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Implementation of continuous improvement cells: a case study from the civil infrastructure sector in the UK

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ABSTRACT

The interest in lean management in the UK's civil infrastructure sector is on the rise. In parallel with this interest, a team-based, participative management technique called Continuous Improvement (CI) cells has been widely adopted by the sector. The research on the technique has been scarce even though it has been adopted widely in some sectors as part of lean management. The study presented in the paper explores implementation characteristics, benefits, challenges and roles of CI cells in other management strategies through a case study conducted at a large public client organisation in the infrastructure sector in the UK. Both qualitative and quantitative data were collected through interviews, participant observation at CI cell meetings, and from organisational and team records. It was found that CI cells show some similarities and differences in application with other participative management techniques in lean management. A large set of CI cell benefits and challenges were identified. CI cells were also found linked with Visual Management, *kaizen*, *hoshin kanri*, work coordination and planning, and employee training at team level.

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Lean management; continuous improvement; work planning; participative management; CI cells

1. Introduction

Participative management is at the core of many management concepts (Gallie 2013; Marchington 2016; Swearingen 2017). In simple terms, it refers to employees' involvement in influencing decisions about work (Magjuka and Baldwin 2006; Hanna, Newman, and Johnson 2000). Research papers on the concept have been published regularly since the 1930s from different perspectives such as workplace democratisation, organisational citizenship behaviour, empowerment, employee motivation and organisational change (Lawler 1993; Turnipseed and Rassuli 2005). Modern organisational management endorses participative management to cater for employees' higher-level needs for consultation, involvement, contribution and usefulness (Pardo-del-Val, Martinez-Fuentes, and Roig-Dobón 2012; Hosseinabadi et al. 2013). The aim of this research is to evaluate the practical adoption of a participative management technique called Continuous Improvement (CI) cells. As explained in subsequent sections of the paper, the technique has been scarcely researched although it has been referred to in the lean management literature and adopted widely in certain sectors for team-based work improvement, problem solving, planning and coordination efforts.

The literature on modern management concepts such as lean management, Total Quality Management (TQM) and Six Sigma emphasises the operational benefits of participative management (Andersson, Eriksson, and Torstensson 2006; van Assen 2021), associating it with building consensus, creating ownership, work coordination and directing employees' efforts to work improvement and efficiency (e.g. waste reduction, gradual quality improvement, problem solving) (Brunet and New 2003; Singh and Singh 2009; Prajogo and Cooper 2010; Cecilia Martinez Leon et al. 2012; Bhamu and Sangwan 2014; Evans and Lindsay 2014; Kiran 2016). Furthermore, there is evidence in the literature showing that employee participation can help increase productivity and quality, reduce employee monitoring/control costs and increase work commitment and satisfaction (Cabrera, Ortega, and Cabrera 2003; Lines 2004; Kitapci and Sezen 2007; von der Weth and Starker 2010; Bhatti, Nawab, and Akbar 2011; Gallie 2013; Irawanto 2015). Alongside the diffusion of those modern management systems into a wide-range of sectors beyond manufacturing, the participatory techniques for work improvement and team coordination were also successfully introduced to the education, service, information technology, healthcare and the public sector over the last 30 years (Donabedian 2002; Venkatraman 2007; Chand 2010; Niquille et al. 2010; Nicolay et al. 2012; Hosseinabadi et al. 2013; Sharabi 2013; Arsenyan and Büyüközkan 2014; Andrés-López, González-Requena, and Sanz-Lobera 2015).

Participative management takes different forms, ranging from informal participation to employee ownership of organisations (Gonzalez 2009; Kalleberg 2011). Three of the prominent team-based participative management techniques widely adopted by the operations management and

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industrial engineering communities for work coordination and improvement are Quality Circles (QCs), *kaizen* events and daily huddle (stand-up) meetings (Glover et al. 2011; Beckford 2016; Stray, Sjøberg, and Dybå 2016; Butler, Szwejczewski, and Sweeney 2018). These techniques and their likes are often classified as direct, consultative participation methods in which the management consults with employee teams directly for their input in work related matters but holds the ultimate decision making power; although, in some cases that power can be delegated to the teams to varying degrees (Green and Hunton-Clarke 2003).

Two high-profile industry reports published in the mid and late 1990s highlighted lean management as one of the way-forwards for the civil infrastructure sector in the UK (Latham 1994; Egan 1998). Over the past 10 years, the civil infrastructure sector in the country has been increasingly adopting lean management in its operations with explicit requirements from the public sector clients (Wolbers et al. 2005; Chen et al. 2012; Daniel et al. 2017; Tezel, Koskela, and Aziz 2018) as part of the aim for improving the whole system performance (Infrastructure and Projects Authority (IPA) 2017). This is in line with the UK Government's ongoing productivity and efficiency-increasing efforts in its operations (IPA 2017). that gained momentum after the 2007–2008 economic crisis in 2013, the UK Government announced the objective of 33% reduction in the initial cost of construction and the whole life cost of built assets in the country as part of their 2025 vision (HM Government 2013). Following this, the main public highways construction client announced a strategic plan to attain 250 million GBP in savings in highways projects through lean management techniques between 2015 and 2020 (Highways England (HE) 2016). The Government announced in 2017 the increase in the National Productivity Investment fund to 31 billion GBP to support investments in transport, housing and infrastructure as part of its industry strategy (HM Government 2017). Simultaneously, CI cells, as a participative, small group activity for work planning, control and improvement, have also been introduced in the civil infrastructure sector's supply chains within this lean management movement. The researchers could not identify much discussion as to the use of CI cells in the literature. However, as highlighted in the subsequent sections, CI cells bear many similarities and some differences in application with those more established participative management techniques adopted within lean management programmes – QCs and *kaizen* events, as team-based work improvement efforts, and huddle meetings, which are used mainly for day-to-day coordination of operational teams.

It should be highlighted that like many systems in the production management domain, CI cells seem to have evolved organically and incrementally in practice as a countermeasure to challenges rather than on the basis of theoretical knowledge (Fujimoto 1999). It is important to understand those practical arrangements as one of the tasks of management research is to explain and generalise managerial innovations done by practitioners (David and Hatchuel 2007). Furthermore, there are various references in the literature to CI cells' core document/content for rapid continuous improvement and problem-solving, the 3Cs (concern, cause and countermeasure) (Radnor 2010; Radnor and Bucci 2011; Sadreddini 2012; Procter and Radnor 2014; Panneman 2015; Radley 2015), which was implemented in the civil infrastructure sector in the UK in the mid/late 2000s first by consultants and lean management practitioners working for various service providers and later expanded and evolved into 'CI cells' in the early 2010s as a common practice. The term 'cells' was devised by practitioners and refers only to CI cells' work group or team-based nature with no other connotations to it.

To better understand the underlying dynamics of CI cells, it is deemed necessary to firstly explore those mainstream participative management techniques alongside cellular organisation. Moreover, the literature by consultants and practitioners in particular presents those participative management techniques as part of strategic management, performance management, process improvement, and day-to-day management of teams in often an overly positive tone (Bodek 2004; Alukal and Manos 2006; Jackson 2006; Kattman et al. 2012; Lawal et al. 2014; White 2016). Under the light of these explanations, following on a detailed literature review on cellular work arrangements and the established participative management techniques used in lean management, findings on CI cells from a case study at a large public organisation operating in the civil infrastructure sector in the UK are presented and discussed in the rest of the paper with the following research questions:

- How are CI cells implemented at the case organisation?
- What are the benefits of CI cells?
- What are the challenges associated with CI cells?
- What is the role of CI cells in other management strategies?

2. Literature review

2.1. Quality circles

QCs are work groups ranging from 4 to 15 members (Sillince, Sykes, and Singh 1996; Robbins 2003; Ehigie and McAndrew 2005; McGovern, Small, and Hicks 2017) that meet regularly under a group leader or a facilitator to discuss quality and productivity problems, and recommend, evaluate and implement solutions for those problems (Tang, Tollison, and Whiteside 1996; Flores and Utley 2000; Robbins 2003; Darlington et al. 2016; Barad 2018; Gutierrez-Gutierrez, Barrales-Molina, and Kaynak 2018). The deployment of QCs started in Japan in the 1950s as a decentralised and preventive quality control mechanism (Ishikawa 1985). They were widely imported in the early 1980s first by quality-conscious manufacturing companies in the West (e.g. automotive, aerospace, aeronautics) as a form of systematic employee involvement for gradual quality improvement (Karlsson and Åhlström 1996; Lagrosen and Lagrosen 2005; Zink, Steimle and Schröder 2008; de Menezes 2012; McGovern, Small, and Hicks 2017; Barad 2018; Gutierrez-Gutierrez, Barrales-Molina,

and Kaynak 2018). The originality brought by QCs was that problems were discussed by the people who were directly confronted with them, and who implicitly were invested with the moral authority to resolve them (Middleman 1983; Blaga and Jozsef 2014; Mitra 2016).

In the West, the interest in QCs peaked in the early 1980s and gradually diminished in one decade (Abrahamson and Fairchild 1999; Ehigie and McAndrew 2005; Mitra 2016). Companies progressed towards other Japanese-imported management systems such as TQM and lean management that also encompass QCs and similar participatory techniques such as *kaizen* events in their toolboxes (Berry 1991; Hill 1997; Chiarini 2011; Nakano, Muniz, and Dias Batista 2013; Rahani and Al-Ashraf 2012; Ota, Hazama, and Samson 2013; Samuel, Found, and Williams 2015; Barad 2018).

