

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.

Keywords: lean management; continuous improvement; work planning; participative management; CI cells

1. Introduction

Participative management is in 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 1991; 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 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

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3 and Cabrera 2003; Lines 2004; Kitapci and Sezen 2007; von der Weth and Starker 2010;
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5 Bhatti, Nawab and Akbar 2011; Gallie 2013; Irawanto 2015). Alongside the diffusion of
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7 those modern management systems into a wide-range of sectors beyond manufacturing, the
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9 participatory techniques for work improvement and team coordination were also successfully
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11 introduced to the education, service, information technology, healthcare and the public sector
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13 over the last 30 years (Donabedian 2002; Venkatraman 2007; Chand 2010; Niquille et al.
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15 2010; Nicolay et al. 2012; Hosseinabadi et al. 2013; Sharabi 2013; Arsenyan and
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17 Büyüközkan 2014; Andrés-López, González-Requena and Sanz-Lobera 2015).

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22 Participative management takes different forms, ranging from informal participation
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24 to employee ownership of organisations (Gonzalez 2009; Kalleberg 2011). Three of the
25
26 prominent team-based participative management techniques widely adopted by the operations
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28 management and industrial engineering communities for work coordination and improvement
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30 are Quality Circles (QCs), *kaizen* events and daily huddle (stand-up) meetings (Glover et al.
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32 2011; Beckford 2016; Stray, Sjøberg and Dybå 2016; Butler, Szejczewski and Sweeney
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34 2018). These techniques and their likes are often classified as direct, consultative
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36 participation methods in which the management consults with employee teams directly for
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38 their input in work related matters but holds the ultimate decision making power; although, in
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40 some cases that power can be delegated to the teams to varying degrees (Green and Hunton-
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42 Clarke 2003).

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47 Two high-profile industry reports published in the mid and late 1990s highlighted lean
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49 management as one of the way-forwards for the civil infrastructure sector in the UK (Latham
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51 1994; Egan 1998). Over the past 10 years, the civil infrastructure sector in the country has
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53 been increasingly adopting lean management in its operations with explicit requirements
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55 from the public sector clients (Wolbers et al. 2005; Chen et al. 2012; Daniel et al. 2017;
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57 Tezel, Koskela and Aziz 2018) as part of the aim for improving the whole system
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3 performance (IPA 2017). This is in line with the UK Government's ongoing productivity and
4 efficiency-increasing efforts in its operations (IPA 2017). that gained momentum after the
5 2007-2008 economic crisis in 2013, the UK Government announced the objective of 33%
6 reduction in the initial cost of construction and the whole life cost of built assets in the
7 country as part of their 2025 vision (HM Government 2013). Following this, the main public
8 highways construction client announced a strategic plan to attain 250 million GBP in savings
9 in highways projects through lean management techniques between 2015 and 2020 (HE,
10 2016). The Government announced in 2017 the increase in the National Productivity
11 Investment fund to 31 billion GBP to support investments in transport, housing and
12 infrastructure as part of its industry strategy (HM Government 2017). Simultaneously, CI
13 cells, as a participative, small group activity for work planning, control and improvement,
14 have also been introduced in the civil infrastructure sector's supply chains within this lean
15 management movement. The researchers could not identify much discussion as to the use of
16 CI cells in the literature. However, as highlighted in the subsequent sections, CI cells bear
17 many similarities and some differences in application with those more established
18 participative management techniques adopted within lean management programmes– QCs
19 and *kaizen* events, as team-based work improvement efforts, and huddle meetings, which are
20 used mainly for day-to-day coordination of operational teams.
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45 It should be highlighted that like many systems in the production management
46 domain, CI cells seem to have evolved organically and incrementally in practice as a
47 countermeasure to challenges rather than on the basis of theoretical knowledge (Fujimoto
48 1999). It is important to understand those practical arrangements as one of the tasks of
49 management research is to explain and generalise managerial innovations done by
50 practitioners (David and Hatchuel 2007). Furthermore, there are various references in the
51 literature to CI cells' core document/content for rapid continuous improvement and problem-
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3 solving, the 3Cs (concern, cause and countermeasure) (Radnor 2010; Radnor and Bucci 2011;
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5 Sadreddini 2012; Proctor and Radnor 2014; Panneman 2015; Radley 2015), which was
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7 implemented in the civil infrastructure sector in the UK in the mid/late 2000s first by
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9 consultants and lean management practitioners working for various service providers and
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11 later expanded and evolved into “CI cells” in the early 2010s as a common practice. The term
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13 “cells” was devised by practitioners and refers only to CI cells’ work group or team-based
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15 nature with no other connotations to it.
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19 To better understand the underlying dynamics of CI cells, it is deemed necessary to
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21 firstly explore those mainstream participative management techniques alongside cellular
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23 organisation. Moreover, the literature by consultants and practitioners in particular presents
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25 those participative management techniques as part of strategic management, performance
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27 management, process improvement, and day-to-day management of teams in often an overly
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29 positive tone (Bodek 2004; Alukal and Manos 2006; Jackson 2006; Kattman et al. 2012;
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31 Lawal et al. 2014; White 2016). Under the light of these explanations, following on a detailed
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33 literature review on cellular work arrangements and the established participative management
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35 techniques used in lean management, findings on CI cells from a case study at a large public
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37 organisation operating in the civil infrastructure sector in the UK are presented and discussed
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39 in the rest of the paper with the following research questions:
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45 • How are CI cells implemented at the case organisation?
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47 • What are the benefits of CI cells?
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49 • What are the challenges associated with CI cells?
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51 • What is the role of CI cells in other management strategies?
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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; Guiterez-Guiterez 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; Guiterez-Guiterez 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 2012; Rahani and Al-Ashraf 2012; Ota, Hazama and Samson 2013; Samuel, Found and Williams 2015; Barad 2018).

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3 As for the benefits of QCs and QC-like participative team-based arrangements, job
4 enrichment and greater employee autonomy, cost savings through work improvement,
5 providing a systematic goal setting and feedback mechanism for employees, team work and
6 participation in work decisions, supporting organisational learning and increased interaction
7 between team members are noted in the literature (Osayawe and McAndrew 2005; Pereira
8 and Osburn 2007; Chen and Kuo 2011; Lee et al. 2012; Miron et al. 2016; Barad 2018).
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10 Badu and Wright (2012) specify eight conditions for QC success; (i) voluntary participation
11 in QCs, (ii) cross functionality in QC members, (iii) problems to be addressed in QCs should
12 be chosen by QC members, (iv) adequate management support with necessary funds and time
13 set for QCs, (v) QC members must receive appropriate training in problem solving techniques
14 (e.g. Pareto analysis, cause-and-effect diagrams), (vi) QCs must be empowered to choose
15 their own leaders, (vii) the management should appoint managers as QC mentors, and (viii)
16 the management's genuine interest in and action on suggestions generated by QCs.
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34 **2.2. Kaizen events**

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37 A *kaizen* event is a “focused and structured improvement project, using a dedicated cross-
38 functional team to improve a targeted work area, with specific goals, in an accelerated
39 timeframe” (Farris et al. 2008, p. 10). They are often implemented in conjunction with lean
40 management and known also as “rapid improvement events,” “accelerated improvement
41 workshops,” “*gemba kaizen*,” and “*kaizen blitz*” (Glover et al. 2011). *Kaizen* events are the
42 reflection of swift and radical *kaizen* implementations at team-level (Hodge et al. 2011; van
43 Dun and Wilderom 2016; Hirzel, Leyer and Moormann 2017). They evolved, taking
44 inspirations from QCs, from a group of Toyota consultants, named Toyota Autonomous
45 Study Group, who were banded together to instil lean management techniques in Toyota's
46 suppliers in the West in the late 1980's (Bodek 2004). The main differences between QCs
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3 and *kaizen* events in application are that the latter is typically executed faster within three to
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5 five days while QC projects may last for several months, and focuses mostly on reducing
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7 processing times and the amount of non-value adding activities through radical improvements
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9 (Manos 1997; Russell and Taylor 2002; Glover, Farris and van Aken 2014; Garza-Reyes et
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11 al. 2020). Bicheno and Holweg (2008) suggest that *kaizen* events are concerned with the
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13 stimulation of swift and even flow of throughput within a value stream, and should be the
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15 responsibility of senior management.
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19 Relatively short improvement durations, team training, cross-functional team
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21 structures, and a strong need for team leadership and work improvement authority are the
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23 defining characteristics of *kaizen* events (Melnik et al. 1998; Bateman 2005; Stone 2010;
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25 Glover, Farris and van Aken 2014). Clarity and achievability of goals within shorter time
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27 frames, management support, sufficient team decision making authority and post-event
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29 follow up activities are their key success factors (Farris et al. 2008; Farris et al. 2009; Glover
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31 et al. 2011).
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37 **2.3. Daily huddle (stand up) meetings**

