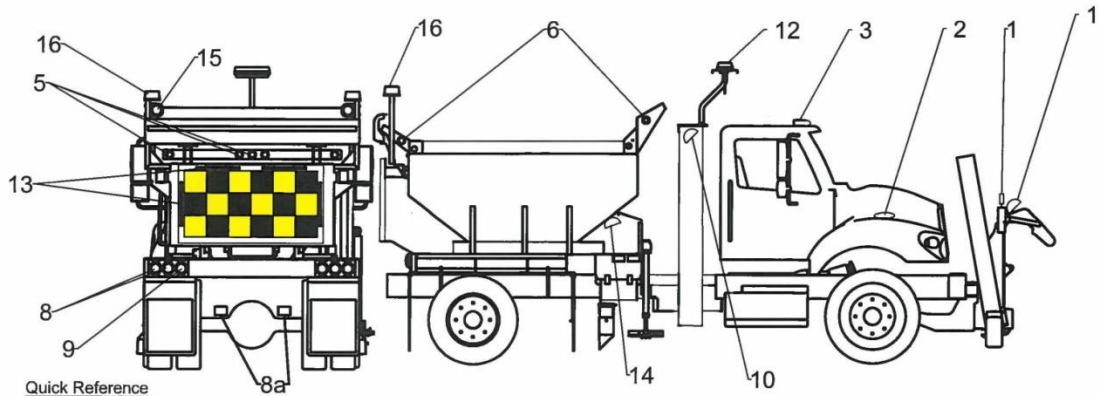


OTHER PATTERNS / CONFIGURATION

- Amber / green reviewed
 - Conflicts with HTA, volunteer firefighters and traffic signals
 - Visibility less than amber / blue



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.

CONCLUSIONS

- VE is a good tool for incorporating Human Factors
- Testing and Proof of Concept is critical for implementation

