Transport for NSW Submission:

Inquiry into the role of smart ICT in the design and planning of infrastructure

Terms of Reference

The Committee is to inquire into and report upon the role of smart ICT in the design and planning of infrastructure, in particular:

- Identifying innovative technology for the mapping, modelling, design and operation of infrastructure;
- Identifying the new capabilities smart ICT will provide;
- Examining the productivity benefits of smart ICT;
- Harmonising data formats and creating nationally consistent arrangements for data storage and access;
- Identifying international best practice in the use of smart ICT in the design and planning of infrastructure;
- Considering the use of smart ICT in related fields, such as disaster planning and remediation; and
- Considering means, including legislative and administrative action, by which government can promote this technology to increase economic productivity.

Introduction

Smart ICT can and should aid decision making for designing and delivering new infrastructure, as well as maintaining existing infrastructure.

Transport for NSW contends that smart ICT will only be as effective as the appropriateness, completeness, accuracy and consistency of the infrastructure data on which it draws.

Recommendations

	Recommendation	Page
1	That the Council of Australian Governments (COAG) appoints a single 'Champion' that will lead a task group for smart ICT and digital engineering innovations for infrastructure.	7
2	That the task group develop a measurable, medium term national plan identifying policies and strategies to accelerate domestic implementation of new technologies and innovations.	7
3	That the task group engage with industry and advise Governments on global innovations that will achieve broad productivity benefits.	7
4	To maximise the relevance and utility of its work, the task group should: • Learn from international government best practice for digital engineering strategies • Develop its plan to align with best international best practice • Be given a mandate from COAG or the Transport and Infrastructure Council (TIC) that clearly defines a vision for the adoption of Smart ICT, goals and timeframes.	7
5	That COAG or TIC oversees the development of a National Standard for Infrastructure Asset and Location Classification.	15
6	That COAG or TIC oversees the development of a National Standard for infrastructure data formats and data exchange protocols, based on Industry Foundation Classes (IFC).	15
7	That COAG or TIC oversees the development of a National Standard for object based design, with the aim of creating a national library of design objects.	15
8	That COAG or TIC establishes guidelines and principles for establishing a Common Data Environment structured in accordance with the above three Australian Standards.	15
9	That the Australian Government funds research and development of new technologies for disaster planning, emergency response and humanitarian relief.	21
10	That the Australian Government funds the establishment of Virtual Cities or Precinct Information Models in Australia.	21
11	That Australian Governments, through COAG, replicate the UK model, and where possible, utilise and build on the established UK Standards, supporting technologies, training modules, accreditation frameworks and contract models.	23

Identifying innovative technology for the mapping, modelling, design and operation of infrastructure

Innovation and rapid advances in smart ICT continue to enhance and evolve the way infrastructure is now planned and delivered. Early adopters of these new technologies are gaining a market advantage as they are enabled to work smarter, faster and more efficiently.

Smart ICT and Asset Management

Within Transport for NSW, the Asset Standards Authority is leading the development and strengthening of Transport for NSW assurance processes across all modes of transport (e.g. rail, bus and ferry) and leading initiatives to:

- enable greater efficiencies and effectiveness of public transport service delivery
- support industry growth
- cut red tape and drive CAPEX and OPEX savings initiatives in engineering governance and design
- increase productivity
- support the delivery of major transport and infrastructure projects.

The focus of this work is to assure the public and government that Transport for NSW is working within an integrated model to deliver customer-focussed, cost effective, safe and fit for purpose infrastructure or assets throughout their whole of life - from the identification of their need through to their disposal.

Whole of life approach – Transport for NSW Asset Management Framework

Transport for NSW sets the direction and priorities of asset investments and oversees the delivery of integrated transport services by public and private Operators & Maintainers (in line with contractual and regulatory obligations).

The Transport for NSW asset portfolio primarily covers both network (fixed) and fleet (mobile) assets and associated infrastructure that supports each transport mode in delivering efficient and sustainable services.

