Lean and IT—Working Together? An Exploratory Study of the Potential Conflicts Between Lean Thinking and the Use of Information Technology in Organisations Today

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Abstract The main objective of this paper is to carry out an initial investigation into the relationship between Lean Thinking and the use of business applications in contemporary organisations. Although both are arguably critical to business success today, traditionally the two fields have often been thought to be in conflict. A review of the available literature identified a number of potential Lean-IT conflicts, and a survey was used to validate if those conflicts exist in organisations today, if they have an impact on successful lean transformation, and whether or not the relationship is changing. The research findings indicate several potential relevant conflicts between Lean and IT. Those conflicts having the most impact on lean transformation all relate to business process management, and include: the introduction of too much complexity, automating processes where it does not make sense, and the automation of poor processes. Conflicts where improvement effort should be focused were also considered, based on a combination of high impact and poor current state. The top areas highlighted in this category were again the need to avoid complexity, the need to ensure that automation does not inhibit learning, and the importance of adopting an incremental rather than a 'major event' change culture. The objective of understanding whether the situation is improving or otherwise generated only limited findings.

Keywords Information technology · Business applications · Lean IT · Lean thinking

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1 Introduction

> The many benefits of electronic information systems are often offset by the waste they generate (Bell and Orzen 2011, p. 53).

It is an inescapable fact that Information Technology (IT) is critical to most if not all businesses today. Over the decades since computers were introduced into the workplace, their role has evolved from merely automation of transaction processing to much more that of strategic enabler. Bell (2013, p. 18) advises that 'we live in an age where skilful application of IT is an essential component of the value proposition for every enterprise'. He provides three reasons: IT capabilities are integrated in virtually every product and service delivered to our customers, IT competency allows us to serve our customers better, and IT knowhow enables us to better understand the voice and behaviour of our customers. The role of IT is arguably even more important in the service sector, where information does not just support the product, it *is* the product. 'In the knowledge worker space, information isn't metadata such as project status or scheduling—it is the process—and IT needs to be a critical part of it' (Gonzales-Rivas and Larsson 2011, p. 117).

Lean Thinking is a well-established business system relating to flow, value, and waste. Its value has been demonstrated, initially in many manufacturing organisations, and subsequently also in the service environment (Bicheno 2012). In recent years the term 'Lean IT' has become more widespread in the business world (e.g.: Bell 2006; Bell and Orzen 2011; Cunningham and Jones 2007; Schrader and Murphy 2012). McKinsey and Company state that 'IT is the next frontier for the application of Lean in business' (www.mckinsey.com), and an annual European Lean IT Summit, introduced in 2011, is now well established. However, the term is yet to be formally recognised within the academic community. Further, it is interesting to consider if it encompasses a broader scope than just a Lean IT Function. The discussion on 'What is Lean IT?' will be revisited at the end of this paper.

Traditionally Lean and IT have been in conflict (e.g.: Piszczalski 2000; Bell 2006; Crabtree and Astall 2006). A number of the reasons for this are due to fundamental differences. For example, lean thinking advocates simplicity, but the use of computer systems introduces great opportunity for complexity. Other conflicts, such as the opposing views of 'push' and 'pull', are due to how the disciplines have evolved. Historically, many IT systems based on MRP logic have worked on the philosophy of 'pushing' product through the manufacturing process. This is not aligned with the fourth of Womack and Jones' original five lean principles, namely 'let the customer *pull* value from the producer' (Womack and Jones 2003, p. 10). These and other conflicts raise the question: *does the use of IT in an organisation support a lean transformation, or are the two objectives more often pulling in different directions?* The aim of this research is to begin to address this question, and several potential Lean-IT conflicts are explored in more detail throughout this paper. Such an understanding is important as, since both Lean and IT are arguably critical to the success of businesses today, an organisation needs to be

able to embrace both Lean Thinking and the use of IT and enable them to complement rather than work against each other. Further, it is important to recognise that the two fields of Lean and IT are both changing very rapidly. The pace of change of technology has exceeded all predictions, whilst Lean, as a relatively new field, continues to evolve. A current state study of Lean-IT interaction, which is simply a snapshot in time, is therefore missing a key element. In recognition of this, an objective of understanding if the relationship between Lean and IT is changing has been included in this study.

The research undertaken involved two phases. The literature review not only provided an understanding of what has already been written in this area, but also uncovered a number of potential Lean-IT conflicts. The second step was to survey the Lean Practitioner community to enhance understanding of the potential conflicts identified. The objectives of the survey were to validate if the identified conflicts exist in organisations today, if they present a barrier to successful lean transformation, and also to understand if the situation is improving or otherwise. This third objective was approached by asking respondents to consider whether or not the current state has changed over the last two years. Despite some limitations, a survey approach was considered appropriate for this research as the objective was to understand the current state across a broad range of organisations, so a resource-intensive qualitative approach was impractical. Since the survey data is based on respondents' opinions, analysis has avoided complex statistical techniques and is restricted to descriptive statistics only.

It is important to clarify the scope of both Lean and IT for the purpose of this research. Although the origins of Lean Thinking were in the manufacturing environment (Womack et al. 1990), its application has since expanded into service and administration (e.g.: Swank 2003; Bicheno 2012; Suárez-Barraza et al. 2012) and evolved to consider an enterprise-wide approach (Womack and Jones 1994). This study is not restricted to manufacturing organisations, it recognises the broader applicability of Lean Thinking and its relevance in all businesses today. From an IT perspective, the scope has been restricted to business applications only, defined as 'any application that is important to running your business' (Microsoft Technet). The IT Function is relevant to this work, but this study encompasses a broader scope than just consideration of the IT Function. Where mentioned, the term IT refers to the technology rather than the function within an organisation. Figure 1 provides a visual illustration of a broader view of IT, and clarifies the scope for this study.

The next section reviews the literature available on Lean-IT interaction and also highlights the Lean-IT conflicts identified during the literature review. Section 3 provides more detail on the research methodology, and the survey results are presented and discussed in Sect. 4. Conclusions are provided in Sect. 5, and Sect. 6 provides a discussion on the limitations of this study and opportunities for further research.

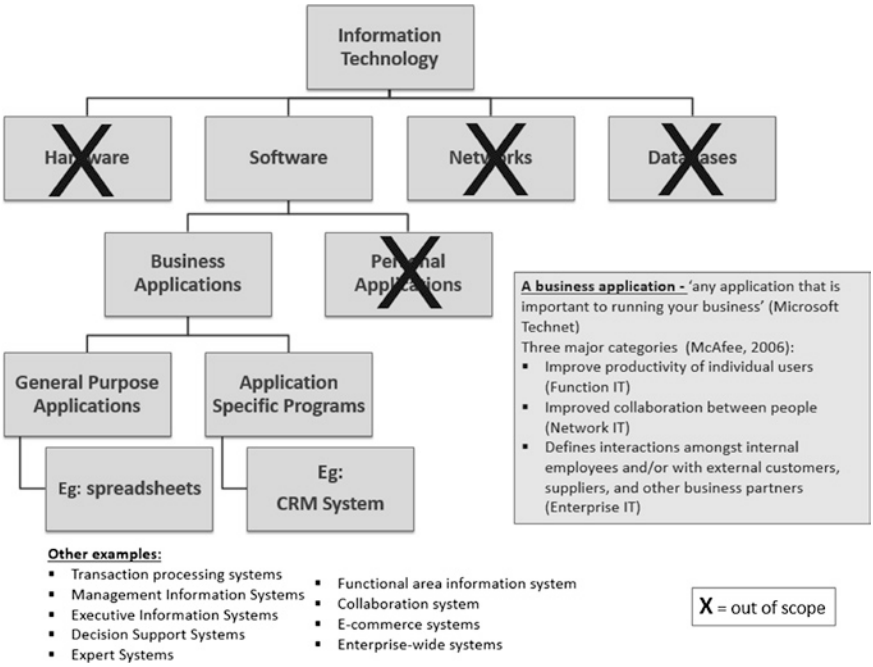

Fig. 1 Scope of IT for this research. *Source* Author

2 Literature Review

Two related areas of Lean-IT interaction that have been well researched and published are those of Lean and Enterprise Resource Planning (ERP), and Lean Software Development. A brief summary of literature in these areas has been provided, however this study then considers Lean and IT in a broader context.

A major element of IT in the current business environment is ERP, a term now used to represent enterprise-wide systems. MRP and MRP II (Materials Requirements Planning and Manufacturing Resource Planning respectively), the precursors of ERP, were based on a 'push' philosophy, developing a production schedule based on forecast demand, and 'pushing' product to the line to support that schedule. This is in contrast to the lean 'pull' approach, one of Womack and Jones' original five lean principles (Womack and Jones 1996). The early view that Lean Manufacturing and IT were in competition was driven largely by this push-pull disconnect. Several authors have commented on this relationship (e.g.: Carroll 2007; Deis 2006; Crabtree and Astall 2006). However more recent thinking has evolved to suggest that Lean and ERP can be implemented concurrently, that ERP implementation can 'behave as a catalyst for lean implementation' (Powell et al. 2013, p. 324), and together they can be an enabler for competitive advantage (Powell 2013). Powell et al. (2013) point out the value of a combined approach due to reduced time and resource requirements. They propose an approach for an ERP-based lean implementation.

