SYSTEM VALUE ANALYSIS: MODEL AND EXAMPLE

Lavi, Emilia;
Reich, Yoram

Tel Aviv University

ABSTRACT

Systems design, being a socio-technical discipline, is highly affected by available technologies, the global economy, the state of the environment, and social issues. Hence, in recent years, the ultimate objective of design started to shift from best-performance systems to ones providing value to customers, enterprises, and society. This paper presents a holistic concept of system value, equipping the stakeholders participating in the design process with a broad view of this measure. The contribution of this paper includes a proposal for general system value taxonomy, which can be used as a foundation for a comprehensive, case-specific, system value model (SVM). As an all-round perspective of value is possible only when all stakeholders are represented, we suggest deploying the PSI framework for mapping the relevant stakeholders. The system value analysis of Tesla's Model Y electrical vehicle is demonstrated, as a test case for SVM application. We conclude that a detailed analysis of SVM, performed by a carefully chosen group of diverse stakeholders, highlights less conventionally discussed aspects of the system during design decision processes, hence is expected to improve the system's overall value.

Keywords: Systems Engineering (SE), Design methodology, Evaluation, System value, Value-oriented systems engineering

Contact:
Lavi, Emilia
Tel Aviv University
Israel
emilialavi@mail.tau.ac.il

Cite this article: Lavi, E., Reich, Y. (2023) ‘System Value Analysis: Model and Example’, in *Proceedings of the International Conference on Engineering Design (ICED23),* Bordeaux, France, 24-28 July 2023. DOI:10.1017/pds.2023.329

1 INTRODUCTION

In recent years, the ultimate objective of design started to shift from best-performance systems to ones providing value to customers, enterprises, and society (INCOSE, 2021). The value-focused approach to the design process enhances the creation of new alternatives, guides strategic planning, and facilitates multi-stakeholders' decisions (Keeney, 1992). Thus, the notion of value should be instrumental throughout the system lifecycle, from the requirements elicitation phase, throughout the design process, and up to the retirement plan. It is recognized that compliance with the system's performance and functionality requirements is not enough for optimal system design and might result in a considerable loss of value (Hazelrigg, 1998). A holistic concept of system value, considering the multifaceted socio-technical environment, is essential in a modern, highly connected, and dynamic, world.

Design and system engineering (SE) practices tend to adopt quantifiable value measures. Commonly, various aspects of value are converted into a single dimension, enabling design alternatives evaluation and comparison. The value engineering method refers to value as the ratio between the worth of an item and its actual life-cycle costs (Mandelbaum & Reed, 2006; SAVE International, 2021). Approaches applying the multi-attribute utility theory in design suggest that the value measure is a one-dimensional utility function, mainly representing monetary value. The value-driven design (VDD) method is a prominent example, defining system value as a combination of system attributes converted into a comparable scalar score (Collopy & Hollingsworth, 2011), in most cases conveying the monetary value of a system. Studies applying multidisciplinary system design optimization (MSDO) generally employ quantifiable value metrics, such as total system cost (Sternberg, et al., 2015), or conjoin engineering and financial design expressing value through performance, cost, and revenue (Markish & Willcox, 2003). Some researchers integrate the MSDO approach with VDD, also representing value as a monetary measure (Kannan, et al., 2020). Several design approaches incorporate qualitative elements of value: the value-sensitive design aims to design technology accounting for human values; the value-based software engineering (Boehm, 2006) aspires to reach maximal satisfaction of the success-critical stakeholders.

A holistic view of value is possible only when all stakeholders are represented, however, it seems that this aspect is seldom covered. While the value proposition of product-service systems (PSS), comprising integrated solutions of products and services, should address multiple stakeholders and consider the complete lifecycle of a system (Martins & Rozenfeld, 2019), it usually includes only the customer's and provider's value analysis, with the latter being less dominant (Matschewsky, et al., 2020). In value-based requirements engineering (VBRE), the prevalent criteria for prioritizing the requirements are their cost and importance to identified stakeholders, usually the customers. However, as the stakeholders' views are typically partial, the result, although improving projects' success rates, does not optimize system value. Globalization and resource scarcity emphasize the need for inclusive stakeholders' mapping during system value assessment.

As a socio-technical discipline, complex systems design is highly affected by available technologies, the global economy, the state of the environment, and social issues. As a result, the definition of system value is inclined to change from the conservative performance vs. cost formula to a more inclusive measure. The need for such a general notion of system value and the absence of one, is widely recognized (Design Council, 2020; Watson, et al., 2020; World Economic Forum, 2020; INCOSE, 2021).

