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Standardized Interface Matrix (SIM): Enhancing Multi-Contractor Coordination in Large-Scale Projects

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ABSTRACT

This white paper introduces the Standardized Interface Matrix (SIM), an innovative tool designed to address the challenges of multi-contractor coordination in large-scale projects. The purpose of this SIM to reduce delays, avoid cost overrun, improve quality, and minimize risks associated with complex project interfaces by clearly defining interface points (IPs), responsibilities, and deliverables. This paper outlines the development, implementation, and benefits of the SIM, using a case study from the King Salman Energy Park (SPARK) Phase 1 Program to illustrate its practical application. This Paper demonstrates that the SIM has the potential to significantly enhance project efficiency, quality, and risk management in complex, multi-contractor environments.

INTRODUCTION

Large-scale projects, particularly in the energy sector, often involve multiple contractors working on interdependent activities. The complexity of these projects can lead to delays, cost impacts, quality issues, and increased risks due to unclear responsibilities at interface points. The lack of a standardized approach to managing interfaces between contractors frequently results in schedule and cost impacts due to conflicting interpretations of scope, quality issues arising from discrepancies in interface task execution, and increased project risks, including disputes and reworks.

As Sun et al. (2024) highlighted, "the tension between project management success and operation success is widely acknowledged". They further noted that one root cause of this tension lies in the conflicting interests among stakeholders, especially project managers and owners. The SIM aims to address this issue by providing a structured approach to interface management that aligns the interests of various project stakeholders.

This paper presents the Standardized Interface Matrix (SIM) as a solution to enhance multi-contractor coordination, improve project efficiency, and reduce risks associated with complex interfaces. The SIM provides a structured approach to defining and managing interface points, ensuring clear communication and responsibility allocation among various project stakeholders.

Yeh et al. (2017) emphasized that "managing the engineering interfaces of mass rapid transit (MRT) projects is difficult and exhausting work because thousands of complex interrelated construction interfaces are embedded among multiple sub-works and subsystems". They further noted that when these interfaces are not revealed and thoroughly preplanned to achieve timely execution, they generate countless disputes among project parties and delay the overall progress considerably. The SIM aims to address these challenges by providing a comprehensive and empirical solution for managing complex engineering interfaces.

Furthermore, as highlighted by Yeganeh et al. (2019), poor interface management may result in low productivity, poor quality, and cost overruns, significantly reducing overall project performance. The authors emphasize that the use of interface management has many benefits, including creating a deep understanding of project complexity and interface issues, optimizing the quality and constructability of designs, and improving project planning by avoiding or eliminating potential interface issues. The SIM incorporates these insights to enhance project performance through effective interface management.

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METHODOLOGY

The development of the SIM involved a wide-ranging process that engaged Subject Matter Experts (SMEs) from various disciplines and backgrounds based on organization's nature of programs and/ or projects. Assigned SMEs must be well-familiar with scope of work (SoW), governmental processes, procedures and standards, and it is highly recommended to be approved by cross-functional SME committee Chairman (Executive-Level). The methodology includes the (1) formation of a "cross-functional SME committee (CFSMEC)", (2) draft development of the SIM document, (3) pilot implementation and validation, (4) formal review, update, and approval processes, and a (5) formal implementation and merging into organization's procedure related to early stages of conceptual design or master-planning.

As Sun et al. (2024) noted, intra-organizational and inter-organizational boundaries between project owners and managers can result in differentiated decision rights distributions, communication channels, and diverse sanctions available to enforce authority. Shokri et al. (2015) also identified that reliable processes for the identification of key interface points (IPs) and systematic approaches for integrating iterative or cyclical interface management systems (IMS) are crucial for efficient interface management solutions. The SIM development process aimed to address these boundary differences and knowledge gaps by engaging diverse stakeholders and incorporating their perspectives.

The SIM is structured as a matrix that clearly defines interface points between contractors, responsibilities of each contractor at these points, deliverables expected at each interface, and standardized symbols representing common project activities. This structure allows for a clear visualization of complex project interfaces and facilitates easier understanding and implementation across diverse project teams.

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Yeh et al. (2017) proposed a stepwise procedure to provide an empirical and comprehensive solution for managing the engineering interface of MRT projects, which involves four steps: "(1) identification of the key interface correlation and work scope using a work-breakdown structure; (2) allocation of interface scope responsibilities and criteria using a phase approach; (3) preplanning the interface work items; and (4) setting up interface organizations using veto authorization". The SIM incorporates similar steps to ensure effective interface management.

