



Systems and Standards, Lean and Learning, Problems and Potholes

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Introduction

It is interesting that the week that this article was due saw three related events. One was the death of Robert McNamara, arguably the most famous large-scale systems analyst ever. In his work with Ford, the Kennedy and Johnson administrations, Rand Corporation, and The World Bank, he insisted on quantification and calculation, competitive evaluation, cost-benefit analysis, customer surveys, objective setting, and targets and measures. He was by all accounts a passionate thinker. But later in life, he reflected that 'rationality will not save us'. The second event was the death on 11 July 2009 of Peter Scholtes, long term friend and promoter of W Edwards Deming. The third was the publication, in Harvard Business Review, of an article on Irrationality in Business. The theme is the unexpected, non-linear behaviour of customers, and that rational thinking cannot be assumed. It is almost as if it is the end of one era, and the start of another.

This article has been written not only because of this opportunity, but also because road potholes have been the subject of a public sector case study on systems thinking. (Vanguard, 2009). By coincidence the writer once worked in a local authority roads department, was taught systems by Peter Checkland and used this in public service, and has spent over 20 years in the field of what is now known as 'Lean'.

Discussion of 'the pothole problem' may have relevance to a wider service audience. Certainly there are lessons for a whole host of local authority services, as well as health care and what Vanguard refers to as 'break fix' services.

'Systems Thinking' is not an easy concept. The views of different 'systems thinkers' such as Checkland, Ackoff, Deming, Senge, Forrester, Ohno, Seddon (to mention but a few) do not fully coincide. Indeed, it is likely that who is considered a 'systems thinker' would itself be the subject of lengthy debate. Although there are differences in approach and methodology (or lack of methodology), that systems thinking is powerful and useful is well accepted. This is the case for both 'service' and 'manufacturing'.

Likewise, 'Lean Thinking' is not easy to define – at least in brief. Several leading 'Lean academics' failed to reach consensus. (LeanEdu, 2009). They disagree somewhat on what it is, but agree that it is powerful and useful in both 'service' and 'manufacturing'!

But David Cochrane of MIT explains that "Lean is not what organisations need to do. Lean is what organisations should become by effective system design and implementation." This point strongly suggests that lean is not just a set of tools, but a way of thinking that organisations should use to become more successful.

Service and Manufacturing

'Service' and 'manufacturing' are still seen by some as separate entities. Thus Gronroos has listed the characteristics of services, contrasting them with manufacturing. Seddon and O'Donovan also see service as different from manufacturing but, confusingly, talk about people from 'communications' positions who are 'unlikely to be familiar with service operations'. By contrast, Mahesh and others, by contrast, talk about 'the product service bundle' – that sees manufacturing and service intertwined. To the author, very manufacturing organisation has service elements; virtually every service organisation has some transactional elements that can be seen as having manufacturing characteristics – like 'manufacturing' a road or putting a letter into an envelope. In truth, both service and manufacturing cover vast spectrums. Whilst there are differences, there are also great similarities. In fact, of course, John Seddon bases much of his service practice on the Toyota Production System.

This 'two world view' seems to the author as limiting the considerable potential of many ideas. Thus 'service' people state categorically that standards have no place in service; manufacturing people insist that standards always are relevant. Failure demand is seen as a service concept. 'Absorbing variation' is service; 'reducing variety' is manufacturing. In the famous article 'Production Line Approach

to Service'. XXXXX, shows manufacturing concepts applied to McDonalds. For such a repetitive, standardized service where one of the selling points is product consistency across the world, this would seem reasonable, but has nevertheless been criticized. (XXX). On the other hand several Lean publications, it would seem, have advocated the application of tools such as value stream mapping and 5S, unaltered from their manufacturing origins, to a wide variety of service situations. (See, for example, Office Kaizen XXX)

