Integrating Traffic Incident Management Interfaces

Katherine Atwell
University of Maryland,
Baltimore County
Baltimore, USA
katwell@iastate.edu

Christopher Kawell
Samford University
Birmingham, USA
ckawell@iastate.edu

Celia Loya
Texas A&M University
College Station, USA
cloya@iastate.edu

ABSTRACT
Traffic incident managers (TIMs) are the first people to report on an accident or traffic-related incident. Currently fifteen different applications are used to manage traffic incidents by the Iowa Department of Transportation (DoT). This leads to repeating information and frequently switching programs, causing a delayed response time. A task analysis was performed on the TIMs in Iowa DoT, and the results were used to design a new simplified UI. The new UI will undergo usability testing and be compared to the existing system by simulating an incident and measuring the amount of time taken to identify, report, and clear traffic incidents. The UI is expected to reduce the number of clicks, forms, task switching and overall time necessary to respond to an incident. This UI resolves traffic incidents in an efficient manner by providing a consistent and structured environment for TIMs.

AUTHOR KEYWORDS
User interfaces; traffic incident management; machine learning; rapid prototyping; department of transportation; task analysis

ACM CLASSIFICATION KEYWORDS
H.5.2. [Information Interfaces and Presentation]: User Interfaces --- graphical user interfaces; D.2.m [Software Engineering]: Miscellaneous --- rapid prototyping

INTRODUCTION

With the rise of technology in industry, personnel in the workforce find themselves using various pieces of applications and software. For many, these applications are numerous and often created by different software companies. Thus, switching between several applications often requires workers to operate various user interfaces (UI) that all have different design structures and layouts. This disconnect between user and software creates usability issues for the operator, which can confuse the worker and decrease productivity [4].

One area where these issues are present is in the field of traffic incident management. Traffic Incident Managers (TIMs) are tasked with monitoring and managing traffic incidents [2]. Thus, TIMs must perform numerous tasks and handle considerable amounts of data. This includes scanning for incidents, filling out reports, updating higher-ups, and dispatching emergency vehicles. Choi, Taib, Shi, and Chen (2007) describe the job of a TIM as complicated and hectic, with phone calls, video feeds, and numerous monitors compelling them to respond to varying types of visual and auditory information. At the same time, Choi et al explain that TIMs must cope with numerous software applications with varying user interfaces [3].

This lack of a unified software is evident in the Traffic Management Center at the Iowa Department of Transportation (DoT). At Iowa DoT, the TIMs currently use over fifteen different applications to identify, report, and manage traffic incidents. A task analysis on these TIMs' systems revealed high visual, auditory, cognitive, and psychomotor (VACP) values [insert reference im press Quinn's paper] which demonstrates the high mental workload sustained by the TIMs. These applications were not designed to work together, and often overlap in their functionality. The current system is therefore not intuitive and provides extraneous and repetitious information to the users.

The difficulties plaguing traffic management are far more reaching than Iowa DoT; traffic management in the United States as a whole is becoming increasingly difficult. According to the Texas A&M Transportation Institute (TTI), in 2014 congestion in urban areas forced drivers to travel nearly 7 billion additional hours, with a total congestion cost of $160 billion. The TTI warned that congestion will continue to worsen if no improvements are made to traffic management [1]. Thus, if congestion issues are to improve, enhancements must be implemented into the areas of the traffic system where they will be most effective, and Traffic Incident Management is one such area.

In the past, reducing these congestion issues would mean creating new roadways or adding lanes to existing roads. However, expanding roadways has become increasingly

Figure 1. The five steps of a Traffic Incident Manager when responding to an incident

difficult [5]. Instead, creating a new single user interface (UI) that manages traffic will increase the ability of the system to adapt to the growing population and lessen the complexity of the current systems that TIMs use.

By creating a UI that unifies all the necessary functionality and incorporates modern innovations such as machine learning, issues currently faced by TIMs will be alleviated. The new UI will reduce mental workload, allow TIMs to more effectively interact with the human-computer system, and ultimately streamline the process of traffic incident management.

This work is part of a multi-phase project called Traffic Incident Management Enabled by Large-Data Innovations (TIMELI), which is working to address the issues with Iowa DoT by delivering a unified software for the TIMs that incorporates machine learning. Currently the project is in Phase 1 in which the TIMs' functional requirements are defined by a task analysis and a prototype design is created to test the usability of its UI. Future work will include Phase 2, the development of a functioning prototype that integrates machine learning. Phase 3 will involve testing, evaluating and integrating the prototype.

