Framing success: the Netherlands railways experience

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Abstract: Here we introduce the success framework, an integral view on the critical success factors to accommodate flexibilities required for tacking with the dynamism of rail industry both technically and organisationally. The success framework adapts two basic strategies that contribute to success. First, a clear set of objectives across the stakeholders. Second, cooperation and co-creation of values for achieving the objectives. We propose an integral approach for identification and accomplishment of the critical success factors. The application of the framework is further explained through a case study.

Keywords: critical success factor; CSF; success framework; railway; Netherlands.

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1 Introduction

Transport is a key to sustainable development directly linked to growth. A well-functioning transport system supports regional economies and connects them to world market. These are reasons for the European Union to aim for developing an efficient transportation system with less congestion and fewer emission to keep its competitor advantages. The main goals for Europe are sustainable fuel systems with optimised performances across the whole life-cycle which is flexible to act based on market-incentives (Kallas, 2011).

There are a few concrete goals set by European Commission to ensure a competitive transport system in which rail transport plays a key role (Kallas, 2011). One of the goals is that "thirty percent of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors." To accomplish this goal, a trans-European rail transport which is capable of high speed for medium distances is unavoidable. Others are that "by 2050, all core network airports should be connected to the rail network, preferably high-speed; all core seaports are sufficiently connected to the rail freight and, where possible, inland waterway system." This leads to a single European rail area operating openly across the whole Europe under agreed (non-)technical demands.

However, there are challenges for the rail sector to achieve these goals. The rail sector requires functioning within increasingly complex networks with dynamic interconnections and in a changing environment. Surprises regularly happen which may impose risk to people or society. The surprises include (non)intentional incidents, failure of train systems, poor-design issues, incompetent use or misuse of the system. For example, failure of the train systems or windstorms are surprises that often largely influence the system and hinder its operation at the rush/normal hours. The domino effect of such safety surprises negatively influences system values and discards its quality. As the interconnectivity offered by internet grows (see, e.g., smart industry outlook), the side-effects of these surprises may become large-scale, complex and beyond the foreseeable outlook.

Besides, there are different views, skills, responsibilities, behaviour and interests which may form a set of common interest within the rail transport and gradually apply pressure on safety management which ultimately may hinder robust reactions to the safety surprises. Extra rules and measures do help but also may add to the complexity, and there is doubt if extra regulations can provide a higher safety level in risky circumstances. In other words, a hundred-fold increase in regulations between 1947 and 2008 may decrease the probability of anything going wrong, yet they may increase the possibility of negative event because of extra tight coupling. Furthermore, the need for higher performance by reducing the cost of service puts also pressure on the safety management (see Rajabalinejad et al., 2016).

As a result of these circumstances, European Agency for Railways (ERA) monitors a decreasing progress in safety improvement: "despite a positive long-term trend in the risk of fatal train collisions and derailments over the past two decades, the data suggests that the progress has been slowing down since 2004" (ERA, 2013). At the national level, the Dutch Safety Board (onderzoeksraad) realises that too much focus on availability or maintenance may cause overlooking concerns that are relevant to safety. In brief, the degree of fragmentation of the system of systems and its interconnectivity, multi-stakeholder nature of making decision, variety of views (and spoken languages) of stakeholders, numbers of (revised) rules and regulations, and arrival of new technology may intensify the effects of the safety surprises and impose further risk to the rail system, people and society (see Rajabalinejad et al., 2016).

European Union has an ambitious target for transport to achieve. However, as briefly indicated above, the railway transportation is a complex system in a very dynamic and open environment which requests to use high technology and perform ultimately predictable and safe. The nature of this system leads to many factors that influence the system performance. Yet, we would like to highlight the critical factors for this system to function successfully. For this purpose, we first explain our research method and then review the success experience for railway in several countries in Sections 2 and 3, refer to the Netherlands Railways (NS) experience in Section 4, conclude a framework for the key success factors in Section 5 and present a case study as an example of interconnectivity of these factors in Section 6. Discussion and conclusions are presented in Sections 7 and 8.

2 Research method

This research is based on a case study of the NS. For this research, interviews have been carried out in NS at different levels of management and operation. Project reports have been reviewed and face-to-face interviews have been carried out from the level of senior technology officer, project manager, operational management, train driver and conductor. The suggested framework in this paper formalises the findings through interviews, literature/report reviews.