CASE STUDY: KING SALMAN ENERGY PARK (SPARK) PHASE 1: INFORMATION & COMMUNICATION TECHNOLOGIES (ICT), SAUDI ARABIA

To illustrate the practical application of the SIM, we present a case study from the King Salman Energy Park (SPARK) Phase 1 Program, focusing on the Information & Communication Technologies (ICT) Package. The SPARK Phase 1 Program involves the development of infrastructure for a major energy park, including complex ICT systems.

The SIM was applied to the ICT package with the interfacing points (IPs) with other contractors (ICT Contractor, Infrastructure Contractor, and Building Contractor), covering areas such as Digital Central Office Building, Corporate Auditorium, GSM Towers, Outside Plant (OSP) and Inside Plant (ISP), Corporate Data-Center, Security Equipment Room, Security Control Room (SCR), Command Control Center (CCC), Telecommunication Equipment Room (TER), Telecom Rooms (TRs), Uninterruptible Power Supply (UPS) Rooms, Corporate Data Network, Security Network, Security Systems, Audio-Visual (AV) Systems, Building Management Systems (BMS), Control Systems' integrations, IP-Telephony, GSM Boosters, and Wireless Access-Points.

The package included also, sub-structure and superstructure works. Basically, civil, structural (sub-structure & super-structure), electrical, mechanical, plumping, and architectural works were included.
The aforementioned interface matrix has been created during the early program planning stage, and included into the bid-packages. The implementation of the SIM in this context resulted in clearer delineation of responsibilities between contractors, improved coordination in the installation of interdependent systems, and reduced conflicts and delays at interface points. In addition, it significantly participated in keeping the original scope of work (SoW) on track.

Table 1 presents a simplified version of the interface matrix used in the SPARK Phase 1 ICT package:

Sr. No	Interface Point	Sub- IP	System	Description of Activities	INFRASTRUCTURE CONTRACTOR		BUILDING CONTRACTOR	ICT CONTRACTOR
					NORTH PACKAGE	SOUTH PACKAGE		
248		m		FOC Duct Bank with Pull Boxes and Cable: From PV Streetlights to Admin Building CCC	D,P,I,Cs,L,C	D,P,I,Cs,L,C	Mo,Sv	
249		n		Admin Building First Fix - Cable runways & fittings, grounding & bonding			D,P,I,Cs,L,Te,Sv	In,Sv,A
250		o		Admin Building Second & Third Fix - Information Outlets & Faceplates			In, Sv	D,P,I,Cs,L,Te,Sv,C
251		p		Potable & Fire Water System: Instrument and power cables from RTU's to MOV's, Zone Flow meter, WQMS and Flow Switches	D,P,I,Cs,L,C	D,P,I,Cs,L,C		
252		q		Potable & Fire Water System: Instrument Cables from Tenant TR Room to Electrical Billing Meter and Water Billing Meters	D,P,I,Cs,L,C	D,P,I,Cs,L,C		
253		r		Irrigation & TSE Pump Station System: Instrumentation cables from RTU's to MOV's and Zone Flow meters	D,P,I,Cs,L,C	D,P,I,Cs,L,C		
254	IP-TEL-015	a	SMART CITY / COMMAND AND CONTROL CENTER	FOC Cable	Sv	Sv		D,P,I,Cs,L,Te,Sv
255		b		OSP Duct-banks, FOC conduits, pulling pits / manholes and accessories	D,P,I,Cs,Sv	D,P,I,Cs,Sv		Sv,A
256		c		OSP Route Marker Post concrete & fiber type	D,P,I,Cs,Sv	D,P,I,Cs,Sv		Sv,A
257		d		Mandrel Test, Rope, Duct plugs, Fire Stopping & sealing	D,P,I,Cs,Sv	D,P,I,Cs,Sv		Sv,A
258		e		Outdoor LV Panel	D,P,I,Cs,L,Te,Sv	D,P,I,Cs,L,Te,Sv		Sv,A
259		f		LV underground armored cable, Circuits Breakers inside FEC	Sv	Sv		D,P,I,Cs,L,Te,Sv
260		g		Console Furniture with equipment			In,Sv	D,P,I,Cs,L,Te,C,Sv
261		h		Audi visual Equipment (video wall and other AV equipment)			In,Sv	D,P,I,Cs,L,Te,C,Sv
262		i		power with complete containments, wiring and terminations			D,P,I,Cs,L,Te,C,Sv	In,Sv,A
263		j		complete data containments			D,P,I,Cs,L,Te,C,Sv	In,Sv,A
264		k		complete data wiring and terminations			In,Sv	D,P,I,Cs,L,Te,C,Sv
265		l		complete Audiovisual containments			D,P,I,Cs,L,Te,C,Sv	In,Sv
266		m		wall & ceiling finishes, door, HVAC, dimmable lights, safety lights & signage, fire system			D,P,I,Cs,L,Te,C,Sv	In,Sv,A
267		n		Workstations/PC with monitor and complete accessories				D,P,I,Cs,L,Te,C,Sv
268		o		Printer with complete accessories				D,P,I,Cs,L,Te,C,Sv
269		p		Raised Floor			In, Sv	D,P,I,Cs,L,Te,C,Sv

