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RESEARCH ARTICLE

How industrial maintenance managers perceive socio-technical changes in leadership in the Industry 4.0 context

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ABSTRACT

Innovations and advancements in technology create new opportunities to run and maintain manufacturing plants, which we refer to as digitalised manufacturing. This development is recognised as a socio-technical system (STS) change, where a change in the production system's goals, technology, processes, people, or environment may lead to ripple effects between those sub-systems. Despite this, technology development and technology use cases account for most of the research within digitalised manufacturing, while little attention has been devoted to leadership practices considering digitalised manufacturing from a socio-technical perspective. This paper focuses on the maintenance organisation, whose mission in a company is to keep production systems functional. We aim to describe leadership in industrial maintenance from an STS perspective. This is a unique interview study where twenty maintenance managers from Swedish manufacturing industry offer their perspective on the changing leadership within maintenance, providing a unique insight into the challenges facing leaders of maintenance in digitalised manufacturing. We frame the empirical findings using an STS framework and propose an overall consideration model for leadership that supports the development of a functional maintenance organisation in the face of pervasive digitalisation.

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Maintenance management; smart manufacturing; Industry 4.0; manufacturing systems; digitalisation; leadership

1. Introduction

The manufacturing industry is currently undergoing a change, where innovations and advanced technology create new opportunities to run and maintain production, aiming to increase productivity and competitiveness (Dalenogare et al. 2018; Hermann, Pentek, and Otto 2016): in short, digitalised manufacturing. Digitalised manufacturing is characterised by computer science and advanced manufacturing technology where production equipment is highly interconnected (Kagermann et al. 2013; Xu, Xu, and Li 2018) alongside humans. Information can continuously be exchanged to decentralise decisions and control, thus enabling autonomous systems that operate by themselves (Hermann, Pentek, and Otto 2016; Monostori et al. 2016).

Maintenance in digitalised manufacturing has become a popular research topic, mainly elaborating how digital technologies can be used to enable e.g. condition monitoring of equipment, remote services, modelling wear of components, calculating remaining useful life, and prediction of failures (Grubic and Peppard 2016; Lee et al. 2015; Li, Wang, and Wang 2017; Roy et al. 2016). This technological focus in maintenance research does not fully consider that humans and their interactions with technology will be goal-oriented, adding system properties to digitalised manufacturing (Neumann et al. 2021; Sgarbossa et al. 2020). To understand the rationales and multiple considerations that inform leaders, qualitative studies (particularly interviews) with purposive sampling of interviewees (i.e. recruitment on the basis of holding a particular professional position and having sufficient experience thereof) are widely used and accepted in a variety of fields to explore the perceptions of individual leaders. Examples include healthcare management (Kidholm et al. 2015, n = 53; Tegelberg et al. 2019, n = 17), industrial safety management (Tappura, Nenonen, and Kivistö-Rahnasto 2017, n = 49), SME internationalisation (Stoian, Dimitratos, and Plakoyiannaki 2018, n = 18) and resilience among industrial managers (Foerster and Duchek 2017, n = 27), to name a few. However, this type of study seems practically absent from the maintenance research literature.

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At its core, leadership within advanced manufacturing companies has long been recognised as a socio-technical matter (Kast and Rosenzweig 1974; Shani et al. 1992), also specifically within maintenance (Kelly 2006), meaning that there is an inevitable human aspect of the system to be considered. Framing something as an STS is viewed as 'a useful organisational design tool for examining and changing the workplace environment' (Shani et al. 1992, 92). Wise leaders with awareness of STS are therefore equipped with a mindset enabling them to consider the interdependencies between different sub-systems. It may seem overly reductionistic to focus all leadership challenges purely on technological developments – yet, this remains a tendency in contemporary digitalisation literature.

This paper aims to answer the research question: *which aspects of leadership in maintenance organisations are important in the face of pervasive digitalisation?* In this study, we interviewed 20 maintenance managers (MMs) from Swedish industry, seeking their perspectives on maintenance leadership. As a result, this paper provides unique insights into maintenance organisations from various manufacturing sectors and the challenges facing the leadership of maintenance in digitalised manufacturing. From here, the paper is structured as follows: a theoretical background is presented, followed by an explanation of our research methodology. Next, we present the empirical findings and analysis, where the interviewees' perceptions of leadership in maintenance are presented. Finally, we summarise and discuss the study, propose future work and present our conclusions.

2. Theoretical background

2.1. Digitalisation, maintenance and leadership

Recent innovative technology developments enable highly automated and interconnected production systems, which creates new opportunities to run manufacturing plants. Industrie 4.0 was initiated by the German government in 2011 as a strategic move for the digitalisation of the manufacturing industry (Culot et al. 2020; Kagermann et al. 2013); a phenomenon described in many concepts (Culot et al. 2020; Ivanov et al. 2021) such as digital transformation, fourth industrial revolution, and smart factories (Frank, Dalenogare, and Ayala 2019; Hermann, Pentek, and Otto 2016). In this paper, *digitalised manufacturing* refers to the concept of digitalisation of the manufacturing industry.

The technology development has led to high expectations on advances within the maintenance field, described as a new paradigm in maintenance management (Silvestri et al. 2020). Maintenance is described by Groover (2007) as 'procedures that make production systems work', and the new paradigm in maintenance management is changing these procedures. Reviews by Bokrantz et al. (2020) and Huang et al. (2020) show that several researchers have described maintenance management in digitalised manufacturing. Summarised, they cover technologies for condition monitoring of equipment, remote supervision and services, root cause analysis, calculation of remaining useful life, and failure prediction (Grubic and Peppard 2016; Lee et al. 2015; Li, Wang, and Wang 2017; Roy et al. 2016). Especially predictive maintenance has received a high level of interest; foreseeing breakdowns by detecting anomalies in equipment data (Usuga-Cadavid et al. 2021). Despite the promising technologies, the approach in maintenance practice is still reactive and many industrial companies are experiencing too much downtime (Jin et al. 2016) not associated with digitalisation. To break this, the whole maintenance organisation needs to develop (Bokrantz et al. 2020). Digital technologies have the potential to improve both maintenance control and execution (Silvestri et al. 2020). However, such implementation requires competence development of the employees (Akkermans et al. 2016; Roda, Macchi, and Fumagalli 2018) as well as management support (Bokrantz et al. 2020; Ghobakhloo 2020). Despite this, technological challenges dominate in maintenance research (Roy et al. 2016; Silvestri et al. 2020). Maintenance management in the context of digitalisation is being developed with high focus on technology (e.g. Kłos and Patalas-Maliszewska 2018; Bodo, Bertocco, and Bianchi 2020; Ashjaei and Bengtsson 2017). Aiming at advancing maintenance management, maturity models have been used in both academia and industry to assess maintenance practices and identify possible improvements. Table 1 provides an example of references including maintenance maturity models.

The maturity models assess both technological and managerial aspects, which both are important for maintenance in digitalised manufacturing. However, the criteria (pre-defined by researchers) are targeting the operational aspects of maintenance with less (no) focus on practices of leadership in the changing maintenance organisation. Leadership is a central part of organisational change (Battilana et al. 2010; Stouten, Rousseau, and De Cremer 2018) and plays an important role the implementation of maintenance in digitalised manufacturing (Bokrantz et al. 2020).

To the best of our knowledge, there are no empirical studies in established production research journals where industry practitioners offer their in-depth view on leadership in the development of maintenance organisations. This is because the topic of interest is at an intersection

Table 1. Examples of references using maturity models to assess maintenance management, including how the maturity model was developed and/or used (methodology), number of dimensions for assessment, and number of maturity levels.

