32nd Annual INCOSE international symposium
hybrid event
Detroit, MI, USA
June 25 - 30, 2022

Storytime, Audience to Authors:
Enhancing Stakeholder Engagement

Dale Brown
Hatch
Chicago, IL
Dale.Brown@hatch.com

Chamara Johnson
WSP
New York, NY
Chamara.Johnson@wsp.com

Allison Ruggiero
Metropolitan Transit Authority
New York, NY
Allison.Ruggiero@mtacd.org

William Gleckler
Metropolitan Transit Authority
New York, NY
William.Gleckler@mtacd.org

Devon McDonnell
WSP
New York, NY
Devon.McDonnell@wsp.com

Denis Simpson
WSP
London, UK
Denis.Simpson@wsp.com

Abstract. This paper is largely aimed at Public Agencies, such as Infrastructure and Transit authorities. The creation and development of projects at these agencies impacts multiple layers of stakeholders, who, in the collective experience of the authors, are often not involved in the project until the middle or end of the development phase or not until they have to use the system. These neglected end users and influencers of the system do not have a timely voice – they are effectively excluded.

This paper advocates for the early engagement of all defined stakeholders; the obvious and the unconventional, both internal and external to the agency. This paper does not provide a detailed ConOps process but rather defines what a ConOps is, why it is necessary, and at what stage in the project should one be developed**.** The principal conversation herein focuses on how to determine who the audience is for the system of interest (SOI) and ways to engage them. The paper describes a holistic approach to the creation and development of a ConOps deliverable by engaging the audience, who become stakeholders and effectively, authors. This paper concludes with a case study encompassing the discussion.

Introduction.

During the Concept Planning Stage, when the problem is defined and the beginnings of a project/ program are initiated, stakeholder needs are identified, ideas and technologies are discovered, and feasible concepts are explored, leading to the creation of a Concept of Operations (ConOps). A main factor in developing a useful ConOps document is early and thorough identification of stakeholders, followed by appropriate levels of engagement and management of those relationships. Stakeholders of all levels, both internal and external to an organization, are valuable resources for a Systems Engineer to involve in the development process no matter when the content of the document is captured.

ConOps vs OpsCon. The IEEE Standard 1362™-1998 (R2007) states in their terminology, the ConOps document is sometimes called an operational concept definition (OCD), or OpsCon. Recognizing that

ANSI/AIAA G-043A-2012 states that the terms "concept of operations" and "operational concept" are often used interchangeably, it is noted that an important distinction exists in that each has a separate purpose and is used to meet different ends. Table 1 shows definitions from ISO/IEC/IEEE and AIAA.

Table 1: ConOps vs. OpsCon

	ConOps	OpsCon
ISO/ IEC/ IEEE 29148	The ConOps, at the organizational level, addresses the leadership's intended way of operating the organization. It may refer to the use of one or more systems, as black boxes, to forward the organization's goals and objectives. The ConOps document describes the organization's assumptions or intent in regard to an overall operation or series of operations of the business with using the system to be developed, existing systems, and the possible future systems. This document is frequently embodied in long-range strategic plans and annual operational plans. The ConOps document serves as a basis for the organization to direct the overall characteristics of the future business and systems, for the project to understand its background, and for the users of [ISO/IEC/IEEE 29148] to implement the stakeholder requirements elicitation.	A System OpsCon describes what the system will do (not how it will do it) and why (rationale). An OpsCon is a user-oriented document that describes the system characteristics of the to-be-delivered system from the user's viewpoint. The OpsCon document is used to communicate the overall quantitative and qualitative system characteristics to the acquirer, user, supplier and other organizational elements.
ANSI/ AIAA G-043A-2012	A document for recording a concept of operations. It is developed at the organization (enterprise) level, independent of any specific system solution, to describe how the organization (enterprise) will operate to execute strategy and doctrine. The Concept of Operations Document is not a requirements document. It describes the organization (enterprise) operational intent and context, and is used to derive needs and requirements.	A document for recording an Operational Concept. It is prepared at the acquisition organization and developer level to describe how a particular system (new, modified, or existing) will be operated to satisfy its user and operator needs. The description is independent of specific design solutions, although it will make reference to a possible design solution at the highest level of abstraction. The Operational Concept Document is not a requirements document. It describes the system operational intent and context, and is used to derive needs and requirements.

Purpose of a ConOps. A ConOps ensures there is a common understanding and consensus among the system's stakeholders regarding the purpose and goals of the system, what it will do, how it will be used, and who will be using it. When these internal and external stakeholders are identified, the document should be constructed to ensure the project's vision is clear and confirmed by all parties. It will serve as a "contract" between all the stakeholders. A ConOps is a commitment to the high-level system functionality and capability that will be delivered, and the resources that will operate and maintain it. It can also serve as a basis for developing operational and maintenance plans for the new system, via operational scenarios comprised in a ConOps.

The ConOps describes user's operational needs without designing a system. The ConOps does not focus on technical details or issues, as these details are addressed during system design development/ system analysis and described in a Detailed Design Document.

By not having the expectation of a designed system, the development process of a ConOps allows users to express concerns about what the current systems lack, or need improvements on; users can share desires, visions, and expectations *without* detailing quantified, testable specifications. Users are able to discuss possible solution strategies, while acknowledging known constraints and current work arounds.

The OpsCon describes the system functionality from the system operator's perspective, whereas the ConOps describes the overall mission, or system-of-systems (SoS) operation, from the perspective of the enterprise or organization. This is illustrated with the simple context diagram below.

In Figure 1, a major infrastructure program, such as a new High Speed Rail line, is shown with constituent Systems A, B and C, such as Civil Works, Track Works, Vehicles, etc. Each of the Constituent Systems may be developed and delivered by disparate suppliers and designers at differing timelines, but all will need to align with the overall mission as narrated in the primary program level ConOps. The ConOps for a large SoS or program drives the mission goals and objectives down into the subordinate systems to provide continuity of purpose.

