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A Brief Discussion on Trade Studies

Dr. Srinivasan Palamalai
Associate Professor, Masters In Business Administration (General Management), Presidency University, Bangalore, India,
Email Id-srinivasanp@presidencyuniversity.in

ABSTRACT:

Trade studies are a crucial part of system engineering that aids in the process of making well-informed decisions. In order to maximise system performance, cost efficiency, and general usefulness, these studies seek to investigate and assess numerous design choices. Trade studies help engineers make well-informed decisions by methodically comparing and analysing options, which results in the creation of reliable and effective systems. The main ideas and goals of trade school for system engineering are summarised in this abstract. It emphasises their importance in handling difficult design problems and reconciling conflicting needs. The paper emphasises once again how interdisciplinary and iterative trade studies are, incorporating many different disciplines and stakeholders to guarantee thorough research and decision-making. The paper also covers the essential procedures for carrying out trade studies, such as issue characterization, defining the standards of assessment, developing alternatives, performing quantitative and qualitative analyses, and trade-off analysis. It emphasises how crucial it is to use the right analytical methods and tools to assist rational decision-making and takes into account how simulations, models, and simulations fit into the trade research process. It emphasises the extensive use of trade studies in a variety of sectors, including manufacturing, aerospace, automotive, and telecommunications. The emphasis is on how they contribute to the performance, dependability, maintainability, and lifetime cost optimisation of systems.

KEYWORDS:

Cost Effectiveness, Optimization, System Design, Trade Studies.

I. INTRODUCTION

Trade studies are an essential part of the decision-making process in system engineering when building and creating complex systems. Trade studies entail analysing and contrasting several alternatives, choices, or design possibilities to find the optimal course of action that meets the needs and goals of the system. Trade studies are intended to carefully analyse and quantify the trade-offs between numerous parameters, including performance, cost, schedule, reliability, maintainability, and other pertinent criteria. System engineers may make educated judgements and improve the performance of the system by performing trade studies to get insight into the possible repercussions and consequences of various design decisions [1], [2].

Establishing a precise definition of the issue or choice that has to be made is the first stage in any trade study. This involves knowing the precise design feature or parameter that has to be assessed and being aware of the needs and limitations of the system. The next step for system engineers is to discover and develop a list of workable alternatives or design solutions that may be able to satisfy the system's criteria. These options could come in the form of various components, technologies, designs, or combinations [3], [4].

The selection of assessment criteria is made by system engineers using the goals and specifications of the system. Performance indicators, costs, schedules, risks, safety concerns, environmental effects, and user satisfaction are a few examples of the criteria that may be included. System engineers analyse and assess each possibility in light of the established criteria. To evaluate the benefits, drawbacks, and trade-offs of each alternative, this may include using simulations, mathematical modelling, performance testing, cost analysis, or other relevant techniques. System engineers make well-informed judgements and suggestions based on the findings of the assessment. They weigh the trade-offs between the various options while taking into consideration the needs, limitations, and stakeholder preferences of the system [5], [6].

The results of the trade research, as well as the conclusions of the assessment and the suggested course of action, are recorded and distributed to the relevant parties. This promotes accountability and justifies the decision-making process. Trade studies provide an organised, methodical approach to system engineering decision-making. They provide system engineers the ability to assess the effects of various design options and make wise

choices that enhance the system's functionality, efficiency, and overall success. Trade studies assist in reducing risks, spotting possible problems, and improving awareness of the system's trade-offs by carefully analysing all available options [7], [8].

II. DISCUSSION

During the systems engineering process, integrated teams employ trade studies as a formal decision-making tool to make decisions and settle disputes. The integrated team is required to participate in effective trade study analyses; otherwise, the solution may be based on erroneous assumptions or may show the absence of crucial data. Between requirements, technical goals, design, programme timeline, functional and performance criteria, and life-cycle costs, trade studies are identified and carried out to determine desired and viable alternatives. Then decisions are made based on a predetermined set of standards. At the different levels of the functional or physical architecture, trade studies are specified, carried out, and recorded in sufficient detail to facilitate decision-making and result in a well-balanced system solution. Any trade study's degree of information has to correspond to the consequences on cost, schedule, performance, and risk [9], [10].

Any endeavour involving systems engineering conducts both formal and informal trade studies. Formal trade studies often end up being employed in formal decision-making venues, such as milestone decisions. These are usually well documented and included to the decision database that is characteristic of system development. On the other hand, trade-offs and judgements that resemble the trade study process are present in every engineering decision at every level. The majority of these less formal studies are simply summarised in detail, but they are significant since they help define the design as it develops.

