Development of a Work Zone Intrusion Reporting System

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MN Work Zone Intrusions

- Minnesota recognized threat of work zone intrusions
  - From 2005 to 2010, the U.S. suffered the loss of 733 road workers, approximately half struck by motorists *(FHWA, 2015)*
- Addressing intrusions is an important step toward ensuring a safe work environment for work crews on our roadways.
  - MN had no formal work zone intrusion documentation process
- A 2015 research synthesis commissioned by MnDOT found that only 3 of 19 states surveyed had work zone reporting practices
  - Pennsylvania, North Dakota, and Iowa

Take Away Message

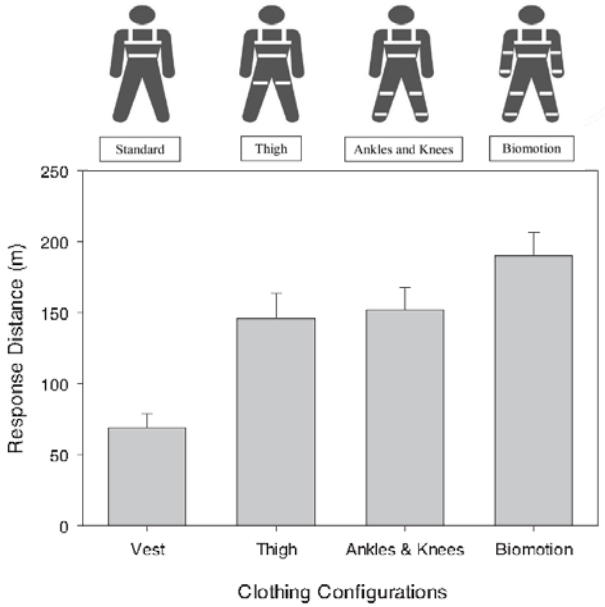
- Examining crash data provides some useful information about work zone intrusions
- Relies on extreme cases
- Limited data
- **Must create a reliable method to document non-crash involved work zone intrusions**
  - **Challenge:** places burden on work crews

Purpose/Goal

- Design efficient, comprehensive, user-friendly reporting system for intrusions in work zones

- Information from intrusion reporting to be used to:
  - Examine risk factors and areas of interest to reduce intrusions and risk to workers
  - Provide feedback to workers and management on safety data
  - Provide empirical basis for future policy recommendations to the state

Environmental Conditions



- Nighttime work at risk
  - Drowsy drivers
  - Poor visibility
  - Greater alcohol risk
  - Poor lighting is especially a risk factor
  - Retro-reflectivity is beneficial
    - Body placement is important for biomotion
    - Proper maintenance and positioning for barriers and vehicles

