Recognizing a need for guidance in this area the Construction Industry Institute (CII) recently formed a research team with the goal of studying interface management and coming up with the best approach to manage project interfaces.

Interface management is a critical element in the delivery of LIPs. In addition to managing interfaces, SI, as a life cycle project activity, encompasses integration testing leading to substantial completion, safety and security certification (such as in the rail transit industry), and operational readiness assessments for infrastructure projects.

It is also important to note that SI could be called "project" integration. In addition to electrical, mechanical, architectural and civil systems, SI involves the planning of the procurement, contractual, organizational project management processes necessary to deliver an integrated solution. For people who are not intimately involved with SI it can be difficult to understand its scope and value. Systems Integration is critical throughout the project lifecycle.

For projects to succeed, SI must be utilized from the earliest project stage. Delaying integration activities until the testing stage may lead to the costly retrofit to resolve integration issues which could have been identified and resolved during the planning, design or construction stages.

Useful References

Construction Industry Institute (2014). *Interface Management Implementation Guide.*

International Council On Systems Engineering (2011). *Systems Engineering Handbook:* A *Guide For System Life Cycle Processes and Activities*.

International Council On Systems Engineering (2012). *Guide for the Application of Systems Engineering in Large Infrastructure Projects.*

This Leaflet

This leaflet is part of a series intended as a brief introduction to the application of systems engineering approaches to infrastructure projects. It was developed by the International Council On Systems Engineering (INCOSE) Infrastructure Working Group in the interest of aiding industry.

For further information about the application of systems engineering in large infrastructure projects, including a Guide applicable to the Construction project stage, go to www.incose.org and look for publications.

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Applying Systems Engineering to Industrial & Infrastructure Projects

Systems Integration

What is Systems Integration?

Systems Integration (SI) for the infrastructure industry is the integration of systems within a project, not just the electrical, mechanical, architectural and civil systems, but also all technical and human elements. SI emphasizes a holistic view, focusing on projects and the systems they are delivering as a whole. SI includes technical (functional, operational, logical, physical, geographical) interfaces as well as schedule-related and organizational interfaces. It is necessary to ensure an integrated solution from conception, through design, construction, testing and into service. It ensures changes during construction consider the impact on the designed solution and facilitates required modifications.

Large Infrastructure Projects (LIPs) benefit from consideration of SI aspects from the outset. Early contributions ensure the proposed solution and delivery strategy achieve the desired outcome by defining the target system configurations and resulting level of service at each implementation phase.

In Design-Build projects, some interfaces are not always identified or specified until late in the projects, creating difficulties and so they need to be managed. Good SI does not stop at design; it evolves through construction/installation through testing and commissioning and into operation. As a result, it is critical to the effective management of project risk.

Systems Integration and Project Management

SI is not the same as Project Management (PM). It complements it. It is critical in determining the best project phasing and execution and it has a unique goal of interface definition and management. In addition, SI is necessary as a way to mitigate project risks by requiring a systematic, fully documented process to deal with transitions (migration phases), system configuration control and interfaces hence avoiding many of the typical design and construction mishaps.

Systems Integration Strategy

Integration Management requires a structured approach for identifying and resolving all parameters, interfaces and conflicts, and addressing the inter-dependencies which will exist between functional and physical project elements.

For large, complex projects, the Systems Integration Manager (SIM) has a vital role to play. As required, this Manager may be augmented to form the Systems Integrator team, with the primary purpose of defining and executing the systems integration strategy devised for the project.

In addition to assigning staff with the sole responsibility of dealing with systems integration issues, it is important that a systems integration toolset be developed to help model and specify the progressive configurations of the system and their resulting operational performance (or levels of service) and to serve as a repository for documenting interfaces throughout the project lifecycle. It is beneficial if the toolset is internet-based so as to provide up-to-date information about system configurations and project interfaces to all stakeholders (interested parties).

Systems Integrator as an Effective Communicator

An effective SI strategy will facilitate excellent communications between project teams. Without this, interfaces can remain unidentified or unattended, leading to integration gap and ultimately to project failure.

In addition to possessing a broad knowledge based in the infrastructure domain, the SIM needs to be an effective communicator. The SIM should be personable, focused, flexible, and an excellent problem solver. Because they are specialists in detailed functional disciplines, some engineers feel most comfortable working in "silos" with others in their discipline. The SIM will ensure they also consider the big picture and will help facilitate the interactions necessary for integration.

Expensive mistakes can be avoided by ensuring that teams responsible for the progressive realization of the project and developing product components communicate more effectively. Of course with complex projects, one can never be certain that all contingencies are planned for. However, in the design stage, companies benefit from focusing on the critical points of contact among their various component development teams to ensure that everyone knows when and with whom they should be sharing information.

Interface Control Program

An effective SI process starts with a good control program that contains the following characteristics:

- Comprehensive – includes all equipment, software, hardware, systems, and subsystems
- Hierarchical – done to a carefully delineated hierarchy (e.g., system, sub-system, assembly, etc.)
- Specific and unique – equipment is classified as belonging to groups (systems, sub-systems, etc.) on a specific basis, with clearly defined boundaries

Interface Management Process

To effectively manage interfaces, the following elements must be addressed:

- Define how and at what levels the interfaces will be managed. This allows the understanding of how the requirements for each system relate to each other, other contracted work, and the outside world.
- Identify all the interfaces, even if they are initially broad and the details are not known, so the scale of the work can be estimated, planned and resourced.
- While initial efforts might concentrate on technical interfaces, just as critical are those interfaces that control planning, information, and person-to person communications. It is important to note that interfaces are not always things you can touch!

Note that interfaces can be between systems, elements, functions, objects, organizations, people, projects, etc.

Interface Sources

There are many sources of information on the interfaces to be tracked and managed, including:

- Interface Agreements
- Request for Information (RFIs)
- Design Criteria and Design Criteria Manuals
- Design Development and Specifications
- Requirements Matrix
- Interface Workshops
- Weekly interface coordination meetings with project staff
- Minutes of other project meetings

Interface Management Plan

Once the interface management process is established, project teams must write an Interface Management Plan or an overall Systems Integration Plan. This plan must include at a minimum the following:

- Interface Management and Control
  - Interface Identification
  - Interface Documentation
  - Interface Resolution
  - Interface Monitoring and Control
- Integration Risk Management and Control
  - Integration Risk Identification
  - Integration Risk Allocation
  - Integration Risk Control and Mitigation
- Lifecycle Integration Management Process
  - Preliminary Engineering and Detailed Design
  - Construction
  - Testing and Commissioning

How to Implement SI

In order to implement SI, the organization should take the following actions:

- Develop a System Architecture which can be presented according to stakeholder's areas of interest.
- Develop a web-based toolset to control the system configuration and serve as a central repository of all project interfaces
- Develop a collaborative environment to facilitate effective information exchange between project team members, and include relevant project stakeholders.
- Write a procedure to serve as a guide for documenting interfaces.
- Proactively identify, define and deliver interfaces.

The complexity of infrastructure projects has tended to increase in many industry sectors, creating the need to manage more and more internal and external interfaces. This complexity has resulted in the need for project teams to be able to manage diverse requirements, which may include competing goals and resources.