The concept of agile software development was first introduced in 2001 with the development of four values and the 12-point Agile Manifesto (www.agilemanifesto.org). It was introduced to address the challenges of 'rapid changes in competitor threats, stakeholder preferences, software technology and time-to-market pressures' (Ramesh et al. 2010, p. 449), and its use has 'grown dramatically in recent years' (Wang et al. 2012, p. 435). The key objective is the 'ability to efficiently and effectively respond to user requirement changes' (Lee and Xia 2010, p. 88). Several of the Agile Manifesto principles are closely aligned to Lean Thinking, for example the need for simplicity, and learning through experimentation. At a similar time, Poppendieck (2001), introduced the concept of Lean Programming, stating that methodologies such as agile were in effect applying lean principles to software development. Further, she aligned ten Lean Manufacturing rules with software development practices as shown in Table 1. These principles reinforce the need for iterative development (a Plan-Do-Check-Act approach) and the ability to accommodate uncertainty and changing requirements. These concepts were subsequently discussed at length in the Lean Startup (Ries 2011). Ries introduces the concept of the Minimum Viable Product (MVP), and discusses the many advantages of launching an MVP into the market as quickly as possible and then refining it. The iterative approach reflects the spiral model of software development first outlined by Boehm (1986).

At a broader scope of IT than that of ERP and software development, a review of the available literature identifies three sources of Lean IT thinking. Figure 2 illustrates the three sources with associated key themes, showing similarities and differences.

As can be seen from Fig. 2, some themes are common to all three sources. These are: the challenge of recognising Information Waste due to its intangible nature, the need to accommodate changing customer requirements, and the importance of avoiding complexity. It is also of note that the annual European Lean IT Summit, introduced in 2011 and attended by many current Lean IT Thinkers (Bell, Orzen,

Table 1 Lean manufacturing rules applied to software development

Lean manufacturing rule	Applied to software development
• Eliminate waste	• Eliminate waste
• Minimize inventory	• Eliminate intermediate artifacts
• Maximise flow	• Drive down development time
• Pull from demand	• Decide as late as possible
• Empower workers	• Decide as low as possible
• Meet customer requirements	• Now and in the future
• Do it right the first time	• Incorporate feedback
• Abolish local optimisation	• Sub-optimised measurements are the enemy
• Partner with suppliers	• Use evolutionary procurement
• Create a culture of continuous improvement	• Create a culture of continuous improvement

Source Adapted from Poppendieck (2001)

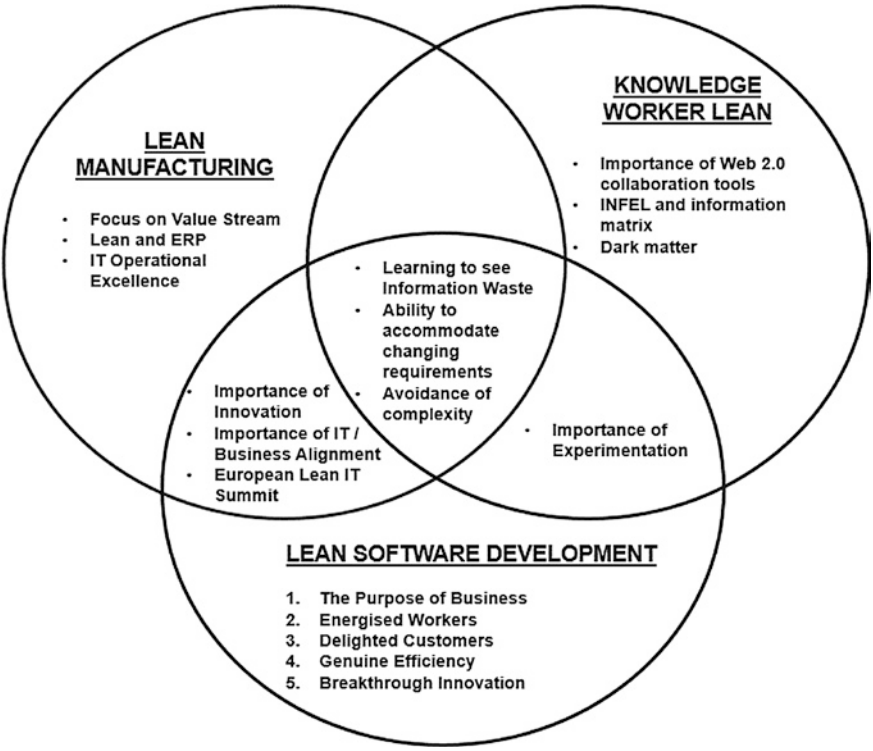

Fig. 2 Lean IT thinking—from three sources. *Source* Author, using: Bell (2006), Bell and Orzen (2011), Bell (2013), Gonzales-Rivas and Larsson (2011), Poppendieck and Poppendieck (2014)

Jones, Cunningham, Poppendieck), illustrates that two of the three sources are coming together. Further, the Lean-Agile discussion session that took place at the 2013 summit highlights that the relationship between these two areas is of interest.

Bell (2006) was the first to publish on Lean IT as a broader subject than just ERP or software development. His earlier work (2006) focused primarily on supporting lean manufacturing through IT, but his recent book (2013) takes a broader view, discussing innovation in detail and highlighting the need to balance managing current IT operations with funding innovation. He also states that aiming to align IT and 'the business' should no longer be required, as they should be as one. 'There is no "IT value" separate from business value. And in this new and often disruptive information age, there is increasingly limited business value separate from IT' (Bell 2013, p. xxxi). There is a strong focus on understanding and managing the value stream throughout Bell's work. Powell's work, on the relationship between lean manufacturing and ERP, also fits into this category (Powell 2013; Powell and Strandhagen 2011; Powell et al. 2013).

Poppendieck and Poppendieck have written extensively on the subject of lean software development, although their latest book, *The Lean Mindset* (2014), covers a wider scope. Two key themes from this book relating to software development

Table 2 Information management journals reviewed

Journal title	ISSN number
Communications of the ACM	0001-0782
IEEE Transactions on Software Engineering	0098-5589
Decision Support Systems	0167-9236
Journal of Information Technology	0268-3962
MIS Quarterly	0276-7783
Information Processing and Management	0306-4573
Information and Management	0378-7206
Journal of Management Information Systems	0742-1222
Expert Systems with Applications	0957-4174
European Journal of Information Systems	0960-085X
Journal of Strategic Information Systems	0963-8687
Information Systems Research	1047-7047
International Journal of Human-Computer Studies	1071-5819
ACM Transactions on Computer-Human Interaction	1073-0516
International Journal of Electronic Commerce	1086-4415
INFORMS Journal on Computing	1091-9856
Information Systems Journal	1350-1917
Information and Organisation	1471-7727
Journal of the American Society for Information Science and Technology	1532-2882
Journal of the Association of Information Systems	1536-9323
R and D Management	0033-6807
Technovation	0166-4972
Journal of Product Innovation Management	1540-5885

Source Author

are the importance of iteration to solve complex problems, and the value of innovation, including the need to understand and deliver what will really add value for customers. They discuss the potential of isolating innovation effort, particularly in larger companies that may be risk-averse. The themes of iteration and understanding customer requirements relate to two of the Lean-IT conflicts identified.

Gonzales-Rivas and Larsson's book, *Far From the Factory* (2011), approaches Lean IT from a different perspective. The focus is on Lean for the Knowledge Worker, beginning with a discussion on information, which leads naturally into consideration of the technology that supports it. The authors caution against taking the factory lean analogy too literally in an information environment, and use the example of 5S—'a tidy workflow strikes us as more relevant than a tidy storage room' (2011, p. 4). They propose that the challenge in the information world is to fully understand constantly evolving information flows, by making the 'invisible visible'.

The literature review included a review of the major Information Management journals, in order to understand topical subjects in the IT community. Details of the journals reviewed are shown in Table 2. All articles published between January

2010 and September 2014 were included in the review. It is notable that, of all the journals reviewed, there were only three articles found where *Lean* was included in the subject term, in each case as part of the phrase *Lean Manufacturing*. This suggests that, although Lean IT is a fast-moving emerging field in the business environment, it is not being widely discussed or acknowledged within the academic community and there is as yet no Lean IT body of knowledge. Twenty-one articles were found with *Agile Software Development* as a subject term, suggesting a higher level of recognition in this area. As agile can be considered to be the application of lean practices to software development (Poppendieck 2001) this means that arguably lean practices are being discussed in the IT community, but under a different name.

2.1 Potential Conflicts Between Lean and IT

Several authors have commented on the uneasy relationship between IT and Lean. For example, Piszcsalski (2000, p. 26) refers to 'two opposing camps' and suggests that the lean movement has been 'almost anti information systems in its stance'. Bell (2006, p. 11) refers to a 'curious tug of war', and the 'natural state of conflict between the paradigms of IT and Lean practitioners'. The literature review has identified a number of possible conflicts between IT and Lean Thinking. These conflicts divide into three different categories as listed in Table 3, and are discussed further below. Validating if these conflicts are real and impacting lean transformation in businesses today is the objective of this research.