As for the benefits of QCs and QC-like participative team-based arrangements, job enrichment and greater employee autonomy, cost savings through work improvement, providing a systematic goal setting and feedback mechanism for employees, team work and participation in work decisions, supporting organisational learning and increased interaction between team members are noted in the literature (Ehigie and McAndrew 2005; Pereira and Osburn 2007; Chen and Kuo 2011; Lee et al. 2012; Miron et al. 2016; Barad 2018). Basu and Wright (2012) specify eight conditions for QC success; (i) voluntary participation in QCs, (ii) cross functionality in QC members, (iii) problems to be addressed in QCs should be chosen by QC members, (iv) adequate management support with necessary funds and time set for QCs, (v) QC members must receive the appropriate training in problem-solving techniques (e.g. Pareto analysis, cause-and-effect diagrams), (vi) QCs must be empowered to choose their own leaders, (vii) the management should appoint managers as QC mentors, and (viii) the management's genuine interest in and action on suggestions generated by QCs.

2.2. Kaizen events

A *kaizen* event is a 'focussed and structured improvement project, using a dedicated cross-functional team to improve a targeted work area, with specific goals, in an accelerated timeframe' (Farris et al. 2008, 10). They are often implemented in conjunction with lean management and known also as 'rapid improvement events', 'accelerated improvement workshops', 'gemba *kaizen*', and '*kaizen* blitz' (Glover et al. 2011). *Kaizen* events are the reflection of swift and radical *kaizen* implementations at team-level (Hodge et al. 2011; van Dun and Wilderom 2016; Hirzel, Leyer, and Moormann 2017). They evolved, taking inspirations from QCs, from a group of Toyota consultants, named Toyota Autonomous Study Group, who were banded together to instil lean management techniques in Toyota's suppliers in the West in the late 1980s (Bodek 2004). The main differences between QCs and *kaizen* events in application are that the latter is typically executed faster within three to five days while QC projects may last for several months, and focuses mostly on reducing processing times and the amount of non-value adding activities through radical improvements (Manos 2007; Russell and Taylor 2002; Glover, Farris, and Van Aken 2014; Garza-Reyes et al. 2020). Bicheno and Holweg (2008) suggest that *kaizen* events are concerned with the stimulation of swift and even flow of throughput within a value stream, and should be the responsibility of senior management.

Relatively short improvement durations, team training, cross-functional team structures, and a strong need for team leadership and work improvement authority are the defining characteristics of *kaizen* events (Melnyk et al. 1998; Bateman 2005; Stone 2010; Glover, Farris, and Van Aken 2014). Clarity and achievability of goals within shorter time frames, management support, sufficient team decision making authority and post-event follow-up activities are their key success factors (Farris et al. 2008; Farris et al. 2009; Glover et al. 2011).

2.3. Daily huddle (stand up) meetings

Daily huddle (stand-up) meetings refer to 10–15-min, fast-paced meetings of a work team to share information that is supposed to be relevant to the team's daily work planning, coordination, priority setting and progress (Paez et al. 2005; Stray, Sjøberg, and Dybå 2016; Demirkesen, Sadikoglu, and Jayamanne 2020). Daily huddles are deliberately kept short and focussed to save the time wasted during meetings (Stray, Sjøberg, and Dybå 2016). Indeed, employees usually spend a lot of unproductive time in meetings, causing serious work interruptions (Rogelberg et al. 2006). The meetings are coordinated by team leaders and are structured generally around 'what has been done since the last meeting', 'what will be done until the next meeting' and 'what impedes the team from making progress' (Sutherland and Schwaber 2013; Wells 2013; Butler, Szwejczewski, and Sweeney 2018). They emphasise team-based work coordination and planning in shorter time windows more than QCs and *kaizen* events.

Daily huddles have been associated with the agile methods such as Scrum in software development (Coplien 1994; Schwaber and Beedle 2002; Pikkarainen et al. 2008; Murphy et al. 2013) since the mid-1990s and later implemented also in other industries such as the construction industry (Paez et al. 2005; Salem et al. 2006; Zhang and Chen 2016). Alongside work coordination and improvement, daily huddle meetings were also found promoting team building, creating shared mental models and trust within a team, greater commitment to the course of action, and quick decision making (Sutherland and Schwaber 2013; Wells 2013). The daily meetings are often held around teams' visual boards to steer discussions, to maintain information flows and to support decision making, linking the technique with Visual Management for teams (Dreyer et al. 2009; Stray, Sjøberg, and Dybå 2016; Verbano, Crema, and Nicosia 2017; Choudhary et al. 2019).

In the lean management literature, the visual boards that work teams have their daily meetings around for coordination and improvement are called 'Daily Management Boards' or 'Daily Visual Management Boards', with display teams' key performance indicators (KPIs) with target vs actual team performance figures, availability of team members and other Human Resources related information, and the

continuous improvement process (Berlanga and Husby 2016; Lawal et al. 2014; White 2016; Verbano, Crema, and Nicosia 2017).

2.4. Cellular organisations

In production management, cellular organisation refers to a manufacturing process that produces families of parts within a single line or cell of machines operated by workers who work only within the line or cell (Singh and Rajamani 2012). A cell is a small scale, clearly-defined production unit within a production setting. This unit has complete responsibility for producing a family of similar parts or a product. All necessary machines and manpower are contained within this cell, thus giving it a degree of operational autonomy (Choobineh 1988). Each worker is expected to have mastered a full range of operating skills required by the cell. Therefore, systematic job rotation and training are necessary for effective and flexible cell development (Hyer and Wemmerlov 2004). Workers are encouraged to think creatively about production problems and are expected to arrive at pragmatic solutions to them with some problem-solving authority, giving rise to continuous improvement efforts and mechanisms (Al-Mubarak, Khumawala, and Canel 2003). Presenting workers with those challenges for work improvement is considered as a motivational factor. The need for supervision is reduced as cells lead to a flattened organisational structure.

In organisational research, cellular organisation is defined somewhat differently and refers to an organisational setup which is made up of 'cells' or 'nodes' or 'teams' that work independently as self-managing, autonomous units to work on tasks, to solve work-related problems and to execute continuous improvement (Miles et al. 1997). These cells exist in a broader network in which they frequently communicate with each other, exchanging information, to produce more potent business mechanism (Snow 1997). This structure exists in direct contrast to the traditional hierarchical setup, where one type of supervisor gives specific orders to another supervisor down in the hierarchical chain. Some organisations establish self-directed work teams as the basic work unit akin to production cells in a manufacturing firm or customer service teams in an insurance company. At other organisational levels, cross-functional teams may be established, either on an ad hoc basis (e.g., for problem solving) or on a permanent basis as the regular means of conducting the organisation's work. This type of autonomous teams can be also seen in the large-scale project management domain, in civil infrastructural projects in particular (Jolivet and Navarre 1996).

2.5. Continuous improvement cells

Cellular structures are thought to be well suited for continuous improvement and TQM efforts due to their flexibility (Schonberger 1992; Tan and Tan 2002). Nevertheless, the available literature on CI cells is limited. For example, Barad (1995: 85), while discussing and comparing the team-based quality efforts on shop floors in China and Australia in the early 1990s, places CI cells within the Western concept of cellular organisation as a response to the Eastern cultural feature of collectivity orientation or groupism:

> By creating Continuous Improvement Cells (or Teams) comprising of groups of employees working in the same environment (cell), by training and educating them and empowering them to make decisions, the active participation of employees in the improvement process could be boosted. Such ideas draw heavily from the Western Socio-technical Systems school of thought and represent a challenge for future research and implementation.

Barad (1995) suggests in her comparison of Western CI cells practices to the conventional QC practices originated in Japan that the improvement tasks of CI cells are meant to be simpler and reminiscent of those encountered in the QCs, with the main difference between the two being that the conventional QCs are practised on a voluntary basis, and the CI cells within a cellular organisation are not voluntary, but part of the system's formal organisation. Barad (2018) later links the CI cell practice in the West with those cellular structures as an instrument to facilitate the participation of cell workers in the improvement process on shop-floors, reiterating the differences between QCs and CI cells from a shop floor perspective.

Miron et al. (2016) position CI cells more broadly within lean management as a distinct continuous improvement and work coordination technique similar to and rooted from QCs and other small group activities. MacLennan and Chueke (2018) report a wide implementation of CI cells in Brazil for work improvement according to the lean manufacturing philosophy.

Radnor (2010), while evaluating the transfer of a lean management approach by a global manufacturing and logistics company into a large UK government department, identified evidence for the practical use of some core CI cell elements such as the 3Cs document and Visual Management/performance boards for work coordination and improvement. Radnor's work can be considered as an early academic evidence for the adoption of CI cell-like practices in the public sector, in which also the case organisation presented in this study operates. Similar practices of using Visual Management boards and the 3 C document within lean management and continuous improvement efforts were later identified in the UK's higher education sector (Radnor and Bucci 2011). Procter and Radnor (2014) classify the adoption of regular problem-solving/coordination meetings, the 3 C document and team Visual Management boards as opportunities for greater staff involvement through structured approaches to improvement and problem-solving for lean in the UK's public services. The three systems actually form the basis of the CI cells concept in practice as explained in the subsequent sections of this paper. Sadreddini (2012) calls for the deployment of CI cells as part of developing a lean culture in the highways sector in the UK. Oakland and Marosszeky (2017) include the CI cell practice in their case summary of the highways sector's lean objectives. In line with this, the CI cell can be traced in the documents summarising the recent service provisions offered by various

business consultants (EY 2014; Bourton Group 2017), providing evidence for the practice-led nature of the concept.

