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# Project managers and systems engineers - "Can two walk together, except they be agreed?" Recent research findings on development projects

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# Project managers and systems engineers - "Can two walk together, except they be agreed?" Recent research findings on development projects

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**Abstract**

There are two significant "players" in development projects: the project manager and the systems engineer, both working together in cooperation with the aim of carrying out technical (execution/performance, quality) and managerial (schedule, costs, and customer satisfaction) project goals.
The goal of the current study (Kordova, Kats and Frank, 2019) is to identify the management processes shared by project managers and systems engineers in the defense industry, understand which factors influence how joint project management is accomplished and how it impacts meeting project goals, and provide recommendations for joint project management that will lead to project success.
The research method was qualitative, based on 16 semi-structured interviews with project managers and systems engineers in defense companies that deal with the development of technological systems.
The main recommendations for joint project management are: clear distribution of responsibility and delegation of authority between the two professionals before starting the project; choosing a project manager who was once a systems engineer or who possesses engineering knowledge; insistence on an ongoing dialogue between the two professionals and solving/preventing conflicts through discussion and persuasion; as well as expanding common ground between the project manager and systems engineers' areas of responsibility.

Keywords: systems engineering; development projects; project management.

## 1. Research Goals

The current study discusses project management methods and processes from the perspectives of both project managers (based on the PMBOK) and systems engineers (based on the SE Handbook). The study objective was to identify the management processes shared by both project managers and systems engineers in the defense industry, understand which factors influence how joint management is executed, define the consequences of joint management regarding meeting project targets, and provide recommendations for joint project management methods that lead to project success.

## 2. Literature Review

Systems engineering management is a practice that grows and develops together with systems engineering, with standards that address the close relations between systems engineering management and project management, emphasizing how critical they are in improving project management. While project-related issues methods have traditionally focused on schedule, budget, and scope, systems engineering management centers on managing the project-product and issues related to developing project technology (Sharon, 2010). Systems engineering management and project management are two areas that flow together, a fact addressed in at least three prominent project management and systems engineering books:

1) The SE Handbook (INCOSE, 2011) includes the technical processes, management processes, and extra-organizational processes relevant to systems engineers.
   The chapter dealing with project management processes focuses on processes that are relevant to the project's technical coordination, as well as presenting management processes referenced in the PMBOK (PMI, 2013).
2) NASA Systems Engineering Handbook (NASA, 2007). Figure 1 is taken from this book and describes the overlapping areas between systems engineering and project management. According to NASA (2007), in these areas systems engineering provides information on the technical aspect, while project management entails the management, costs, and scheduling aspects.

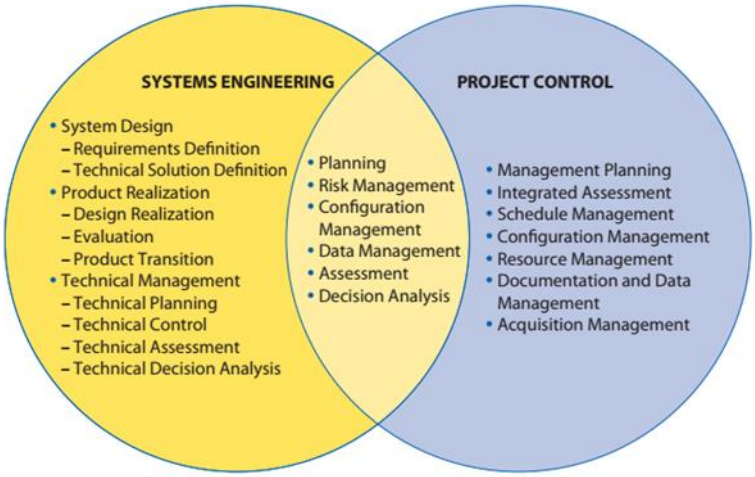


Fig. 1. NASA - Overlaps between systems engineering and project management (NASA, 2007)

3) Defense Acquisition Guide (DoD, 2010), an internet source provided by the US Department of Defense, containing basic project management principles and processes.

