Infrastructure Projects: from Planning Proposal to Successful Operation

Principles and Guidelines

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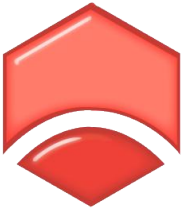
Pre-release Draft



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and the
Australian Chapter of the International Council on Systems Engineering

Notices:

This SESA Technical Document is a product of working groups participating in the Australian Systems Engineering Workship (ASEW) 2018. It is approved by the SESA Technical Director for release as a SESA Technical Document.

Foreword

Each year, the Systems Engineering Society of Australia (SESA) hosts the Australian Systems Engineering Workshop (ASEW).

The format of ASEW enables participants to engage directly with their peers to work through challenges considered relevant at the time. The ASEW promotes discussion and problem solving around current issues being faced in each functional domain and industry sector. It allows all participants to draw on the collective experience that exists only when representatives of the Systems Engineering and allied communities are brought together in an interactive forum like ASEW.

In 2018 ASEW facilitated active engagement across Telecommunications, Transport, Cooperative & Automated Vehicles, Model Based Conceptual Design & Contracting, Systems Engineering, Project Management, Healthcare, and Decision Analysis.

ASEW 2018 was the first occasion to workshop pain points impacting infrastructure projects (principally transportation related). Approximately 40 sector representatives brainstormed and listed a variety of issues that were having negative impacts on the development, construction, and implementation of large infrastructure projects. All up, there were 43 suggested pain points, which were loosely grouped into eight categories, from which the top three pain points were investigated, as these were considered the most crucial. These pain points are:

The need for interface management;

The need to establish and maintain a common stakeholder understanding throughout the project; and

The need for collaborative working environments.

The results of these investigations have been condensed into this Principles and Guidelines document.

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This Principles and Guidelines document has been prepared with the view of being broadly applicable to a wide range of infrastructure projects. However, since the initial investigations were based on experiences of those particularly involved in transportation projects, many of the examples used herein are drawn from these experiences.

In one form or another, projects for the development of civil infrastructure has been occurring for centuries. Such projects include the construction of highways, railways, electricity generation and distribution, water collection, storage, and distribution, and waste water collection and transfer. The genesis of these projects is to satisfy the needs of society (people have always needed to travel between places, conveniently, comfortably, and safely; communities have always needed clean and reliable water supply; and for the past century, society and industry have become increasingly reliant on electrical power and telecommunications). Providing good solutions for these is the hallmark of advanced civilization.

Although the core needs haven't changed, what has changed is the combination of people's expectations, society's expectations, and the advancement of technology.

People's expectations have risen dramatically. To travel conveniently is synonymous with getting from A to B quicker and with minimal disruption; therefore access to transport arterials should be as short and simple as possible, and swapping modes of transport should be nearly seamless. Travelling comfortably now has the expectation of air-conditioning, smoothness, quietness, and cleanliness. Travelling safely not only has the expectation of arriving at one's destination without injury or incident, but also avoiding the possibility of "undesirable individuals" assaulting travellers (whether as car-jacking or "road rage" on the roads, or within public transport – train/tram/bus compartments, bus-stops and interchanges, and train stations).

Society's expectations have changed. There is greater emphasis on environmental impacts, accessibility, equality, and population growth. There is also a seemingly greater emphasis on urgency – people need to be contactable anywhere, anytime. Places of work are now more dispersed. Whilst transportation to the CBD still needs the capacity for the majority of commuters, there is a large proportion who commute to other locations.

The rate of advancements in technology is ever-increasing. Systems installed 30 years ago were technically simple and the equipment could be maintained to specification for 20 years without issues. Now, some of the equipment used in systems installed 5 years ago is already obsolete and cannot be repaired. Furthermore, the more modern systems are required to interface with a multitude of other systems, some of which are equally new, some of which are legacy systems not yet due for replacement.

Thus, to successfully develop, implement, operate and support an infrastructure system these days necessitates dealing with all the complexities alluded to above. The risks of getting it wrong are enormous.

