Rethinking Interface Management[1]

Bob Prieto

Introduction

Today's infrastructure and facilities are "smart". At least that is our objective as we seek to enhance lifecycle performance and capital efficiency. These "smart" facilities transcend any given sector and bring new challenges to the engineering and construction industry. In some ways our more traditional projects are today outcomes focused or capabilities delivering IT projects with bits of concrete and steel wrapped around them!

This "smart" focus is not limited to just a technology and systems dimension but goes further, demanding an increased and increasing environmental, social and governance (ESG)[iii] focus as well. Together "smart" and ESG create a greatly expanded set of interfaces for program and project managers to manage. These interfaces, both familiar and new, include:

- Physical
    - Systems, structures, components (existing and new)
    - Supply chain and logistical
    - Intermediate and final states
- Digital
    - Information/signaling
    - Digital twin (design and construction models)
    - Operating models
    - Enterprise asset models
- Human
    - Users (internal to project execution team)
    - Stakeholders[iii] (External to project execution team)
- Governance[iv], management, and decision making
    - Communication
    - Contractual – recognize that interfaces may span many contracts and agreements
    - Regulatory and reporting

These interfaces require changed perspectives with respect to:

- Constraints[v], emerging and changing over time
- Assumptions, activity and timing sensitive, also changing over time

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- Coupling[vi] (immediate and lagged)
- Life cycle phase (planning; engineering; construction; startup and testing; commissioning; operating, including maintenance; end of life/decommissioning)

Importantly, these interfaces include both direct and nested interfaces. Additionally, a system of systems perspective must pervade our thinking recognizing that many of the elements above are themselves part of other, broader systems.

Interface management in this expanded context requires increased attention and different constructs to prior interface management efforts primarily focused on physical or other more direct, one-to-one interfaces. The complexity of interface management requires a step change.

What is interface management?

Interface management includes all the activities associated with identifying, defining, characterizing, controlling, confirming, and communicating information to enable distinct objects, activities and actions to function in a coordinated and complementary way, as intended. This co-functioning should be value adding, efficient and effective. In the "smart" and ESG contexts laid out above this requires interface management to support interoperability in an increasingly dynamic and complex world.

Numerous industry interface management standards exist. This paper is focused on the expansion in thinking required to deal with the expanding open system's nature of large complex projects especially those with growing "smart" and ESG requirements and emergent outcomes.

Interface management goes beyond the traditional constructs or configuration management, which focuses on consistency of attributes through a system or components lifecycle. In today's increasingly complex world with increasingly complex projects we must recognize that desired outcomes themselves are emergent and as such interface management must ensure that appropriate value adding relationships are sustained even in complexity.

While interface management must still ensure that all information required to enable co-functionality is present, its role in using various interface performance attributes as constraints is modified with the addition of "smart" and ESG considerations. The number of interface dimensions is greatly expanded, and interface management is the process to bring the various bits of the project together to achieve the desired outcomes or capability additions.

Nested interfaces

Nested interfaces have always existed in interface management but take on new importance and challenges as today's projects become "smarter" and address expanded environmental, social and governance needs. In addition, a growing emphasis on pre-assembly and modularization create a new layer of interface management for physical interfaces. Similar modular approaches are found within the digital realm as knowledge assemblies develop. Finally, many of today's projects, while complex often layered systems in their own rights, are merely one system in an even broader system of systems context.

Special attention must be paid to nested interfaces, ensuring that they are absorbed by other interfaces and not neglected either unintentionally or by organizational design. ***Neglected interfaces lead to degraded project lifecycle performance.***

How does the interface management process change?

The traditional interface management process begins with a definition of interface requirements from users, system, and program designers. As the project evolves interface changes arising from technical and project requirements are managed utilizing a set of interface management procedures that work hand-in-hand with configuration and change management processes. Traditional interface management occurs at a work breakdown level (WBS) and occurs as various systems, structures and components are integrated within a WBS element as well as the integration of WBS elements in the project. Positive control is exerted on interfaces and interface management reports capture these efforts and provide input into configuration management and change control when requirements have changed.

As we move into a project setting where "smart" interfaces become more dominant and ESG interfaces take on an increased importance, traditional interface management processes are found lacking. An expanded interface management process must include several added considerations. These include:

- Moving beyond traditional interface parameters that specify location (x, y, z coordinates); material properties at the interface (material specification (material composition/alloy; thickness; pressure/temperature ratings); coupling related requirements (weld type/electrical/ I&C coupler type; cleaning requirements; weld or coupler materials and ratings)); and flow characteristics (fluid/current properties).

