

## **User Interface of Mobile Applications for Railway Transport Operation**

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### **Abstract**

As part of the authors' broader work - the methodology for transport mobile applications designing - this article focuses on the user interface (UI) of mobile applications. When designing UI for applications for rail traffic, functionality and ease of use are essential, and the emphasis is on efficiency over aesthetic design or other features that are not as important for this type of applications. A systematic literature review methodology was used in the development of this paper. The sources of information were mainly Web of Science, Scopus and other scientific literature. The current principles of effective UI, focused on mobile applications, were summarized in the article. The most widely used design systems that are currently used by developers to create applications were described. Finally, the methods used to test the quality of UI were presented. The aim of the research is to provide a basis for establishing uniform recommendations in the development of effective, consistent and user-friendly mobile applications in rail transport operation.

**KEY WORDS:** *mobile apps, user interface, railway, transport*

### **1. Introduction**

With the rapid development of information and mobile technologies, mobile applications have become an integral part of rail transport operation. There are many technologies and approaches to their development. In such a specific area as rail operation, is it possible to create uniform recommendations for mobile app development that will benefit both developers and users? The authors address this idea in the broader context of designing a methodology for developing mobile applications to support rail traffic operation, as mentioned in the research [1].

This article focuses on the user interface (UI) as one of the key features for the usability of the application and its adaptation to the needs of rail transport operation.

The principles that an effective and friendly UI should meet have been investigated in many studies. From this available information, there appear to be requirements that need to be considered when designing a quality UI. The actual development of UI can be directed in several ways - in addition to self-development, existing methodologies - design systems are often used, or UI is developed using user-centered design techniques [2], etc. Analyses have been published that compare the advantages and disadvantages of different approaches, according to which a procedure can be selected according to the needs of a specific mobile application. For the selected and implemented UI solution, it is advisable to perform testing to help the developers identify and correct errors and shortcomings, or modify the application according to the wishes and needs of a specific user group. Different approaches to UI testing have been analysed and compared in comparative studies.

The operation of rail transport has its own specifics, which will of course be reflected in mobile applications. Efficiency and performance of the application is a priority. Therefore, the UI should be adapted to the tasks performed by users, be intuitive and easy to use. The goal is to create an app that enables users to work productively and meets other necessary requirements, including security. It is also advisable for the application to have a unified design and control in important areas, especially if the user is working with multiple applications at their workstation.

The aim of this study was to answer the following questions: what are the key UI parameters and what principles should be met to create an effective and user-friendly mobile application? What technologies are currently used in this area? How to effectively test the quality of UI? The results of this analysis will be further used to inform the design of a more general methodology for the design and development of mobile applications for rail transport operation.

The article first identifies the UI principles that should be met by an efficient and user-friendly application. Then, the development options are mentioned and the most used design systems and their specific features are listed, highlighting the advantages and disadvantages of using them. Furthermore, attention is given to the possibilities of testing the implemented UI.

### **2. Materials and Methods**

This paper uses the systematic literature review methodology described by Durach, Kembro and Wieland in their research [3]. This methodology is based on previous research by Mulrow [4] and serves to achieve transparent and

objective results in the evaluation of selected literature sources. The procedure consists of the following downstream phases:

- Identification of the areas that are the target of the research.
- Establishing detailed objectives and requirements.
- Selection of appropriate scientific sources and databases for collecting information.
- Selective selection of relevant literature sources.
- Analysis of selected articles, searching for connections and common conclusions.
- Presentation of results that includes both quantitative and qualitative aspects and meets the requirements.

The goal of a systematic literature review is to find gaps in existing knowledge, which means identifying a suitable topic that will allow the generation of important conclusions that can provide suggestions for practical implementation, such as methodological improvements or software development. One of the outcomes of this research is also to gain an overview of the subject area.

For the purposes of scientific research, the renowned databases Web of Science and Scopus, which are considered the largest and most frequently used databases of scientific articles in this field, were used. In addition, highly specialised current articles were used as a source of information; their sources are listed in the reference list. Scholarly articles and literature searches from 2017-2023 were included in the selection process. In total, 14 sources were selected for detailed analysis.

First, a thorough analysis of the selected sources was carried out in the context of the focus of the individual journals and their publication in different years. Keywords, references, numbers and quality of citations were examined. Detailed analysis was also focused on the thematic focus of the articles, the methods used and their conclusions.