References	Methodology	No. of assessment dimensions	No. of maturity levels
Schuh et al. 2010	• Based on 'House of Maintenance' [referring to previous research project] • Applied to one case	9	5
Chemweno et al. 2015	• Developed by extending the work by Van Horenbeek and Pintelon (2014) • Applied to two cases	19	5
Mehairjan et al. 2016	• Developed based on literature review and (industrial) stakeholder brainstorming • Applied to one case (twice, with 2 years in between)	5	4
Macchi, Roda, and Fumagalli 2017	• Developed based on maturity model by Macchi and Fumagalli (2013) • Applied to 300 industrial companies in Italy for benchmarking	10	5
Nemeth, Ansari, and Sihn 2019	• Developed based on knowledge-based maintenance • Applied to one case	4	4
Oliveira and Lopes 2020	• Developed based on literature review • Applied to three cases	10	5
Schmiedbauer, Maier, and Biedermann 2020	• Developed based on design science and structed literature review • Not tested/applied	9	5
Johannes et al. 2021	• Developed based on four empirical cases • Applied to the four cases	8	2–3 depending on dimension

between very specific themes – (i) the domain of industrial maintenance, (ii) the phenomenon of digitalised manufacturing, (iii) the research type qualitative and/or interview studies, and (iv) the perspectives of actual practicing MMs. A search for academic literature in this intersection yields very few satisfying results. We found just one Swedish interview study in a conference contribution by Kans (2019) where not all interviewees were in a maintenance leadership position, and the interview questions focused much more on mapping upcoming technologies than eliciting leadership perspectives; still, the study found that future maintenance leadership challenges would not be about technology, but about 'factors such as strategic planning, culture and lack of competence.' (1). That result offers justification for this study, which examines those themes in particular. Thus, this paper aims to elaborate important qualitative and empirical aspects of leadership for the development of maintenance organisations in the face of pervasive digitalisation.

2.2. Socio-technical systems

At their core, socio-technical systems (STS) models are used to design functional organisations that include a symbiosis of humans, technology, and tasks that interact together in a given environment (Walker et al. 2008). Several variants of STS models exist, but their common purpose is to study how humans and technology co-exist and interact, within an environment, executing intentional processes to fulfil goals. Using an STS model as a theoretical lens when analysing empirical material brings the benefit of emphasising how the interactions and interrelations of observed sub-systems produce ripple effects (Hendrick and Kleiner 2001) that affect the overall system's goals and ability to adapt to external and internal changes in a viable manner. The chosen STS model requires that the nature of the sub-systems be made explicit, as opposed to regarding them as 'black boxes' with unknown internal processes. Consequently, joint optimisation of the sub-systems is the main target of STS analyses, to ensure a functional organisation.

For this particular study, we have adopted Davis et al.'s (2014) STS framework, which considers the interplay between six sub-systems: Goals, People, Processes/Procedures, Buildings/Infrastructure, Technology, and Culture. Furthermore, their framework proposes that the system (in this case, the manufacturing company) exists within an external environment characterised

Table 2. Sample demographics including age, experience, manufacturing sector, gender distribution, and positions held.

Sample demographics - 20 interviewees			
Age range	38 - 62 years old (mean 48.6 yrs ± SD 6.2)*		
Years of experience	4 - 26 years of maintenance management experience in a leadership role (mean 13.3 yrs ± SD 7.1)**		
Description of manufacturing	Sector, (SNI*** division)	Number of interviewees	Interviewee aliases
sector	Machinery and equipment, (28)	4	Machinery-01,02,03,04
	Motor vehicles, trailers and semitrailers, (29)	3	Vehicles-01,02,03
	Basic metals, (24)	3	Metals-01,02,03
	Paper and paper products, (17)	3	Paper-01,02,03
	Food products, (10)	2	Food-01,02
	Basic pharmaceutical products and pharmaceutical preparations, (21)	1	Pharma-01
	Chemicals and chemical products, (20)	1	Chemicals-01
	Coke and refined petroleum products, (19)	1	Petroleum-01
	Electrical equipment, (27)	1	Electrical-01
	Other transport equipment, (30)	1	Othertransport-01
Gender distribution	19 Male, 1Female		
Positions held	• Maintenance manager at one or several plants • Maintenance manager responsible for their products at the customers' facilities (service manager) • A central maintenance manager responsible for managing and developing the maintenance within the whole or parts of the corporation		

* Note: age data was not given by 4/20 interviewees.
** Note: number of years of experience was not given by 8/20 interviewees.
*** SNI stands for 'Swedish Standard Industrial Classification' and is a system for classifying enterprises and workplaces according to the activity they carry out.

by Financial/Economic Circumstances, Regulatory frameworks, and Stakeholders. The framework by Davis et al. (2014) has been used in several recent works related to manufacturing (Neumann et al. 2021; Beier et al. 2020; Sony and Naik 2020), making it suitable for our present topic of studying the complexity of maintenance leadership in digitalised manufacturing. The framework was also originally used by Davis et al. (2014) to examine accidents at crowd events related to arena sports and implementing environmental sustainability at workplaces. In this study, the framework has been used as a complementary deductive analytical framework to compare and contrast the experiences and views of several different company representatives.

3. Methodology

The present paper describes a semi-structured interview study based on 20 interviews with MMs from large companies in the Swedish manufacturing and process industry. The interviews were carried out during the winter of 2017–2018. The sample covered companies from several different industrial manufacturing sectors (see Table 2). An in-depth description of the sampling and methodology is offered in the appended COREQ checklist (Tong, Sainsbury, and Craig 2007) at the end of this paper (Appendix A), to increase the transparency of the researchers' methodological decisions.

3.1. Sample

Interviewees were selected and recruited using purposive sampling (Palys 2008) of experienced MMs, since the target of the study was to explore in-depth insight and experiences regarding an industry-wide potential for change and how it would differ from an earlier status quo. Purposive sampling means that participants are recruited based on having particular characteristics, experiences or abilities that make them particularly suitable as informants for a study, on the merits of being able to describe certain sought-after insights in-depth. For this study, individuals with leadership experience in industrial maintenance were intentionally sought out and recruited through membership in a Swedish professional network with sustainable maintenance management as its central focus. In a sense, opportunistically recruiting through the network greatly facilitated the search for appropriately knowledgeable professionals, but effectively barred non-members of the network from being recruited. Managers were selected based on having at least two years' work experience in a maintenance management role, as well as being available and willing to participate. Participants were promised anonymity. Table 2 provides an overview of the sample demographics, and interviewee aliases to be able to track quotes while upholding the promised anonymity of the interviewees. For individual MMs, the alias will

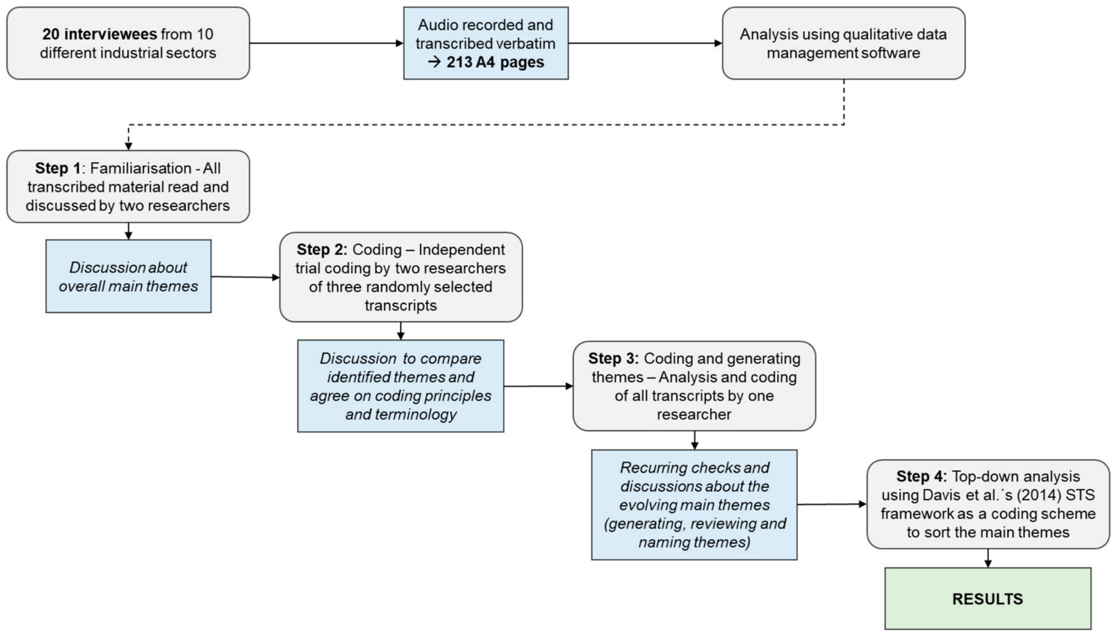

Figure 1. The analysis was done in four major steps.

be used, while referrals to them as a group will be 'the interviewees'.