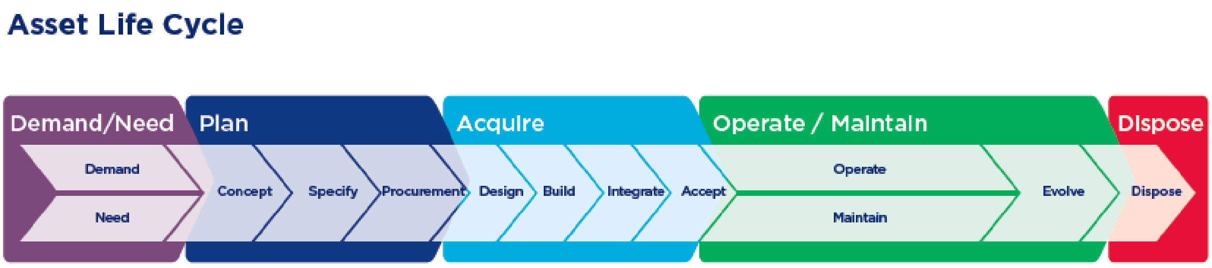
Asset Standards Authority is leading and coordinating the development of Transport for NSW's Asset Management Framework. Asset Management is a holistic approach to balancing infrastructure cost, risk and performance and will produce a balanced delivery of organisational outcomes and customer service. The Transport for NSW Asset Management Framework will support its vision of providing freight and public transport customers with an integrated transport system that is safe, effective, reliable and efficient.

In order to achieve the most value, smart ICT will be used across the whole asset life cycle, from supporting decisions based on demand and need, to planning the right asset to build, building that asset and then operating and maintaining the asset.

Data built across the asset life cycle can be used from planning and designing through to operating and maintaining.

Transport for NSW's experience is that the Tier 1 construction and consultancy organisations have experience with smart ICT systems and have embraced the productivity benefits that they can provide. The challenge for government is to ensure that the smart ICT systems not only serve the efficient and effective delivery of projects but the effective and efficient delivery of ongoing services. Key to this is the avoidance of cost and incompatibility in the transfer and integration of data from the smart ICT used by the construction and consultant industry with government owned systems.

Common definitions, data sets and data portability standards will maximise the benefits of smart ICT whilst avoiding proprietary vendor lock in.



Future opportunities also exist in applying innovative ICT technologies to support:

- Timetable modelling
- Reliability modelling
- Design modelling
- Network modelling (growth, sustainability and capacity including power).

All uses of smart ICT will require robust configuration control processes to ensure that the information is accurate and remains current, particularly during the Operate & Maintain phase of the asset life.

Enterprise Asset Management

In order to implement its whole of life asset management approach, Transport for NSW is exploring an Enterprise Resource Planning (ERP) Program to streamline processes and provide better quality information to unify the cluster approach to asset management.

Digital Engineering and Smart ICT

At the centre of the transformation in smart ICT is Digital Engineering (DE), otherwise known as Building Information Modelling (BIM). DE may be defined as a collaborative way of working, supported by integrated information management and smart ICT systems, which drive efficiencies throughout the lifecycle of infrastructure assets. From a practical perspective, the use of DE provides a step change in the quality and cost effectiveness of planning, delivering and maintaining infrastructure assets.

The BIM framework for structuring information, integrates with an organisation's existing asset management systems to store and make available complex plans, models, drawings, photographs and information attached to any asset, and makes it available to staff anywhere and at any time.

Through DE, it is now possible to create fully detailed, data-rich, virtual models of everything that we survey, conceive, design and deliver. These models can be continually re-used and leveraged to unlock significant benefits, with the greatest returns seen in operations and maintenance. DE now enables considerable savings and performance enhancements across industries, and is rapidly becoming business-as-usual for a number of sectors including buildings, infrastructure, oil and gas, and bulk materials.

At its core, DE is a purposeful combination of:

- **Information management** – recognising the value and importance of accurate, structured asset information to make informed decisions
- **Business processes** – establishing collaborative processes for production, management and sharing of information
- **New technologies** – capitalising on new and advanced ICT innovations to improve infrastructure operations and delivery.

BIM is currently under consideration by Transport for New South Wales and its cluster agencies.

Transport for NSW and Digital Engineering

Transport for NSW's DE Working Group has been following the advances of smart ICT since 2012 and determining the implications and benefits for infrastructure delivery and operation.

Over the past 12 months, Transport for NSW has developed a strategy for implementing digital engineering processes and technology, with a focus on improved project delivery. Work is now underway to establish the DE Task Group, which will manage this initiative and deliver the strategic benefits over the next three years.