Our goal is to equip the system stakeholders participating in the design process with a wide view of the value measure, frequently determining the success of a system. The contribution of this paper includes a proposal for general system value taxonomy, which can be used as a foundation for a holistic, case-specific, system value model (SVM). For this purpose, the paper is organized as follows. Section 2 describes the stakeholders to be taken into account during the value model formulation and the methods for their inclusive mapping. Section 3 elaborates on the proposed SVM taxonomy. Section 4 summarizes the use case of Tesla's electric vehicle (EV) SVM. Finally, section 5 discusses the potential utilization of holistic system value definition, including a comparison of the proposed system value model to the PESTEL framework, and presents future research directions.

2 STAKEHOLDERS OF THE SYSTEM

Menger (2007) claims that "value does not exist outside the consciousness of men". We agree with this observation and argue that if a system emerges from a vacuum, created without utilizing any resources, and no one recognizes its existence or deploys it, the system's value is annulled. Following this reasoning, the value of a system is dependent on its stakeholders, involved in each phase of its lifecycle: imagining the system or the product, coveting it, designing it, using it, influenced by it, selling it, disposing it, or even remembering that such a system existed, either as nostalgia or for learning from experience. Each feature of the system contributes to its value only if there exists a stakeholder appreciating it. Otherwise, as each attribute is generated through resource investment, an unnecessary feature lessens the overall value of a system. This "unproductive labour" destroys value, e.g., the resources invested in creating features unvalued by customers, or the re-work required to repair the product after-sale (Bowman & Ambrosini, 2002). Negative components of value should also be considered, as a system might have negative, as well as positive, impacts. Therefore, to define system value properly, all related stakeholders should be identified.

PSI (Reich & Subrahmanian, 2022), being a framework for modelling design contexts, can be deployed to map the relevant stakeholders. The problem space (P) specifies the scope of the problem, including the definition of the issue to be solved and its context. The social space (S) analyses the participants of the design process, including their skills and motivations. The institutional space (I) addresses the procedures used to execute the design, including the organizational structure and methods. Analysis of the problem, social, and institutional spaces in the multi-layer PSI network model reveals the incentives of each stakeholder and the relationships between them. To perform successfully, the spaces of the PSI layers and matrixes should be aligned. We suggest the SVM be used as an alignment tool between the PSI components.

At this initial phase of holistic SVM development, we specify three PSI matrixes representing major stakeholders' groups:

- customers, who could be individual consumers or entire business organizations
- society, including local and global community, mankind, and in some cases, the industries in the same business
- the enterprises, including all organizations involved in the system's design, manufacturing, and commerce

Each PSI matrix could include one to three layers: vision (V), alignment (A), and operation (O). The matrix should be constructed according to the specific case. For example, while approaching a commodity product, the customer-representing matrix could include a single layer. However, for a governmental purchase, the customer matrix embraces all three layers. The society matrix may include the government, local community leadership, and the citizens. Each group may be represented by a single layer in the matrix or by a separate matrix, according to the issue. The enterprise matrix O-layer includes those executing the design: system engineers, designers, and manufacturers. Its A-layer comprises groups managing the infrastructure processes supporting the design, such as mid-range management, human resources (HR), information technology (IT), quality assurance (QA), and other organizational processes. The V-layer includes the organization's leadership outlining the vision and the strategy. In some cases, a detailed analysis of the enterprise stakeholders will require more than a single PSI matrix, including subcontractors, manufacturing plants, suppliers, etc. (Reich & Subrahmanian, 2022).

Figure 1 illustrates an example of a PSI network model of system design. The analysed system is an industrial air filter reducing the pollution caused by manufacturing processes. Each stakeholder group is represented by a 3-layer PSI matrix. The customer is a production plant. At the customer's operational layer (Oc) is the manufacturing facility generating the pollution. The characterization and the purchase of the filtration system are at the alignment layer (Ac), verifying that the facility's emissions meet both the governmental regulations and the management's vision (Vc) of sustainable manufacturing. Society is represented by the local and global community (Ss in Os), while the regulations are set at the alignment level (P's in As), according to the global community vision (Vs). The enterprise matrix includes system design at the operational layer (Oe), and an alignment layer (Ae) synchronizing the system design with top-level management vision (Ve). Each of these stakeholders owns a specific perspective on the system value, originating in their PSI layer position, the specific role they fulfill, and their personal and organizational values. The depicted connections partially reflect the network inter-relations. Link (1)

https://doi.org/10.1017/pds.2023.329 Published online by Cambridge University Press

means that the problem space of the customer, in this case, air pollution reduction, is a part of the problem space of society. Link (2) illustrates that the employees of the polluting plant (Sc) are also a part of the society's social space (Ss), as they are a part of the community. Link (3) demonstrates that the pollution problem the society faces is part of the problem space of the enterprise designing the filtration system. Link (4) emphasizes that the vision of the customer and the enterprise are related, as a customer with high environmental awareness is likely to turn to an enterprise with similar values.

