20th Int. Conf. Accel. Large Exp. Phys. Control Syst. (ICALEPCS'25), Chicago, IL, USA JACoW Publishing
ISBN: 978-3-95450-255-4 ISSN: 2226-0358 doi: 10.18429/JACoW-ICALEPCS2025-MOCR004

IMPLEMENTING DESIGN PRINCIPLES IN THE ROCK-IT GUIs: A UI/UX DEVELOPMENT CASE*

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Abstract

Effective UI/UX design is essential for scientific GUIs, especially when complex workflows and time constraints challenge usability. By grounding GUI development in UI/UX design principles, accessibility, and user feedback; one can implement user-centred improvements that will lead to higher user satisfaction and increased productivity in experimental physics control systems. This paper explores the UI/UX design phases within the demonstrator case of the ROCK-IT project, shaped by theory and in-person user interviews. The key points in each phase are also highlighted; such as principles of screen design, visual accessibility, and examples of user feedback. The paper ends with how this process evolved in response to tight timelines, workforce availability, and shifting priorities in ROCK-IT - steering the route toward an efficient, yet user-centred and accessible solution.

INTRODUCTION

ROCK-IT [1] (Remote, Operando-controlled, Knowledge-driven, and IT-based) is a project that aims to develop all necessary tools for the automation and remote access of in-situ and operando synchrotron experiments, funded by the Helmholtz Association in Germany. Aiming at users from various experience levels, the project enables remote access for experimental users, experiment automation including the use of robots, data management following FAIR data principles, and nearly real-time analysis and optimization using machine learning (ML) and artificial intelligence (AI). The ROCK-IT project is being implemented in four partners (and their beamlines) as a pilot development case, mainly for catalsysis operando experiments: Deutsches Elektronen-Synchrotron DESY (P65 beamline), Helmholtz Zentrum Berlin (HZB) (mySpot beamline), Helmholtz Zentrum Dresden-Rossendorf (HZDR) (HAMSTER beamline) and Karlsruhe Institute of Technology (KIT) (CATACT beamline). Sharing a considerable amount of mutual users, one of the project's aims is to maintain a consistent look-and-feel of user interfaces between these Helmholtz institutions.

Within this context, a task was to revise and enhance the existing GUIs among the partner institutions, which varied from command-line interfaces (CLI) to patchwork graphical user interface (GUI) solutions developed by various beamline scientists throughout a wide timeframe. This process consisted of 5 phases (see Fig. 1): Phase 1 - Field Research I; Phase 2 - Field Research II; Phase 3 – Evaluation; Phase 4 – Drafting UI/UX concepts; Phase 5 – User testing; Phase 6 – Final outcome. The following part will explore these phases within the UI/UX development case of ROCK-IT.

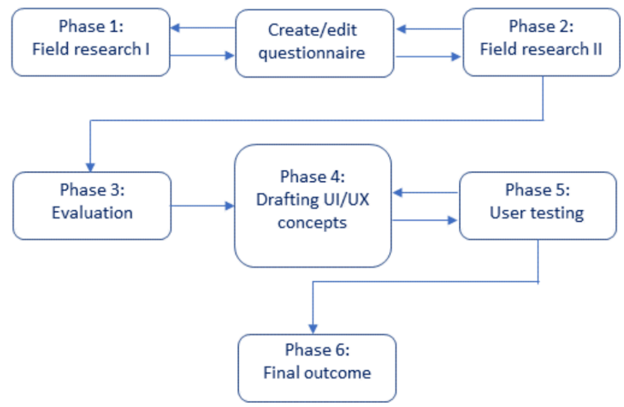

Figure 1: UI/UX Design Process Workflow at ROCK-IT.

Phase 1: Field Research I

In order to outline the necessities of the task at the beginning, it was necessary to learn about the configuration and working process of the beamlines. This process was supported by in-person project meetings including control room and beamline visits at the partner institutes. Discussions among developers and beamline scientists were very valuable to gather information on the system, the needs, and possibilities of what can be done. These meetings also gave a chance to examine the current GUIs and observe some user interactions, creating a base for the user interviews.

Phase 2: Field Research II

The second phase was to understand the users' needs with a qualitative research by in-person user interviews. The user interviews had two steps; i) Answering the questionnaire, ii) Collecting feedback through the existing GUI visuals. In this context, a questionnaire [2] was created to collect information on users' experiences and their needs. The questionnaire[1] consisted of 3 parts: i) Use cases; ii) User experience questions; and iii) Experiment processes[2]. These questions were first addressed to users at the ROCK-IT Outreach Meeting [3], which was held as a hybrid satellite meeting within the DESY Photon Science Users' Meeting in 2024 [4]. Following some revisions on the content, a preliminary question on the users' experience level was added to get an insight of different user types, and the questionnaire evolved into its current state with 18 questions. The question "Since what year have you been

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[1]Special thanks to Alexander Schökel (DESY) and Mehdi Kazemi (DESY) for their support and feedback on the questionnaire.
[2]Special thanks to Diana Rueda (DESY), Marc-Olivier Andrez (DESY), and Tim Schoof (DESY) for creating the "Experiment Processes" questions.

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experimenting at beamlines?" was an important key point to compare the feedback of the more experienced users (who have witnessed various beamline UI's and their developments throughout the years) and the more recent users, which were all very valuable in their own aspects. Later on, two further questions on metadata standardization and searchability were added due to the developers' needs, and to bring the project into compliance with FAIR [5] data principles, in cooperation with the DAPHNE4NFDI [6] consortium. The process started as an online questionnaire by reaching out to the users through digital channels – however, after 1 month, there were no completed questionnaires. Then, the methodology evolved into in-person interviews that took about 60 minutes on site, some joined by developers[3], which gave a great opportunity to interact with the users and observe the process in action. The in-person interviews were successful in giving a chance to further investigate topics, getting instant feedback while organically evolving questions, and observing the experiment processes.

