Computerized Crash Reports
Usability and Design Investigation

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Kathleen Haney
Human Factors Overview

• Human factors psychologists study human capabilities and limitations
• Apply knowledge to systems and environments
  – Enhance human performance
  – Minimize error
  – Multidisciplinary approach
• Why do we need Human Factors?
  – Increased system complexity
  – Cost of redesign is extremely costly
I apologize for being too stupid to print a state report.
Project Objectives

• Design and create a crash report interface that improves accuracy, speed, reliability, and meaningfulness of crash report data
  
  o Utilize Human Factors analyses and principles
  o Capitalize on the experience and expertise of law enforcement
Phase 1: Human Factors Analysis

- Assess existing crash report using HF principles to address human and system performance issues
  - Hierarchical Task Analysis
  - Cognitive Walkthrough Analyses
  - Interviews
  - Card Sorting Tasks
  - Survey
Hierarchical Task Analysis (HTA)

- HTA is a systematic process of examining tasks
  - Analysis of plans, goals, and sub-goals

0. Document Motor Vehicle Crash

1. Complete MN Crash Report

1.1 Enter officer information
   - 1.1.1 Enter the Local Case #
   - 1.1.2 Enter Officer Name
   - 1.1.3 Enter Rank
   - 1.1.4 Select agency Type
   - 1.1.5 Enter Badge #
   - 1.1.6 Enter State Patrol STA#

1.2 Locate Crash

Plan 0: 1-then, if death occurs within 30 days of crash--2

Plan 1: 1-2-3. Then 4 and/or 5 as appropriate

Plan 1.1: 1 to 5. Then, if state patrol-6

Plan 1.2: 1—2. Then, if crash occurred on a divided highway—3. Then, if state patrol—4; otherwise 5 or 6 as appropriate—then 7. Then 8—9.
HTA Results

• The HTA describes the tasks shared between the user and the system
  – There are up to 175 steps in total
  – Division of responsibilities between the user and the system is 151:24

• The goal of future iterations of the crash report will be to shift more responsibilities to the system
Phase 1: Human Factors Analysis

• Cognitive Walkthrough Analyses
  – Evaluate current user interface usability
  – Identify goals: are the actions correct?
  – Assess validity and reliability

• Interviews
  – Sampled 12 officers from 7 different agencies with 1-20+ years of experience

• Card sorting
  – 167 officers from 68 law enforcement agencies participated
    • 57 Police departments, 10 Sheriff’s departments, and Minnesota State Patrol
  – Determined new logical grouping and organization of items in report
Validity & Reliability Issues

• Hit & Run or Parked Vehicles
  – Elements under-used, required for accurate entry of other required elements

• Sequence of Events
  – Unclear inclusion of *Collision with* “Motor Vehicle in Transport”
  – Non-collision events under utilized
Other Issues Impeding Complete Data

• Court implications
  – Officers are hesitant to include factors they cannot prove in court
  – Crash report is inadmissible in MN courts
    • “Defense attorneys use it all of the time”

• Reconstruction constraints
  – Officers are hesitant to contradict findings of a reconstruction report
  – Think reconstruction report will “fill in” missing data they left out or were unsure about
Graphical depiction of one possible organization of the items within the crash report. Organization is based upon card sorting analyses and cognitive walkthroughs.
HF Design Outcomes

• Users preferred a one-to-many structure and ordering
Phase 2: Design & Usability Testing

• Aim: Build a mock-up crash report based on the findings and recommendations of the HTA, card sorting, and cognitive walkthrough analysis

• Test law enforcement on mock report
  – Assess error rate, subjective usability and acceptance, and mental demand
  – Shift responsibilities from user to the system
Decision Aids

- Embedded hyperlinks and information bubbles
Decision Aids

State of Minnesota Traffic Crash Report

Unit 1:
1st Event 2nd Event 3rd Event 4th Event

What was the 1st event that happened to unit 1?

- Lane Departure or Non-Collision
  - Ran Off Roadway Right
  - Ran Off Roadway Left
  - Cross Median
  - Cross Centerline
  - Reentering Roadway
  - Separation of Units
  - Downhill Runaway
  - Overturn/Rollover
  - Fire/Explosion
  - Immersion (Full or Partial)
  - Jackknife
  - Cargo/Equipment Loss or Shift
  - Fell/Jumped From Motor Vehicle
  - Thrown or Falling Object
  - Other Non-Collision
Outcomes

• Conducted iterative usability testing with 41 law enforcement officers (varied age, rank, and experience)
  • 23 agencies
• High User Preference
  – Most users preferred the new system to the existing system
  – Rated new interface with high usability, low mental workload
  – Simple 2-unit crash took approximately 15 min on first exposure
• Shift of Responsibilities: 165 user; 174 system
  – Nearly 1:1 ratio!
  – Remarkable given increase in new fields via improved MMUCC compliance
Final Product Testing

• Collaborated with Appriss to ensure interface designs were fully implemented
  – Quality control, Beta Testing, User Acceptance Testing

• Continued usability testing to guide final modifications
  – 2 final rounds of testing of final report platforms
  – 18 law enforcement officers (9 agencies)
    • Recommended final design modifications to resolve any observed errors, confusion, or frustrations
MNCrash Usability vs Data Quality

• Where are we now?
  – Positive feedback!