This paper argues that instead of insisting that service and manufacturing are different, it is more useful to see them as a continuum or spectrum. Systems concepts are applicable right along the continuum, but the nature of the system concept changes. By so doing, the best of both can be tailored to any situation. It is not a question of a manufacturing concept or a service concept. This applies in two dimensions: within and between 'value streams' (A value stream is Lean phraseology meaning the sequence of activities that deliver value to the customer). Within an end-to-end value stream there is likely to be more service concepts applicable in customer-facing stages and more manufacturing concepts applicable in non-customer facing activities. Between value streams – some service streams are more repetitive and more customer-interactive than others. This leads to a two dimensional classification. (Bicheno, 2007)

Potholes as a Case Study

The case of 'potholes' will be considered in order to explore Systems Thinking and Lean Thinking - particularly as it applies to service situations in general and to public services in particular. What applies to potholes may in many respects be applied to other considerations – from the ambulance service to transport. The 'solution' to the pothole problem has been put forward as an example of systems thinking in the public service.

Why Potholes? Potholes have become a big story in the public sector. It is estimated that there are 3.5million holes in English and Welsh roads, and £53 million was spent on damage claims resulting from potholes. (Probably to say nothing of the administrative costs and legal costs involved!) In common with other services such as health, delaying pothole repair leads to non-linear cost escalation. Possible causes are almost endless, from trapped water turning into ice to uneven wear, and remedies ranging from cold mix to hot mix (with endless formulations) temporary to permanent. In short, a classic 'systems' problem. (See Cost of Potholes, 2008)

For many public organizations, 'pothole repair'

is a combination of a reactive and a proactive process. Reactive in as far as the public makes calls are made to their local authority or County Council (typically to a call centre) that then eventually sends out a repair gang, normally after at least one visit to the site by a technician to see the nature of the repair that is needed. Proactive in as far as many every (?) road authority period sends out assessors to examine the state of repair of roads, and hence to plan road resurfacing.

A reported case of the application of systems thinking to potholes has been described by Wiltshire County Council. (Vanguard, 2009). Previously it took 45 days on average from call to repair. Now it takes 12 days. Productivity (measured by the amount of road surfacing material applied) has increased five fold, and pothole teams now actually repair roads for '7, 8 or 9 hours' per day as opposed to '2 or 3 hours' previously. This 'systems thinking' approach involves, apparently:

- The use of 'parish stewards', with local knowledge to feed jobs into the system
- 'Trying to fix all the things' when the gang is there
- Different methods to used to fix different types of potholes.

It is pointed out by Seddon that all calls to a call centre about potholes are in fact failure demand. Failure demand is defined as 'demand caused by a failure to do something or to do something right from the customers' point of view'. Failure demand is waste – waste being a concept that is strongly associated with Lean. 'Predictable failure demand is preventable.' Reducing failure demand frees up capacity and leads to better service. So try to make demand predictable. 'In (Seddon's) experience all transactional service organizations have largely predictable demand'.

At this point is worth quoting from a recent Vanguard newsletter (2009), written by John Seddon:

'Imagine the typical design: if you were a pothole, how many people turn up to see you, what do they do, who does the 'value work' (fills you in)? When you study potholes as a system, much of the crazy behaviour you discover is driven by measuring, recording and sorting potholes into their relevant target category, and management's perceived need to control the people who do the work. Systems thinkers design the pothole service against predictable demand, organising workers into geographies, capturing data on potholes when the work is done (thus once only and accurately) and ensuring that the workers use their own data on potholes to manage their own work. The result is as much as a five-fold increase in productivity and, most importantly,

massive reductions in failure demand.

The systems design for potholes also reveals that much of the reporting of potholes by citizens, while thought of as value demand, is actually failure demand in as much as potholes in certain geographies are entirely predictable.'

Systems Thinking?

Clearly, this approach to potholes is effective. But to what extent is it 'systems thinking'?

If you send out a road or pothole gang - what do they in fact do? Do they do a quick fix, a longer fix, or a really substantial fix? Considerations include road usage and flood water. A parish steward may have an idea of this – certainly a better idea than a gang visiting for the first time. But what about projected usage? Another consideration is the general condition of the road, and how long is it before resurfacing, and should scheduled resurfacing be reviewed? Moreover, the public really objects when a pothole is fixed and then the road is resurfaced soon after. Or where a pothole is fixed, and then gas or electricity come along and dig a trench. Thus, fixing a pothole can generate more failure demand.

