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A Benchmarking Study on existing VSM software

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Abstract. Every Lean optimization path typically starts with the mapping of a process, to identify criticalities and wastes embedded in manufacturing processes. Value Stream Mapping (VSM) represents the main and most suitable Lean technique to this purpose, thanks to its simplicity and immediacy residing in its visual effectiveness. Originally designed as a “draw by hand” mapping technique, VSM is moving on digital platforms; different software has in fact been developed over the last few years, each with its own functionalities and characteristics, reason why a software may not be always valid, but useful only within certain contexts. According to a classification of software based on mapping, analytical and collaborative functionalities, crucial aspects for a successful VSM application, the paper aims to depict, through a benchmark analysis, the current situation regarding VSM software and, therefore, serve as a reference model to orient manufacturing companies towards best suited VSM applications.

Keywords: Lean Management, Value Stream Mapping, Industry 4.0, Benchmark, Software.

1 Introduction

The many benefits that the implementation of Lean Management (LM) tools and principles provides to companies, leading them to gain of a relevant competitive advantage [1], has led in the last four decades to an increasing interest of scientific community towards this topic [2]. Embarking on such a path is not, though, a simple matter but rather requires undertaking different steps through adopting appropriate methods and tools. Among others, the Value Stream Mapping (VSM) technique manages to provide a precise, immediate, and easy-to-understand representation of the whole production process, combining process inputs, outputs, activities, actors and information flows (mapping) [3]. Moreover, according to the customer’s needs [4], VSM is helpful to pinpoint the non-value-added sources (e.g., main criticalities and wastes) nestled into the process [5], thus identifying the best management approach towards optimization, by orienteering the necessary improvement interventions into a structured roadmap (analysis). Finally, it helps the development of teamwork based on a common language

and a systematic process that lays the foundations for a strategic and shared improvement plan (collaboration) [6].

Originally born as a “draw by hand” tool [6], VSM has yet proven to be ineffective in production contexts characterized by process uncertainty [7] due to frequent changes of products, short product life cycle or high fluctuations of customer orders [8]. However, with the advent of digital technologies, much new mapping software has been developed, which has indeed contributed to exceeding the constraints typical of traditional VSM. Thanks to a permanent and continuous visualization of the value stream, achieved by means of real-time monitoring systems which allow for a high level of sensitivity in relation to possible production fluctuations, operation managers can obtain a constantly updated view of the processes under observation [9]. In addition, supported by the simulation functionalities provided by software, they can test several improvement proposals and identify the best approach among a set of potential future scenarios. The achieved benefits lie not only in more frequent, fast, and accurate control of data coming from the field, but also in a greater integration and transparency of information, as well as in the possibility of studying and comparing several improvement alternatives simultaneously, by analyzing the interactions of different material and information flows in a simpler and more effective way, in order to identify time and economic savings at an early stage [10].

Despite the manifest benefits of the new VSM software applications, it is not yet clear what functionalities are compulsory for creating VSM suitable for dynamic and uncertain contexts, and to what extent the software available on the market cover these functionalities. On these premises, aim of the paper is to outline an overview regarding the current VSM software available on the market and their distinctive functionalities, to understand to what extent they match the main VSM characteristics, namely mapping, analysis and collaboration.

Following this brief introduction, the paper is then structured as follows: section 2 describes the research methodology; section 3 provides an overview of the current software and functionalities available on the market, whose benchmark results are then reported in section 4. Section 5 includes a discussion over the main outcomes of the analysis, whose most relevant considerations are then reported in the conclusive section of the paper, along with hints regarding possible future research.

2 Methodology

From a methodological standpoint, the research was built upon three main phases, each one composed of one or more subphases (Fig. 1). Three researchers participated in the whole research process.