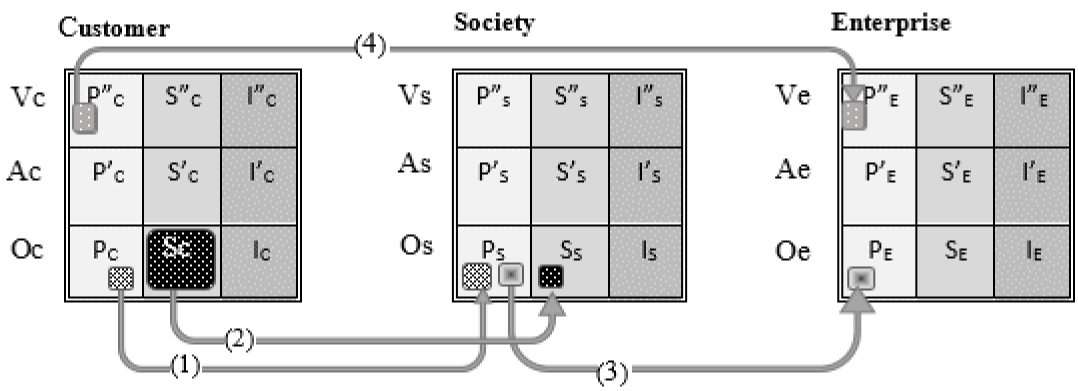

Figure 1 – Illustration of exemplar PSI network model of system design

To generate an all-inclusive and balanced SVM, the stakeholders should execute a well-planned and controlled process. A diverse group of stakeholders, representing distinct value enablers, should be introduced with achievable benefits of the system, as well as with the required costs (Lavi & Reich, 2022).

While recognizing the stakeholders, and examining their position regarding system value, multiple perspectives should be brought to attention. Ethical, environmental, emotional, technical, and commercial are several of the views influencing the decisions making in the design process. The eco-system of the stakeholders' groups should be considered as well. As opposed to free market mechanisms, frequently allowing the natural alignment of stakeholders' interests, system design requires initiated consideration and aggregation of the utility created by the system for all stakeholders (Hulse, et al., 2019). As organizations must align employees' values to perform efficiently (Drucker, 2009), so must the participants of the design ecosystem coordinate the value they observe in the system.

3 VALUE MODEL PROPOSITION

Value is specific for each design and every system. Our goal is to propose a generic SVM to be used as the foundation for a specific system value exploration. We follow the logic described in the previous section and compose the model from stakeholder-perspective value segments. Figure 2 illustrates the SVM taxonomy. SVM is composed of customer-related, society-related, and enterprise values.

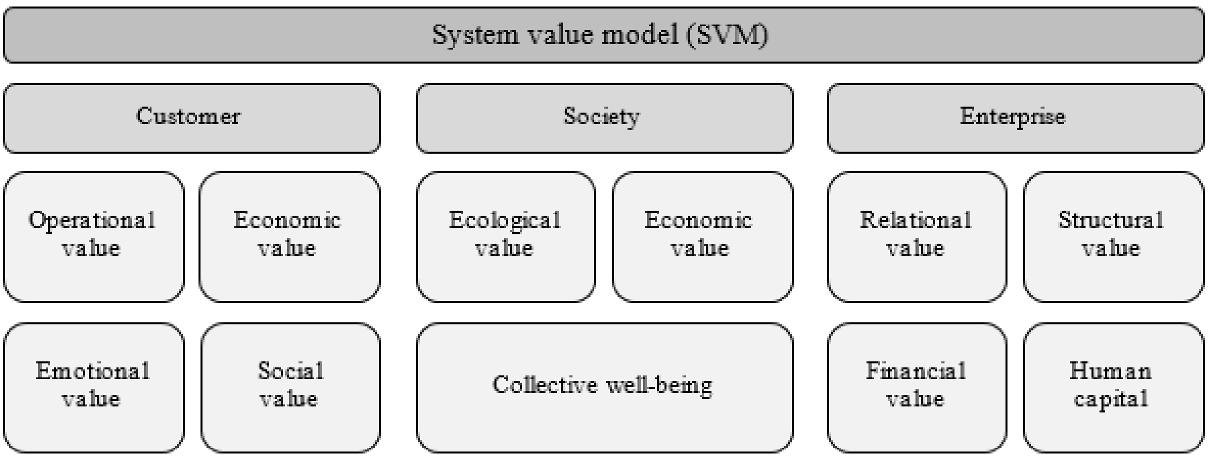

Figure 2 - The system value model

https://doi.org/10.1017/pds.2023.329 Published online by Cambridge University Press

The customer-related value segment is characterized by the following dimensions:

- Operational value denotes the system's compatibility with the customers' current and future needs, such as applicability, efficiency, quality, and safety.
- Economic value represents the change in the financial state of the customer over time, as induced by the system.
- Emotional value demonstrates the impact the system has on the customer's emotional wellness, as well as the correlation of the system's deployment, design, and manufacturing methods, to ethical values.
- Social value reveals the impact of the system's ownership and operation on the customer's alliance formations and public image.