Transport for NSW is also managing Australia's first trial of 5D BIM for infrastructure, trialling innovative new technologies such as mobile laser scanning, augmented reality and 3D printing. A number of projects are also using various aspects of DE to improve performance and delivery outcomes. This project experience, coupled with the long-term strategy has enabled Transport for NSW to become a leader in this field.

As a major deliverer of transport infrastructure, Transport for NSW has been interacting with the industry on the topic of smart ICT in recent years. Transport for NSW has introduced elements of smart ICT in major project procurement and has obtained experience in some of the issues that will need to be resolved across industry in order to ensure that the benefits offered by smart ICT systems are delivered.

The ICT landscape is constantly evolving, and is now shaping the way infrastructure is planned and delivered. Smart ICT presents a range of new capabilities for the infrastructure sector, and in particular, the growing field of DE.

DE brings together numerous technologies, such as:

- GIS and smart 3D models
- Advanced information management
- Mobile Technology and cloud based storage and applications
- Augmented and Virtual Reality
- 3D printing of prototype models, components and structures
- Spatial mapping and monitoring e.g. laser scanning, LiDAR and photogrammetry
- Drones
- Automated construction, 3D printing and prefabrication
- QR Codes and RFID chips
- Real-time remote monitoring and 'The Internet of Things'.

These technologies, when combined with DE business processes, present a diverse range of capabilities that offer significant benefits across the asset lifecycle for infrastructure.

Transport for NSW DE Benefits Matrix provides a comprehensive summary of Smart ICT infrastructure technologies, capabilities and the resulting productivity benefits (at Appendix A).

In order to maximise benefits realised, DE processes must be applied throughout the asset lifecycle, commencing in the early planning and design phases. This will enable smart 3D models to be created and built-up progressively throughout delivery, providing a data-rich asset model at the point of handover into operations and maintenance. Processes and resources to manage these models during operations and maintenance are critical and must be established.

Smart ICT and Road Network Operations

The application of ICT technologies to transport – known as Intelligent Transport Systems (ITS) – can achieve substantial benefits in the efficiency, reliability and safety of transport networks, and can greatly enhance the experience of transport users.

ITS technologies can greatly assist with the collection and presentation of transport infrastructure mapping. Detailed, highly accurate and up-to-date mapping of transport infrastructure is becoming increasingly important to support the implementation of new ITS technologies and to meet increasing customer expectations.

Modelling of proposed transport infrastructure prior to construction is essential to ensure that expected benefits will be realised, and that any potential issues and risks are identified and managed. For complex road infrastructure projects, simulation tools are used to model predicted traffic to assess project designs. These tools are continually being enhanced with new innovations to improve modelling outcomes.

The adoption of smart innovative traffic management technologies can greatly enhance the operation of road transport infrastructure assets through improvements to efficiency, reliability and safety. The deployment of these systems can be cost-effective mechanisms for maximising utilisation of existing road network infrastructure, and delaying or preventing the need for costly new infrastructure. Typically the introduction of these systems has very favourable benefit-cost ratios when compared to traditional infrastructure projects.

Smart traffic-adaptive traffic signal technologies bring significant benefits to traffic in busy cities around the world. The Sydney Coordinated Traffic System (SCATS), developed by Roads and Maritime Services (RMS) in NSW, is used for this purpose in Sydney, all states in Australia, New Zealand, and many other cities around the world.

A recent study has demonstrated SCATS delivers substantial economic benefits to Sydney in travel time savings – estimated to be around $3.6 billion per annum – when compared to simpler methods of traffic signal control. The study further indicated that SCATS produced environmental benefits of 235 tonnes of CO2, 835 kilograms of NOx and 16 kilograms of particulate matter PM^{10} avoided, and 623,000 fewer vehicle stops, per weekday on the studied corridor. RMS continues to enhance SCATS to further improve these outcomes.

RMS is currently in the process of defining a suite of innovative enhancements to SCATS that will be funded by State Infrastructure Strategy funding. These enhancements will deliver substantial traffic congestion improvement benefits to Sydney, and will also other cities using SCATS, including all states of Australia, New Zealand, and many other cities around the world. A detailed strategic business case is now being finalised supporting this work to secure the required funding.

Smart Managed Motorways technologies – in particular the use of ramp signalling – are broadly recognised as among the most beneficial current ITS technologies available to road network managers to improve road network outcomes. Deployments of these technologies around the world, and in several Australasian jurisdictions, have achieved substantial safety, efficiency and reliability improvements.