This document has been developed as an aid for those involved in civil infrastructure projects, both large and small. Appendix A describes the systematic process that was used to identify the factors that have given rise to these principles

and guidelines.

The business case for this document is the generally accepted view that the industry could benefit from better organisation and integration of activities leading into and during the construction stage of the project lifecycle. This would help manage the uncertainty associated with the cost estimation and changing scope and could improve construction productivity through reduction of defects and delivery time, hence making the project delivery more cost effective.

Large infrastructure projects are characterised by their scale (typically over $1billion), duration (project delivery of years rather than months), uniqueness (every project has a significant difference in its solution and/or execution), complexity (number of interacting parts, stakeholders and/or activities) and cost uncertainty (due to unpredictable construction conditions and other economic, political and technical factors), and by the substantial proportion of cost, time and effort dedicated to the construction stage within the project lifecycle. In many cases, large infrastructure projects are also characterised by the difficulties associated with changing the asset once it is in service. Thus, getting it right first time is of paramount importance!

A significant discriminator between infrastructure projects and other types of projects is that the former are usually triggered by public pressure, thus involving government ministers and departments or government instrumentalities to initiate the project.

An infrastructure project normally starts as a high level problem statement (e.g. more power needs to be supplied to area X, or more people need to get from A to B in a shorter time) by a major stakeholder (e.g. a Government Department). The definition of the solution to the problem emerges from the consideration of options and the development of a conceptual design. Thus the project starts to specify a particular solution (e.g. a new power station, a wider highway or a high speed railway) and the way to achieve it. Throughout this stage the infrastructure project depends on a large number of uncertain and optional factors for which the estimated costs can vary substantially. In new and unique fields, the lack of sufficiently similar reference cases creates a major headache for cost estimators.

During a two-day workshop in November 2018, a number of practitioners (project managers, engineers, etc.) working on large infrastructure projects examined three interdependent “pain points” which had been identified as having negative impacts on the success of infrastructure projects. Success in this context is where the operating solution is fully conformant with the business case that was submitted for government approval at the project initiation stage. Although the “as built” solution might fully satisfy the community’s expectations, in most cases the original business case inadequately addressed all the aspects involved. The consequences of having an inadequate business case include:

- Low benefit realisation (not fit for purpose);
- Delays in schedule (and consequent higher costs);
- Contract amendments;
- Regret works (doing work at an earlier stage, and realising later on that this work was either not necessary, or inappropriate);
- Poorly defined requirements (inaccurately defined project scope);

Defining the Context

» Higher defects (additional rework and testing, further delaying schedules);

» Lack of stakeholder identification (who are the stakeholders for this project?), and limited recognition that different stakeholders have different views.

Avoiding these consequences is a complex process. The principles set down in this document are intended to provide the necessary guidance for organisations responsible for implementing infrastructure projects (both acquirer and supplier roles).

The actual scope of an infrastructure project can be fully understood only after all stakeholders (or stakeholder representatives) have been identified and consulted. Thus, the initial project scoping documents and the business case should be prepared only after all stakeholders have been consulted.

Recommendations and Guidance

It is often useful to initially establish the lifecycle phases of the project, typically along the lines of Concept, Design, Construction, Testing, Operations, Support, and Disposal. Within these, identify relevant sub-phases or activities. For example, within Support are activities such as Training; within Operations there might be a need for a Transition into Service sub-phase, perhaps involving the "operator" of an existing system as well as the "operator" of the new system which replaces the old (or has to work alongside). Within the Concept and Design phases, there can be Modelling and Simulation activities.

Having broken down the project into its lifecycle phases, it is then easier to identify the stakeholders, bearing in mind that many stakeholders have involvement with several of the lifecycle phases. Thus, when preparing to consult with stakeholders, having them grouped according to where their involvement in the project lies can facilitate this consultation process.

As a starting point, the following list can be used to identify stakeholders.