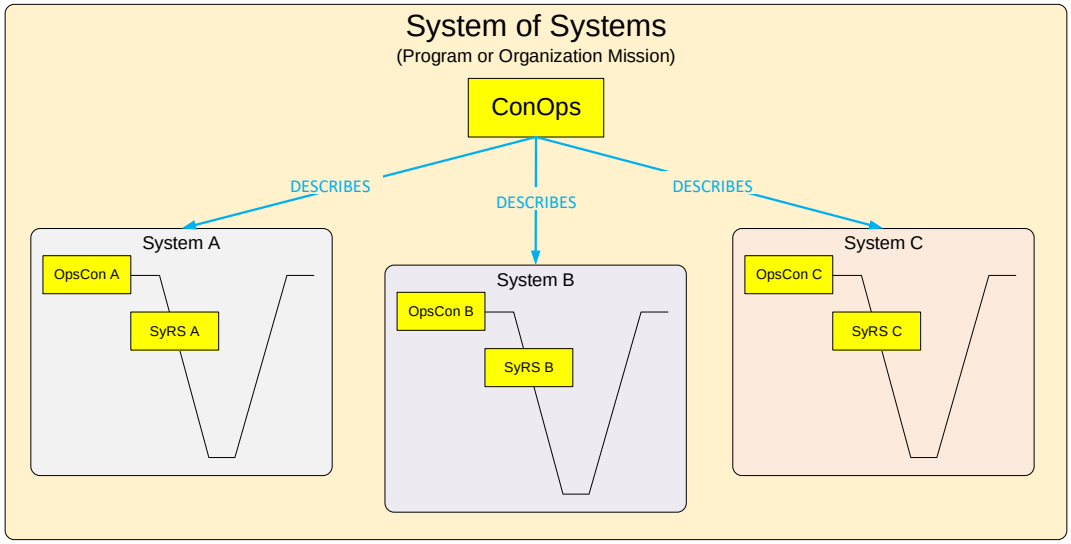

Figure 1. ConOps vs. OpsCon - View based on a SoS and Major Systems

ConOps in a Transportation Project Lifecycle. ConOps development ideally occurs during the early phases of a project lifecycle; Project Initiation and/or Project Planning/Concept Development (see Figure 2). Additional refinement of the ConOps into subsystem level OpsCon documents would typically occur as the concept development transitions into preliminary. This does not occur in transportation projects. During design stages, the OpsCon is not a stated deliverable – instead there are documents such as Basis-of-Design or Design Description documents that often provide the detailed Operations Concept content found in an OpsCon. This situation is specific to the Transportation and Infrastructure industry which is dominated by Civil Engineering norms and the Construction Specifications Institute (CSI) approach.

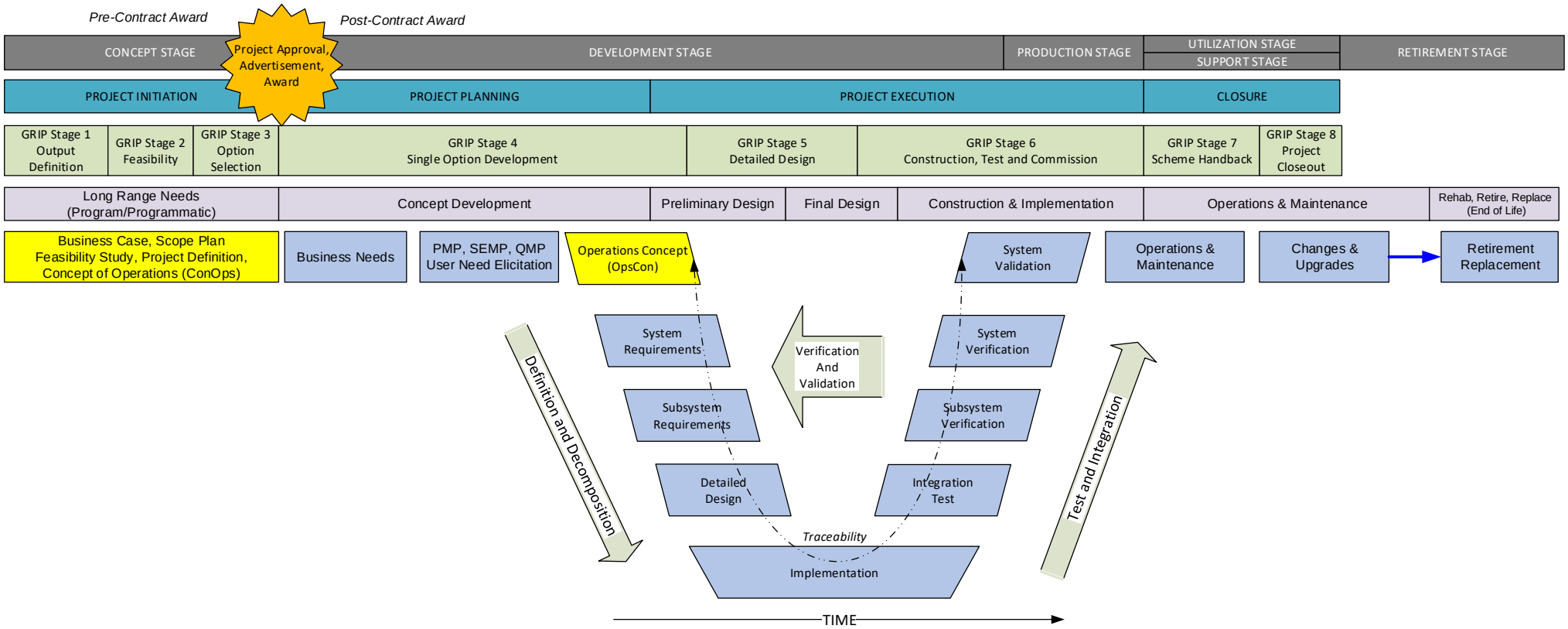

Figure 2. Transportation Project Lifecycle

For the purposes of this paper, all activities described, whether for a ConOps or OpsCon, will be addressed as the development of a Concept of Operations (ConOps), as this is the language typically used in the transportation infrastructure industry.

The left side of the V-diagram, shown in Figure 2, identifies where these documents are developed, in correlation to typical transportation project lifecycles. While Table 2 details the phase and corresponding document.

Table 2: Project Phase ConOps Development

Project Phase	Project Initiation/ Concept Stage	Project Planning/ Development Stage
Stage	Pre- Contract Award	Post- Contract Award
Terminology relative to IOS/IEC/IEEE 29148	Concept of Operations	Operations Concept
Definition	Authority prepares the document internally to describe the desired functionality of a proposed system; helping to determine the business-level requirements	Upon award, the project creates the document to describe the system; helping to determine the system-level requirements
Evolution	As feasibility studies provide more information and the scope plan evolves, the document should be updated as necessary.	Flexibility to evolve when updates are necessary when the project definition/ direction changes
Delivery	Include in Contract Advertisement	Program/Project Deliverable
Authors (SEs from)	Authorities/ Agencies/ Consultants	Contract Prime/ Subcontractors/ Consultants

ConOps development guidance is provided in numerous Data Item Description documents from NASA, DOD, as examples, and it is not the intention of this paper to describe the development of a ConOps. This document is intended to highlight the importance of early stakeholder identification and involvement. The ConOps provides a way of communicating the stakeholder needs, as that input is imperative in shaping what requirements must be satisfied by the system. The iterative nature of the stakeholder needs elicitation using a ConOps review cycle is a key method used by Systems Engineers for capturing the most complete set of stakeholder needs and operational scenarios across the entire lifecycle of the system.

The System Lifecycle and its timing relationship to ConOps development and OpsCon development is provided in the Vee model diagram that follows.

The Audience.

Who is the ConOps for? Who will the document be distributed to? What level of influence? What is the knowledge level; subject matter experts (SMEs), or board of directors?

Proposal: Write it like a children's storybook; accessible to everyone.

Assume the Concept of Operations document will be distributed, and/or available, to various knowledge levels within the agency. With this approach, readers within the organization with general knowledge of the topic should be able to comprehend the intent and have the same understanding level, as well as determine and define the project expectations.