3.2. Procedure

The interviews and analysis were carried out in Swedish, and a bilingual author with dual native languages (English and Swedish) translated all terms and quotes. The interviews, being explorative, aimed to be as open as possible and result in interviewees associating freely, but they were semi-structured in the sense that all interviewees were asked the same two open-ended questions:

(1) Think about your past experiences as a leader and tell [me] about occurrences that have influenced your views on leadership in maintenance.
(2) Tell [me] how you think that demands on leadership in maintenance will change in the coming five to ten years.

No other prompts were used, apart from the interviewers requesting interviewees to clarify niche terms from their industrial sector or encouraging them to expand on mentioned experiences, occurrences, and practices. This interviewing strategy was modelled on a similar study by Källström (1995) about perceptions of leadership in Swedish industrial management, where two very similar open-ended questions were posed to top managers at various Swedish enterprises. All interviews were audio-recorded and transcribed verbatim. To provide a sense of scale, the resulting amount of data occupied 213 A4-size pages of transcriptions (approximately 115 000 words in Swedish).

3.3. Data analysis: coding

A four-step process for analysis was used; a bottom-up thematic analysis (Braun and Clarke 2006) including (1) an initial scanning of the material and (2) trial coding of three randomly selected transcripts, (3) coding of all the transcripts, followed by (4) a top-down categorisation based on Davis et al.'s (2014) STS framework to usefully group and consolidate responses from the interviews, avoiding a purely descriptive analysis. Figure 1 describes the analysis procedure.

The analysis procedure was done with a mix of a bottom-up (step 1–3) and a top-down (step 4) approach. In step 1, the entire material was read by two of the researchers – the main analysts – to get an idea of the content and some overall main themes. In step 2, three transcribed interviews were randomly selected to be coded by two researchers, independently of each other. Another discussion compared the themes identified by the analysts, reaching a consensus on a common set of themes and coding principles for the coding of all material. In step 3, all transcripts were coded by one main researcher with regular checks and discussions with another researcher in the team, resulting in a set of semantic (explicit) codes that stay close to the data items. The codes were organised into cohesive key themes by grouping similar codes together, inspired by constant comparison (Glaser and Strauss 1967). As the coding progressed, key themes emerged and were named based

1. Observations about change and resistance to change (15)
1.1 Rapid changes
1.2 Propensity for change
1.3 ”Things were better before”
1.4 Investments and new technology

2. Roles and responsibilities within maintenance (20)
2.1 Decision-making
2.2 Shared or delegated responsibility
2.3 Coaching leadership
2.4 Role of the leader
2.5 Role of the co-worker

3. Personnel (19)
3.1 Personnel turnover
3.2 Recruitment
3.3 Attracting recruits
3.4 Young potential recruits
3.5 Diversity
3.6 Developing personnel

4. Competence (20)
4.1 Competence of the leader
4.2 Competence of the co-worker

5. Setting goals (18)
5.1 Vision
5.2 Strategy
5.3 Formulating goals
5.4 Progress
5.5 Key performance indicators
5.6 Individual goals

6. Coherence within the organisation (20)
6.1 Cross-functionality
6.2 Maintenance as coordinator
6.3 Relation to operations
6.4 Relation to projects/investments
6.5 Relation to IT
6.6 Technological integration
6.7 Barriers
6.8 Collaboration within the maintenance organisation

7. Dependencies outside the organisation (19)
7.1 Customer-supplier relations
7.2 Research and education
7.3 Networks
7.4 Benchmarking
7.5 Partnerships

8. Social practices (19)
8.1 Corporate culture
8.2 Trust
8.3 Experience
8.4 Human-centredness
8.5 Processes, practices

9. Minor themes
9.1 Centralisation of maintenance
9.2 Flexibility of the organisation
9.3 Role model
9.4 Holistic view
9.5 Hierarchical structures
9.7 Instructions
9.8 Self-support
9.9 Standardisation
9.10 Incremental change
9.11 Maintenance plan
9.12 Maintenance management system
9.13 Vibration technology

Figure 2. Coding structure with eight key themes and the ninth theme for minor subcategories.

on the codes within the theme. Within each key theme, the codes were grouped into sub-themes to specify more in detail what is within each key theme. Thirdly, a top-down coding of the sub-themes was applied using the main themes from the Davis et al. (2014) framework. The content of each sub-theme was analysed in relation to each element of the STS framework using a matrix structure. The matrix was used to organise the main themes in relation to the STS framework, aiming for an overall understanding of the various experiences among the interviewees.

4. Empirical findings and analysis

This section presents the analysis of the interviews with 20 maintenance managers. First, the coding structure from the Thematic analysis (bottom-up coding) is presented. Next, the insights from the interviews are framed using the Davis et al. (2014) STS framework, including supporting evidence (quotes from the interviews).

4.1. Thematic analysis

From the corpus of qualitative data, eight key themes emerged. These were: (1) Observations on change and resistance to change; (2) Roles and responsibilities within maintenance; (3) Personnel; (4) Competence; (5) Setting goals; (6) Coherence within the organisation; (7) Dependencies outside the organisation; (8) Social practices. To avoid force-fitting and the risk of losing items and subcategories, a ninth theme of minor themes was added. Figure 2 provides an overview of the coding structure including the key themes and the sub-themes. The number in parentheses represents how many of the interviewees spoke about each theme (max 20). The themes do not have any mutual order but are numbered simply to clarify future references to each theme and subcategory.

(1) *Observations on change and resistance to change* covers specific statements about the change and potential resistance to change. (2) *Roles and responsibilities within maintenance* represents how the role of the leader and the co-worker is projected to be. (3) *Personnel* describes what becomes important to secure the personnel in the maintenance organisation; keeping current employees as well as recruiting new ones. The technological development and the transformation of industry set new requirements of the (4) *Competence*. This theme describes what competencies are needed among the leaders and the co-workers. Theme (5) *Setting goals* describes how maintenance leaders need to relate to goals; both in terms of vision and strategies related to the overall company, as well as individual goals for the co-workers. (6) *Coherence within the organisation* stands for increased collaboration between maintenance and other functions within the company; but also collaboration within the maintenance organisation. There is also a projected increased collaboration outside the walls of the manufacturing plant, reflected in (7) *Dependencies outside the organisation*. (8) *Social practices* describes how people are interacting; a focus on informal practices rather than formal work processes. (9) *Minor themes* serves as an ‘other’ category

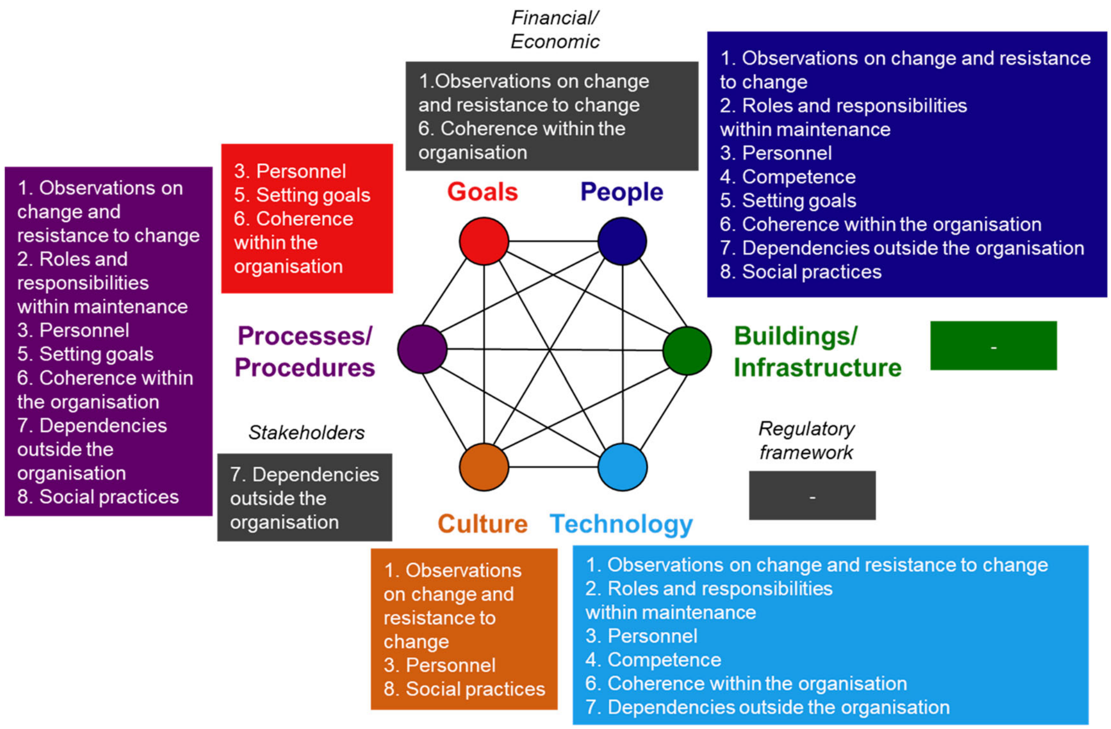

Figure 3. The main themes from the bottom-up coding, lined up using Davis et al.'s (2014) STS framework.

to avoid force-fitting. Minor themes is not further analysed.

