An Extension of Process Mapping for the Identification and Reduction of 'Green Waste'.

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Organizational Improvement

A significant volume of literature explores the way in which lean thinking, tools and approaches can provide benefit and competitive advantage for modern businesses (Syddell, 2005; Verstraete, 2004; Alavi, 2003; McCurry and McIvor, 2001; Mason-Jones, Naylor and Towill, 2000; Segerstedt, 1999; Bowen and Youngdahl, 1998; Ugadawa, 1995; Drucker, 1990). Discussions of lean implementation have not always centred around its successes though, and there has been much debate over the ability of Eastern (mainly Japanese) management techniques and approaches to be transplanted or adopted in Western (mainly Europe and US) organisations with their own unique style and approaches (Sopow, 2007; Griffith, Myers and Harvey, 2006; Ball, 2005; Magana-Campos and Aspinwall, 2003; Holden, 2003; Fink, 2003; Stamm, 2003; Fairris and Tohyama, 2002; Mann, Radford, Burnett, Ford, Bond, Leung, Nakamura, Vaughan and Yang, 1998; Lincoln, Kerbo and Wittenhagen, 1995; Bamber, Shadur and Howell, 1992; Bushe, 1988; Barker, 1983).

Lean thinking, tools and approaches have stirred considerable rethinking of established management and organisational practices. For example, where significant operational improvements have not resulted in meaningful financial improvements the methods for controlling costs and accounting in leaner and agile businesses have been challenged (Pohlen and Coleman, 2005; Kroll, 2004; Hulme and Bryan, 2003; Lea and Min, 2003; Said, Hassab, Hassan and Wier, 2003; Sterman, Repenning and Kofman, 1997; Fine, 1986). There have also been increasing concerns over the psychological and sociological pressures that lean initiatives may put upon workers and organisations, factors that have been shown to be important influences upon the processes of knowledge production and transfer in organisations (McManus, 2003; Gagnon and Michael, 2003; Needy, Norman, Bidanda, Ariyawongrat, Tharmmaphornphilas and Colosimo, 2002; Ezzamel, Willmott and Worthington, 2001; Franchini, Caillaud, Nguyen and Lacoste, 2001; Millar, 1999; Emiliani, 1998). The pursuit of lean to its ultimate state has even been criticised for tending to result in dramatically reducing an organization's agility and ability to respond to the changing needs of dynamic and uncertain market conditions (Coldwell, 2010).

What has received little attention to date is the applicability of lean tools to the improvement of an organisation's environmental practice and performance. This is significant since the issue of sustainability and the green agenda has become of greater interest to society in general and is of particular concern to businesses with the introduction of legislation and rising stakeholder interest.

Organizations are facing increasing pressure to reduce the environmental impact of their activities. These pressures arise from legislation that governs the immediate effects of their actions, such as emissions and wastes, and often places targets for future emissions and waste reduction. It also arises from the market's complex expectations that an organization will endeavour to act responsibly for the long-term benefit of the wider society (DEFRA, 2011; Clark, 2004). Environmental issues and the sustainability agenda continue to be of key strategic and operational concern to organisations across all sectors of commerce including small, medium and large enterprises, and those that are profit-making and non-profit making (White and Lomax, 2010; White, Jenkins and Roberts, 2011). Environmental performance is therefore becoming a key component of an organisation's competitive advantage.

This paper presents an extension of the tool of process mapping that aims to capture data about the environmentally harmful wastes that are present within an organization's processes. By incorporating the capture and analysis of 'green wastes' alongside other process data this tool aims to integrate the continuous improvement of green initiatives alongside continuous improvement initiatives. Green initiatives then cease to be '*something else'* that needs to be done in the organisation, or are tasks that are done by '*someone else'* but become embedded in the everyday management of the organisation and become part of the organisational improvement philosophy and practice.

Process Mapping

Among the variety of lean techniques that may be employed to facilitate organizational improvement value stream mapping (VSM) and process mapping (PMapping) are widely regarded as being useful tools. VSM and PMaps are outwardly similar techniques, for simplicity, a VSM can be considered to be an organisation-wide map constructed from multiple interconnected PMaps (BeyondLean, 2011).