• MNCrash considered a user-friendly product
  made with the officer in mind
  – BUT...did we improve data quality??
  – Crash data audit
    • Examine converted data
    • Determine the reliability and validity of new crash data
    • Make new recommendations for improvement
Crash Data Audit Purpose

- Determine the extent to which the MNCrash reporting system improved data quality characteristics, compared to the legacy system
- Mixed-Methods Qualitative Analysis 2015 vs 2016
  - Method 1: Validity, Consistency, and Verifiability
    - Review of 720 narratives
    - Compared to form fields
  - Method 2: Completeness and Accuracy
    - Review of form fields
    - Compared based on business rule violations
Method 1: Validity, Consistency, and Verifiability

- Leverage officer recorded narrative as “gold standard” for crash events
- Compare form fields to narrative
  - Matching information
    - Same information in form and narrative
  - Mismatching information
    - Conflicting information in form and narrative
  - Missing information
    - Information in narrative but not in form
Stratified Crash Report Sample

Crash Data (April-Dec)

2015

Fatal Crash

Single Unit Crash

2-Unit Crash

Pedestrian/Bike Crash

Serious Injury

2016

Fatal Crash

Single Unit Crash

2-Unit Crash

Pedestrian/Bike Crash

Serious Injury

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Stratified Crash Report Sample

Agency Sample

- Minnesota State Patrol
- High Volume Reporting Agencies
- Low Volume Reporting Agencies
## Crash Sample Stratification

<table>
<thead>
<tr>
<th></th>
<th>2015 (April-Dec)</th>
<th>2016 (April-Dec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fatal Crash (K)</td>
<td>Serious Injury (A)</td>
</tr>
<tr>
<td><strong>Single-Unit Crash</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Patrol</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td>High Volume Reporting Agency</td>
<td>10</td>
<td>38</td>
</tr>
<tr>
<td>Low Volume Reporting Agency</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td><strong>Two-Unit Crash</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Patrol</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>High Volume Reporting Agency</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Low Volume Reporting Agency</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td><strong>Pedestrian/Cyclist Crash</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Patrol</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>High Volume Reporting Agency</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Low Volume Reporting Agency</td>
<td>5</td>
<td>19</td>
</tr>
</tbody>
</table>
Coding Methodology

• Researchers first coded all form items into Excel coding tool

• Separately, *without examining form items*, coded all information in narrative into coding tool

• Codebook automatically record all instances of:
  – Mismatching data, missing form data, and matching data
## Missing Data by Reporting Agency

<table>
<thead>
<tr>
<th>Agency</th>
<th>Severe Injury (A)</th>
<th>Fatal Injury (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Patrol</td>
<td>3.28% increase **</td>
<td>6.42% increase **</td>
</tr>
<tr>
<td>High Volume Reporting Agency</td>
<td>2.63% increase **</td>
<td>1.27% increase</td>
</tr>
<tr>
<td>Low Volume Reporting Agency</td>
<td>1.45% increase</td>
<td>4.07% increase **</td>
</tr>
</tbody>
</table>

* = < .05; ** = < .01
# Mismatching by Reporting Agency

<table>
<thead>
<tr>
<th>Mismatching Data</th>
<th>Severe Injury (A)</th>
<th>Fatal Injury (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Patrol</td>
<td>1.62% decrease</td>
<td>0.57% decrease</td>
</tr>
<tr>
<td>High Volume</td>
<td>5.41% decrease **</td>
<td>5.95% decrease **</td>
</tr>
<tr>
<td>Reporting Agency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Volume</td>
<td>5.26% decrease **</td>
<td>0.10% decrease</td>
</tr>
<tr>
<td>Reporting Agency</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = < .05; ** = < .01
Year-to-Year Totals

<table>
<thead>
<tr>
<th></th>
<th>Missing Data</th>
<th>Mismatching Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe Injury (A)</td>
<td>2.4% increase in 2016**</td>
<td>4.72% decrease in 2016 **</td>
</tr>
<tr>
<td>Fatal Injury (K)</td>
<td>4.06% increase in 2016 **</td>
<td>2.02% decrease in 2016</td>
</tr>
</tbody>
</table>