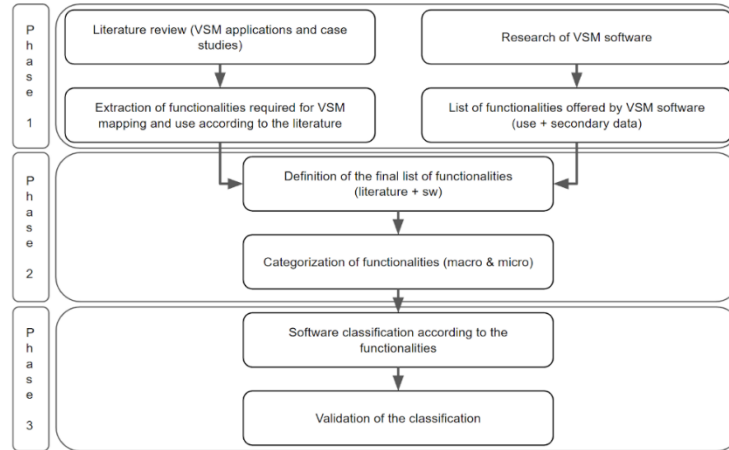


Fig. 1. Research methodology and related steps

The first phase, carried out through two parallel streams, aimed at identifying the main functionalities required and offered for VSM projects. The literature review focused on case studies reporting VSM applications aimed at understanding the relevant information necessary to conduct a VSM analysis. On the other hand, exploratory research of VSM software was carried out to identify the main commercial solutions available on the market and the functionalities (i.e., “any aspect of software application or any computing device can do for the user”) [11] offered. From this research, 18 software was found and analyzed in detail. When both free and paid versions of the software were available, the ‘full version’ - i.e., the one with the greatest number of available functionalities - was considered. Functionalities were identified both by using the software and analyzing secondary data (e.g., tutorials, marketing material).

The second phase involved the preparation of the final list of functionalities. Such a list was created by merging the results of the literature review and exploration of the commercial software. Eventually, a list of 64 functionalities was defined. Starting from this list, functionalities were clustered into micro- and macro-categories, where the former represent a specification of the latter: for example, the macro-category “Mapping” includes the micro-categories “Data”, “Formatting”, “Icons”, “User experience”. In turn, each micro-category entails one or more functionalities. For instance, the micro-category “Formatting” contains the functionalities “Customization of color of the stencil”, “Highlight value added processes” and “Taking and integrating pictures”.

Finally, each software was classified according to their distinctive functionalities. After testing the software and collecting data from secondary sources, each researcher ran the classification independently. Then, the classification was validated by comparing and, when necessary, discussing the analysis of each researcher. Such approach was carried out until reaching an agreement on the software classification.

3 Overview of VSM software functionalities

As stated in the previous section, the literature review and exploratory research phase enabled the identification of 64 different functionalities characterizing VSM applications. These functionalities can be clustered into 10 micro-categories and, in turn, be grouped into 3 main macro-categories according to the dimensions of VSM found in literature. Table 1 reports the list of micro-categories and relevant macro-categories. The latter are briefly described in the following.

Table 1. List of software functionalities, grouped in micro and macro-categories

Macro-category	Micro-category	Description
Mapping	Data	Calculate data boxes variables
	Formatting	Format personalization of mapping stencils
	Icons	Standard or customized icons and stencils
	User Experience (UX)	Software supportive tools for the drawing phase
Process Analysis and Optimization	Basic	Calculate basic KPIs and production indexes typical of a VSM representation (LT, OEE, Takt Time, EPEI etc.)
	Optimization	Compute line balancing and Kanban optimization, compare multiple what-if scenarios
	Personalization	Generate customized reports
	Simulation	Capability to simulate a production process, through discrete-event models
	Visualization	Display mode of reports generated at the end of the simulation
Collaboration	Asynchronous	Possibility for several people to access, edit and collaborate on the same map, not simultaneously
	Synchronous	Possibility for several people to access, edit and collaborate on the same map simultaneously

- **Mapping.** It covers all the functionalities concerning the drawing phase, including the customization of templates, icons, symbols, and areas for data and information management. Formatting options and other supporting functionalities to enrich the User Experience in the mapping phase, with particular mention to the auto-draw capabilities, are also taken into account;
- **Process analysis and optimization.** It refers to functionalities concerning the software's ability to process data and find solutions to static or dynamic problems [12], i.e., when the amount of input data changes continuously, in terms of fluctuations in demand and resources, product and variant mixes, and non-sequential production processes [13]. In other words, it specifies the set of functionalities concerning graphs, calculations and simulations, in the form of discrete events or of scenario analysis, to support the simultaneous comparison of multiple what-if scenarios. The category also considers the possibility to represent analysis results through 'ad hoc' performance indicators, designed by the user;