PMapping is used extensively throughout manufacturing industries but has also been used in laboratories, construction, and is equally useful in service industries (Linton, 2007; Winch and Carr, 2001; Frederick, Kallal and Krook, 2000). Though there are numerous variants of this approach they all attempt to provide a mechanism for gaining detailed understanding of the current-state of the way in which the organization works (Nash and Poling, 2009; Innovations, 2005; Hines and Rich, 1997). Despite the usefulness of PMapping, as can be seen in Table 1, it is a relatively poorly researched technique.

Table 1 – Lean Tools and Approaches Literature: compiled in May 2011 utilising the Business Source Premier research repository.

Research Area, Subject or Tool	Number of Articles

Supply Chain Management	882
Six Sigma	623
Total Quality Management	611
Balanced Scorecard	365
Continuous Improvement	313
Value Stream Mapping	189
Business Process Reengineering	109
Kanban	65
Lean Organisation Case Studies	62
Constraint Theory	43
5S	31
Process Mapping	29
Statistical Process Control	27
Zero Defects	26
Control Theories	25
Workplace Organisation	22
Just In Time	20
Kaizen	12
Overall Equipment Effectiveness	5
Single Minute Exchange of Dies (SMED)	4
Waste Elimination	2
Single Piece Flow	1

PMapping is a technique that captures knowledge contained within an organisation (Parry, Mills and Turner, 2010). Vollmer and Phillips (2000) note that process maps enable the organization to "*understand where knowledge resides today in an organization… where knowledge is used, how it is dispersed and who uses it*" (p130) and, since knowledge requires context or framing to be of use, conclude that "*when properly mapped, processes provide the context*" (p130). Kesner (2001) even ventures that process mapping forms the first steps in the process of developing a knowledge management system itself.

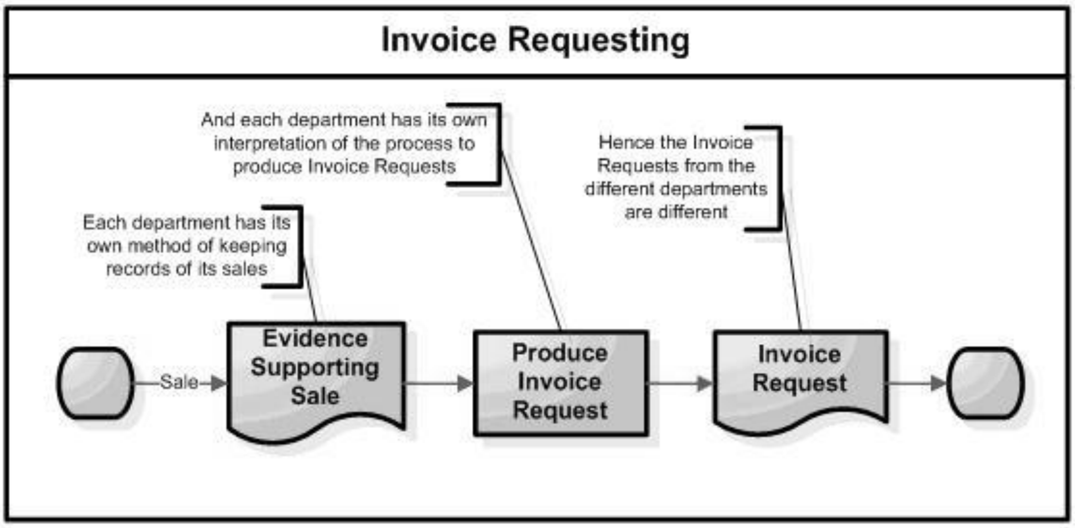
PMapping is "*an analytical technique*" (Paradiso and Cruickshank, 2007, p32) that graphically depicts how areas of an organization work and is an "*effective tool*" (p32) for documenting the current-state. Furthermore, this is not merely an approach for recording a snapshot of current-state but "*with process mapping, organizations create not only an 'is' map…but also a 'should' map that tells where you want to go*" (HFMA, 2006, p1). Tuggle and Goldfinger (2004) proffer that PMapping is a way of acquiring knowledge about processes and that the knowledge can be extracted from the maps since "*there is much valuable tacit knowledge contained in organizational processes*" (p12). Paradiso and Cruickshank (2007) further highlight the value of process mapping in protecting organizations from "*the risk of losing knowledge capital*" (p32) by encapsulating knowledge about processes that could otherwise be lost if individuals leave the company.