The society-related value segment refers to a wider influence the system has on indirect stakeholders, which usually are not involved in system design. This segment includes the following elements:

- Ecological value is the system's impact on the ecological ecosystem, such as natural resources preservation, climate change, and eco-footprint. It refers to a system's complete lifecycle, including deployment and manufacturing.
- Economic value includes the system's donation to the financial assets of the community and the state, such as intellectual property, fixed assets, and national productivity.
- Collective well-being is the system's influence on the life quality of society, considering all social groups. Prominent examples are connectedness, equal opportunities, and social wealth.

The enterprise-related value considers the implications of the system on all organizations taking part in its lifecycle. This segment comprises the following components:

- Relational value is the impact of the system's lifecycle ownership on the firms' ability to form productive long-lasting relations with stakeholders, such as customers, suppliers, investors, and even competitors.
- Structural value contains the tangible and intangible assets the lifecycle ownership of the system donates to the organization. It may include intellectual property, advanced manufacturing and design methods, productivity enhancement, and even improved organizational culture.
- Financial value represents the change in the firms' economic performance, as a consequence of their involvement in the system's lifecycle. It includes conventional accounting indicators, such as net and gross profit, in addition to the impact on future potential earnings expressed by the stock market value and the market share.
- Human capital represents the ability of the organization to recruit and retain highly skilled and effective employees. Furthermore, it reflects the skills and the well-being of the personnel.

Value is a complex property of a system, owning structure and properties (Francesco & Paoletti, 2022). Understanding system value characteristics and the dependence of value on internal and external factors, support design optimization and are likely to improve design methods (Lavi & Reich, 2022).

The SVM presented in this section seeks to include all elements relevant to decision-making junctures in system design. It could be used either to outline the discussions accompanying these processes, to assure all aspects are considered, or to perform design optimization. The latter requires quantification of the system value measure. As the system value should be adaptable to a specific system, the addition or reduction of elements is enabled. Further study will elaborate on these processes, as well as suggest prioritization and quantification schemes of system value components.

4 USE CASE – TESLA VALUE

To exemplify SVM analysis, we have examined the 2022 Tesla Model-Y EV. The information used as analysis input was collected from academic and press publications, along with Tesla company reports. While this example emphasizes the scope and the data required for system value analysis, the conclusions might vary with a different perspective, at varying points in time, or with newly discovered knowledge.

At this preliminary phase of the research, we assume all dimensions have equal weight and use a qualitative, rather than quantitative, analysis. These assumptions could be relaxed in the future, for example, by using methods such as the analytic hierarchy process (AHP) (Saaty, 1990) to prioritize SVM dimensions.

https://doi.org/10.1017/pds.2023.329 Published online by Cambridge University Press

4.1 Customer-related segment of value

The operational value of Tesla's Model-Y lies in improving the life quality of the owner by enabling mobility. However, as this function is supplied by all private vehicles, additional factors, such as efficiency, reliability, and safety should be examined. Model-Y implements effective safety measures, excelling in this aspect (IIHS, 2022). Its battery is considered efficient, enabling long ranges between charges (Forbes, 2022). However, the reliability of Model-Y is regarded as problematic (CNBC, 2021; CR, 2022).

The economic value of Tesla EV to the customer should be analyzed against other available means of private or public transportation. Although Tesla presented that the five years average ownership costs of Model 3 are roughly identical to the Toyota Camry Internal Combustion Engine (ICE) conventional vehicle (Tesla, 2020), this component of value heavily relies on the personal circumstances of the customer, such as financial state and location. Hence, a generic evaluation of the economic value is ineffective. Detailed analysis of all possible states, while exceeding the scope of this paper, provides an understanding of the impact factors, and contributes to decision-making both by the customer and by the enterprise.

Emotional value: Ownership of Tesla EV correlates with the personal value of caring for nature, as described in the refined theory of basic human values. Therefore, it has a positive emotional value for the customer. It could be argued that EV contribution to sustainability is disputable. The balance between CO2 emissions reduction in EV operation and the pollution produced by manufacturing and charging processes could take years and is location-dependent (Buekers, et al., 2014). However, objectivity is less relevant for this element of SVM. Emotional value is a perceived utility derived from feelings or affective states (Sheth, et al., 1991), so it is influenced by marketing efforts, brand image, and the perceived green value of the product.

Social value: As a vehicle is classified as a highly visible product, its choice is often driven by the social image it evokes (Sheth, et al., 1991). The social value of EV lies in the innovative and environment-conscious public image it creates for the customer (Forbes, 2020).