Trade Studies and the Process of Systems Engineering

To support choices made throughout the systems engineering process, trade studies are necessary. needs are weighed against other needs or limitations, such as cost, throughout the requirements analysis process. Trade studies on requirements analysis look at and analyse different performance and functional requirements to settle disputes and meet client wants.

Functions are balanced with interface requirements, prescribed equipment, functional partitioning, requirements flow down, and configuration item designation concerns during functional analysis and allocation. Trade analyses are carried out both within and between functions to:

1. Support functional analyses, performance requirement allocation, and design constraint allocation.
2. Establish a set of performance criteria that best meets the defined functional interfaces.
3. When higher-level performance and functional needs cannot be easily resolved to the lower-level, determine the performance requirements for those functions.
4. Consider various functional designs.

Trade studies are used during design synthesis to assess various options in order to optimise cost, schedule, performance, and risk. During synthesis, trade studies are carried out to:

1. Encourage choices between newly developed items and processes and non-developmental ones;
2. Create configurations for the system, its subsystems, and its components;
3. Assist in the selection of system ideas, designs, and solutions (including availability of personnel, components, and materials);
4. choices on the manufacture, purchase, method, price, and placement of support supplies;
5. Consider suggested adjustments;
6. Look into alternate technologies, particularly those for moderate- to high-risk technologies, to meet functional or design requirements;
7. Assess the financial and environmental effects of products and procedures;
8. Compare various physical architectures to choose the best items and procedures; and
9. Choose standardised parts, methods, facilities, and services that lower system lifetime costs and satisfy system effectiveness standards.

Trade studies are used to explore different system-level ideas and scenarios throughout the early programme stages, such as Concept Exploration and functional baseline development, in order to determine the system configuration. Trade studies are utilised at later stages to look at lower-level system segments, subsystems, and end goods to help choose component part designs. It is necessary to compare and exchange performance, cost, safety, dependability, risk, and other effectiveness metrics against physical attributes.

Trade Study Principles

Examining various options to decide which is preferable is a procedure known as a trade study (trade-off analysis). As a foundation for a choice, it's critical to create standards that all members of the integrated team can agree upon. In addition, a method for comparing alternatives to the criteria must be decided upon. The trade research should result in judgements that are repeatable, logical, and objective if these guidelines are followed. Finally, trade research findings must be presented in a way that makes them understandable to consumers and decision-makers. It is doubtful that a trade research would produce timely choices if the findings are too complicated to express clearly.

Trade Study Methodology

As depicted in Figure 1, the steps in the trade-off analysis process are problem definition, problem boundary establishment, trade-off methodology establishment (which includes decision criteria establishment), alternative solution selection, key characteristic determination for each alternative, evaluation of the alternatives, and solution selection:

a. Creating a problem statement that includes any limitations is required for problem definition. Problem definition has to be done very carefully. After all, you won't obtain the proper solution if your issue isn't the right one.
b. Determining the applicable system requirements for the research is necessary for constraining and comprehending the challenge.
c. Inconsistencies between the intended properties of the investigated product or procedure and the data's limits. Databases that may provide relevant, historical "actual" information to assist assessment judgements should be found.
d. Choosing the mathematical technique of comparison, creating and specifying the comparison criteria, and figuring out weighting variables (if any) are all parts of establishing the approach. The logic, objectivity, and reproducibility of the research will be determined by the use of proper models and methods. Experience has shown us that both ignorance and deliberate misuse of this stage are possible. The selected technique should, to the greatest degree feasible, evaluate options based on their actual value to the customer and developer. Relationships between trade-offs should be sensible and relevant. The issue of "what is the actual value of the increased performance, based on what rationale?" should be addressed by the choice of utility or weights.
e. Identifying all feasible approaches to fixing the issue and choosing those that seem workable are necessary steps in the process of choosing alternative solutions. The cost of analysis may be influenced by the amount of possibilities; therefore, only obviously feasible options should typically be considered.
f. Deriving the data needed by the research technique for each option is necessary to determine the main features.
g. The analytical phase of the investigation involves evaluating the options. It involves creating a trade-off matrix to evaluate the options, doing a sensitivity analysis, choosing a preferred option, and re-evaluating (sanity-checking) the options and the research process. The sensitivity analysis is essential because weighting variables and certain "quantified" data may have arbitrary characteristics. The research is likely flawed, and the methodology needs to be evaluated and altered if the answer may be modified with just minimal adjustments to the data input. Following the completion of the aforementioned procedures, a solution is picked, described, and entered into the database.