The results of the systematic literature review showed that the selected issue is very topical in the professional world and the number of publications in this area has increased significantly in recent years. However, it is important to emphasize that the chosen topic is extensive and includes various sub-areas that would require separate research. The authors of the methodology dealt with both qualitative and quantitative processing of the results of the literature review.

### **3. Results**

Designing a suitable UI for a mobile application is one of the key features for its usability. Functionality and ease of use are essential when designing an app for rail operation. Thus, the focus is on the efficiency of the application over aesthetic design or other features that are not as important for this type of applications. The focus of the UI should be on the practical performance of specific tasks (e.g., taking train data, using track schedules, etc.). However, it is still necessary to maintain a certain level of user experience (UX) to make the application usable [5]. However, the situation is different in mobile applications for rail traffic than in traditional commercial applications, where the UI and UX need to be adapted more to the user's taste [6]. It often happens that a user works with several applications at his workstation - unifying their UI would create a coherent user environment, which would lead to an increase in work comfort and thus productivity.

Currently, these applications are mainly run on smartphones and tablets; the full use of their capabilities and advantages can be ensured by designing a responsive UI.

#### **3.1 Principles of effective UI**

The principles that an effective and friendly UI should satisfy have been investigated in many studies, e.g. [7] and [8]; there is also a large number of developer community websites dealing with this topic. In principle, the following areas arise from this available information and need to be considered when designing a good UI:

##### *Minimalistic design*

The minimalist design allows users to easily navigate the app. It allows you to focus on the main functions of the app and avoids unnecessary distractions. In the case of applications used for work purposes, it is not advantageous to use animations, complex graphic elements, etc., which are desirable in applications designed for leisure and entertainment.

##### *Simple navigation*

The navigation menu should be simple and easy to understand. Users should be able to quickly find what they need and easily return to the main screen.

##### *Clear and structured data display*

Since a relatively large amount of data is expected to be displayed in the form of tables, forms, etc., it is important to display it in a clear and structured way so that users can easily read and interpret the information.

##### *Easy to use*

The handling should be simple and intuitive. The controls should be large enough and clearly arranged. One-handed operation is preferred, if this is possible in the context of the task to be performed. For mobile applications for

rail transport operation, the assumption is that they are used in workplaces that are specific in terms of the use of the mobile device - working on the track, at the driver's station, etc., therefore simple and fast operation is essential.

#### *Highlight important elements*

Important elements of the application should be highlighted through the use of colour, size or placement. When there is a need to display a large amount of information on one screen, it may be difficult to display the necessary elements in this way. This is also why it is important to maintain consistency of interface across the application - the user will already be intuitively familiar with the controls and placement of elements and can easily find them on other screens.

#### *Colours*

Colours should be used to support functionality, not as decoration. The text font should be clearly legible and the colour contrasting with the background. The app must be ready to respond to changes in the phone's light mode (light and dark mode) and be readable in all cases.

#### *Responsive design*

The app should be designed to be usable on a variety of devices, especially the aforementioned smartphones and tablets. Ensuring responsiveness is based on a similar principle as with websites - the app detects the current display size and renders the design accordingly.

### **3.2 Design systems**

In addition to developing your own solutions, there are a number of ready-made methodologies - so-called design systems - to ensure the above principles.

- Material Design - a methodology created by Google that focuses on creating a unified and consistent user interface across different platforms. This methodology emphasizes quality graphics, animation, consistency and intuitiveness.
- Human Interface Guidelines (HIG) - are methodologies created by Apple that provide developers with detailed information on user interface design for iOS and macOS. These methodologies focus on simplicity, consistency, intuitiveness, and the use of Apple's default elements.
- Microsoft Fluent Design System - focuses on using motion, depth, and light to create visually rich and intuitive user interfaces that are suitable for all types of devices, including mobile phones.
- Atlassian Design System, IBM Carbon Design System and others.

There are several advantages of using existing design systems. By using an already prepared solution, the development of the mobile application is accelerated and streamlined - the methodology can be used as a whole, there is no need to invent each detail separately. Systems are usually created based on research and testing, which means they are designed to be as intuitive and easy to use as possible for the user - especially in the case of the aforementioned extended methodologies. They are released with comprehensive documentation, so they are relatively easy to implement. In addition, there is a large developer community using these systems that provides support to each other.