- Incorporating the various digital characteristics associated with physical interfaces. These could relate to associated digital twin properties; control points or systems in automated information, signaling and command and control system operating features; digital information required for effective asset management systems. We may think of this as meta data that is now associated with physical elements not just the systems information flows. This is important since information flows have increased interfaces with the characteristics, properties, and performance of various system components.

- ESG interfaces that are becoming increasingly more pervasive into lifecycle project systems. Examples for each of the components of ESG include:
  - Environmental – embedded carbon; water footprint; end of life disposal considerations
  - Social – flow down diversity and local sourcing requirements; modern day slavery requirements
  - Governance – Buy America; sub-tier sourcing from embargo countries

  This ESG metadata becomes integral to the interfaces at lower and lower levels.

- Substitution of the uncertainties[vii] associated with human interfaces especially in control loops with the probabilistic (vs deterministic) actions of artificial intelligence (AI)[viii, ix, x, xi] and machine learning.

- Addressing the changing nature of interfaces driven by:
  - Changed stakeholder requirements and agreements (these may include changed regulatory requirements or even joint venture agreements[xii, xiii, xiv])
  - Changed externalities (market; technological)
  - Operating environment and broader system performance (transportation, water, electrical and other network performance that act to modify interface requirements either with respect to initial asset deployment or in an operating environment)
  - Component substitution from that initially specified

  This is akin to metadata being represented as a function of time – meta(t).

- While interface management focuses on direct interfaces as well as those which may be cascaded down, there are two other interface criteria worth calling out:
  - Constraint coupling[xv] – this is an indirect interface where changes in one element or activity causes modification in an interfacing element associated with another element or activity.
  - Assumptions may also be thought of as interface criteria. As such "assumption migration" becomes an area of interface management concern.

Figure 1 illustrates the expansion of traditional interface management stages (design, construction, operations and maintenance) and the associated physical properties that traditionally defined interface parameters to now include the growing digital project (simulation/scenario optimization, BIM/digital twin, enterprise asset management).

Governance addresses the myriad of organizational interfaces. We are heavily dominated by a reductionist view of interfaces but the lifecycle perspective we see on more and more projects necessitates a stronger eye on the holistic outcomes we desire. We will see later that the strong addition of "smart" and ESG considerations further drives this holistic view and increases the importance of governance as reductionist and holistic views must both be satisfied.