The Process Mapping Technique

PMaps can vary widely in their format and level of detail that they attempt to capture and portray. Figure 1 shows a pictographic PMap that was generated to depict the stages of generating an invoice. The PMap not only captured the 'as is' condition but also served as a discussion document around which ideas for improving the process were developed.

Figure 1 – Pictographic Process Map.

Source: White, Samson, Rowland-Jones and Thomas (2009)



Keller and Jacka (1999) used PMaps to "*heighten management's understanding*" (p62) of business processes, interviewing the individuals that 'own' the processes to gather the necessary data to compile the maps. They recognised the difficulties in generating such maps and resort to using two personnel, one to interview the process owners and one to generate the map: this approach is vital to enable the 'live' generation of maps that they deem is important in producing accurate maps. The process owner's involvement in the activity of developing and completing the PMaps are seen as vital for gaining their future buy-in. Similar to the way in which the example given in Figure 1 was used by the organisation, Keller and Jacka (1999) point out the value of the PMaps to the process and department managers as discussion documents and as training tools.

PMaps are also constructed in order to identify the type and location of waste in an organisation. These wastes may be classified according to Ohno's '7 Wastes' of overproduction, waiting, transporting, over processing, stock, wasted motion and defects. There are no strict rules governing the data that is captured for each task in the process. The objective of using the tool is to focus an observer's attention on the process at hand, gathering data that is pertinent to the purpose to which the map will be put, e.g. process improvement, waste identification and elimination etc. These maps therefore are often found to contain a variety of data types including for example, time taken for an activity to be performed, the frequency of its performance, distance travelled, and volume of material consumed and produced.

Figure 2 shows a tabular form of PMapping that captures detailed information regarding the separate activities within a process, and this example shows data about the waste captured in the form of measures of time and distance. Described in detail by Hines and Rich (1997) this form of map aims to quantify the productive work and the waste within a process and highlight whether the individual activities are either value-adding or non-value adding. The value-adding activities are those that serve to transform the primary resources and are effectively what the customer is expected, or prepared to pay for. These activities are classed as 'Operations' (column O in Figure 2). Non-value adding activities are noted as Transports (T), Storage (S) and Delays (D). The overall aim of the approach is to capture data about the value-adding activity (Operations) on the left of the form and non-value adding activities to the right.

There are some activities that are non-value adding but are nevertheless essential parts of the process and these are usually some form of quality control and are generically termed Inspections (I). Interestingly, Hines and Rich (1997) use the sequence OTISD in their discussion of the tabular form of PMap whereas extensive experience of using the technique in industry suggests that the sequence OITSD is in fact more common. The underlying rationale for this is that while Inspections are recognised as being non-value adding activities they are often necessary and are therefore not a waste that can be eliminated. Their necessity may be driven by the adoption of an inherently incapable activity, or may even be required by customers or legislation: for example, testing of automotive components (e.g. SAE, 2011) or regulations pertaining to the manufacture of foodstuffs (e.g. FSA, 2011).

The order of the types of activities found, OITSD, reflects the notion that the value-adding activities are recorded nearest the left side of the form and the wastes are recorded to the right. Also, that as one reads the PMap the wastes to the right are deemed to be more harmful, and arguably easier to eliminate, than those to the left. Analysis of the PMaps usually takes the form of identifying areas where the most waste occurs, i.e. those activities that are non-value adding. This usually takes the form of a pareto analysis of the map data and serves to prioritise those activities to improve or eliminate first. Used in this manner the organization is able to focus its resources on reducing waste in the most efficient manner.

Figure 2 – Tabulated Process Map

	Activity	**O**	**I**	**T**	**S**	**D**	**Notes**
1	Load			10 secs			
2	Process	60 secs					
3	Check Thickness		20 secs				

4	Clean		5 secs				1:5 require cleaning with Isopropanol
5	Unload			10 secs			
6	Warehouse			100 metres	Up to 48 hours	Wtg forklift, 30 mins	Forklift not available.