The MMs indicate an upcoming change that they need to respond to. The advancement in technology is pervasively reshaping the industry, which has an impact on the maintenance organisation. Although the new technologies are anticipated to support maintenance employees in their work, there are also barriers. Many maintenance employees have worked in the same analogue way for years, which is not coherent with digitalised industry. To keep up with the change in the environment, someone has to lead the change in the maintenance organisation: the maintenance manager.

The role of the MM is to make the maintenance function work in the digitalised context, meaning more focus on leading employees and the organisation through a change rather than directly managing the daily maintenance activities. A tradition within the maintenance field has long been that skilled technicians are promoted to the role of MM, thus being a manager with highly specialised skills within technology. The role of a MM is currently evolving towards greater responsibility for connecting the technology with the people working with it. A digital-era MM will need generic skills, focusing on leading and developing people rather than knowing the technology in detail.

4.2. Socio-technical framework analysis

> I also think that maintenance (…) as an organisation needs to change. (Machinery-01)

Here we use Davis et al.'s (2014) STS framework to structure and synthesise the eight main themes on future leadership in maintenance (The ninth theme, Minor themes, will not be considered in this analysis; relatively little was said compared to the eight main themes). In Figure 3, the main themes are lined up with the framework. None of the emergent themes were related to Buildings or Regulatory frameworks.

Each theme consists of a set of subcategories used to describe the finding more in detail. The following sections will present each part of the STS framework and the related themes and subcategories. Also, a selection of interviewee quotations will be given to exemplify and clarify. The subcategories occur in several parts of the STS framework; a sign that much of what the MMs talked about is interconnected. For each part of the framework, not all associated subcategories will be retold; rather, these are used to highlight and exemplify the main themes. The sub-systems are presented in the following order: technology, goals, people, processes, culture, financial, and stakeholders (buildings and regulatory frameworks were not applicable).

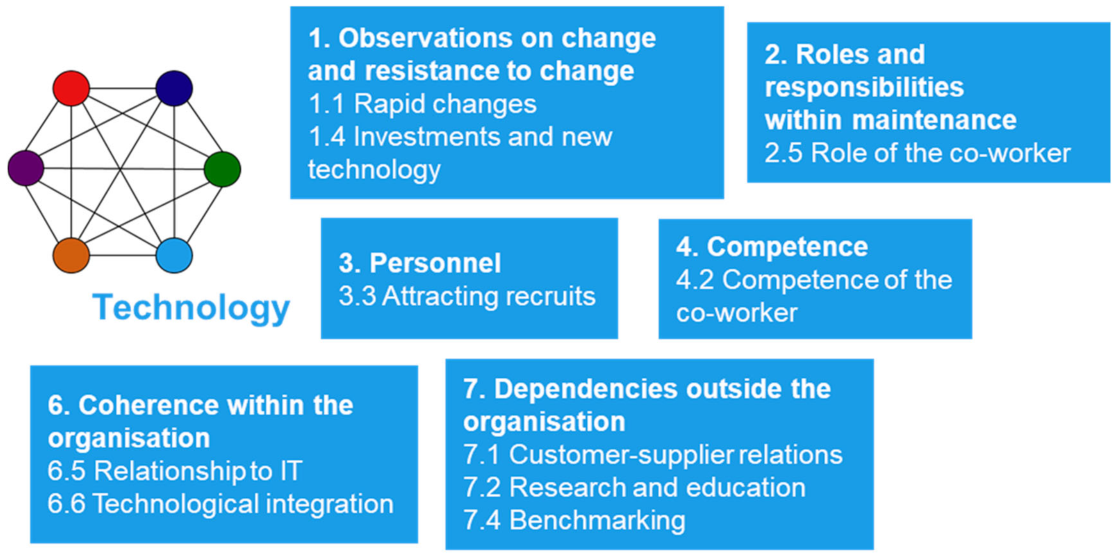

Figure 4. Technology and the associated main themes and subcategories.

4.2.1. Technology

The main themes and subcategories related to technology are presented in Figure 4.

Fifteen of the interviewees talked explicitly about *Rapid changes* (*1.1*) in industry related to technology development. However, new technology may entail negative attitudes among some people in the corporate organisation. One MM reflected that previous experience of failed IT projects may shape the staff's attitudes to new technology, both in terms of its use and the willingness to spend financial resources for investments (*1.4 Investment and new technology*). On the other hand, the interviewees foresaw increased use of predictive maintenance technologies to replace traditional working methods (like preventive maintenance based on calendar time and reactive maintenance) and that this will require investments.

The new technologies were anticipated to support maintenance employees in their work, but according to the interviewees, too many employees see the new technology as complicated to work with, or as a threat. As one manager exemplified: '(…) then a 3D-printer will be there doing these things instead, which I think will cause everyone to worry, "what will I do then?"' [Machinery-02]. On the other hand, the interviewees also discussed the new technology as a way for *Attracting recruits* (*3.3*). 'And it isn't dirty, monotonous, awful and boring in the big industries anymore, we have peak technology in our shop, and we make market-leading products. We need to show that, in a wholly different way.' [Metals-01]. Some pointed out that there will still be equipment that requires oil and lubrication, but all interviewees talked about *Roles and responsibilities within maintenance (2)* as something that the new technology will impact. One clear example was the *Role of the co-worker (2.5)* and the *Competence of the co-worker (4.2)*. A strong trend in the industry has been to collect data using technology, and one MM expressed quite clearly what is needed:

> This thing that we have a bunch of systems that we collect a lot of data [from], it's OEE-systems and APC-systems and quality systems and a bit of everything (…) But the data and the [decision] support and these things (…) risk ending up in a big [expletive] database-hole, more or less. [Food-01]

The interviewees foresaw that the new technology will create new roles and will require new competencies, with an increased amount of specialists among the co-workers.

All interviewees talked about *Coherence within the organisation (6)*. From a technology perspective, they talked about how the maintenance application approaching the IT domain, requires a *Relationship to IT (6.5)*. Further, they talked about *Technological integration (6.6)* between systems. However, there is currently no standard, and different suppliers have different solutions. As summed up by one of the interviewees: 'Ten different standards and ten different systems make it a lot more complicated if you want to progress with integrating and updating, and having technical equipment that can be modernised.' [Metals-01].

Meanwhile, the interviewees did offer optimistic projections on *Customer-supplier relations (7.1)*. The new technology development has made it possible to connect production equipment to the supplier and thereby access the equipment for data collection and analysis from the other side of the world. This makes it possible to involve suppliers in diagnosis and troubleshooting; very helpful, felt one interviewee, as 'that [supplier] is sitting with 300 000 [people/plants] who have the same problem as oneself.' [Petroleum-01].