> Ideally, the ConOps document should be written by representatives of the user community. In practice, other individuals or organizations may write the ConOps (e.g., the buyer, a third-party consultant, and/or the software developer). In these cases, it is essential that user representatives be involved in reviewing, revising, and approving the ConOps document. The primary goal for a ConOps document is to capture user needs, and to express those needs in the user's terminology. (IEEE Std 1362) [2]

Given the audience of a ConOps is the user community, the audience members with a vested interest in the SOI can transition to stakeholder. These identified stakeholders can provide pertinent input to the development of the document, thus transition from audience member to a contributing author to the creation of the ConOps.

Determine the Stakeholders

A simple, useful definition of 'Stakeholder' is provided by the Association for Project Management (APM) which states: "Stakeholder: individuals or groups who have an interest in the project, programme or portfolio because they are involved in the work or affected by the outcomes."

Analyzing an organization's current business capabilities and organizational charts helps to identify which groups will be impacted by the SOI. Within each identified stakeholder group, first, second, tertiary, etc. levels of personnel are identified, so the correct form of stakeholder engagement is held with individuals in the correct level role/responsibility. For instance, it may not be effective to include Executives in needs elicitation workshops with end users, but a meeting to elicit the organization's high-level goals and objectives that are driving the need for the project is appropriate for the executive-level.

Typically, projects are initiated within the Program & Planning Department of an agency. Resources from this department include Project Initiators, Project Managers and Portfolio Managers. The Project Manager determines the business case and/or business need and works with Portfolio Managers and Engineers to determine the scope of the project and what must be delivered for project completion. Once defined, the Systems Engineer begins the stakeholder identification process, and identifies which resources have a vested interest in the SOI.

Vested Interest. Obvious project stakeholders that have a vested interest in the SOI are resources from the Program & Planning Department since they provide the justification of project needs, via business cases, and determine the scope and goals of the system. End users also have a vested interest, as they will receive the delivered system, and will be responsible for its operations and maintenance, and are able to recognize the system needs, as well as constraints.

Figure 3 depicts an SE approach, via an input-process-output (IPO) diagram, to the process of determining stakeholders who would have a vested interest in the system.

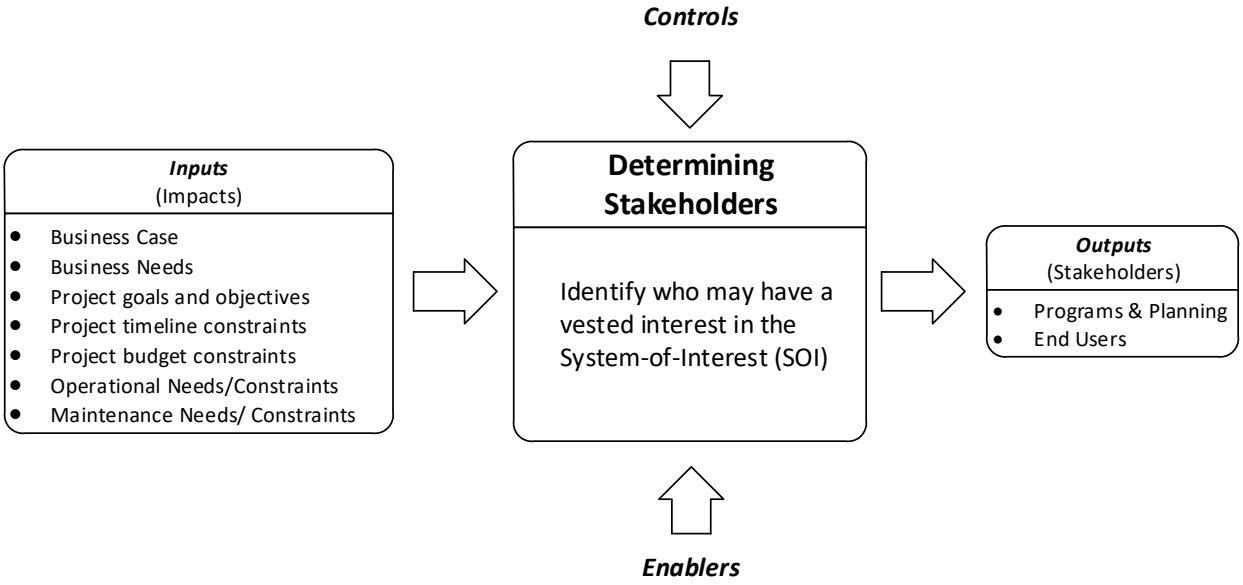

Figure 3. Determining Stakeholders IPO example

But a well-versed SE would realize there may be other influences that could impact the SOI that need to be engaged to provide a comprehensive ConOps document.

Influencers. What else could impact the proposed system? What other impacts may have an influence on the system being developed? How could audience members from other organizations and departments influence the proposed system? Do these influencers unknowingly have a vested interest?

Considering further project/system impacts, Figure 3 was updated to Figure 4, to show 'Controls' (applicable laws and regulations) and 'Enablers' (policies, procedures and standards, and organization and project infrastructure) as additional inputs that may influence system needs and/or constraints, which could potentially impact the system, and should be taken into consideration into the development of a ConOps. Table 3 displays the system impacts traced to potentially identified stakeholder.