4.2 Society-related segment of value

Ecological value: Wide adoption of EVs reduces CO2 emissions (Wolfram, et al., 2021), and eliminates the use of gasoline resources. However, a true positive ecological value for the global society depends on the EVs related environmental hazards management, such as cobalt and lithium recycling (Hannan, et al., 2018).

Economic value: Tesla stands at the forefront of the technology innovation environment promoting disruptive technologies (Liu & Meng, 2017), and the data collected by a single car contributes to the general effort. This component of value is specifically emphasized by Tesla, as the company's patent pledge releases all its patents for activity related to EVs to promote sustainability (Tesla, 2014). Furthermore, Tesla improves community productivity by creating multiple job opportunities in its facilities (US Department of Energy, 2017), while localizing vehicle production and optimizing factories for local workforces (Tesla, 2022). Model-Y specifically is manufactured in California, Texas, Shanghai, and Berlin (Tesla, 2022) contributing to the economic value of local communities.

Collective well-being: Although Tesla as an enterprise is committed to accelerating the world's transmission to sustainable energy, which in its turn is expected to improve the life quality and health of society, we must note that current analysis evolves around Tesla's single product and its impact on the collective well-being. Viewing Model-Y independently of the ecosystem, one might assume that it has a negative impact on the collective well-being, as private vehicles overload the roads and cause traffic congestion. However, this component of value is also context-dependent. Allegedly, an EV causes less pollution than a conventional ICE vehicle. This claim is subject to the location of the EV's manufacturing facilities and region of deployment, following dependency on local clean energy production (Buekers, et al., 2014).

4.3 Enterprise-related segment of value

Relational value: Model-Y further established Tesla as a successful automotive company. Its top-rated safety rating (Euro NCAP, 2022), along with high performance and energy efficiency (Forbes, 2022), strengthens the enterprise's reputation and its ties with customers, contributing to the relational aspect of value. As evidence, Tesla's Model-Y was the top registered new car in Europe in September 2022 (Reuters, 2022).

https://doi.org/10.1017/pds.2023.329 Published online by Cambridge University Press

Structural value: Model-Y's popularity steadily enhanced Tesla's manufacturing processes, increasing production rates in the company's Gigafactories located in California, Texas, Shanghai, and Berlin (Tesla, 2022), positively affecting the structural value component. Large-size castings deployed in Model-Y production are innovative and have never been mass-produced before (Tesla, 2022). This capability adds an advantage to Tesla and brings new methods to the entire automotive industry. Furthermore, Model-Y is the first to inhabit the advanced 4680 battery cells expected to increase the range and decrease the overall weight of the car (Inside EVs, 2022).
Financial value: Tesla's gross profit in the automotive segment raised from 751 million dollars in the first quarter of 2019 (Tesla, 2020) to 5,212 million dollars in the third quarter of 2022 (Tesla, 2022), becoming the industry's highest gross margin of 27.9% (Forbes, 2022; Tesla, 2022). The assumed 29.4% gross margin specifically for the China-produced Y model (Inside EVs, 2021); the high volume of Model Y and 3 vehicles, sharing a common platform and largely utilizing similar parts, likely driving down production costs (Forbes, 2022); and the high 94.5% share of Model-Y and 3 of Tesla's automotive deliveries in the third quarter of 2022 (Tesla, 2022), lead to conclude that the Model-Y has a highly positive financial value for the Tesla company.
Human capital: Tesla more than multiplied its workforce between 2019 and the end of 2021, when in December 2021, its workforce included 99,290 employees worldwide (Tesla, 2022). It has opened local Gigafactories in China, Germany, and Texas, manufacturing Model-Y EVs, enabling local recruitment. The advanced technologies deployed in Model-Y manufacturing, including innovative batteries, are expected to attract and retain a quality workforce. The multiple pieces of evidence are Tesla being second at the top choice of graduate engineers, receiving more than three million unique applicants in 2021, and improving employees' satisfaction over time (Tesla, 2021). Consequently, Model-Y positively influenced the human capital of Tesla enterprise.
This section qualitatively analyses the discrete components of system value. While the overall impression is that Model-Y has a positive system value, both inclusively and for separate stakeholders' segments, further research will include quantification and ranking of the SVM elements to provide more applicable insights.

5 DISCUSSION AND CONCLUSIONS

SVM is intended to facilitate the SE decision-making processes with constructed criteria, broadening the discussions, and assuring the holistic impact of the system is considered. The SVM analysis can be performed either for a single property of the system, for a constituent system, or for the complete product. Actual use of SVM in practice could be performed as illustrated in Figure 3, depending on if the system already exists or is being designed.