In summary, the academic and grey literature treat CI cells as a distinct, small group activity for continuous improvement and work coordination with its core elements; a Visual Management board for group information transparency and coordination, regular and structured meetings, and the 3Cs document for work improvement. The concept is often mentioned within lean transformation and management efforts. This study therefore defines CI cells as a small-group, participative management technique with a regular meeting structure and a real or a virtual information board used for team coordination and work improvement/problem solving within lean management efforts. CI cells are also associated with other small group, participative management techniques such as QCs. However, the similarities and differences between CI cells and other more popular concepts such as QCs and huddle meetings as well as CI cells' implementation mechanisms in practice with their benefits and challenges have not been sufficiently discussed in the literature.

3. Research method

Participative management techniques are complex configurations that are shaped by many organisational and team-related parameters (McGovern, Small, and Hicks 2017; Barad 2018; Gutierrez-Gutierrez, Barrales-Molina, and Kaynak 2018). This renders them well-suited for case research as case studies offer flexibility for explorative and theory building research in real-life contexts as, during the study, the research scope can be re-addressed, complementary data sources can be acquired, while the method also serves several types of research objectives (Beach et al. 2001; Voss, Tsikriktsis, and Frohlich 2002; Brax and Jonsson 2009; Kim, Rhee, and Oh 2011; Alblas and Wortmann 2014). Case studies have often been used to study implementation characteristics of different production management philosophies and techniques (Seth and Gupta 2005; Kumar et al. 2006; Vlachos 2015). According to Flyvbjerg (2006, 219), there are common misunderstandings about case study research:

> (1) theoretical knowledge is more valuable than practical knowledge; (2) one cannot generalise from a single case, therefore the single case study cannot contribute to scientific development; (3) the case study is most useful for generating hypotheses, while other methods are more suitable for hypotheses testing and theory building; (4) the case study contains a bias toward verification; and (5) it is often difficult to summarise specific case studies.

Many methodologies are aligned with specific philosophical positions that guide the research process. Case study, however, has a practical versatility in its agnostic approach whereby 'it is not assigned to a fixed ontological, epistemological or methodological position' (Rosenberg and Yates 2007, 447). Epistemologically, a pragmatist stance is adopted in this research, accepting both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question, focussing on practically integrating different perspectives to help interpret the data. Hence, this research is based on a qualitative and quantitative study of the CI cell practice at the case organisation. Complementing qualitative findings with quantitative data is a preferred approach in case studies for increased validity (Yin 1994; George and Bennett 2005). The study was initiated by the case organisation's invitation of the researchers in mid-2016 to evaluate its CI cells that had started under the organisation's lean management and process improvement efforts in the early 2010s. The case organisation is one of the main clients in the civil infrastructure sector in the UK. The civil infrastructure sector in the UK is led by a few public client organisations that drive innovation and lean management techniques such as Building Information Modelling (BIM) and Lean Construction in their supply chains, which are characterised by large private companies or consortia (Tier 1 suppliers) as the main product and service providers employing smaller organisations (Tier 2 s, 3 s and 4 s) and typically follow the lead of their public clients for implementing continuous improvement, innovation and various lean management techniques. The transitivity between the client organisation and its large service providers allows mutual copying of different management techniques, including the CI cell technique, among those sector players. The case organisation is also one of the leading organisations in the civil infrastructure sector in terms of its lean and process improvement efforts. Alongside construction project management, the organisation is responsible for managing and operating a large network of public transportation assets in the UK.

A case protocol, presented in Table 1, was developed for the study. One requirement for properly carrying out a case study is producing a case protocol for information gathering (Choudhari, Adil, and Ananthakumar 2012). The case protocol is a necessary tool while collecting data from multiple sources in a case study (Yin 1994). Data collection and analysis were completed in approximately 10 months in early 2017. Following the data collection and analysis, a case report was written and shared with the organisation for its feedback. The case narrative was improved as per the organisation's feedback, which helped further increase the internal and external validity. The data collection was executed in two main stages.

In the first data collection stage, after a detailed literature review, semi-structured interviews, each lasting between 45 and 60 min, were conducted with 3 lean/process improvement managers who are responsible for the general execution and supervision of the CI cells at the organisation. Semi-structured interviews are effective data collection methods in eliciting rich and often unexpected insights when researchers seek depth in their exploration of complex phenomena (Bourne et al. 2002; Grütter, Field, and Faull 2002; Beer and Micheli 2017; Wilhelm and Dolfsma 2018).

During the interviews, the implementing managers were asked about the CI cell background, the execution parameters and mechanism, and their observations as to the benefits and challenges of the CI cells. To further validate and expand on the initial findings, 12 team leaders and team members who are facilitating and leading their teams' CI cell

Table 1. Case study protocol.

Research boundaries and case justification.	The case is a large public organisation operating in the civil asset construction and maintenance/operations sector in the UK. The organisation started adopting lean management practices in the late 2000s (decade), of which CI cells are a part and were subsequently introduced to the organisation in the early 2010s. Being the main client in the civil infrastructure sector, it has influenced and led management practices of its service providers. Many of its management practices have been copied and adopted by its supply chain.
Unit of analysis.	CI cells (multiple) deployed at the case organisation.
Rationale for single case study.	Single case studies enable empirically-rich, context-specific, holistic accounts that can be used for theory-building and, to a lesser extent, theory-testing (Yin 1994; May 2011).
Construct validity	Multiple sources of evidence: 15 interviews, 7 participant observations in CI cell meetings, informal discussions with 11 CI cell teams, 12 CI cell board observations, organisation's records/ documents, CI cell team performance records and comparison between similar teams adopting and not adopting the CI cell technique.
Internal validity	Pattern-matching: exploration of the research questions' empirical relationships with literature. A case report was prepared for the organisation to obtain feedback.
External validity	Replication logics from multiple sources – data triangulation. A case report was prepared for the organisation to obtain feedback.
Reliability	A case study protocol and its database are developed including: the purpose of the research, interview notes, organisation documents, completed semi-structural interviews, team records and empirical data from the teams, and general descriptions of the CI cell structure.

meetings were interviewed for around 60 min using semi-structured questions. The teams were chosen from different operational areas in cooperation with the lean/process improvement managers to capture data from a wider work context. Having multiple perspectives on the CI cells enhanced the construct validity, since, within each of the aforementioned interviews, the interviewees expressed some shared understandings and uses of the CI cell practices. The interview questions can be found in Appendixes A and B.

Furthermore, the researchers attended 7 CI cell meetings in two locations, location A and B, in Northern England to observe the actual CI cell execution and to further validate the interview findings (see Appendix C). Additionally, informal discussions with the team members of 11 CI cells were conducted and 12 real and virtual CI cell boards of the teams were examined, which helped the researchers understand the connection between the CI cells and other management practices. To establish internal validity, the researchers triangulated the data sources by comparing quotes from the interviews with the observations and the team discussions. Finally, for reliability and traceability of the findings, a case database was constructed at the beginning of the research where all documents, photos, notes, and interview transcriptions were stored and labelled (Voss, Tsikriktsis, and Frohlich 2002). The first stage of the data collection yielded a large set of qualitative data that was analysed to explore the research questions. Regarding the characteristics of cells, two different patterns were recognised, and thus cells were grouped as Type I and Type II as explained in the subsequent sections. Also, both virtual cells for dispersed teams and real cells for co-located teams were identified. Details of the first stage of the data collection and studied CI cells are presented in Table 2.

In the second stage of the data collection, the researchers sought empirical evidence from the teams to validate the previous findings. This was challenging due to the fact that not much data that could be associated directly with the CI cells had been recorded by the organisation. Firstly, the claim that the introduction of the CI cells helped increase the staff engagement and work satisfaction at the organisation was investigated. To do this, the organisation's most recent annual staff engagement survey scores (retrieved from organisation records) conducted at the end of 2015 and 2014 targeting its customer operations teams across the country were analysed to statistically compare the engagement scores of the teams deploying and not deploying the CI cell technique. The customer and operations teams are the first teams that systematically started deploying the CI cell technique at the organisation. The staff engagement score represents a team's overall satisfaction covering areas such as satisfaction with job, management, team, organisational goals, work load, learning and development opportunities, inclusion and treatment, pay and benefits, and leadership. Due to the sensitive nature of the survey data, only the overall scores from the teams were shared with the researchers. Following this, meeting durations as well as some performance and continuous improvement records of Team 4 (Table 2) were statistically compared to the records of a similar team, Team 13, operating in a neighbouring area with the same responsibilities and number of team members as Team 4; but unlike Team 4, not deploying the CI cell technique. Finally, the planned work completed scores of Team 8 and Team 10 (Table 2) were calculated to validate the teams' claim that the CI cell technique directed the team members to make better promises regarding their work plans. The research process can be seen in Figure 1.

4. Findings

4.1. CI cell execution

CI cells were first adopted by some large service providers to the client organisation through combining their work teams' daily huddle meetings (Ghosh 2014), visual team performance/ communication boards (Bateman, Philp, and Warrender 2016; Bititci, Cocca, and Ates 2016) and a mechanism called 'the 3 C', which refers to systematically reviewing work concerns, causes and countermeasures as part of the civil infrastructure sector's lean initiative in the late mid/late 2000s (see Table 3 for the description of the '3 C' mechanism on CI cell boards). The early CI cells were devised by consultants coming from the manufacturing industry to the sector. The case organisation started

Table 2. Details of the studied CI cells.