This is similar in some ways to the classic, OR (operations research) problem of 'the light bulb replacement problem'. This is where the optimal trade-off between replacing a failed bulb, with a call-out cost, and replacing all bulbs irrespective at x interval, is explored. There is an optimal solution for the simple case.

But first, what is a 'pothole'. There is no clear definition. It is a matter of perception. In the author's experience the notification of a pothole from the public can range from a small shallow depression (from a notorious Mrs. Bucket figure) being immediately notified, to a major series of holes in a rural road that remained unreported for several weeks. And the area over which potholes appear is also relevant – from a single depression to a road looping like it had been the target of a cluster bomb exercise.

There is also a question of public safety. This may be an overriding factor, especially in a time of a litigious public.

Yet another issue is revenue and capital spending – both of which have limits or budgets. Repair is revenue. Resurface is capital. So if a road has a few potholes but is scheduled for resurfacing in (say) a year, what do you do? And, of course, what about the road one mile along, that may fall outside the parish stewards area, but where there are sufficient funds only to do one or other? How does one decide?

It is certainly a good thing to design the system against predictable demand. But, one has to ask what demand – short term pothole

repair demand, or medium term road usage, or both. In practice, there is another demand – that by city councilors for ‘service’ to their constituency. This certainly varies according to nearness to an election.

So the little pothole problem is actually a complex system problem. Who should decide on the action? Moreover, there are hundreds even thousands of potholes in the average Council area. Who has the time, ability and authority to prioritise and decide?

It can probably be concluded from this that ANY decision will be a sub-optimization. The ‘solution’ is quite complex. Certainly not optimal, but moving from what Ackoff calls ‘a mess to an improved mess’. In fact, it is a typical complex system problem to which there are better answers, but no best. ‘Satisficing’ not optimizing, as Herbert Simon would say. And, hence, a need to put a Deming style ‘check’ in place, in order to learn more about the problem and the effectiveness of its ‘solution’.

To get to a good systems solution involves multi-discipline systems thinking. This includes what Checkland calls building a ‘rich picture’. Checkland, amongst other systems thinkers, has a number of useful concepts. One is ‘system boundary’. This needs careful, and explicit consideration. Drawing the system boundary too narrowly leads to severe sub-optimisation, maybe even the wrong response. A good solution to the wrong problem? (What Ackoff calls doing the wrong thing right – and the righter you do the wrong thing, the wronger you become!). Too wide, and the system becomes unworkable. Getting the system boundary right, leads to what Ackoff calls ‘Doing the right thing wrong’ – in the realization that you will never get it quite right, but may get it righter. A guideline is to first consider the appropriate decision maker, then to look at his or her decision boundary. (This is a concept also used by Senge.) Should you be fixing potholes or should you be ensuring safe flow? This is the value of asking what is the system purpose – a concept used by Seddon in the systems context and by Womack in the Lean context. A clear purpose was also a point emphasized by Deming, as articulated by Scholtes (Chapters 2 and 5).

Asking about system purpose leads to a good Lean Thinking (but also a good System) question – what is the appropriate value stream to do the work in as flow-like a method as possible.

Checkland also uses the CATWOE mnemonic, as a prompt to systems thinking. Who are the Clients? (Checkland prefers ‘Client’ to ‘Customer’) (Local road users, national road users, Councilors, ratepayers?) All may have differing agendas. This is why Checkland uses the notion of a series of ‘Root Definitions’ of

the problem, reflecting the different clients, rather than a single ‘purpose’. (Deming offers additional insight about a system’s aim saying, ‘It is important that an aim never be defined in terms of activity or methods. It must always relate to how life is made better for everyone’.