The following paragraphs, begin by describing the duties of the TIMs and explaining the tasks they must perform. Related works are then discussed and how they influenced design choices, and from there the methods for creating and testing our UI are outlined.

BACKGROUND

Traffic Management Centers (TMCs) are the central hub for monitoring and managing traffic [2]. TMCs are operated by TIMs who monitor roadways while scanning for issues in the flow of traffic, such as stalled vehicles, wrecks, and debris. TIMs are tasked with maintaining and reinstituting steady traffic flow through five main steps, outlined by Carson (2010). These steps are: (1) detecting and verifying an incident, (2) relaying traveler information, (3) responding to the incident, (4) manage the scene and the traffic implications, and (5) incident clearance [7] (Figure 1). If TIMs can effectively and quickly clear traffic incidents from roadways, the safety of motorists and crash victims is protected and congestion decreases [8].

Detection and Verification

Incident detection is the identification of the type and location of a traffic event by bystanders, traffic personnel, or artificial intelligence [7]. There can be many problems such as, "inconsistent notification," when the traffic personnel does not relay correct information, or "dispatcher overload", when many witnesses call and report an incident at once [8]. Even among those TMCs which use automatic incident detection (AID) algorithms to detect incidents, there are often issues with excessive false alarms or low detection rates. A survey by Williams and Guin (2007) of 32 nationwide TMCs, 12.5% reported having an operational AID algorithm. The most common reasons cited for not using an AID algorithm were high false alarm rates, the process of algorithm calibration, and detection rates [9].

After an incident is detected, the TIMs must verify its location and information. Verification of the incident is the confirmation of the detected location and type of incident [7]. This step requires the TIM to visually identify the incident on traffic cameras or verbally confirm the incident with dispatched personnel [8].

Traveler Information

In this step it is critical that TIMs inform the public about the incident to prevent an increase of traffic congestion [8]. Dynamic Message Signs (DMSes) and 511 systems are often used as part of this step (Figure 2). This can be challenging if DMSes or online databases are incorrectly filled out [6, 7, 8]. Iowa DoT uses DMSes, Iowa 511, and Iowa 511's corresponding traveller information website [40] in order to relay traffic information to the general public.

Response

Response to the incident involves sending resources and traffic personnel to the site [7]. There can be issues in completing this step if there is too much or too little deployment of resources, or the response time is too slow [8].

Management

Once highway helpers and first responders have arrived on the scene the incident can be managed accordingly [8]. Issues arise when there is not a clear understanding of leadership, roles, or response plan [8].

Clearance

Incident clearance begins when the authorities on the scene confirm the incident to be cleared. It involves returning the roadway back to the set standards, resetting DMSes, and updating the 511 website [8].

RELATED LITERATURE

To develop the GUI, a comprehensive literature review on multitasking, multiple monitors, UI design principles, and usability was conducted. Interfaces previously designed specifically for TIMs were also looked at.

Figure 2. Example of a Dynamic Message Sign, or DMS board.

Multi-monitors

As the TIMs typically use a display involving three desktop monitors placed side-by-side, the effectiveness of multiple monitors in relation to multitasking was researched. In 2004, a study by Colvin et al was conducted which found that multiple monitor configurations, both dual and three-monitor, increased usability over single monitors [10]. Truemper (2008) supports this conclusion. Truemper also noted that those who used the multiple monitor display were more inclined to multitask, but they performed better when multitasking than those who used a single monitor [11]. Jonathon Grudin suggests that this difference is due to the natural partitioning created by multiple monitor displays, and uses the analogy of a "one-room house" – a single-room house is not as effective for dividing people and tasks as a house with multiple rooms. A multi-room house can be split into the kitchen, living room, etc. Grudin found that users tended to use different screens for different tasks [12], using the screens as a "rooms" to divide up individual tasks. This was important to the design decision of dividing tasks by monitors.