General information						Data collection methods			
Team No	Location	Team operations	Number of team members	CI cell type	Virtual or real CI cell	Interviews	CI cell board observation	CI cell meeting participant observation	Discussions with team members
1	A	Process improvement	8	Type II	Virtual	1 Team leader and 1 team member	Done	No	Done
2	A	Project management	7	Type I	Real	1 Team leader	Done	No	Done
3	A	Property acquisition	10	Type II	Real	1 Team leader and 1team member	Done	Done	Done
4	A	Asset management and operations	6	Type I	Real	1 Team leader	Done	Done	Done
5	A	Contract and commercial management	8	Type I	Real	1 Team leader	Done	Done	Done
6	A	Health and Safety	8	Type I	Real	No	Done	N/A – Team stopped their CI cell meetings	Done
7	B	Asset management and operations	6	Type II	Real	1 Team leader	Done	Done	Done
8	B	Project management	6	Type I	Real	1 Team leader	Done	Done	Done
9	B	Area level management coordination team	12	Type II	Real	1 Team leader	Done	Done	Done
10	B	Project management	5	Type I	Real	1 Team leader	Done	Done	Done
11	B	Contract and commercial management	8	Type I	Real	1 Team leader	Done	No	No
12	B	Project management	6	Type II	Real	No	Done	No	Done

to adopt CI cells around 2014 by keeping this initial CI cell structure intact. The first unit to adopt CI cells at the case organisation is customer operations.

A CI cell in the sector, therefore, consist of a regular meeting mechanism (daily, weekly, bi-weekly or monthly), elements of work coordination, team key performance indicators (KPIs), a continuous improvement section (the 3 C), and a real (e.g. a board) or virtual (e.g. a spreadsheet) medium for co-located or dispersed teams respectively, which is accessible to members of the organisation and openly displays information to increase work transparency. In fact, CI cells were frequently associated with Visual Management (Bateman, Philp, and Warrender 2016; Bititci, Cocca, and Ates 2016; Tezel, Koskela and Tzortzopoulos. 2016) and *kaizen* by the interviewees. Under their team leaders' supervision, the team members cover the information on their CI cell medium to coordinate their work, to review their performance and to identify work improvement opportunities on a regular basis. Attendance to CI cell meetings is compulsory for the team members. The adoption of CI cells remained solely across operational teams at the case organisation with little effort at the middle or senior management level towards having their own CI cells, which creates various challenges in utilising the technique's full potential as explained in the subsequent section.

Two main types of CI cells were identified at the case organisation; Type I and Type II cells. Of the two types of CI cells, the Type I cells are more focussed on work coordination and planning with minimal or ad-hoc work improvement. There are three sections generally covered in Type I cell meetings and cell boards; (i) team member availability, often in the form a team member availability matrix for the week commencing, (ii) a work planning and control section in which each team member can negotiate with other team members and visually declare his/her responsibility for the completion of a task and can provide updates on the task's completion by using post-it notes, and (iii) a notes section displaying key events or success stories (see Figure 2). Some Type I cell boards also display team KPIs. Most Type I cells were started with their team leaders' initiative and through copying the CI cell structures of other teams. Therefore, the level of standardisation was lower among the Type I cells in terms of their medium structures, meeting frequencies, information covered and so on.

Alongside work coordination, the systematic execution of continuous improvement is more conspicuous in the Type II cells than the Type I cells. A Type II cell board contains generally three main sections: (i) a team performance section, in which various team KPIs are collectively reviewed and evaluated by the team members, (ii) a '3 C' section (concerns, causes and countermeasures), in which current and anticipated work issues are captured and discussed with their root reasons and preventive actions, countermeasures defined as best practices are communicated and disseminated for future use along with success stories, and (iii) a section showing various Human Resources related figures (e.g. team members' availability, absence statistics, training information, etc.) (see Figure 3). The structure of the Type II cells is more

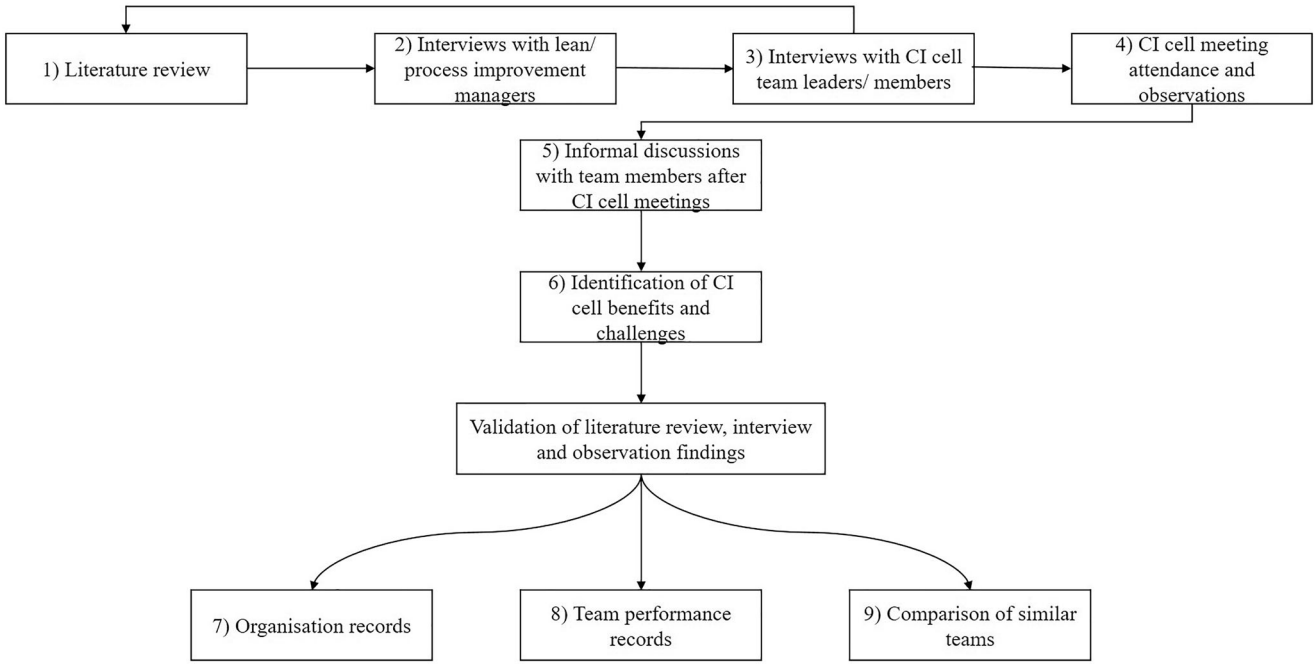

Figure 1. Research process.

standardised across different teams. Also, the Type II cells were initiated and are facilitated by one of the organisation's process improvement/lean staff members. See Table 4 for the comparison of Type I and Type II cells.

4.2. Benefits of CI cells

Following the interviews with lean/process improvement managers to explore the background of CI cells, the interviews with CI cell team members and leaders were completed (12 in total) to better understand the benefits and challenges associated with CI cells at the case organisation. The interviews were recorded, transcribed, and emerging patterns across the interviews were identified, grouped and compared to the literature. A coherence between the interviews and literature was found. The identified CI cell benefits according to the analysis of the interviews are;

- enabling structured and succinct team meetings,
- supporting better coordination of team work,
- increasing team engagement and morale,
- aligning team performance with team targets,
- increasing information transparency,
- supporting team building,
- facilitating task ownership,
- prompting team members to make more reliable promises (peer pressure),
- helping teams allocate and level their resources (work balancing/prioritising),
- serving as a training mechanism for junior and new team members,
- supporting task delegation, empowerment and employee autonomy,
- simplifying progress reporting and creating meeting minutes,
- helping save team resources through work coordination and improvement.

The identified benefits were validated using the other three qualitative data collection methods; discussions with CI cell team members (11 in total), participation in CI cell team meetings (7 in total) and observation of CI cell boards or other media (12 in total). Table 5 shows how many times the identified benefits were found or validated using which data collection method. Also, the Sankey diagram of the findings showing how each qualitative data collection method feeds into what identified benefit can be seen in Figure 4.

To validate the CI cell benefit of increasing team engagement and morale, the organisation's customer operations teams' (28 teams in total) staff engagement survey scores in 2014–2015 were compared from the organisation's records. The comparison was conducted between the customer operations teams deploying (10 teams in total) and not deploying (18 teams in total) the CI cells technique. As the data sets from the two team groups are not of equal size and normality cannot be assumed, the non-parametric Mann–Whitney *U* test was employed on the differences (increase or decrease) of the engagement scores as measured in 2014 and 2015 to check whether there is a statistically significant difference in the two team groups' medians (Higgins 2003; Field 2013). At 95% (Ptest $= 0.05$) confidence level, the hypothesis for the Mann-Whitney U test is as follows:

> **H_0**: The two populations represented by the two groups have the same distribution in terms of their staff engagement difference scores. In other words, there is no statistically significant difference between the two groups (deploying and not deploying CI cells) in staff engagement.

The descriptive and Mann-Whitney U test statistics of the data set can be seen in Table 6. With respect to descriptive statistics, the mean of the difference in the staff engagement

Table 3. 3 C section of a CI cell board.

No	Date	Concern	Cause	Countermeasure	Who	When	Status
Number of the "3C" entry	Date of the "3C" entry	Problem description – ideally linked with team KPIs	Root cause of problem as identified by team members. No systematic root-cause analysis.	Corrective or preventative measures to concerns	Owner of countermeasures – a team member	Deadline date for countermeasure implementation	 A cycle to visualise the status of "the 3 C". Filling the first quarter (top-right) means the problem has been identified, the second quarter (bottom-right) means the counter measure has been found, the third quarter (bottom-left) means the countermeasure has been implemented and the fourth quarter means (top-left) the problem has really been solved.

scores of the teams deploying CI cells was found as 10.7 while the mean of the difference in the staff engagement scores of the teams not deploying CI cells remained at 4.05 for the same term. Although both team groups displayed a positive difference (improvement) in their mean staff engagement scores, the teams with CI cells had recorded a far higher mean staff engagement improvement (165% more) than the teams without CI cells between 2014 and 2015. To quote from the organisation's related archive file: 'Teams with CI cells are showing twice the engagement improvement rate of their non-CI cell doing colleagues'. From Table 5, it can be inferred that since the U-statistics value (45) is smaller than the U-critical value (48), H_0 must be rejected. Therefore, with 95% confidence, it is statistically valid to claim that there is a significant difference between the teams deploying and not deploying the CI cell technique. Although it is not possible to infer from the data set that the greater staff engagement and morale improvement of the teams utilising the CI cell techniques is only due to their CI cell practices, the Mann–Whitney non-parametric test suggests that the teams utilising the technique saw statistically significant improvement rates in their staff engagement and morale scores, highlighting a positive effect of CI cells and further validating the qualitative findings.

