

Managing the Transition to Digital Radio Networks in Smart Grids: An Asset and Change Management Case Study

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Abstract

The increased demand for smart grids in the energy sector requires improved communication and automation to ensure reliable electric grid management. Migrating from legacy radio communication technologies to digital radio networks is a crucial part of the evolution of the telecommunications network. This study explores asset optimisation and change management in a smart grid during a telecommunications technology migration project. The study focuses on migrating legacy radio technology to an IP-based digital platform. Using an exploratory mixed-methods approach, the research focuses on collecting perceptions and comments from newly migrated system participants (engineers, technologists, and network planners) through open-ended survey questions, as well as secondary data from the management system. Analysis of the results shows divergence between a higher user perception of the new system's usability and the obtained low reliability score (Mean Time Between Failure, MTBF) of 2.4 hours/failure. Human factors contributed to system instability due to training and communication from management. This study recommends the use of integrated asset and change management through tools such as the Configuration Management Database (CMDB) and predictive maintenance tools, and the adoption of change management tools such as Awareness, Desire, Knowledge, Ability, Reinforcement (ADKAR) and Kotter's 8 Steps to improve skills, training, and management alignment.

Keywords

Asset Management, Change Management, Digital Mobile Radio (DMR), Smart Grid, Predictive Maintenance.

1. Introduction

There is a rapid evolution of telecommunications networks from more analogue to digital networks as demand increases, bringing about reliable, easily expandable networks and better network security (Achaal et al., 2024). An application of digitized telecommunications is in the power grid industry, where there is increased demand for smart grids, improved communication, and automated maintenance and grid management (Platunina et al., 2023). Migrating from legacy radio communication technologies to digital radio networks is a crucial part of the evolution of the telecommunications network (Rodriguez et al., 2023). Once evolved telecommunication networks are used in the power utility environment, this improves utility performance and equips utility subsystems with intelligence through technical interventions, such as configuration management, real-time monitoring, and remote asset management, to enable smart grid capabilities (Kanaev et al., 2024). Additionally, once a power utility operates as a smart grid, the asset management shifts from manual to intelligent strategies, with capabilities such as predictive maintenance and improved efficiency in smart grid operations (Nkosi & Emuze, 2024; Sinha et al., 2021). Risk Management is another factor that needs to be addressed in evolved digital networks as a result of this transformation (Platunina et al., 2023). An important risk mitigation procedure in this case is the Configuration Management Database (CMDB), an asset

management application that enables grids to manage, monitor, and track changes across a modern network (Rodriguez et al., 2023). One factor affected by the fast-changing telecommunications network and smart grid operations is change management, given the human aspects of technology migration. During this change, organizations have to evaluate factors around the rate at which the staff adapt to the new technologies, also evaluate if the technology is doing what it is supposed to do, and if adequate training is provided to help reduce resistance, guarantee workers preparedness, and promote smooth transitions into the new system (Hajishirzi et al., 2024; Rodrigues et al., 2024).

1.1 Objectives

This study aims to explore the relationship between system reliability during technology migration and stakeholder impacts through the following objectives:

- To adopt asset management techniques in the transition of VHF/UHF radio technology to IP-based systems within smart grids and ensure that security policies and mitigation techniques are followed, and data integrity is maintained in the migrated networks, increases network security, reliability, and efficiency.
- Adopting management techniques to encourage staff participation in fast-changing technology environments does improve operational efficiency, focusing on factors such as training and adaptation.

2. Literature Review

This section provides technical theory and background on different asset management and change management approaches applicable to the technology migration environment. The section discusses theories such as Predictive maintenance, asset management techniques, and frameworks like the Configuration Management Database (CMDB) and Kotter's 8-step framework.