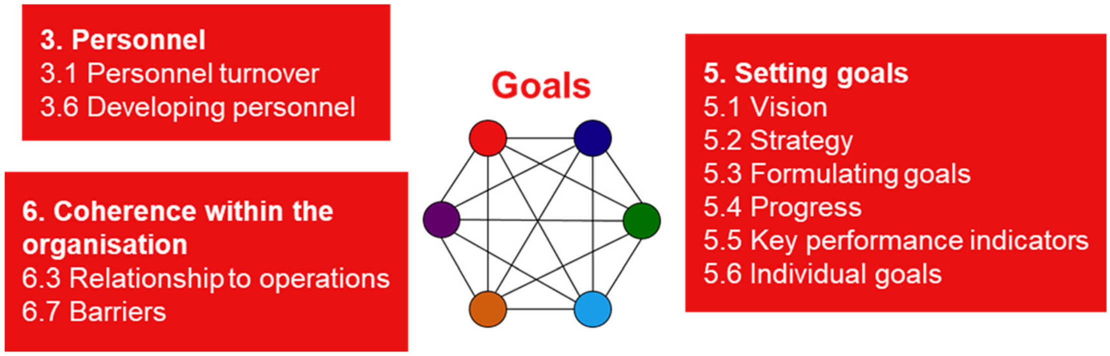

Figure 5. Goals and the associated main themes and subcategories.

To summarise, MMs emphasised the importance of the development of new technology, and how it is impacting the organisation. New technology sets new requirements for co-workers, at the same time providing opportunities to support co-workers in daily work. Further, new technology opens up more collaboration, both within and outside the corporate organisation.

4.2.2. Goals

The main themes and subcategories related to goals are presented in Figure 5.

In terms of Goals, interviewees described a transition from leaders pursuing purely operational, technical goals (such as technical availability) to an increased need for them to be visionary (*5.1 Vision*) and strategic (*5.2 Strategy*). For example, they must be capable of setting visions of what to achieve in the future, as well as 'Driving long-term strategies regarding technology choices even though resources are not yet available today, while having thought out a direction to strive towards.' [Metals-01].

The interviewees also spoke about an increased need for *Formulating goals (5.3)* and following up on *Progress (5.4)* related to the development of the maintenance organisation.

> It's not just about the leadership (…) there may be a demand placed on future leaders that they should be very skilled at (…) being able to both show where we are currently within maintenance, and to demonstrate a development (…). [Metals-03]

When it comes to follow-up of that development, some interviewees proposed that the scope of *Key performance indicators* (KPIs, *5.5*) for maintenance is about to shift from a dominance of technical parameters (such as technical availability and mean time to failure) to also include employee turnover rate, organisational attractiveness, employee engagement, and other parameters related to the organisation.

The interviewees emphasised that formulating and working with goals is an increasingly important aspect regarding the retention of *Personnel (3)*; they projected that future employees will most likely expect a plan for their development, to continuously develop their skills, and get new responsibilities (*3.6 Developing personnel*). If their expectations cannot be met, there is a risk of high *Personnel turnover (3.1)*. At the same time, interviewees acknowledged that work within the production industry is still too often associated with monotonous tasks without development opportunities. One interviewee said: 'So they'll come to the industry and be given an operator station where about four things happen per hour, what [expletive] kind of motivation and engagement are they supposed to have for these workplaces in the future?' [Food-01]. The MM, therefore, will need to ensure that goal-oriented and driven employees are given the personal development they want by actively addressing *Individual goals (5.6)*, thus working with development goals for both the organisation as a whole and its individuals. *Coherence within the organisation (6)* will be essential to avoid sub-optimisations and ensure common goals, particularly between the maintenance department and production department (*6.3 Relationship to operations)*.

To summarise, system goals from a maintenance perspective were understood by the MMs as being in a transition state, from an equipment availability-focused mindset to a state where the future emphasis must be placed on personnel- and competence-related development.

4.2.3. People

The main themes and subcategories related to people are presented in Figure 6.

Fifteen of the interviewees offered *Observations on change and resistance to change.* From a people aspect, they talked about stimulating a *Propensity for change (1.2)* among the co-workers, and at the same time being able to deal with resistance to change. Some of the interviewees mentioned the attitude 'Things were better before' (1.3); not as their own opinion necessarily, more as a reflection

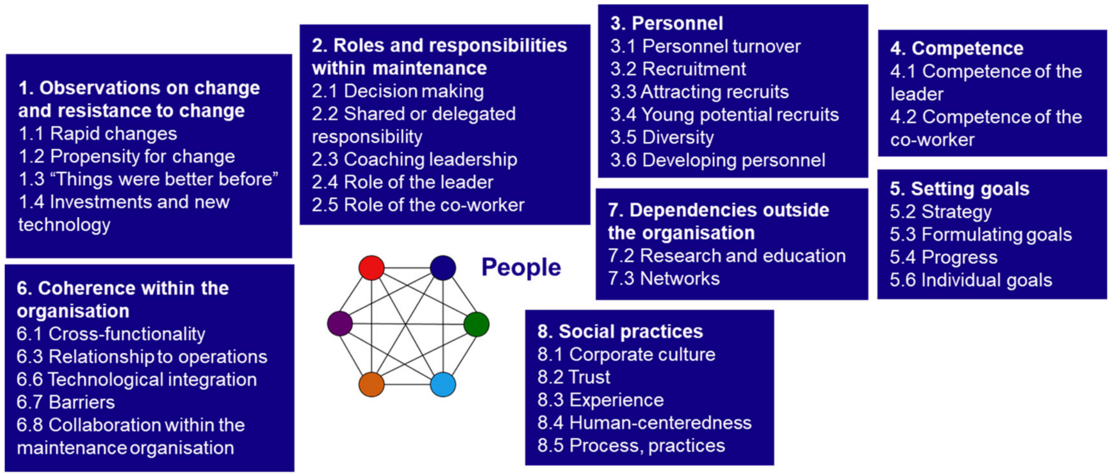

Figure 6. People and the associated main themes and subcategories.

of some co-workers' attitudes. Maintenance organisations are still comprised of a majority of relatively senior and experience-driven people, and their attitude towards change is not always positive. Two of the interviewees exemplified with commonly heard quotes like: 'Things were better beforé things like that' [Chemicals-01] and 'but (…), why should we change things, we've always done it this way' [Paper-03]. The interviewees believed that so-called 'simple jobs' will end up somewhere else and that the maintenance organisation will primarily consist of engineers with analytical skills, impacting the *Role of the co-workers (2.5)* as well as their competence (*4.2 Competence of the co-worker*). One of them used a metaphor: 'Maintenance will don white coats and stethoscopes and become like surgeons, whose job is to analyse and [say], "now we see this pattern"'. [Machinery-01]. To ensure the right competence of future co-workers, the interviewees think that industrial companies need to engage in education (*7.2 Research and education*), providing input on what is expected in the maintenance profession. However, even if new competencies would be needed, the maintenance organisation will most likely continue to need skilled mechanics and electricians on the 'nuts and bolts level'. One of the interviewees gave a clear example: '(…) when the job is to be done, when you're about to exchange a piston in a piston compressor, you'll have to do it the same way as it's been done before, even in 20 years, I think'.[Petroleum-01].

The MMs projected an organisation with more specialists among the co-workers, making the leader's role (*2.4 Role of the leader)* more of a generalist working with people. However, the current situation was described by one of the interviewees as 'Unfortunately I think we have too many technicians as leaders today.' [Pharma-01]. Others pointed out the increased importance of soft leadership competence among MMs. The changing *Competence of the leader (4.1)* was simply described by one of the interviewees: 'The way I see it, the era of these [technical] specialist managers is coming to an end.' [Paper-02]. On the other hand, one MM pointed out: 'You need a basic technical competence for this, even if a leader is supposed to make use of their co-workers, you still need the basic technical competence to gain acceptance among the co-workers.' [Food-02]. Further, the interviewees talked about *Human-centredness (8.4);* a MM must be able to see individuals and be interested in their development.

The MMs predicted more cross-functional work (*6.1 Cross-functionality*) across departments and an increased need for collaboration within the maintenance organisation, especially given the trend of specialisation among the employees. Meanwhile, they described an interesting contrast; while they foresaw a need for specialists in new digital technologies, there still exist prejudices and perceptions of industrial work, expressed as '(…) this impression of service and maintenance (…) being just grease and hammers and sawing things'.[Machinery-04]. The interviewees talked about the importance of *Attracting recruits (3.3)*, especially young people (*3.4 Young potential recruits*) to their organisation to secure the right competence and future co-workers. This was perceived to be a challenge. One of the MMs explicitly said that he is 'worried'; partly about the prejudices regarding industry work and partly about expectations of interest from MMs to develop their personnel (*3.6 Developing personnel*).