Extension to Process Mapping

Organisations often develop and implement Environmental Management Systems (EMSs) in order to control their efforts toward complying with relevant legislation (Figure 3). In the UK, EMSs are typically developed in line with BS8555 and many companies seek to achieve certification to ISO14001. Other organisations, recognising the market value of being able to demonstrate their commitment to being socially responsible corporations, pursue the higher goal of being certified as having achieved the requirements of the Eco-Management and Audit Scheme (EMAS) (IEMA, 2011).

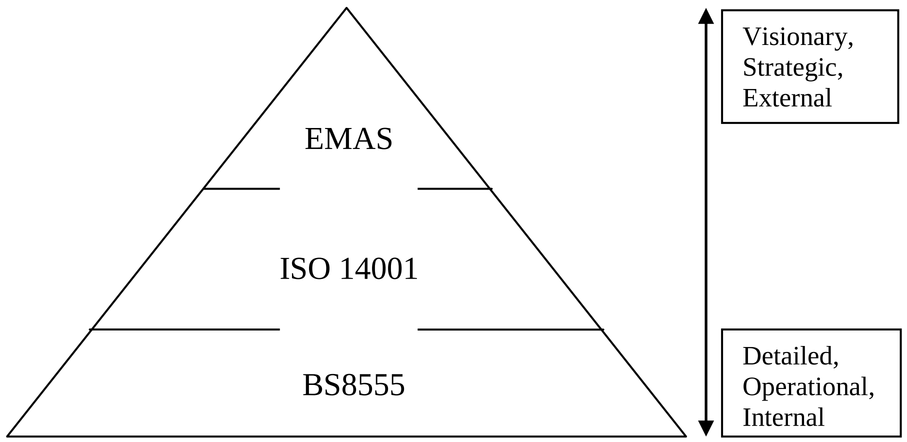


Figure 3 – relationship between EMS approaches

The construction of PMaps has been found to be most useful in developing an EMS. The creation of these PMaps has also been shown to be more than merely a knowledge-*capturing* activity as suggested in the literature, but that as part of a programme of work to develop an environmental management system it is also a valuable knowledge-*generative* activity for an organisation (White and Lomax, 2010).

An organisation's environmental performance may be measured in numerous ways, but typically, organisations aim to reduce factors such as their carbon consumption, energy use and production of waste. Some process waste may however be profitably utilised, such as the use of dissipated heat energy to provide office heating, thereby reducing overall energy consumption. It is therefore important to recognise the holistic nature of environmental performance and management, and this is where the approach of PMapping may offer benefits over other improvement efforts that consider activities in isolation. Through the construction of PMaps, entire VSMs can be generated that provide an organisation-wide view of the size, type and location of 'green wastes'.

In order to maintain the importance of viewing the process as a whole this paper defines 'green waste' as any non-human resource consumed or produced by a process that does not comprise an input to a further process, such as carbon or energy consumption, energy emissions and waste materials. By extending the PMapping technique to incorporate measures of 'green waste' the organisation is able to acquire knowledge about its environmental performance (Figure 4). Through pareto analysis of recorded wastes the organisation can identify where the largest or most cost effective environmental improvements may be made.

It will be argued that 'green waste' should be recorded in the form of measures of energy consumption etc within the existing tabulated mapping technique, either in the individual activity columns or in the notes (Figure 2). However, by identifying and measuring 'green waste' separately the technique serves to highlight the importance that an organisation places upon its environmental management. Capturing information about 'green waste' in this manner will be useful in the communication of the organisation's efforts to reduce its environmental impact, for example in the production of annual environmental statements that are required for EMAS certification (IEMA, 2011).

Figure 4 - Extended Tabulated Process Map incorporating measures of 'green waste'

	Activity	**O**	**I**	**T**	**S**	**D**	**G**	**Notes**
1	Load			10 secs				
2	Process	60 secs						
3	Check Thickness		20 secs					
4	Clean		5				Disposal of	1 in 5

			secs				dirty isopropanol. (100 litres per week)	require cleaning with Isopropanol
5	Unload			10 secs				
6	Warehouse			100 metres	Up to 48 hours	Wtg forklift, 30 mins	Diesel fuel (100 litres per day) and forklift emissions.	Forklift being refuelled. 1000 litres in storage.

Methodology

The development of the extended PMapping technique is a result of its extensive use as a business improvement tool by the author and, most recently, through conducting three Knowledge Transfer Partnerships (KTP, 2011). KTPs were carried out between 2006 and 2011with SMEs engaged in non-profit agricultural development, industrial heating and ventilation, and military systems design and manufacture. Each KTP took place over approximately two years and used the technique of PMapping to undertake the analysis and redesign of business processes.