2.1. Asset Management

2.1.1. Predictive Maintenance

Predictive maintenance is an asset management concept that aims to shift reactive or periodic maintenance to a proactive, data-driven approach by using Internet of Things (IoT) sensors and artificial intelligence (AI) to prevent system failures before they occur. Industries such as Smart energy grids, telecommunications networks, construction equipment, and manufacturing systems have adopted this strategy as the core component of asset management interventions (Nkosi & Emuze, 2024). Predictive maintenance improves maintenance when it is included in the business's strategy, thereby reducing operational costs. For a business to be asset-intensive, asset management must be a priority to comply with the requirements of the Industry 4.0 era. One predictive maintenance strategy includes the use of pervasive IoT sensor networks for ongoing condition monitoring, edge computing for real-time data processing, and machine learning algorithms for intelligent fault prediction (BOUSDEKIS et al., 2020; Sharma et al., 2024). A combination of these technologies forms the ultimate predictive maintenance system, maintenance teams can proactively identify problems early and take appropriate action to increase reliability and reduce downtime (BOUSDEKIS et al., 2020). Figure 1 below shows how IoT sensor networks, Edge computing, and machine learning are used for predictive maintenance, which is described with a P-F (Potential-Failure to Functional-Failure) curve. The figure shows that the window for preventive action widens when sensors and AI analytics are used to "move" the detection point closer to the onset of degradation. Predictive maintenance systems aim to separate the "P" (potential failure) from the "F" (functional failure) as much as possible so that maintenance can be planned in time (BOUSDEKIS et al., 2020).

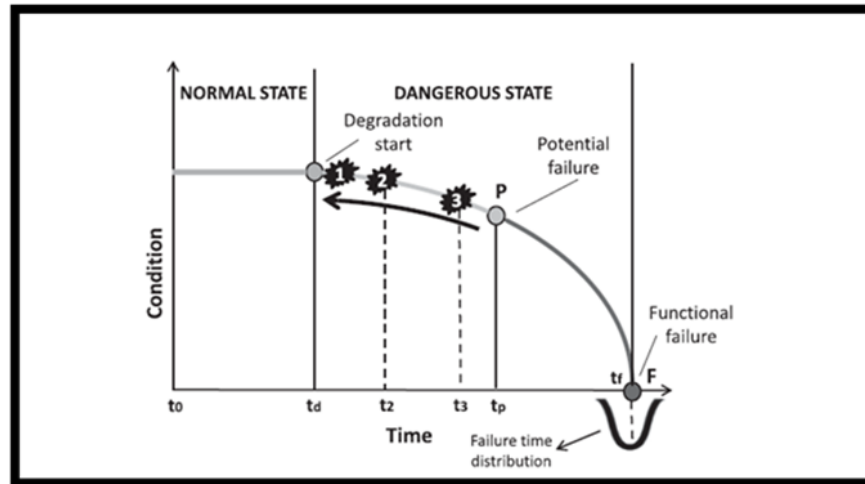


Figure 1. A P-F (Potential-Failure to Functional-Failure) curve (BOUSDEKIS et al., 2020).

2.1.2. Configuration Management Databases (CMDB)

The Configuration Management Database (CMDB) is an asset management application that incorporates elements of change management, holding detailed information about the configuration items (CIs) and technical assets of an organization, including their attributes, relationships, and change history. As a single system of record for digital services and technology infrastructure, the CMDB supports asset management, service outage diagnosis, change impact assessment, and compliance assurance in IT environments (Dande et al., 2024; Kanaev et al., 2024). A CMDB provides a single point of asset and configuration data, including current metadata for each component and its interconnections (Dande et al., 2024).

2.2. Change Management

Change management procedures provide an organization with stability and the ability to adapt during and after change. Throughout the development and operation of technology systems, it refers to a standard methodology for carrying out and documenting changes. This process guarantees that any changes are appropriate for the organization and are duly approved, authorized, documented, and tested (Conklin et al., 2021). One of the well-established change management procedures that have proved to work are Kotter's 8-step model and McKinsey's 7-S highlighting organizational structure alignment and the critical role that leadership plays in directing change (Hajishirzi et al., 2024). Significantly, the introduction of new technologies leads to structural changes in workflows, services, and products; therefore, effective digital transformation necessitates strong change management that emphasizes people (the human factor) to manage these changes (Conklin et al., 2021; Hajishirzi et al., 2024). The ADKAR model, a goal-oriented framework for change management that emphasizes change at the individual level. The acronym for the five results a person must attain for a change to be successful is ADKAR: Awareness of the necessity of change, Desire to support and participate in it, knowing how to change, and Ability to implement new behaviours or skills, and providing Reinforcement to maintain the change (Pulido & Taherdoost, 2023). To ensure that staff members actually adopt new tools or systems, this model has been used extensively in technology adoption scenarios (Laine & Ojanen, 2024; Pulido & Taherdoost, 2023).