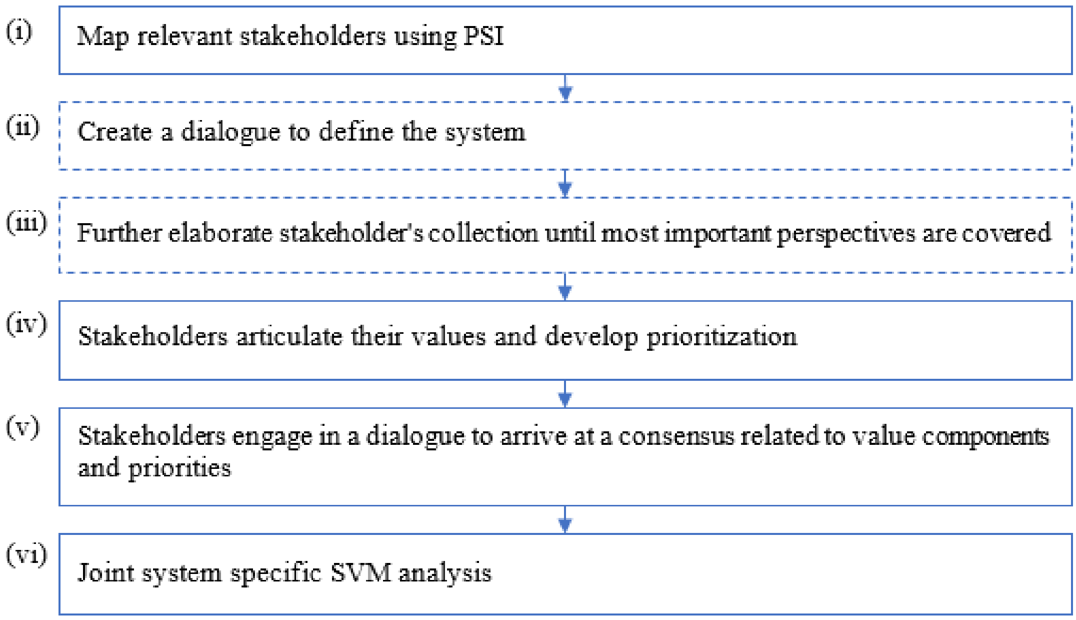

Figure 3 - SVM evaluation process, for existing and future systems. Steps (ii) and (iii) are relevant for future systems only.

https://doi.org/10.1017/pds.2023.329 Published online by Cambridge University Press

The generic SVM structure presented in Figure 2 includes multiple broad perspectives, some of which might be irrelevant to a specific system. For example, the emotional value element, while relevant for most personal use products, probably will not be included in the evaluation of an anti-virus software system for an organization. Hence, to enable further flexibility in SVM interpretation, in future work we intend to detail the processes of adding or removing components from the model to enable its adjustment to the analysed system.

While evaluating the enterprise-related segment of SVM, the user of the model should pay attention to analysing the impact that a specific system has on the enterprise, rather than the general performance of the organization. In contrast to the PESTEL framework (Sammut-Bonnici & Galea, 2015), investigating the external political, economic, social, technological, environmental, and legal factors influencing the enterprise, the SVM is dedicated to a single system's holistic impact on its stakeholders. For example, Tesla's exclusion from the S&P 500 ESG Index (Dorn, 2022), is presumably irrelevant to Model-Y's value to Tesla company. Whereas PESTEL is essential to organizational strategic planning and understanding its DNA, the SVM focuses on a specific system and its value to the company and other stakeholders. Therefore, these models are complementary rather than substitutable.

One of PESTEL's limitations is its purely qualitative nature, which does not offer specific guidelines for criteria ranking or objective quantification, required to emphasize relative importance or rationally compare alternatives (Yüksel, 2012). As to SVM, further research will define prioritization and quantification schemes enabling comparable results and practical conclusions.

While performing the SVM analysis demonstrated in the previous section, we realized that although a generic SVM structure can be designed for a generic type of system, the analysis and the evaluation should be performed for a specific system and specific stakeholders. Had Model-Y been designed in another era, by a different company with dissimilar core values, our SVM analysis would substantially alter. This conclusion is expected due to SVM characteristics, such as being context-dependent and biased (Lavi & Reich, 2022).

An additional conclusion drawn from Tesla's Model-Y SVM examination process is the evaluation's dependency on the objectivity, coverage, and resolution of the available information. Multiple pieces of evidence of the system's influence on the enterprise, along with the specifications of the system, are supplied by the enterprises themselves. Because of the apparent conflict of interests, the data might be partial or presented in a biased nature, affecting the assessment of SVM components. Furthermore, superficial knowledge or low-resolution data might distort the conclusions. For example, ignoring Model-Y reliability issues, or disregarding the pollution caused by its manufacturing processes, will diminish the potential effect of value analysis, and cause the erroneous course of action of multiple stakeholders.