The extended PMapping technique was then trialled in four further organisations to independently assess the logic of identifying 'green wastes' separately from the wastes of Inspection, Transport, Storage and Delays, and to identify any practical issues in using the tool to identify 'green wastes' in an organisation.

These further trials were all undertaken in SMEs engaged in the design and manufacture of automotive components. The trials were undertaken independently by an Industrial Engineer in each organisation who was familiar with the general principles and practices of the PMapping technique outlined in Figure 2. The Engineers, named A, B, C and D, were asked to select a process with which they were familiar and then to compile a PMap using the extended mapping technique. The data contained in Figure 4 is compiled from those maps and is indicative of the issues encountered, and Figure 5 is a reproduction of one of the actual PMaps that were generated. Following construction of the PMaps each Engineer was interviewed to determine the benefit of separating 'green wastes' from other wastes and to comment upon the difficulties encountered in generating the PMaps.

Discussion of the Logic of Separating 'Green Wastes'

Identifying green wastes using the extended PMapping technique outlined in this paper assists in the holistic management of environmental efforts. Figure 4 shows two instances, at activities 4 and 6, where the separation of ‘green wastes’ from other wastes had identified opportunities to make considerable improvements to the organisation’s environmental impact that may otherwise have been overlooked.

Activity 6 of the process outlined in Figure 4 in particular, highlights an issue with the availability of a forklift truck. Delays of thirty minutes were experienced and were due to the forklift requiring refuelling. By using the standard mapping technique shown in Figure 2 the emphasis would be placed upon reducing the delay, probably through some form of preventive maintenance that would assure the forklift was always refuelled at the start of every shift. However, by adopting the extended PMapping method shown in Figure 4, the organisation’s attention is drawn to the nature of the ‘green wastes’ that are encountered at this stage of the process. In this case the forklift is diesel powered and therefore involves the storage and consumption of fossil fuel along with the corresponding exhaust emissions.

The environmental impact of forklifts that use combustion engines is considerable and it is known that variants that are powered by batteries or fuel cells are considerably less harmful to the environment (Argonne, 2011). Either through analysis of the ‘green wastes’ attributable to forklifts in existing PMaps, or by mapping and analysing all the activities that involve forklifts, the organisation may calculate the overall cost and environmental impact of its forklift equipment. It now becomes possible to compile a business case for investing in alternatively powered forklifts or to modify its practices so that the consumption of diesel for example is reduced or minimised.

In addition to reducing its environmental impact, the organisation will have captured quantitative evidence of its efforts to make improvements. These figures may include for example, the reduction in fossil fuel consumption, a reduction in the emissions produced from having the diesel delivered, eliminating the risk of storing large quantities of diesel on-site, and the reduction of the ongoing forklift exhaust emissions. These improvements can be reported to the wider community, either as part of the organisation’s annual disclosure under EMAS, or via other communications and press releases.

As mentioned previously, it will be argued that ‘green wastes’ can be captured within the existing PMapping technique shown in Figure 2. However, Engineer A vouched that while ‘green waste’ could be captured in the traditional mapping technique, it relied upon the individual to “*remember to think green*”. Contrastingly, as Engineer C stated, the extended mapping technique afforded the opportunity to look upon the process “*through a green lens*”.

Discussion of Practical Issues in Identifying ‘Green Wastes’

Constructing a PMap using the traditional mapping technique requires some considerable understanding of the details of the activities that comprise the process, particularly when being undertaken in a technical or manufacturing environment. It is, for instance, necessary to be able to clearly distinguish between an Operation and an Inspection activity. It is also desirable to be able to accurately measure the time taken by each activity and this can be difficult when processes comprise multiple simultaneous activities with short cycle times.

Including ‘green waste’ in the PMapping technique has added some degree of complexity to the task of compiling the maps. Not only must the compiler have an understanding of the activities within each process but they must also have the ability to identify such factors as the power rating of electric motors, or have the time to measure the volume of effluent produced (e.g. Activity 4 in Figure 4 and Activities 1 and 6 in Figure 5). Engineers A, B and C specifically commented upon the significant amount of time that was required in order to establish the electrical power consumption of large items of capital equipment.