Firstly, the use of IT introduces a number of risks to a lean approach. Lean advocates simplicity, whilst IT solutions provide opportunity to introduce complexity (Piszcsalski 2000; Bell 2006; Bell and Orzen 2011; Jones 2012; Plenert 2012). Two examples of such complexity are excess process automation (Cunningham and Jones 2007; Plenert 2012; Bell 2014) and unnecessary software functionality (Bell and Orzen 2011; Poppendieck and Poppendieck 2014; Seddon 2005; Gonzales-Rivas and Larsson 2011). Secondly, IT solutions present a risk of valuable data being hidden, in contrast to the lean approach of keeping status fully visible (Gonzales-Rivas and Larsson 2011; Mann 2010). Further, several authors comment on the need to avoid the automation of poor processes, which, once automated, become much more challenging to change and therefore improve (Hammer 1990; Bell 2006; Bicheno and Holweg 2009; Seddon 2005; Bell and Orzen 2011). Also the lean philosophy of respect for people is challenged by both the risk of technology, such as excessive email usage, weakening relationships (Schonberger 2007; Gonzales-Rivas and Larsson 2011), and the risk of process automation stopping 'learning by doing' and thereby inhibiting operators from truly understanding how processes work (Crabtree and Astall 2006).

The second category relates to conflicts between Lean Thinking and traditional IT thinking. Lean advocates the use of cross-functional teams, whilst IT has traditionally adopted a 'silo' approach to working, not only between IT and

Table 3 Lean-IT conflicts identified from literature review

Category		Lean	IT
Risks introduced by the use of IT	1	Simplicity	Complexity
			• Over-automation of process
			• Unnecessary software functionality
	2	Keeping status visible	Automation hiding visibility
	3	Ongoing process improvement	Automation of poor process
	4	Respect for people	• Technology weakens relationships
			• Automation inhibits learning
Conflicts between lean thinking and traditional IT thinking	5	Cross functional teams	Working in silos
			• Between IT and 'the business'
			• Within IT
	6	Pull	Push
	7	Culture of experimentation	IT control and compliance
			• Overly restrictive IT security
			• Over-standardisation
	8	Incremental approach to change	'Major-event' approach to change
	9	Everyone involved	Only experts can make changes
Conflicts between lean thinking and IT current practice	10	Focus on the voice of the customer (VOC)	Insufficient understanding of the VOC
	11	Understand demand to drive flow	Poor demand management
	12	Measure the things that matter	Inappropriate IT metrics

Source Author

the rest of the organisation (Bell and Orzen 2011; Seddon 2005; Markus and Keil 1994; Poppendieck and Poppendieck 2014), but also within the IT Group between different IT functions (Orzen 2011). Secondly, a fundamental concept of a lean approach is 'pulling' demand through the system. The advent of IT systems supporting pull production (Powell et al. 2013) means the original Lean/IT conflict may be less of a concern. However the pull-push conflict is potentially still valid as IT solutions have traditionally been 'pushed' out to users (Seddon 2005; Plenert 2012). Also, a lean culture is one of experimentation and learning, whilst traditional IT thinking adopts a control and compliance approach. Two such examples are overly restrictive IT security (Gonzales-Rivas and Larsson 2011; Cunningham 2012; Bell and Orzen 2011), and over-standardisation of process (Gonzales-Rivas and Larsson 2011; Hopp and Spearman 2008; Jones 2012),

both of which are in conflict with an experimentation approach. A third conflict in this category is that between the lean approach of incremental change, and the traditional IT philosophy of 'major-event' change (Poppendieck and Poppendieck 2014; Ries 2011; Gonzales-Rivas and Larsson 2011; Orzen 2011; Bell 2006; Cunningham and Jones 2007). Finally, Jones (2012) highlights the 'everyone versus experts' conflict—lean aims to involve everyone in creating value and improving their work, whereas in the traditional IT world, often only 'experts' can design and implement changes.

The third and final category of conflicts considers differences between Lean Thinking and current IT practice. A key Lean concept involves understanding the voice of the customer (VOC), whilst in many cases the IT Group does not sufficiently understand either their internal or external customers (Jones 2012; Bell and Orzen 2011; Seddon 2005; Markus and Keil 1994). Also, a lean approach involves understanding demand, as well as supply, in order to enable flow, but poor IT demand management is often a problem (Gentle 2007; Bell and Orzen 2011; Poppendieck and Poppendieck 2014). Finally, the right metrics are key to an effective lean approach, but inappropriate metrics are often used in an IT environment (Markus and Keil 1994; Spitzer 2007; Jarrett 2012; Bell 2013).

3 Methodology

The author has adopted a pragmatist philosophy, which avoids the need to take one of the opposing positions of positivism or interpretivism. As Saunders et al. (2012, p. 130) state, pragmatists recognise that there are many ways of interpreting the world, and they will use whichever method or methods that will 'enable credible, well-founded, reliable and relevant data to be collected that advance the research' (quoting Kelemen and Rumens 2008). The aim of the research was to develop a theory of possible conflicts based on the available literature, and then test it by asking Lean Practitioners for their opinions on related questions. Whilst this is a deductive approach usually associated with a positivist philosophy, the data gathered in this case is opinions rather than facts, fitting better with the interpretivist end of the continuum.

The process used to gather the opinions of Lean Practitioners was through an online survey. Although a qualitative approach may initially be considered more appropriate for opinion data, in this case a survey was used. This is because of the need to gather a sufficient volume of responses, as one aim of the research is to understand the current state in a broad cross-section of organisations. Use of a resource-intensive qualitative interview technique would not have accommodated the collection of a sufficient volume of data within a reasonable timescale.

Aside from some initial demographic and concluding open text questions, the survey asked for respondents' opinions on the potential Lean-IT conflicts identified in Table 3. In order to design a survey to achieve the research objectives,

one or two related *statements* and *objectives* were developed for each identified conflict. For clarification, the label *conflict* is used for the initial potential incompatibilities between Lean and IT, as identified in the Literature Review. Asking respondents how strongly they agreed or disagreed with each *statement*, using a Likert scale, provided information on the current state of each conflict. The aim of asking respondents how much impact they thought achievement of each *objective* would have on lean transformation was to gather data on the impact of resolving each conflict. An example is illustrated in Fig. 3.

The research constitutes a cross-sectional study, as the objective was to understand the current state at one point in time regarding Lean-IT conflicts. As both fields are moving rapidly, it is recognised that this analysis may quickly become obsolete. Each survey question was therefore followed with a subsequent question which aimed to capture respondents' views on whether the situation is improving or otherwise. This was to address the research objective which sought to understand how the relationship between Lean and IT is changing, in recognition of the fast-changing landscape. A time period of two years was selected as appropriate for this objective, so respondents were asked to identify if the situation was better, worse, or unchanged since June 2012. Three questions for each conflict were therefore included, with the objectives of understanding: whether or not the conflict exists in the respondents' organisations, if the situation has changed over the last two years, and if that conflict has an impact on lean transformation. The survey questions took one of three forms in line with these objectives, as illustrated in the example in Fig. 4. Careful consideration was given to the design of the statements and objectives relating to the conflicts, since opinion questions 'are harder

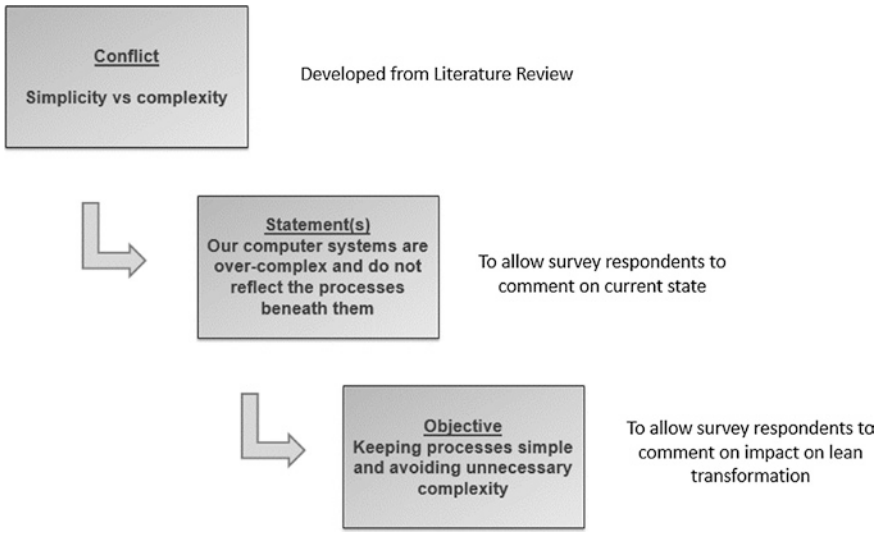

Fig. 3 Relationship between conflicts, statements and objectives. *Source* Author

15. Risks introduced by the use of Information Technology
Please choose the answer that states how much you agree with each statement, when considering the current situation in your organisation

	strongly disagree	disagree	neither agree nor disagree	agree	Strongly agree
• Our computer systems are over-complex and do not reflect the processes beneath them	○	○	○	○	○

16. Risks introduced by the use of Information Technology
Please choose the answer that specifies whether or not you think the situation in your organisation has changed from where it was two years ago (June 2012)

	Better	No Change	Worse	Don't know	
• Our computer systems are over-complex and do not reflect the processes beneath them	○	○	○	○	

21. Please choose the appropriate answer that specifies how much impact you think the objective stated will have on successful lean transformation for an organisation
4 – high impact (if we get this right it will really help the lean journey)
1 – no impact (it doesn't matter whether or not this changes)

	1 – no impact	2 – minimal impact	3 – some impact	4 – high impact	Don't know
Keeping processes simple and avoiding unnecessary complexity	○	○	○	○	○

Fig. 4 Examples of survey questions. *Source* Author

to construct as they are much more sensitive to small changes in question wording' (Chatfield 1988, p. 212). Also, both positive and negative statements were included to ensure the respondent had to consider their response rather than just selecting the same answer for every question.