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39 Daily huddle (stand-up) meetings refer to 10 to 15-minute, fast-paced meetings of a work
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41 team to share information that is supposed to be relevant to the team's daily work planning,
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43 coordination, priority setting and progress (Paez et al. 2005; Stray, Sjøberg and Dybå 2016;
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45 Demirkesen, Sadikoglu and Jayamanne 2020). Daily huddles are deliberately kept short and
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47 focused to save the time wasted during meetings (Stray, Sjøberg and Dybå 2016). Indeed,
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49 employees usually spend a lot of unproductive time in meetings, causing serious work
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51 interruptions (Rogelberg et al. 2006). The meetings are coordinated by team leaders and are
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53 structured generally around “what has been done since the last meeting”, “what will be done
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55 until the next meeting” and “what impedes the team from making progress” (Sutherland and
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3 Schwaber 2013; Wells 2013; Butler, Szwejczewski and Sweeney 2018). They emphasise
4 team-based work coordination and planning in shorter time windows more than QCs and
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8 *kaizen* events.
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10 Daily huddles have been associated with the agile methods such as Scrum in software
11 development (Coplien 1994; Schwaber and Beedle 2002; Pikkarainen et al. 2008; Murphy et
12 al. 2013) since the mid-1990s and later implemented also in other industries such as the
13 construction industry (Paez et al. 2005; Salem et al. 2006; Zhang and Chen 2016). Alongside
14 work coordination and improvement, daily huddle meetings were also found promoting team
15 building, creating shared mental models and trust within a team, greater commitment to the
16 course of action, and quick decision making (Sutherland and Schwaber 2013; Wells 2013).
17 The daily meetings are often held around teams' visual boards to steer discussions, to
18 maintain information flows and to support decision making, linking the technique with Visual
19 Management for teams (Dreyer et al. 2009; Stray, Sjøberg and Dybå 2016; Verbano, Crema
20 and Nicosia 2017; Choudhary et al. 2019).
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35 In the lean management literature, the visual boards that work teams have their daily
36 meetings around for coordination and improvement are called "Daily Management Boards"
37 or "Daily Visual Management Boards", with display teams' key performance indicators
38 (KPIs) with target vs actual team performance figures, availability of team members and
39 other Human Resources related information, and the continuous improvement process
40 (Berlanga and Husby 2016; Lawal et al. 2014; White 2016; Verbano, Crema and Nicosia
41 2017).
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52 **2.4. Cellular organisations**

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55 In production management, cellular organisation refers to a manufacturing process that
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3 work only within the line or cell (Singh and Rajamani 2012). A cell is a small scale, clearly-
4 defined production unit within a production setting. This unit has complete responsibility for
5 producing a family of similar parts or a product. All necessary machines and manpower are
6 contained within this cell, thus giving it a degree of operational autonomy (Choobineh 1988).
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8 Each worker is expected to have mastered a full range of operating skills required by the cell.
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10 Therefore, systematic job rotation and training are necessary for effective and flexible cell
11 development (Hyer and Wemmerlov 2004). Workers are encouraged to think creatively about
12 production problems and are expected to arrive at pragmatic solutions to them with some
13 problem-solving authority, giving rise to continuous improvement efforts and mechanisms
14 (Al-Mubarak et al. 2003). Presenting workers with those challenges for work improvement is
15 considered as a motivational factor. The need for supervision is reduced as cells lead to a
16 flattened organisational structure.
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31 In organisational research, cellular organisation is defined somewhat differently and
32 refers to an organisational setup which is made up of “cells” or “nodes” or “teams” that work
33 independently as self-managing, autonomous units to work on tasks, to solve work-related
34 problems and to execute continuous improvement (Miles et al. 1997). These cells exist in a
35 broader network in which they frequently communicate with each other, exchanging
36 information, to produce more potent business mechanism (Snow 1997). This structure exists
37 in direct contrast to the traditional hierarchical setup, where one type of supervisor gives
38 specific orders to another supervisor down in the hierarchical chain. Some organisations
39 establish self-directed work teams as the basic work unit akin to production cells in a
40 manufacturing firm or customer service teams in an insurance company. At other
41 organisational levels, cross-functional teams may be established, either on an ad hoc basis
42 (e.g., for problem solving) or on a permanent basis as the regular means of conducting the
43 organisation's work. This type of autonomous teams can be also seen in the large-scale
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3 project management domain, in civil infrastructural projects in particular (Jolivet and Navarre
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5 1996).

9 **2.5. Continuous improvement cells**

11 Cellular structures are thought to be well suited for continuous improvement and
12 TQM efforts due to their flexibility (Schonberger 1992; Tan and Tan 2002). Nevertheless, the
13 available literature on CI cells is limited. For example, Barad (1995: 85), while discussing
14 and comparing the team-based quality efforts on shop floors in China and Australia in the
15 early 1990s, places CI cells within the Western concept of cellular organisation as a response
16 to the Eastern cultural feature of collectivity orientation or groupism:
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25 “By creating Continuous Improvement Cells (or Teams) comprising of groups of
26 employees working in the same environment (cell), by training and educating them
27 and empowering them to make decisions, the active participation of employees in the
28 improvement process could be boosted. Such ideas draw heavily from the Western
29 Socio-technical Systems school of thought and represent a challenge for future
30 research and implementation.”
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39 Barad (1995) suggests in her comparison of Western CI cells practices to the
40 conventional QC practices originated in Japan that the improvement tasks of CI cells are
41 meant to be simpler and reminiscent of those encountered in the QCs, with the main
42 difference between the two being that the conventional QCs are practised on a voluntary
43 basis, and the CI cells within a cellular organisation are not voluntary, but part of the system's
44 formal organisation. Barad (2018) later links the CI cell practice in the West with those
45 cellular structures as an instrument to facilitate the participation of cell workers in the
46 improvement process on shop-floors, reiterating the differences between QCs and CI cells
47 from a shop floor perspective.
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3 Miron et al. (2016) position CI cells more broadly within lean management as a
4 distinct continuous improvement and work coordination technique similar to and rooted from
5 QCs and other small group activities. MacLennan and Chueke (2018) report a wide
6 implementation of CI cells in Brazil for work improvement according to the lean
7 manufacturing philosophy.
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14 Radnor (2010), while evaluating the transfer of a lean management approach by a
15 global manufacturing and logistics company into a large UK government department,
16 identified evidence for the practical use of some core CI cell elements such as the 3Cs
17 document and Visual Management/performance boards for work coordination and
18 improvement. Radnor's work can be considered as an early academic evidence for the
19 adoption of CI cell-like practices in the public sector, in which also the case organisation
20 presented in this study operates. Similar practices of using Visual Management boards and
21 the 3C document within lean management and continuous improvement efforts were later
22 identified in the UK's higher education sector (Radnor and Bucci 2011). Procter and Radnor
23 (2014) classify the adoption of regular problem-solving/coordination meetings, the 3C
24 document and team Visual Management boards as opportunities for greater staff involvement
25 through structured approaches to improvement and problem-solving for lean in the UK's
26 public services. The three systems actually form the basis of the CI cells concept in practice
27 as explained in the subsequent sections of this paper. Sadreddini (2012) calls for the
28 deployment of CI cells as part of developing a lean culture in the highways sector in the UK.
29 Oakland and Marosszeky (2017) include the CI cell practice in their case summary of the
30 highways sector's lean objectives. In line with this, the CI cell can be traced in the documents
31 summarising the recent service provisions offered by various business consultants (EY 2014;
32 Bourton Group 2017), providing evidence for the practice-led nature of the concept.
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3 In summary, the academic and grey literature treat CI cells as a distinct, small group
4 activity for continuous improvement and work coordination with its core elements; a Visual
5 Management board for group information transparency and coordination, regular and
6 structured meetings, and the 3Cs document for work improvement. The concept is often
7 mentioned within lean transformation and management efforts. This study therefore defines
8 CI cells as a small-group, participative management technique with a regular meeting
9 structure and a real or a virtual information board used for team coordination and work
10 improvement/problem solving within lean management efforts. CI cells are also associated
11 with other small group, participative management techniques such as QCs. However, the
12 similarities and differences between CI cells and other more popular concepts such as QCs
13 and huddle meetings as well as CI cells' implementation mechanisms in practice with their
14 benefits and challenges have not been sufficiently discussed in the literature.
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32 **3. Research method**

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34 Participative management techniques are complex configurations that are shaped by many
35 organisational and team-related parameters (McGovern Small and Hicks 2017; Barad 2018;
36 Guiterez-Guiterez 2018). This renders them well-suited for case research as case studies offer
37 flexibility for explorative and theory building research in real-life contexts as, during the
38 study, the research scope can be re-addressed, complementary data sources can be acquired,
39 while the method also serves several types of research objectives (Beach et al. 2001; Voss,
40 Tsiriktsis and Frohlich 2002; Brax and Jonsson 2009; Kim, Rhee and Oh 2011; Alblas and
41 Wortmann 2014). Case studies have often been used to study implementation characteristics
42 of different production management philosophies and techniques (Seth and Gupta 2005;
43 Kumar et al. 2006; Vlachos 2015). According to Flyvbjerg (2006:219), there are common
44 misunderstandings about case study research:
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3 “ (1) theoretical knowledge is more valuable than practical knowledge; (2) one cannot
4 generalise from a single case, therefore the single case study cannot contribute to
5 scientific development; (3) the case study is most useful for generating hypotheses,
6 while other methods are more suitable for hypotheses testing and theory building; (4)
7 the case study contains a bias toward verification; and (5) it is often difficult to
8 summarise specific case studies”.