Who are the Actors? The people in the value stream – end-to-end – that may include reporters of the problem (public as well as employees, some of which do not necessarily work for the Highways department, such as refuse collection teams that cover every road every week.) Others include road engineers, and asphalt researchers. What Transformation is taking place? (Fixing holes, restoring the road, improving the road, and so on.) What is the organisation’s Weltanschauung or World View? (The attitude or culture, seldom expressed but certainly a dominant guide to action. We care. We don’t care. We work for Councilors not for ratepayers, Meeting targets is the prime consideration, and so on.) Who are the Owners? (Who owns the problem? Who owns the road?) What is the system Environment and where is the system Boundary? The boundary is discussed above. The Environment would include, for instance, the economy that may in turn affect road spending, leading to a different response this year to last year.

The Checkland ‘soft systems methodology’ involves building a ‘rich picture relevant systems’ From this deep understanding a number of ‘root definitions’ are postulated, reflecting the viewpoints of various clients. Root Definitions are validated against CATWOE. For each root definition, a ‘could be’ conceptual model is developed. Then a comparison is made between the rich pictures and the conceptual models, to identify feasible, desirable changes. Different root definitions for potholes could encompass quick response, cost minimization, public safety, traffic flow, and others. There is no one best definition or purpose.

Ackoff uses a different approach called ‘Idealized Design’. After an initial analysis, adopt the view that ‘the system was destroyed last night’. Then a new way of operating the system – an idealized design- is derived by equal participation by all relevant parties – both constrained (limited to entities over which the designers have control), and unconstrained (including entities that may be influenced but not controlled). A new idealized design is arrived at by consensus, usually of expert parties. Then, work back from the idealized design, identifying and prioritizing barriers and changes that can be made over the time horizon. In other words, Ackoff’s approach appears to be similar to the ‘Open Systems Approach’ used in interventions, or the ‘Whole Systems Improvement Strategy’ approach used by Marvin Weisbord. Radical

thinking is encouraged. (Should the County Council be responsible? Should pothole repair be funded directly from the road licence fee, or from petrol tax, by area?).

The Vanguard Systems approach uses the Check-Plan-Do framework. ‘Check’ is a detailed procedure comprising at least 5 elements. What follows is an outline only. The reader is referred to Seddon (2003) for a more detailed description.

- Purpose. The reason for doing the task; an ‘outside in’ not an ‘inside out’ view. Essentially it is a helicopter view of the system, not necessarily the existing organizational boundary.
- Demand. Distinguish value demand from failure demand. Listen to the actual voice of the customer. How much of the demand is failure demand? But beware, what may appear to be value demand is not necessarily so. See above. Try to identify how much demand is predictable and preventable. Also identify the top (say) 10 high frequency value demands. These become the basis of training for response. (Listening is also advocated by many others – notably Covey and Scholtes.)
- Capability. Is the system capable of meeting the demand placed on it in a stable, predictable way? Measure the end-to-end response times, and plot on a graph to distinguish common causes from special cause variation. What are the patterns of variation? (A pattern may be time-based, geography based, event-based, or others.) Then ask if the resources are capable of meeting these demand patterns.
- Flow. How is value delivered to the customer? We are concerned with the flow of work that delivers purpose. Is there a smooth steady flow of work, or are there interruptions? For instance, is there a one-stop process, or multiple hand-offs. This may involve drawing a map of the process.
- System Conditions. Why does the system behave in the way that it does? In particular, what measures and targets influence the behavior of the people in the system.

The Seddon approach also includes intervention by roll in and not roll out. This is process of discovery by participants. Although a vital part of the process, it will not be discussed here.

Learning and PDSA

Checkland, Ackoff and Seddon apparently say little about going back and checking assumptions. In other words Learning appears not to

figure prominently. Deming's Plan Do Study/Check Act (PDSA / PDCA) is not prominent. Seddon's Check Plan Do comes closest to Deming's PDSA. But there appear to be important differences. Deming's 'Plan' stage includes 'identify our purpose', 'formulate our theory', 'define how we will measure success', and 'plan our activities'. Study or Check includes 'monitor the outcomes', 'test the validity of our theories and plan', 'study for signs of progress, success or unexpected outcomes', 'look for new lessons to learn or problems to solve'. Act, for Deming, includes 'integrate lessons', 'reformulate our theory', 'adjust our methods', 'identify where we need to learn more'. (Scholtes, p 34). Seddon devotes only two sentences in his book to this topic – coming under the 'Do' stage - saying 'Take the planned action and monitor the consequences versus purpose. And then you go back to Check' (Seddon, 2003, p 114). So, Seddon's 'Check' is largely up front, examining current conditions, but Deming's is at a later stage, concerned with looking back.