In October 2012, PMI and INCOSE conducted a joint survey in an attempt to better understand the roles of project managers and systems engineers, and determine the level of integration between the two (Confronto, Rossi, Rebentisch, Oehmen & Pacenza, 2013). The survey included a total of 680 systems engineers and project managers.

The survey findings showed that:

- 30% of respondents believe there is a certain level of undesirable tension between project managers and systems engineers.
- The three factors leading to this tension are:
    - Lack of an integrated plan for carrying out the project management/systems engineering activities
    - Failure to identify the responsibilities related to each area
    - Conflicting project management and systems engineering practices

According to Stratton and Lang (1997), the key to successful project management in the 21st century is understanding the relationships of all of the disciplines (project management/systems engineering), their shared processes and differences, and finding the most efficient way to integrate the components, and thus maximize project management. Project management, systems engineering, and content supervision are the

three essential required disciplines needed to achieve effective project management.

**3. Methodologies**

The study design was qualitative and predominantly based on semi-structured interviews with project managers and systems engineers employed in security companies dealing in development, integration, and upgrading of technological systems.

The interview sample included 16 experienced project managers and systems engineers, all recognized as experts in their fields. The 16 experts are recognized for their expertise based on their position, education and wide experience.

Main study findings, particularly recurring patterns, were categorized into groups with each pattern then examined for frequency and intensity of repetition.

Several procedures were conducted to ensure trustworthiness (internal validity) of the qualitative study findings:

- Triangulation: finding was considered trustworthy/valid if they appeared in at least three interviews. This is a qualitative study based on semi-structured interviews. Therefore, there is no statistical analysis process as usually be done in a quantitative study. Three interviewees that mentioning the same topic is one of the triangulation procedures to ensure trustworthiness (internal validity) of the qualitative study.
- Over the course of the interviews, cross validation was conducted to examine the extent of respondents' agreement with the given definitions (respondent validation).

In order to ensure confirmability:

- The extent of objectivity was examined throughout the study.
- The interview questions were clearly worded in an unbiased manner.
- Efforts were made to avoid errors due to false first impressions and early assumptions, so that research findings could be applied to the general population (external validity – fittingness).
- The research sample was not biased towards either of the two domains (project management/systems engineering); as far as was possible, an equal number of project managers and systems engineers were interviewed.
- Known experts from the project management/systems engineering communities were chosen as experts in their fields.

**4. Research Results**

As mention before the main study was a qualitative study. As such, the key objective of qualitative analysis was to identify conceptual similarities and to discover types, classes, processes, patterns, key points or wholes.

Therefore, after transcription and summarizing all of the interviews, content analysis was performed aimed to find the patterns and common themes that emerged from the interviews. These patterns helped to illuminate the study questions. The content analysis process included:

1. Mapping the management processes shared by project managers and systems engineers (such as: risk management, purchasing processes management, budget management, customer relationship management, etc.).
2. Mapping the factors that influence joint management methods (such as: personality, interpersonal relations, interpersonal communication, the project's organizational structure, professionals' background and experience, etc.).
3. Consolidation of recommendations regarding the project's joint management.

The main findings of the study are:

1. The overlapping areas between project management and systems engineering which cause the most conflict between the two professionals are:
   Risk management; procurement management; systems engineering-architecture decisions, concept definition and integration processes, and validation/verification tests (impact on schedule and resources), and work program management.
2. In most projects, cooperation between the two professionals is achieved through a peer approach to determining project goals and how to achieve them. Conflicts mainly relate to professional orientation (meeting requirements and performance demands/compliance with cost and schedule constraints). All organizations strive towards processes that clearly state the responsibilities of each professional involved in the process, with project managers and systems engineers at the top of the management pyramid. If there is good synergy between them, they can help one another and together decide on technical and management-oriented subjects. Lack of good level of cooperation between the two inevitably may hamper the project success (all interviewees unanimously agreed about this subject).
3. Factors influencing the joint project management method included: the personality of the involved professionals, the organizational culture they are accustomed to, project managers' familiarity with

systems engineering processes, level of mutual trust and professional appreciation of each other, project organizational structure (in particular, systems engineers under the supervision of project managers), and background (specifically, education and professional experience).