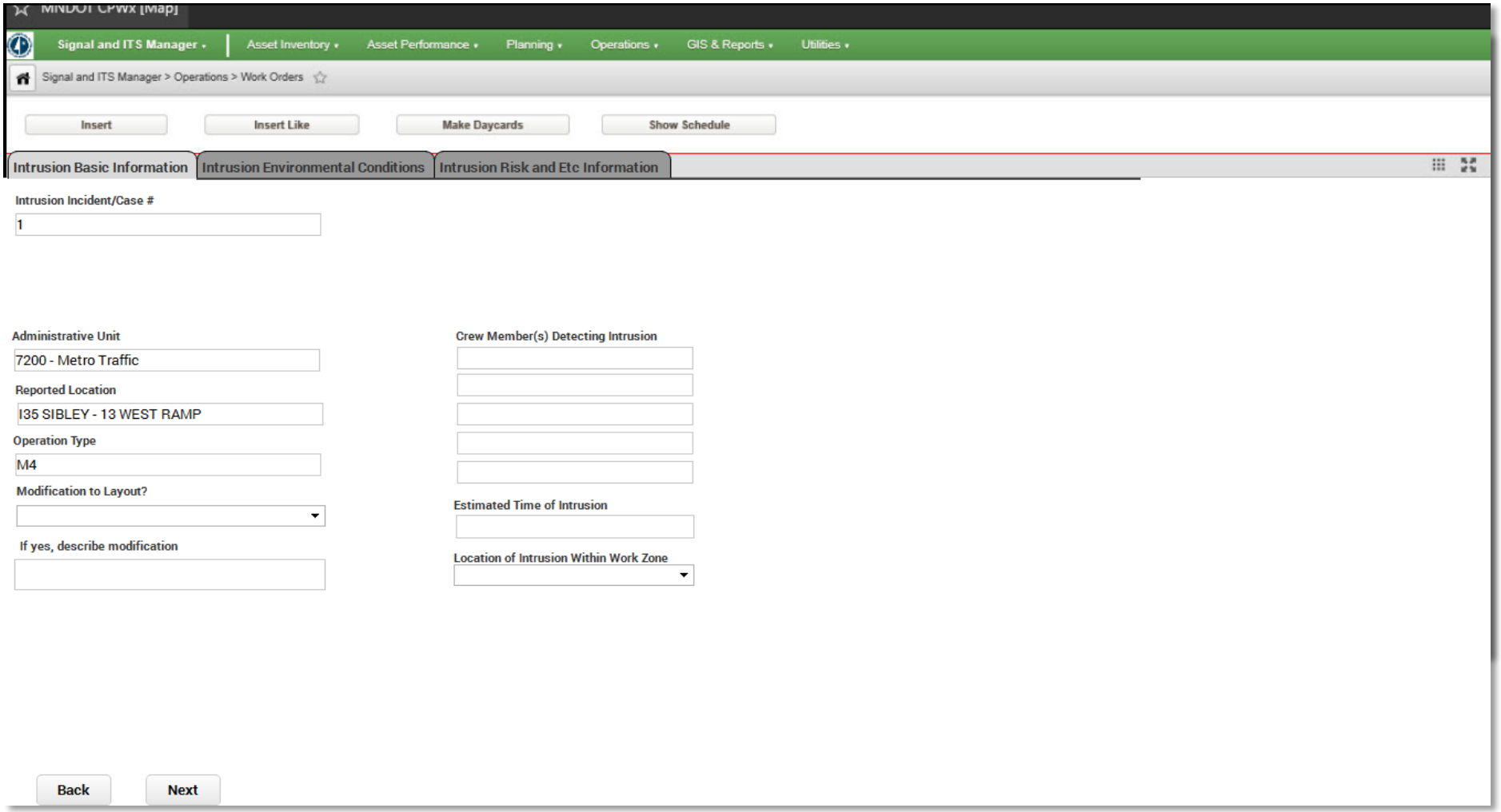
Understand Supervisors and the Reporting Task

- **Conceptually:** Intrusions understood as a vehicle entering the area cordoned off by cones
- **Practically:** Intrusions are thought of as reportable:
  - *Occurs close to the activity area and threatens active workers*
  - *Threatens a flagger during flagging operations*
- The key reportable elements of an intrusion from the crew are as follows:
  - Layout, Environment (lighting and weather), Location, Time, Road condition, Vehicle maneuvers, and Operation type.

Addressing Redundancy

- Original aim
  - Incorporate the Work Zone Intrusion Report into another report already being completed on normal basis and contains shared information
- Lane Closure Form
  - Not reliably completed outside of metro
- TAMS
  - Originally perceived as viable option for integration to be completed by supervisors
  - Met with TAMS vendor to discuss feasibility

Initial Design and Testing



General Testing Protocol

- Iterative testing with workers across multiple MN truck stations
- The researchers asked users to input either:
  1. Self-generated scenario and 4 researcher-written scenarios, or
  2. Video recordings of actual intrusions on Minnesota work zones
- Workers were asked to “think aloud”
  - Provide feedback about any positive or confusing features of the work flow and system design
- Measures
  - Time to complete the reports
  - Usability Scale *(SUS; Brooke, 1986)*
  - Other questionnaires
  - Series of interview questions for areas for improvement

Critical User Feedback

- The interface had to be **available on-site**
- The interface was **easy to quickly open**
- ***Employees needed to feel like the data they were entering was going to actually be seen and analyzed***