Multitasking

This research adopts the definition of multitasking as switching between multiple tasks simultaneously [29]. Multitasking has been demonstrated to be routine in most workplaces [20]. Many believe this is the best way to complete their work in a timely matter. However, research has shown that multitasking has negative effects on job performance [14, 21, 22, 23], learning [24], attention deficit trait (ADT) [25], productivity [26] and stress [27]. The negative effects of multitasking can be minimized by exploring what causes the inefficiency. Pairdon and Kaufmann (2010) conducted a study that compared the effects of gender and age on multitasking. Neither were found to have a significant effect, but the type of task did have an effect. The findings indicated that if someone worked on a task that did not require all of their attention they would be able to work on a second task simultaneously. However, if both tasks required all of their attention then the task could not be completed [28]. Although multitasking cannot be eliminated it can be presented in a more effective manner [30]. Facilitating effective multitasking guided the design of the new UI presented in this work.

There exists a large body of research on the ability of humans to multitask and the effect of task-switching on prospective memory. Prospective memory involves remembering the tasks needed to complete a certain action - in other words, remembering what one needs to do [13]. O'Connail conducted an observational workplace study which found that 41% of the participants did not resume their current task after an interruption [14].

User experience

When designing the interface, UI design principles were considered. Watzman recommends a simple design and the use of icons and graphics, as well as a grid structure. She also warns against having a lot of saturated color, saving that specifically for parts of the UI that stand out [15]. A 2011 study by Alberts showed that the participants judged blue as the most trustworthy and black as the least trustworthy color [16]. This influenced the researchers' decision to use blue throughout the prototypes. Ferris and Zhang emphasize the utility afforded by color coding, claiming that logical color coding reduced the amount of time and clicks to complete a task [17]. Brown et al found that color and layout adaptations significantly reduce the time and number of clicks for users to complete a task [18].

Usability

The field of usability has been in a rapid growth for the past two decades [37] because of the ability to improve a product with a low cost [38, 39]. IOS 9241 defines usability as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [31]. This research aimed to achieve IOS' standards of usability by creating the user interface based off an iconographic journey map of the TIM's tasks. Nielsen [32] and Shneiderman [33] outline some of the fundamental criterion for usability in user interfaces. Their research suggests that decreasing the amount of information a user needs to memorize their mental workload resulting in a better user experience [34].

Other TIM Studies

Other studies have looked into improving interfaces for traffic incident management. Choi et al. developed two multi-modal user interfaces for use by an Australian TMC. One incorporated a tablet with which the TIMs enter information, and the other used gestural and speech recognition to go through scenarios [3]. Since the TIMs at Iowa DoT do not require handwritten notes like the ones at the Australian TMC, the tablet feature was unnecessary. In addition Iowa DoT does not possess the space or the resources to make the second UI feasible.

The United States Federal Highway Administration conducted a gap analysis on traffic incident management in the U.S. One of the gaps identified was in traffic incident management technology. Specific gaps listed were "aging communications and Intelligent Transportation Systems (ITS) architecture" and "need to identify new technologies and their use in [traffic incident management] (how new technologies can help reduce the time for an investigation of the incident scene)" [19].

Different TMCs have addressed these gaps in different ways. Many studies have looked into automated incident detection systems as a way to manage traffic.

Figure 3. An early sketch (left), followed by a paper prototype (center) and a functional computer prototype (right).

METHODS

Participants

There were a total of four participants from Iowa DoT to aid in analyzing both the new and old software. Of these four, the highest level of education was a bachelor's degree for two and a high school diploma for two. In regards to age, one was in the 18-21 range, two were 22-30, and one was 31-40. All reported near 20-20 vision, and all reported working in teams on a daily basis. Before any research was conducted it was IRB approved.

Task Analysis

From these four participants, over 270 hours of on-the-job video footage was collected. This footage was taken during their shifts and showcased their day-to-day duties. To collect data from these videos, a behavioral coding software called Behavioral Observation Research Interactive Software (BORIS) was used to mark individual events [35]. About eight hours of recording were coded as either "point events" (happens once for a brief period of time) or "state events" (happens over a measured length of time). While point events were marked once when they happened, state events were marked at both their starting and ending points in the video. These coding data made it possible to determine the total amount of time spent preforming individual tasks, as well as generate the number of occurrences of any particular behavior or task.

Using this information, a iconographic journey map was developed to evaluate the TIMs' necessary tasks and current method of completing those tasks (Figures 4, 5).

Prototyping

To design the prototype, the principles of Agile design were followed, which are outlined in Beck 2000 [36]. In keeping with these principles, a new prototype was created once or twice a week, with 7 separate iterations created in total.