4. The main management problem resulting from overlapping responsibilities is schedule delays, but there were additional consequences related to performance.
5. Recommendations for joint project management:
    a. Coordinate responsibilities and authority between the two professionals before project onset.
    b. Document the responsibility and authority in PMP and the SEMP documents.
    c. Define a mechanism for settling disputes.
    d. Train project managers in engineering development processes (the project manager is the systems engineer's boss – he/she is also responsible for technical supervision).
    e. Use shared tools to manage the project (for example, CORE systems engineering software).
    f. Ensure the systems engineer takes cost and schedule considerations into account while making systems engineering decisions.
    g. Come to a clear agreement about project goals and how to achieve them.
    h. Clarify interrelations between the project manager and the systems engineer during professional training.
    i. Appoint a project manager who was a systems engineer in the past.

## 5. Discussion

Current study findings indicate that the management processes shared by both project managers and systems engineers are as follows:

- risk management
- systems engineering processes
- schedule management
- procurement management
- scope management
- cost management
- HR management

In contrast, a literature review reveals summaries describing the management processes that appear in both the PMBOK and the SE Handbook. These overlapping processes include:

- management of lifecycle processes

- requirements management
- project planning
- project monitoring and control
- risk management
- configuration management
- information management
- procurement processes management
- portfolio management
- HR management

A certain congruence is observable between findings in this current study and that of the literature review: risk management, requirements management (a top priority of systems engineering processes), procurement processes, HR management, and schedule management (project planning). In addition, there is partial congruence with the work of Scott, Townsend, and Carlos Confronto (2015), indicating that the shared areas of management are risk management, subcontractor management (procurement processes management), quality management, and product lifecycle planning.

Management processes that were found to overlap in this study, but were not mentioned in the literature review, include: scope management and cost management. We will now specifically discuss the following overlapping management processes:

**Risk management** – project risks include management-related risks (such as cost or organizational expenses), as well as technical/engineering risks (such as requirements, performance demands, premature technology). During the project, a joint discussion about risk takes place in which they are ranked, and a risk reduction plan is formed. Most of the interviewees mentioned that project managers usually integrate all risks, while systems engineers are generally responsible for identifying and managing only technical risks. However, technical risks often have managerial consequences, as risk reduction plans generally entail the allotment of resources (schedule/budget) that are managed by the project manager.

**Systems engineering processes** - These processes, managed by the systems engineer, include major project decisions – which technology should be used (including level of maturity), what is the system architecture, what is the concept behind the integrations and tests; what optimal design, the number of development cycles (versions), how many prototypes will be built, and so forth.

These decisions all have significant implications on project success and the ability to meet project

goals. Both professionals need be involved, as each one of these decisions necessitates resources and is therefore a subject that needs to be discussed. All technical requirements are the systems engineer's responsibility, and so attention must be given to each and every requirement and their related aspects. If a requirement cannot be met, systems engineers may try to convince their project managers that this is the case. If the project manager is convinced, it will then be his/her responsibility to carry out the necessary negotiations with the customer.

**Project schedules** - aim to provide a framework regarding time constraints, as dictated by the customer. Schedules for development entail identifying the scope of work, dividing it into appropriate activities, and understanding the constraints and order of activities of the different development processes. Project milestones are usually determined (according to project goals) and roughly dictated in a top-down approach by the project manager, and a bottom-up schedule is drafted by the systems engineer. Striking a balance between vision and reality is seldom achieved in the first planning cycle. This iterative process requires multiple discussions between project managers and the systems engineers.