The latest deployments of Smart Managed Motorways – including several in Australasia – have adopted new innovations to improve their operation. NSW is currently planning the implementation of its first Smart Managed Motorway on the M4 Motorway which will introduce further innovation. One of the key objectives of the NSW Smart Managed Motorway implementation is to manage the entire road network – arterial roads and motorways – as a single integrated network. In most other jurisdictions these different road types are managed independently. This will primarily be achieved through the use of SCATS as the principal traffic control system for NSW motorways as well as arterial road traffic signals.

One of the key challenges currently facing road agencies internationally is the rapid development and near-term introduction of Cooperative Intelligent Transport Systems (C-ITS) and Automated Vehicles. These fast approaching technologies will deliver substantial benefits, but will also bring fundamental changes to communities and to the role of the road network manager.

C-ITS and Automated Vehicles are emerging technologies that will substantially change transport as we know it, and will deliver substantial safety, efficiency, reliability and mobility benefits. Trials of these technologies are well advanced overseas. C-ITS – also known as Connected Vehicle – technologies will start to appear in production vehicles around 2017, with the emergence of publicly available highly automated vehicles expected around 2020.

Substantial quantities of data collected by ITS can be utilised to assess the operational performance of transport infrastructure assets.

Many Smart ICT roads projects are focussed on optimising use of existing roads rather than constructing new roads. This is particularly important in densely settled urban areas where it may be expensive or not possible to construct new roads.

Recommendations

1. That the Council of Australian Governments (COAG) appoints a single ‘Champion’ that will lead a task group for smart ICT and digital engineering innovations for infrastructure.

2. That the task group develop a measurable, medium term national plan identifying policies and strategies to accelerate domestic implementation of new technologies and innovations.

3. That the task group engage with industry and advise Governments on global innovations that will achieve broad productivity benefits.

4. To maximise the relevance and utility of its work, the task group should:
   - Learn from International government best practice for digital engineering strategies
   - Develop its plan to align with best international best practice
   - Be given a mandate from COAG or the Transport and Infrastructure Council (TIC) that clearly defines a vision for the adoption of Smart ICT, goals and timeframes.

Identifying the new capabilities smart ICT will provide

Smart ICT would enable better decision making at the planning stage of infrastructure and assist to build evidence-based, data-driven models that provide better understanding of future network needs.

Smart ICT technologies offer new capabilities in the Motorway and Tunnels Control system (OMCS). The following are examples of new technologies implemented for key objectives:

- Improving safety for all occupants on the motorway and amenity for the tunnel occupants:
    - New air-quality sensor technologies to improve accuracy and reliability
    - New fire detection technologies (fibre optic detection) and deluge control systems
- Managing and mitigating the effects of incidents on the motorway:
    - Incident Management Systems with automatic generation of the incident response plans and associate traffic incident management plans with setting various ITS devices.
- Managing and safeguarding the motorway tunnel from damage – prohibited (over height and dangerous goods) vehicle protection:
    - Detection and identification of the prohibited vehicles with automatic number plate recognition systems
    - Communication systems in addition to roadside Variable Message Signs (VMS) to notify offending vehicle to exit using radio systems. New Cooperative ITS technology via 5.9GHz communication has the potential to automatically stop an offending vehicle.
- Effective motorway management and operations:
    - Implementation of the fully interoperable free flow electronic toll collection (ETC) systems
    - Implementation of travel time information in real time
    - Implementation of the Ramp Management and Smart Motorway functionality to improve traffic flow management.

Examining the productivity benefits of smart ICT

Road Network Operations

The productivity benefits of Intelligent Transport System (ITS) initiatives can be achieved through simulation modelling or through before and after studies. Data collected by ITS can be utilised to assess the productivity benefits of the application of smart ICT to transport infrastructure assets.

Roads and Maritime Services has outsourced most of its road and ITS maintenance services to industry partners who have not only experience in ITS maintenance but have the proven capability and international experience to implement smart ICT that targets and delivers on productivity benefits.

The Centre to Centre (C2C) interface provides connection between the independently operated motorway control systems and Transport for NSW traffic control systems. The C2C interface offers a consistent driving experience whether travelling on a government controlled road or a private motorway. The control centre operators interact via the C2C interface to extend information and control to other operators across system boundaries.