The finalised online survey, distributed in June 2014, was circulated in two different ways. An email invitation to complete the survey was sent to: University of Cardiff M.Sc., in Lean Operations Alumni, University of Buckingham M.Sc., in Lean Enterprise current students, and Lean Practitioner contacts known to the researcher. In addition a discussion requesting people complete the survey was posted on several LinkedIn groups: Systems Thinking and Lean, Lean Thinking, Lean Debate, Lean Enterprise Academy, Lean Offices. This is a convenience sampling approach. Clearly this may generate some concern as the sample was not random, which raises the question of how much it can reasonably be used to generalise findings across a population. However there are justifications for such an approach in this case. Firstly, identifying, accessing, and soliciting responses from a truly random sample would be extremely challenging. Also, this is an initial exploratory study only, and, as such, is seeking to provide general rather than detailed findings. A more rigorous sampling approach could be considered for subsequent more detailed research if appropriate.

4 Discussion

It is not possible to determine a survey response rate, as the use of LinkedIn Groups meant that the survey was available to an unknown number of people. However a total of 82 people viewed the survey, with 66 completing it. This response total should generate valid conclusions as it is more than the small sample definition of 30 responses (Bock and Sergeant 2002). Further, 87 % of the respondents stated that they either had, or were working towards, a qualification in Lean. It is therefore reasonable to assume that the majority of responses are based on a comprehensive understanding of lean principles and practices. Figures 5 and 6 provide further demographic data about the respondents. These figures highlight that this analysis will represent a European perspective as the majority of respondents (close to 80 %) are based in Europe, and also that more than 50 % of respondents are based in very large organisations.

The survey data analysis has been kept very simple, and not ventured into complex statistical analysis due to the nature of the raw data and the recognition that it is based on opinion only. Two simple measures were used to assist in drawing some conclusions. Firstly, for the questions asking for respondents' views on the impact of each objective, an Impact Index was calculated. This is a weighted average, calculated as shown in Step 1 in Fig. 7. Two differing weighting approaches were explored but the difference in results was minimal. The objective of calculating a number is for comparison purposes only rather than because of any significance of the number itself.

A second measure was developed with the aim of addressing the further objective of understanding on which of the conflicts identified should improvement effort be focused. This requires identifying which conflicts are both in a

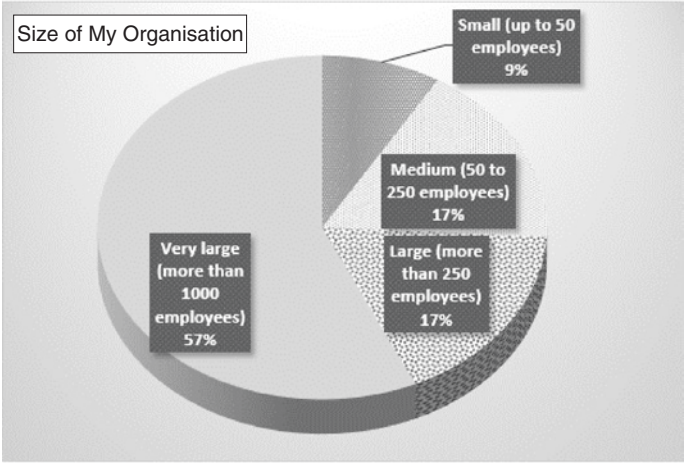

Fig. 5 Size of respondents' organisation. *Source* Survey data

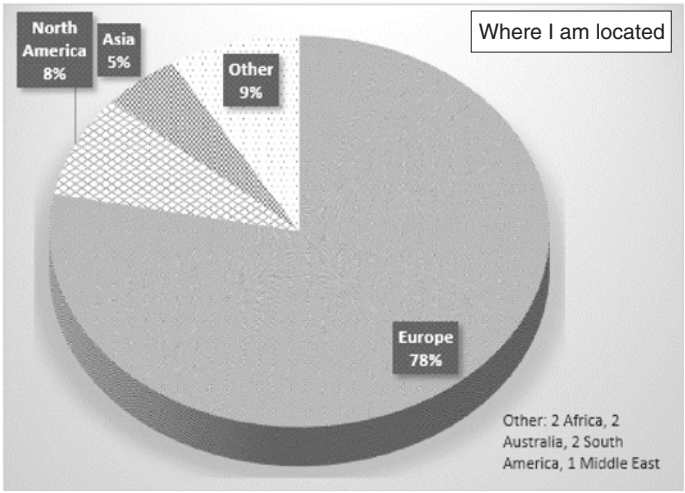

Fig. 6 Location of respondents. *Source* Survey data

Step 1 – Calculation of Impact Index

Answer Options	1 – no impact	2 – minimal impact	3 – some impact	4 – high impact	Don't Know	Response Count
Weighting	0	4	7	10	-	-
Keeping processes simple and avoiding unnecessary complexity	0	0	6	60	0	66

Impact Index = ((0*0) + (0*4) + (6*7) + (60*10))/66 = 9.73

Step 2 – Calculation of Impact – Current State Index

Percentages	Strongly disagree	disagree	Neither agree nor disagree	agree	Strongly agree	% 'good'	% 'bad'
Our computer systems are over-complex and do not reflect the processes beneath them	4%	20%	13%	47%	16%	24%	63%

This is a negative statement, so need to identify the people who agree with the statement, to obtain 'bad' current state measure. ***Current state % 'bad' = 47% + 16% = 63%***

Impact – Current State Index = 9.73 * 0.63 = 6.11

Fig. 7 Example calculation of impact/current state index. *Source* Author

'poor' current state position *and* have the most impact on lean transformation. An Impact-Current State Index (ICSI) was calculated which combines a current state measure with the Impact Index discussed above. Again, the objective is to obtain numbers for comparison rather than for an absolute value. The current state score was obtained by reviewing the percentage of responses indicating a 'bad' current state. This was determined by looking at the proportion of respondents who either agreed or strongly agreed with a negative statement, or disagreed or strongly disagreed with a positive statement. So, a higher number means a worse current state. Where there were two survey questions supporting the objective, the average 'bad' proportion of the two numbers was taken.

Figure 7 provides an example ICSI calculation. The higher the number, the more opportunity for improvement, as these represent objectives where the current situation is poor and there is a high impact on successful lean transformation if the issue is resolved.

4.1 Observations—Current Situation

Figures 8, 9, 10 illustrate the proportion of respondents in each Likert category for the current state statements, and brief discussions on the results follow.

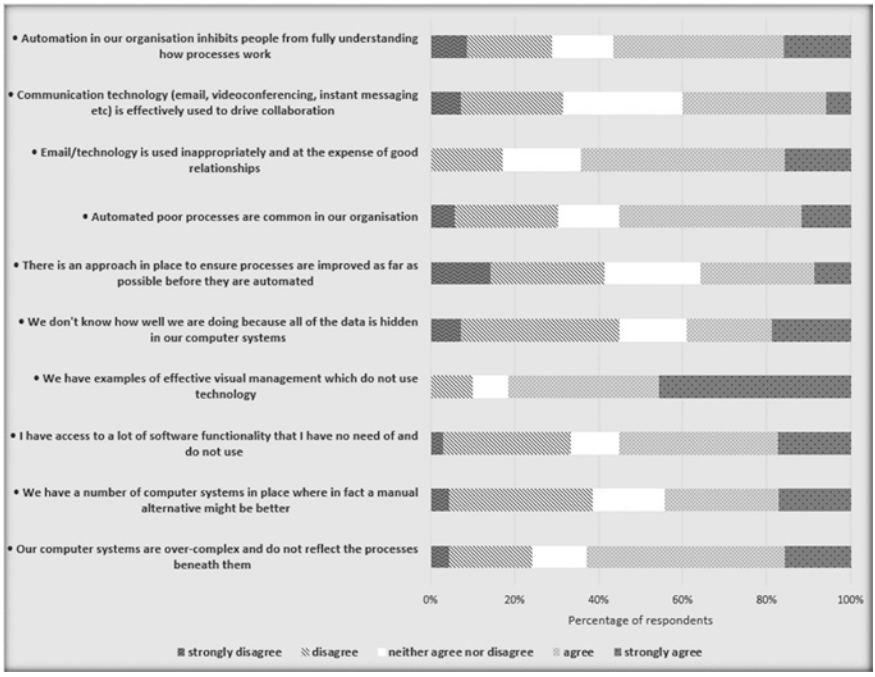

Fig. 8 Current state data: risks introduced by the use of IT. *Source* Survey data