3. Methods

3.1. Research Approach and Design

The research followed a convergent parallel mixed-methods design, in which both quantitative and qualitative data were collected concurrently and integrated during data analysis. The design further followed an embedded design, whereby open-ended questions provided a basis for qualitative analysis and were integrated with a quantitative approach (Williams et al., 2024). To further clarify the design approach relative to the research objectives, Table 1 provides the justification.

Table 1. Research design

Research Approach Components	Data Collection Method	Targeted objectives	Data form	Role
Quantitative	Likert Scale	1 and 2	Perception and Performance	Stakeholder Readiness and Technical Competency
Qualitative	Open Ended	1 and 2	User Experience and Perception	Thematic analysis
Secondary Data	Events Logs & Performance Logs	1	Performance	Reliability Measurements
Cross-validation	All data methods	Optimisation Approach	Merged results and analysis	Reliability and validation

Quantitative data will be analysed, focusing on perceived adoption rates, training scores, and system performance indicators, utilizing descriptive statistical analysis and correlation analysis, with the secondary data system logs will be used to evaluate performance through reliability metrics (Park et al., 2025). Open-ended surveys as qualitative data will form part of the thematic analysis to identify themes related to system usability, change resistance, and organizational readiness (Platunina et al., 2023). Integrating both datasets, through cross-validation, will be the crucial element of the mixed-method approach analysis.

3.2. Research Population and Sampling

3.2.1. Population

The population for this research will consist of various technical professionals within the telecommunication field in a power grid environment, e.g., Engineers, Technologists, Technicians, Network Planners, and Trainees. This population is justified by experience in the research area, the need for information-rich cases for an exploratory research study, and the insights they can provide on technology migration projects and overall experience with digitization in a smart grid. As a result, this research focuses on asset and change management within a telecom environment, and the population will include individuals directly in this field who are directly impacted by the environment. A target population is a more specific subset of a population that meets criteria based on research objectives and constraints (Willie, 2024).

3.2.2. Purposive sampling and sample size

This study focuses on extracting deep, contextual knowledge and does not aim to statistically generalize results to a population; purposive sampling is used. Purposive sampling makes it easy for a researcher to obtain expert insights, insider knowledge, and domain-specific understanding (Hossan et al., 2023). The use of professional networks within the telecoms power grid environment exhibits a criterion-based selection pattern due to the recentness of the migration, the direct involvement in the migration process, and the project. This can create sample bias; however, through the cross-validation strategy discussed in the next section, this will be mitigated by validating the actual system data against stakeholder perception (Willie, 2024). A sampling size of 10-50 participants is selected utilising purposive sampling, which is suitable when a broader range of stakeholder perspectives is required and applicable within this research (Emmel, 2013). The use of sample size of 10-50 participants is justified by characteristics of exploratory research to prioritise information richness over statistics as the survey will provided more qualitative data vs quantitative data and the sample size is appropriate based on that qualitative data collection is stopped once there is thematic saturation and due to the study being conducted in a specific environment there are limitations to the sample size (Omid Tajik, 2024).

4. Data Collection

The quantitative results used a 5-point Likert scale, specifically focusing on participants' perceptions of how effective the migration process was, how adequate the training was, the usability of data management and DMR technology, general management support, and communication. The qualitative results used an open-ended approach and focused on the same areas as the quantitative survey. Furthermore, both quantitative and qualitative methods were triangulated

to demonstrate how the data converge and validate their reliability. Secondary data from the Data Management System for the DMR is also presented to show system performance, provide alarm and interface data, etc.

5. Results and Discussion

5.1 Participants' Biographical Analysis

This section presents the biographical analysis of the survey respondents, and the data follows a descriptive analysis focusing on roles, years of experience, and involvement in technology migration projects.

5.1.1. Participant's Role

A total of 23 individuals participated in the survey; they are all professionals in telecommunications within the power grid environment, involved in various roles, from engineers to technicians. Figure 2 shows the representation of the respondents and their roles, comprising 61% Engineers, 13% Technicians, 4% Engineers-In-Training, 4% Technologists, 4% Supervisors, 4% Project Managers, and 9% Network Planners.