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10 Many methodologies are aligned with specific philosophical positions that guide the
11 research process. Case study, however, has a practical versatility in its agnostic approach
12 whereby "it is not assigned to a fixed ontological, epistemological or methodological
13 position" (Rosenberg and Yates 2007: 447). Epistemologically, a pragmatist stance is adopted
14 in this research, accepting both observable phenomena and subjective meanings can provide
15 acceptable knowledge dependent upon the research question, focusing on practically
16 integrating different perspectives to help interpret the data. Hence, this research is based on a
17 qualitative and quantitative study of the CI cell practice at the case organisation.

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19 Complementing qualitative findings with quantitative data is a preferred approach in case
20 studies for increased validity (Yin 1994; George and Bennett 2005). The study was initiated
21 by the case organisation's invitation of the researchers in mid-2016 to evaluate its CI cells
22 that had started under the organisation's lean management and process improvement efforts
23 in the early 2010s. The case organisation is one of the main clients in the civil infrastructure
24 sector in the UK. The civil infrastructure sector in the UK is led by a few public client
25 organisations that drive innovation and lean management techniques such as Building
26 Information Modeling (BIM) and Lean Construction in their supply chains, which are
27 characterised by large private companies or consortia (Tier 1 suppliers) as the main product
28 and service providers employing smaller organisations (Tier 2s, 3s and 4s) and typically
29 follow the lead of their public clients for implementing continuous improvement, innovation
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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.

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.

In the first data collection stage, after a detailed literature review, semi-structured interviews, each lasting between 45-60 minutes, 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 of 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 meetings were interviewed for around 60 minutes 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 Appendix 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.

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 1 team 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

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.

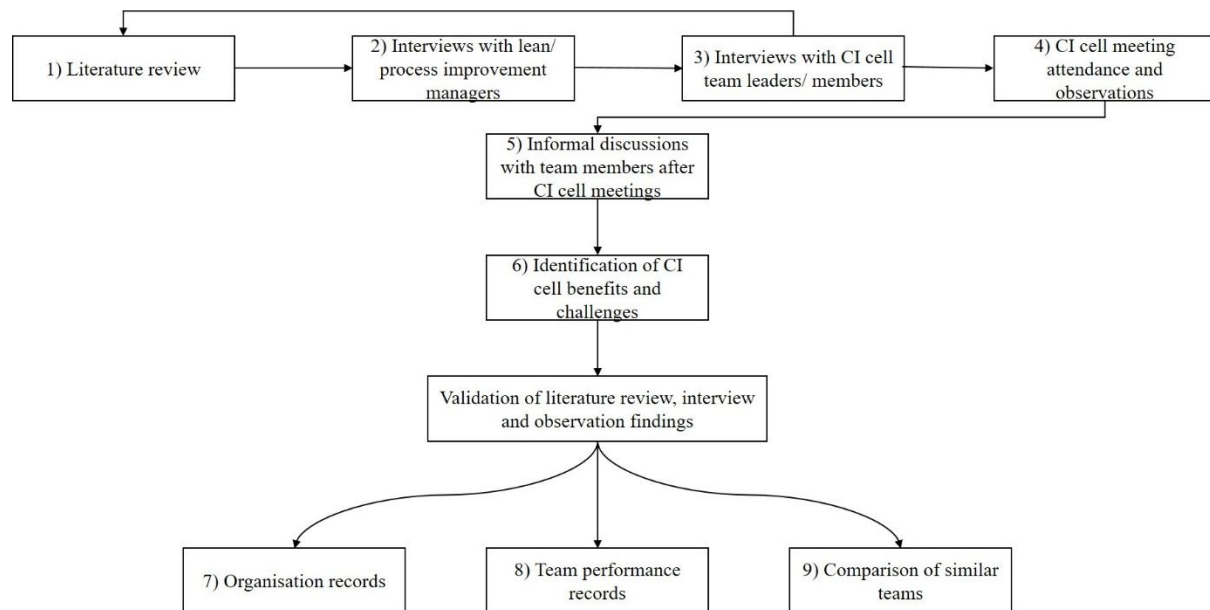


Figure 1. Research process

4. Findings

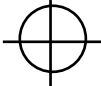
4.1. CI cell execution

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 3C", 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 "3C" 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 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 3C), 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 toward having their own CI cells, which creates various challenges in utilising the technique's full potential as explained in the subsequent section.

Table 3. 3C 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	 <p>A cycle to visualise the status of "the 3C". 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.</p>

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 focused 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.

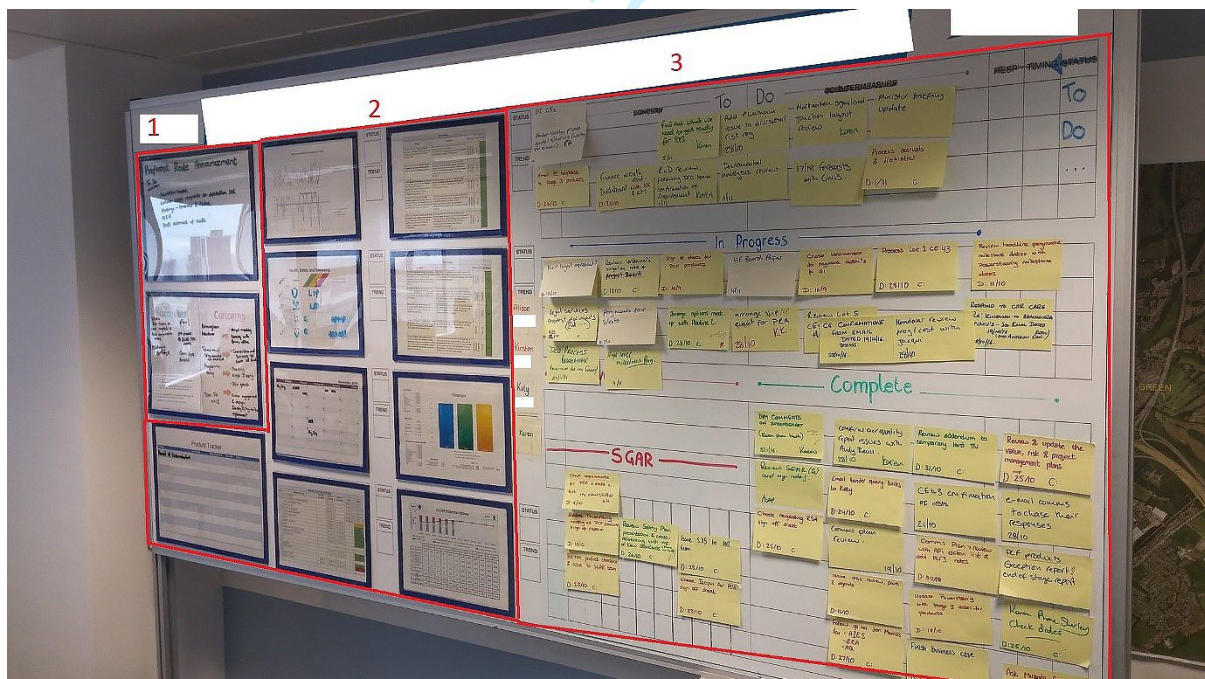


Figure 2. A Type I CI cell board with stronger focus on team KPIs and Human Resources related information (section 2), work coordination and planning (section 3) but ad-hoc approach to work improvement based on concern recording (section 1).

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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 “3C” 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 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 the Type I and Type II cells.