- Government Minister
- Government Departments (Finance, Environment, Transport, Health, etc. dependent upon the specific project)
- Statutory Authorities
- Asset Owner or Project Sponsor
- Steering Group/Committee (in Victoria, these are referred to as "Authorities", such as the Level Crossing Removal Authority; in other states, different labels (e.g. Agency or Instrumentaility) might be used)
- Community/general public
- Customers (e.g. train passengers, car drivers, electricity consumers, water users)
- Industry Regulators and/or Approving Authorities
- Suppliers
- Prime Contractors and/or System Integrators
- Interface Entities (i.e. organisations responsible for operations or systems that will interact with the proposed system, for example establishment of a new rail corridor will involve interaction with the transport ticketing system, and also with organisations responsible for providing personnel at the train stations,

whether as station staff to assist travellers, or as Authorised Officers and Security personnel)

» Training organisations and Universities, and in-house Trainers

» Professional Communities

» System Operators (both those who work in a Control Centre and those who operate other elements of the system, such as train drivers)

» System Maintainers

At the very beginning of the Concept phase, it is recommended that a Systems Engineer (or small Systems Engineering team) be engaged to assist with the identification of stakeholders and to elicit their respective requirements. The Body of Knowledge that has been established for Systems Engineering, along with the associated Systems Engineering processes provides a very good foundation for this work in the early stages of the Concept phase. In fact, the present maturity of Systems Engineering processes is such that the guidance which is offered though the associated Body of Knowledge should be applied throughout the project lifecycle. It is therefore recommended that the Guide for the Application of Systems Engineering in Large Infrastructure Projects (Document # INCOSE-TP-2010-007-01, 25-Jun-2012) be read in conjunction with this Principles and Guidelines document.

Principle 2: Establish and Maintain a Common Stakeholder Understanding

It is vitally important that there is a common understanding by all Stakeholders (as established through Principle 1) during each and every phase of the project lifecycle.

Recommendations and Guidance

Underpinning this Principle is recognition that different Stakeholders have different views, depending upon their roles, their backgrounds and their experiences. Compounding the difficulties of stakeholder management to ensure common understanding is the fact that individuals (and indeed, whole governments) will change during the project delivery. Thus, concerted on-going efforts need to be applied to re-establishing stakeholder relationships and understanding.

Interestingly, leadership is probably the most significant factor that contributes to stakeholder understanding. There are several facets to this leadership, including:

- Establishing organisational champions (domain experts with the ability to explain technical complexities in the vernacular of their audience);
- Providing an environment that enables trust (safe and inclusive);
- Ensuring there are clear and open communications channels;
- Providing clear understanding of authority and responsibility (i.e. how to escalate an issue when necessary);
- Providing targeted competency frameworks and associated training;
- Providing and maintaining applicable tools, techniques and practices to best suit the needs of staff;
- Encouraging the training of staff;
- Identifying risks, issues, and outcomes, and where they can be most appropriately managed and controlled.

Recommendation 1: Engage all relevant stakeholders

For each specific project phase or activity, target and engage those stakeholders who can impact, or who might be impacted by, decisions made during that project phase. Consideration needs to be given to at least these groups of stakeholders:

- End users, those with the identified need for which the project outcome provides the solution. End-users typically have less of an interest in the nature of the physical system and more of an interest in getting the right system to address their need;
- Operators/Maintainers, those who are directly affected by or interact with the system in terms of being able to operate, maintain and sustain the system;
- Contractors and sub-contractors, those responsible for developing and

constructing the system, and therefore must fully understand what is to be built, and why.

Recommendation 2: Establish and foster Integrated Project Teams (IPTs)

Integrated Project Teams comprise representation from the relevant stakeholders to focus on particular elements of the system, especially during the design and development phases. In addition to the benefits of information management described under Principle 3 below, IPTs provide and work with common, current and consistent information and, in turn, communicate this back to their stakeholders which they represent.