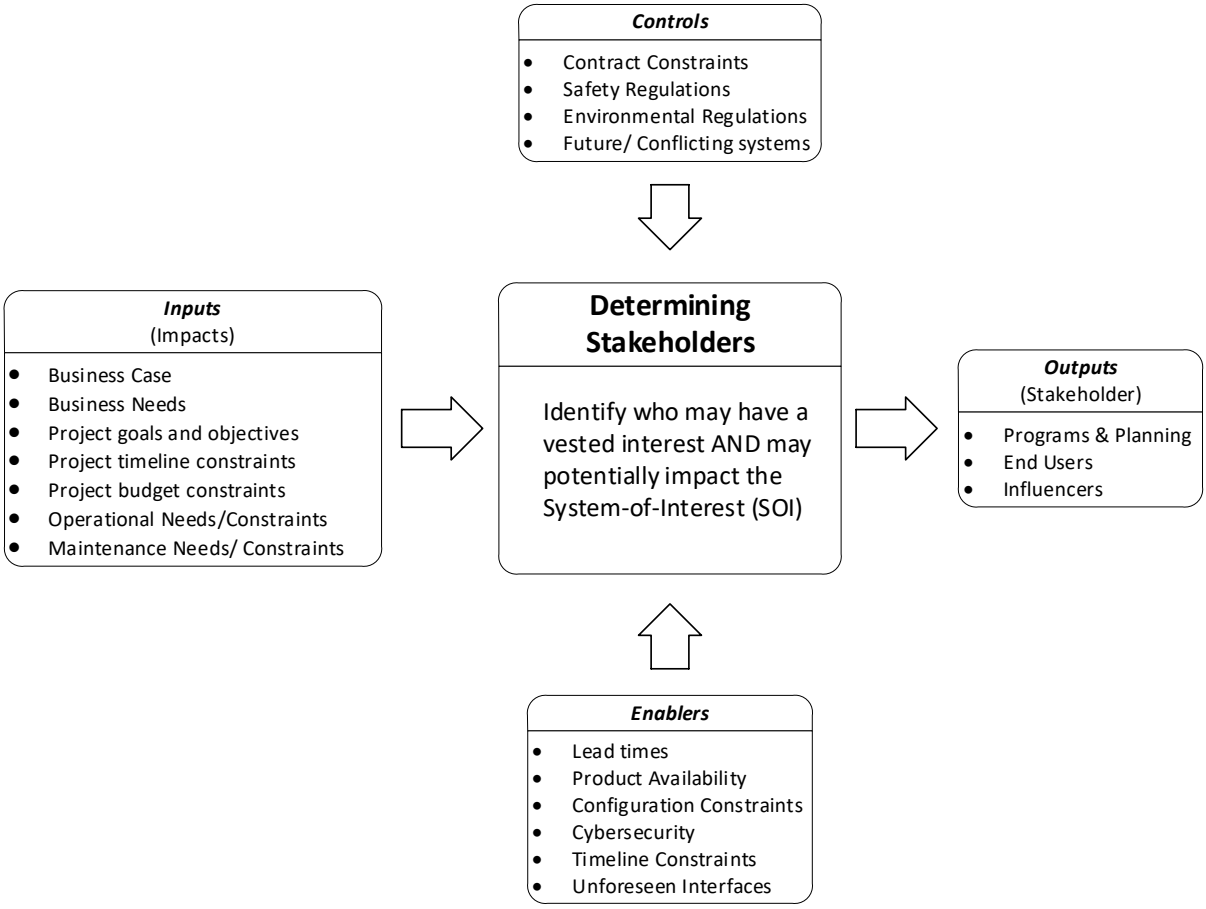

Figure 4. Stakeholder IPO with Influencers

Table 3: Stakeholder Impacts

Impacts *(Inputs)*	**Stakeholder** *(Output)*	
• Business Case • Business Needs • Project goals and objectives • Project timeline constraints • Project budget constraints • Determines what must be delivered for project completion	Project Initiators - Executive Leadership - Project Managers - Portfolio Managers	Programs & Planning
• Measures of Effectiveness (MOE) • Measures of Performance (MOP)	Engineering - Subject Matter Experts	
Potential worker constraints: i.e., union may not allow certain job activities	Operations Management	End Users
• Identify and prioritize user needs • Identify potential/unforeseen interfaces	Operators - Operators - Dispatchers	
• Identify Fault Monitoring and System Performance needs • Identify redundancy, sparing, storage and backup needs	Maintainers	

Impacts *(Inputs)*	**Stakeholder** *(Output)*	
• Potential configuration constraints • Potential cybersecurity constraints	Information Technology	Influencers
• Permits • Regulations, legislative constraints • Environmental Studies • Community/ Public Relations	Environment & Sustainability	
• Potential contract constraints • Potential extended lead time • Potential product unavailability	Procurement	
• Potential contract constraints • Insight into potential legal impacts to organization based on solution alternatives (i.e. potential increase of litigation cases against organization that could result due to implementation of new/updated system)	Legal	
Potential safety regulations/ constraints	Safety	
Potential/unforeseen interfaces	Construction Management	
Project timeline constraints	Schedulers	
Future projects, conflicting projects or interfacing systems that may affect the functionality of desired system, both internal and external to the SOI boundary	Interfacing Systems	

Stakeholder Engagement and Management.

Once stakeholders are identified, stakeholder engagement and stakeholder management are critical for successful project delivery, and yet are often regarded as bureaucratic activities that can be outsourced to administrative staff who are not, themselves, directly engaged in the project. Ultimately the way people perceive the project and react to it dictates, to a great amount, how successful the project will be.

For discussion purposes, this paper will define Stakeholder Engagement as the process of eliciting or receiving of information from stakeholder or other resources. Stakeholder Engagement is the main path to discovering requirements and design information.

The development and continuous improvement of the ConOps by stakeholders requires a level of emotional commitment on the part of the Stakeholders that must be engendered, in part, by the ConOps. If the Stakeholders are not involved in the early and full development of the ConOps, they will not 'feel' engaged.

Barriers to Engagement

The difficulty of engaging stakeholders in the development of a ConOps should not be underestimated or trivialized. This can be demonstrated by substituting the phrase "Employee Engagement" for the phrase "Stakeholder Engagement" in the following discussion.

Gallup has been studying Employee Engagement for several years and the 2018 estimate of engaged employees is now up slightly (in the US) to 34%. The number of "actively disengaged" employees is currently estimated to be 16.5%, with the balance of 49.5% being simply "disengaged".

Consider a large infrastructure project with 250 stakeholders that have been identified. Based on the Gallup study cited above, you could statistically anticipate that around 85 stakeholders will be positively engaged in the ConOps work and around 41 could be disruptive or even passively acting as saboteurs. The other 124 may simply not participate or may only participate to a very minimal level. With approximately 165 of 250 stakeholders not properly engaged, this is not a trivial issue.

SE Role in Engagement

The mandate for a Systems Engineer is to be a cross-discipline communicator. With that goal, the SE must ensure that the ConOps development process is engaging for the Stakeholders and that they, in turn, 'feel' engaged in the development of the works. Successful stakeholder engagement requires relationship building, communication, negotiation, and compromise skills. Successful completion of a project is defined by how the Stakeholders view it. Stakeholder requirements, expectations, perceptions, personal agendas and concerns will influence the project and inform what success looks like. Table 4 exhibits some benefits and risks to stakeholder engagement.

Table 4: Benefits-Risks from Stakeholder Engagement

Benefits of Stakeholder Engagement	• More complete picture of current problem space and needs • Increased trust and confidence across the project community • Clearer understanding of remaining resistance • More robust risk management • Increased awareness of progress and delays • Increased awareness of organizational issues • Innovation - Increased awareness of industry benchmarks • Improved Strategic Thinking from varying viewpoints • Early buy-in from user and maintainer groups
Risks of poor Stakeholder Engagement	• Reactive vs. Proactive, strategic approaches • Uncertainty of project outcome • Emotional failure, shortcoming • Unprofessional or unethical behaviors • Diversion and distraction of resources • Silo Thinking • Potential Conflicts

Stakeholder Management

Stakeholder Management is often misunderstood as 'the power to force stakeholder engagement' to occur. Stakeholder Management is a process consisting of Identification, Analysis and Management and is defined in the APMBoK as: "the systematic identification, analysis, planning and implementation of actions designed to engage with stakeholders".

Stakeholder Complexity. An example of the variety and quantity of Infrastructure Project Stakeholders within a single organization is provided in Figure 5. Multiplying this by the number of organizations involved provides a realistic sense of the complexity of the stakeholder engagement task in a transportation infrastructure project.

Table 5 shows key success factors for Stakeholder Management.