Figure 3. A Type II CI cell board. It has a more systematic focus on work improvement with the 3C 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.

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)

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.

Table 5. Identified benefits of CI cells. The numbers represent mentions or observations for each benefit.

CI cell benefits													
Data collection method	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

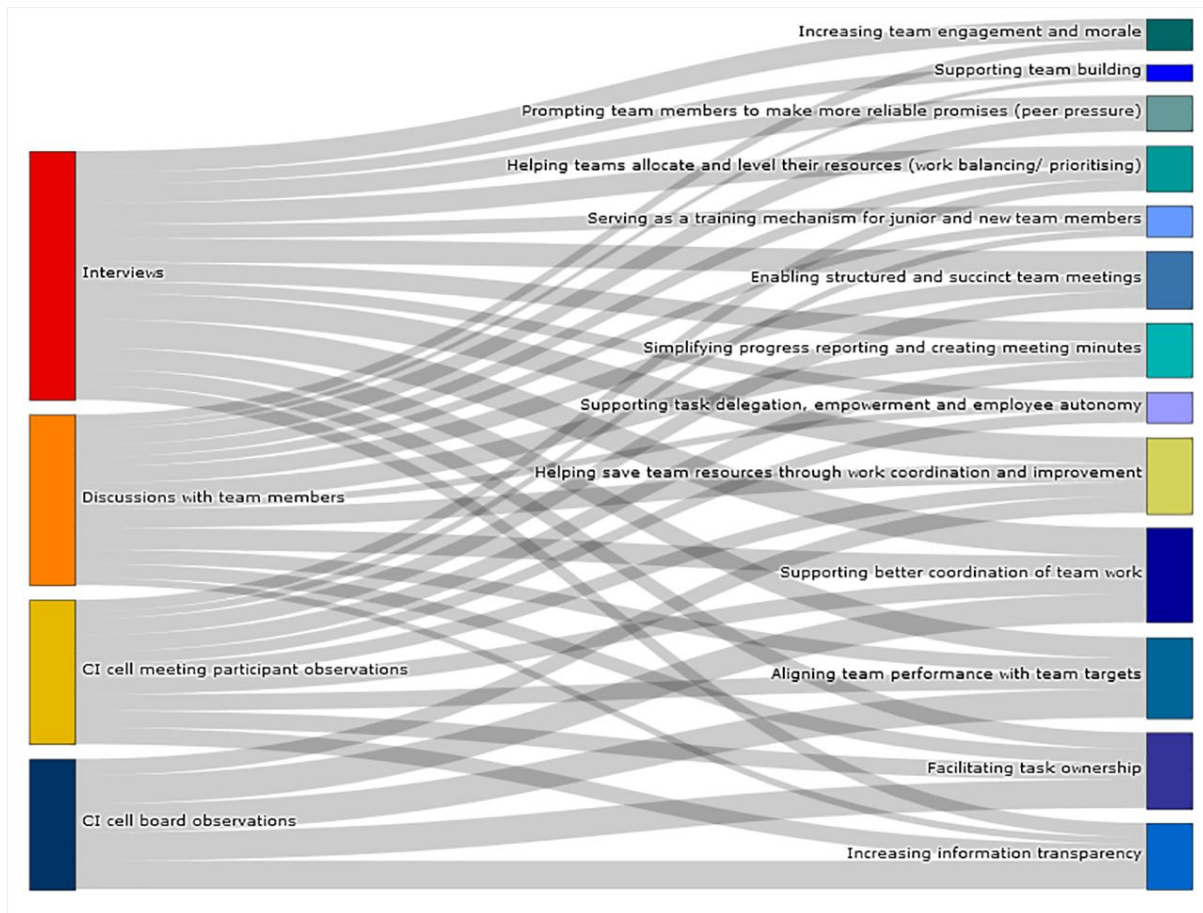


Figure 4. Sankey diagram of the initial findings showing what data collection method identified what CI cell benefits from Table 5

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:

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3 **H₀**: The two populations represented by the two groups have the same distribution in terms of
4 their staff engagement difference scores. In other words, there is no statistically significant
5 difference between the two groups (deploying and not deploying CI cells) in staff
6 engagement.
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14 The descriptive and Mann-Whitney U test statistics of the data set can be seen in
15 Table 6. With respect to descriptive statistics, the mean of the difference in the staff
16 engagement scores of the teams deploying CI cells was found as 10.7 while the mean of the
17 difference in the staff engagement scores of the teams not deploying CI cells remained at 4.05
18 for the same term. Although both team groups displayed a positive difference (improvement)
19 in their mean staff engagement scores, the teams with CI cells had recorded a far higher mean
20 staff engagement improvement (165% more) than the teams without CI cells between 2014-
21 2015. To quote from the organisation's related archive file: "Teams with CI cells are showing
22 twice the engagement improvement rate of their non-CI cell doing colleagues". From Table
23 5, it can be inferred that since the U-statistics value (45) is smaller than the U-critical value
24 (48), H₀ must be rejected. Therefore, with 95% confidence, it is statistically valid to claim
25 that there is a significant difference between the teams deploying and not deploying the CI
26 cell technique. Although it is not possible to infer from the data set that the greater staff
27 engagement and morale improvement of the teams utilising the CI cell techniques is only due
28 to their CI cell practices, the Mann-Whitney non-parametric test suggests that the teams
29 utilising the technique saw statistically significant improvement rates in their staff
30 engagement and morale scores, highlighting a positive effect of CI cells and further
31 validating the qualitative findings.
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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	

To further explore the CI cell benefits and to 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

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3 technique (Type II) and Team 13, a similar team not employing the CI cell technique at the
4 organisation, were statistically compared over a 8 month period with data recorded from their
5 monthly meetings. Both teams are responsible for the operations of the organisation's assets
6 in neighbouring geographic regions with similar routine tasks, number of team members and
7 team member profiles. The teams were chosen because of their similarity and because their
8 work context enabled a comparative study. The independent-samples t-test was employed on
9 the collected data assuming the teams' independence of each other and data normality to
10 check whether there is a statistically significant difference in the two teams' mean
11 performances (Higgins, 2003; Field, 2013). At 95% ($P_{test} = 0.05$) confidence level, the
12 hypothesis for the independent-samples t-test is as follows:

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30 **H₀:** There is no statistically significant difference between the two teams' (deploying and not
31 deploying CI cells) mean performance scores.

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35 The descriptive and independent-samples t-test statistics of the data set can be seen in
36 Table 7. It can be inferred from the descriptive statistics in the table that the team deploying
37 the CI cell technique recorded shorter meeting durations with fewer near misses and higher
38 KPI achievement percentages. As the Levene's significance values were found bigger than
39 0.05 for the teams' meeting durations, number of near misses, achieving team KPIs (%) and
40 team member availability (%) figures, the variances are assumed to be equal. H₀ was rejected
41 at 95% confidence for the meeting durations, number of near misses and achieving team KPIs
42 (%) scores as their equal variance $P_{statistics}$ scores are smaller than 0.05, meaning there is a
43 statistically significant difference between the two teams' mean performance scores in those
44 team performance areas. However, no significant difference was found in the team
45 availability numbers, suggesting no effect of the CI cell technique in this area. As Team 13
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3 could not systematically record their number of work improvement suggestions, no
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5 comparison could be made between the teams over that score. This comparative analysis
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7 supported the benefit claims that CI cells enable more succinct meetings, support better
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9 coordination and team work, and help align team performance with team KPIs as seen in the
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11 smaller number of near misses and higher percentage of team KPI achievement recorded by
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13 Team 4. Also, the team employing the CI cell technique showed a more systematic approach
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15 to continuous work improvement than the team not deploying the technique.
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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			