Before updating each paper prototype, group members made sketches and plans individually. Then, during scheduled meetings, the group met to discuss the layout and sketch the product. From there, the new paper components were designed and laid out. After gaining feedback about each iteration, the group started work on a new one. In addition, the UI was designed to incorporate machine learning.

After this fine-tuning process was complete, the final prototype was completed on Axure. This prototype then underwent preliminary testing, in which the participants would use the new software and give feedback.

Preliminary Testing

To test this prototype, participants were asked to walk through controlled scenarios using the prototype created in Axure. These scenarios were developed based on the task analysis and existing knowledge of the TIMs' process. Each TIM went through the same scenarios.

In order to test these scenarios, the think-aloud method was used. This method is used as a way to analyze the cognitive processes of someone using this software, and the reasoning behind each decision [41]. The participants used this method while testing the software, and then provided feedback afterwards, which has been shown to provide a holistic description of the process (Jaspers 2004) [42].

As the TIMs were testing this system and working through these scenarios, the time it took to complete the scenario, notes on missteps, errors, and assists, and notes based off the think aloud method were taken. 30-minute interviews were then conducted with each participant to gain feedback on the new system. The questions and responses are detailed below.

RESULTS

(The iconographic journey map showed the TIMs' basic process and the steps required for each part of that process. For instance, during the first part of the process, "Detect Incident", TIMs can find an incident through an alert (via email, highway helper, or police) or through scanning. To scan, they must open ATMS, open a video feed, and manually position the camera. In addition, a list of system requirements was provided for the new software based on this data and Iowa DoT's specifications. This information, as well as the coding data itself, provided knowledge that aided in designing a functional prototype.)

LIMITATIONS

One limitation to this research was the sample size of test subjects. Only four subjects were tested, all from Iowa DoT. This small sample size was largely due to the specificity of the field (only TIMs were eligible), but future research will hopefully involve more TIMs from other states and countries.

Another limitation is that the prototype was not tested on real traffic incidents. The test incidents were designed to mimic actual scenarios, but the research would benefit from analyzing a fully functional UI used by a TIM in his/her real work environment. Future work will accomplish this; the current research is part of a larger, three year project after which a fully functional UI will be implemented at the Iowa TMC.

FUTURE DIRECTIONS

In the future, further usability testing will be performed on this prototype. It will then be updated based on the results of these tests and feedback from the participants. This process will continue until the prototype has undergone its final design change. At this point, a study will be done which evaluates its effectiveness and efficiency compared to the old system. After development for this product is completed, this software will be presented to Iowa DoT for purchase as a replacement of their old systems.

Future research could be done on other TMCs, in which a task analysis could be performed on the TIMs and potential areas of improvement could be identified. In addition, more research could be done on the effectiveness of condensing multiple user interfaces into one. Research could also be conducted on the efficacy of three monitors for traffic incident management, and whether there exists a setup that is more intuitive for the TIMs and increases the ease of multitasking. Furthermore, because TIMs must monitor and manipulate numerous data and preform many computer aided tasks, they are perfect candidates for Human and Computer Interaction (HCI) studies. Thus, more research in the areas of HCI and UI design would benefit from TIM and TMC involvement.

CONCLUSION

Dealing with multiple software packages in the workplace often leads to excessive task-switching and a high mental workload. TIMs often deal with many different software packages which were not designed to work together. Reducing this load through incorporating machine learning and a single unified user interface has the potential to increase the TIMs' efficiency while decreasing their response time at Iowa DoT.

The UI developed was evaluated based on number of errors, total time needed, and the number of steps needed in order to complete a typical traffic incident. Preliminary testing showed few errors when completing the designated scenarios. There was also a time reduction between the initial and final scenarios, although that was likely due to the participant becoming familiar with the new system's functions. Upon performing a task analysis on the new system, it was discovered that the number of steps was significantly reduced from the old system to the new system.

Traffic is a problem in the United States and improving traffic incident management has the potential to reduce traffic costs and even save lives.