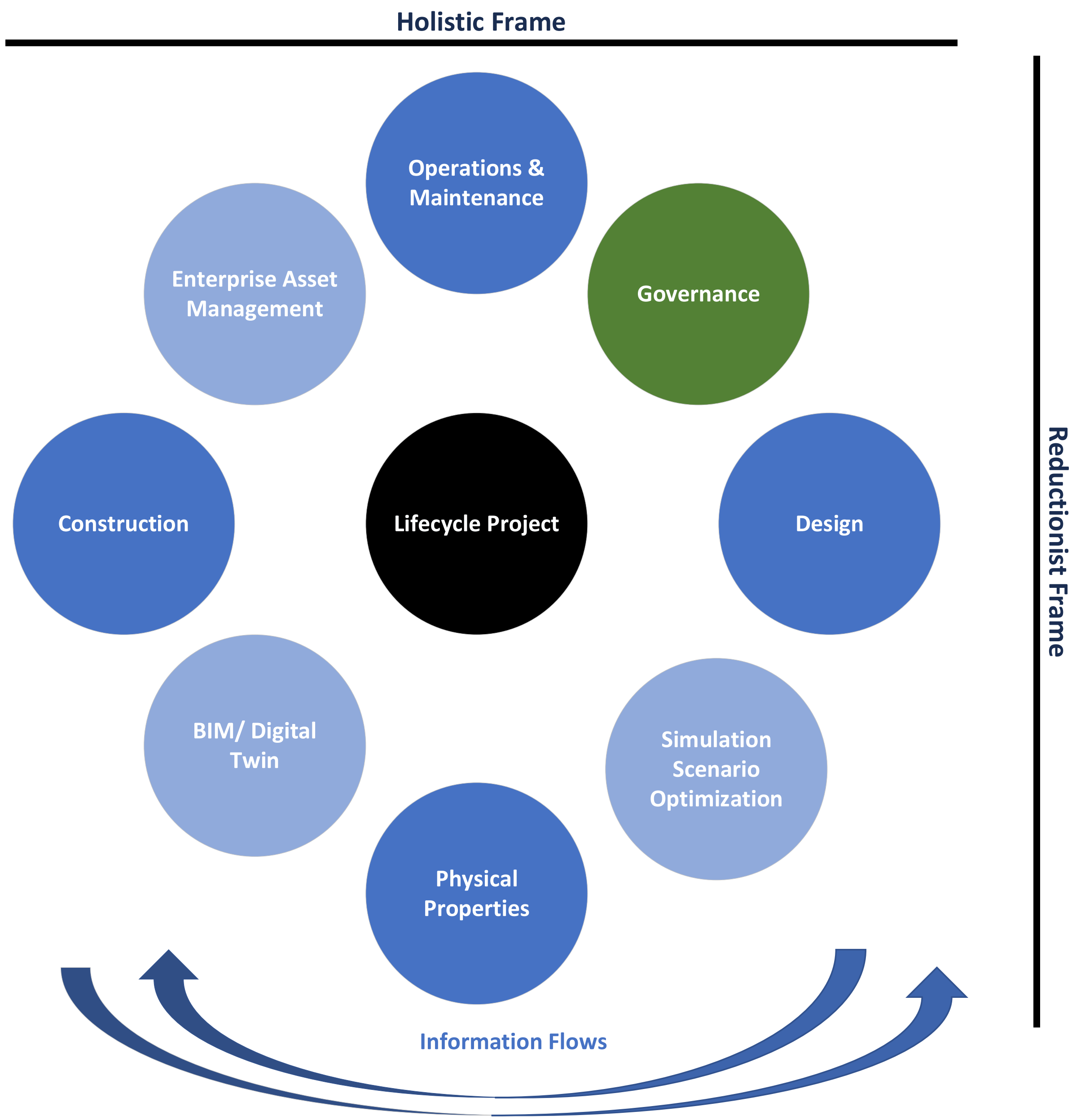

Figure 1

The systems challenge

We see the expanded nature of our project system with the introduction of "smart" and ESG considerations. But the system's challenge is compounded by the further expansion of our system from a more closed system to one that is increasingly an open[xvi] one. Interface management in an open system is one which battles emergence at every stage. Documentation of system boundaries becomes more notional than the well bounded traditional approach to interface management would allow for. As such the clarity required for determining where interfaces exist becomes opaquer and even when we believe that we have comprehensively defined them, new ones may emerge.

The systems challenge can only be met if we initiate interface management at the basis of design[xvii] [xviii] stage when we are first defining requirements. It is here that the special requirements that interfaces must accommodate first begin to emerge. It is here where the discussions on "smart" integration into the basic project concept and our commitments to ESG can shape our approach to interface management and the process and procedures we put into place.

Interface control "documentation"

Interface requirements documents begin development at the basis of design stage. In addition to the digital elements which are now central to definition of systems, structures, and components we must now incorporate our ESG requirements from a documentation and flow down perspective, not just a setpoint perspective. Importantly these interface requirements documents must now encompass the full project lifecycle and do so from a triple bottom line perspective. Assumption registers must begin development and the relationships of assumptions to various interface points and criteria documented. Tracking of assumption migration now gains a tighter link with the project's change control process.

Traditional interface control drawings representing physical and control interfaces (P&IDs for example) must be complemented by information flow diagrams, logic diagrams, incorporated algorithms (to be tracked as they may evolve over a project's lifecycle), and BIM and enterprise asset management system metadata. Interface control documents aim to clearly communicate all potential actions and interactions whether they are internal to a system, structure, component (or their digital twins) or transparent to external users and stakeholders. This interface control documentation increasingly is database driven and model-based interface management will likely be required to address these expanded interface considerations.

Interface data definitions become greatly expanded and the number of organizational elements involved in effective interface control likely becomes all encompassing. The challenge of interface control has grown exponentially but new tools such as artificial intelligence and model-based approaches to interface management may make the impossible practical. The introduction of bias[xix] [xx] [xxi] [xxii] in both AI and model-based interface management must be avoided.

In the open systems[xxiii] [xxiv] [xxv] context we are likely to find ourselves in, we may discover that there are sets of changes at interface points which are beyond the project team's ability to control or limit. The interface management function now shifts to early identification of such potential interface impacts (anticipating is desirable), assessing the range of impacts, choosing a timely response to optimize outcomes within this changed context, and ensuring all aspects of the interface have been addressed in responding to what may be an imposed change.

Additionally, project flows[xxvi], their anticipation and identification, become ever changing aspects of what now must be model-based interface management. As such, interface control documents must extend descriptions of interfaces and interface types and specifically describe how information is communicated within a subsystem or WBS; across subsystems or various WBS; with external systems or project elements or other related projects; and its ultimate users and stakeholders. This may be accomplished by layering of interface control information, providing for different views of the project system as shown in Figure 2.