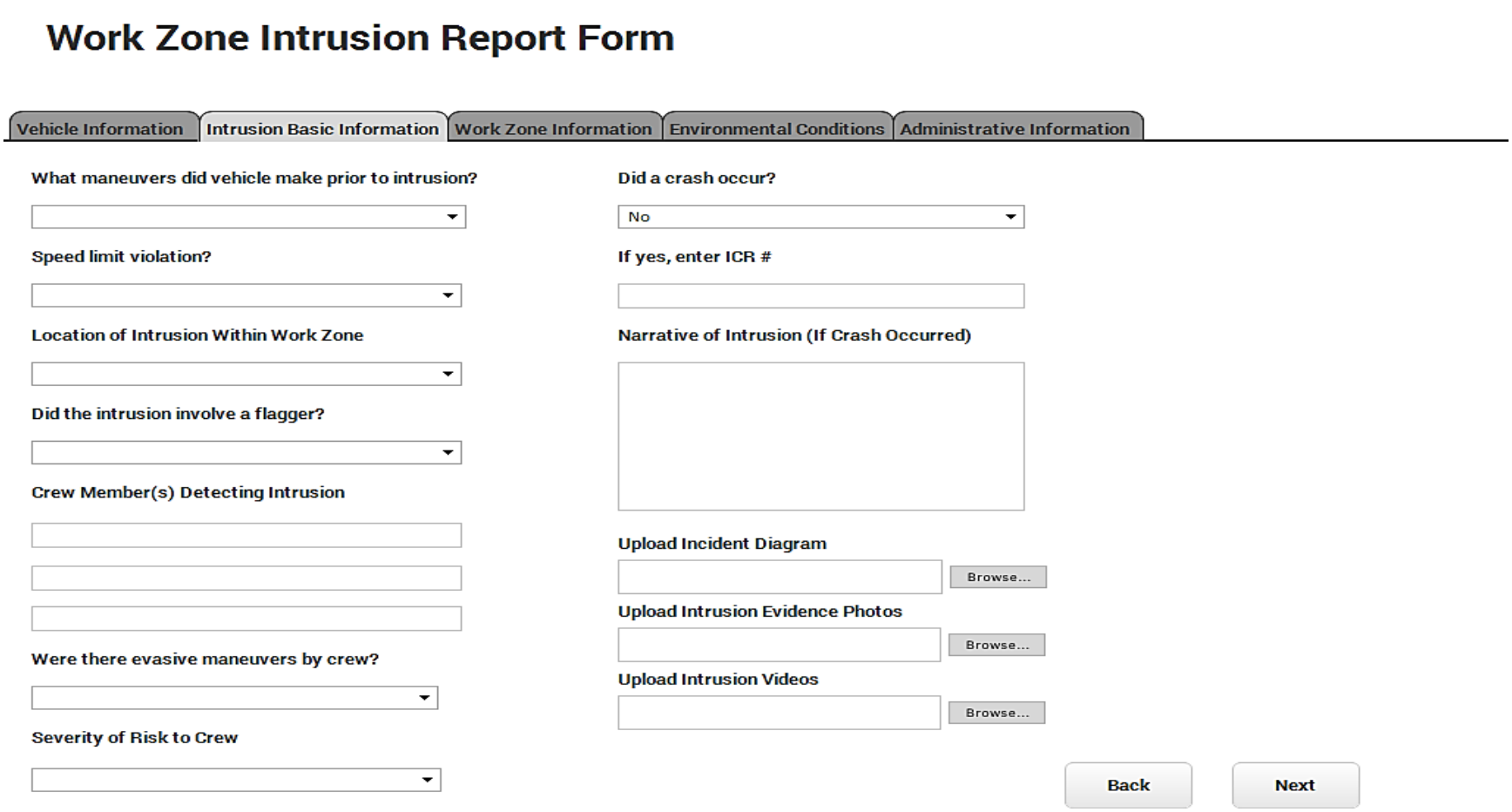
Creating a Standalone Report

- TAMS
  - User interface does not meet minimal standards of usability
  - Cluttered displays and small buttons
  - Limited to supervisor use off-site
- Design was redirected to function as a standalone document, not relying on other data capture
  - **Limitation**: does not work to address redundancy or automation
  - **Benefit**: can include better standards of usability and design and is more inclusive for all users

User Feedback for Iterative Design

- Vehicle Importance
  - Workers reported a high value in documenting intruding vehicle
  - Short-term memory limitations
- Inside-Out Design
  - Flow of report was redesigned to lead with vehicle information and flow outward to wz information
    - Vehicle→ WZ Event → WZ Location → Environmental conditions → Organizational Information

Revisions and Further Testing I



Revisions and Further Testing I

- The interface design specs were provided to the software programmer and implemented into a beta test version for further testing and revision.
- A paper form was created to mirror the information presentation and flow of the electronic interface.