To further explore the CI cell benefits and to the test the findings, the meeting durations, the number of near misses for Health and Safety, the teams' actual KPI achievements against their targets (%), the team member availability (%) and the number of work improvement suggestions of two similar teams, Team 4, a team employing the cell technique (Type II) and Team 13, a similar team not employing the CI cell technique at the organisation, were statistically compared over an 8-month period with data recorded from their monthly meetings. Both teams are responsible for the operations of the organisation's assets in neighbouring geographic regions with similar routine tasks, number of team members and team member profiles. The teams were chosen because of their similarity and because their work context enabled a comparative study. The independent-samples *t*-test was employed on the collected data assuming the teams' independence of each other and data normality to check whether there is a statistically significant difference in the two teams' mean performances (Higgins 2003; Field 2013). At 95% (Ptest $=$ 0.05) confidence level, the hypothesis for the independent-samples *t*-test is as follows:

> **H_0**: There is no statistically significant difference between the two teams' (deploying and not deploying CI cells) mean performance scores.

The descriptive and independent-samples *t*-test statistics of the data set can be seen in Table 7. It can be inferred from the descriptive statistics in the table that the team deploying the CI cell technique recorded shorter meeting durations with fewer near misses and higher KPI achievement percentages. As the Levene's significance values were found bigger than 0.05 for the teams' meeting durations, number of near misses, achieving team KPIs (%) and team member availability (%) figures, the variances are assumed to be equal. H_0 was rejected at 95% confidence for the meeting

Figure 2. A Type I CI cell board with stronger focus on team KPIs and Human Resources related information (section 2), work coordination and planning (section 3) but ad-hoc approach to work improvement based on concern recording (section 1).

Figure 3. A Type II CI cell board. It has a more systematic focus on work improvement with the 3 C process (section 2), alongside work planning and coordination. Team KPIs (section 1) and Human Resources related information (section 3) can also be found on those boards.

durations, number of near misses and achieving team KPIs (%) scores as their equal variance $P_{statistics}$ scores are smaller than 0.05, meaning there is a statistically significant difference between the two teams' mean performance scores in those team performance areas. However, no significant difference was found in the team availability numbers, suggesting no effect of the CI cell technique in this area. As Team 13 could not systematically record their number of work improvement suggestions, no comparison could be made between the teams over that score. This comparative analysis supported the benefit claims that CI cells enable more succinct meetings, support better coordination and

Table 4. Characteristics of Type I and Type II cells.

Characteristics	Type I cells	Type II cells
CI cell initiation	By copying from other CI cells	By a member of the organisation's lean/process improvement department
Meeting facilitation	By team leader	By a member of the organisation's lean/process improvement department
Main meeting purpose	Work coordination and planning with ad-hoc work improvement	Improvement, work coordination, and planning
Format	Meetings taking place around real or virtual CI cell boards	Meetings taking place around real or virtual CI cell boards
Meeting medium	Real team boards or virtual spreadsheets	Real team boards or virtual spreadsheets
CI cell membership	Members of a team – no cross team/department involvement	Members of a team – no cross team/department involvement
CI cell meeting content	Team KPIs, work coordination and planning section, team notes or KPIs	Team KPIs, the 3Cs and HR related information
Meeting participation	Obligatory	Obligatory
Meeting continuity	Regular and continuous	Regular and continuous
Meeting frequency	No standardisation across teams (Daily, weekly, bi-weekly or monthly)	No standardisation across teams (Daily, weekly, bi-weekly or monthly)

team work, and help align team performance with team KPIs as seen in the smaller number of near misses and higher percentage of team KPI achievement recorded by Team 4. Also, the team employing the CI cell technique showed a more systematic approach to continuous work improvement than the team not deploying the technique.

As the last type of benefit validation, the researchers checked the Plan Percent Complete (PPC) numbers – the ratio of completed tasks to planned tasks in a planning period, which is used as a measure of planning reliability (Russell et al. 2015), of two teams (Team 8 and Team 10) claiming their CI cells prompted them making more reliable tasks promises. The teams were chosen as they had kept their task planning records since short after their CI cells' initiation. The teams are responsible for supervising the delivery of construction projects as client representatives and have weekly CI cell meetings. The PPC calculation was performed covering the teams' recent project execution period between September 2015 to May 2016. The PPC records of the teams can be seen in Figure 5. With 94% and 88% average PPC scores respectively, the teams' task promise reliability was found to be high, supporting their claim regarding their CI cells' positive contribution to making more reliable promises. The teams did not have their pre-CI cell planned and completed task performance numbers recorded. Therefore, no comparison between the teams' before and after CI cell task completion performances could be made, which can be noted as a limitation.

4.3. Challenges for CI cells

Alongside the CI cell benefits, some issues that impede the CI cell technique reaching its full potential at the case organisation were identified. The identification of those challenges was more exigent as the studied teams' members and interviewees would hold a predisposition to expressing the benefits of the technique. However, mainly from comparisons against the literature, through the CI cell meeting and board observations, and after the investigation of the case organisation's and the teams' records, the following challenges were identified:

- ad-hoc and non-standardised data recording as to the continuous improvement (the 3Cs) section of CI cells, which hinders learning from the 3C exercise,
- not understanding what to measure and how to measure with respect to CI cell benefits for the justification of the technique's use by different teams,
- hardships faced in identifying root causes of problems, which cause some teams to face similar work-related problems repeatedly,
- ad-hoc problem solving, particularly in Type I cells,
- insufficient standardisation among the teams in their CI cell executions (i.e. the frequency of meetings, the content and design of CI cell boards, the governance of CI meetings, some teams ignoring or only superficially executing the continuous improvement function),
- providing the teams with only basic training as to the CI cell execution and lack of training in systematic problem-solving techniques (e.g. Pareto charts, fishbone diagrams, 5 Whys, scatter plots, etc.)
- root problem causes not being systematically recorded, classified and visualised, particularly in Type I cells,
- the lack of senior management engagement as middle and senior management do not have their CI cells (this interrupts the information flow between the operational level teams' CI cells and middle/senior management),
- the lack of systematic incentivisation practices for the CI cells,
- the limited authority of the teams to make work improvements as they are mostly restricted within their work domains, which is also linked to the senior and middle management not having their own CI cells,
- the case organisation not having systematic audits across different types of CI cells but selectively concentrating on delivering, supporting and monitoring the CI cells, mostly of Type II, of some teams,
- the lack of any benchmarking effort against similar participatory management techniques in different sectors and industries, which hinders learning for an improved CI cell practice.

4.4. Role of CI cells in other management strategies

CI cells are seen as part of other management strategies developed within lean management at the studied organisation. As a CI cell regularly exposes the team to the information associated with their work in the form of team

Table 5. Identified benefits of CI cells.

Data collection method	CI cell benefits												
	Enabling structured and succinct team meetings	Supporting better coordination of team work	Increasing team engagement and morale	Aligning team performance with team targets	Increasing information transparency	Supporting team building	Facilitating task ownership	Prompting team members to make more reliable promises (peer pressure)	Helping teams allocate and level their resources (work balancing/ prioritising)	Serving as a training mechanism for junior and new team members	Supporting task delegation, empowerment and employee autonomy	Simplifying progress reporting and creating meeting minutes	Helping save team resources through work coordination and improvement
Interviews	10	12	9	9	6	5	7	8	9	6	5	8	11
Discussions with team members	7	9	4	6	3	2	6	7	5	4	3	8	8
CI cell meeting participant observations	7	7	N/A	7	7	N/A	7	N/A	5	3	5	7	6
CI cell board observations	N/A	12	N/A	12	12	N/A	12	N/A	N/A	N/A	N/A	N/A	7

The numbers represent mentions or observations for each benefit.

performance metrics, team-member availability, training records, work-related issues, the continuous improvement process or work coordination/follow-up, CI cells can also be included in efforts towards increasing process transparency within Visual Management (José Martínez-Jurado, Moyano-Fuentes, and Jerez Gómez 2013; Bevilacqua, Ciarapica, and Paciarotti 2015; Bateman, Philp, and Warrender 2016; Bititci, Cocca, and Ates 2016; Eaidgah et al. 2016). The information presented on CI cell media of different teams remains accessible to all and by creating information fields, the boards serve as a summary of the team performance and the issues for the interested (Tezel, Koskela, and Tzortzopoulos 2016; Bellisario and Pavlov 2018).

Additionally, the importance of having structured team coordination meetings and two-way communication channels from the operational level to the strategic management level and vice versa has been underlined in disseminating organisational strategic goals as part of *hoshin kanri*, a policy deployment method for ensuring that the strategic goals of a company drive top-down progress and action by focussing on eliminating the waste that comes from inconsistent direction and poor communication (Lee and Dale 1999; Witcher and Butterworth 2001; Nicholas 2016; Giordani da Silveira et al. 2017; Vijaya, Ganesh, and Marathe 2018). However, in the studied case, due to the fact that senior and middle management do not have their CI cells, there are disconnections in the two-way flow of information over the CI cells from the strategic level to the operational level and vice versa for the execution of the *hoshin kanri* functions of deploying objectives from top management down and continuously improving performance towards those objectives (Nicholas 2016; Giordani da Silveira et al. 2017; Vijaya, Ganesh, and Marathe 2018). The studied teams' limited capability in making work improvements beyond their own domains can be attributed to this interruption in the information flow between the strategic and the operational level as the operational teams cannot effectively reflect more extensive issues identified during their CI cell meetings to higher organisational levels. Ideally, top management would set strategic targets for their subordinates and their subordinates would be able to identify and communicate the issues they cannot solve to their super-ordinates through their CI cell exercises as shown in Figure 6.