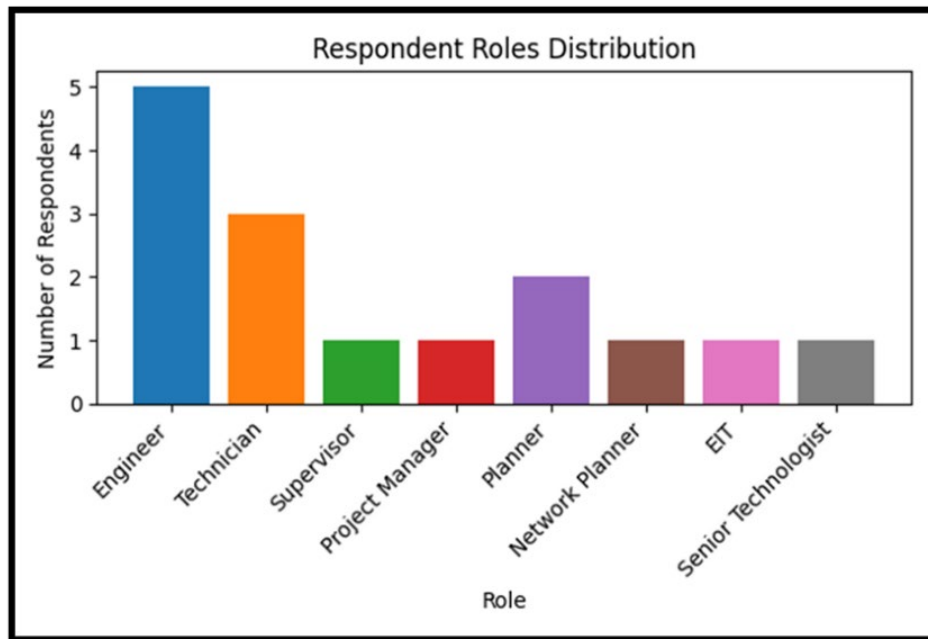


Figure 2. Role Distribution for Respondents of the Survey

5.1.2. Professional Years of Experience

As represented in Figure 3 below, the distribution shows various years of experience of the participants, with more than 15 years of experience forming 21,7% of the survey, 11-15 years of experience = 13%, 5-10 years of experience = 34.8% and less than 5 Years of experience = 30.4%. This range of experience shows that the survey participants included both experienced participants, participants still gaining experience, and new entrants, bringing different perspectives to the migration project.

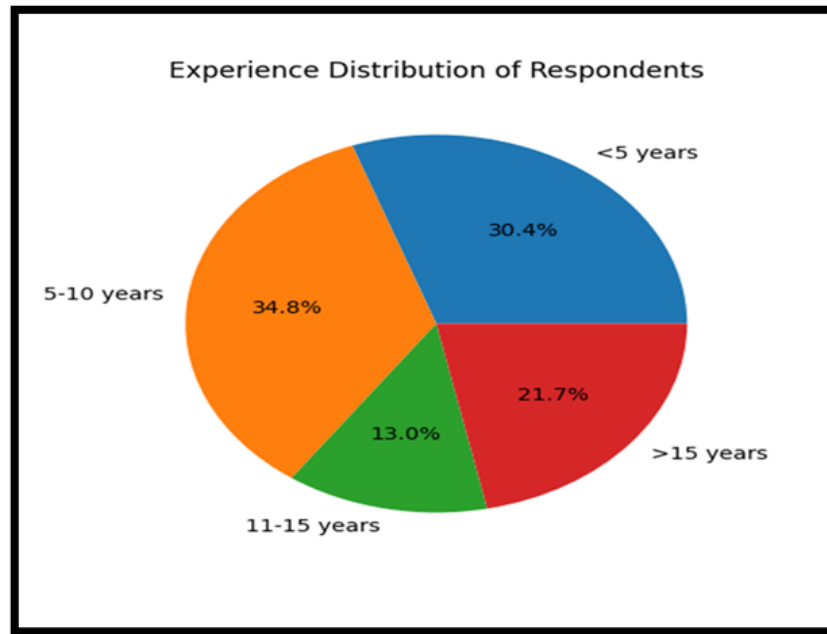


Figure 3. Participants' Professional Years of Experience

5.1.3. Statistical Analysis of the Technology Migration Factors

The Table 2 below presents the statistical analysis of the technology migration factors, focusing on the mean to indicate the direction of the responses, the median as an indication of central tendency, and the standard deviation to represent response dispersion. There is also an indication of valid responses, as the no-experience responses were excluded.