MnDOT ID _____ Employee Name _____

Supervisor _____ Administrative Unit _____

Intrusion Date & Time _____ Work Request # _____

MnDOT: *Work Zone Intrusion Report*

Vehicle Information

License Plate: _____ **Description of Driver/Vehicle:** _____

Vehicle Type: _____

Vehicle Color: _____

Intrusion

Vehicle Maneuver Prior to Crash _____

Speed Limit Violation? ☐ Yes ☐ No ☐ Unknown

Flagger Involved? ☐ Yes ☐ No ☐ Unknown

Crew Evasive Maneuvers? ☐ Yes ☐ No ☐ Unknown

Crash Occur? ☐ Yes ☐ No

Location of Intrusion
- ☐ Taper
- ☐ Activity Area
- ☐ Advance Warning
- ☐ Termination
- ☐ Unknown

Risk to Crew?
- ☐ None
- ☐ Mild
- ☐ Moderate
- ☐ Severe

Narrative: _____

State Patrol ID (if crash) _____

Crew Witnessed: _____

Work Zone

Layout Type: _____

(ex. 6K – 65, Exit Loop Closure)

Layout Modification? ☐ Yes ☐ No

If yes, please describe:

_____

Location of Layout:
- ☐ Right Shoulder
- ☐ Right Lane
- ☐ Multiple Lanes (Right)
- ☐ Center Lane(s)
- ☐ Multiple Lanes (Left)
- ☐ Left Lane
- ☐ Left Shoulder

Location and Environment

Route: _____

Mile Post: _____

Work Zone Speed Limit: _____

Road Alignment: ☐ Straight ☐ Curve Lt ☐ Curve Rt

Road Grade: ☐ Level ☐ Hillcrest ☐ Sag (bottom) ☐ Uphill ☐ Downhill

Road Condition: _____

Glare Conditions (sun)? ☐ Yes ☐ No

Road Type:
- ☐ Intersection
- ☐ 2-way Undivided
- ☐ 2-way Unprotect. Med.
- ☐ 2-way Med. Barrier
- ☐ One-way
- ☐ Intersection
- ☐ Entry / Exit Ramp
- ☐ Intersection
- ☐ Driveway
- ☐ Railroad Crossing
- ☐ Other

Weather:
- ☐ Clear
- ☐ Cloudy
- ☐ Fog/Smog/Smoke
- ☐ Rain
- ☐ Sleet/Hail
- ☐ Snow
- ☐ Severe Crosswinds
- ☐ Blowing Sand/Oil/Dirt
- ☐ Unknown

Lighting Conditions:
- ☐ Daylight
- ☐ Sunrise/Dawn
- ☐ Sunset/Evening
- ☐ Dark w/ Streetlights
- ☐ Dark w/ No Streetlights
- ☐ Dark Lighting Unknown
- ☐ Unknown

Signature: _____

Date: _____

Revisions and Further Testing I

- The average time for completion of the first report:
  - **6 minutes and 18 seconds**
- The average time for completion of the second report:
  - **3 minutes and 9.3 seconds**

	Average
Information Entered Accurately	3.75 out of 5
Confidence While Using Form	4.50 out of 5
Interface Has Annoying Features	2.25 out of 5
Overall User-Friendliness	5.50 out of 7