Returning to the approaches described in the introduction section, it is now possible to claim that the proposed SVM substantially varies from a unidimensional value estimation. Detailed analysis of SVM, performed by a carefully chosen group of stakeholders, highlights less conventionally discussed aspects of the system during SE decision processes, hence is expected to improve the system's overall value.

REFERENCES

Inside EVs, 2022. Musk Says Model Y's Structural Battery Pack "Far From Optimized". [Online] Available at: https://insideevs.com/news/596775/musk-says-model-structural-battery-pack-far-from-optimized/ [Accessed 16 November 2022].

Boehm, B., 2006. Value-based Software Engineering: Overview and Agenda. In: S. Biffl, et al. eds. Value-Based Software Engineering. Berlin, Germany: Springer, pp. 3-11.

Bowman, C. & Ambrosini, V., 2002. Value Creation Versus Value Capture: Towards a Coherent Definition of Value in Strategy. British Journal of Management, 11(1), pp. 1-15.

Buekers, J., Van Holderbeke, M., Bierkens, J. & Panis, L. I., 2014. Health and Environmental Benefits Related to Electric Vehicle Introduction in EU Countries. Transportation Research Part D: Transport and Environment, Volume 33, pp. 26-38.

CNBC, 2021. Here's Where Tesla and Other EVs Ranked in This Year's Consumer Reports Reliability Survey. [Online] Available at: https://www.cnbc.com/2021/11/18/consumer-reports-2021-auto-reliability-survey-how-tesla-evs-fared.html [Accessed 11 November 2022].

Collopy, P. D. & Hollingsworth, P. M., 2011. Value-Driven Design. Journal of Aircraft, 48(3), pp. 749-759.

CR, 2022. 10 Least Reliable Cars. [Online] Available at: https://www.consumerreports.org/car-reliability-owner-satisfaction/10-least-reliable-cars-a2967595976/ [Accessed 9 November 2022].

Design Council, 2020. Moving Beyond Financial Value, London, UK: Design Council.

Dorn, M., 2022. The (Re)Balancing Act of the S&P 500 ESG Index. [Online] Available at: https://www.indexologyblog.com/2022/05/17/the-rebalancing-act-of-the-sp-500-esg-index/

Drucker, P. F., 2009. Management Challenges for the 21st Century. E-Book ed. s.l.:HarperCollins Publishers.

Euro NCAP, 2022. Asian Newcomers Make Strong Safety Debut, but Model Y Steals the Show. [Online] Available at: https://www.euroncap.com/en/press-media/press-releases/asian-newcomers-make-strong-safety-debut-but-model-y-steals-the-show/ [Accessed 16 November 2022].

Forbes, 2020. Tesla’s Brand Believers. [Online] Available at: https://www.forbes.com/sites/larrylight/2020/07/27/teslas-brand-believers/?sh=746255f24395 [Accessed 15 November 2022].

Forbes, 2022. 2022 Tesla Model Y: America’s Most Popular EV Compact Crossover. [Online] Available at: https://www.forbes.com/wheels/cars/tesla/model-y/ [Accessed 15 November 2022].

Forbes, 2022. Are Tesla’s Margins Under Threat?. [Online] Available at: https://www.forbes.com/sites/greatspeculations/2022/06/01/are-teslas-margins-under-threat/?sh=3912331a896c [Accessed 16 November 2022].

Francesco , O. & Paoletti, M. P., 2022. Properties. In: E. N. Zalta, ed. The Stanford Encyclopedia of Philosophy. Spring 2022 ed. s.l.:Metaphysics Research Lab, Stanford University.

Hannan , M. A., et al., 2018. State-of-the-Art and Energy Management System of Lithium-Ion Batteries in Electric Vehicle Applications: Issues and Recommendations. IEEE Access, Volume 6, pp. 19362-19378.

Hazelrigg, G. A., 1998. A Framework for Decision-Based Engineering Design. Journal of Mechanical Design, December, Volume 120, pp. 653-658.

Hulse, D., Hoyle, C. & Tumer, I., 2019. Ethics and Strategy in Decision-Based Design Frameworks: Problems and Solutions. Delft, The Netherlands, Proceedings of the International Conference on Engineering Design, ICED.

IIHS, 2022. Vehicle Ratings - 2022 Tesla Model Y. [Online] Available at: https://www.iihs.org/ratings/vehicle/tesla/model-y-4-door-suv/2022 [Accessed 11 November 2022].

INCOSE, 2021. Systems Engineering Vision 2035, San Diego, CA, USA: INCOSE.

Inside EVs, 2021. Tesla Model Y Made In China Has 29.4% Gross Margin Per Analysts. [Online] Available at: https://insideevs.com/news/464539/tesla-model-y-30-percent-gross-margin-china/ [Accessed 16 November 2022].