> I think the kind of personnel we will be getting in the future won't be as (…) loyal, and I think they seek challenges (…) you can jump more easily between employers (…), which I think places very high demands on us

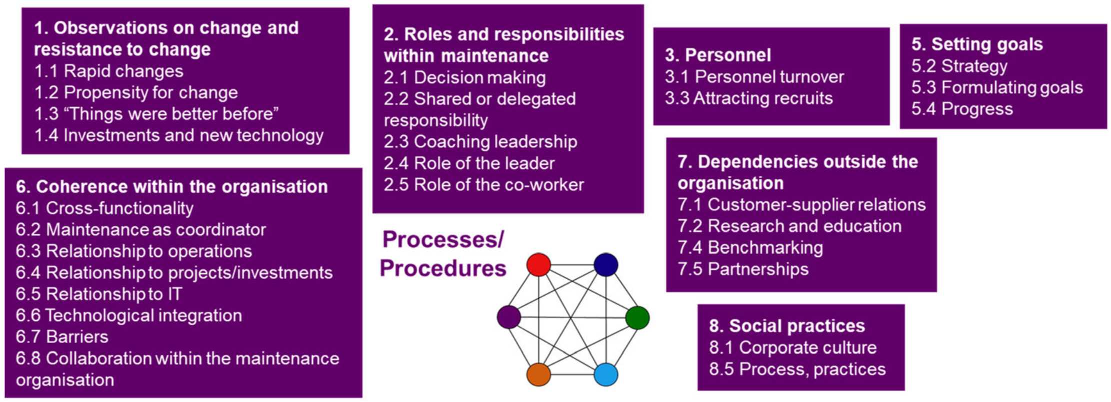

Figure 7. Processes and the associated main themes and subcategories.

> that [employees] really should thrive in the workplace. [OtherTransport-01]

They projected that decreasing loyalty would lead to higher *Personnel turnover (3.1)*. One MM mentioned a workplace where an operator takes action only four times an hour, while another highlighted that they are working with the latest digital technologies, making it easier to attract future employees. Some interviewees stated that to create an attractive organisation to work in, the manager would need ability in *Formulating goals (5.3)* and following up on *Progress (5.4),* especially on an individual level (*5.6 Individual goals*).

To sum up, MMs understood the people aspect as increasingly important; personnel skills and attitudes are important for the future maintenance organisation. As leaders within maintenance, they saw that it will become crucial to deal with people in a way that develops the organisation as well as the individuals.

4.2.4. Processes

The main themes and subcategories related to processes are presented in Figure 7.

The interviewees talked explicitly about changes in work procedures in maintenance (*8.5 Processes, practices*). It might not be evident how these changes will present such a challenge, but one of the interviewees expressed a quite emblematic example of work procedure for a large generation within the maintenance profession, who

> for twenty years have been given a slip of paper saying to "do this and go do this" on the slip of paper, then go sit and wait until they get a new slip of paper in their hand to do again. I'm exaggerating a little now when I say this, but some of that mentality has been around. [Food-02]

This quotation reflects a largely reactive approach. Although many of the changing work practices are intended to support the co-worker, interviewees noted some resistance to change among employees:

> You're quite satisfied with the way you're working and maybe you were hired for a way of working that was passable twenty years ago, or ten years ago, and have a bit of a harder time adapting to new things. [Metals-02]

The MMs did however foresee an accelerated development and implementation of machine learning (ML) and artificial intelligence (AI), entailing a more predictive way of working: 'We're going to be able to predict a lot, lot more, and I think that will be much more convenient both for me as a manager and for all our co-workers.' [OtherTranspor-01]. The co-workers will get the technological responsibilities, and the MMs' responsibilities will change to '[no longer being] that technical leader anymore, instead you're more like a personnel administrator.' [Electrical-01]. The role of the MM was pictured as facilitating motivation and purpose for the employees and driving their development. Further, the interviewees talked about involving employees in decisions (*2.1 Decision-making*) and use a coaching approach (*2.3 Coaching leadership*), which will impact work procedures for both co-workers and the managers. They also mentioned changing work processes in terms of *Shared or delegated responsibility (2.2).* The MM will need to be able to delegate responsibility rather than work tasks, and the co-workers will need to take that responsibility.

The interviewees predicted a more cross-functional way of working (*6.1 Cross-functionality*), where maintenance will involve all parts of the organisation, with closer collaboration and *Relationship to operations (6.3)* and *investment projects (6.4)* in particular. One of the interviewees described experiences where the maintenance organisation became involved late in the investment process to 'clean up' what was left out from the investment project due to time- or cost limitations. On the other hand, the importance of involving maintenance early in the process has been learned and was seen as crucial for successful investment projects in the future. The interviewees also believed in shared work

Figure 8. Culture and the associated main themes and subcategories.

processes outside the organisation; a classic example being *Customer-supplier relations (7.1)*, where suppliers access data from the equipment delivered. Suppliers can thus connect remotely; one MM exemplified how the work procedures will change '[to seeing] what I see and, and help[ing] to guide me (…) to reduce my troubleshooting and repair time.' [Pharma-01].

In summary, MMs understood work procedures to be changing from reactive work to more predictive methods. On one hand, it might be difficult to get all co-workers on board with the new work procedures, while on the other hand, new work practices were projected to contribute to more exciting work tasks, which has the potential to attract new employees to the maintenance profession.

4.2.5. Culture

The main themes and subcategories related to culture are presented in Figure 8.

The MMs expressed a wish to employ a more diverse group of people (*3.5 Diversity*) with varying backgrounds, ages, and gender. More explicitly, some of the interviewees conveyed a need for more women, noting that women rarely apply for positions within maintenance. A harsh jargon was pointed out as one reason by one of the interviewees. Another MM equated the *Corporate culture* (*8.1*) to the work environment, arguing that the culture is essential to facilitate diversity within the maintenance organisation. Culture was also related to change itself, especially the sought-after *Propensity for change (1.2)*: '(…) driving change work without a good culture in the company is really hard.'[Paper-02].

The MMs hinted at increased importance of culture for the digitalised maintenance organisation. One of the interviewees stated clearly that there is a need to change the harsh culture into a culture with mutual respect. However, the cultural aspect was often neglected in change: '(…) maybe the emphasis has been on (…) depending on the time era, working purely with structure and indicator numbers, and completely forgetting the culture.' [Metals-02].

4.2.6. Financial

Davis et al.'s (2014) STS model brings up Financial/Economic aspects as a peripheral influence surrounding the STS. The findings in the interviews concerned Observations on change and resistance to it (1); and Coherence within the organisation (6).

Interviewees recognised that this technological shift requires *Investments in new technology (1.4)*. Despite that, some of the MMs experienced difficulties in justifying maintenance-related investments, especially those that cannot meet the set pay-back time. One of them expressed that management and economics functions do not understand, while another was convinced that you have failed in communication if you cannot justify investments in maintenance. *Coherence within the organisation (6)*, in terms of having a good relationship between maintenance and projects (*6.4 Relationship to projects/investments*) is a prerequisite for making investments towards the plant's long-term profitability. One of the interviewees exemplified *Barriers (6.7)* related to sub-optimisation: 'We can't have a bunch of obstacles [in the form of] sub-optimisations, like procurement having their mission to drive cost efficiency.' [Metals-01]. Another one described a mantra to make money on all investments within a specific pay-back time. Recently, increased awareness of maintenance aspects in other parts of the organisation have made it easier to get investments approved; 'And actually for the first time in many years, this year we have more investments that are actually related to reliability and function of our equipment, instead of just having profitable investment projects.' [Food-01]. The interviewees believed that cross-functional work (*6.1 Cross-functionality*) will help in getting an understanding of how maintenance impacts the overall company, including the financial aspects.