However, Scholtes, like Seddon, recommends starting with 'Study' when starting an improvement project. Scholtes' Questions to ask overlap with those of Seddon, and include 'Why have you selected this purpose', 'how well is it working', 'what do we hear from customers – what do they need that they aren't getting, and what are they getting that they don't need?', 'what data can you show me about the process: waste, errors, rework, breakdowns, cycle times, average and range of variation'. (Scholtes, Chapter 8).

Standards

Checkland and Ackoff don't appear to consider standardisation. Seddon is positively against standardisation, saying that it often drives costs up, and that 'the single greatest reason for transactional service systems to fail to absorb variety is standardization'. Scholtes, a friend of Deming, appears to disagree saying that the best known method should be established, and citing the example of a salesman making a presentation. 'Who decides what is a good presentation?' ;'The customer does!'; 'And how do your customers define a good presentation?' Most people would agree that they would be uncomfortable using a service such as an airline or hospital having no standards. In Lean, some distinguish between standards (the what) and standard work (the how). Standards are set by the customers, designers, managers. (An example is Disney Theme Parks where 'Mickey Mouse' is taught to give the same autograph whether in California, Florida or Paris.) Standard work is set by operators in consultation with managers or engineers.

In service, Zeithaml et al, refer to 'customer-defined hard and soft standards'. Note the first two words. This approach to standards begins by asking what it is that customers value. These are then translated into hard standards – things that can be counted, timed or observed - and soft standards that are opinion based. Both types are important for learning to improve.

Liker, quoting Adler, speaks of the 'Toyota Paradox' whereby standard work, far from being restrictive, is actually an enabler to allow innovation and improvement within defined parameters. How so? An example is 'Rules of Engagement' adopted by the military that provide guidelines for action which, if followed are, in the case of Iraq, fully supported by the United Nations. Such guidelines are certainly appropriate in the case of public service, covering for example politeness and authority in the case of emergency.

By contrast, having no or inappropriate guidelines can be a cause of failure demand, or worse. Where a call centre operator takes it upon himself to make inappropriate decisions, chaos can result. Steven Spear uses an example of a hospital receptionist insisting on booking a pregnant woman into a time slot that is too late to take preventive action. She loses the baby. The hospital is sued.

So, it is a mistake to attempt to over-specify or over-standardise. There will always be unforeseen situations, particularly at demand entry: 'My child's leg is stuck in a pothole.' A standard response set should not and cannot be set. But there are three parallel activities:

- Cover uncertainty with experts. Put well qualified people at the point of activity ('the Gemba' in Lean language). These people have the knowledge and authority to deal with almost the full range of possible demands without needing special instructions other than their professional expertise. For potholes this may mean putting road engineers in the call centre, and supervisors and engineers at the point of repair. But these people don't just take calls and do repairs – they document procedures.
- Identify high frequency activities, and best practice. The procedures that are documented are only the high frequency activities. As these tasks are established, the experts withdraw and hand over to less experience staff who are trained on the newly established procedures. The experts remain on call. Toyota's Ohno once said that the ideal system would not need managers. They gradually work themselves out of a job – or at least the current job, and move onto new problems. (Bicheno, 2009).

- Rapid response. When an unusual or unexpected event occurs, what is called a 'rapid response team' in Lean springs into action. They may do the equivalent of an 'A3' analysis. Best is to go to the Gemba to do this. The aim is to eliminate root causes (or failure demand) or to revise the standards.
- Listen to customers. The best people to specify how demands should be handled are the customers themselves. Ask them.

Remember, though, standards should not be fixed in stone. They evolve. As Steven Spear (2009) explains, many systems are too complex to understand in total. Indeed, 'potholes' turns out to be a complex system. So the best approach involves making a prediction of what will happen in operation. Then, in operation, determine if your prediction was correct. If it was not correct, you need to revise your model or standard. Note that it does not matter whether the operation was better or worse than predicted. If it was different, it means that your understanding was not sufficient and is in need of re-examination. This is proper PDSA. This applies from cooking, through fixing potholes, to nuclear reactors.