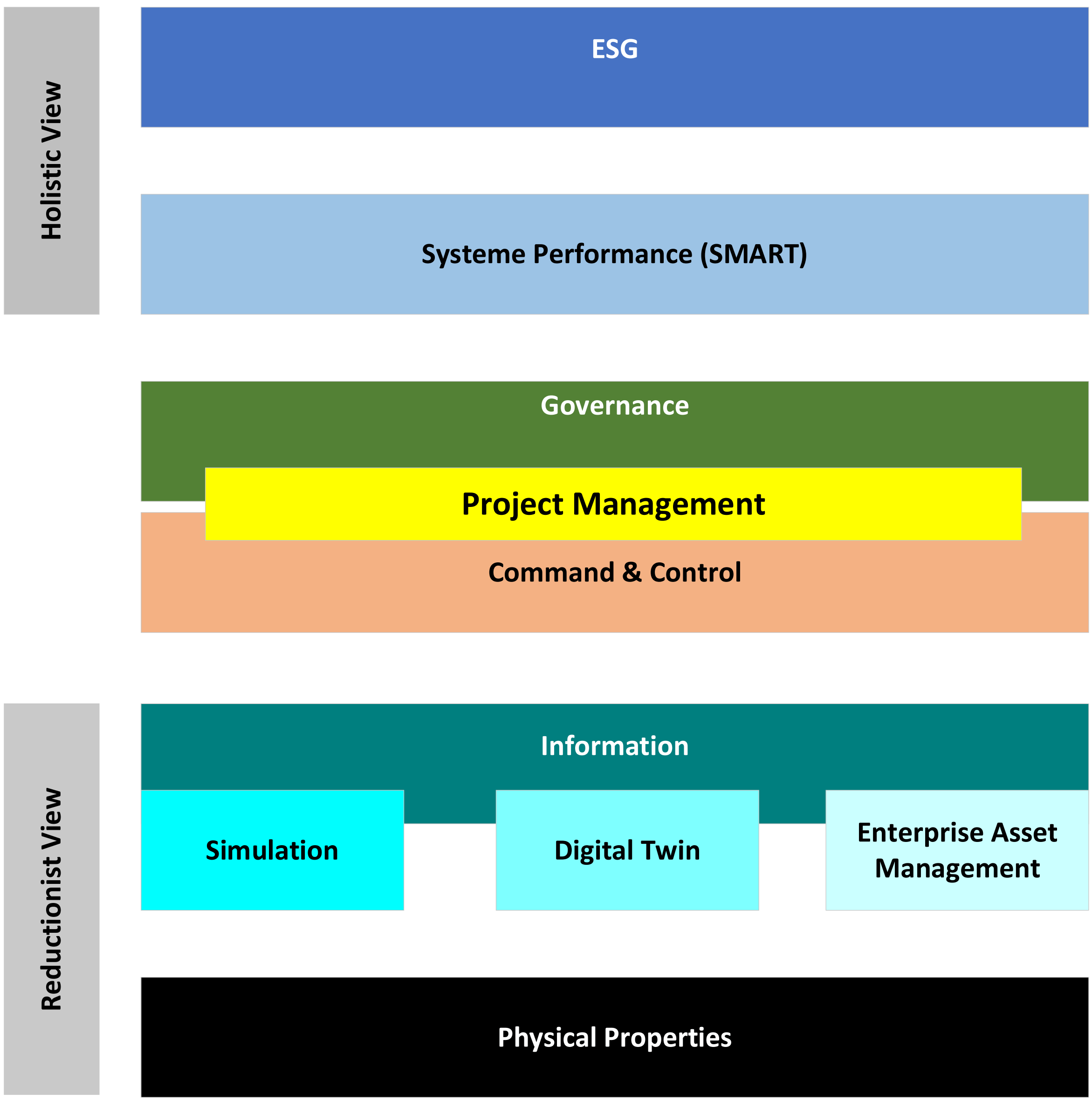

Figure 2

As seen in Figure 2, ESG and system performance interfaces are principally contributors to, and drivers of the requisite outcomes-focused holistic view. Information and physical properties benefit from a reductionist view providing necessary granularity for interface management.

Governance, project management, and command and control integrate these two views to deliver the level of interface management these increasingly complex projects require. Project management addresses the traditional interfaces one would expect related to **scope** (addressing both outcomes and outputs), **schedule** (engineering, supply chain and construction physical and temporal interfaces together with attendant information flows), **cost** (assumptions and their migration; required characterizations to be achieved (Buy America; various set asides)), **risk** (importantly including emergent risk including those associated with correlation and coupling), effective **integration** (a primary focus of interface management), and **change management**, recognizing the multi-dimensional, multi-level effects of neglected interfaces or inadequate synchronization of the various project activities.