3 Towards success

Success means completing an objective or reaching a goal according to the online business dictionary. There are many factors that may contribute to the success (or failure) of an organisation or system at different levels of abstraction. A simple search in Google for ‘success factors’ returns more than five million results. To focus on the principal elements contributing to success, the term critical success factors (CSFs) often used in the management or leadership context referring to the elements that are necessary for an organisation, project or system to achieve its mission (see online business dictionary). Yet, CSFs may differ from one organisation or project to another. Therefore, here we do not aim to list many CSFs that are applicable to railways, but we aim to focus on strategic processes that the CSFs can be identified based on the objectives or goals of the organisation.

Success is in strategic alliance with value creation, and organisations need to make proactive investments to manage their alliance in order to enjoy a competitor advantage and greater success; this has been concluded by reviewing more than 200 organisations through as discussed in Kale et al. (2001). As a matter of fact, a wide range of literatures conclude that value creation requires cooperation among stakeholders or alliances and is not any longer achievable by a single organisation. For example, Gebauer et al. (2010) conclude that co-creation is a key factor to success of public transport services according to SBB experience; SBB is the Swiss federal railway company operating one of the most punctual railways in the world. In this perspective, the passengers, for example are not as passive consumers as used to be in accordance with the conventional thinking about public transport (Vargo and Lusch, 2008). In contrast, value is co-created with passengers as value-in-use in the consumer context (Vargo and Lusch, 2008). This demands cooperation and co-creation of stakeholders for achieving the expected values. In this perspective, the role of supplier changes from 'value facilitator' to 'value fulfiller', where suppliers become value co-creators by proper engagement with customers during their value-creating processes, and this strategy ultimately adopts a new business model for operation of public transport (Grönroos, 2008).

In rail transport, the necessity of co-creation of value for success is widely agreed. For illustration, Chan et al. (2004) argue that win-win climate and synergistic teamwork are sound basis for success. They also conclude that proper project partnering and gain-share and pain-share plays a key role in the success of an underground railway extension in Hong Kong (Chan et al., 2008). Yeung (2008) in his book refers to governance, passenger interests and looking to the future from the past as headlines for the commercial success of rail industry in Hong Kong. Australian Transport Council (Rail Level Crossing Group, 2010) in its safety strategy for the period of 2010–2020 describes the following principles for success: safety, shared responsibility and cooperative approach, engagement with all stakeholders, building on facts and proven developments. In next chapter, we refer to the NS experience where the importance of alliance with outside world for co-creation of values is fundamentally acknowledged at the national and international level.

4 The NS experience

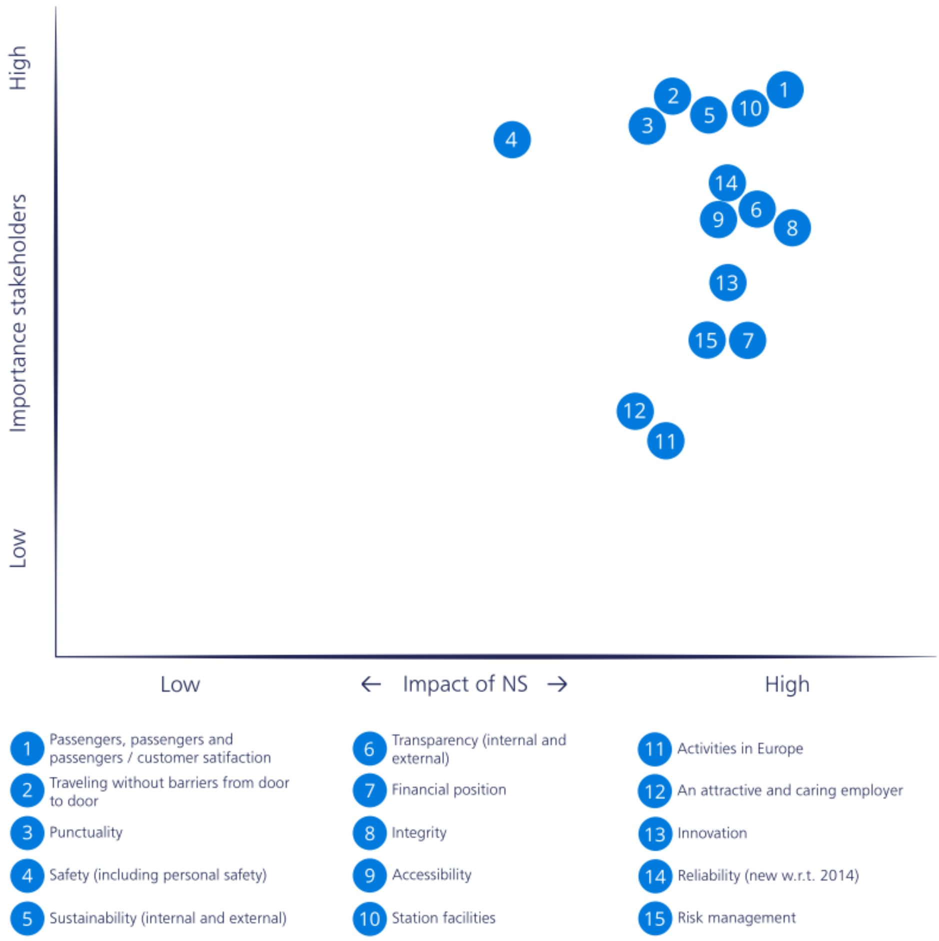
In Netherlands, the rail transportation in one of the key means for transportation across the country. In one of the most densely populated countries in the world, the rail network predominantly supports the passenger transport. The NS adapts three strategic tasks of:

1 improving performance on main rail network
2 creating world-class stations
3 contribution to door-to-door journey.

Safety of passengers and the tracks, operational performance and gaining experience on the European railway market have been among the priorities of the supervisory board of NS.

NS must act in a multi-stakeholder environment where stakeholders are internationally distributed. At the European level, Community of European Railways (CER), UIC (The Worldwide Railway Organization), ERA are the main international parties. Stakeholders at the national level are customers (individuals or organisations), Ministry of Infrastructure and the Environment, Ministry of Finance, National Political Bodies, supervisory authorities, ProRail, interest groups and NGOs, unions, suppliers, media, and regional authorities. Through a study conducted in NS Annual Report (2016), the key themes for success from the stakeholders perspective are passengers satisfaction, door-to-door journey, punctuality, safety, sustainability and facilities at stations. These have been shown through Figure 1. These factors are like the factors indicated in 2015 indicating the maturity level/stability of criteria.

Figure 1 Key materially relevant factors for NS in 2016 (see online version for colours)

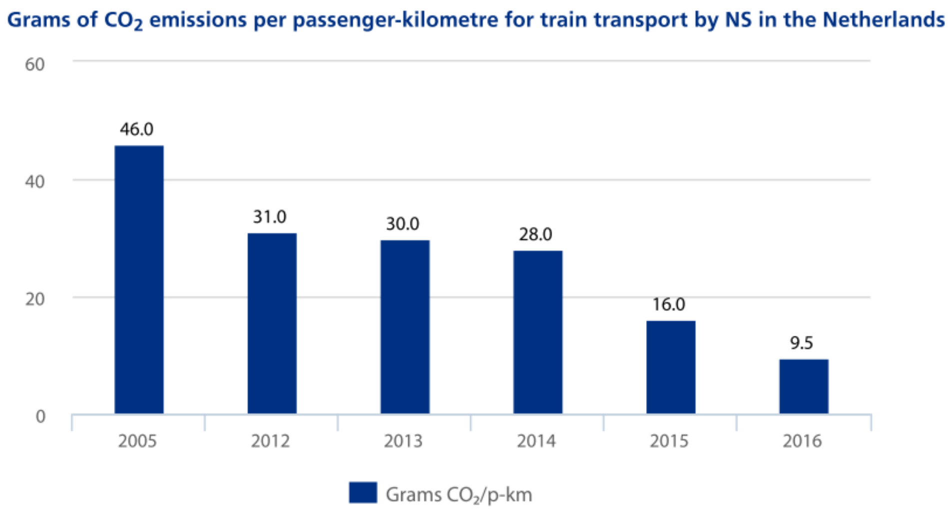


Source: NS Annual Report (2016)

4.1 Sustainable growth and development

Aiming for sustainable mobility, which is in line with the interest of railway users[1], NS has been continuously reducing the CO_2 emission as shown in Figure 2. Furthermore, the fuel consumption is well below the UIC international railway norm. Next to these, NS is among the top five transparent organisations according to the study conducted by Ministry of Economic Affairs.[2] This reflects on insight on operation, business model, and fundamental organisational capabilities required for a sustainable operation (Transparency Benchmark, 2016).