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3 As the last type of benefit validation, the researchers checked the Plan Percent
4 Complete (PPC) numbers– the ratio of completed tasks to planned tasks in a planning period,
5 which is used as a measure of planning reliability (Russell et al. 2014), of two teams (Team 8
6 and Team 10) claiming their CI cells prompted them making more reliable tasks promises.
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8 The teams were chosen as they had kept their task planning records since short after their CI
9 cells' initiation. The teams are responsible for supervising the delivery of construction
10 projects as client representatives and have weekly CI cell meetings. The PPC calculation was
11 performed covering the teams' recent project execution period between September 2015 to
12 May 2016. The PPC records of the teams can be seen in Figure 5. With 94% and 88%
13 average PPC scores respectively, the teams' task promise reliability was found to be high,
14 supporting their claim regarding their CI cells' positive contribution to making more reliable
15 promises. The teams did not have their pre-CI cell planned and completed task performance
16 numbers recorded. Therefore, no comparison between the teams' before and after CI cell task
17 completion performances could be made, which can be noted as a limitation.
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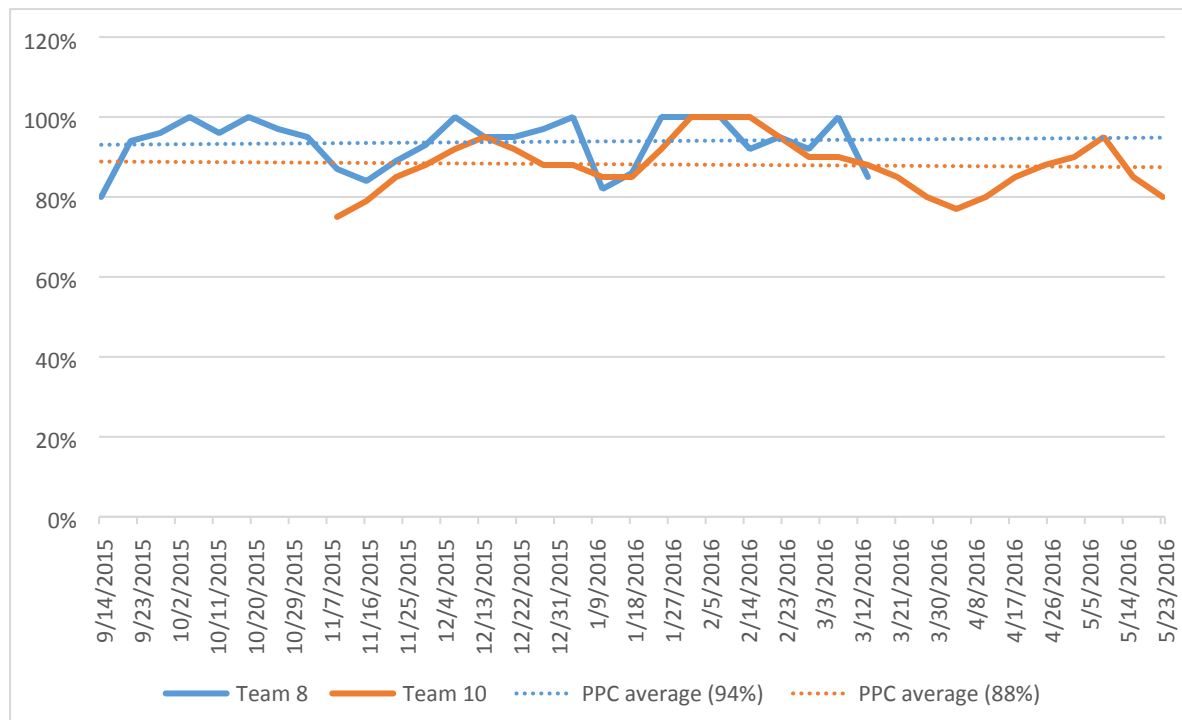


Figure 5. Plan Percent Complete (PPC) percentages of Team 8 and Team 10 over time

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 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 toward increasing process transparency within Visual Management (José Martínez-Jurado et al. 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 focusing 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.

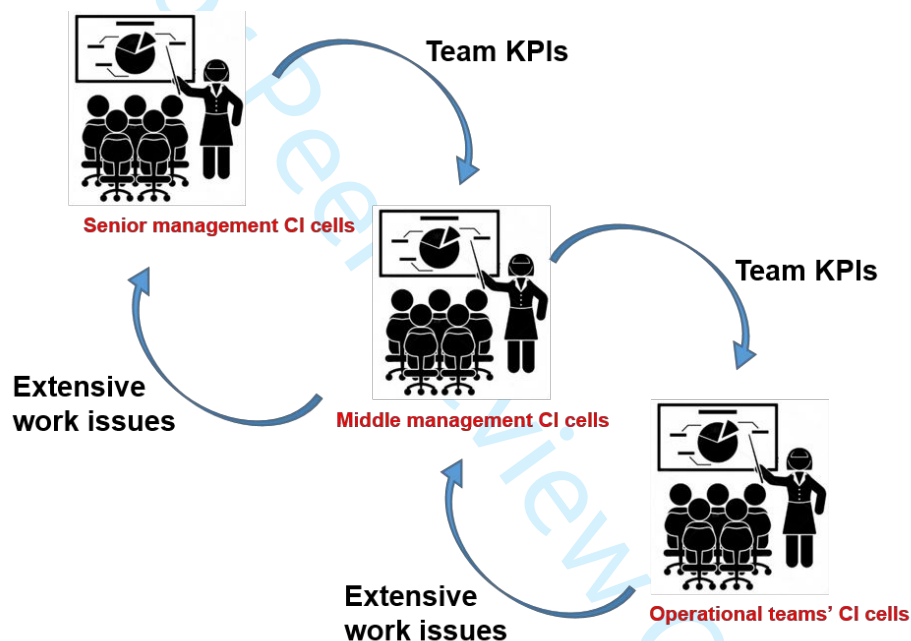


Figure 6. Suggested two-way flow of information over CI cells for *hoshin kanri*

Although some issues in the continuous improvement (*kaizen*) function (Chakravorty and Hales 2018) 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.

1
2
3 Systematic problem solving skills, awareness and training of team members in that
4
5 respect, particularly of team leaders and CI cell facilitators, are deemed as determining
6
7 factors in the effective execution of CI cells' continuous improvement function. The
8
9 visualisation of the continuous improvement process and the 3C exercise was insufficient as
10
11 the teams rely on spreadsheets with extensive written descriptions, unlike, for instance, the
12
13 highly visual A3 problem solving technique (Hadid and Mansouri 2014). Also, the lack of
14
15 incentivisation for CI cells and the teams' limited power in implementing change at the case
16
17 organisation were observed to negatively affect the motivation for continuous improvement.
18
19 Alongside Visual Management, *hoshin kanri* and *kaizen*, the CI cell technique was also found
20
21 to facilitate work planning and control for teams, and training for junior team members. Some
22
23 CI cell benefits like supporting better coordination of team work, prompting team members to
24
25 make more reliable promises (peer pressure), helping teams allocate and level their resources
26
27 (work balancing/ prioritising) and serving as a training mechanism for junior and new team
28
29 members correspond to those roles of CI cells (see Figure 7).
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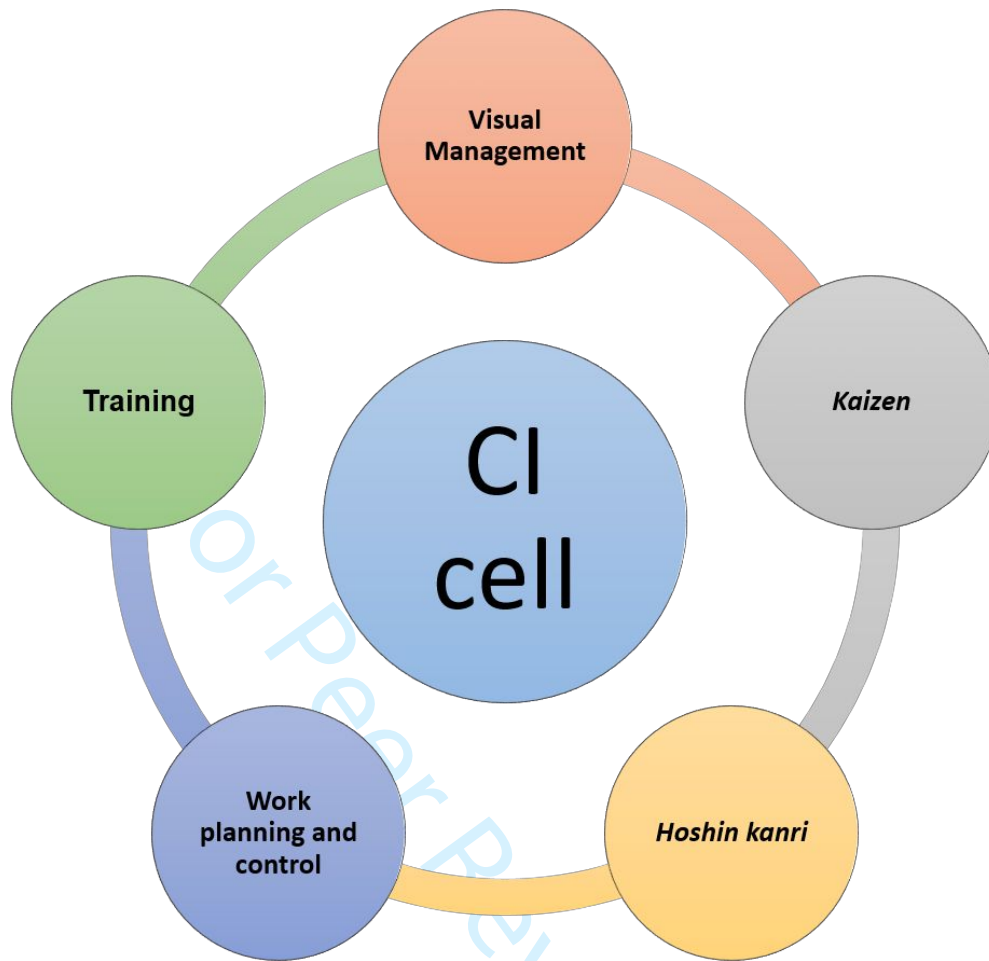


Figure 7. The role of CI cells in other management strategies and efforts.