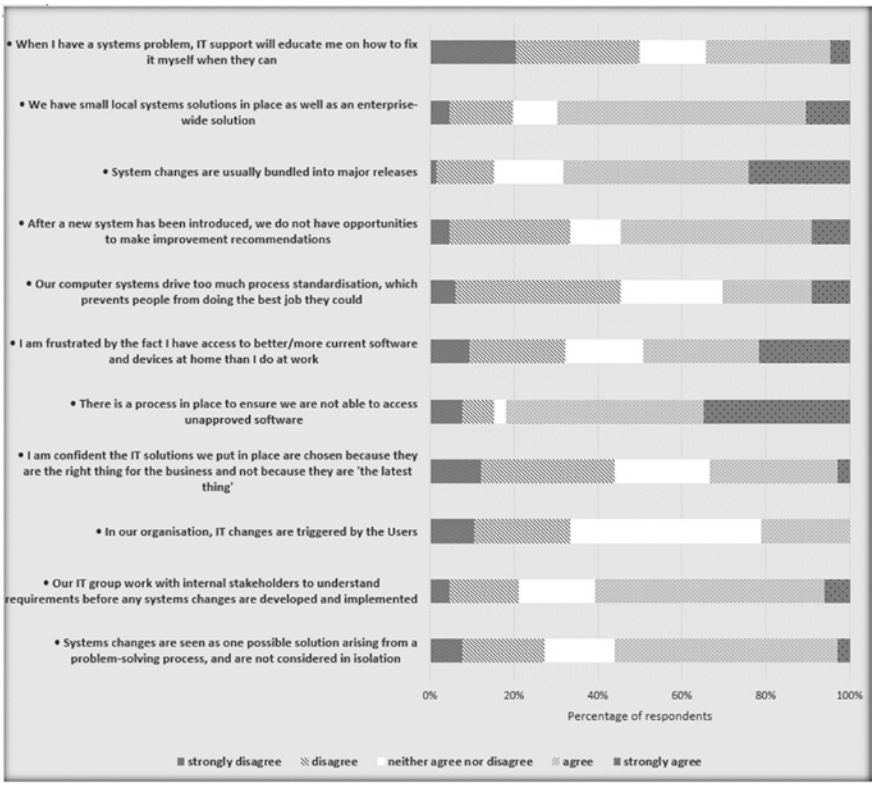

Fig. 9 Current state data: conflicts between lean thinking and traditional IT thinking. *Source* Survey data

Observations are made by summing the agree/strongly agree or disagree/strongly disagree percentages.

The most significant concerning conclusion from Fig. 8 is that more than 60 % of respondents raise a concern about the over-complexity of technology, believing that '*our computer systems are over-complex and do not reflect the processes beneath them*'. Also, just over 55 % believe that *automation inhibits learning*, and nearly 65 % think that *email is used inappropriately and at the expense of relationships*. However there are some positive themes emerging, most notably around visual management. More than 80 % of respondents state they have examples of effective visual management that do not use technology. This is the most conclusive response in the entire survey, although that is possibly due to the question being less opinion-based than others.

The most conclusive response illustrated in Fig. 9 relates to unapproved software, where more than 80 % of respondents agree or strongly agree that there is a process in place to prevent them from accessing it. This suggests that many

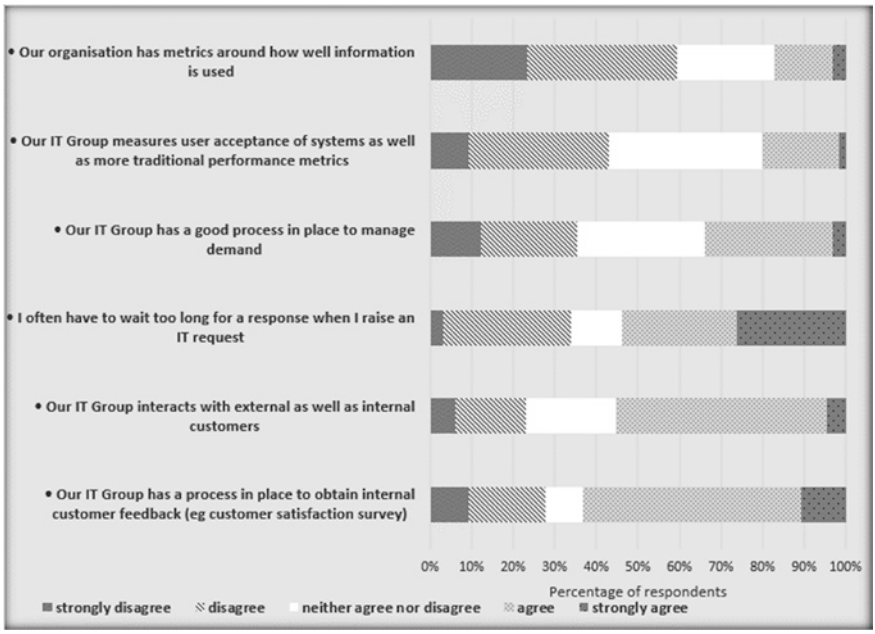

Fig. 10 Current state data: conflicts between lean thinking and IT ways of working. *Source* Survey data

users are not able to experiment with new software and technologies. However this is a complex area worthy of further discussion, as there are many good arguments for organisations restricting access to unapproved software. Nearly 70 % of respondents agree that systems changes are bundled into major releases, and more than 50 % state that they do not have opportunities to make improvement recommendations once a system has been implemented. This suggests that an incremental approach to system development is not yet widespread. Interestingly, a relatively high proportion of respondents (45 %) have no opinion on whether or not systems changes are triggered by users in their organisation. This indicates a concerning lack of user understanding as to how their system change process works.

Figure 10 illustrates that less than 20 % of respondents believe their organisation has metrics around how information is used, and only 20 % think user acceptance of systems is measured. Also, more than 50 % believe they have to wait too long for a response from IT after raising a request, indicating a demand management issue. However, on a more positive note, more than 50 % of respondents believe their IT Group interacts with external customers and seeks feedback from internal customers.

Table 4 Statements with the highest proportion of 'worse' responses

Statement	Proportion of worse' responses (%)
Our computer systems are over-complex and do not reflect the processes beneath them	23
I often have to wait too long for a response when I raise an IT request	22
I am frustrated by the fact I have access to better/more current software and devices at home than I do at work	18
After a new system has been introduced, we do not have opportunities to make improvement recommendations	17
When I have a systems problem, IT support will educate me on how to fix it myself when they can	17

Source Survey data

4.2 Observations—Is the Situation Changing?

The attempt to capture survey feedback on whether or not the situation is changing, as illustrated in Fig. 4 Question 16, was relatively crude. This is recognised as a limitation of the research. However, due to the rapidly changing environments of both Lean and IT, this subject was felt too important to exclude. Table 5 illustrates the proportion of responses in each of the three categories. The clearest observation arising from the data is that, with one exception, the majority think the situation is unchanged from two years ago. This is a concern when considering that this is a field that is believed to be rapidly evolving. The exception is a statement around visual management. The majority (more than 50 %) believe that the situation regarding use of visual management without technology is improving, which is a positive move away from automation where it is not required. It is also interesting to note that a number of respondents believe the situation is getting worse in each case. Table 4 shows the five statements with the highest proportion of 'worse' responses. The most concerning observation is the number of respondents who believe that the over-complexity of computer systems is getting worse rather than better. Respondents who selected the 'Don't Know' category in the Better-Worse questions were excluded from the analysis. Whilst this was a low percentage in the majority of cases, it is interesting to note that a higher proportion of respondents did not know whether the metrics situation was improving.