Analyses of cost effectiveness

Cost effectiveness assessments are a specific kind of case study that evaluates the performance of a system or component in relation to its price. These studies aid in determining the relative costs and benefits of alternative options. In particular, they are used to:

a. Encourage the establishment of feasible, economically advantageous mission and performance criteria.
b. Encourage performance allocation to an ideal functional structure,
c. Offer standards for choosing between alternate options,
d. Offer analytical verification that designs adhere to customer objectives while staying within budgetary limits, and
e. Assist with process and product verification.

Trade studies are conducted to help people choose the best alternatives by helping them make more intelligent judgements. Initial trade studies emphasise the principles and needs of alternative systems. Later research is

useful for choosing component part designs. Cost-effectiveness studies provide evaluations of the performance of different solutions in relation to cost.

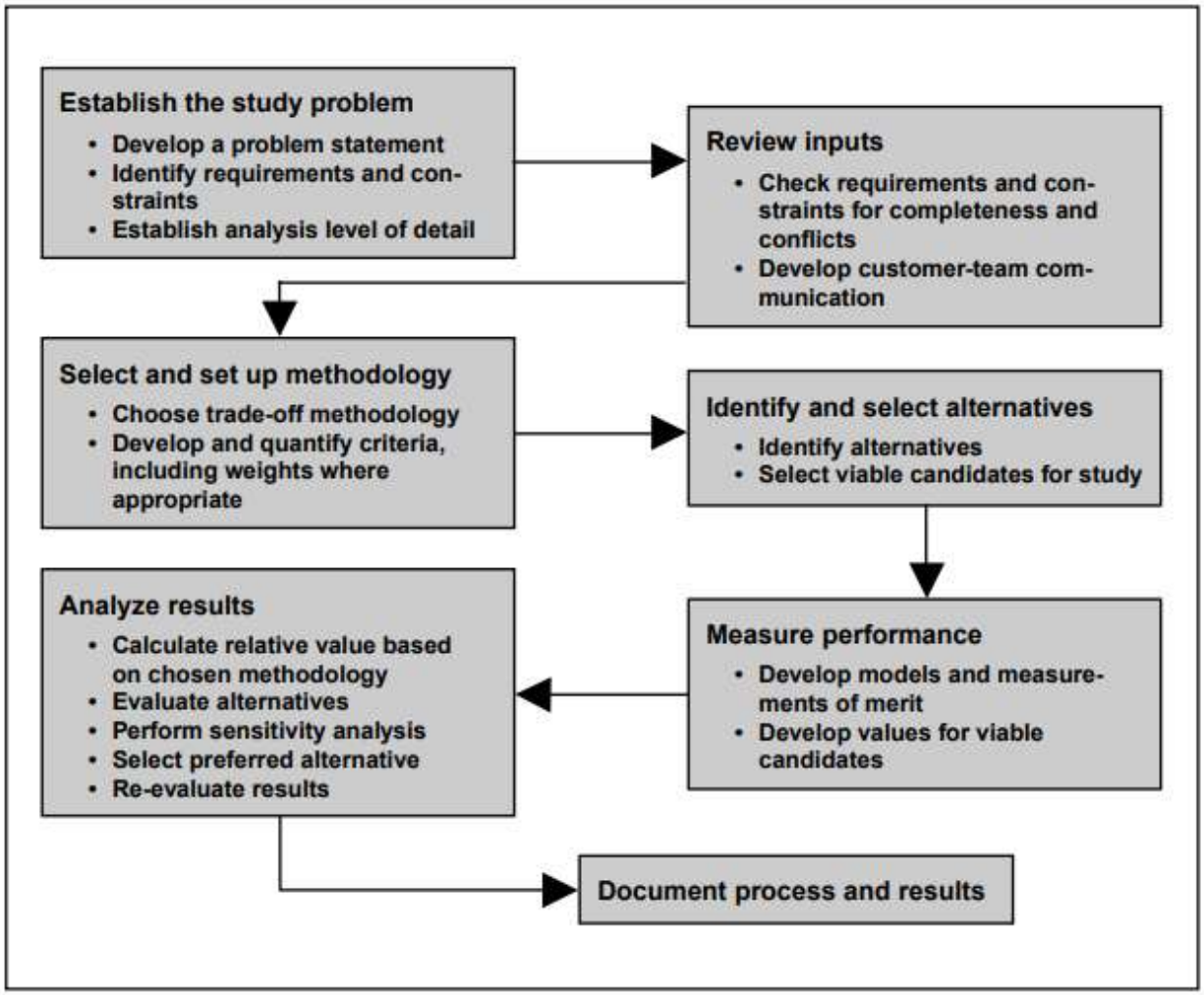

Figure 1: Trade Study Process [ocw.mit.edu].