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 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

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3 among the members of a team. As another difference to QCs and *kaizen* events, participation
4
5 to CI cell meetings is obligatory for a team member, unless the member has a valid excuse,
6
7 and the meetings are continual – there is no particular improvement project within a set
8
9 timeframe. Although each concern point may have its set timeframe, work improvements and
10
11 problem-solving are planned within “the 3C” process continually. The continuity of meetings
12
13 without any set improvement project timeframe is similar to huddle meetings. Likewise,
14
15 similar to huddle meetings, CI cell discussions are facilitated by visually displaying various
16
17 team-related information. Furthermore, similar to *kaizen* events and QCs, the continuous
18
19 improvement process is systematically visualised through “the 3C”, particularly in the Type
20
21 II cells. The team board structure within CI cells bears similarities with Daily Management
22
23 Boards’ structure. Considering these points in common and the differences in application, it
24
25 can be asserted that CI cells display hybrid characteristics across some of those well-known
26
27 participatory management techniques. Given the technique was developed by practitioners
28
29 with support from process improvement consultants who are experienced in those established
30
31 participative team-based techniques, it seems likely that the practitioners and consultants
32
33 combined different aspects of those techniques into CI cells. Further investigation related to
34
35 the origins of CI cells is necessary for the validation of this assertion.
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42 The identified CI cell benefits reflect this hybridism as well. Benefits associated with
43
44 huddle meetings such as better work coordination and commitment, succinct meetings, better
45
46 team engagement and team building were also found as CI cell benefits. Similarly, benefits
47
48 relating to QCs and *kaizen* events like resource saving and work improvement, facilitating
49
50 task ownership and empowerment were identified. Transparency, a benefit that is frequently
51
52 identified with Visual Management (Tezel, Koskela and Tzortzopoulos 2016), and aligning
53
54 team performance with team targets, something that is deemed crucial in *hoshin kanri*
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56 (Giordani da Silveira et al. 2017) are also two of the benefits. Interesting benefit findings here
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3 are CI cells' role in training and orientating junior team members by exposing them to the
4 whole spectrum of team tasks and problems, and facilitating more reliable promises by team
5 members. The benefits, which were identified by most data collection methods from Table 5,
6
7 in no particular order of importance are:
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9

- 10 • Helping save team resources through work coordination and improvement.
- 11
- 12 • Supporting better coordination of team work.
- 13
- 14 • Aligning team performance with team targets.
- 15
- 16 • Increasing information transparency.
- 17
- 18 • Facilitating task ownership.
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26 There are also serious challenges identified for the CI cells at the case organisation.
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28 The existence of two types of CI cells in practice is a sign of low standardisation. The Type I
29 cells are initiated and run thanks to the initiatives of a few members of a team through
30 copying from other teams. Moreover, with ad-hoc work improvement practices, the Type I
31 cells fall short in one of the main purposes of CI cells. Although this intrinsic motivation for
32 establishing CI cells enables the Type I teams to attain some of the benefits of CI cells, it also
33 creates a dualism in application and confusion among the teams as to what a CI cell is. The
34 organisation allocates resources for the introduction and facilitation of CI cells for some
35 teams, which results in the formation of Type II cells with greater focus on continuous
36 improvement.
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49 Even in the Type II cells there are hardships in identifying root-causes of problems
50 and recording the continuous improvement process with achieved benefits, which relate
51 partly to the "3C" structure itself as a concise work improvement and problem solving
52 exercise, and the lack of training on basic root-cause analysis tools. Another serious concern
53 is the execution of work improvement, which is not cross-departmental/functional and can be
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3 done only in the control domain of a team. Coupled with the non-existence of systematic
4
5 root-cause analysis, this leads to some recurring or persistent problems that cannot be
6
7 effectively solved by the teams, creating frustration and suspicions regarding the
8
9 effectiveness of CI cells among the team members. Additionally, as the teams' CI cell efforts
10
11 are not linked with each other, the CI cells are executed in silos. The nonexistence of similar
12
13 participative management systems for senior and middle management and the direct link
14
15 between the teams' CI cell exercises and those management levels engender follow-up
16
17 challenges for the CI cells, which is a critically important matter for the success of
18
19 participative work improvement techniques (Farris et al. 2008; Farris et al. 2009; Glover et al.
20
21 2011). Recognising this, toward the end of the study the case organisation started
22
23 preparations for the introduction of CI cells to the middle-management level, which would be
24
25 linked with the teams' existing CI cells.

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31 CI cells' role in other management strategies like Visual Management, *hoshin kanri*,
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33 *kaizen* (continuous improvement) allows for the opportunity that CI cells can be introduced to
34
35 an organisation as part of one or more of those strategies and activities. However, for a firmer
36
37 link with Visual Management, "the 3C" process in particular should be better visualised
38
39 beyond its tabular and text-heavy format at the moment. For *hoshin kanri*, the information
40
41 flow between the senior management and work teams should be maintained as shown in
42
43 Figure 6. For *kaizen*, the continuous improvement process should be systematic with proper
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45 root-cause analyses and be in the focus of all CI cells; not only of the Type II cells. Work
46
47 coordination and planning is one of the core elements of all CI cells. Keeping better records
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49 in this aspect is important. For instance, all CI cell teams can be asked by the management to
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51 track their PPC scores and to take the problems preventing them from achieving a 100% PPC
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53 score in a time period to "the 3C" process. However, the training function of CI cells is
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55 neither initially planned nor expected, and happens naturally due to the interaction between
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3 senior team members, junior team members and work itself over CI cells. This function can
4
5 be further supported by the management with modifications on CI cell boards and meeting
6
7 structures; for instance, by introducing a formal mentoring mechanism between junior and
8
9 senior team members over CI cells.
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12 From the cellular organisation point of view, CI cells can be likened to production
13
14 cells “producing” work planning/coordination, improvement, transparency, policy
15
16 deployment and employee training. Although the case organisation adopts multi-skilled
17
18 project teams to manage and control their large-scale infrastructural projects as its core work
19
20 unit, no further evidence for its extensive adoption of a cellular organisational structure was
21
22 found. Therefore, it can be asserted that although cellular organisation concerns the whole of
23
24 the organisation, the CI cells in the studied case organisation operate in practice alongside the
25
26 organisation proper. However, Barad’s (1995) observations as to the Western CI cell practice
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28 apply to the studied case as the scope of continuous improvement in the studied CI cells is
29
30 generally broad with somewhat shallow root-cause analyses whereas the CI participation is
31
32 mandatory subject to team leaders’ decisions.
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38 From a participative management point of view, it was identified that CI cells can be
39
40 considered as another form of modern, small-group, consultative participative management
41
42 technique associated with lean management with some operational benefits (Andersson,
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44 Eriksson and Torstensson 2006). The findings for CI cells support the general assertion that
45
46 participative management techniques can help create consensus, facilitate work ownership,
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48 work coordination and directing employees’ efforts to work improvement and efficiency with
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50 improved employee morale and engagement (Kim 2002; Akbar 2011; Gallie 2013; Irawanto
51
52 2015).
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56 Alongside continuous improvement (*kaizen*), the identified roles of the technique (i.e.
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58 team-based work planning and control, Visual Management, *hoshin kanri*) may help
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3 organisations diffuse and realise lean management at the team/small-group level in their day-
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5 to-day activities, which is also suggested in the literature while positioning participative
6
7 management within lean management (Poksinska et al 2013). On the other hand, the
8
9 existence of two different cell types with differing contents and focus demonstrates the
10
11 importance of adopting a consistent approach to participative management techniques in
12
13 implementation and auditing (Singh and Singh 2009; Prajogo and Cooper 2010; Cecilia
14
15 Martinez Leon et al. 2012). At the case organisation, the management had originally intended
16
17 to introduce the Type II cells as a standard; however, through copying, another type of cell
18
19 (Type I) was later developed ad-hoc by some teams. The copying led to deviations from the
20
21 intended cells. The difference between these two types is significant as it aligns to the current
22
23 dividing line in the practice and theory of operations management, namely whether
24
25 continuous improvement is systematically done (Type II) or not (Type I).
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31 Sound insights on general challenges associated with participative management
32
33 techniques such as their limited capacity in changing employee behaviour and organisational
34
35 culture (Bradley and Hill 1983) and hardships in sustaining those techniques (Hill 1991)
36
37 require more longitudinal studies covering longer time periods, which could not be realised in
38
39 this study due to resource and time limitations. However, some points for consideration while
40
41 implementing participative management techniques at the operational level such as the need
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43 for providing teams/employees with sufficient training on the execution of those techniques,
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45 and a systematic auditing and benchmarking for the techniques at the organisational level
46
47 were recorded. It was also observed that to avoid the managerial attitude leading to a lack of
48
49 co-operation, notably among senior and middle managers; and consequently, diminished
50
51 enthusiasm among operational teams for those techniques (Collard and Dale 1989), the
52
53 techniques should be extended to cover those organisational levels serving as a link between
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55 them.
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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 3C" 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