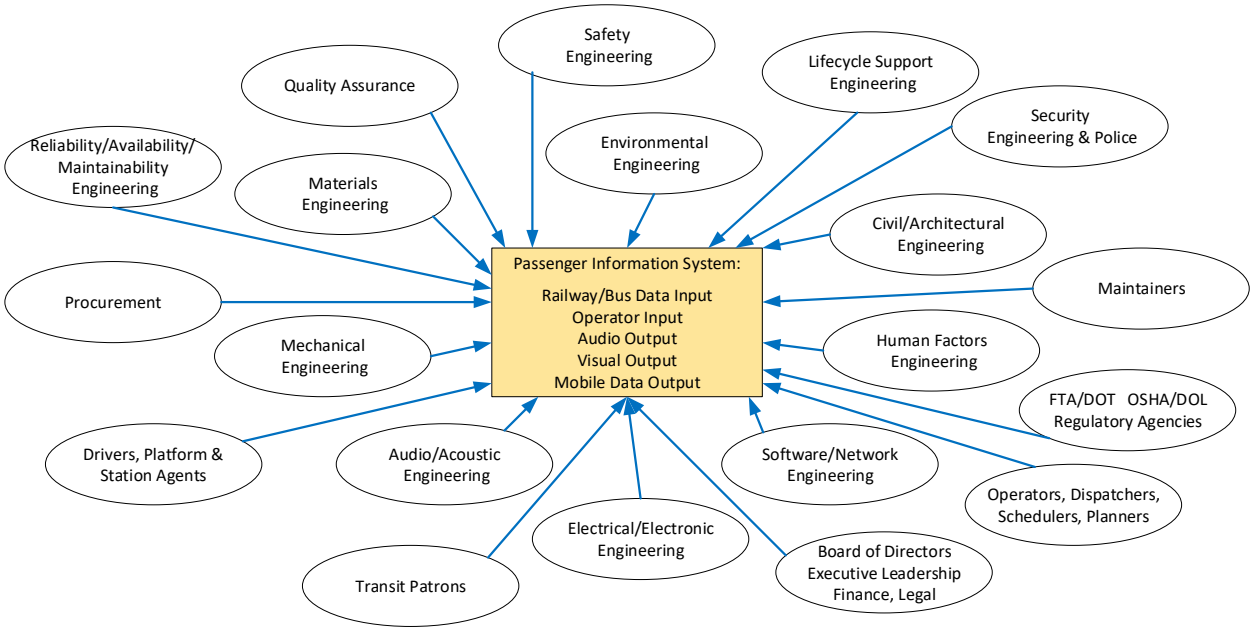

Figure 5. Typical Infrastructure Stakeholder Group

Table 5: Key Success Factors for Stakeholder Management.

Stakeholder Management Planning	Use a conscientious approach to stakeholder management
The Stakeholder Management Plan is not Static	The SMP is dynamic, respond as needs arise.
Define Project Success	Project success means different things to different stakeholders.
Understand the spectrum of Stakeholders	Consider the abilities of each stakeholder.
Compromise and Consensus – Decision Support	Ensure that decisions are agreed, supported.
Human Variables	Humans do not always behave in a consistent or predictable way. Stakeholders may not always seem rational or reasonable. It is necessary to operate with an awareness of human feelings – this is often ignored by technical staff. Also, understand that there will be personal agendas. Understand the Reward Structures = root cause of behavior, i.e., PM are rewarded by adherence to budget and schedule
Stakeholder Engagement	Early, Continuous, Transparent communications, keep records, plan.
Build Relationships	Developing relationships results in increased trust and confidence. Ensure conflicts are identified and mitigated early.
Group Roles – RACI	Define early: Responsible, Accountable, Consulted, and Informed.
Stakeholders can represent Project Risks.	Potential sources of risk - depends on influence level.

How to Engage

There are many methods used to engage with stakeholders. Several different methods may be required for a particular stakeholder group. There is no "one size fits all" approach to engagement – the techniques required vary as significantly as the variety of people involved.

Use Case 1: Not all people are adept at reading or providing written specifications, needs and requirements. Non-technical stakeholders may require a lot of visual aids. Models, rapid prototypes, and simulations can provide the stimulus to generate comments, from which the SE can extract user needs.

Use Case 2: Technicians or maintenance staff may prefer to be shadowed in their duties. This allows better questions to be generated and allow these stakeholders a true sense of being listened to.

Use Case 3: End users of a Graphical User Interface (GUI) would like to "try before they buy" as much as possible. Consider rapid prototyping of the GUI and several sets of training sessions to keep stakeholders engaged for the entire project.

Practical techniques and tips for engagement with stakeholders are provided in the Table 6.

Table 6: Engagement Techniques

Technique	Procedure	Notes & Tips
Interview	Conduct interviews to gain an understanding of the current system. Gather ideas and concepts to gauge where everyone's understanding, and expectations are for a proposed system. Identify current issues and system constraints known to that stakeholder. Identify the external interfaces and interactions. Identify potential and known risks.	Interviews can be conducted individually, within user groups, using focused groups then multiple user groups together, and/or departments with common needs. It is not uncommon for the ideas gathered from each group/individual to be vastly different and contradictory. It is the task of the Systems Engineer(s) to guide the development and deliver a viable product.
Requirements Workshops	Focused working sessions with Stakeholders to review user needs to ensure they are clear, feasible, and conflict-free.	Doing this early in the project cycle facilitates requirements agreement later during design and verification activities.
Surveys and Questionnaires	Use this when the Stakeholders are geographically dispersed, or face-to-face interactions are very much constrained.	Limit use of remote techniques. Limit use of requiring persons unfamiliar with engineering to perform self-elicitation.
Diagrams, schematics, figures, photos and graphs	Drawings can help convey the stakeholders' visions and display their expectations. What some may not be able to describe with words, they may be able to display with figures.	There is truth behind the saying pictures are worth a thousand words. Many people are visual learners and thinkers – a visual approach optimizes their ability to contribute.
Benchmarking	Score best practices and market analysis for the system of interest – contrast the new system concept against what is currently available	Helps to "sell" the concept – may assist in the generation of new stakeholder needs missed otherwise.
Document Analysis	Review existing documentation (e.g., standard operating procedures, system documentation, screen layouts, etc.) to gain better insight into the current system and operations in order to more effectively engage the stakeholders.	Also allows for an "audit" of whether current procedures and processes are working well and where gaps need to be addressed.

Technique	Procedure	Notes & Tips
Observation	Shadowing an end user, observing how they use the current system and discovering ways in which to improve the process.	This represents gathering a sense of "a day in the life of…" This approach can showcase issues or features which the stakeholder may otherwise forget to mention or may have not noticed because of repetition.
Brainstorming	Provide a platform that enables Stakeholders to share their ideas and visions through a free-flowing, creative discussion. Information captured during these sessions will influence decision-making going forward.	Use of formal brainstorming methods such as 'Brainwriting-6-3-5' and 'Affinity Diagramming' can yield excellent results and can improve teambuilding for the project.
Peer Reviews	Reviews of project Concept of Operations or similar documents builds consensus and stakeholder acceptance. Stakeholders realize that they have a true voice in the project.	Several peer reviews may be necessary to refine the purpose and use of the proposed system, as well as address any potential conflicts and mitigate to achieve concurrence. Use this technique to review the Stakeholder List and Management Plan.
Training Sessions	Provide training sessions to different stakeholder groups for different aspects of the SOI. The User Interface is an excellent example of early training. This solves two user needs – actual training and user feedback.	Use this several times during the concept and development cycle to maintain engagement. This technique makes official training at the end of the project less onerous and provides better training quality.

The end goal of Stakeholders Engagement is continuous buy-in (i.e., ownership) of the project and the project Concept of Operations. 'Buy-in' is a phrase which represents the emotional attachment and satisfaction that a stakeholder will experience when they feel like a contributing part of a project team; an author of the ConOps.