Figure 2 CO_2 emission per passenger-kilometre for train transport (see online version for colours)

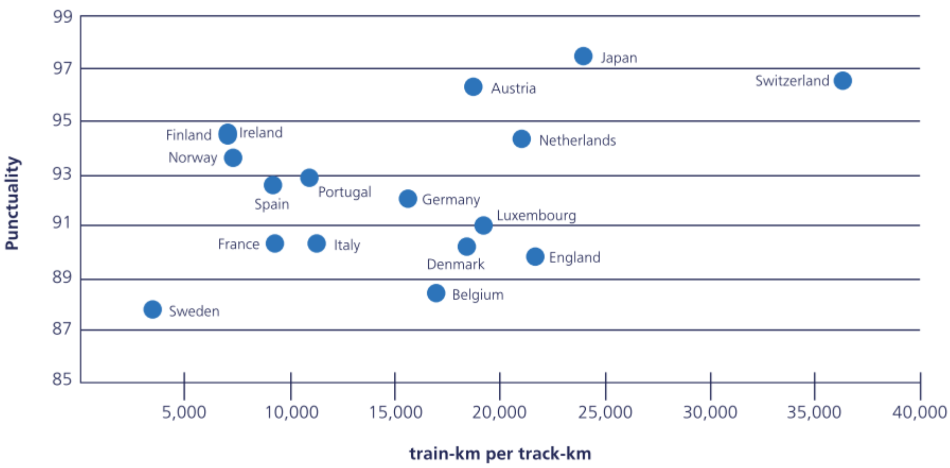


Source: NS Annual Report (2016)

4.2 *Competing operational excellence*

The Netherlands railway is among the most punctual and reliable railway system all over the world. A comparison between punctuality and track occupancy in eighteen countries concludes that NS is among the top five service providers.

Figure 3 Punctuality as a performance indicator, a comparison between eighteen countries (see online version for colours)

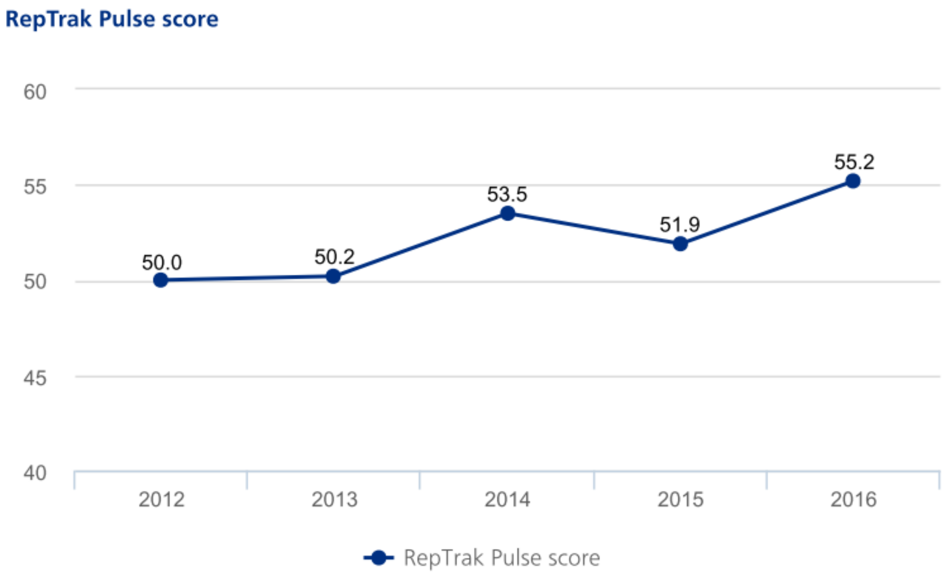


Source: NS Annual Report (2016)

4.3 Reputation: an integral indicator

Reputation is an integral indicator used to assess the attractiveness of travel by NS. Reputation is measured by the RepTrak method exceeding the target for 2016. Reptrack measures reputation on basis of how the public views the best-known companies.[3] Continuous monitoring of such an integral indicator provides an insight about the overall performance of the system. Figure 4 represents the measured reputation for NS since 2012. This can may be used as an indication of the overall performance for the rail transport across the Netherlands. In this case, for example, the dissatisfactory results for 2015 is mainly results of irregular disruption, aggressions against NS staff, and the developments around Fyra according to the annual report.

Figure 4 The measured reputation for NS since 2012 (see online version for colours)



Source: NS Annual Report (2016)

4.4 Managing risks

Being ranked among the top ten transparent organisations in the Netherlands, NS believes that the staff must be aware of risks, the so-called risk culture. NS has identified three areas for risks: strategic, operational and financial. Among the operational risk factors, introduction of new rolling stock with respect to time and quality is one of the priorities for risk management. This is very interesting as introducing proper rolling stock and introducing them properly substantially reduces operational risks. Lack of infrastructure capacity is another risk area identified with high priority.