This interface provides bilateral exchange of incident and traffic data from across the NSW motorway network to allow remote monitoring of traffic movements and incident management. It includes the visibility and ability to control ITS devices, such as Variable Message Signs on private motorways. This functionality is particularly critical in coordination of traffic management between adjacent motorways along the Sydney Orbital.

The implementation of the C2C interface provides the following productivity benefits:

- Automated generation and usage of the Incident Response Plans across system boundaries to achieve complementary incident response.
- Access to motorway network information providing improved decision making for analysis (i.e. network operations and network optimisation).
- Improved decision making and overall operator efficiency for Transport Management Centre (TMC) operators.
- Improved situational awareness and incident verification process (16 per cent of M7 incidents directly affect Transport Management Centre controlled roads).
- Motorway devices locations, status and information visible to the Transport Management Centre and Roads and Maritime Services.
- Improved decision making for motorists due to motorway operator and Transport Management Centre and Roads and Maritime Services being able to display information in motorway Variable Message Signs for Real Time Travel Time Information (RTTTI).
- Collaborative incident detection, response, and resolution (on average thee to nine incidents per day).

Critical Infrastructure and Security

Smart ICT may be a focus for reducing the requirements for labour intensive network monitoring tasks. A reliable system (with inherent redundancy) integrating operational monitoring and incident detection technologies can enhance situational awareness, reduce response times and improve productivity across security, safety and operational continuity for critical infrastructure.

Smart ICT presents opportunities in the following areas:

- Integration and optimisation of CCTV networks

- video analytics
- electronic access control systems
- intruder detection systems
- vehicle tracking systems
- response crew work status
- (voice and data) communications networks in a single user interface.

Asset Management

Smart ICT will contribute to greater productivity in asset management by:

- Substantiating asset decisions and better outcomes (investment planning, design, maintenance and disposal) through access and collaboration (single source data).
- Enhancing performance due to swift & accurate comparison of different design options.
- Optimising solutions through cost effective optimisation and optioneering against agreed parameters.
- Providing greater predictability by visualising at an early stage.
- Driving faster project deliveries through time saved by agreement of design concept early.
- Reducing safety risk design, constructability and maintenance by supporting human factors and operational safety at an early stage.
- Enabling “Fit for Purpose” integration by integrating multi-disciplinary design into a single model.
- Reducing waste with procurement by scheduling just-in-time.
- Facilitating whole life asset management - information to assist commissioning, operation and maintenance is managed through the infrastructure / asset whole of life management model.
- Enabling continual improvement by inputting project feedback into performance of processes and equipment.

Harmonising data formats and creating nationally consistent arrangements for data storage and access

In order to achieve nationally consistent data that is secure and accessible, it is critical that the Government, in partnership with asset owners and industry, establish the following four core elements of Digital Engineering (DE):

- Standardised Asset and Location Classification System
- Standardised Open Data Format
- Standardised Object-Based Design
- Common Data Environment.

These four elements are introduced in the attached DE Benefits Matrix (Attachment A), and explained in further detail below.

Standardised Asset and Location Classification System

The overarching aim of a universal classification system is to ensure all infrastructure asset information is generated in a single, common structure that is consistent and searchable. This concept is fundamental to digital engineering and will enable a paradigm shift in the way asset information is managed in Australia. The resulting benefits with enable significant advancements in project automation and the development of smarter infrastructure for society.

This is a complex and challenging problem that will require significant leadership and cross-sector alignment to solve. For example, in the transport sector alone, a single unified system must consistently classify asset data for all asset types, for example rail, road, ferry, buses, utilities, buildings. There are a number of classification initiatives currently under development in Australia that are not harmonised. If these continue down their divergent paths, both the long-term productivity losses and rectification costs for Australia will be significant.

The vision for a single asset classification system has yet to be achieved globally, however there are currently a number of government led initiatives underway. The UK Government is currently the global leader in this field, with their on-going investment and development of “Uniclass”.

Uniclass is currently the most advanced classification system in the world. This system was originally established by the Royal Institute of British Architects (RIBA) and is now owned and being further developed by the UK Government. Over time, Uniclass is expected to become an ISO standard, along with a number of other associated UK DE (or Building Information Modelling (BIM)) Standards.

Given data classification is pivotal to cross-sector standardisation, this challenge cannot be resolved by private industry alone. Put simply, Government must take a leading role in the design and implementation of a nationally consistent asset classification system. This is the only way data from all infrastructure owners around Australia can be harmonised, and will ensure the best outcome for government, industry and end customers.