III. CONCLUSION

In conclusion, trade studies are an essential step in the system engineering process since they help with decision-making and performance and design optimisation. In trade studies, several alternatives, choices, or trade-offs are analysed and compared to find the best approach for accomplishing the intended system goals. Trade studies provide insightful information on the possible advantages, dangers, expenses, and effects linked to various design decisions and trade-off choices. They aid in determining the best way to strike a balance between conflicting aspects including performance, cost, schedule, dependability, maintainability, and stakeholder needs.

Trade studies assist in comprehending the trade-offs and ramifications of various design choices by methodically analysing and contrasting numerous solutions. They provide quantitative and qualitative evaluations to help choose the best option that complies with project criteria and best satisfies system needs. In conclusion, trade studies are an essential tool in system engineering for weighing trade-offs, assessing design alternatives, and reaching wise choices. By taking into account a variety of aspects, including performance, cost, schedule, and stakeholder needs, they allow optimisation of system design and performance. Trade studies support effective stakeholder communication, documentation, and risk management, which ultimately results in the successful design and execution of complex systems.

REFERENCES

[1] P. Panagiotou, S. Fotiadis-Karras, and K. Yakinthos, "Conceptual design of a Blended Wing Body MALE UAV," Aerosp. Sci. Technol., 2018, doi: 10.1016/j.ast.2017.11.032.
[2] A. J. Nuss, T. D. Blackburn, and A. Garstenauer, "Toward Resilience as a Tradable Parameter during Conceptual Trade Studies," IEEE Syst. J., 2018, doi: 10.1109/JSYST.2017.2703608.
[3] P. Z. Chadzynski, B. Brown, and P. Willemsen, "Enhancing Automated Trade Studies using MBSE, SysML and

PLM," INCOSE Int. Symp., 2018, doi: 10.1002/j.2334-5837.2018.00572.x.

[4] D. I. Atsir and S. Sunaryati, "The Effect of Corruption on International Trade: A Case Study of Indonesian Trade to Nine Countries," EKO-REGIONAL J. Pengemb. Ekon. Wil., 2018, doi: 10.20884/1.erjpe.2018.13.1.1160.

[5] F. Gerhard and V. Peñaloza, "Resilience in trade fairs: A study in Brazilian context," Interações (Campo Gd., 2018, doi: 10.20435/inter.v19i4.1699.

[6] M. Burton, C. Courtin, M. Drela, D. F. Colas, N. H. Roberts, and V. S. Suryakumar, "Solar aircraft design trade studies using geometric programming," in 2018 Multidisciplinary Analysis and Optimization Conference, 2018. doi: 10.2514/6.2018-3740.

[7] M. M. Larsen, T. Seppälä, and J. Ali-Yrkkö, "The changing geography and ownership of value creation: evidence from mobile telecommunications," Ind. Innov., 2018, doi: 10.1080/13662716.2017.1329086.

[8] J. Tangudu, G. Ouyang, and J. Cui, "Trade Studies for a Manganese Bismuth based Surface Permanent Magnet Machine," in 2018 IEEE Transportation and Electrification Conference and Expo, ITEC 2018, 2018. doi: 10.1109/ITEC.2018.8450233.

[9] D. Schaffer-Smith, S. A. Tomscha, K. J. Jarvis, D. Y. Maguire, M. L. Treglia, and J. Liu, "Network analysis as a tool for quantifying the dynamics of metacoupled systems: An example using global soybean trade," Ecol. Soc., 2018, doi: 10.5751/ES-10460-230403.

[10] M. Novan Prasetya and S. Rizky Deovanka, "Regional Government Policy in Preventing Illegal Drug Trade Case Study: North Sumatera," J. Islam. World Polit., 2018, doi: 10.18196/jiwp.2111.