Recommendation 3: Avoid information overload

In part due to the standards and regulations regarding aspects such as environmental issues, accessibility, etc. and in part due to the need for the new or modified system to interwork with other existing systems, infrastructure projects involve considerable complexity. Different stakeholders have different views regarding this complexity – some need to know certain details, others need to know other details. To avoid stakeholders becoming inundated with information, it is recommended that:

- A communications plan be developed, implemented and maintained to ensure that information regarding the project can be disseminated appropriately and in a timely manner;
- Training in leadership and communications skills development be provided. This leads to being able to explain the complexities in the vernacular of the audience as well as succinctly articulating where the complexity lies;
- Existing Bodies of Knowledge (e.g. Project Management, Systems Engineering) be used with caution, as the terminology used within these tends to be specific to those inside that “community”, and not for wider audiences.

Recommendation 4: Promote the value of the project

There are two elements to be considered here. The first is to promote the value to the public and the community. Some infrastructure project have quite obvious advantages (e.g. relieving traffic congestion, faster travel times, etc.), but for other projects the benefits to the community are not so obvious. Since funding for infrastructure projects typically comes from the public, it is important that they correctly understand the value of the project, and what it means for them. Furthermore, during the construction phase there will probably be periods of disruption to the public. It is vital, therefore, to ensure that members of the public are made aware that there is a long-term gain for some short-term pain.

The second is to promote the value of the project to the staff involved in the project, particularly those of the prime contractor and sub-contractors involved in the design and development stages. Within Defence, this is achieved principally through an operational concept document (or similar) which describes the operational need and explains why all the aspects of functionality are needed and the circumstances in which these functions would be utilised, often with a comprehensive suite of scenarios and vignettes. To date, very few civil infrastructure projects have developed equivalent documents in sufficient detail for those involved in the design and development of such projects to gain a deep appreciation of the full scope of the project.

Because the operational concept document is written in operational terms and avoids technical design details, it facilitates the ability of all stakeholders to share a common understanding of the overall project. At the earliest feasible stage of the infrastructure project, a full suite of the operational concepts should be developed and documented.

Principle 3: Establish an Over-arching Framework and Culture of Collaboration

This Principle is synonymous with a unified or "One Team" approach, which facilitates a clear and transparent visibility of all stakeholder goals, in turn yielding significantly higher likelihood of success, and the sharing of all information and data guarantees this success at the best value for money.

An important aspect of this Principle is the need to ensure that the outcomes are sufficiently flexible to facilitate and enable change, both as the project progresses, and for application (re-use) on future projects.

There are two components which contribute to this Principle. The first, and more complex, is Silo Mentality. The second is Information Management.

Recommendations and Guidance Regarding Silo Mentality

The intention is to avoid the so-called Silo Mentality, which is the mindset present when certain departments or sectors concern themselves only with issues which they perceive to impact on their domain and share only the information which they think others need to know. This type of mentality will reduce efficiency in the overall operation, reduce morale, and may contribute to the demise of a productive company culture. Silo is a business term that has been passed around and discussed at many board room tables over the past 30 years. Unlike many other trendy management terms this is one issue that has not disappeared over the years. Departmental silos are seen as a growing pain for most organisations of all sizes.

In the context of large infrastructure projects, the "organisation" is not one government department, not one contracted company, but a Body Corporate, which we define as comprising all parties relevant to the design, development, construction and implementation of the infrastructure project. That is, the government department or statutory authority, the acquirer, and the supplier (prime contractor and sub-contractors). Although there is some commonality, the Body Corporate does not necessarily include all the stakeholders identified through Principle 1.

Symptoms or evidence of the Silo Mentality might appear on face value to be well-meaning and include:

» Confidentiality;

» Intellectual Property implications;

» Commercial implications (Probity/Commercial in Confidence);

» Internal processes.

Added to these are the endemic behaviours such as an absence of trust, commitment fear (holding back critical information), and lack of basic training.