4.3 Which Conflicts Have the Greatest Impact on Lean Transformation?

Figure 11 illustrates the survey data showing respondents' views on how much impact the differing objectives have on successful lean transformation. An initial review of this chart confirms that all objectives identified have an impact, as

Table 5 Proportions of better/unchanged/worse responses

	Better (%)	No change (%)	Worse (%)
System changes are usually bundled into major releases	8	81	11
I am frustrated by the fact I have access to better/more current software and devices at home than I do at work	8	74	18
Our computer systems drive too much process standardisation, which prevents people from doing the best job they could	10	74	16
I have access to a lot of software functionality that I have no need of and do not use	10	75	15
Our organisation has metrics around how well information is used	14	75	11
Automation in our organisation inhibits people from fully understanding how processes work	14	73	13
When I have a systems problem, IT support will educate me on how to fix it myself when they can	16	67	17
Our IT Group measures user acceptance of systems as well as more traditional performance metrics	16	75	9
Email/technology is used inappropriately and at the expense of good relationships	18	71	11
Automated poor processes are common in our organisation	18	72	9
In our organisation, IT changes are triggered by the users	19	67	14
We have a number of computer systems in place where in fact a manual alternative might be better	20	67	14
There is a process in place to ensure we are not able to access unapproved software	21	67	13
We have small local systems solutions in place as well as an enterprise-wide solution	21	65	15
I often have to wait too long for a response when I raise an IT request	22	57	22
After a new system has been introduced, we do not have opportunities to make improvement recommendations	22	60	17
Our IT Group has a good process in place to manage demand	24	60	16
I am confident the IT solutions we put in place are chosen because they are the right thing for the business and not because they are ‘the latest thing’	24	63	13
Our computer systems are over-complex and do not reflect the processes beneath them	24	53	23
Our IT Group work with internal stakeholders to understand requirements before any systems changes are developed and implemented	25	65	10

(continued)

Table 5 (continued)

	Better (%)	No change (%)	Worse (%)
Our IT Group interacts with external as well as internal customers	25	69	5
Systems changes are seen as one possible solution arising from a problem-solving process, and are not considered in isolation	27	65	8
There is an approach in place to ensure processes are improved as far as possible before they are automated	29	58	14
Our IT Group has a process in place to obtain internal customer feedback (for example—customer satisfaction survey)	29	58	14
We don't know how well we are doing because all of the data is hidden in our computer systems	38	52	11
Communication technology (email, videoconferencing, instant messaging etc.) is effectively used to drive collaboration	42	50	8
We have examples of effective visual management which do not use technology	55	41	5

Source Survey data

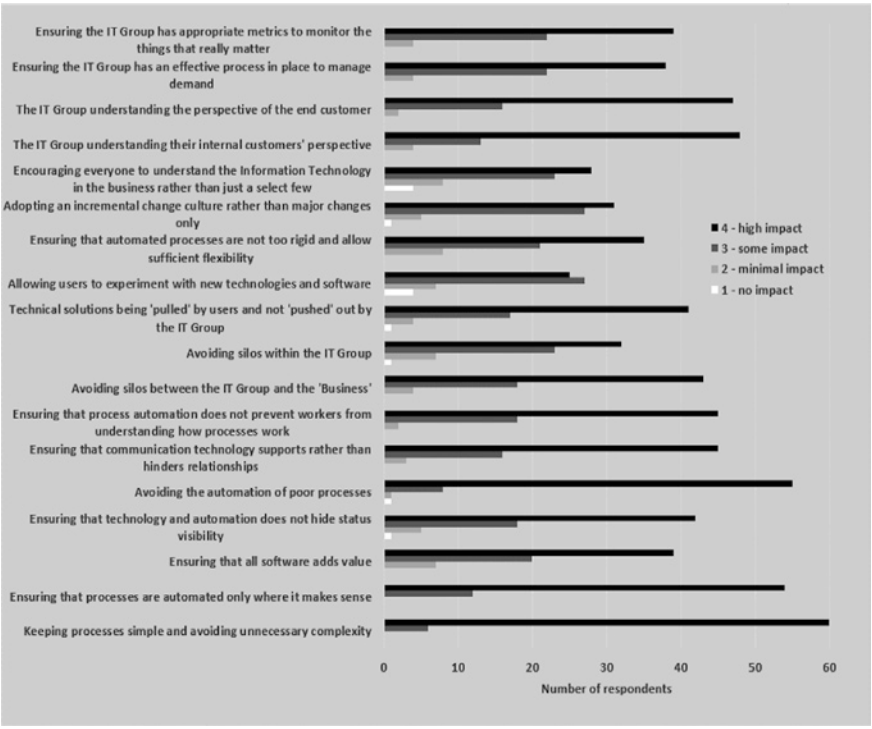

Fig. 11 Impact of conflicts identified. *Source* Survey data

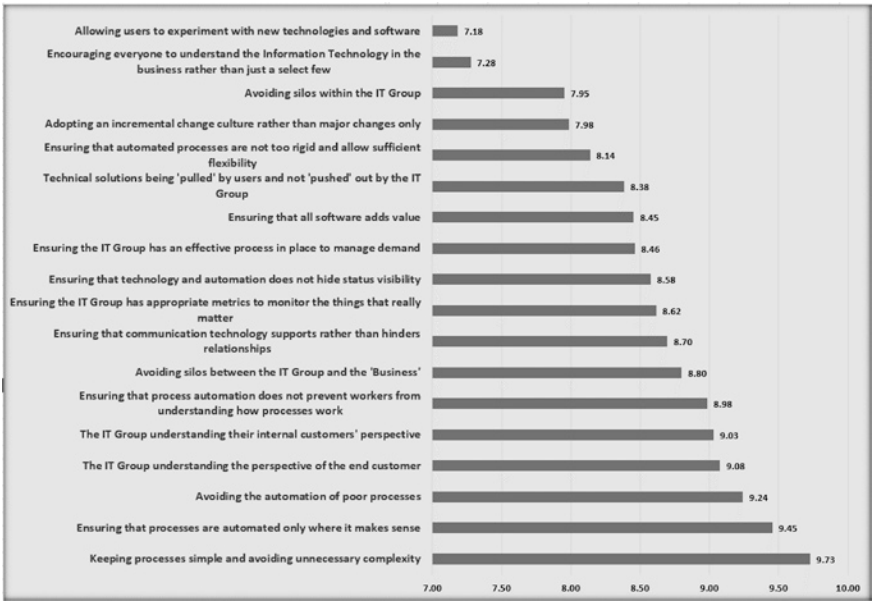

Fig. 12 Impact index of conflicts identified. *Source* Survey data

it shows a high proportion of 'high' and 'some' impact bars, with the size of the 'minimal impact' and 'no impact' bars being small in comparison. This is confirmation that the conflicts identified at the start of this study are valid.

As the responses are similar for each objective, further analysis was carried out with the aim of drawing out the differences. An Impact Index, as explained in Fig. 7, was calculated for each of the objectives and these are shown in Fig. 12. This illustrates that the objectives considered to have the most impact on lean transformation all relate to process design and automation. It reinforces the need to keep processes simple, to ensure processes are optimised first, and to automate only where it makes sense.

4.4 Where Should Improvement Effort Be Focused?

The Impact-Current State Index (ICSI) was developed to identify where to focus effort around IT to make a difference to lean transformation, by understanding which conflicts have the most impact *and* the worst current state. The measure was calculated using the Impact Index combined with a measure of 'bad' current state, as illustrated in Fig. 7. The ICSIs for each conflict are shown in Table 6 with the Top 3 highlighted. This identifies that the first area of focus for improvement should be aiming to keep processes simple and without undue complexity. It is unclear from Table 5 if the situation is improving or deteriorating. Whilst

the survey data highlighted this area as receiving the highest number of 'worse' responses (23 %), a similar proportion believe that the situation is improving. The second area of focus is the need to ensure that automation does not inhibit process understanding, whilst the third area reflects the importance of accommodating incremental changes. This is another instance where a slightly higher proportion of respondents believe the situation is getting worse and not better (Table 5).

4.5 Comparison of Data Subsets

Due to the demographic data collected at the start of the survey, it was possible to carry out some limited analysis comparing responses from differing groups of respondents. In particular a review was undertaken of data from respondents who stated their organisation was at a mature stage of lean transformation. Further, the responses from individuals who worked in the IT function were also reviewed. It should be noted that both of these groups are much smaller sample sizes (14 respondents at mature stage of lean transformation, and 7 respondents who work within the IT function). These small samples will have an impact on the validity of any findings and therefore conclusions should be considered provisional only. In addition only limited analysis has been completed and there is much scope for further work.

Figure 13 identifies the breakdown of respondents by stage of their organisation's lean transformation. This section focuses on comparing the 14 responses who stated their organisation was at a mature stage of their lean journey, 'the mature group', with the full sample. The comparison provided several interesting observations. Perhaps unsurprisingly, with regard to whether or not the situation was improving, the proportion of 'better' responses was higher for the mature group in all but three instances. The average proportion of 'better' responses was 34 % for the mature group in comparison to 22 % for the full sample. This suggests that the situation is improving more for those organisations at a mature stage of lean transformation. Also, it is notable that 64 % of mature group respondents either agree or strongly agree with the statement 'our computer systems are overcomplex and do not reflect the processes beneath them'. This is very similar to the result for the full group (63 %), which calls into question whether this problem is reduced as an organisation matures through a lean transformation.