TWI (Training Within Industry)(Graup and Wrona, 2006) methods, that revolutionized work training during the second world war, and were later adopted by Toyota, teaches that a 'job breakdown sheet' is an essential prior step to standard work. TWI job instruction has been adopted in service and in manufacturing. There are 'Important Steps' and 'Key points'. Not all steps are important – only perhaps 15% of steps require analysis. In repair of potholes, you would not specify how to unload the vehicle, but you are likely to include 'compacting the sub-base', and 'selecting the cold mix formulation' as important steps. Most important steps would also have 'key points' – these are of three types: things essential to job success or failure, safety matters, and things that make the task easier to do. The reasons for key points also need to be understood by those doing the work. Interestingly, TWI JI (job instruction) methods do not include a time standard. Of prime importance is getting the important steps and points correct; the time comes later. It would seem that many call centre managers have fallen into the trap of doing the reverse.

Pothole and road repair could also take a leaf out of Toyota maintenance standards. Here, a comprehensive list of 'inspection items' is built up through experience as well as brainstorming. An inspection item would, in the pothole and road case, be something that all who are concerned with identifying problems and monitoring conditions, would

look out for – with the idea of anticipating and predicting rather than reacting to failure demand. Each 'inspection item' would have an associated 'judgement standard' which would be a clear description what to look out for, how to identify the problem. Also, each 'judgement standard', like TWI, would have an associated reason that must be understood. This builds into a learning system with the frequency of monitoring or inspection being derived by experience for different classes of roads and who is best placed to do the monitoring.

The well-established tool of FMEA (Failure mode and effect analysis) can also be most useful here. FMEA, of course, attempts to identify the failure modes and to prioritise the risks. Thus a road (and a pothole) having a medium probability death risk, is far more important to address than a high probability situation where the main risk is damage to a car suspension.

It is difficult to see why such thinking could not be applicable right across the pothole end-to-end value stream. However, the degree of standards and standard work would vary along the stream. In customer-facing activities, guideline standards need to be derived from the customer or client. Soft standards may dominate. At the non-customer facing activities, standards are derived from employees. Hard standards may dominate. But throughout, standards should come to mean targets – especially reward-based targets.

Problem Solving

Lean puts emphasis on 'root cause' problem solving. When the road gang reaches the area requiring repair, a good lean thinker would ask why the pothole(s) have appeared in the first place. They should learn to look around and question. For instance, are the potholes due to flash flood (a special cause), or to simple wear out (common cause), or to increased road usage (could this have been predicted?). It is a wasted opportunity simply to go out and repair, and not to learn. Good lean thinkers treat every problem as an opportunity to learn.

SAB Miller calls this activity 'when the bobby on the beat meets the body on the beach'. First, look around and see if the murderer is running away. If so, go after him. But if not, collect the evidence before the tide comes in and destroys it. This would mean recording relevant data for later examination.

Is the standard correct? Check the road surface construction standard for that type of road and situation. Check that standard work has been carried out correctly. In both cases, if not, why not? If yes, are the standards still appropriate. What can we learn?

Where appropriate, problem solving needs to be both single loop and double loop learning.

(Argyris, XXXX). In single loop problems (also known as type 1 problems or Apollo 13) the problem is just fixed. But double loop problem solving asks why the problem has arisen in the first place and tries to prevent it from occurring again. Maybe the standards need to be revised. Lean practitioners will be familiar with this type of double loop learning. A good Lean system attempts to 'surface' problems. Anything that is unexpected is a problem that needs addressing. In road potholes, this may involve making a prediction on the life of a road, and then, whether the life turns out to be shorter OR LONGER than predicted, a problem is indicated. Then 'crowd' the 'problem' by a multi-discipline team and revise the standard or 'exchange curve'.

Understanding the System: Kingman's Equation.