Principle 3: Establish an Over-arching Framework and Culture of Collaboration

It is the duty of the executive leaders and management of the entities comprising the Body Corporate to prepare and equip their teams with the proper mindset to break down this destructive organisational barrier. A unified Body Corporate leadership team will encourage trust, create empowerment, and break managers out of the "my department" mentality and into the "our organisation" mentality. The following steps are a guide to achieving this.

Depending upon the project and the number of project participants, there may be value in including clauses in the respective contracts to ensure that there is the collaboration amongst the managers of the project participants.

Recommendation 1: Create a Unified Vision

Rather than trying to deal with the symptoms, address the contextual issues that are present at the heart of the Body Corporate. For large infrastructure projects where there are many parties represented in the Body Corporate, it is imperative that the leadership team agrees to a common and unified vision for the works program (or project, as the case may be). There must be a large level of executive buy in and core understanding of the Body Corporate's long term goals, department objectives, and key initiatives within the leadership team prior to passing it down to the teams.

Recommendation 2: Work Towards Achieving a Common Goal

Once the leadership team has agreed to the over-arching unified vision, it is important that this team determines underlying root problems that may be causing the ripple effect of silos. Many times there are multiple tactical goals and objectives identified (particularly due to the different project participants comprising the Body Corporate), but it is up to the Leadership team to remain on task and define the single, qualitative focus that is shared among them as the top priority. Once the "elephant in the room" has been identified it is important that all executives and all members of management work together towards achieving that common goal. It is also important that all the employees in all the respective organisations and entities are aware of this objective and understand how they can make an impact individually. This thinking, along with a unified focus, should be applied across teams to encourage collaboration, team work and ultimately accomplishment of the common goal.

Recommendation 3: Motivate and Incentivise

Having successfully established a unified, common goal and understood how each project participant contributes to this goal, it is essential that individuals in each of the teams for the project are motivated to contribute. All the tactics associated with motivation are designed to avoid the "it's not my job" behaviour and instead

encourage input, team work and, most importantly, productivity.

Whilst the unified vision is established at the Body Corporate level, it is up to the managers of the individual project participants to generate this motiviation. Motivation can vary across teams, as well as across individuals. A successful manager is one who is able to identify what key components motivate each of their employees and how to communicate this effectively to a wide range of audiences. Leaders and managers need to remember that motivation encompasses a wide variety of tactics including common interests, individual investment in growth, shared voice, and positive words of encouragement.

Recommendation 4: Collaborate and Create

There are a few factors that are fundamental to creating a thriving and productive team: knowledge, collaboration, creativity, and confidence. Without these four basic factors any team is destined to fail. To encourage each of the various teams across the project to exhibit all of these traits, it is recommended that management allows and fosters cross-departmental and cross-organisation interaction. The exchange of knowledge and the collaboration that will inevitably take place between teams is absolutely priceless. To maximise collaboration, knowledge, creativity and confidence it is suggested that management works to implement the recommendations contained in the following section about Information Management as part of this Principle.

Breaking down the silos is not an easy task for any organisation; however, failing to address these issues will be more detrimental to the employees and ultimately the overall health of the project teams.

Recommendations and Guidance Regarding Information Management

In essence, Information Management is about ensuring that the right information is available to the right people at the right time.

A key element is to recognise the interconnections and interfaces between all members and constituent parts of the project, and then being able to synthesize them into a unified view.

Recommendation 1: Establish Information Governance

The overall intention is to govern, create, describe, store, preserve, retain and manage project information with the end purpose of making it easy to find, easy to use and easy to share for reuse, for as long as needed. Therefore, plan and implement an information framework that ensures:

1. Project information is fit for purpose, i.e. contains sufficient detail to meet

current project needs and can be understood by others in the future, is accurate, and is created in a format that enables efficient business processes and maximises its potential for use and reuse.