Although some issues in the continuous improvement (*kaizen*) function (Chakravorty and Hales 2016) of the cells such as problems' root cause not being systematically recorded, ad-hoc problem solving or some teams' ignoring the CI cells' continuous improvement function were identified in practice at the case organisation, the CI cells' positive effect and potential in reviewing and identifying work improvement opportunities, particularly in the Type II cells, were also documented.

Systematic problem-solving skills, awareness and training of team members in that respect, particularly of team leaders and CI cell facilitators, are deemed as determining factors in the effective execution of CI cells' continuous improvement function. The visualisation of the continuous improvement process and the 3 C exercise was insufficient as the teams

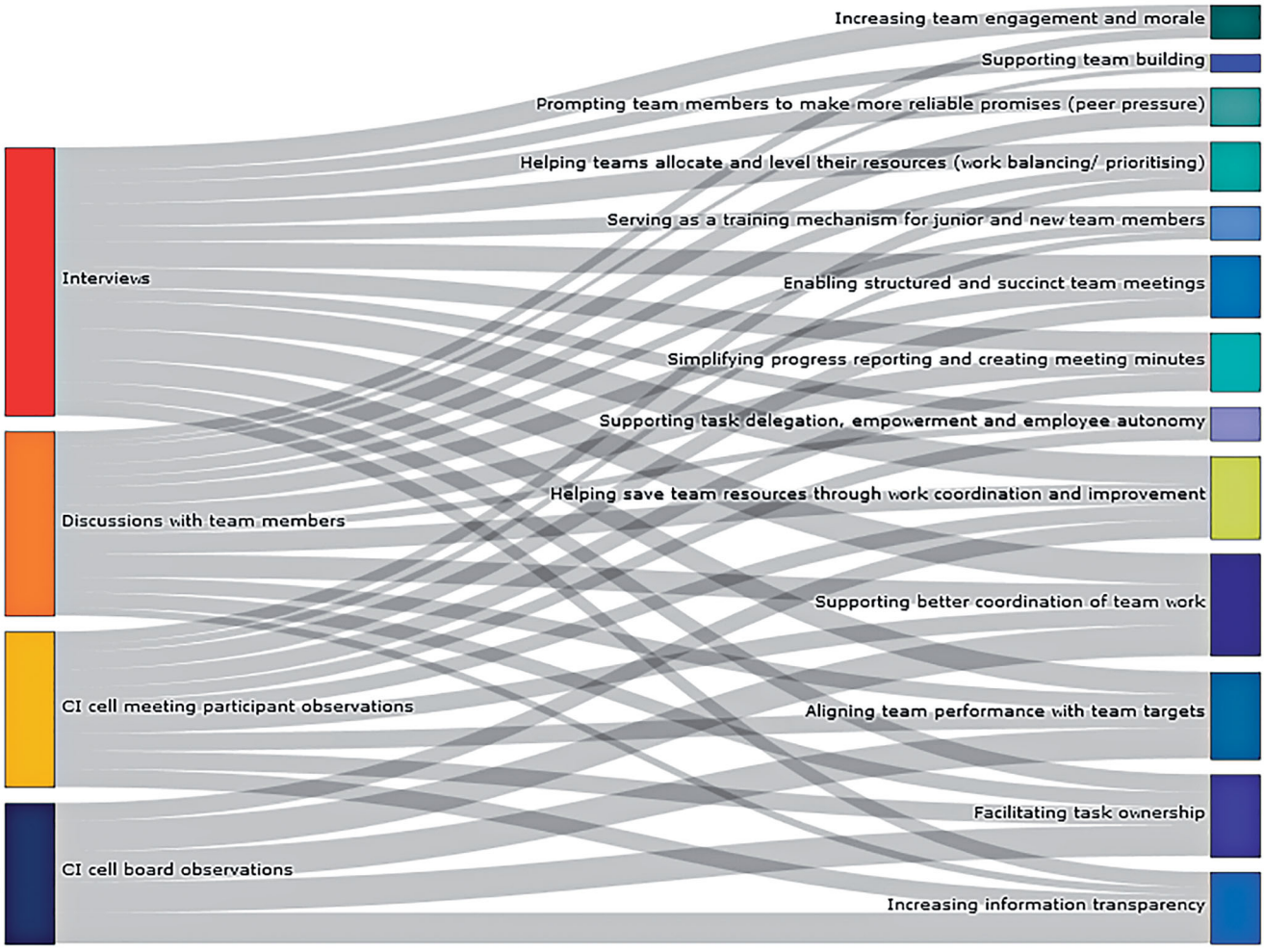

Figure 4. Sankey diagram of the initial findings showing what data collection method identified what CI cell benefits from Table 5.

Table 6. Staff engagement scores of the customer operations teams with and without CI cell.

Number of customer operations team (*N*)	Difference (increase(+) or decrease(−)) in the teams' engagement scores (2014–2015 period)		Rank values of the teams' staff engagement difference scores for Mann–Whitney *U* test	
	Teams with CI cell	Teams w/o CI cell	Teams with CI cell	Teams w/o CI cell
1	20	9	8	1
2	17	−1	9	2
3	13	12	10	3
4	5	5	13	4
5	2	−2	21	5
6	18	8	23	6
7	11	6	25	7
8	17	−3	26	11
9	2	−2	27	12
10	2	0	28	14
11		−1		15
12		6		16
13		−1		17
14		6		18
15		6		19
16		4		20
17		7		22
18		14		24
Mean value	10.7	4.05		
Standard deviation (sample)	7.07	4.94		
Sample variance	50	24.39		
Rank sum			190	216
Number of observations			10	18
U_{value}			135	45
$U_{statistics}$			45	
$U_{critical\ (10,18)}$			48	

Table 7. Statistical comparison between Team 4 and Team 13.

Monthly team meetings in 2016	Meeting durations (minutes)		Number of near misses (health and safety)		Achieving team KPIs (%)		Team member availability (%)		Number of work improvement suggestions	
	Team 4 with CI cell	Team 13 w/ o CI cell	Team 4 with CI cell	Team 13 w/ o CI cell	Team 4 with CI cell	Team 13 w/ o CI cell	Team 4 with CI cell	Team 13 w/ o CI cell	Team 4 with CI cell	Team 13 w/ o CI cell
May	100	260	2	5	75	60	95	95	5	N/A
June	95	230	0	6	80	60	95	90	4	N/A
July	120	250	1	4	85	65	90	90	2	N/A
August	110	280	0	4	85	60	90	90	2	N/A
September	105	240	2	3	80	65	95	95	3	N/A
October	100	300	1	1	85	65	95	95	5	N/A
November	90	260	1	4	80	60	90	90	4	N/A
December	105	250	0	3	80	65	90	90	6	N/A
Mean	103.10	259.00	0.88	3.75	81.25	62.50	92.25	91.88		
Std. dev.	9.23	22.32	0.83	1.488	3,536	2.673	2.673	2.588		
Levene's sig.	0.101		0.298		0.642		0.506			
Equal variance assumed	Yes		Yes		Yes		Yes			
$P_{statistics}$ for equal variance	0.000		0.000		0.000		0.642			
H_0	Rejected		Rejected		Rejected		Accepted			

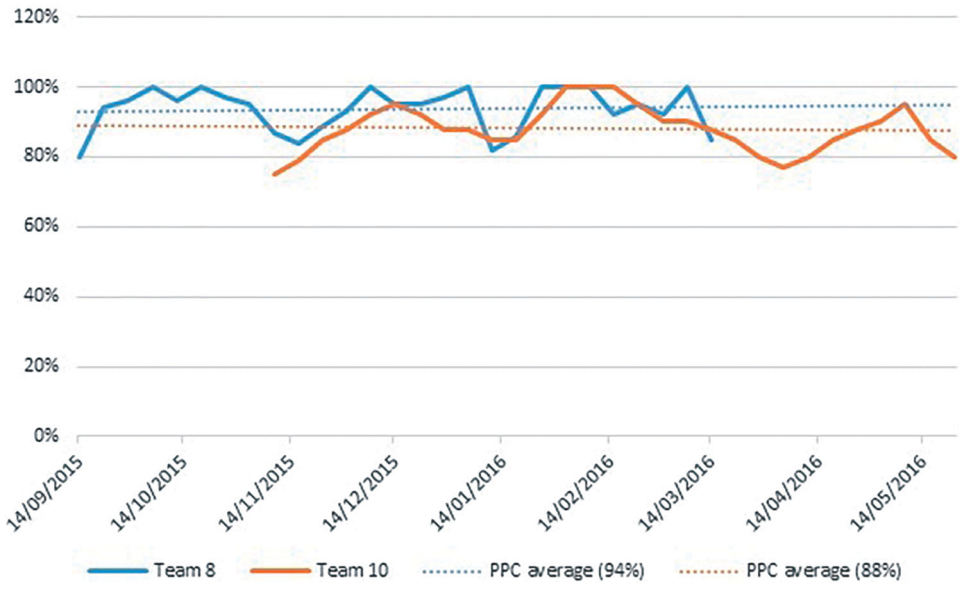

Figure 5. Plan percent complete (PPC) percentages of Team 8 and Team 10 over time.

rely on spreadsheets with extensive written descriptions, unlike, for instance, the highly visual A3 problem-solving technique (Hadid and Mansouri 2014). Also, the lack of incentivisation for CI cells and the teams' limited power in implementing change at the case organisation were observed to negatively affect the motivation for continuous improvement. Alongside Visual Management, *hoshin kanri* and *kaizen*, the CI cell technique was also found to facilitate work planning and control for teams, and training for junior team members. Some CI cell benefits like supporting better coordination of team work, prompting team members to make more reliable promises (peer pressure), helping teams allocate and level their resources (work balancing/prioritising) and serving as a training mechanism for junior and new team members correspond to those roles of CI cells (see Figure 7).