When to Engage

Figure 6 depicts points within the project lifecycle, stakeholder engagement would be initiated.

During Project Initiation, engagement with stakeholders from both the Program & Planning Department and Operations Management should begin. These stakeholders have the insight of the current system's deficiencies and when the useful life of the system is nearing replacement. As the project details and needs are realized, engagement from Influencers, such as Procurement and Legal should be engaged to identify any potential constraints, i.e., sole source procurements.

Once a project moves into the planning phase, the SMEs, Operators and Maintainers should be engaged to describe how the new system will be used. It is not unforeseen for these stakeholders to be engaged even sooner.

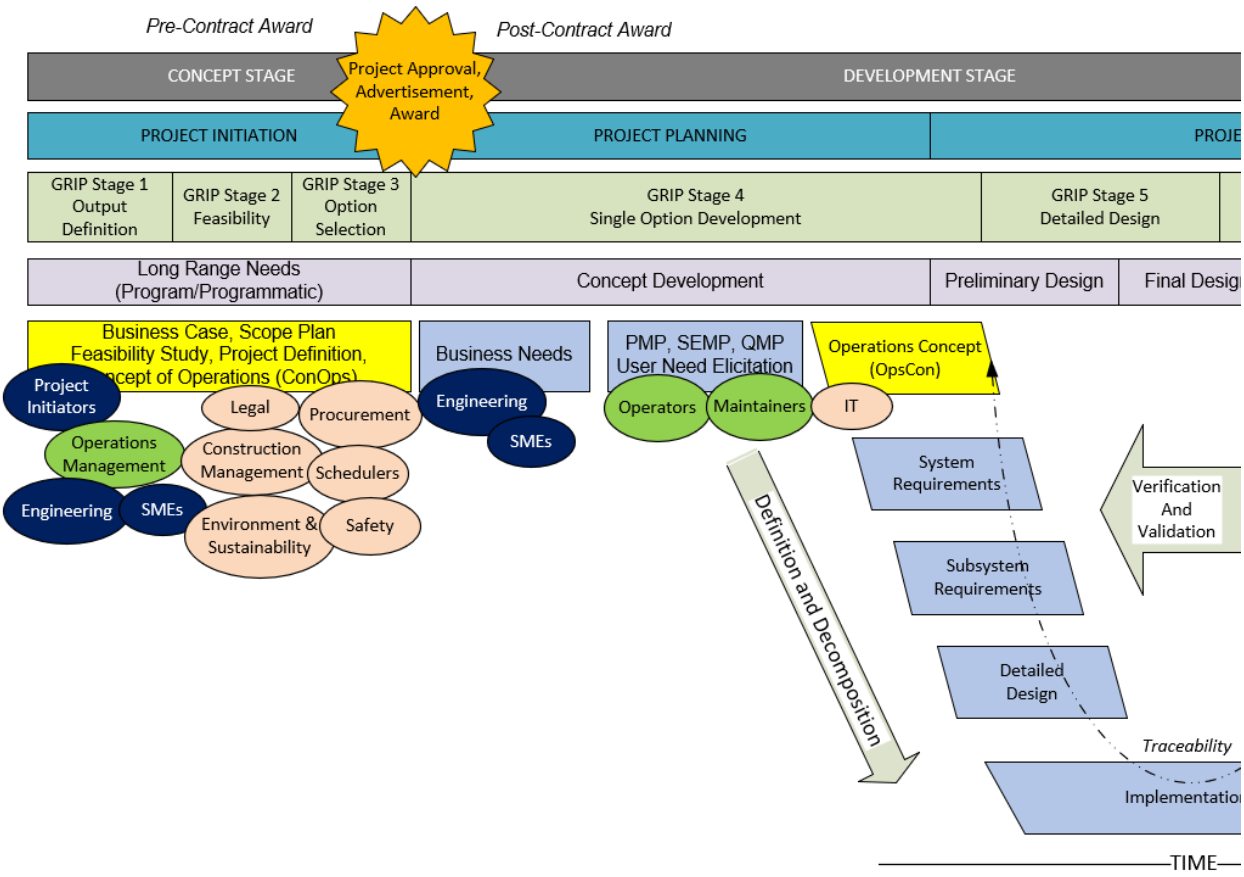

Figure 6. Stakeholder Engagement within Transportation Project Lifecycle (V-Snapshot)

Where to Engage

Figure 7 shows a broad example of areas within a Concept of Operations where various stakeholders can provide pertinent input.

The ConOps Document Outline shown is a reference from IEEE Standard 1362™-1998 (R2007), which was synchronized into ISO/IEC/IEEE 29148:2011.

Phase		Stakeholder Roles/ Contributions	Stakeholders													
			Prgs & Planning			*End Users*			*Influencers*							
Project Initiation	Project Planning	**CONOPS Documents Outline [2]**	Project Initiators	Engineering	SMEs	Ops Management	Operators	Maintainers	Procurement	Construction Mgt	Environ & Sustain.	IT Department	Schedulers	Safety	Legal
x	x	Title page		x											
x	x	Revision chart		x											
x	x	Preface	x	x											
x	x	Table of contents		x											
x	x	List of figures		x											
x	x	List of tables		x											
x	x	1. Scope	***x***	***x***	***x***	***x***					***x***				
x	x	1.1 Identification	x	x		x					x				
x	x	1.2 Document overview		x											
x	x	1.3 System overview	x	x	x						x				
x	x	2. Referenced documents		x	x						x				
x	x	3. Current system or situation	***x***	***x***	***x***	***x***	***x***	***x***			***x***	***x***			
x	x	3.1 Background, objectives, and scope	x	x	x	x					x				
x	x	3.2 Operational policies and constraints		x	x	x	x	x			x	x			
x	x	3.3 Description of the current system or situation		x	x	x	x	x			x				
x	x	3.4 Modes of operation for the current system or situation		x	x	x	x	x			x				
x	x	3.5 User classes and other involved personnel		x	x	x	x	x			x	x			
x	x	3.6 Support environment		x	x	x	x	x			x				
x	x	4. Justification for and nature of changes	***x***	***x***	***x***	***x***	***x***	***x***			***x***				
x	x	4.1 Justification of changes	x	x	x	x					x				
x	x	4.2 Description of desired changes		x	x	x					x				
x	x	4.3 Priorities among changes		x	x	x	x	x			x				
x	x	4.4 Changes considered but not included	x	x	x	x					x				
x	x	5. Concepts for the proposed system	***x***	***x***	***x***	***x***	***x***	***x***			***x***	***x***		***x***	
x	x	5.1 Background, objectives, and scope	x	x	x	x					x				
	x	5.2 Operational policies and constraints	x	x	x	x					x			x	
	x	5.3 Description of the proposed system		x	x	x					x				
	x	5.4 Modes of operation		x	x	x	x	x			x				
x	x	5.5 User classes and other involved personnel		x	x	x	x	x			x	x			
x	x	5.6 Support environment		x	x	x	x	x			x				
	x	6. Operational scenarios		x	x	x	x	x			x				
x	x	7. Summary of impacts	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***	***x***
x	x	7.1 Operational impacts		x	x	x		x			x		x	x	x
x	x	7.2 Organizational impacts	x	x	x	x				x	x		x	x	x
	x	7.3 Impacts during development		x	x	x	x		x	x	x	x	x	x	x
x	x	8. Analysis of the proposed system	***x***	***x***	***x***	***x***	***x***		***x***	***x***	***x***	***x***		***x***	***x***
x	x	8.1 Summary of improvements	x	x	x	x	x				x				
x	x	8.2 Disadvantages and limitations		x	x					x	x	x		x	
x	x	8.3 Alternatives and trade-offs considered	x	x	x	x			x		x				x
x	x	9. Notes		x							x				
x	x	Appendices		x							x				
x	x	Glossary		x							x				

Figure 7. Stakeholder Engagement

Case Study.