* = < .05; ** = < .01
Qualitative Analysis 1 Summary

• State patrol tends to have the most accurate and complete data followed by high then low volume reporting agencies

• Data completeness initially seems lowered, but we are now capturing ~double the overall amount of data per crash report

• Data accuracy has significantly improved in nearly every category

• Increased accuracy and capture provide clearer picture about what is happening in crashes on Minnesota roadways
Method 2: Overall Data Completeness and Improvement

- Examine larger data sets and test data against business rules for data entry
- Examined specific design features of the new MNCrash system for data improvement
## Sample by Year and Agency

<table>
<thead>
<tr>
<th>Total Observed</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crashes</td>
<td>996</td>
<td>1,572</td>
</tr>
<tr>
<td>Persons</td>
<td>2,260</td>
<td>3,356</td>
</tr>
<tr>
<td>Vehicles</td>
<td>1,571</td>
<td>2,198</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Agency</th>
<th>2015</th>
<th></th>
<th></th>
<th>2016</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crashes</td>
<td>Persons</td>
<td>Vehicles</td>
<td>Crashes</td>
<td>Persons</td>
<td>Vehicles</td>
</tr>
<tr>
<td>MSP</td>
<td>330</td>
<td>823</td>
<td>523</td>
<td>374</td>
<td>905</td>
<td>573</td>
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<tr>
<td>500+</td>
<td>208</td>
<td>507</td>
<td>367</td>
<td>414</td>
<td>901</td>
<td>577</td>
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<tr>
<td>&lt; 500</td>
<td>458</td>
<td>930</td>
<td>681</td>
<td>784</td>
<td>1,550</td>
<td>1,048</td>
</tr>
<tr>
<td>Total</td>
<td>996</td>
<td>2,260</td>
<td>1,571</td>
<td>1,572</td>
<td>3,356</td>
<td>2,198</td>
</tr>
</tbody>
</table>
Completeness Analysis

• Missing:
  – No input or data entry in field
  – Unknown if it was intentional or erroneous omission

• Unknown
  – Officer is aware of what information is requested but does not have the information (e.g. driver fled scene and vehicle make unknown)

• Other
  – Selected when the options supplied do not apply.
  – In some items, officers were provided an open text entry field to input their own attribute to specify which ‘other’ had occurred

• Not Applicable
  – Inputted due to conditional logic for data points that are not applicable to the crash (e.g., no work zone-related data if the crash did not occur in a work zone).
Conditional Skip Logic
Reduced Data: Missing Analysis

- All year to year differences are statistically significant.
“Not Applicable” by Year and Data Type

Not Applicable Data Entry

Crash | Person | Vehicle
---|---|---
0.5% | 0.3% | 0.2%

2015 | 2016
“Other” by Year and Data Type

Other Data Entry

- Crash
- Person
- Vehicle

Year: 2015 vs. 2016
Sequence of Events

State of Minnesota Traffic Crash Report

Unit 1:
1st Event
2nd Event
3rd Event
4th Event

What was the 1st event that happened to unit 1?

- Lane Departure or Non-Collision
- Collision w/ Non-Fixed Object
- Collision w/ Fixed Object
- Ran Off Roadway Right
- Ran Off Roadway Left
- Cross Median
- Cross Centerline
- Reentering Roadway
- Separation of Units
- Downhill Runaway
- Overtake/Rollover
- Fire/Explosion
- Immersion (Full or Partial)
- Jackknife
- Cargo/Equipment Loss or Shift
- Fell/Jumped From Motor Vehicle
- Thrown or Falling Object
- Other Non-Collision
## Collision With MV

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th># of MVs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1</td>
<td>249</td>
<td>1,006</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>24</td>
<td>74</td>
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<td></td>
<td>3</td>
<td>11</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>293</td>
<td>853</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th># of MVs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>1</td>
<td>60</td>
<td>1,238</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>66</td>
<td>1,380</td>
</tr>
</tbody>
</table>

Collisions with MV in Transport

Statistically significant, $\chi^2 (1, N=2,526) = 221.83$, $p < 0.0001$
Angle of Impact/Manner of Collision

Single-Unit Manner of Collision Entries

Statistically significant, $\chi^2 (1, N=1,660) = 1560.94, p < 0.0001$
Motorcycles
Motorcycle Ejection

Motorcycle Ejection Errors

<table>
<thead>
<tr>
<th>Year</th>
<th>Error</th>
<th>Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>2016</td>
<td>100%</td>
<td>0%</td>
</tr>
</tbody>
</table>

statistically significant, $\chi^2 (1, N=2,526) = 221.83, p < 0.0001$
Non-collision Event Reporting

Non-Collision in 1\textsuperscript{st} Event

- 2015: 9%
- 2016: 15%

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Driven to Discover

Roadway Safety Institute
Next Steps

• Continue iterative usability testing and design to address confusing, frustrating segments in the report
  – Make recommendations for improvements
  – Already addressed time widget rounding issues
• Develop enhanced training tools
• Create new decision aids
  – Injury and damage aids
CRASH REPORTING Tips, Tricks, & Myths

COMPLETE
Don't hold back information! Describing the ENTIRE sequence of events leading up to the crash in data format is critical to understanding how crashes tend to occur across the state!