4.5 Integral safety and culture

Not only NS offers extra resources in terms of staff or facilities, e.g., cameras and monitors, but also pays explicit attention to improve safety culture aiming to achieve a state where the employees are taking proactive actions against risks. This means that the organisational culture has to move toward the direction that every employee believes that any unattended risk, which can influence the system, may influence him or her (Booster and Rajabalinejad, 2016). From the organisational perspective, the need for an integral safety management system is sensed and pushed through all qualified departments. This is based on the need to develop up-to-date tools adequately address the needs for development or operation of safe systems (Rajabalinejad et al., 2015).

4.6 Quality maintenance services

From the asset management prospective, the excellence of operation is strictly connected to the evolution of the rolling-stock maintenance strategy for delivering the expected results. One of the first decisions at NS was to improve the current preventive approach (time/used-based maintenance) adopting reliability centred maintenance method for planning the operations and minimising the likelihood of erroneous or unstructured initial spare parts assortment that could lead to undesired downtimes increasing the risk of obsolete or unavailable components. The results were impressive. The number of couches taken out of service for short-term routine maintenance decreased from 450 to 200, resulting in savings amounting to 30 million euros per annum (see Rajabalinejad et al., 2016).

4.7 Continuous technological support

The technology evolution offers day-by-day new opportunities and solutions to achieve the appropriate goals. Modern trains are increasingly equipped with mechatronics and computer-based control systems able to store large amount of data and technical information on the behaviour and the conditions of the different sub-systems and parts. Sensors and information systems permit to better understand the machine health state showing not only the status but a trend to move the level of attention from a rate prospective to an asset-level utilisation. Since the life-span of a train is about 40 years long, NS started few years ago a R&D program to follow the mentioned technical concepts. A pilot project for 54 trains involved the installation of a train-to-shore connection to download existing on-board failure reports, operational events (doors opening/closing, coupling), counters (compressor operating hours etc.) and many sensor measurements from TMS. Information on GPS location and time is also stored in a generic database for use by different user groups, for different applications. Yet, the management of this increasing amount of data requires the availability of a strong and well-structured information system which can integrate isolated IT applications.

Concepts, maintenance process standardisation, scheduling and planning, training and certification of staff, maintenance performance quality check-ups, controlled release of rolling stock reported finished, development of rolling stock failure elimination strategies, and registration of all work performed must be accessible and available in every moment at the right time to ensure punctuality and excellence both in operational, tactical and strategic level.

In other words, the operations to ensure a reliable railway transportation is no longer static and mechanic. Real-time monitoring is changing the way of working in maintenance, introducing electronic, robotic and mechatronic system able to offer a flexible, dynamic and proactive response for the maintenance operations and for the normal working conditions. In 2018, NS applies real-time monitoring for 222 InterCity Double Decker and 131 Sprinter Light Trains. The most important train equipment that are being monitored are traction system, brakes, door system, air-conditioning.