The success, completeness, and effectiveness of a ConOps is based largely on engaging the right stakeholders, at the right level (i.e., roles and responsibility), and at the right time in the development cycle. Looking beyond the usual go-to Stakeholders, like the end users and maintainers, to groups that may not typically be considered as influencers on or interested parties in the project can provide perspectives that end up shaping the system's development.

For this Case Study, one such influencer group is the Legal Department.

Upon initial identification of Stakeholders for a system-wide Subway Platform Safety Project, ConOps development began with engagements of the end users to understand the initial need for a system that would increase passenger's safety on the platform while also providing agency personnel with increased situational awareness of potential safety-related events.

The Systems Engineers used various elicitation techniques throughout this process including benchmarking, questionnaires, document analysis and white paper review, interviews, requirements workshops, and illustrations to depict the boundary of the system under discussion. On a suggestion from the design management's team, the SEs invited the Legal Department to participate in engagements with the Safety Department, as these two groups work together to gather and analyze safety data.

At the time, the Legal Department was in the midst of a lawsuit which focused on passenger safety on the platform. The insight and background information that the Legal Department provided during the development of the ConOps shed a new light on the solution concepts under discussion. Given their field of expertise, discussions centered around potential liability-related concerns, background on current agency safety policies and practices, and insight into the effectiveness of deploying low-tech solutions versus high-tech solutions, from their point of view. Internal to their own operations and to support their defense in lawsuits, they noted the importance of performing feasibility studies for deploying safety systems and benchmarking with other agencies.

Legal raised some good discussion points, such as, what if the system fails or why was the system installed at Station A, but not a Station B. Safety is the Agency's priority, but by implementing new safety systems, lawsuits are still a risk; as "safety is often difficult if not sometimes impossible to entirely predict, manage and guarantee". Legal stated that if the Agency performs the analysis to ensure that the systems are well designed and can provide rationale for decisions to implement different systems at station locations this would help in their defense of potential lawsuits.

Systems Engineering used this information during subsequent stakeholder elicitation sessions and included the Legal Department in the impact analysis within the ConOps document which identifies how (positively and negatively) the SOI could impact each stakeholder group. An added benefit of involving the Legal Department in the ConOps discussions with other stakeholders was their exposure to discussions about systems that are currently deployed in the subway stations of which they may not have been familiar. This new insight could help them in their legal operations going forward.

The Legal Department was appreciative of being asked to participate in the development of the ConOps, noting that they are not usually included in discussions during the development of new systems, but only get involved from a legal aspect if there are incidents resulting from the deployment of new systems.

Conclusion.

Stakeholder identification, engagement and management play a significant role in how a project/ system ConOps is developed. By realizing underlining impacts, identifying the intended audience of a ConOps, as contributing stakeholders, aides in the development of a more robust document.

This paper offered stakeholder engagement techniques, with the expectation to gain insight of system impacts, while collecting audience contributions that can be incorporated into the ConOps. The stakeholders, through these activities, become authors to several sections of the ConOps document outline. All while the Systems Engineer thoughtfully manages the engagement activities.

References.

Haskins, C. (ed.), 2015, *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities*, Version 4.0. Revised by D. Walden, G. Roedler, K.J. Forsberg, R.D. Hamelin, T.M. Shortell. INCOSE, San Diego, CA (US).

IEEE Computer Society, Approved 19 March 1998, Reaffirmed 5 December 2007. *IEEE Guide for Information Technology - System Definition-Concept of Operations (ConOps) Document*, IEEE Standard 1362-1998 (R2007).

IEEE Computer Society and ISO/IEC Joint Technical Committee. First Edition, 1 December 2011. *Systems and Software Engineering – Life Cycle Processes – Requirements Engineering*, ISO/IEC/IEEE 29148:2011.

American Institute of Aeronautics and Astronautics, January 22, 1993, *ANSI/AIAA G-043-1992, Guide for the Preparation of Operational Concept Documents*, Washington, D.C.

Association for Project Management, APM Body of Knowledge, 6th edition (2013) – Definition of the word Stakeholder, Ibis House, Regent Park, Bucks, UK

Concept of Operations, *MITRE Systems Engineering Handbook*, viewed on 20 August 2019, <https://www.mitre.org/publications/systems-engineering-guide/se-lifecycle-building-blocks/concept-development/concept-of-operations>

Eby, Kate. 15 December 2017, *Write a Winning Request for Proposal and Conquer the Process in Your Company*. Smartsheet., Viewed on 3 September 2019, <https://www.smartsheet.com/request-for-proposal>

Cloutier, Robert. 31 May 2010, *Investigation of a Graphical CONOPS Development Environment for Agile Systems Engineering - Phase II*. Report No. SERC-2010-TR-007.

International Institute of Business Analysis (IIBA), 2015, *Business Analysis Body of Knowledge (BABOK)* Version 3.0.

Department of Defense, 1985. DID DI-MCCR-80023, Operational Concept Documents, SDS Documentation Set – Data Item Descriptions for DoD-STD-2167.

Department of Defense, DID DI-IPSC-81430, Operational Concept Description (OCD)

Lano, Robert J, *"A Structured Approach for Operational Concept Formulation"*, reprinted in Thayer, Richard H and Dorfman, Marlin, System and Software Requirements Engineering, IEEE Computer Society Press Tutorial, IEEE Computer Society Press, Los Alamitos, California, 1990.

Structured Approach for Operational Concept Formulation (OCF), TRW Defense and Space Systems Group, T-031-979, Redondo Beach, California, January 1980.

Strengers, George. 2000, *Development of Operational Concept Descriptions (Analyzing what the customer needs)*, Proceedings of the 2000 Systems Engineering / Test and Evaluation Conference, Australia.

Federal Highway Administration, August 2005, *FHWA-HOP-07-001, Developing and Using a Concept of Operations in Transportation Management Systems.*

ISO 14711:2002(E), *Space systems – Unmanned mission operations concepts – Guidelines*, 2002.

Vogwell, D. (2003). *Stakeholder management*. Paper presented at PMI® Global Congress 2003—EMEA, The Hague, South Holland, The Netherlands. Newtown Square, PA: Project Management Institute.