In reviewing responses from IT Practitioners, it was found that seven respondents stated they worked within the IT function of their organisation. Six of the seven stated that they either have or are working towards a certification in Lean, so it is assumed that they have a good understanding of lean principles. However only five IT respondents completed all the questions, making the sample size very low, and therefore drawing any conclusions is risky. Further investigation into this area would be a great subject for future research. Bock and Sergeant (2002) state that one possible conclusion that can be drawn from a small sample is the 'all or none' conclusion, where every participant gives the same response to a question. In this

Table 6 Ranked impact-current state index

Statement	Impact Index (II)	Current State Index (CSI)	Impact – Current State Index (ICSI)	ICSI Rank
Keeping processes simple and avoiding unnecessary complexity	9.73	63%	6.11	1
Ensuring that process automation does not prevent workers from understanding how processes work	8.98	57%	5.08	2
Adopting an incremental change culture rather than major changes only	7.98	61%	4.90	3
Allowing users to experiment with new technologies and software	7.18	66%	4.71	4
Ensuring that all software adds value	8.45	55%	4.66	5
Avoiding the automation of poor processes	9.24	48%	4.46	6
Ensuring the IT Group has appropriate metrics to monitor the things that really matter	8.62	51%	4.41	7
Ensuring that processes are automated only where it makes sense	9.45	44%	4.19	8
Ensuring that communication technology supports rather than hinders relationships	8.70	48%	4.16	9
Ensuring the IT Group has an effective process in place to manage demand	8.46	45%	3.78	10
Technical solutions being 'pulled' by users and not 'pushed' out by the IT Group	8.38	39%	3.24	11
Encouraging everyone to understand the Information Technology in the business rather than just a select few	7.28	35%	2.54	12
The IT Group understanding their internal customers' perspective	9.03	28%	2.50	13
Ensuring that automated processes are not too rigid and allow sufficient flexibility	8.14	30%	2.47	14
Avoiding silos between the IT Group and the 'Business'	8.80	24%	2.13	15
Ensuring that technology and automation do not hide status visibility	8.58	25%	2.11	16
The IT Group understanding the perspective of the end customer	9.08	23%	2.09	17

Source Survey data

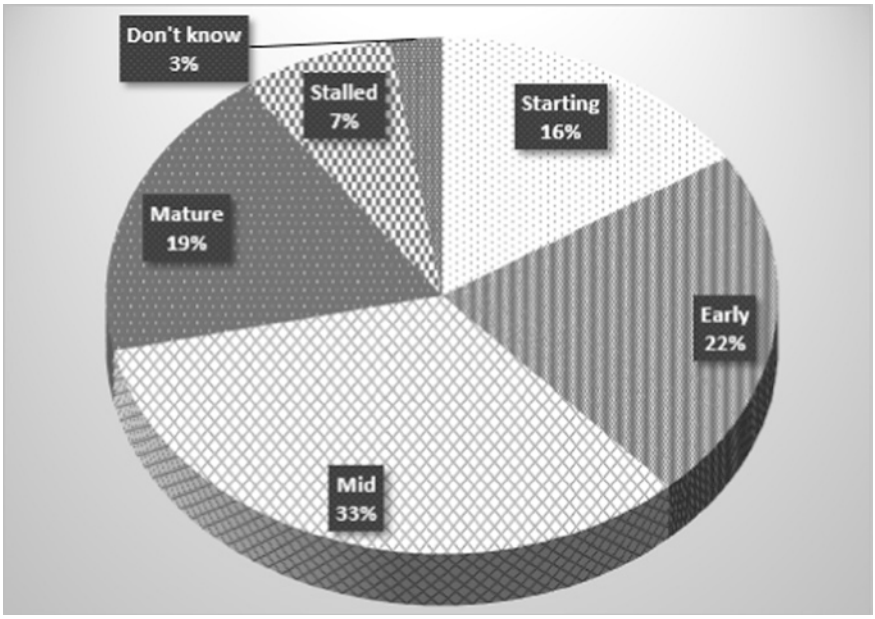

Fig. 13 Stage of lean transformation of respondents' organisations. *Source* Survey data

case, for most questions the responses were spread across all possible answers, making any conclusions challenging. The exceptions to this allow a small number of observations. Four out of five respondents agree that they have access to unnecessary software (the fifth has no opinion). All five respondents are agreed that over the last two years there has been no change to the major release approach to system change. Further, all respondents recognise either 'some' or 'high' impact, of: keeping processes simple, avoiding the automation of poor processes, and ensuring processes are sufficiently flexible. Finally, metrics is one area where the small group of IT respondents is in full agreement. They all agree that their organisations do not have metrics around how information is used.

5 Conclusions

The aim of this research was to carry out an initial exploration of the relationship between Lean and IT in businesses today, specifically to understand the situation regarding the conflicts discussed in the available literature. The literature review identified a number of potential conflicts between Lean and IT, which fall into three different categories. Some conflicts are due to risks that naturally arise when using IT in organisations, others have evolved due to differences between lean thinking and traditional IT thinking, and there are also conflicts between lean thinking and current IT practice.

Having identified a number of potential Lean-IT conflicts, the first objective of this research was to investigate whether the conflicts exist in organisations today. Data from the survey carried out validate the existence of all the conflicts. The results indicate that respondents recognised all conflicts identified, and their potential to impact lean transformation, although to varying degrees. Based on the survey results, there is abundant opportunity in organisations today to improve the situation with regard to these conflicts, thereby enhancing the Lean-IT relationship. If not recognised and addressed, the potential conflicts present risks to achieving successful lean transformation. The survey results indicate that the conflicts which have highest impact on lean transformation all relate to process design and automation. Ensuring that processes are not over-complex, that they are automated only where it makes sense, and that they are optimised prior to automation are the key objectives that will be most effective in supporting successful lean transformation. The survey analysis also identified those conflicts with a combination of both 'poor' current state *and* high impact on successful lean transformation. This was with the aim of understanding those areas that require the most improvement focus in order for Lean and IT to become more aligned. The top three objectives from this analysis were: keeping processes simple and avoiding unnecessary complexity, ensuring that process automation does not prevent workers from understanding how processes work, and adopting an incremental change culture rather than major changes only.

The challenge that requires the most fundamental change to the way organisations work is the move to an incremental change culture rather than 'bundling' changes. Since the majority of organisations treat IT as a cost centre and need to charge resource costs accordingly, they require a project approval process to be followed to secure IT resources to work on system improvements. This drives the requirement to bundle changes, which is fundamentally different from a lean approach as it hinders the implementation of an incremental change culture for IT solutions. Also, it is possible that the requirement to bundle changes increases solution complexity, as users may aim for perfection at the start due to lack of confidence they will ever see any improvement after the initial implementation.

A second objective of the research was to explore whether the relationship between Lean and IT is changing, a pertinent question due to the fast-moving nature of both fields. It is challenging to answer this question conclusively based on the survey results. Whilst some respondents believe the situation is getting better, others think the opposite, and a clear majority think the situation has not changed over the last two years. The one exception to this was the question on the use of manual visual management. This was the only instance where there was a higher number of 'better' than 'no change' responses, suggesting that organisations are now more likely to resist the temptation to automate visual management where it is unnecessary.

A logical next step for this research is to understand to what extent the identified conflicts can be overcome. Although not covered in detail as part of this paper, some initial work to explore this was undertaken, using a case study of an example that demonstrated alignment between lean thinking and the use of IT in the

workplace. The example in question was a recently implemented automated touch-screen visual management board, which effectively used lean visual management principles but was also a good technological solution. It was recognised within the organisation as a success, and additional implementations had followed the original pilot. This case study, although only one example, is a valid illustration of Lean and IT being aligned within an organisation, demonstrating that it is possible for some of the conflicts identified to be overcome.

Studying the case study in depth identified the relevance of a number of the conflicts identified earlier in this paper. The project was an interesting balance between pull and push, as the IT Group's desire to showcase innovation was achieved whilst at the same time meeting several genuine business requirements. In addition, the team working on the project had made a conscious effort to keep the solution simple, despite some challenges in doing so. Further, the solution designed allowed users to make incremental improvements, avoiding the need to refer everything to IT which necessitates 'bundling' of changes. Although the project team had not consciously been recognising and addressing Lean-IT conflicts, the adherence to the principles of simplicity and accommodating incremental change had clearly been key success drivers, which was validated by interviews with selected key project stakeholders.

A further success driver of the project, identified through the stakeholder interviews, was the fact that it was the 'right time' to implement such a solution. Reasons cited for this included employee acceptance of touch-screen technology, decreasing cost of technology, and general organisational maturity in use and understanding of data. This highlights the significance of the rapid evolution of the fields of Lean and IT, and reinforces that this study represents a snapshot in time only.

Table 7 Guidelines to drive Lean-IT alignment

Number	Guideline
1	Keep processes simple and avoid unnecessary complexity
2	Ensure that processes are automated only where it makes sense
3	Avoid the automation of poor processes
4	Ensure the IT Group understands the perspective of their customers—both the end customer and internal customers
5	Ensure that process automation does not prevent workers from understanding how processes work
6	Avoid silos between the IT Group and the rest of the organisation
7	Ensure that communication technology enhances rather than restricts relationship building
8	Ensure that the IT Group has the right metrics to monitor the things that really matter
9	Ensure that technology and automation does not hide status visibility
10	Ensure that the IT Group has an effective process in place to manage demand

Source Author

Earlier in this paper, the author raised a question over the meaning of Lean IT, a term which has become increasingly used in the business environment in recent years. Having completed this research and started to understand the many challenges to Lean and IT working effectively together, the author proposes guidelines to drive alignment between the two fields rather than suggesting a definition of Lean IT. Ten guidelines are provided as illustrated in Table 7. They are ranked in order of importance, and are based on the ten objectives, derived from the Lean-IT conflicts, that the survey results have identified as having the highest impact on lean transformation.

The top three of the guidelines proposed identify that software development is the area requiring the most focus to ensure IT alignment with lean principles. They all relate to the relationship between business process management and software development. The need for shared ownership between the business and technical experts, regardless of organisation structure, is key to adhering to these principles.