5. Discussion

CI cells are adopted by the case organisation through practitioners and focus both on work coordination and improvement, taking strands from some well-known participatory management techniques like daily huddle meetings, QCs and *kaizen* events. Unlike huddle meetings though, they are not necessarily executed daily or do not focus mostly on work planning and coordination, particularly the Type II cells. With

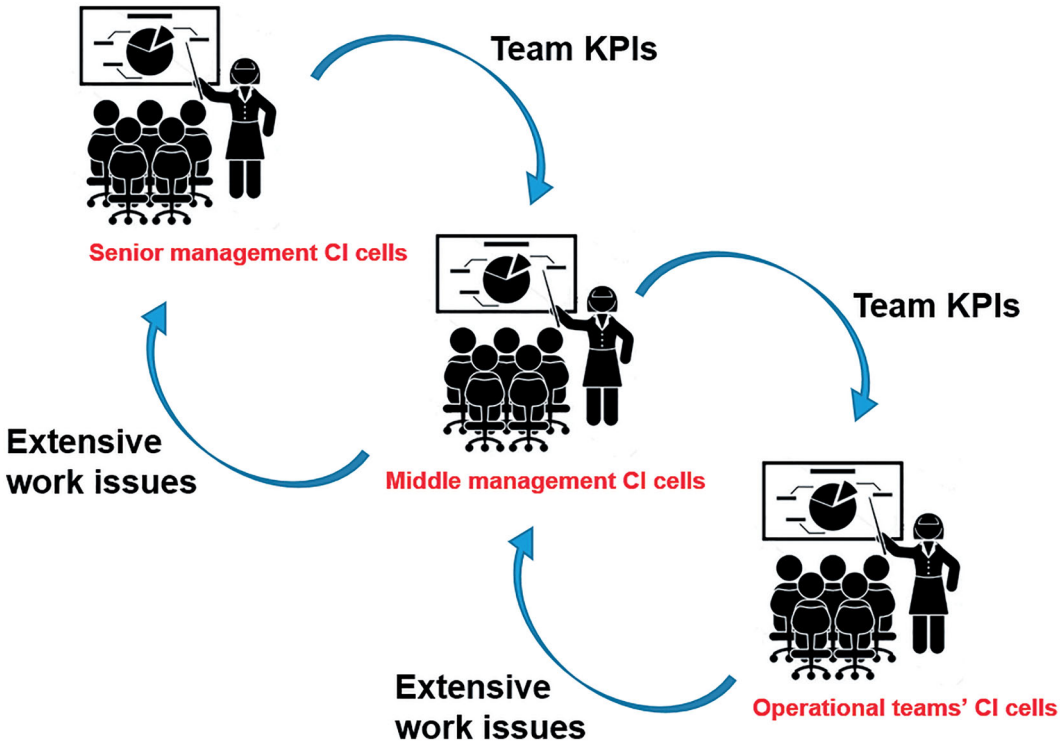

Figure 6. Suggested two-way flow of information over CI cells for *hoshin kanri*.

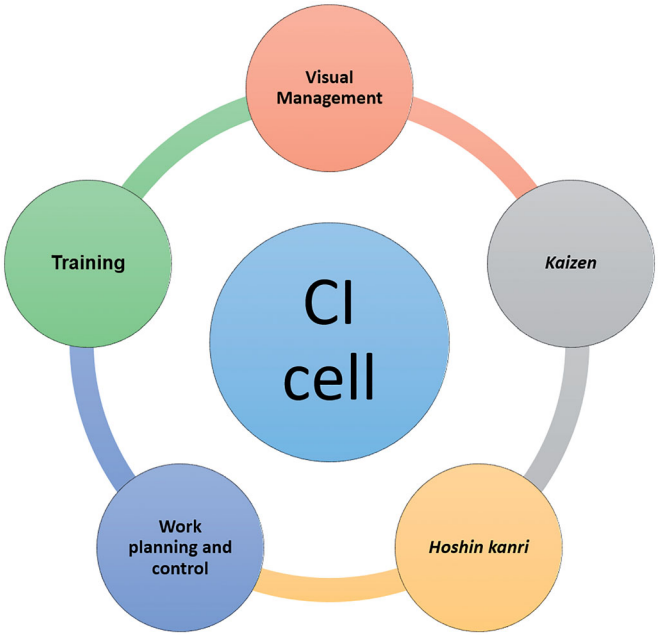

Figure 7. The role of CI cells in other management strategies and efforts.

their main focus being more on work planning and coordination, the Type I cells are closer to huddle meetings in that sense. CI cell meeting durations are not as short as huddle meetings as well. Also, unlike *kaizen* events and QCs, both Type I and Type II cells have a strong work planning and coordination dimension. Additionally, unlike *kaizen* events, CI cells are not made up of cross-functional teams with people from different work departments. CI cell meetings are held among the members of a team. As another difference to QCs and *kaizen* events, participation to CI cell meetings is obligatory for a team member, unless the member has a valid excuse, and the meetings are continual – there is no particular improvement project within a set timeframe. Although each concern point may have its set timeframe, work improvements and problem-solving are planned within 'the 3 C' process continually. The continuity of meetings without any set improvement project timeframe is similar to huddle meetings. Likewise, similar to huddle meetings, CI cell discussions are facilitated by visually displaying various team-related information. Furthermore, similar to *kaizen* events and QCs, the continuous improvement process is systematically visualised through 'the 3 C', particularly in the Type II cells. The team board structure within CI cells bears similarities with Daily Management Boards' structure. Considering these points in common and the differences in application, it can be asserted that CI cells display hybrid characteristics across some of those well-known participatory management techniques. Given the technique was developed by practitioners with support from process improvement consultants who are experienced in those established participative team-based techniques, it seems likely that the practitioners and consultants combined different aspects of those techniques into CI cells. Further investigation related to the origins of CI cells is necessary for the validation of this assertion.

The identified CI cell benefits reflect this hybridism as well. Benefits associated with huddle meetings such as better work coordination and commitment, succinct meetings, better team engagement and team building were also found as CI cell benefits. Similarly, benefits relating to QCs and *kaizen* events like resource saving and work improvement, facilitating task ownership and empowerment were identified. Transparency, a benefit that is frequently identified with

Visual Management (Tezel, Koskela, and Tzortzopoulos 2016), and aligning team performance with team targets, something that is deemed crucial in *hoshin kanri* (Giordani da Silveira et al. 2017) are also two of the benefits. Interesting benefit findings here are CI cells' role in training and orientating junior team members by exposing them to the whole spectrum of team tasks and problems and facilitating more reliable promises by team members. The benefits, which were identified by most data collection methods from Table 5, in no particular order of importance are:

- Helping save team resources through work coordination and improvement.
- Supporting better coordination of team work.
- Aligning team performance with team targets.
- Increasing information transparency.
- Facilitating task ownership.

There are also serious challenges identified for the CI cells at the case organisation. The existence of two types of CI cells in practice is a sign of low standardisation. The Type I cells are initiated and run thanks to the initiatives of a few members of a team through copying from other teams. Moreover, with ad-hoc work improvement practices, the Type I cells fall short in one of the main purposes of CI cells. Although this intrinsic motivation for establishing CI cells enables the Type I teams to attain some of the benefits of CI cells, it also creates a dualism in application and confusion among the teams as to what a CI cell is. The organisation allocates resources for the introduction and facilitation of CI cells for some teams, which results in the formation of Type II cells with a greater focus on continuous improvement.

Even in the Type II cells, there are hardships in identifying root-causes of problems and recording the continuous improvement process with achieved benefits, which relate partly to the '3 C' structure itself as a concise work improvement and problem-solving exercise, and the lack of training on basic root-cause analysis tools. Another serious concern is the execution of work improvement, which is not cross-departmental/functional and can be done only in the control domain of a team. Coupled with the non-existence of systematic root-cause analysis, this leads to some recurring or persistent problems that cannot be effectively solved by the teams, creating frustration and suspicions regarding the effectiveness of CI cells among the team members. Additionally, as the teams' CI cell efforts are not linked with each other, the CI cells are executed in silos. The non-existence of similar participative management systems for senior and middle management and the direct link between the teams' CI cell exercises and those management levels engender follow-up challenges for the CI cells, which is a critically important matter for the success of participative work improvement techniques (Farris et al. 2008; Farris et al. 2009; Glover et al. 2011). Recognising this, towards the end of the study the case organisation started preparations for the introduction of CI cells to the middle-management level, which would be linked with the teams' existing CI cells.