4.2.7. Stakeholders

Another peripheral influence surrounding the STS in Davis et al.'s (2014) model is Stakeholders. Overall, stakeholders were not a widely discussed topic, but interviewees mentioned an expanding range of external stakeholders for maintenance-related questions. Especially, the scope was expanding from within the own organisation (typically the production department) to also being outside the organisation. Most clear was *Partnership (7.5)*; a positive synergy can make more companies grow and stimulate sustainable development faster than companies trying to develop on their own. Therefore, it was projected that there will be more stakeholders outside the own organisation in the future, interested in the development and achievements of the maintenance organisation.

4.3. Summary: important aspects of leadership in maintenance

The interviewees mainly spoke about themes related to the sub-systems of technology, people, processes, and how these relate to each other. Managers were clearly aware that digitalised technology development is changing processes and work procedures. The technology itself and the changing processes were perceived to set new requirements on people's skills and influence their attitude. Among young people, key technologies will have the potential to entice them to start working within maintenance, while resistance to change is likely to arise among the more traditional/conservative employees. The role of the MM will be to deal with people of both extremes and everyone in between. One way is to work with individual goals and create opportunities for people who want to develop. Further, the maintenance function will need a stronger organisational link to the production department, the investment/project department, and the IT department. Digital technology can enable interconnected systems for sharing information, facilitating joint work procedures, and providing people with appropriate information to make decisions. MMs will have a crucial role in making this socio-technical interaction work.

5. Discussion

This paper distils insights from industry practitioners with leadership experience in industrial maintenance, aiming to answer the question, *which aspects of leadership in maintenance organisations are important in the face of pervasive digitalisation?* We identified eight main themes, summarised using Davis et al.'s (2014) STS framework into an overall consideration model. Thereby, this paper makes both theoretical and practical contributions.

5.1. Methodological discussion

Some methodological limitations of this study should be mentioned first, as they have shaped the results and offer learning opportunities that can be passed on to future maintenance leadership. The interview guide was intentionally very brief and wide-open in its scope, comprising only two open-ended questions to be interpreted freely (i.e. a semi-structured interview bordering on an unstructured execution), with follow-up questions purely aiming to make participants elaborate themes they themselves brought up. This reflects the study's kinship to a previous research endeavour by one of the authors, who used a very similar setup to explored enterprise leadership in a grounded, individual manner from a management-theoretical perspective Källström (1995). The advantage of such an interview technique is to catch the interviewees' perspective of leadership with minimum influence from the researchers' preconceptions; the interviewees steered the conversation toward topics that they found particularly central to their personal challenges and convictions. It also ensures that the interviewee spends much more time talking that the interviewer. Asking questions in this manner supplies researchers with very rich and detailed material that takes a long time and plenty of methodological care to analyse in a dependable and trustworthy way; also, since it is difficult to predict how they will respond, their answers cannot be easily mapped against each other for comparison. Therefore, a bottom-up coding was done initially to understand the interview material's main themes without shaping it in an early phase. Thereafter, a top-down coding was carried out using the STS framework (Davis et al. 2014) to organise our understanding of how the mentioned subsystems interact with each other; above all, to structure the MMs' stories. Not all material from the interviews was reported – the STS framework's scope effectively curated a selection of what to report.

Due to the wide-open questions being paired with an a-priori analysis framework, the content match between the empirical material and the STS components did not correspond 100%. This is perhaps most evident in that few to no mentioned themes were attributed to *Buildings/Infrastructure* or *Regulatory frameworks*, and that the topics of *Stakeholders*, *Culture*, *Financial/Economical* aspects and *Goals* were sparsely populated with examples (at least fewer compared to *People*, *Processes* and *Technology*). A different interview guide could have offered opportunities to target under-explored/missing themes with more direct questions. At the same time, this might limit the in-depth richness of professional experiences reported in this study.

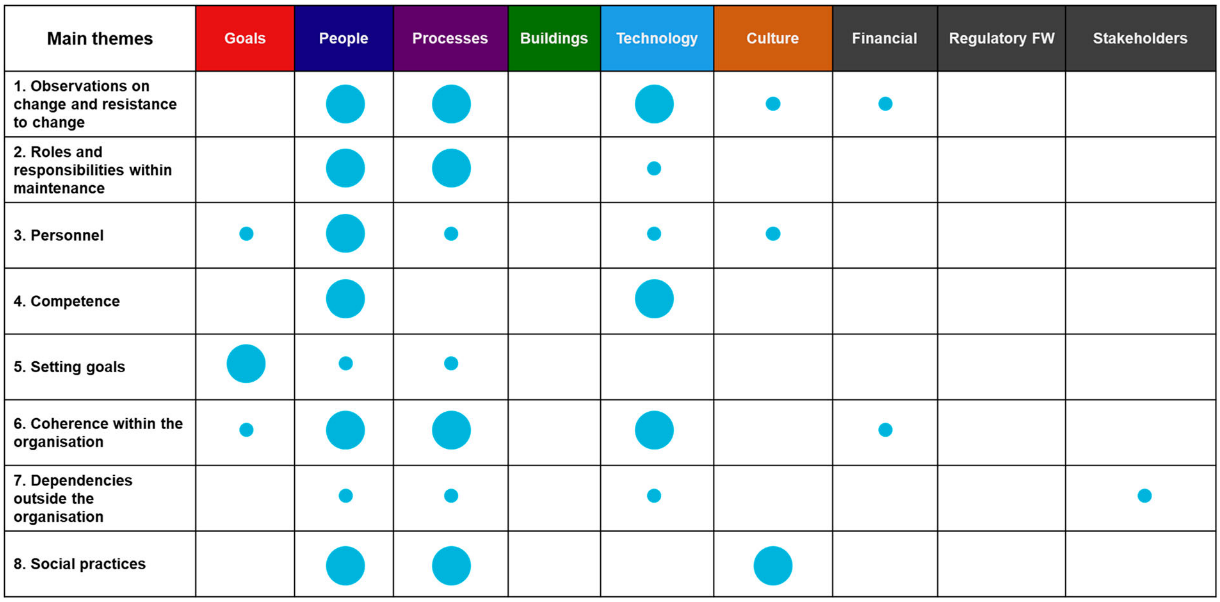

Figure 9. An overall consideration model for leadership in maintenance in digitalised manufacturing based on the main themes and the sub-systems in Davis et al.'s (2014) STS framework.

5.2. Theoretical implications

This paper focused on practitioners' descriptions of leadership based on their experiences and projected demands of leadership in maintenance. Research in maintenance management is most often dominated by technological perspectives (Kłos and Patalas-Maliszewska 2018; Bodo, Bertocco, and Bianchi 2020; Ashjaei and Bengtsson 2017), and little focus has been devoted to leadership in maintenance. To the best of our knowledge, there are no similar qualitative studies on industry practitioners' perspective of leadership in maintenance.

Further, assessment of maintenance management is commonly done using maturity models with pre-defined criteria set by researchers (please see overview of maturity models in Table 1). Such maturity models tend to emphasise factors that play a part in influencing maintenance outcomes, but they do not highlight the interactions between those factors and the empirical conditions given. This paper contributes with a different theoretical angle by framing the future leadership of maintenance from an STS perspective. This has allowed us to demonstrate some interdependencies between the sub-systems that MMs need to consider in designing a functional organisation around the goals of digitalised maintenance, avoiding dysfunctions arising from sub-optimisation. One caveat is that combining statements from so many diverse industrial sectors may depart from the more common application of Davis et al.'s (2014) framework as an explanatory tool targeting single, specific events; however, our aim here has been to summarise the diverse insights on leadership in maintenance and to map commonalities in a coherent way. From these insights, we propose an overall consideration model, presented in Figure 9.

A large circle indicates a strong connection between the main theme and the sub-systems, while a small circle indicates a weaker connection. This overall consideration model illustrates how industrial MMs perceive leadership in the face of pervasive digitalisation. It guides MMs in how to approach the main themes with a holistic emphasis on especially people, processes, and technology. Also, the insight from this study implies that maintenance as a research field needs to emphasise the aspects presented in the overall consideration model – the key themes, as well as the elements of the STS framework.

5.3. Practical implications

This paper's practical contributions prepare industry practitioners to work towards digitalisation by presenting insights and best practice ideas from industry colleagues. The overall consideration model, together with the detailed descriptions of the empirical findings and the analysis in Section 4, provides deep insights for industrial MMs in what and how their leadership needs to be changed to secure the future development of the maintenance organisation (according to their experienced peers). The overall consideration model can be used for structuring training and education programmes for current MMs and students interested in maintenance. Thus, future MMs may focus on the right things in leading the development of the maintenance organisation.