Kruse, Kevin. 22 June 2012, *Leadership: What Is Employee Engagement*, Forbes, Viewed on 21 September 2019, <https://www.forbes.com/sites/kevinkruse/2012/06/22/employee-engagement-what-and-why/#35d63caa7f37>

Hastings, Rebecca R., 4 March 2019, *The 'What' and 'Why' of Employee Engagement*, SHRM Article, Viewed on 21 September 2019, <https://www.shrm.org/resourcesandtools/hr-topics/employee-relations/pages/ whatandwhy.aspx>

Merriam Webster as "emotional involvement or commitment". Viewed on 12 October 2019, https://www.merriam-webster.com/dictionary/engagement

Harter, Jim., 26 August 2018, *Employee Engagement on the Rise in the U.S.*, Gallup: ECONOMY. Viewed on 21 September 2019, <https://news.gallup.com/poll/241649/employee-engagement-rise.aspx>

Adkins, Amy., 28 January 2015, *Employee Engagement: Majority of U.S. Employees Not Engaged Despite Gains in 2014*, Gallup, Viewed on 21 September 2019, <https://news.gallup.com/poll/181289/majority-employees-not-engaged-despite-gains-2014.aspx>

Morgan, Jacob, 10 March 2017, *Organizational Culture: Why the Millions We Spend on Employee Engagement Buy Us So Little*, Harvard Business Review, Viewed on 21 September 2019, <https://hbr.org/2017/03/why-the-millions-we-spend-on-employee-engagement-buy-us-so-little>

Yohn, Denise Lee. *MANAGING PEOPLE: Engaging Employees Starts with Remembering What Your Company Stands For*, Harvard Business Review, Viewed on 21 September 2019, <https://hbr.org/2018/03/engaging-employees-starts-with-remembering-what-your-company-stands-for>

Brook, Jessica, 13 March 2018, *Why Employee Engagement Is Key To Company Success*, Employee Experience, May 7, 2019, Viewed on 21 September 2019, <https://www.socialchorus.com/employee-engagement-key-to-company-success/>

Goodall, A. & Buckingham, M., 13 June 2019, *Leadership & Managing People: The Real Secret to Employee Engagement*, Harvard Business Review, Viewed on 12 October 2019, <https://hbr.org/webinar/2019/05/the-real-secret-to-employee-engagement>

PMBOK Guide and Standards. Project Management Institute. Viewed on 7 September 2019, <https://www.pmi.org/pmbok-guide-standards>

STEVENS, M., ed., 2002, Project Management Pathways, GB: The Association for Project Management Limited.

Hessami, A.G.. (2012). *A Systems Approach to Assurance of Safety, Security and Sustainability in Railways.* 10.5772/36426.

Biography

Authors (**Shown in alphabetical order, not based on contribution*)

Dale Brown joined Hatch in 2019 as Director - Systems Engineering. Dale has recently completed work as the seconded Requirements Manager for Bombardier on the Long Island Railroad / Metro-North Positive Train Control program. Dale is currently the Systems Engineering Manager for the BART CBTC train control modernization program.

Dale has acquired expertise in embedded control of specialty equipment, mining, heavy construction, military and rail vehicles throughout the US, Canada, South America, and Europe. Dale is a licensed professional engineer with extensive design, management, and business development experience. He has been awarded a number of patents in the areas of PTC, train control and inter-consist trainline communications.

Dales' industry experiences include: WSP (AVP Systems Engineering), MARTA (Seconded Director of Systems Engineering), Atkins (Director of Systems Engineering), NYCT (ANA SE Manager for the ISIM-B Project), Electro-Motive Diesel (Systems Engineering – PTC and Locomotive Control), GE Transportation Systems (Section Manager - Controls and I-Based), Alcatel Transportation Automation Systems (Design Manager – Vehicle Controls), Rovehn Engineering Corporation (President & Founder), Alford International (Senior Consulting Engineer), GM Light Armored Vehicle (Senior R&D Engineer) and General Motors Locomotive Group (Senior QA Test Engineer, Senior Design Engineer).

Dale is co-Chair of the INCOSE Transportation Working Group and co-Chair of the INCOSE Configuration Management Working Group. Dale is the chair of the APTA Systems Engineering Subcommittee, the relationship manager for the APTA/INCOSE cooperative agreement and technical lead / project manager for the new APTA Systems Integration Standard currently under development.

William Gleckler is the Director & Principal Systems Engineer for the MTA, Construction & Development (C&D) business unit. After 18 years in the design and manufacturing of products and systems used in the automotive, defense and aerospace industry Bill joined the MTA-NYCT agency in 2003 to work in Subway Operations. In 2005 he joined the Capital Program Management Department as Deputy Commissioning Officer and later in 2010 transferred into the Systems Engineering business unit which he leads for the MTA C&D Organization.

Chamara Johnson is a Director, T&R Systems Engineer at WSP. Her systems engineering experience spans the whole system lifecycle with a strong emphasis on requirements and test, working across various industries, including DOD, non-profit Oceanographic, and Transportation, in the US and UK. Chamara has a BS in Electrical Engineering from the Georgia Institute of Technology and a MS in Engineering Management/ Systems Engineering from the University of Maryland, Baltimore County.

She is an active member of INCOSE's Transportation WG, Infrastructure WG, and Integration, Verification and Validation WG; Vice-Chair of Section Activities of the IEEE New York Section Executive Committee, and Chair of the IEEE NY Chapter of the Vehicular Technology Society; as well as a member of the APTA Systems Engineering Subcommittee. Chamara is also a Certified Systems Engineering Professional.

Devon McDonnell is a Systems Engineer within the Transit and Rail Division of WSP. Her experience across the systems engineering lifecycle includes analyzing clients' existing processes, developing to-be solution concepts, leading stakeholder engagement sessions, soliciting system needs and requirements, developing Concept of Operations documents, supporting requirements management, and modeling system architecture, capabilities, and operational activities. Devon is a Certified Associate Systems Engineering Professional.

Allison Ruggiero is a Systems Engineer within MTA's Construction and Development department. Allison joined the agency in 2013 after completing a M.S. in Systems Engineering from Johns Hopkins University. She previously acquired work experience as a Project Manager for the NYC Fire Department and as a Packaging Design Engineer and Project Lead at Sandia National Laboratories in New Mexico, where she attained a B.S. in Electrical Engineering from the University of New Mexico.

Allison applies systems engineering system and software lifecycle processes to MTA's complex communications system projects along with specialty activities like Human Factors and Reliability, Availability, and Maintainability. Allison is also a Certified Systems Engineering Professional, a member and co-Chair of the INCOSE Transportation Working Group, and a member of the APTA Systems Engineering Subcommittee.

Denis Simpson is an Associate Director (Systems Engineering, Integration & Assurance) in the Transportation & Infrastructure Strategic Business Unit for WSP UK. He has over 30 years' experience from systems and software requirements analysis and capture through to integration and user acceptance in many sectors. He has worked as a systems engineer on some of the UK's major engineering programmes: including, London Heathrow's Terminal 5, and Network Rail's Thameslink Programme.

Denis has a B.Sc. in Mathematics from Imperial College London and a Ph.D. in Nuclear Engineering from Queen Mary University of London. He has Chartered Engineer status with the UK's Engineering Council as well as being a Chartered Scientist and Mathematician with the UK's Science Council. Denis is an active member of the INCOSE UK Railway Interest Group and is a co-Chair (EMEA) for the INCOSE Transportation Working Group. Also, he volunteers as a Mentor and Professional Registration Assessor for the Institution of Engineering & Technology.