5 Framing success factors

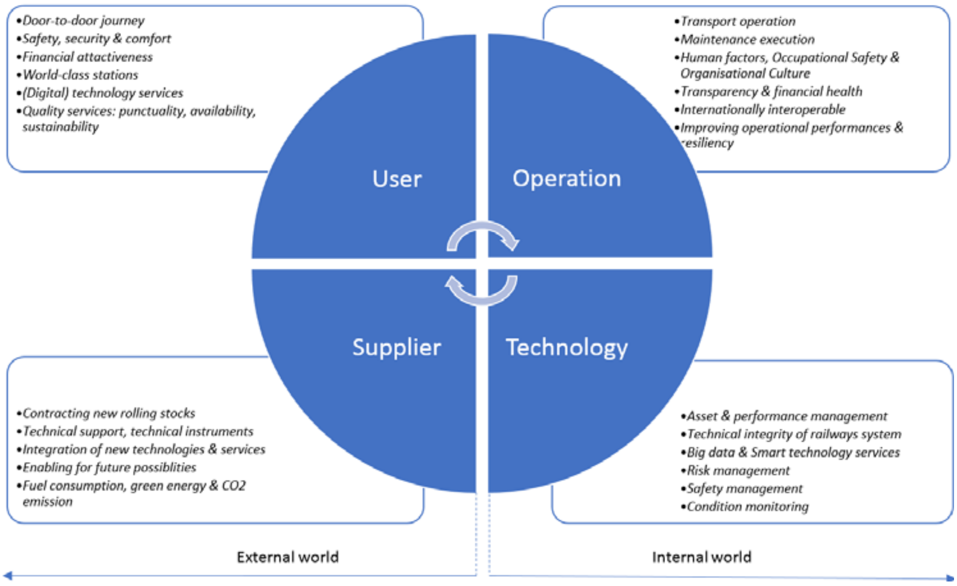
5.1 Framework

It is a set of clear objectives and maintaining them across the organisation that fundamentally contributes to success. The importance of objectives is becoming more and more evident given the rising system complexities. Clear objectives ensure directing the organisation towards the preidentified goals. In practice, however, there are still many technical factors contributing to the final goals. To highlight the interconnectivity of these factors, one should view the influence of any design or decision on these factors at the system or subsystem level. As discussed earlier in Section 2, it is no longer the case that one single organisation can make the rail transport successful. Having a clear set of objectives, stakeholders need to work together and co-create shared values and win-win situation. We build on the previous study where three factors of user, supplier and maintainer were considered for the integral life cycle performance (van Dongen, 2015). Based on the conducted interviews, reports and literatures, we conclude four different pillars of user, operation, technology and supplier for creating shared values. These have been described as follows:

- User is the individual or organisation that uses the service provided by the system.
- Operation is the set of activities needed for operating the system. This includes hosting passengers, (re)scheduling and driving trains, and offering the services that users demand.
- Technology is the technical installation that enables operation of the system.
- Supplier is the product producer or service provider for the system.

This concludes the operational experience in NS and further develops the previously published literature (van Dongen, 2015). Figure 5 presents these four pillars with their principal factors. Some of the key factors for a successful transportation system were published in the call for paper for this special issue, yet there are too many other factors that play roles at different levels of system or society. For example, ISO 9001 presents the key requirements for a Quality Management System (2015), ISO 55001 (2014) provides guidelines for asset management and management systems, EN 50126 specifies the reliability, availability, maintenance and safety (RAMS) process for the rail industry, or ISO 27001 describes the requirements for information security management system (ISMS) (EN-ISO/IEC 27001, 2013). Here in this study, we do not aim to provide a complete list of success factors. However, we believe in a system view where the influence of choices must be explored across different pillars contributing to a coherent system. Based on our observation, these four key pillars sufficiently address this need. In other words, Figure 5 presents an integral view for the success so that the system owners have a clear perspective on what to pay attention to. We discuss this in further details through the following subsections.

Figure 5 The key factors for successful transport system indicted through the call for this special issue (see online version for colours)



5.2 Levels of maturity

To achieve best results, proper implementation of each CSF is fundamental. In general, there are three levels of maturity identified as do it right, do the right things, and design for doing it right shown in Figure 6. For example, for a successful maintenance practice the maintenance operation must be carefully performed. The concept of 'doing it first time right' must become a culture across the organisation. The next level of maturity is that making sure the right maintenance is taking place which can be achieved by engineering maintenance. For example, by remote monitoring of wheel temperature, NS is able to identify the best timing for maintenance actions on train axle bearings (Peters, 2017), or by using the generated data, NS has been able to detect air leakage in train braking pipes (Lee, 2017). The third level of maturity is to implement the changes into design of technology or operation to overcome operational issues and reduce the cost of maintenance. As a matter of fact, improving the maturity level requires a multidimensional approach (see, e.g., 5 M for business managers), where the quality of material or equipment, availability of resources, methods for maintenance and operation or educating the system operators play substantial roles. The case study presented here in this paper is a good example of learning from operation and embedding the changes into design of new rolling stocks so that the identified problems have been solved in the first place, and there is no need for extra actions.

Figure 6 Concept of operation for technological enablers (see online version for colours)

5.3 Levels of priority

It can be argued that the indicated key factors per pillar are not of equal importance. One, for example, can identify them as the functional and nonfunctional factors, or primary and secondary factors. Although this is a valid argument, acting in a competitive market forces the rail industry to address the key success factors simultaneously. For instance, one may argue that providing safe transport is prior to the number of seats. In practice, however, safety, reliability, punctuality and availability go hand in hand.

5.4 Cooperation and co-creation

Close cooperation of different departments of an organisation is needed to reach the desirable level of performance. This, however, covers only one-half of the success according to the picture presented in Figure 5. The other half remains in the outside world. In other words, it is equally important to have cooperation among stakeholders e.g. ministries, suppliers, or other service providers. Tackling the issues effectively is only possible by effective cooperation of different disciplines. This means that the organisation should be able to minimise the overlap between different departments and sections to minimise overlapping works and maximise the efficiency. To achieve the desired level of maturity, the organisation must be able to provide the support required. The purpose should be to minimise the uncertainty in achieving the goal (Rajabalinejad and Spitas, 2012). This means that every person in the organisation has a clear understanding of the system goal/purpose and his/her contribution for achieving the goal.