When maintenance leaders talk freely about leadership in maintenance, people, processes and technology are the three most prevalent elements, while goals, culture, financial aspects, and stakeholders are discussed to some extent. Nothing was said spontaneously about buildings or regulations; at least too little to be regarded as a trend in the bottom-up coding. In an alternative scenario, using interview questions developed from the STS framework might have led to more specific and well-tailored answers.

Individuals with leadership experience in industrial maintenance were intentionally sampled, recruited through membership in a Swedish professional network with sustainable maintenance management as its central focus. The sampled MMs have an interest and/or experience in working towards digitalisation, making the results from this study applicable in industrial organisations working towards digitalisation. The interviews were conducted during 2017–2018, and the development in both research and industry has continued since then. Mainly, the technology has developed at a rapid pace; the development of the organisation however has not, and the leadership aspects presented in this paper remain a valid topic. Above all, it is a challenge in industry practice.

5.4. Future work

The authors suggest future research where the overall consideration model is tested on a larger and more diversely recruited sample, in order to include MMs without membership in the network from which the participants in this study were recruited, and possibly also to extend the scope to several countries. Further, it may be interesting to use a cross-case analysis approach to study (possible) differences between manufacturing sectors. It would in that case be necessary to recruit an appropriate minimum number of interviewees per sector, so as not to draw conclusions based on too few representative informants.

As mentioned before, carrying out a similar study with a different, semi-structured interview guide more closely designed to match the analysis framework by Davis et al. (2014) could be a way to capture the overlooked aspects in the system model.

To provide complementary views to this study, it would be of interest to see additional studies with a qualitative, socio-technical systems starting point in other countries and settings, to explore the extent to which MMs in different countries have made similar observations, and perhaps also to test the applicability of theoretical STS models (and their proposed sub-systems) as a sound and rigorous 'backbone' to more detailed and targeted interview guides. Another possibility would be to analyse the topic of changing maintenance leadership with a cybernetic system model instead, concentrating on identifying feedback- and feedforward-loops that may serve to reinforce or mitigate (resist) the changes brought about by major technological transitions. Future research directions for studying maintenance leadership could also include an expansion of the topic to concern manufacturing industry's external drivers for change from a policy point of view, e.g. the European Union's increasing focus on societal prosperity and sustainability aspects as proposed in the Industry 5.0 agenda (European Commission 2021), or in terms of the current-day pervasive electrification of transport systems within and between manufacturing sites.

6. Conclusions

This paper presents a unique perspective of leadership in maintenance. We bring scientific and practical contributions by describing how 20 industrial maintenance managers (MMs) perceive leadership of maintenance from an STS perspective. Specifically, we propose an overall consideration model describing how MMs should consider the interdependencies of a functional organisation around the goals of digitalised maintenance. The overall model consists of a set of main themes that emerged from a bottom-up analysis and their connection to subsystems from a sociotechnical systems framework.

The results make important theoretical and empirical contributions to production research, since leadership in industrial maintenance is an infrequently explored area. Our results, albeit shaped by their Swedish, industrialised context, indicate that management and leadership of maintenance is likely to be systemically impacted by how industrial digitalisation alters opportunities, expectations, collaboration demands and modern understandings of leadership concerns. This makes the adoption of a sociotechnical systems perspective crucial, to effectively allow the mapping of behaviours, relationships and interdependencies between the human and non-human subsystems. It also enables a contrasting qualitative research perspective to enter an arena dominated by technological state-of-the-art-driven reasoning about management logics.

From a practical point of view, industry practitioners (i.e. MMs) gain structured insights from industry peers on ways to act as leaders, recruiters and strategists in the face of industrial digitalisation transformations. Our results imply that achieving a systemic understanding of multiple sociotechnical factors is necessary for individual MMs to keep abreast of rapid digital change, and to know which specific outcomes they should monitor. By continuing and amplifying research in maintenance leadership, and suggesting avenues for future work, we hope to continue the development of sustainable and highly productive production systems in digitalised manufacturing.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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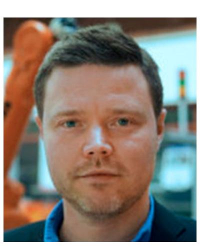

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Data availability statement

The data that support the findings of this study are available from the corresponding author, Cecilia Berlin, upon reasonable request.

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Appendix A - COREQ Checklist (Tong, Sainsbury, and Craig 2007).

Domain 1: Research team and reflexivity		
Personal Characteristics		
1. Interviewer/facilitator	Which author/s conducted the interview or focus group?	Author2 (A2), Author3 (A3), Author4 (A4), during 2017-2018. Author1 (A1), joined the project in 2020 to analyse the interviews with A2.
2. Credentials	What were the researcher's credentials?	All interviewers had a PhD in engineering at the time the interviews were carried out. A1 was a PhD student with a Lic. Eng. degree at the time the analysis was carried out.
3. Occupation	What was their occupation at the time of the study?	A1, A2, and A3 were employed at **will add for publication**; A1 as PhD student, A2 and A3 as Associate Professors, while A4 was an Adjunct professor at **will add forpublication**.
4. Gender	Was the researcher male or female?	A1 and A2 are female, A3 and A4 are male.
5. Experience and training	What experience or training did the researcher have?	A2, A3, and A4 had all conducted semi-structured interviews routinely prior to this project. A1 had experience of qualitative analysis from previous research work.
Relationship with participants		
6. Relationship established	Was a relationship established prior to study commencement?	Yes, the interviewees were recruited through a professional network of Maintenance managers combined with personal contacts.
7. Participant knowledge of the interviewer	What did the participants know about the researcher?	Due to the recruitment through the aforementioned professional network, some participants were familiar with one of the interviewers (A4) as chairman of that network, while the other researchers were new acquaintances.
8. Interviewer characteristics	What characteristics were reported about the interviewer/facilitator?	A3 and A4 were investigators in a parallel research project aimed at developing and promoting the concept of 'Smart Maintenance'. A1 was a PhD student within that project. A2 was outside of the project but was interested in carrying out a leadership study on managers representing maintenance, as their main concern might be considered non-primary to each company's business (which is similar to her previous research on human factors/ergonomics involvement in change projects).
Domain 2: Study design		
Theoretical framework		
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study?	The study employs a *thematicanalysis* (Braun and Clarke 2006) as an initial bottom-up coding strategy, followed by the use of Davis et al.'s (2014) socio-technical system (STS) framework as a deductive frame to report the results.
Participant selection		
10. Sampling	How were participants selected?	The sampling was purposive, as the recruitment targeted individuals with certain characteristics regarding work position and experience, at companies representing a variety of industries.
11. Method of approach	How were participants approached?	Face-to-face and via telephone in some cases
12. Sample size	How many participants were in the study?	24 people were recruited, of which 20 were interviewed.
13. Non-participation	How many people refused to participate or dropped out? Reasons?	Four participants from the originally recruited sample (24) dropped out prior to their interviews due to lack of time or interest.
Setting		
14. Setting of data collection	Where was the data collected?	The data was collected via phone or face-to-face interviews, depending on where in the country interviewees were located.
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16. Description of sample	What are the important characteristics of the sample? e.g. demographic data, date	Age range: 38–62 Male/Female ratio: 19M/1F Date: 15th Nov 2017 – 19th March 2018
Data collection		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Two questions were used as an interview guide. Three pilot interviews were conducted successfully and were thus included in the study.
18. Repeat interviews	Were repeat interviews carried out? If yes, how many?	No
19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	Interviews were audio recorded.
20. Field notes	Were field notes made during and/or after the interview or focus group?	No, interviews were transcribed verbatim from audio recordings.
21. Duration	What was the duration of the interviews or focus group?	30m 39s - 48m 15s (based on length of audio recordings)
22. Data saturation	Was data saturation discussed?	No (opportunistic study)
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	Full transcripts were not returned to participants; but an early-stage aggregated descriptive report including some initial findings and quotes from the interviews were distributed to the participants.

(*continued*).