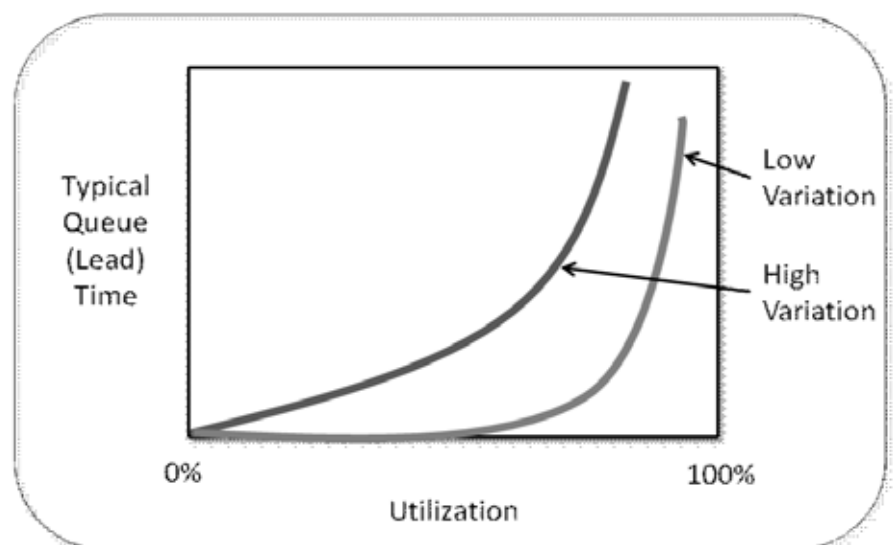
Systems thinkers often emphasize 'understanding the system'. According to Seddon, 'understanding' was Ohno's 'favourite word'. But understanding the system can range from a high level listing of the entities (such as in the Six Sigma SIPOC methodology) to modeling the system by Forrester's System Dynamics. A valuable understanding of any system where queues or delays are involved comes from Kingman's Equation. (Interestingly, the study of queues began in call centres, but transferred into manufacturing via for, example 'Factory Physics'.)

Some might say that quantification is not necessary – that the system can find its own level. But all public service (from potholes to health) is a question of resource tradeoff. One can provide huge capacity, reduce response times, and hence improve the 'quality' of service – but at a cost. And the reverse. The point is that the curve is non linear, and is affected by variation. To know where one is on the curve, even approximately, is valuable insight for decision makers in setting resource

levels. Without knowing this, one cannot claim to understand the system.

Kingman's equation may be expressed as $RT = f(V, U, T)$ or Response Time is a factor of demand variation, work rate variation, utilization, and average process time. A simple dice game can be used to understand the interactions. (Bicheno, 2007). Utilization is the average arrival rate of work divided by the average rate at which work can be undertaken. In potholes, the arrival rate is the jobs that arise per day, the rate of work is the capacity of the gangs to do the work. Not a target, but a measure derived from experience. (Note that actual capacity, excluding idle or waiting time must be used, otherwise Parkinson's Law will come into play and utilization will always be assumed to be unity.) A typical curve is shown below. Notice that at low utilization, the arrival and process variation does not matter very much. But at high utilization variation can be disastrous. The point is, many public services are cutting back on resources – attempting to increase utilization. But where are they on the curve?

If one does not understand Kingman's equation, then the understanding of the interplay of critical variables is likely to be superficial. Sizing of, for example, the number of road repair crews, the response times under various demand situations, and the effect of reducing the variation of demand rates and repair rates is likely to be unknown. This is not to say that targets need to be set – that does not reduce variation. It does not mean that waste should not be taken out of the system – waste is responsible for much of the average process time. (Capacity is work plus waste said Ohno). It does mean that we should attempt to increase predictable demand. Thus, understanding the system through Kingman's equation is necessary but not sufficient.



Potholes and Lean

A few thoughts on 'systems approaches' to potholes have been examined. Would a 'Lean' approach differ? First, like 'systems', there is great variety in what constitutes Lean. There is also much overlap between 'systems

thinking' and 'lean thinking', but what follows is speculation based on the experience of the author as a one-time roads engineer, a student of systems, and a long time Lean practitioner. Each feature will be commented on. (Note: the word feature is used rather

than step, or stage, or tool – each of which has disadvantages.)