6 Limitations and Future Research Opportunities

Although this research has produced some interesting findings, it is not without limitations, and these should be recognised. The implications of using convenience sampling have already been mentioned. In particular, the survey was circulated to Lean Practitioners only. This approach was chosen to ensure respondents could provide informed views on the impact of the conflicts on lean transformation, however it will definitely influence the current state data. Secondly, sample size is a consideration. Although 66 respondents is a reasonable number, clearly a greater number would provide more reliable results. Finally, the 'better/worse' analysis was somewhat crude and provided only limited conclusions.

Further, there are a number of limitations to any survey approach, which are also relevant in this case. It is possible that people who take the time to respond to the survey will only be those who have an interest or strong opinion, thus biasing the data. Also, as the survey was relatively lengthy, the risk of respondent fatigue is introduced—'a well-documented phenomenon that occurs when survey participants become tired of the survey task and the quality of the data they provide begins to deteriorate' (Lavrakas 2008). Finally, we should not forget the volume of surveys to which we are all exposed in today's world, and the impact this may have on respondents being focused on accurate completion.

With regard to further research opportunities, as this is an initial exploratory investigation only, there is abundant potential. Firstly, there is opportunity to address two of the limitations identified. The first possibility is to carry out the same current state survey with an IT Practitioner community, and understand the different perspectives between practitioners of IT and Lean. This would address the concern that the current results are biased towards a Lean Practitioner view. The second possibility, with the aim of building on the limited 'better/worse' analysis, is to repeat the same survey on a regular basis and compare with previous

results to provide greater understanding of if and how the situation is changing. Also, it would be valuable to carry out more case study work, by identifying further examples where lean and IT are successfully aligned, to understand what learnings can be identified.

Aside from additional research with the broader scope, it would also be valuable to drill into one or more of the conflicts in detail to understand why they exist and how they can be overcome. Whilst it is a good first step for organisations to be able to recognise Lean-IT conflicts, guidance and suggestions on how to address them would be a logical and highly valuable follow-up. One possibility is deeper research into process complexity, including understanding the motivations within organisations to introduce complexity, and considering how to differentiate between necessary and unnecessary complexity, and therefore avoid the latter. Similarly, a second option is to seek to understand the difference between necessary and unnecessary process automation in organisations today. As this research provides an initial indication that the situation regarding use of visual management without technology is improving, a further research option would be to validate this more thoroughly, understand how it came about, and consider if there are learnings that can be used to avoid unnecessary automation in other areas.

As a final point, this research has raised many interesting questions about the role of the IT Group in lean transformation. Understanding more about the role the IT Group plays today, what the ideal role should be for an IT Practitioner or Leader in an organisation undergoing lean transformation, and identifying actions to close the gap, would be a fascinating future research subject.

References

Bell S (2006) Lean enterprise systems: using IT for continuous improvement. Wiley, Hoboken

Bell S (2013) Run grow transform: integrating business and Lean IT. CRC Press, Boca Raton

Bell S (2014) Lean and information technology: finding the right balance. Lean Manage J 3(5)

Bell S, Orzen M (2011) Lean IT: enabling and sustaining your lean transformation. CRC Press, Boca Rotan

Bicheno J (2012) The service systems toolbox. PICSIE Books, Buckingham

Bicheno J, Holweg M (2009) The lean toolbox: the essential guide to lean transformation. PICSIE Books, Buckingham

Bock T, Sergeant J (2002) Small sample market research. Int J Mark Res 44(2):235–244

Boehm B (1986) A spiral model of software development and enhancement. Available via http://csse.usc.edu/csse/TECHRPTS/1988/usccse88-500/usccse88-500.pdf. Accessed Aug 2014

Carroll (2007) Lean versus ERP: can't we just all get along? Available via http://www.ced-inc.com/clientuploads/Lean_Certificate_Programs/Lean_VS_ERP_Article.pdf. Accessed Aug 2014

Chatfield C (1988) Problem solving: a statistician's guide. Chapman and Hall, London and New York

Crabtree R, Astall C (2006) Lean manufacturing and IT—it's not an Oxymoron! Available via http://www.cincom.com/pdf/CM050210-2.pdf. Accessed April 2014

Cunningham J (2012) Launch Lean in a Global IT Organisation. Presented at European Lean IT Summit 22–23 Nov 2012. Available at http://www.slideshare.net/InstitutLeanFrance/jean-cunningham-at-the-european-lean-it-summit-2012

Cunningham J, Jones D (2007) Easier simpler faster: systems strategy for Lean IT. Productivity Press, New York
Deis P (2006) Lean and ERP—can they co-exist? Available at http://www.articlesbase.com/strategic-planning-articles/lean-and-erp-can-they-coexist-47604.html. Accessed Feb 2014
Gentle M (2007) A new model for IT demand management. Available at http://www.cio.com.au/article/196728/new_model_it_demand_management/. Accessed March 2014
Gonzales-Rivas G, Larsson L (2011) Far from the factory: lean for the information age. CRC Press, Boca Raton
Hammer M (1990) Re-engineering work: don't automate, obliterate. Harvard Bus Rev 68(4):104–112
Hopp W, Spearman M (2008) Factory physics. McGraw Hill, New York
Jarrett R (2012) The Lean tower of IT: the concise how-to guide to implementing lean concepts to achieve a world class IT organisation. Lean Strategies
Jones D (2012) How can IT support a lean transformation. Presented at European Lean IT Summit 22–23 Nov 2012. Available at http://www.slideshare.net/LeanUK/lean-and-it. Accessed April 2014
Kelemen M, Rumens N (2008) An introduction to critical management research. SAGE Publications, Thousand Oaks
Lavrakas P (2008) Encyclopedia of survey research methods. Available at http://srmo.sagepub.com/view/encyclopedia-of-survey-research-methods/n480.xml?rskey=EOxNtx&row=1. Accessed Jan 2015
Lee G, Xia W (2010) Toward agile: an integrated analysis of quantitative and qualitative field data on software development agility. MIS Q 34(1):87–114
Mann D (2010) Creating a lean culture: tools to sustain lean conversions. CRC Press, Boca Raton
Markus M, Keil M (1994) If we build it they will come: designing information systems that people want to use. Sloan Manage Rev 35(4):11–25
McAfee A (2006) Three technologies, three opportunities: a framework for IT leadership. Available at http://andrewmcafee.org/2006/03/three_technologies_three_opportunities_a_framework_for_it_leadership/. Accessed Sept 2014
Orzen M (2011) Lean IT from theory to application—moving beyond the what to the how. Presented at European Lean IT Summit 13–14 Oct 2011. Available at http://www.slideshare.net/operaepartners/lean-it-practices-from-theory-to-application-by-mike-orzen. Accessed May 2014
Piszczalski M (2000) Lean versus information systems. Automot Manuf Prod 112(8)
Plenert G (2012) Lean management principles for information technology. CRC Press, Boca Raton
Poppendieck M (2001) Lean programming. Available at http://www.leanessays.com/2010/11/lean-programming.html. Accessed June 2014
Poppendieck M, Poppendieck T (2014) The lean mindset. Addison Wesley, Boston
Powell D (2013) ERP systems in lean production: new insights from a review of lean and ERP literature. Int J Oper Prod Manage 33(11/12):1490–1510
Powell D, Alfnes E, Strandhagen J, Dreyer H (2013) The concurrent application of lean production and ERP: towards an ERP-based lean implementation process. Comput Ind 64:324–335
Powell D, Strandhagen J (2011) Lean production versus ERP systems: an ICT Paradox? Oper Manage 37(3):31–36
Ramesh B, Cao L, Baskerville R (2010) Agile requirements engineering practices and challenges: an empirical study. Inf Syst J 20(5):449–480
Ries E (2011) The lean start-up. Crown Business, USA
Saunders M, Lewis P, Thornhill A (2012) Research methods for business students. Pearson Prentice Hall, Upper Saddle River
Schonberger R (2007) Japanese production management: an evolution—with mixed success. J Oper Manage 25(2):403–419
Schrader S, Murphy M (2012) Using Lean IT to do more with less. Available at http://www.lodestonemc.com/files/pdf/white%20papers/WP_LeanIT_web_271112.pdf. Accessed June 2014

Seddon J (2005) Freedom from command and control: a better way to make the work. Vanguard Consulting Ltd, Pennsylvania
Spitzer D (2007) Transforming performance measurement: rethinking the way we measure and drive organisational success. AMACOM, New York
Suárez-Barraza M, Smith T, Dahlgaard-Park S (2012) Lean service: a literature analysis and classification. Total Qual Manage 23(4):359–380
Swank C (2003) The lean service machine. Harvard Bus Rev 81(10):123–129
Wang X, Conboy K, Pikkarainen M (2012) Assimilation of agile practices in use. Inf Syst J 22(6):435–455
Womack J, Jones D, Roos D (1990) The machine that changed the world: how lean production revolutionalised the global car wars. Simon & Schuster, New York
Womack J, Jones D (1994) From lean production to the lean enterprise. Harvard Bus Rev 1994:93–103
Womack J, Jones D (1996) Lean Thinking: banish waste and create wealth in your corporation. Simon & Schuster, New York
Womack J, Jones D (2003) Lean Thinking: banish waste and create wealth in your corporation. Simon & Schuster, New York