If the mobile app needs to be adapted to existing design requirements (e.g. corporate design), it is necessary to evaluate whether it is more advantageous to create your own look and feel or to adapt an existing design system. When attempting to adapt a methodology, there may be certain rules and constraints that will not allow existing elements to be adapted to the exact design or needs desired, or the work would be more challenging than creating a custom look and feel. In the study [9], aspects of using design systems and common problems encountered by developers in implementing them were discussed, including practical examples on specific UI elements. As noted here, to some extent these can be eliminated - the study also provided guidelines and recommendations on how to achieve this. However, it depends on the extent to which existing elements need to be adapted, and an objective assessment of the final benefits of both solution options.

Since mobile apps for rail traffic are very often created for large companies that use the corporate look and feel, this situation is very likely.

### **3.3 UI quality testing**

Testing the user interface of mobile applications is of great importance because it allows developers to identify and correct errors and shortcomings, or to modify the application according to the wishes and needs of a specific group of users. There are various methods to test and evaluate the user interface.

#### *User testing of UI*

It includes processes for user testing, functionality testing and performance testing. These methods allow you to find out how users interact with the application, what their needs and preferences are, and where there is room for improvement.

A useful indicator of a successful mobile app design is the amount and intensity of interactions users have with the app. These indicators can be measured, for example, by analysing data on app usage

#### *Automatic UI testing*

Tests can also be performed through automated tools and scripts, without manual user intervention. This testing is usually done using automated tools and scripts that can simulate user interactions with the application. These tools are usually very effective in testing different scenarios that may be difficult or impossible to test manually. However, automated testing should be complemented by user testing anyway, as not all aspects of the user experience can be automated. An interesting summary of the evolution of automated testing has been described in a research paper [10] that maps approaches to automated AI testing from 2013 to 2021. The paper states that there are three basic approaches in automated testing white-box testing (methodology based on internal structure), black-box testing (methodology based on specification, based on application code) and greybox testing (combination of the previous approaches).

To measure the quality of UI, there are metrics described in study [10] that can help in evaluating the proposed UI. They focus on factors that affect the user experience, such as application responsiveness, ease of use, clarity, etc. They have the advantage of measuring the quality of the UI based on specific and objective indicators, which reduces the subjectivity of the assessment. Preferably, these metrics can also be applied to existing mobile apps - they allow to identify specific areas that need improvement.

For automated testing, mostly existing tools are used, e.g. according to the comparison [12] and description [13] and [14] - Appium, Espresso, Robotium, Testsigma, SelenDroid. There are also several studies that deal with the development of frameworks for specialized purposes. In study [14], a framework based on the use of deep-learning technology is proposed, which is able to perceive the application state through the user interface and automatically generate functional test cases. Such a tool could be suitable, for example, for sophisticated applications with a large amount of functionality.

## **4. Discussion**

Based on the conducted research, the current principles of effective UI focused on mobile applications were summarized. The key points identified were minimalist design, simple navigation, overall UI consistency, clear and structured data display, ease of use, highlighting important controls, and proper color selection to support functionality. The most common design systems currently used by developers in application development were described and their main advantages for application developers were identified - speed and efficiency in development, intuitive use by users, etc. The need to compare the advantages and disadvantages of using a prepared methodology or self-development in the design and development of a specific mobile application was stated. Finally, the importance of UI application testing was explained and the methods by which UI can be tested - user and automated testing - were presented.

These results show that there is currently a wide range of ways to approach UI design. These approaches have different characteristics and each is suited to a particular type of application. Therefore, it is necessary to carefully define the desired characteristics and requirements expected of the UI before selecting the technology to be used for UI design. According to these defined characteristics, only then the selection of the technology can be made.

These findings are important in making recommendations on the appropriate approach for selecting a technology for designing a mobile application for rail traffic operation. Based on the defined requirements for UI, which are mainly efficiency, performance, ease of use and consistency across an application (or multiple applications), a suitable technology can be recommended, an overview of which has been provided.

The research carried out needs to be complemented by a detailed description of the requirements for UI mobile applications for rail traffic, then technologies and procedures can be recommended. Furthermore, it is expected to verify the established procedures and recommendations in the design of a specific mobile application in a real environment of a company designing information systems including mobile applications for rail freight traffic.

## **5. Conclusions**

In conclusion, after examining the available technologies for UI design, it is possible to find uniform recommendations for mobile applications for rail traffic operation. The technologies have quite specialized features among which suitable application specifications for the investigated domain can be found. Recommendations on the choice will therefore depend on the desired characteristics of the UI - efficiency and ease of use, display of the desired data structure, etc.

In the follow-up work, it is advisable to perform the same analysis for other key parameters of mobile applications, which will be the basis for the design of a unified methodology for the design of mobile transport applications. To validate the methodology, it is advisable to design and verify a specific mobile application in a real environment.