PARKING
Parking lot crashes are not reportable crashes for the state of Minnesota. If you wish to use MNCrash to document them, be sure to select parking lot in "location relative to trafficway".

PROPERTY
Documenting public or private property is an important part of crash reporting, but privately owned or publicly owned vehicles do not qualify as property in this sense.

HYPERLINKS
Click on blue text throughout the report. They will open boxes that contain useful definitions and business rules that may reduce uncertainty for what you are being asked.

SHORT CUTS
Use short cuts such as "Same as Owner", "Same as Unit 1" and MnFILL to help the report auto-populate information for you.

KEYSTROKES
Save time by using keystrokes instead of your mouse. You can navigate most of the report through the use of the Tab, arrows, and Enter keys.

MNCrash Tips & Tricks

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ROADWAY SAFETY INSTITUTE
CRASH REPORTING
Tips, Tricks, & Myths

**MYTH #1**
Crash reports are just for insurance companies

**FACT**
Crash reports have the power to save lives!

**MYTH #2**
Important details will be figured out by the reconstruction team

**FACT**
Reconstruction reports never add information to a state crash report!

**MYTH #3**
Crash report details need evidence

**FACT**
Crash reports should provide your best guess

---

The state’s crash report is inadmissible in court for the explicit reason that crash data supports safety first and isn’t hindered by the burden of proof!
CRASH REPORTING Narrative Tips

**VEHICLE INFO**
First state the vehicle(s) direction, position, and roadway/intersection location.

**SEQUENCE OF EVENTS**
Sequentially state ALL events that led up to and following the crash for the vehicle(s) including the manner of collision if more than one motor vehicle was involved.

**CRASH LOCATION**
Describe where on the roadway the crash occurred as well as where the final resting point of the vehicle(s)

---

**4 DRIVER(S) FACTORS**
List any contributing factors to the crash including driver physical condition if pertinent

**ROADWAY FACTORS**
Briefly describe the roadway conditions as well as the weather if it may have played a role in the crash

**OCCUPANT INFORMATION**
Without using personal descriptors, list if any occupants were ticketed, injured or killed

**FORM CLARIFICATION**
Be sure to elaborate on any instances from the crash report form where the officer selected ‘Other’ or ‘Unknown.’

Tip: Use mix-case letters, not UPPERCASE!
Acknowledgments

• Research Staff from HumanFIRST Laboratory
  – Andrew Ryan, Jacob Achtemeier, Jennifer Cooper, Alice Ton, David Libby, Colleen Peterson, McKenzie Sheppard
• Minnesota Traffic Records Coordinating Committee
  – Kathleen Haney (MnDPS)
  – Brad Estochen & Katie Fleming (MnDOT)
• Minnesota Crash Data Users Group
  – Nathan Drews
• Minnesota Law Enforcement Agencies:

<table>
<thead>
<tr>
<th>Albany PD</th>
<th>Bloomington PD</th>
<th>Dakota Co. SD</th>
<th>Hopkins PD</th>
<th>Melrose PD</th>
<th>Owatonna PD</th>
<th>Rochester PD</th>
<th>St. Peter PD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple Valley PD</td>
<td>Blue Earth PD</td>
<td>Deephaven PD</td>
<td>La Crescent PD</td>
<td>Metro Transit PD</td>
<td>Park Rapids PD</td>
<td>Roseville PD</td>
<td>Stearns Co. SD</td>
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<tr>
<td>Austin PD</td>
<td>Brainerd PD</td>
<td>Douglas Co. SD</td>
<td>Lake Benton PD</td>
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<td>Saint Peter PD</td>
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<td>So. Lake Minnetonka PD</td>
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<td>New Prague PD</td>
<td>Rice PD</td>
<td>St. Cloud PD</td>
<td>West St. Paul</td>
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<td>Mankato PD</td>
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<td>St. Joseph PD</td>
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<tr>
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<td>Fergus Falls PD</td>
<td>Marshall PD</td>
<td>North Mankato PD</td>
<td>Robbinsdale PD</td>
<td>St. Paul PD</td>
<td>Zumbrota PD</td>
</tr>
</tbody>
</table>
Thank you!
Questions??

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