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2
3 insufficient links between the senior and middle management level and employee teams' CI
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5 cells.
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8 Many research opportunities arise from the findings made. The differences and
9
10 similarities between different techniques (e.g. QCs, CI cells) can be further investigated to
11
12 advise improvement suggestions for CI cells in the future. A comparative study of those
13
14 different techniques and the execution of CI cells at the studied large public client and private
15
16 service organisations in the civil infrastructure sector will also provide interesting insights
17
18 into CI cell applications. Studying and comparing the execution of CI cells or similar
19
20 methods at multiple organisations from different sectors or cultural contexts may yield
21
22 interesting insights. This may address the generalisability concerns of the findings of this
23
24 research as it was conducted over a single case study. Additionally, the meeting structure, and
25
26 physical or virtual board contents/design in CI cells can be analysed in more detail in future
27
28 studies. Longitudinal studies investigating the pre and post CI cell conditions of teams will be
29
30 useful for further validation, expansion or falsification of the claims regarding their benefits.
31
32 Also, a longitudinal study at the case organisation researching how the CI cell mechanism is
33
34 maintained and the effects of the introduction of CI cells to the senior and middle
35
36 management level will yield interesting insights. Investigating the critical success factors
37
38 (CSF) for CI cells, a popular type of research in participative management techniques, will
39
40 present another opportunity for researchers. Replicability of the CI cell concept in other
41
42 sectors with its implementation mechanisms, structure, benefits and challenges can be
43
44 explored. Cross-sectoral and cross-cultural analyses of CI cells are also possible in this
45
46 regard. Investigation of the team dynamics in a CI cell environment will be interesting.
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54 The various roles of CI cells in other management strategies like VM, *hoshin kanri*,
55
56 *kaizen*, etc., will help justify its implementation for practitioners. Also, the technique can find
57
58 itself a place in the literature concerned with those management strategies. However, further
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3 improvements are necessary on the current execution of and used media (physical/virtual
4 boards) for CI cells, as explained in the discussion section, to provide stronger links with
5 those management strategies in terms of information visualisation, execution of the
6 continuous improvement and problem solving process, and maintaining the information flow
7 between higher and lower organisational layers over CI cells. Nevertheless, CI cells can be
8 positioned as part of the practice and research relating to VM, *kaizen*, *hoshin kanri*, work
9 coordination and planning and team training.
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22
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24 in the research.
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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?

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3 Q12. What kind of CI cell benefits have you observed (Give examples from the literature if
4 necessary)?
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8 Q13. What kind of CI cell challenges have you observed (Give examples from the literature if
9 necessary)?
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13 Q14. Do you have any future plans for the CI cells? Are you going to keep/remove/
14 expand/modify them?
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For Peer Review Only

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)?

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

For Peer Review Only

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Appendix C. Participant observation grid for CI cell meetings

Observation Grid: Continuous Improvement Cell Meetings			
Location:	Date:	Start time:	Stop time:
Project management team/group:			No of team members:
Area of observation	Notes		
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			

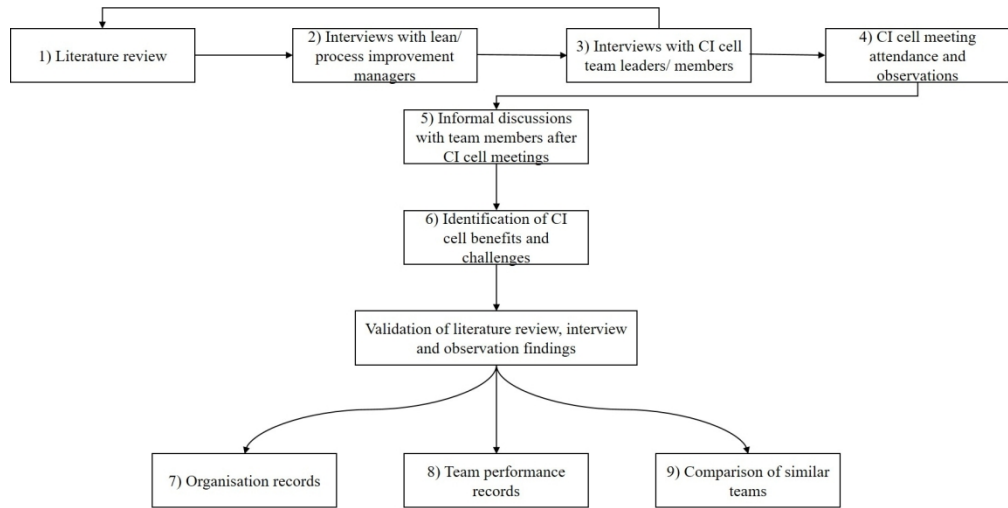


Figure 1. Research process

305x153mm (150 x 150 DPI)



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).

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Figure 3. A Type II CI cell board. It has a more systematic focus on work improvement with the 3C 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

733x412mm (72 x 72 DPI)

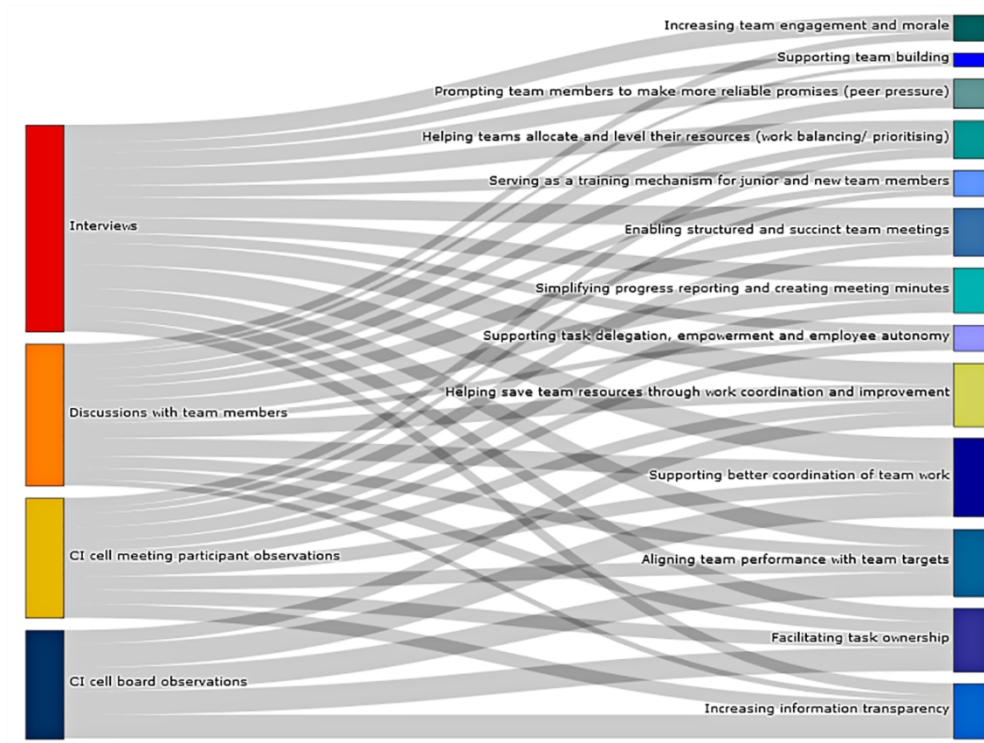


Figure 4. Sankey diagram of the initial findings showing what data collection method identified what CI cell benefits from Table 5

216x164mm (150 x 150 DPI)