Following the questionnaire, printed visuals of the current GUIs were presented to the users for their feedback. The users were invited to stick notes on the GUIs, which gave them the opportunity to act more freely and being creative on their feedback. This was also an interactive process leading to discussions and comparisons to experiences at other beamlines.

Phase 3: Evaluation

The user responses were reported to the developers and beamline scientists regularly. After interviewing a number of users, the responses started repeating and falling into certain user categories. The results were shared with the beamline scientists and developers as an internal presentation for further discussion. Some important remarks regarding UI/UX processes are given below:

- The interviews revealed there was room to improve communication on beamline procedures and needs between users and staff.
- Instead of switching between multiple windows, users wanted to control everything they need in one window.
- Users want to be able to customize the GUI regarding their usage. This also leads to creating different default windows for different user types, which are customizable if needed.
- GUIs should contain clear and precise wordings, unclear wordings and abbreviations should be updated.
- Getting used to a complex software under time pressure is an important challenge. Optional online training before the beamtime would lead to more productive beamtimes.
- Optional pop-up information windows would be helpful.

[3]Special thanks to developers Diana Rueda (DESY) and Tim Schoof (DESY) for joining some of the user interviews

Phase 4: Drafting UI/UX Concepts

After discussing and evaluating the users' remarks, the next stage is to create rough sketches of GUI design concepts, that are subject to change after test use. Customizable, modular GUI designs are emerging among research facilities, and that is considered as a base factor also for ROCK-IT. As for the user experience aspects; role-based user interfaces, various user profiles and accessibilities, and customizable GUIs have been evaluated within the discussion process.

Beamline operation demands working during a wide range of hours with extreme on-screen focus; which may lead to physical fatigue, mental exhaustion, and ocular health issues such as eye strain, eye dryness, and discomfort due to screen exposure. As for the graphical aspects, adhering to screen design fundamentals is essential regarding ocular health, reducing fatigue and stress. Furthermore, following the Web Content Accessibility Guidelines (WCAG) [7] by the World Wide Web Consortium (W3C) [8] embraces inclusiveness for people with colour vision deficiencies.

A very common practice among developers is to use basic RGB (#F50000, #00F500, #0000F5) and basic CMYK (#00FFFF, #FF00FF, #FFFF00, #000000) colour codes on pure white (#FFFFFF) and pure black (#000000) backgrounds. However, the sharp contrast between these colours cause eye fatigue and stress in long-term screen usage. Using softer colours while keeping good contrast (meeting the 1:4,5 WCAG standard), and light & dark mode options will help reduce eye strain due to long screen exposures. It is necessary to avoid risky colours regarding colour vision deficiencies, and checking the accessibility of colour schemes on specialized websites and apps. Warm colours (reducing blue light) help reduce eye stress, while cool tones work better for brightly lit environments. Avoiding sharp edges in screen design also helps to reduce eye stress, while using web-safe sans-serif typefaces such as Arial, Verdana, Tahoma, and Trebuchet, increase readability and legibility on screen (see Fig. 2). A line should contain no more than 80 characters or glyphs (40 characters if CJK) [9]. Last, but not least, creating a mimicry model of the beamline components and using related iconography where necessary will lead to an instant and enhanced perception of the experiment process.

Phase 5: User Testing

When the draft designs of UI/UX concepts are completed, an interactive test version of the GUI design should be presented to users. This test version should not yet be implemented to the experiment setup, but should be clickable and linked to the next steps. Depending on collected user feedback, phase 5 can lead to back to phase 4 or forward to phase 6.

Phase 6: Final Outcome

After finalizing the test phase, the final design outcome should be integrated into the experiment system and prepared for operational use.

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Figure 2: Examples of softened contrasts, warm and cool colours, rounded interface elements, and web-safe sans-serif typefaces that improve on-screen readability and reduce eye strain.

CONCLUSION

A well-established GUI strategy can lead to increased productivity, higher user satisfaction, and a broader user community. UI/UX design remains a critical aspect at research facilities. Despite limited budgets, staff, and expertise; there is a growing awareness of the importance of professional design practices. Events such as the GUI Strategies Workshop [10] have helped build networks and raise awareness in the community.

The user interviews at ROCK-IT revealed valuable anonymous insights into challenges that some of the beamline staff was not always aware of. Some users were hesitant to voice their challenges directly and attempted to resolve issues on their own. Speaking anonymously with an interviewer from a different field made users feel more comfortable expressing difficulties they would be hesitant to share with beamline professionals. This highlights the importance of creating environments where feedback can be shared openly, to establish an enhanced, user-centered UI/UX design.

Facilities are encouraged to establish standardized design guidelines addressing accessibility and visual ergonomics. Additionally, besides providing a User Manual, providing online training materials before beamtime would help users prepare and lead to more efficient beamtimes.

The ROCK-IT project will officially end at the end of 2025. Due to shifting priorities, time and workforce constraints, and the need for maintenance and sustainability, it was decided to adopt the Daiquiri GUI [11] developed by the European Synchrotron Radiation Facility (ESRF), which provides a modular and adaptable solution that can be efficiently integrated into the project. Still, the user feedback gained from ROCK-IT and improvements in visual design can be implemented to already-developed GUIs to align with user needs further enhance the user experience. In the future, UI/UX research and professional design are expected to gain greater attention and recognition as an essential component of large-scale scientific facilities.

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