The Lean framework suggested by Kate Mackle is used in part.

Feature	Brief Explanation	Comment and Opportunities of overlap between 'Systems' and 'Lean'
Value and Purpose	From the customer's viewpoint. 'Go to Gemba' and find out. Gain consensus.	CATWOE would be useful
Demand and Customer	Understand demand types and especially variation over time. Pareto the demand types. Is there data on potholes? Set up a measles chart, colour coded. Plot road usage on a map. Plot road condition on a map. Prioritise. Runner, repeater, stranger type job types? (Runner jobs predictable; strangers not so.)	Value and Failure demand concepts would be powerful. Consider the road itself as a customer – what is it trying to say to you?
Create Flow	Map the process, end-to-end. Understand Work Load and Capacity. Understand Kingman's equation. Understand the bottlenecks to flow. Identify obvious wastes that hinder flow. Work out current end-to-end response times. List all the resources relevant to road repair, their ownership, and reliability. Understand financial and work constraints.	Understanding the two types of variation gives powerful insight into the causes of queues. Appreciation of the utilization curve is most beneficial. Identifying bottlenecks requires estimates of workload and current capacity. The idea of separating value and failure demand should be included. 'Back office' and 'Front office' integrated.
Organise for Flow	Is it possible to organise end-to-end? Is a one-stop process possible? Hold a 'kaizen event' on the process to redesign the system.	Involve all interested internal parties.
Measures and accounting for Flow	Collect up all measures and targets that relate to the process. Critically examine to see if any conflict with purpose. Understand the accounting system, particularly the use of variances. Develop new metrics, not targets. Decide where and how to display, review, update.	Concepts of 'system capability' would seem useful. Accounting for Lean concepts, linked to the value stream would help resolve some apparent conflicts between 'revenue' and 'capital' spending
Design for Flow	Develop a series of 'Exchange Curves' (A Toyota Phrase) as a guide to decision making. For instance: road use vs. condition showing 'do it now' to 'not yet'; tables of road classification vs. surfacing type, interval.	Engineers working with field staff would develop these. They are not standards, but guidelines. They may change with changing financial resources.
Maintain Flow	Can one piece flow be achieved? Develop appropriate standards for physical work and information flow. These will vary along the chain.	Hard and soft standards in customer facing stages. TWI methodology and judgment standards in execution stages.
Problem solve for better Flow.	Every problem is an opportunity to Learn. Collect the evidence. Each pothole is evidence of a 'failed experiment'. What did we not understand? 'Crowd' new problems and adjust standards where necessary. Surfacing, root cause problem solving. Employ PDSA, A3. Employ visual management measles charts.	Try to work towards predictable demand. Ackoff's ideas on 'solving, resolving, dissolving' problems useful. No targets, but measures. The idea is to move steadily towards prevention and predictable work.
Review and escalation procedures	Regular review meetings. 'Leader standard work'. All 'issues' posted up for review.	Visual management tracks deviations from expectations to highlight problems.
Planning for Flow	Policy Deployment. Policies deployed level by level.	Not targets, No blame. But clearly defined measures help.
Changeover and Waste.	Every new job involves a 'changeover'. Lean thinking on changeover – maximize external and minimize internal activities.	Examine the 'white space' between value adding activities. Develop best practices.
Supplier Management	Supplier partnership. Smooth the work. Simplify ordering. Cost not price.	
Other participants	Water companies, Electricity companies, and others who dig the roads. Share information as partners. Use visual management	The 'system' needs to include these in order to increase predictable demand.

Conclusion

It would appear that we are only beginning to appreciate the potential of Systems thinking and Lean in service in general and public service in particular. There remains much to learn. Whilst there are differences, to com-

partmentalize into Manufacturing and Service organizations detracts rather than adds. There would also appear to be over-riding concepts from both Systems and Lean that have wide applicability. It is more useful to see every 'value stream' as a blend of both Lean and

Systems – the question being what to blend, where.

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