ACKNOWLEDGEMENTS

Our research results are based upon work jointly supported by the National Science Foundation Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) program under Grant No. 1632116, National Science Foundation under Grant No. CNS-1464279 and Iowa DOT Office of Traffic Operations Support Grant. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

1. Schrank, D., Eisele, B., Lomax, T., Bak, J. (2015). 2015 urban mobility scorecard, Texas A&M Transportation Institute, INRIX
2. Traffic management Centers (TMCs) – Washington State Department of Transportation. (13-2-2008). Retrieved 7-7-2017, from http://www.wsdot.wa.gov/Operations/Traffic/tmc.htm
3. Choi, E. H. C., Taib, R., Shi, Y., Chen, F. (2007). Multimodal User Interface for Traffic Incident Management in Control Room. The Institution of Engineering and Technology, 1(1), 27-36. 10.1049/eit-its:20060038
4. Usability 101: Introduction to Usability – Nielsen Norman Group. (4-1-2012). Retrieved 17-7-2017, from https://www.nngroup.com/articles/usability-101-introduction-to-usability/
5. Hashemi, H., Abdelghany, K. (2016). Real-time traffic network state estimation and prediction with decision support capabilities: application to integrated corridor management. *Transportation Research Part C, 73,* 128-146. https://doi.org/10.1016/j.trc.2016.10.012
6. Traffic Incident Management – U.S. Department of Transportation. (1-2-2017). Retrieved 19-7-2017, from https://ops.fhwa.dot.gov/eto_tim_pse/about/tim.htm
7. Carson, J. L. (2010). *Best Practices in Traffic Incident Management. Washington, DC*: Federal Highway Administration, Office of Transportation Operations, Emergency Transportation Operations.
8. Olge, J., Huynh, N., Davis, J., Xie, Y. (2017). Integration of the Incident Command System (ICS) Protocol for Effective Coordination of Multi-Agency Response to Traffic Incidents (p. 34-37). Clemson: South Carolina Department of Transportation. Retrieved from http://www.scdot.scltap.org/wp-content/uploads/2017/06/SPR-699-FHWA-SC-17-07.pdf
9. Williams, B.M., Guin, A. (2007). Traffic Management Center Use of Incident Detection Algorithms: Findings of a Nationwide Survey. *IEEE Transactions on Intelligent Transportation*