- **Collaboration.** It concerns the ability of a VSM software to engage multiple users to cooperate, working simultaneously on a specific document. It also includes those functionalities pertaining to the ability of the software to facilitate feedback through the use of real time chats, or a system for tracking changes.

18 software applications, identified in the first phase of the research and reported in Table 2, were then assessed according to the mentioned criteria.

Table 2. List of analysed software

Software (alphabetical order)		
BlueSpring LeanView	Ifakt	Simcad Simulation
BreezeTree	iGrafx	SimVSM
ConceptDraw	LeanLab Visual Factory	VSM SmartDraw
Creately	Lucidchart	Systems2win
EdrawMax	Profit Surge VSM	TecnomatixPlantSimulation
eVSM Mix	ProModel	Visual Paradigm

4 Results

The final assessment of VSM functionalities owned by each application is reported in the benchmark analysis depicted in Fig. 2. The enumeration of software applications in the list is purely coincidental and is not in any way related to the sequence of Table 2.

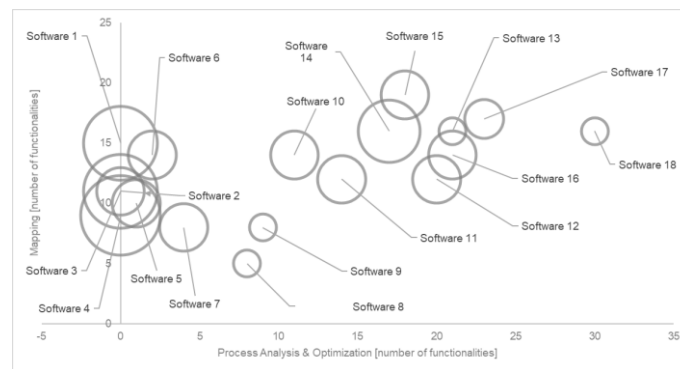


Fig. 2. Benchmark analysis of VSM applications

The bubble chart shows the functionalities owned by the 18 software considered within the benchmark analysis. In accordance with the three characteristic dimensions of VSM systems, the x-axis refers to the amount of functionalities concerning “Process analysis and optimization” possessed by each software, while the y-axis as the “Mapping” functionalities. The diameter of each bubble represents, on the other hand, the number of “Collaboration” functionalities available for each software program. To avoid tracking of applications that do not possess any “Collaboration” tool, the minimum value for

this variable has been set equal to one. In all cases, the higher the number of functionalities available, the higher the score achieved in each category.

5 Discussion

The diagram of Fig. 2 shows that the different VSM software considered in the benchmark analysis widely ranges among the dimensions in terms of owned functionalities. In particular, three main different clusters can be identified, as highlighted in Fig. 3:

- **“Drawing” (blue):** the first cluster is made up of software used exclusively to draw processes. Located along the y-axis software belonging to this cluster, it may be of particular interest to users who only necessitate a map representation tool. Indeed, this kind of software possesses several “Mapping” functionalities to the detriment of “Process analysis and optimization” ones which, for the majority of cases, are completely absent, excluding for software 6 and 7 which respectively includes a couple of functionalities concerning process analysis;
- **“Static Analysis” (red):** the second cluster, that is located in the central area of the diagram involves software applications that possess a fair amount of both mapping and process analysis and optimization functionalities. In particular, “Process analysis and optimization” functionalities featured by software belonging to this category mainly refer to numerical analyses of the key indicators associated with a process, mostly in stationary conditions;
- **“Dynamic Analysis” (yellow):** the last cluster groups software tools that, through simulation, enable the study of alternative scenarios characterized by different flows of material and information, also in non-stationary and highly variable conditions. These applications, which are also characterized by a high number of both “Mapping” and “Process analysis and optimization” functionalities, are particularly useful for the analysis of the process current state, as well as for evaluating alternative improvement strategies.