## References

1. Šmídová, P. & Machalík, S., 2023. A Background to a Methodology for Transport Mobile Applications Designing with a Focus on EU Interoperability. In *Infrastructures*. p. 14. Available at: <https://www.mdpi.com/2412-3811/8/2/34>.
2. Quezada, P., Cueva, R. & Paz, F., 2021. A Systematic Review of User-Centered Design Techniques Applied to the Design of Mobile Application User Interfaces. In *Design, User Experience, and Usability: UX Research and Design. Lecture Notes in Computer Science*. Cham: Springer International Publishing, pp. 100-114. Available at: [https://link.springer.com/10.1007/978-3-030-78221-4\\_7](https://link.springer.com/10.1007/978-3-030-78221-4_7) [Accessed April 22, 2023].
3. Durach, C.F.; Kembro, J.; Wieland, A. A New Paradigm for Systematic Literature Reviews in Supply Chain Management. *J. Supply Chain Manag.* 2017, 53, 67–85, doi:10.1111/jscm.12145.
4. Mulrow, C.D. The medical review article: State of the science. *Ann. Intern. Med.* 1987, 106, 485–488, doi: 10.7326/0003-4819-106-3-485.
5. Sandesara, M. et al., 2022. Design and Experience of Mobile Applications: A Pilot Survey. *Mathematics*, 10(14). Available at: <https://www.mdpi.com/2227-7390/10/14/2380> [Accessed March 03, 2023].
6. Pratama, M.A.T. & Cahyadi, A.T., 2020. Effect of User Interface and User Experience on Application Sales. In *IOP Conference Series: Materials Science and Engineering*. Available at: <https://iopscience.iop.org/article/10.1088/1757-899X/879/1/012133> [Accessed March 11, 2023].
7. Jung, W. & Yim, H.R., 2018. An Exploratory Study of the Interface Design Factors Affecting the User Intention to Use Mobile Applications. *International Journal of Advanced Science and Technology*, 119, pp.103-110. Available at: <http://article.nadiapub.com/IJAST/vol119/9.pdf> [Accessed March 08, 2023].
8. Peter Dey, P. et al., 2019. Best Practices for Improving User Interface Design. 10(5), pp.71-83. Available at: <http://airconline.com/ijsea/V10N5/10519ijsea05.pdf> [Accessed March 10, 2023]. Preventing accessibility barriers: Guidelines for using user interface design patterns in mobile applications
9. Nakamura, W.T. et al., 2022. What factors affect the UX in mobile apps? A systematic mapping study on the analysis of app store reviews. *Journal of Systems and Software*, 193. Available at: <https://linkinghub.elsevier.com/retrieve/pii/S0164121222001509> [Accessed March 20, 2023].
10. Samir, A., Amin, H. & Badr, N., 2022. A SURVEY ON AUTOMATED USER INTERFACE TESTING FOR MOBILE APPLICATIONS. *International Journal of Intelligent Computing and Information Sciences*, pp.1-11. Available at: [https://ijicis.journals.ekb.eg/article\\_238148.html](https://ijicis.journals.ekb.eg/article_238148.html) [Accessed May 02, 2023].
11. Chowdhury, A.R., Automation Mobile Testing Frameworks. *Browser Stack*. Available at: <https://www.browserstack.com/guide/mobile-application-testing-frameworks> [Accessed March 20, 2023].
12. Google, Automate UI tests. *Developers*. Available at: <https://developer.android.com/training/testing/instrumented-tests/ui-tests> [Accessed February 14, 2023].
13. Vaiyda, N., <https://www.browserstack.com/guide/how-to-perform-ios-ui-test-automation>. *Browser Stack*. Available at: <https://www.browserstack.com/guide/how-to-perform-ios-ui-test-automation> [Accessed February 10, 2023].
14. Corral, L., Fronza, I. & Mikkonen, T., 2021. User Interface Matters: Analysing the Complexity of Mobile Applications from a Visual Perspective. In *Procedia Computer Science*. pp. 9-16. Available at: <https://linkinghub.elsevier.com/retrieve/pii/S1877050921014356> [Accessed March 03, 2023].
15. Khaliq, Z., Farooq, S.U. & Khan, D.A., 2022. A deep learning-based automated framework for functional User Interface testing. *Information and Software Technology*, 150. Available at: <https://linkinghub.elsevier.com/retrieve/pii/S0950584922001070> [Accessed May 02, 2023].