Kannan, H., Mesmer, B. L. & Bloebaum, C. L., 2020. Incorporation of Risk Preferences in a Value-Based Systems Engineering Framework. Systems Engineering, 23(2), pp. 237-257.

Keeney, R. L., 1992. Value-Focused Thinking: A Path to Creative Decision Making. Cambridge, MA: Harvard University Press.

Lavi, E. & Reich, Y., 2022. System Value Overview Towards Value-Oriented Design. Under review.

Liu, J. & Meng, Z., 2017. Innovation Model Analysis of New Energy Vehicles: Taking Toyota, Tesla and BYD as an Example. s.l., Procedia Engineering, pp. 965-972.

Mandelbaum, J. & Reed, D. L., 2006. Value Engineering Handbook, Alexandria, VA, USA: Institute for Defense Analysis.

Markish, J. & Willcox, K., 2003. Value-Based Multidisciplinary Techniques for Commercial Aircraft System Design. AIAA Journal, 41(10).

Martins, L. D. & Rozenfeld, H., 2019. Who Are the Stakeholders Mentioned in Cases of Product-Service System (PSS) Design?. Delft, The Netherlands, Cambridge University Press, pp. 3131-3140.

Matschewsky, J., Lindahl, M. & Sakao, T., 2020. Capturing and Enhancing Provider Value in Product-Service Systems Throughout the Lifecycle: A Systematic Approach. CIRP Journal of Manufacturing Science and Technology, Volume 29B, pp. 191-204.

Menger, C., 2007. Principles of Economics. Auburn, Alabama: Ludwig von Mises Institute.

Reich, Y. & Subrahmanian, E., 2022. The PSI Framework and Theory of Design. IEEE Transactions on Engineering Management, 69(4), pp. 1037-1049.

Reuters, 2022. Tesla's Model Y Tops New Car Registrations in Europe in September - Report. [Online] Available at: https://www.reuters.com/business/autos-transportation/teslas-model-y-tops-new-car-registrations-europe-september-report-2022-10-27/ [Accessed 16 November 2022].

Saaty, T. L., 1990. How to Make a Decision: The Analytic Hierarchy Process. European Journal of Operational Research, 48(1), pp. 9-26.

Sammut-Bonnici, T. & Galea, D., 2015. PEST analysis. [Online] Available at: https://www.um.edu.mt/library/oar/bitstream/123456789/21816/1/sammut-bonnici%20pest.pdf

SAVE International, 2021. About the Value Methodology. [Online] Available at: https://www.value-eng.org/page/AboutVM [Accessed July 2021].

Sheth, J. N., Newman, B. I. & Gross, B. L., 1991. Why We Buy What We Buy: A Theory of Consumption Values. Journal of Business Research, 22(2), pp. 159-170.

https://doi.org/10.1017/pds.2023.329 Published online by Cambridge University Press

Sternberg, D. et al., 2015. Multidisciplinary System Design Optimization of Orbit Satellite Assembly Architectures. Big Sky, Montana, USA, IEEE, pp. 1-14.
Tesla, 2014. All Our Patent Are Belong To You. [Online] Available at: https://www.tesla.com/blog/all-our-patent-are-belong-you [Accessed 15 November 2022].
Tesla, 2020. Q1 2020 Update, s.l.: Tesla.
Tesla, 2020. Tesla 2020 Impact Report. [Online] Available at: https://www.tesla.com/ns_videos/2020-tesla-impact-report.pdf [Accessed 15 November 2022].
Tesla, 2021. Tesla 2021 Impact Report, s.l.: Tesla.
Tesla, 2022. Q3 2022 Tesla Quarterly Update, s.l.: Tesla.
Tesla, 2022. Tesla Inc. 2021 Annual Report on Form 10-K. [Online] Available at: https://www.sec.gov/Archives/edgar/data/1318605/000095017022000796/tsla-20211231.htm [Accessed 15 November 2022].
US Department of Energy, 2017. Tesla. [Online] Available at: https://www.energy.gov/lpo/tesla [Accessed 15 November 2022].
Watson, M. D., Mesmer, B. & Farrington, P. A., 2020. Engineering Elegant Systems: Postulates, Principles, and Hypotheses of Systems Engineering, Huntsville, Alabama, USA: s.n.
Wolfram, P., Weber, S., Gillingham, K. & Hertwich, E. G., 2021. Pricing Indirect Emissions Accelerates Low—Carbon Transition of US Light Vehicle Sector. Nature Communications, Volume 12.
World Economic Forum, 2020. System Value. [Online] Available at: https://www.weforum.org/projects/system-value [Accessed 2021].
Yüksel, I., 2012. Developing a Multi-Criteria Decision Making Model for PESTEL Analysis. International Journal of Business and Management, 7(24).