5.5 Non-static and time depended

It is important to note that success factors subject to change over time. For example, the digital technology services have recently become an inseparable part of rail services. Besides, the success factors are not static and independent. In other words, one factor may influence the other factors positively or negatively. For instance, for delivering a service at the expected quality level, the quality of the fleet and operation, proper maintenance operation and condition monitoring influence achieving the expected quality.

6 Door system: an example case study

The door system for trains is an important part of the system interfacing with the users, operators, driver, conductor, train, platform and station. There are almost 35 million train departures in the Netherlands on yearly basis, and the door system and human factors together cause errors which are related to door system on yearly basis. Errors that are safety related, are distinguished as safety related errors (SRE). About 25% of SREs in 2016 were reported to be relevant to the door system, and it has been one of the main reasons for inspection or maintenance activities.

Although the reference architecture for the door system is recommended through TR 50623 (CENELEC, 2014), the development history and details of this system are good examples for highlighting the importance of communication between different disciplines and operating the system at the desired level. The reference architecture demands train control and monitoring system (TCMS) to close and lock the doors when the train departs and release all the left (or right) doors when it stands still.

Observing that the door system error has been one of the main sources of safety related failures, passive and proactive actions have been taken to tackle this issue. A history of this development highlights the challenges, complexity and scope of the problem. We review this development through the coming subsections.

6.1 Sliding doors

The early electric trains constructed in the NS up to the sixties were designed with the sliding door mechanism without any central controls. The door system for these trains allowed the passengers to open/close the exit doors without any controls. There was no safety control system for the doors enabling impatient passengers to leave the train even before the full-stop, late (or nervous) passengers to jump-in the train when it was at low speed and travelling passengers to open the doors when the train was moving sometimes just for the pleasure of enjoying the landscape. The departure process was conducted by the conductor by providing manual/visual signals to the train driver. This resulted in serious consequences for the passengers and the railway operators. These considerations have been presented in Table 1 (rows 1–4) by the black and red colours (or dark and light in black ink prints) indicating desirable and undesirable ones, respectively. Because of these issues, a central door system was introduced for the new fleets.

6.2 Sliding doors, centrally pneumatically operated

The trains which came into service since 1958 up to 1964 were retrofitted with a central lock enabling the conductor (or guard) to centrally close the doors. This was an improvement as late passenger had a smaller chance of interfering with departing trains. However, the technology and process used to allow a passenger to open the doors after departure when the train was moving or before the full-stop at the platform. There was no information for the driver nor for the conductor if any door left open when the train was moving. The departure signal was provided by the conductor by visual/manual and mechanical means. This system resulted in consequences for the passengers and the railway operator. Table 1 (rows 5–8) presents a summary of this information.

6.3 Swing doors with green lamp

Since the sixties, train staff in the Netherlands were in control of the central lock for the new swing door system. Centrally controlled, the driver was informed of opening/closing doors by the so-called ding-dong audio signal. If all the doors closed, the driver was visually informed though the 'green lamp'. A driver could see if the doors are close through the 'green light' signal allowing him to depart. This new system did not allow passengers to open the exit doors when the train was approaching/departing the platform. The train, however, could depart while the conductor door was open because a conductor could override the safety procedure for departure. This caused issues like passengers trying to jump in the train through the open-door risking sever accidents. This system is presented through the success framework by Table 1 (rows 9–12). As a result, because of increasing passenger numbers and increasing risk of accidents, the process was revised so that the train was not allowed to depart with any open doors as discussed in next section.

6.4 Departure process revised

To reduce the risk of accidents, the departure process was revised so that the driver could only start departing the platform after making sure all the doors were closed. A driver was informed about the status of exit doors through the audio (ding-dong) and visual (green light) signals. Human factors in this departure procedure caused several issues leading to many inspections for potential system errors. After conducting tests, the conclusion often was that the system works correctly. Table 1 (rows 13–16) presents this system through the success framework.

6.5 Departure process change implemented

The new trains have the departure process embedded in their systems, so that they cannot depart with open doors. In addition to audio and visual signals, the deriver receives traction release after all the doors have been closed. This leaves no room for personal interpretation and makes the situation safer for the passengers and simpler for the operators, see Table 1 (rows 17–20).