Figure 5 shows one of the extended PMaps that had been compiled as part of this study. All of the Industrial Engineers completed their PMaps using pen and ink, and even though numerous computer-based PMapping systems exist, experience suggests that manual production of PMaps appears to be the most common approach used by most organisations. Engineers A, B, C and D commented upon the flexibility that the pen and ink approach afforded: computer based solutions were viewed as either requiring the map data to be captured manually in the first instance and uploaded later to a desk-based computer, or required the purchase of relatively expensive, hand-held computing devices. Contrastingly, the manual approach to map construction was viewed as being more efficient and cost-effective.

All Engineers however highlighted the limitations that paper-based PMaps presented, including the storage space required, their susceptibility to loss or damage and poor legibility (see Figure 5). Additionally, if PMaps are to be used to compile VSMs then significant manual input is required to extract and recompile the data that they contain. A brief review of computer-based process mapping solutions reveals that many incorporate sophisticated drawing tools and analytical functions. However, the PMapping techniques discussed in this paper are simple tables for capturing data that require little more than pareto analysis. This suggests that a computer-based solution would be relatively simple and inexpensive to produce. It is highly likely that software PMapping applications would be simple enough to be installed on readily available handheld computing devices, such Smartphones, thus alleviating much of the perceived hardware costs of a computer-based solution. Such a development would also allow for compact data storage, secure data storage and backup, and more efficient compilation of PMap data into VSMs than paper-based systems.

Figure 5, similar to Figure 4, identifies the use of a forklift truck in the process. In this example however the Industrial Engineer has highlighted the difficulty in calculating the electrical consumption of the battery-powered truck in activities 1 and 6. All Industrial Engineers highlighted the difficulty in identifying the power consumption of many items of capital equipment: usually electrical motors. This information is often obscured, having been painted over, or is missing from the equipment. Even when information regarding the motors is present it is difficult to ascertain precisely the amount of power consumed by the equipment as a direct result of performing the activity.

Figure 5 – Extended Process Map

Process: Wheelabrator

Created By: R. Witherspoon Date: June 2011

	Activity	O	I	T	S	D	G	Notes
1	P.U. from Store			100M			? Battery Power	electric truck
2	Lineside storage				up to one day			
3	Fettle	60 secs					2kW motor + lighting.	Repack for pallet, 200 items
4	Sample check burrs		5 secs				24V inspection lamp	1-20 parts approximately
5	Lineside storage				up to one day			
6	Transfer to assembly			50M		1 hour	? Battery Power	wait electric truck
7	wait assembly					Up to one day		wait for correct assembly product to begin
8								
9								
10								

Conclusions

Identifying green wastes using the extended process mapping tool outlined in this paper has been shown to be valuable in assisting in the management of an organisation's environmental efforts. Integrating the identification of 'green wastes' within the process mapping tool is found to be an effective way of focussing attention upon the environmental impact of activities within processes. Combining 'green and lean' is also an approach that cements environmental issues into an organisation's continuous improvement efforts and can assist in it becoming part of its improvement philosophy.

Capturing data about 'green wastes' through the extended process mapping technique is useful for an organisation to prioritise its efforts to improve its environmental impact. It is also a valuable source of information that may be used in demonstrating and reporting the organisation's commitment to environmental concerns to its stakeholders and the wider community.

Identifying the technical aspects of some activities, such as motor ratings and power consumption, is often difficult. It is envisaged that many organisations will undertake a program of measuring the power consumption of items of capital equipment as part of an overall approach to environmental and energy management (Director, 2011; Electrical Review, 2011). This data should be useful in completing the collation of 'green wastes' in processes. If this is not present then the process maps may require the input of two people (Keller and Jacka, 1999), one with detailed process knowledge, and the other with knowledge of the technology employed within the process. Capturing 'green wastes' using the method outlined in this paper may therefore be a valuable knowledge-generative activity for an organisation.

The traditional process mapping tool is used extensively throughout a wide variety of organisation types and business sectors. The extended tool shown here has been trialled within four automotive manufacturing companies and found to add value to environmental management and improvement initiatives. In order to assess the tool's wider usefulness in driving environmental improvement it should be trialled in other situations, particularly non-manufacturing environments.

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