Table 2. Statistical Analysis of the Migration Factors

Survey item	Mean	Median	Standard deviation	Valid responses
DMR effectiveness	3.82	4.0	1.01	17
Adaptability	3.71	3.0	0.99	17
Migration understanding	3.89	4.0	0.90	18
Training adequacy	3.71	4.0	1.16	17
Post-training usability	4.06	4.0	0.97	17
Training material clarity	3.94	4.0	1.06	18
Communication clarity	3.63	4.0	1.12	19
Management support	3.67	3.5	0.77	18

Based on the Table 2, it is clear that the median is the value of 4 across all factors of migration, showing that the responses given were either Good or Excellent whereas the standard deviation is around 1 when we are approximating showing moderate and variable views, and again with regards to Training Adequacy the standard deviation is spread at a value of 1.16 showing there is different responses to Training. As described above, the median is used to measure the central tendency of responses on the 5-point Likert scale, given that the interval between responses cannot be equalized, whereas the mean is used as a directional indicator. The standard deviation is another measure used to validate the mean and median as indicators of how scattered the other measures are.

5.2 Stakeholder Perception System Performance and Reliability

The open-ended survey questions were analyzed thematically. These open-ended questions focused on areas such as perceptions of the new system, training, change management, and recommendations for technology migration-related projects, much like the quantitative analysis areas of focus. The analysis focused on the factors highlighted by the low mean scores and high variation in the quantitative analysis: training adequacy, communication, and management migration support.

5.2.1. Theme 1: DMR Issues

From the quantitative data, the DMR effectiveness had a mean score of 3.82, indicating that the system was perceived as effective; however, from the open-ended question, a theme of system issues emerged in the narrative. The issues below were highlighted as a result of system failure.

- Coverage Issues - Several respondents highlighted issues around coverage, and some of the channels have a weaker signal strength.
- Equipment Failure- One of the respondents is quoted as stating, “Some of the radios failed to power on.” Some stated that the audio from the radios was poor, and issues with their calibration further highlighted equipment failure.
- Integration Issues- An issue around the rate at which the old VHF radio system is integrated into the new DMR was slow, with one respondent highlighting “Interoperability with the old VHF system”.

5.2.2. Theme 2: Training Adequacy and Skills Development

Based on quantitative analysis, one factor was training adequacy, which is tied to skills development. This factor from the statistical analysis was calculated to be 1.16, and from open open-ended context, it shows that training was lacking, and the suggestions included the following:

- Lack of practical training- Most respondents highlighted that hands-on training was lacking with regard to troubleshooting the DMR communication components, and that training needed advanced methods, versus the training that was provided, focusing on the network management tool.
- Specialist Knowledge Gaps-Specifically, technicians who responded to the survey highlighted that they did not understand complex components within the DMR system, such as “antenna combiner and receiver multi-coupler,” further showing a need for specialized knowledge to maintain the DMR system.
- Insufficient Stakeholder Training- One of the stakeholders highlighted that only basic training was provided, and was quoted as saying, “No training for clients has been done. Clients were given basic functionality to help them relate to the old way of radio communication. Note that Full DMR functionality of the system has not been given to the client”, further highlighting the issue of training adequacy across the whole organization.

5.2.3. Theme 3: Poor Change Management and Leadership Support

When conducting the quantitative analysis, two factors had a lower mean value of 3.63 for communication clarity and 3.67 for management support across the other 6 remaining factors being closer to a mean value of 4, highlighting perceived issues of change management and leadership alignment as the narratives and further analysis of the open-ended question in this regard showed the key issues below:

- Inadequate Stakeholder Involvement- Based on the open-ended question, the change management process was highlighted as “not proper” by one respondent, further quoted stating that “The Technical team was involved at a later stage during implementation, and customers (Technologist) were not informed and they have to re-program their radios when we go digital” showing lack of proper change management plans.
- Non-clear deployment plans- Several respondents highlighted the issue of clarity regarding pilot testing to address any defects before the actual deployment of the system, and furthermore, one respondent was quoted stating that there are “Poor records of existing installed base” showing misalignment between change management and asset management plans.
- Communication Breakdown- One of the highlighted issues was information transfer and communication clarity between management and field operations staff due to multiple points of communication about migration. One of the respondents recommended that communication needs “Needs to be centralized to all regions. This ensures that communications and plans are received by all the stakeholders all the same time.

5.2.4. System Performance and Reliability

This section highlights the use of secondary data from the DMR Management System, in which the reliability of the system is measured over a 24-hour period to show how many failures can occur within that period.