2. There is adequate description (metadata) of project information so that it can be found, understood and accessed appropriately when needed.
3. Project information is stored in a secure and suitable environment, such that it is preserved in a useable condition for as long as required.
4. Project information is readily available unless there is a reason to restrict or partially restrict access (such as security or privacy considerations).
5. Identify what functionality the information management system will need to enable and support use of project information including the required level of:

» creation or import;
» description (metadata);
» interoperability with other systems;
» access;
» security and preservation;
» destruction or export of all or selected information.

Ideally, the collection and management of metadata should be automated to provide details such as a unique identifier or title, its context (who created it, when and for what purpose), and its history and use (when it was captured into a system, who has accessed or viewed it, and if it has been changed and by whom). To ensure consistency, it is beneficial to use tools (such as data dictionaries) when manual input or modification of metadata is required.

There is merit to determining the degree to which it is necessary to trust or prove that information is genuine, complete, accurate and unaltered.

Recommendation 2: Maintain Project Information

Having established a framework, the following factors should be applied in an on-going manner.

1. Ensure the creation of project information is integrated into business processes and that staff in each of the constituent project organisations are trained to know when and how to create fit-for-purpose information, recognising that on large infrastructure projects there can be considerable staff turnover.
2. Ensure that the information environment prevents unauthorised access, duplication, alteration, removal, or destruction, whilst being accessible and

retrievable for as long as required.

3. Ensure there remains a single source of truth (i.e. the same information does not exist in more than one place, as updates can result in divergence).
4. Ensure that technological change does not compromise the accessibility or useability of information.
5. Implement routine measures to safeguard the information (such as backups) and assure the veracity by performing data restoration periodically.
6. Track or provide audit trails of actions such as access or alteration.
7. Manage data maturity and provenance.

Further details on principles and recommendations for information management are available through the National Archives of Australia *Information Management Standard*.

Principle 4: Ensure all Organisational and Technical Interfaces are Properly Documented and Understood

Adoption of this Principle can provide clarity, certainty and commitment about the boundaries and the information exchanged across them. The primary benefits include reductions in contingency costs, risks, delays and disputes, and also provides the framework for collaboration amongst stakeholders.

Recommendations and Guidance regarding Interfaces

Problems can arise when one or more interfaces get overlooked. Within an organisational context, interfaces exist between departments within a single project participant and between project participants. Some might not be immediately obvious, for instance between the party responsible for developing the software for an operations/control centre, and the party responsible for developing and conducting the training of operations personnel.

The one fact that is common to both organisational interfaces and technical interfaces is that the number of interfaces is related to the number of nodes or entities according to the equation

$$I = N(N - 1) / 2$$

where

N is the number of nodes, and

I is the number of interfaces.

Thus any increase in the number of project participants (or of subsystems) causes a much greater increase in the number of interfaces, in turn demanding a substantially greater management overhead.

For example, an infrastructure project may involve three government departments (e.g. Transport, Environment and Finance), four contractors (covering design, construction, control/management systems, and testing/validation), giving rise to 21 separate relationships, typically managed with contracts. This leaves aside the added complexities when any of the major contractors engage sub-contractors.

Recommendation 1: Explicitly identify and declare each interface

Adopting a thorough approach is essential to ensure that no interface is overlooked. The best way of accomplishing this is by completing a chart, often referred to as an N2 chart. The N2 chart lists every entity (whether an organisational unit or a subsystem element) both horizontally (as column headings) and vertically (as row labels). The cells on the diagonal can be blanked out as they correspond to each entity interfacing with itself. Work within either the upper half (above the diagonal) or the lower half (below the diagonal) to indicate in each intersecting cell which entity is the owner of the interface. An interface may be explicitly eliminated if it can be confirmed that there is no interface relationship

between the two entities. For the purposes of discussion of technical interfaces, it is useful to refer to one end as the master (being the one which determines the protocols, etc.) and the other as the slave (or dependent) end.