Best practices

Consideration of this changed and greatly expanded interface management role and perspective is supported by adopting select best practices:

- Governance is essential, especially as system complexity and abstraction grow. It must evolve throughout the full lifecycle of infrastructure and facility assets.

- Interface management frameworks and processes must be established at the outset of development of a future operating asset and fully engage all stakeholders. All too often stakeholder roles in interface management are added almost as after thoughts.

- Establish interface management KPIs early in the project and focus on progress of completing interface definitions and agreements.

- Match interface management frameworks with project complexity. Not too complex; comprehensive enough; rather just right. Modular open systems approaches provide flexibility in projects where technology development is an important element and also in long lived assets which may undergo many stakeholder or technology driven revisions over the course of their lifetimes.

- Ensure interfaces are sufficiently defined with clarity and acceptance on each side of the interface. Standards should be used where possible, or context ones defined and agreed to.

- Interfaces must be trusted. This is slowly earned but quickly lost. Measure the effectiveness of interfaces in delivering the requisite value desired. Do "smart" systems have the information they need to operate and continuously improve their efficiency and effectiveness? Are ESG commitments being met and importantly, communicated, frequently for ESG interfaces with various stakeholders? Is the provided information satisfactory and trusted? Engage stakeholders continuously.

- Define interfaces clearly and comprehensively so that the information at these points may be used for added, often emergent, purposes. Interfaces should convey the rationale from design decisions and tradeoffs. Recognize that interface decisions introduce system constraints.

- Interface management must facilitate concurrent but correlated project development efforts providing clarity on interdependencies that are sources of uncertainty and risk.

- Interface management must support cross domain interfaces. This is even more important as the range of domains is expanded by the introduction of "smart" technologies and expanded ESG requirements. Even in more traditional interface areas cross domain interface management is often found lacking.

- Interface management must support synchronization across WBS elements, interface layers and broader stakeholders.

- Both holistic and reductionist models of interfaces must be accommodated with each adding value in different domains (higher and lower levels of abstraction). Verify that models are fit for purpose.

- Interface management must support virtual (digital twin) project development and operation throughout its full lifecycle.

- Ensure interface points are user-friendly, logical and useful. Do not make it overly complex. Ascertain the utility associated with various interface points. Are they value adding? You may be surprised how many are not.

- Test, validate and verify that interfaces ensuring sub-tier interfaces have not been neglected and the trust earned is well founded.

- Ensure interface information is broadly available within the project team and others. Avoid reinventing the wheel or setting up competing, or worse, conflicting interfaces. Electronic workflow systems support interface management and tracking.

- Recognize and capitalize on the risk and performance insights available from interface management KPIs.

Concluding thoughts

Recognize that each of the various levels and perspectives associated with interface management provides a valuable insight into the project. Each level of interfaces and each perspective is just a simplified abstraction of the system and its performance characteristics. A fuller view is only gained through the sum of all these levels and perspectives and even this is just an abstraction of the fullness of the project system. How these views link and how they individually interact with each other and evolve over time is the real prize.

Interface management is more about informed decision making than absolute control of interfaces as desirable as this may be. More holistic models with higher level interface definitions aid in decision making, outcomes achievement, system optimization and prediction of system behaviors and performance. Conversely the more detailed reductionist interface definitions are essential for more traditional interface management. The introduction of "smart" systems and ESG requirements requires that both holistic models and the more traditional reductionist ones coexist.

As the physical configuration of the project takes shape based on an expanded basis of design and accompanying technical design requirements, focus must shift to the various other interface parameters such as those associated with digital and ESG parameters to fix a set of higher-level design and interface criteria. These support the advancement of design and analysis efforts, but the more holistic relationships must not be lost.

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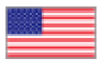

Bob Prieto is a senior executive effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering and construction industries. Currently Bob heads his own management consulting practice, Strategic Program Management LLC. He previously served as a senior vice president of Fluor, one of the largest engineering and construction companies in the world. He focuses on the development and delivery of large, complex projects worldwide and consults with owners across all market sectors in the development of programmatic delivery strategies. He is author of nine books including "Strategic Program Management", "The Giga Factor: Program Management in the Engineering and Construction Industry", "Application of Life Cycle Analysis in the Capital Assets Industry", "Capital Efficiency: Pull All the Levers" and, most recently, "Theory of Management of Large Complex Projects" published by the Construction Management Association of America (CMAA) as well as over 800 other papers and presentations.

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End Notes

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