Systems, 8(2), 351-358. Retrieved from https://doi.org/10.1109/tits.2007.894193

10. Colvin, J., Tolver, N., Anderson, James A. (2004). Productivity and Multi-Screen Computer Displays. Rocky Mountain Communication Review, 2(1), 31-53. http://www.tech-news.com/imagesap/utahdisplaystudy.pdf
11. Truemper, J.M. et al (2008). Usability in Multiple Monitor Displays. The Data Base for Advances in Information Systems, 39(4), 74-89. https://doi.org/10.1145/1453794.1453802
12. Grudin, J. (2000). *Partitioning Digital Worlds: Focal and Peripheral Awareness in Multiple Monitor Use* (Microsoft Research Technical Report No. MSR-TR-2000-94) Microsoft Corporation: Redmond, WA 98052.
13. Ellis, J., Kvavilashvili, l. (2000). Prospective Memory in 2000: Past, Present, and Future Directions. Applied Cognitive Psychology, 14(7), S1-S9.
14. O'Connail, B. & Frohlich, D. (1995). Timespace in the workplace: Dealing with interruptions. CHI '95 Conference on Human Factors in Computing Systems, Extended Abstracts, ACM Press, 262-263.
15. Watzman, S. (2002). Visual Design Principles for Usable Interfaces. The human-computer interaction handbook (pp. 263-285). Hillsdale, NJ: L. Erlbaum Associates Inc.
16. Alberts, W.A., van der Geest, T. (2011). Color matters: color as trustworthiness cue in web sites. Technical Communication, 58(2), 149-160.
17. Ferris, K., Zhang, S. (2016). A Framework for Selecting and Optimizing Color Scheme in Web Design. Proceedings of the 49th Hawaii International Conference on System Sciences (pp. 532-541). http://doi.org/10.1109/HICSS.2016.73
18. Brown, D.C., Burbano, E., Minski, J., Cruz, I.E. (2002). Evaluating Web page color and layout adaptations. IEEE MultiMedia, 9(1), 86-89. http://doi.org/10.1109/93.978356
19. Amer, A., Roberts, E., Mangar, U., Kraft, W., Wanat, J.T., Cusolito, P.C., Hogan, J.R., Zhao, X. (2015). Traffic Incident Management Gap Analysis Primer. Retrieved from https://ops.fhwa.dot.gov/publications/fhwahop15007/index.htm#toc
20. KC, D.S. (2013). Does multitasking improve performance? Evidence from the emergency department. Manufacturing & Service Operations Management, 16(2), 168-183. https://doi.org/10.1287/msom.2013.0464
21. Rogers, R. D., & Monsell, S. (1995). Costs of a predictable switch between simple cognitive tasks. Journal of Experimental Psychology: General, 124(2), 207-231. http://dx.doi.org/10.1037/0096-3445.124.2.207
22. Rubinstein, J. S., Meyer, D. E., & Evans, J. E. (2001). Executive control of cognitive processes in task switching. Journal of Experimental Psychology: Human Perception and Performance, 27(4), 763-797. http://dx.doi.org/10.1037/0096-1523.27.4.763
23. S. Monsell, S. (2003). Task switching. Trends in cognitive sciences, 7(3), 134-140. https://doi.org/10.1016/S1364-6613(03)00028-7
24. Foerde, K., Knowlton, B.J., & Poldrack, R.A. (2006). Modulation of competing memory systems by distraction. Proceedings of the National Academy of Sciences, 103(31), 11778-11783. 10.1073/pnas.0602659103
25. Hallowell, E.M. (2005). Overloaded circuits: Why smart people underperform. Harvard Business Review, 83(1), 55-62.
26. Aral, S., Brynjolfsson, E., & Van Alstyne, M. (2007). Information, technology and information worker productivity: Task level evidence (National Bureau of Economic Research (NBER) Working Paper 13172). 10.3386/w13172
27. Sum, J., Ho, K. (2015). Proceedings from IEEE International Conference on Systems, Man, and Cybernetics. Kowloon, HK: IEEE.
28. Paridon, H. M., & Kaufmann, M. (2010). Multitasking in work-related situations and its relevance for occupational health and safety: Effects on performance, subjective strain and physiological parameters. Europe's Journal of Psychology, 6(4), 110-124.
29. Johnson, P., May, J., & Johnson, H. (2003). Introduction to multiple and collaborative tasks. ACM Transactions on Computer-Human Interaction 10(4), 277-280. 10.1145/966930.966931
30. Otto, S. C., Wahl, K. R., Lefort, C. C., & Frei, W. H. P. (2012). Exploring the impact of multitasking in the workplace. Journal of Business Studies Quarterly, 3(4), 154-162.
31. ISO 9241-11:1998 Ergonomic requirements for office work with visual display terminals (VDTs) -- Part 11: Guidance on usability.
32. Jakob Nielsen and Rolf Molich. 1990. Heuristic evaluation of user interfaces. In Proceedings of the SIGCHI conference on Human factors in computing systems. ACM, 249–256. DOI: http://dx.doi.org/10.1145/97243.97281
33. Ben Shneiderman. 1992. Designing the user interface: strategies for effective human-computer interaction. Vol. 3. Addison-Wesley Reading, MA. 60–63 pages.
34. Lukanov, K., Maior, H. A. & Wilson, M. L. (2016). Proceedings from CHI'16: Conference on

Human Factors in Computing Systems. San Jose, CA: AMC.
35. Friard, O., and Gamba, M. (2016). BORIS: a free, versatile, open-source event-logging software for video/audio coding and live observations. Methods in Ecology and Evolution, 7(11), 1325-1330. doi: 10.1111/2041-210X.12584
36. Beck, K. (2000). Manifesto for Agile Software Development. Retrieved from http://agilemanifesto.org/
37. Stephanidis, C. (Eds.). (2009). The universal access handbook. Boca Raton, FL: Taylor & Francis Group
38. Locascio, J., Khurana, R., He, Y., & Kaye, J. (2016). Utilizing employees as usability participants: exploring when and when not to leverage your coworkers. Computer Human Interactions. 10.1145/2858036.2858047
39. Carol M. Barnum. 2010. Usability Testing Essentials: Ready, Set...Test! Elsevier.
40. Iowa 511. Iowa's 511 Websites and Apps. Retrieved from https://iowadot.gov/511/iowa-s-511-websites-and-apps
41. Fonteyn, M.E., Kruiper, B., Grobe, S.J. (1993). A Description of Think-Aloud Method and Protocol Analysis.