CI cells' role in other management strategies like Visual Management, *hoshin kanri*, *kaizen* (continuous improvement) allows for the opportunity that CI cells can be introduced to an organisation as part of one or more of those strategies and activities. However, for a firmer link with Visual Management, 'the 3 C' process, in particular, should be better visualised beyond its tabular and text-heavy format at the moment. For *hoshin kanri*, the information flow between the senior management and work teams should be maintained as shown in Figure 6. For *kaizen*, the continuous improvement process should be systematic with proper root-cause analyses and be in the focus of all CI cells; not only of the Type II cells. Work coordination and planning is one of the core elements of all CI cells. Keeping better records in this aspect is important. For instance, all CI cell teams can be asked by the management to track their PPC scores and to take the problems preventing them from achieving a 100% PPC score in a time period to 'the 3 C' process. However, the training function of CI cells is neither initially planned nor expected, and happens naturally due to the interaction between senior team members, junior team members and work itself over CI cells. This function can be further supported by the management with modifications on CI cell boards and meeting structures; for instance, by introducing a formal mentoring mechanism between junior and senior team members over CI cells.

From the cellular organisation point of view, CI cells can be likened to production cells 'producing' work planning/coordination, improvement, transparency, policy deployment and employee training. Although the case organisation adopts multi-skilled project teams to manage and control their large-scale infrastructural projects as its core work unit, no further evidence for its extensive adoption of a cellular organisational structure was found. Therefore, it can be asserted that although cellular organisation concerns the whole of the organisation, the CI cells in the studied case organisation operate in practice alongside the organisation proper. However, Barad's (1995) observations as to the Western CI cell practice apply to the studied case as the scope of continuous improvement in the studied CI cells is generally broad with somewhat shallow root-cause analyses whereas the CI participation is mandatory subject to team leaders' decisions.

From a participative management point of view, it was identified that CI cells can be considered as another form of modern, small-group, consultative participative management technique associated with lean management with some operational benefits (Andersson, Eriksson, and Torstensson 2006). The findings for CI cells support the general assertion that participative management techniques can help create consensus, facilitate work ownership, work coordination and directing employees' efforts to work improvement and efficiency with improved employee morale and engagement (Kim 2002; Bhatti, Nawab, and Akbar 2011; Gallie 2013; Irawanto 2015).

Alongside continuous improvement (*kaizen*), the identified roles of the technique (i.e. team-based work planning and control, Visual Management, *hoshin kanri)* may help

organisations diffuse and realise lean management at the team/small-group level in their day-to-day activities, which is also suggested in the literature while positioning participative management within lean management (Poksinska, Swartling, and Drotz 2013). On the other hand, the existence of two different cell types with differing contents and focus demonstrates the importance of adopting a consistent approach to participative management techniques in implementation and auditing (Singh and Singh 2009; Prajogo and Cooper 2010; Cecilia Martinez Leon et al. 2012). At the case organisation, the management had originally intended to introduce the Type II cells as a standard; however, through copying, another type of cell (Type I) was later developed ad-hoc by some teams. The copying led to deviations from the intended cells. The difference between these two types is significant as it aligns to the current dividing line in the practice and theory of operations management, namely whether continuous improvement is systematically done (Type II) or not (Type I).

Sound insights on general challenges associated with participative management techniques such as their limited capacity in changing employee behaviour and organisational culture (Bradley and Hill 1983) and hardships in sustaining those techniques (Hill 1991) require more longitudinal studies covering longer time periods, which could not be realised in this study due to resource and time limitations. However, some points for consideration while implementing participative management techniques at the operational level such as the need for providing teams/employees with sufficient training on the execution of those techniques, and a systematic auditing and benchmarking for the techniques at the organisational level were recorded. It was also observed that to avoid the managerial attitude leading to a lack of co-operation, notably among senior and middle managers; and consequently, diminished enthusiasm among operational teams for those techniques (Collard and Dale 1989), the techniques should be extended to cover those organisational levels serving as a link between them.

6. Conclusion

An analysis of the practical implementation of a team-based participative management technique called CI cells that is used for work planning, coordination and improvement was presented based on the findings from a case study conducted at a large public organisation operating in the civil infrastructure sector in the UK. Many similarities and differences between CI cells and other well-known participative management techniques were identified. Therefore, it is claimed that CI cells are a sort of hybrid of those well-known participative management techniques such as huddle meetings, *kaizen* events and QCs, combining some elements and strands from those techniques. The work planning and coordination dimension of CI cells provides the technique with an advantage over QCs and *kaizen* events. Similarly, CI cells' systematic focus on the continuous improvement process gives it an edge over huddle meetings. However, due to the more comprehensive structure of CI cells, it is not possible to have very brief meetings that can be attained through huddle meetings for day-to-day management of teams. Also, the continuous improvement process in CI cells over the 'the 3 C' is neither as systematic as QCs or *kaizen* events in terms of root-cause problem analysis nor benefitting from a cross-functional input. When choosing between or discussing CI cells and other participative methods, this kind of trade-offs should be noted.

The identified benefits and challenges for CI cells are generally in line with the literature on participative management and also reflect the hybrid nature of CI cells. Some of the benefits such as better employee engagement, shorter meeting durations, better work promises and performance were validated with the quantitative data collected from the case organisation. The main critical challenges identified for CI cells that require attention are insufficient standardisation in CI cells, hardships in properly executing the continuous improvement function, insufficient recording of CI cell benefits for different work teams, and insufficient links between the senior and middle management level and employee teams' CI cells.

Many research opportunities arise from the findings made. The differences and similarities between different techniques (e.g. QCs, CI cells) can be further investigated to advise improvement suggestions for CI cells in the future. A comparative study of those different techniques and the execution of CI cells at the studied large public client and private service organisations in the civil infrastructure sector will also provide interesting insights into CI cell applications. Studying and comparing the execution of CI cells or similar methods at multiple organisations from different sectors or cultural contexts may yield interesting insights. This may address the generalisability concerns of the findings of this research as it was conducted over a single case study. Additionally, the meeting structure, and physical or virtual board contents/design in CI cells can be analysed in more detail in future studies. Longitudinal studies investigating the pre and post CI cell conditions of teams will be useful for further validation, expansion or falsification of the claims regarding their benefits. Also, a longitudinal study at the case organisation researching how the CI cell mechanism is maintained and the effects of the introduction of CI cells to the senior and middle management level will yield interesting insights. Investigating the critical success factors (CSF) for CI cells, a popular type of research in participative management techniques, will present another opportunity for researchers. Replicability of the CI cell concept in other sectors with its implementation mechanisms, structure, benefits and challenges can be explored. Cross-sectoral and cross-cultural analyses of CI cells are also possible in this regard. Investigation of the team dynamics in a CI cell environment will be interesting.

The various roles of CI cells in other management strategies like VM, *hoshin kanri*, *kaizen,* etc., will help justify its implementation for practitioners. Also, the technique can find itself a place in the literature concerned with those management strategies. However, further improvements are necessary on the current execution of and used media (physical/virtual boards) for CI cells, as explained in the discussion section, to provide stronger links with those management strategies in terms of information visualisation, execution of

the continuous improvement and problem-solving process, and maintaining the information flow between higher and lower organisational layers over CI cells. Nevertheless, CI cells can be positioned as part of the practice and research relating to VM, *kaizen*, *hoshin kanri*, work coordination and planning and team training.

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Appendix A.

Interview questions with lean/process improvement managers

Date: Location: Start Time: End Time:

Interviewee:

Hello. Thank you very much for your time. We will ask you a few questions on the Continuous Improvement (CI) Cells at your organisations

Q1. Could you please introduce yourself (position/role/experience)?

Q2. Could you tell us a bit about the background/history of CI cells in your organisation as you know it (When/ how/ by whom)?

Q3. What is the purpose of the CI cells?

Q4. Do you have different types of CI cells at your organisation(real/ virtual/others)?

Q5. What teams/departments/managerial levels are implementing the CI cells at the moment?

Q6. How do you introduce CI cells to the teams?

Q7. Do you have a standard approach/check-list while introducing a CI cell? If so, could you explain it a bit?

Q8. Who is responsible for maintaining a CI cell?

Q9. What are the usual components of a CI cell (VM board/ 3Cs document/ regular meeting)?

Q10. How often do the teams organise CI cell meetings?

Q11. What happens in those CI cell meetings?

Q12. What kind of CI cell benefits have you observed (Give examples from the literature if necessary)?

Q13. What kind of CI cell challenges have you observed (Give examples from the literature if necessary)?

Q14. Do you have any future plans for the CI cells? Are you going to keep/remove/ expand/modify them?

Appendix B.

Interview questions with CI cell team leaders/members

Date: Location: Start Time: End Time:

Interviewee:

Hello. Thank you very much for your time. We will ask you a few questions on the Continuous Improvement (CI) Cells at your organisations

Q1. Could you please introduce yourself (position/role/experience)?

Q2. Could you please introduce your team (tasks/responsibilities/ number of team members/background)?

Q3. How long have you been implementing the CI cell?

Q4. Who initiated the CI cell for your team? and How?

Q5. What is the purpose of your CI cell?

Q6. What are the components of your CI cell (VM board/3Cs document/regular meeting)?

Q7. How often do you organise the CI cell meetings?

Q8. Who is responsible for the execution/sustaining of the CI cell system in your team?

Q9. What happens during those CI cell meetings?

Q10. What kind of CI cell benefits have you observed (Give examples from the literature if necessary)?

Q11. What kind of CI cell challenges have you observed (Give examples from the literature if necessary)?

Q12. Do you have any future plans for the CI cell? Are you going to keep/remove/ expand/modify it?

Appendix C

Participant observation grid for CI cell meetings

Observation grid: continuous improvement cell meetings		
Area of observation	Notes	
Location:	Date: Start time:	Stop time:
Project management team/group:		No of team members:
Board structure (HR information/ team information/ 3Cs information/ work planning and control information/ general project information)		
Board type (virtual/real)		
Meeting execution structure (order/topics)		
Meeting leadership (team leader/ team member/ external)		
Leader's behaviour and tone		
Topics covered (team information/ work planning/control/cont. improvement		
Team member interaction (verbal/ physical/ gestures)		
Team member comments		
Other areas of observation		