Recommendation 2: Define clear responsibility and accountability

For each interface identified from Recommendation 1, determine who is the owner (the party responsible for "getting it right"). Within an organisational context, this means defining which party (project participant) is responsible for ensuring that all the provisions of the contract are met, including the means for handling deviations and waivers, and authorising changes (change management). Similarly for the technical context, the owner establishes the basis for the interface requirements (e.g. protocols, etc.) whilst the party responsible for the other end of the interface must ensure that it is designed and built to match these requirements. Typically, the interface of a legacy system is designated as the master, since the time and effort which would be involved in making changes to it far outweighs the effort of creating or adapting a new interface for the slave side of the relationship/link.

Within the technical (system solution) context, it is strongly recommended that Interface Control Working Groups (ICWG) be established, having representation by those project participants that have an interest in the interface (i.e. at least one member from each system that interfaces with the system of interest). In essence, an ICWG serves as the official communications link between project participants to resolve interface problems, document interface agreements, and coordinate Engineering Change Proposals. An ICWG is established to review, analyse, and evaluate interface requirements, which may impact particular aspects of the design and development effort.

For each ICWG, it is good practice to prepare a Charter, which details important aspects including:

- the general authority by which the ICWG is formed and describes the scope of the ICWG efforts;
- a description of the organisation, membership, and member roles within the ICWG;
- the details of the responsibilities assigned to each ICWG role (e.g. coordinate the working group, prepare meeting minutes, submit reports to Project Managers, etc.);
- Interface Requirements Agreements (IRAs), one for each interfacing system that falls within the scope of the ICWG. As its name implies, the IRA defines the responsibilities and accountabilities relevant to that interfacing system;
- Procedures, covering both general procedures for planning, coordinating,

funding, convening, and running ICWG meetings, and specific procedures for documenting all action items (including the issue, organisations and entities affected by the action item, and a point of contact for the resolution of the action item) and tracking action items to closure.

Recommendation 3: Design for Re-use

As noted previously, large infrastructure projects have their unique differences, even within the same sector. But there are numerous commonalities for both the organisational context and the technical context.

From an organisational perspective, within any given sector (roads, rail, water supply and treatment, etc.) there are often the same project participants: government departments, regulatory authorities, and major contractors. Thus, if a good charter (template) is established on one project for an ICWG, then there is positive value in applying the same template (with only minor tweaking) to other ICWGs on the same project and also to ICWGs established for other projects.

The corollary of this is to record and use the concept of lessons learned; documenting what worked well and what didn't work so well and the reasons why, then making sure that this information is readily available for all participants on the project and for all future projects (refer to recommendations on Information Management under Principle 3 above).

For the technical context, specifying interfaces that comply with international standards rather than allowing for proprietary interfaces enables:

- greater commonality and hence re-use;
- typically lower cost interfaces, since there is a competitive market for suppliers of equipment featuring these interfaces;
- greater probability of future-proofing the design, such that the equipment can be maintained for a longer period, if required.

All the guidance and recommendations offered for these four Principles can be summarised as “common sense”. No doubt, every infrastructure project addresses these. Unfortunately, the pain points identified during the ASEW in 2018 have revealed that these Principles are not being universally and comprehensively addressed at all levels of all projects. If the common desire of those responsible for infrastructure projects is for success (as defined earlier in this document), then it is beholden upon the managers and leaders of all project participants to universally and comprehensively adopt these Principles.

ASEW 2018 was the first occasion to workshop pain points impacting infrastructure projects (principally transportation related), from which only the top three pain points were investigated. All up, there were 43 suggested pain points, which were loosely grouped into eight categories.

The intention is to use the forum of ASEW 2019 and later years to workshop in a similar manner other pain points (both those raised during ASEW 2018 and new ones) and further develop this Principles and Guidelines document to accommodate the recommendations from these workshops.

The Method to Understand and Resolve Pain Points

This Appendix is being prepared and will be inserted when completed. It provides the details regarding the systematic approach which was applied to:

- Analyse the problem space;
- Identify the associated stakeholders;
- Define any constraints;
- Define any impediments;
- Detail identified enablers; and
- Culminate the exercise in producing a list of relevant requirements or actions along with a “value proposition” for the relevant stakeholders.

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