Table 1 Applying the success framework to the different stage of development for the sliding door system (see online version for colours)

Development stage	*Intern extern*	*Key pillars*	*Pros and cons*	*Row no.*
Sliding doors	Internal world	User	– Unsafe departure and arrival	1
			– Unsafe while train is moving	
			– Accidents and delay	
		Supplier	+ Basic (simple) design	2
	External world	Operation	– One-by-one exit door control	3
			– Time consuming departure	
		Technology	+ High technical reliability	4
			– Risk of open doors during travel	
			– No condition monitoring	

Note: The colour black (+) signifies pros and red (–) signifies cons.

Table 1 Applying the success framework to the different stage of development for the sliding door system (continued) (see online version for colours)

Development stage	*Intern extern*	*Key pillars*	*Pros and cons*	*Row no.*
Sliding doors, centrally pneumatically operated	Internal world	User	– Unsafe for late (or nervous) passengers	5
			– Unsafe arrival	
			– Unsafe while train is moving	
			– Accidents and delay	
		Supplier	+ Central closing door system	6
	External world	Operation	– Time consuming departure	7
			– Extra maintenance operation	
		Technology	– Risk of open doors during travel	8
			– No condition monitoring	
			+ High reliability	
Swing doors, with green lamp	Internal world	User	– Unsafe while train is departing passengers	9
			– Possible accident for late/anxious passengers	
		Supplier	+ Central closing and locking door system and driver is notified by TCMS	10
	External world	Operation	– Time consuming departure	11
			– Extra maintenance operations	
		Technology	– Complex door system	12
			+ Pneumatic door operation with electric doors	
Swing doors, with green lamp, departure process revised	Internal world	User	+ Safely step in/out	13
		Supplier	+ Central door system and driver is notified by TCMS	14
	External world	Operation	– Time consuming departure	15
			– Extra maintenance operations	
			– Human factors	
		Technology	– Complex door system	16
			+ Pneumatic door operation with electric doors	
Swing doors, with green lamp, departure process traction release	Internal world	User	+ Safe circumstances	17
		Supplier	+ Interoperable	18
	External world	Operation	+ No human errors in closing doors	19
			– Extra maintenance operation	
		Technology	+ Condition monitoring	20
			– High reliability demanded	

Note: The colour black (+) signifies pros and red (–) signifies cons.

7 Discussion

Although there are many important factors playing substantial roles in a successful railway operation at different levels of organisations or infrastructures, we observe that a set of clear objectives has certainly supported the NS to succeed achieving them. Furthermore, we observe that is not possible for a single organisation to achieve all the objectives for a successful rail industry. It is cooperation and co-creation of values that enable achieving the goals. In other words, framing the objectives and communicating them across the system stakeholders vitally contribute to success. This strategy has been embedded in NS at both national and international levels. Based on our observation and literature reviews, we suggest organising the system objectives through four pillars of user, operation, technology and supplier as shown in Figure 5. For framing success, we recommend developing a customised version of this figure per project and use it for evaluation of design decisions or design alternatives. The application of this framework is shown through the example application for the door system concluding that the current door system is safe for passengers, but it still requires attention from the reliability and maintenance perspective.

To successfully achieve the objectives, a service provider requires effective cooperation both internally and externally. We observe that excellent operation and proper use of technology are two main pillars that matter for NS internally. In the external world, the user and supplier are two other pillars that must be considered. This has been reflected in Figure 5 where the left side focuses on external world and right side focuses on the internal world of the train operator.

While those four pillars of the framework remain constant, objectives may be subject to change. An example of this change is delivering digital services which is becoming more and more important for travellers. However, some system elements are subject to more frequent changes as for example shown through the case study where the door system has been being continuously improved.

8 Conclusions

To achieve successful public transportation, the user, operation, technology and supplier play fundamental roles, and their related objectives must be met. They need to work together to develop objective criteria for decisions or design choices and need to and co-create values to accomplish the objectives. We conclude that rail service-providers must function well both internally and externally to successfully achieve their objectives. As the system components are subject to changes in time, the main objectives remain relatively constant. Most importantly, user, operation, technology, and supplier remain the key pillars contributing to a successful transportation system.

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Notes

1 Based on the research of Dossier Duurzaam 2015 (see http://www.dossierduurzaam.nl) at the national level and research of NS in December 2016.

2 Ministerie van Economische Zaken, see http://www.transparanteibenchmark.nl.

3 For further information, see http://www.reputationinstitute.com.