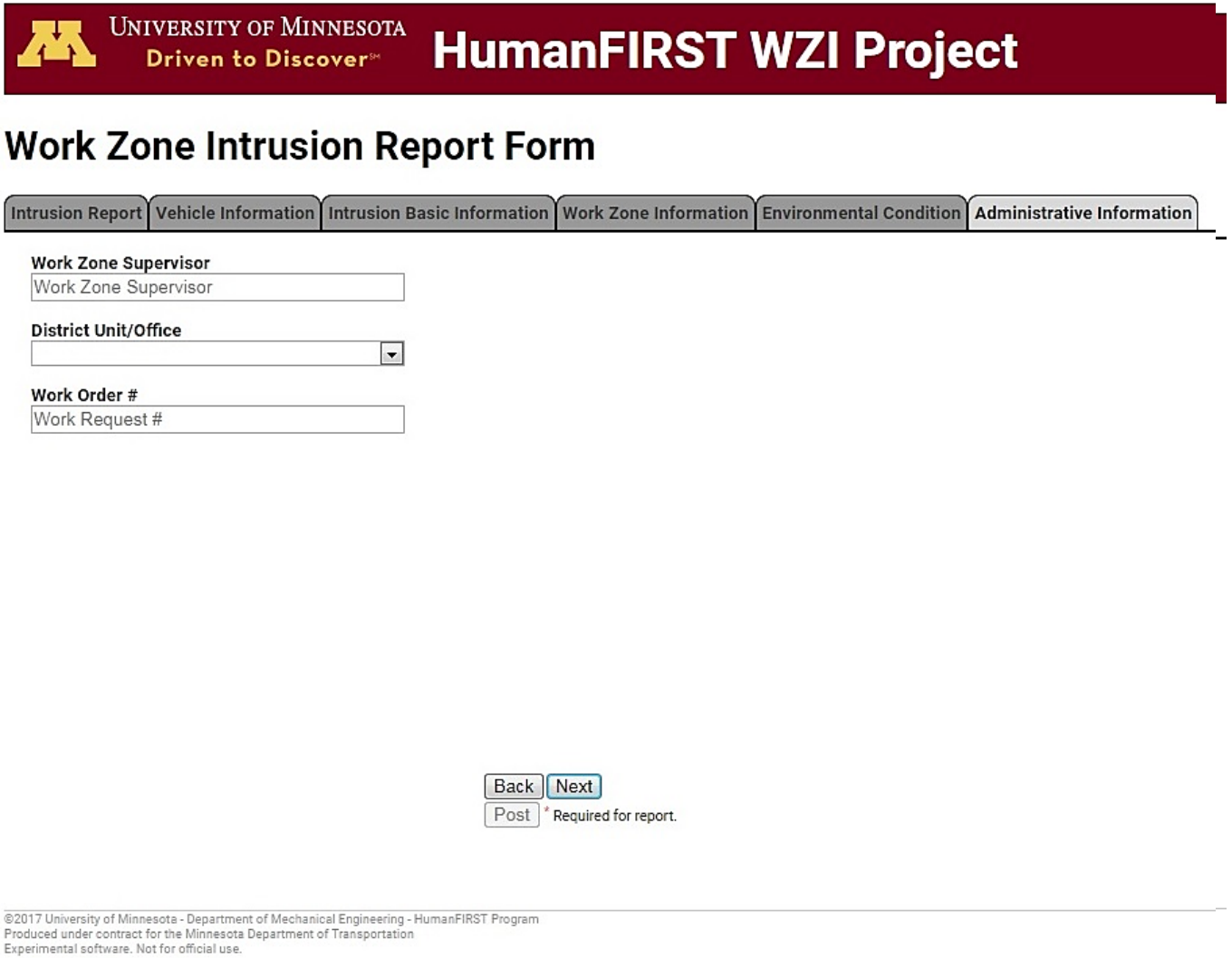
Takeaway from 2nd Testing Phase

- Most popular features: **drop-down menus** and the **comprehensiveness** of the form.
  - This allows for quick use of the form and the ability to enter in and report most useful points of data about a work zone intrusion.
- Least popular features: Reporting minor intrusions **not consider a risk to crew**
  - Especially if the supervisor **could not** fill out a form on site with a **portable electronic device**
- Reported discomfort with reporting **speed limit violation**, did not feel confident in speed limit violations reporting accuracy
- Desire for **clear explanation of the rationale** for the form when the final version is rolled out
  - Provide motivation for filling work zone intrusion reports, ***especially minor ones***