Total Operation time = 24 hours, Total Number of Failure (Trouble Critical) = 10 events

$$MTBF = \frac{\text{Total Operation Time}}{\text{Number of Failure}}$$

$$MTBF = \frac{24 \text{ hours}}{10 \text{ events}} = 2.4 \text{ hours per failure}$$

$$\text{Failure Rate } (\lambda) = \frac{1}{MTBF}$$

$$\lambda = \frac{1}{2.4} = 0.417 \text{ failures per hour}$$

The low MTBF indicates low reliability and suggests the system will fail every 2.4 hours. Qualitative analysis (Theme 3) showed that the change management process was highlighted as “not proper” by one respondent, with the technical team involved at a later stage during implementation.

5.3 Proposed Improvements

The training curriculum for the DMR migration project must be developed for different keyholders based on their responsibilities, focusing entirely on IP networks. The training must be integrated with CMDB to provide stakeholders with the Ability to track assets and have visibility into configurations, system changes, and maintenance. The grid should investigate and pilot an AI-based predictive maintenance tool integrated with the system DMR management tool. The leadership process must change from top-down dependent leadership to a more transformative leadership style

5.4 Validation

Based on Theme 1: DMR System Issues resulting from factors such as coverage issues, equipment failure, and integration issues, as well as Theme 2: Training Adequacy resulting from factors such as Lack of practical training, specialist knowledge gaps, and insufficient stakeholder training, the themes further support the divergence around the performance and perception. Users provided positive feedback on the system's usability as they used its basic functionality; however, the MTBF is low due to system issues covered in Theme 1, and advanced skills are lacking due to training. This shows the link between Asset Management and Change Management, with MTBF linking directly to AM and CM linking directly to training and staff preparedness. The divergence between high user perception shown by the respondent's direction of the survey, with the mean value of 4.06, and the actual reliability measure of the secondary data related to system failure, MTBF = 2.4, is validated by differentiating between users' basic operation functions of the system and the adequacy of advanced skills. This is further validated by Theme 2, which highlights skills gaps and shows how skills impact the stabilization of system issues and troubleshooting; this is also evidenced by the 20-hour interface downtime. Table 3 summarises the cross-validation matrix and the factors associated with the results.

Table 3. Cross-validation Matrix: Perception and Reality reconciliation

Factors	Quantitative Values	Qualitative Values	Secondary Data Values	Cross-validation Conclusion
Reliability	High User perception (mean score =4.06)	System Issues (Theme 1)	Low MTBF (2.4 hrs/failure)	Divergence-perception from basic tools with technical instabilities.
Skills Competency	Training Adequacy (Sd=1.16)	Specialist Knowledge Gaps (Theme 2)	A high number of trouble events and 20 hours of interface failure	Convergence- Poor training leading to bad system management

Factors	Quantitative Values	Qualitative Values	Secondary Data Values	Cross-validation Conclusion
CM/AM integration	Low management support (mean=3.67)	Poor Change Management (Theme 3)	Authentication Failure from one of the interfaces	Convergence-misalignment between asset management and change management

The Cross-validation Matrix serves as a method to further validate the data; it cross-references all the data analysis: quantitative, qualitative, and secondary data. The user-perception score from the survey is compared with secondary data, MTBF, and the thematic analysis of the open-ended survey questionnaire, which explores all factors from the staff and the actual system.

6. Conclusion

This study presented an exploratory case study of asset and change management in smart grids. Based on the results, the calculated MTBF of 2.4 hours/failure indicates that the asset management strategy being followed is reactive. The grid must move to a more proactive approach through the integration of predictive maintenance for DMR component that are exposed to harsh environments (E.g. antennas, base station, servers) and CMDB to provide a more centralized management of the assets records inclusive of database of the stakeholder working on these assets, this does not only focus on asset management but also provides added security and data integrity. The current change management strategy is weak, as evidenced by low mean scores of 3.67 for management support and 3.63 for communication clarity. The grid needs to adapt Kotter's eight step model (steps 1-4) for strategic alignment providing the organisation's management with an ability to be able to integrate and plan with other stakeholder during the change not at a later stage and the ADKAR Model (Knowledge and Ability stages) for individual readiness addressing issues such as specialized skills and training this will ensure stakeholders addresses all the required skills related and readiness at the correct time of the change. The research highlighted a theoretical gap, showing a need for a more holistic, integrated approach to asset and change management.

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Biographies

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