Where:

Acronyms	D = Detailed Design, Construction Design , Shop Drawings	Te = Termination
	I = Equipment Installation	C =Testing / Pre-commission / Commissioning
	P = Procure	Sv = Supervision
	A = Approval	Mo = Monitoring
	In = Inputs	Pr = Programming
	Cs = Construction / Installation	Sp = Specification
	L = Laying	

DISCUSSION

The implementation of the SIM in SPARK Phase 1 ICT package demonstrated several key advantages. These have enhanced coordination among contractors, improved SPARK program efficiency, and reduced program risks, which led to better quality assurance through adherence to standards.

Sun et al. (2024) found that intra-organizational boundaries, enabled by efficient interdepartmental requirements delivery and project managers' continuous life cycle responsibility, can foster a balance between project management success and operation success. In contrast, technical gaps, geographic separation, and a lack of joint responsibility over interorganizational boundaries can hamper this balance. The SIM's structured approach to interface management helps mitigate these challenges by promoting clear communication, responsibility allocation, and collaborative problem-solving.

However, the development and implementation of the SIM also presented challenges. The initial development process was complex, requiring extensive collaboration among diverse stakeholders, and direct supervision by SMEs. The approval process needed to be streamlined to ensure timely implementation. Additionally, maintaining the relevance of the SIM over time required the implementation of an accurate durational review and continuous improvement processes.

As Yeh et al. (2017) highlighted, as MRT projects become more complex with driverless technology and wireless communication-based train control signaling systems, the interfaces among core electrical and mechanical (E&M) subsystems and sub-works become even more closely related and rigorous in terms of integration specification. The SIM provides a structured approach to manage these increasingly complex interfaces effectively.

Furthermore, Yeganeh et al. (2019) suggests that interface management implementation at the early stages of the engineering design phase can improve coordination between different designers, reduce common mistakes and errors, and facilitate integration between design and construction phases. The SIM aligns with this recommendation by promoting early and proactive interface management.

IMPLEMENTATION PLAN

The successful integration of the SIM into project management practices requires a comprehensive implementation plan. This plan includes incorporating the SIM into project scope definition and design stages, making its use mandatory in relevant projects. Additionally, developing comprehensive training programs focusing on proactive interface management techniques is crucial for the effective use of the SIM.

To ensure the ongoing relevance and effectiveness of the SIM, an annual review process has been established. This process incorporates lessons learned from completed projects, allowing for continuous improvement and adaptation to evolving project management needs. As Sun et al. (2024) recommended, improvement in interface management, incentives, controls, and human capital resources should be aligned and strategically employed for overall project success.

CONCLUSION

The Standardized Interface Matrix represents a significant advancement in managing complex, multi-contractor projects. By providing a clear, standardized approach to interface management, the SIM has the potential to greatly enhance project efficiency, quality, and risk management. The successful application in the SPARK Phase 1 ICT Package demonstrates its practical value and potential for wider adoption in large-scale programs and/ or projects.

The SIM addresses a critical need in project management, particularly for large-scale, multi-contractor projects. Its structured approach to defining and managing interfaces provides a foundation for improved project outcomes. As Yeh et al. (2017) concluded, an effective interface management method applied to all types of MRT constructions could be approached through systematic and empirical procedures. The SIM incorporates these principles to ensure its applicability across various project types and industries.

A key point must be highlighted, after approving the SIM, applied changes (among the whole program/ project lifetime) to the original SoW must be inserted and reflected to the SIM. Critical changes might lead to interface point changes in responsibilities and deliverables of more than a sole contractor. This action must be reviewed by “CFSMEC” and to be approved by chairman. A minor change reflection to the SIM would prevent critical interface conflicts in the last stages of execution, contribute in managing and control the budget of program/ project, and streamline execution works. Artificial Intelligence (AI) applications and tools for interface management might be used if its proficiency has been widely proven. Using AI will provide deep accuracy under well-defined monitoring routine.

Finally, future research could explore the long-term impacts of SIM implementation across various industries and project types, as well as its potential integration with digital project management tools and methodologies. As Sun et al. (2024) suggested, additional research could examine how multiple stakeholders co-create value in public projects for both realizations of project management success and operation success.

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