Minor vs Major Reporting

- Research team worked with TAP to address minor intrusion reporting concerns
- Created an adaptable form to allow minor vs major intrusion form based on 3 criteria:
  1. **Did the intrusion involve a flagger?**
  2. **Did the intrusion require evasive maneuver by crew?**
  3. **What was the severity of risk to crew?**

Initial Revisions to Beta Design



Revisions and Further Testing III

- The research team at HumanFIRST followed up the initial redesigns to the beta website and paper prototype with
  - Conducted user testing with MnDOT management and work crews/supervisors of minor/major format
  - User testing the different modes of the interface by testing with a laptop, a tablet, and the paper form

Revisions and Further Testing III

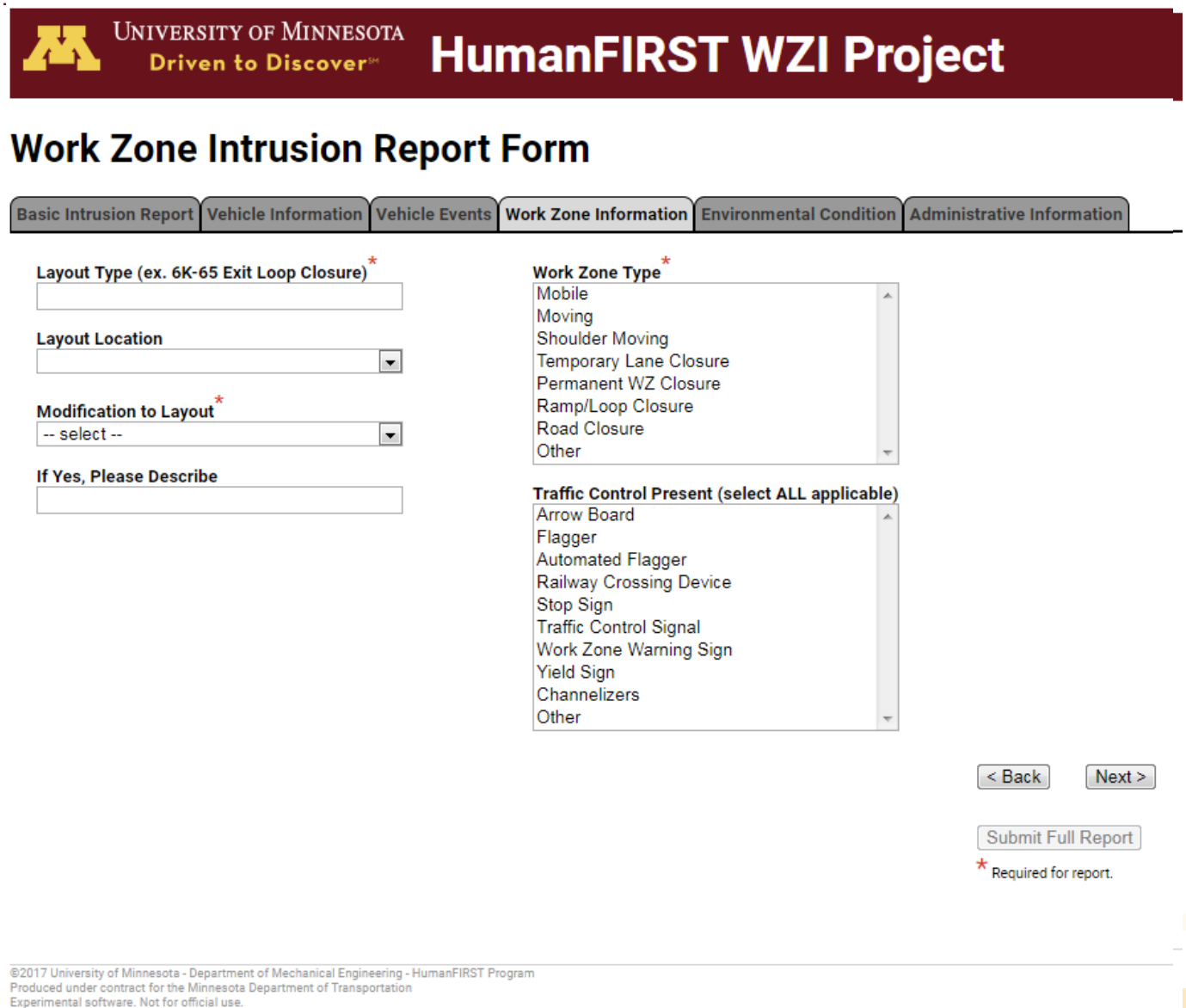
	Laptop	Tablet	Paper Form
SUS	71.67	63.33	65
RSME	38	54	46.5
Completion Time (min.)	5:30	7:22	5:27