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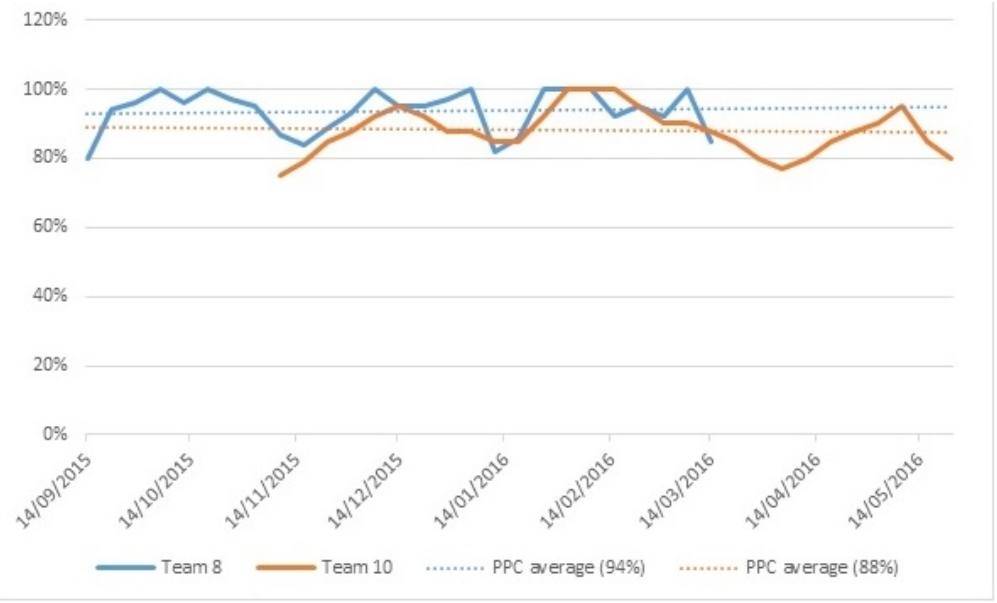


Figure 5. Plan Percent Complete (PPC) percentages of Team 8 and Team 10 over time
156x94mm (96 x 96 DPI)

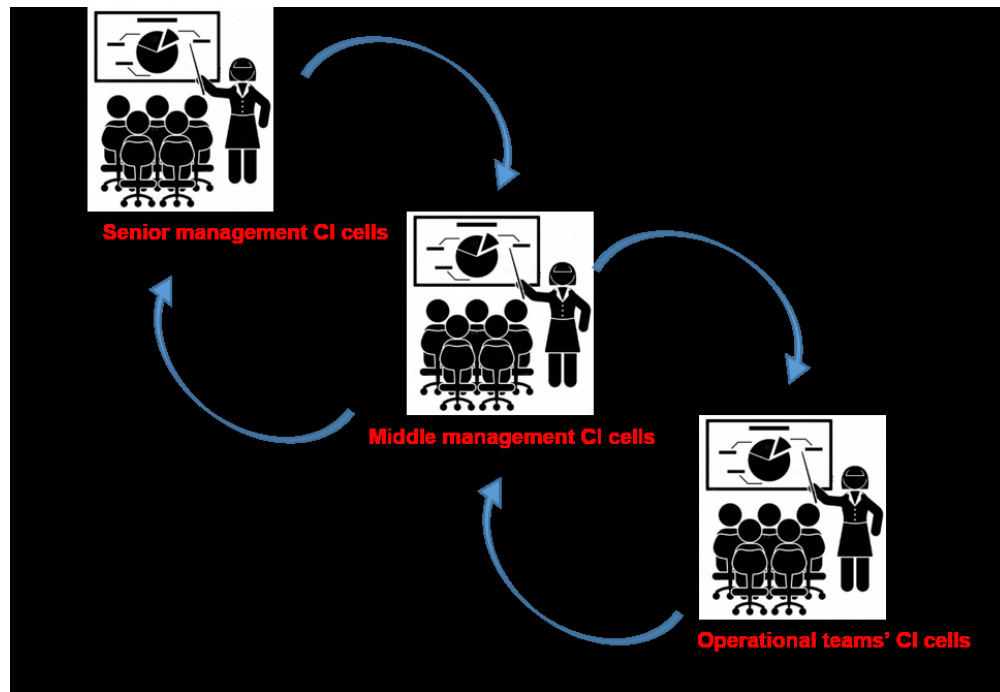


Figure 6. Suggested two-way flow of information over CI cells for hoshin kanri

163x112mm (150 x 150 DPI)

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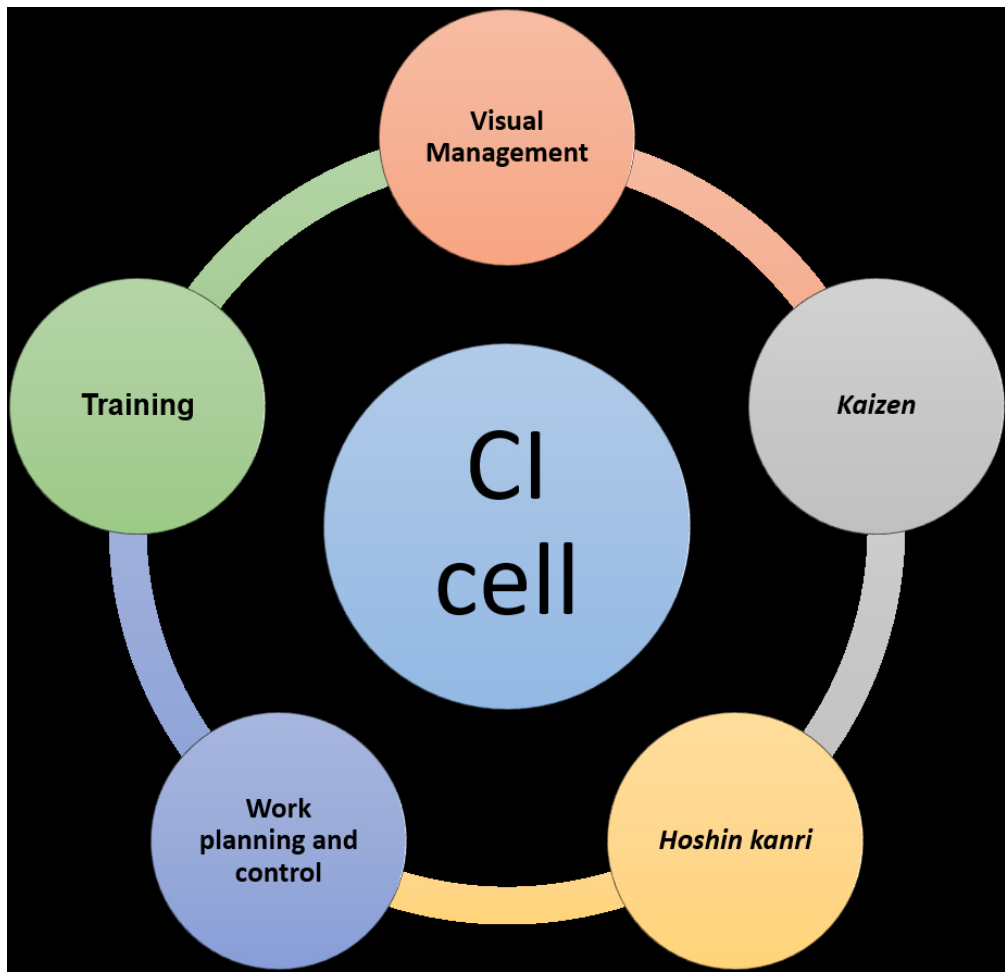


Figure 7. CI cells' role in other management strategies and efforts
155x150mm (150 x 150 DPI)

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.

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 1 team 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

Table 3. 3C section of a CI cell board

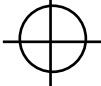
No	Date	Concern	Cause	Countermeasure	Who	When	Status
Number of the "3C" entry	Date of the "3C" entry	Problem description – ideally linked with team KPIs	Root cause of problem as identified by team members. No systematic root-cause analysis.	Corrective or preventative measures to concerns	Owner of countermeasures – a team member	Deadline date for countermeasure implementation	 <p>A cycle to visualise the status of "the 3C". 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.</p>

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)

Table 5. Identified benefits of CI cells. The numbers represent mentions or observations for each benefit.

CI cell benefits													
Data collection method	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

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			
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Appendix C. Participant observation grid for CI cell meetings

Observation Grid: Continuous Improvement Cell Meetings			
Location:	Date:	Start time:	Stop time:
Project management team/group:			No of team members:
Area of observation	Notes		
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			