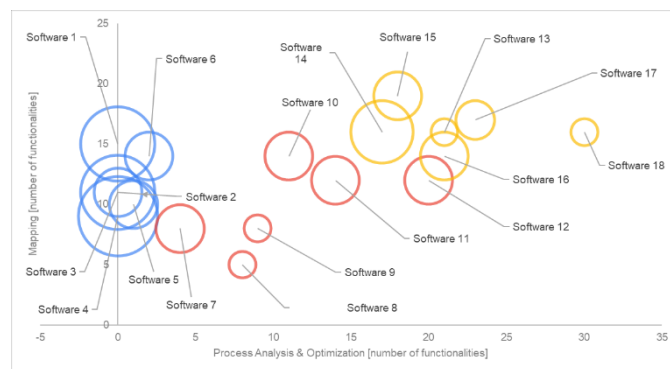


Fig. 3. Clustering of VSM software according to main software utility

Finally, an overall view on different software categories identified, a synthetic bubble diagram, which thickens all the different applications belonging to the same category into a single point, has been elaborated in Fig. 4. The chart shows that, on average, “Drawing” applications have more “Collaboration” functionalities (4,2 on average) compared to the remaining tools available on the market (which count respectively 1,3 and 1,5 available functionalities on average for the “Static Analysis” and “Dynamic Analysis” applications). This distinguishing difference is probably due to the fact that, most likely, software built on a simulation architecture gives the opportunity to evaluate alternative process configurations autonomously, without any need for external support, as opposed to “Drawing” software tools which are, instead, enhanced by the possible inclusion of such functionalities.

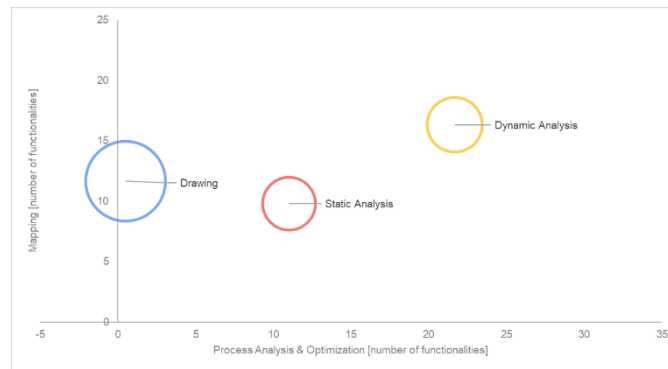


Fig. 4. Cluster mid-points for each VSM software category

6 Conclusion

The benchmark analysis described throughout this paper provides a general overview on the current state of VSM software available on the market, identifying the distinctive software functionalities as well as its main differences with other proposed solutions. The benchmark analysis, therefore, can work as a reference point for both manufacturing and software development companies. On one hand, it may support manufacturing companies in a VSM software selection process, directing them on the alternative solution that best suits their needs in terms of number and type of functionalities. On the other hand, the benchmark analysis may act as a comparison tool to provide software companies some hints regarding new possible functionalities to be implemented, or orient the policy of development towards the specialization on a specific field of usability (i.e. drawing or static/dynamic analysis). Finally, the utility of the analysis undertaken also resides in the fact that the different utilities of VSM identified in literature (namely mapping, analysis and collaboration) are indeed reflected on the software utilities available on the market, confirming the usefulness of such applications in properly drafting a VSM coherently with the theoretical principles.

Further research may be oriented towards the inclusion of software that covers additional semantic areas within the traditional context of a VSM, such as the environmental, sustainability, economic/financial and societal dimensions, as well as taking into account cost, usability, or customer satisfaction in the software assessment. One final aspect of interest could relate the readiness of VSM mapping applications to be integrated with Process Mining methodologies [14] to manage the complexity and variability of modern production systems, through event log-based business process analysis. This new line of research would be instrumental for the creation of what can be called as Dynamic Value Stream Map (DVSM) [15].

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