	Laptop	Tablet	Paper
1. Information Entered Accurately	4.5	4	4
2. Confidence While Using Form	4.5	4	4
3. Interface Has Annoying Features	3	2.5	1
4. Overall User-Friendliness	5.5	5	6

Final Design Changes

- Re-order and re-label components of the minor report
  - Minor form $\rightarrow$ Basic Report
  - Major form $\rightarrow$ Full Report
- Modify next buttons
- Reinstate some required fields in major form

Completed Version



Vehicle Details

License Plate: _____ Description of Driver/Vehicle: _____

Vehicle Type: _____ _____

Vehicle Color: _____ _____

Vehicle Maneuvers Prior to Intrusion: _____

Intrusion Details

Was law enforcement called?
☐ Yes ☐ No
If yes, what agency? _____

Reportable crash or injury occur?
☐ Yes ☐ No
If yes, crash report #: _____

Original Witness(es), if known:
_____
_____
_____
_____

Location of Intrusion:
☐ Advance Warning Area
☐ Transition / Taper
☐ Activity Area Buffer
☐ Active Activity Area
☐ Termination
☐ Unknown

Work Zone Details

Layout Type: _____
(ex. 6K-65, Exit Loop Closure)

Layout Modification?
(including additional layout)
☐ Yes ☐ No

If yes, please describe:
_____
_____
_____

Work Zone Type:
☐ Mobile
☐ Moving
☐ Shoulder Moving
☐ Temporary Lane Closure
☐ Permanent WZ Closure
☐ Ramp/Loop Closure
☐ Road Closure

Traffic Control Present:
☐ Flagger
☐ Automated Flagger
☐ Railway Crossing Device
☐ Stop sign
☐ Traffic Control Signal
☐ Work Zone Warning Sign
☐ Yield Sign
☐ Other_____

Roadway Location:
☐ Right Shoulder
☐ Left Shoulder
☐ Right Lane
☐ Left Lane
☐ Center Lane(s)
☐ Multiple Lanes (Right)
☐ Multiple Lanes (Left)

Environment Details

WZ Speed Limit: _____

Road Alignment:
☐ Straight
☐ Curve Lt
☐ Curve Rt

Road Grade:
☐ Level
☐ Hillcrest
☐ Sag (bottom)
☐ Uphill
☐ Downhill

Road Type:
☐ Intersection
☐ 2-way Undivided
☐ 2-way Unprotect. Med.
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Weather:
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☐ Unknown

Lighting Conditions:
☐ Daylight
☐ Sunrise/Dawn
☐ Sunset/Evening
☐ Dark w/ Streetlights
☐ Dark w/ No Streetlights
☐ Dark Lighting Unknown
☐ Unknown

Glare Conditions (sun)?
☐ Yes
☐ No

Road Condition: _____

Signature: _____
Date: _____

Comments & Recommendations

- Understanding the user, the task, and iterative user testing is key for creating a highly usable interface
- Further success with the interface requires sustained engagement from management with workers and crew
  - Rationale for interface, feedback with data, “what is being done?”

Barriers for Success

- Reporting work zone intrusions, **especially minor ones**, is seen as a low priority by many supervisors and workers
  - *"just another report for the pencil-pushers that doesn't change anything"*
- Paper forms had high degree of user satisfaction but **must be converted into digital format**
  - Paper data perceived to "collect[s] dust in a locked storage room"

Safety Culture Challenge

- Workers see severe intrusions as a serious threat to their work and personal safety
- They will support and provide buy-in on providing this data if their efforts are matched
- MnDOT must follow through to demonstrate that the data is being analyzed on an on-going basis
- Crewmembers must receive feedback on data trends and policy/procedural changes which are the direct result of the data captured

Thank you!

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