# Rail4Future

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## D1.1.1 Report of Requirements (M12)

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# 1 Executive Summary

This report presents the requirements of the R4F platform, based on which we designed a conceptual model-based digital twin for the holistic large-scale railway infrastructure. R4F Platform, denoted as the Rail for Future Platform, is proposed to combine different elements of the holistic railway infrastructure system in a layered model, in which complex interrelations can be broken down into smaller and simpler clusters. With the R4F Platform, different railway infrastructure assets can be automatically and efficiently integrated, and a continuous flow of reliable and meaningful information throughout the entire life span of different railway infrastructure subsystems can be ensured. Moreover, R4F Platform may also lay an essential basis for the design of a virtual assessment platform as a universally applicable solution for digitized railway systems in the future.

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# 3. Description

We carried out a questionnaire among our industrial partners. Based on the results of the questionnaire, the following requirements for preparing, processing and evaluating the proposed R4F Platform get defined. The requirements are based on the demands of a single DT as well as the prerequisite of an efficient model and data integration process. To distinguish the importance of different requirements, each of them is marked with either a letter (M), which means "mandatory", or a letter (E), which means "expected".

## 3.1 Compatibility (M)

The compatibility refers to the platform's ability to access, integrate and analyse the data and models from various subsystems. Standardized file formats and vocabulary should be defined so that any subsystem can be mapped, dynamically interacted with, and well connected in the platform. One of the main benefits of compatibility is that it ensures consistency and efficiency in the platform's operation. With the integration of different subsystems, the platform can provide more accurate and detailed information. It also eliminates the need for individual subsystems to operate independently, which can be costly and time-consuming. Standardized file formats and vocabulary are essential to ensure the subsystems can be mapped and connected to the platform. It allows different subsystems to communicate with one another effectively, reducing the chances of errors and conflicts. Compatibility also enables data and model sharing among different subsystems, enhancing the platform's overall efficiency.

## 3.2 Synchronization (M)

The platform will require the physical entities of different integrated subsystems to be characterized and managed along the same time-axis with a unified data format. These data include the geometry, state, attribute, and internal mechanism of the subsystems, which form a digital virtual mapping of the real-time state of the physical entities.

## 3.3 Reliability (M)

The proposed platform requires a reliability assessment system, in which the system can supervise the states of the components of the platform and make corresponding adjustments. One of the critical benefits of the reliability assessment system is that it can help maintain the platform's operation despite disruptions. This is especially important in the transportation industry, where delays or disruptions can significantly impact the system's reliability and efficiency. With a reliable assessment system, the platform can quickly identify and address any issues, reducing the likelihood of delays and disruptions.

## 3.4 Fidelity (M)

The fidelity of the platform describes the proximity of the integrated model and the physical entity. It is required that the integrated model maintains a high degree of proximity of the geometry, state, phase, tense, etc. High fidelity is the prerequisite for the development of its future functions. Fidelity is particularly important for the development of future functions of the R4F Platform. By maintaining high fidelity, the platform can be used to simulate different scenarios and evaluate various strategies accurately. This can help decision-makers make informed decisions and take the necessary actions to improve the system's performance.

## 3.5 Expandability (E)

The proposed platform should have sufficient expandability to add and integrate new sub-models. It should also allow modifying or replacing existing sub-models and functionalities. Lacking expandability can cause problems for the maintenance and reusability of the platform. The expandability of the platform is critical for its long-term success. It ensures that the platform can accommodate new data sources, models, and technologies, which can improve its performance and provide new insights into the system's operation. The ability to modify or replace existing sub-models and functionalities can also enhance the platform's efficiency, making it easier to maintain and manage.

## 3.6 Interactivity (M)

The interactivity refers to not only the interaction between the users and the platform, but also the interaction between the designers and the platform, as well as between the physical models and the platform. A closed loop should be built based on the above-mentioned interactions, which may help the platform be updated and improved.

## 3.7 Real Time (E)

The requirement for real-time response in the proposed R4F platform is classified as "expected," but it is nevertheless an important characteristic that can significantly impact the efficiency of the platform. The ability to respond to real-time input data is crucial for the platform to identify emergent problems and provide corresponding solutions quickly. Real-time analysis allows for timely interventions, which can prevent potential issues from escalating into major problems. This can be especially critical in the transportation industry, where even minor disruptions can cause significant delays and impact the reliability of the system. The real-time requirement also implies that the platform should track changes as versions and ensure consistent behavior of simulations throughout their lifecycle. This ensures that the platform operates in a dynamic environment and can adjust to changes in real time. While the real-time requirement is classified as "expected," it is important to note that it is not a trivial characteristic to achieve. Real-time analysis requires a high level of data processing speed, which in turn requires a robust computing infrastructure.

# 4. Conclusion

In conclusion, the proposed R4F platform requires a set of specific requirements to ensure efficient model and data integration. These requirements were defined based on the demands of a single DT and through a questionnaire among industry. The identified requirements include compatibility, synchronization, reliability, fidelity, expandability, interactivity, and real-time responsiveness. Each of these requirements is marked as either mandatory or expected to distinguish their importance. These requirements are crucial for the successful development and deployment of the R4F platform, as they ensure its efficiency, consistency, and scalability. By meeting these requirements, the platform will be capable of managing and analysing data from various subsystems, supervising system states, maintaining high model fidelity, supporting the design and user interaction, and providing real-time solutions for emergent problems. Overall, the proposed R4F Platform has the potential to improve industrial processes and systems through its advanced capabilities and functionality.