**Procurement management** - requires a detailed listing of all requirements and scope of work as part of the subcontractor agreement. Systems engineers usually define the requirements, while the statement of work is written jointly with the project manager. The project manager is interested in minimizing the schedule and cost factors, but this is not always in line with the specifications as defined by the systems engineer. Thus, a dialogue is necessary between the two professionals about limitation of resources and compliance with essential requirements.

**Project scope** - has to do with deciding what work packages are included in the project, including the scope involved in handling each project issue. Scope is derived from project requirements in a process led by the systems engineer, while the document listing the project's detailed work contents is usually led by the project manager. Scope is also derived from the system's architectural design, which defines what is within the project's scope. Thus, scope translates to every systems engineering process, how many tests will be conducted, which development and testing tools will be developed, etc. A large part of defining the scope of work and building the WBS in technology development projects is executed by the systems engineer, who leads the system's development process from a technological perspective. Each scope has an impact on project resources on the one hand, and on project success on the other; Therefore, it is also a subject for discussion between the two professionals.

**Project cost** - is managed solely by the project manager. Nevertheless, preparation of a costs

assessment and the rationality of this assessment must be carried out together with the systems engineer, who is usually able to evaluate how much time/scope must be invested regarding engineering development processes.

**HR management** – involves both professionals identifying the required skills for the project (defining the necessary professionals needed for the project, etc.), and of course ongoing manpower management. The level of management varies between the "small" cycle (project management team) and the "large" cycle (the rest of the matrix). In system of systems large development projects, the systems engineer is usually in charge of all work aspects of several additional systems engineers, who he/she manages directly.

Joint processes that failed to meet the validity criteria but are still worth discussion include:

**Customer relations management** - according to most of the interviewees,
project managers usually play the major role in customer relations. Nevertheless, there are many dialogues around technological issues (design reviews, customer acceptance tests, etc.), where systems engineers are at the forefront. Both professionals must agree on the messages they want to convey to customers and decide who oversees discussions of each specific subject.

**Product lifecycle management** –project managers are responsible for planning and managing the product's lifecycle. Systems engineers must take into consideration life cycle cost requirements throughout the development period. Usually additional project team members are involved in managing the project production process, system deployment, and maintenance.

## 6. Conclusions and Recommendations

The study discusses project-related management methods and processes, from the project manager and systems engineer's perspectives.

The main causes influencing joint project management methods are: professionals' personalities, their background and experience, their natural inclinations (the systems engineer towards performance and engineering, and the project manager towards budget/schedule considerations), and the project's organizational structure. Factors that have less impact are mutual trust and appreciation, the project's organizational culture, struggle over project resources (managed by project managers), level of interference of each professional in the other's area of responsibility, and ability to see eye-to-eye regarding project goals and how to achieve them ("goal unification").

In most projects, the two professionals cooperate out of a shared motivation to meet project goals. When conflicts arise between the two, it affects meeting those goals – mainly in the form of

failing to meet project schedule/budget targets.

The main recommendations proposed for joint project management are: coordination of the project's different responsibilities and clear delegation of authority between the two professionals before project onset; choosing a project manager who used to be a systems engineer/has prior engineering background (and if not, provide them training in engineering development processes); strict adherence to ongoing dialogue between the two professionals; resolving/avoiding conflicts through discussion and persuasion; and expanding the overlap between project managers and systems engineers' areas of responsibility.

Secondary recommendations – get systems engineers to think about management considerations; train project managers and systems engineers to discuss relevant management interfaces; provide both professionals with mentoring; and appoint suitable project managers and systems engineers.

This study was conducted solely in security development firms and was not based on additional project data (budget, scope, systems complexity, development time, etc.). Therefore, additional study should be conducted in civilian development companies, and on possible integration of quantitative tools to examine the relationship between project data and level of joint project management between systems engineers and project managers.

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