Open Data Formats

In order to achieve harmonised infrastructure data, the universal classification system (as noted above) must be combined with a reliable open data file format. Open data, stored in a standardised, non-proprietary format is key to the successful implementation of DE in the infrastructure industry. It enables interoperability across technologies and business platforms, resulting in true data exchange that prevents information from becoming misinterpreted, duplicated or lost.

The UK Government, in partnership with buildingSMART, is leading the development of an open industry standard called 'Industry Foundation Classes' (IFC). The intent of the IFC is "the specification for sharing data throughout the project life-cycle, globally, across disciplines and across technical applications in the construction and facilities management industries".

Through the adoption of a standard open data format such as IFC, infrastructure data and information will be guaranteed future interoperability. This will also enable the industry to tap into future technologies and innovations, avoiding the constraints and costs of being restricted to proprietary systems.

It must be noted that all major software vendors will only invest in compatibility to open data formats if there is a suitable pipeline of mandated demand. It is critical that governments commit to one common data format for all asset information to get the greatest return on investment in Smart ICT.

Object-Based Design

A key fundamental of digital engineering is object-based design, which transforms how infrastructure is surveyed, conceived and designed.

2D CAD

Traditionally CAD processes create drawings based on 2D representations of the engineering and architectural elements, with large, multidisciplinary projects broken down into separate packages of work and drawings. While this process has been the industry standard for many years, it is often prone to risk as the design intent is often misrepresented, misinterpreted or poorly coordinated across disciplines. Unfortunately this practice represents 'business as usual' across parts of the Architecture Engineering Construction Operations (AECO) industry in Australia, with little motivation to change or improve established processes.

3D Modelling

With the advent of new technologies, designers can now create highly-detailed virtual models of projects in an online, digital environment. This has enabled design teams to work collaboratively in 3D, providing significant improvements to how multidisciplinary designs are created, represented and, most importantly, coordinated.

Early adopters of 3D object based design have gained a market advantage as they are able to achieve higher quality designs with fewer errors and reduced rework. This form of design also enables design teams to produce detailed visualisations of the design, facilitating improved stakeholder consultation in the early stages of the project.

Object-Based Modelling

The benefits of 3D modelling are significant, however the actual value of the 3D model is short-lived if it can only be used for a single purpose (for example, to enable construction). Object based modelling enables 3D models to become 'smart', as objects in the models may be associated with metadata and asset information. This allows a 3D model, created for a single purpose, to be leveraged for many other uses, adding significant value at marginal cost.

Object-based modelling is rapidly becoming the industry standard globally and is now commonly applied in the design of large-scale infrastructure projects – particularly where BIM has been mandated by clients and government.

Transport for NSW has seen a recent increase in tender submissions with integrated object-based modelling. It must also be noted that these are typically received from consultants with experience outside of Australia. This is concerning, as without intervention, there is a risk that our local industry may become less competitive on the global market.

A standardised approach to coding and classifying model objects will also enable local industry to develop consistent, re-usable libraries of objects. This will allow designers to build-up new designs with pre-designed and assured building blocks, resulting in a significant boost in productivity on infrastructure projects.

Common Data Environment

A Common Data Environment (CDE) is at the core of DE, and comprises of a secure, cloud based environment for collaborative working. A common data environment provides a common platform for all project stakeholders to communicate, re-use and share data efficiently without loss, contradiction or misinterpretation.

The CDE is typically a federated system, whereby information is linked and accessed across multiple sources, allowing all parties to contribute and access project data while retaining clear accountability, ownership and traceability. Information typically indexed on the CDE may include items such as planning approval information, object based design models, engineering documentation, construction quality and assurance documentation, maintenance manuals, operation records.

Increasingly, large international infrastructure clients are choosing to invest in their own cloud-based CDE, allowing suppliers to centralise information on their servers. This approach not only reduces overall cost, but enables clients to have full control of their information. This presents an immediate opportunity for government, where the roll-out of a standardised common data environment for all Australian asset data and information would unlock endless innovations and productivity benefits, and ensures all infrastructure data and information is structured in a way that adds the most value to society.

Motorway Management

The Centre-to-Centre (C2C) interface (discussed previously) is based on standard data specification and uses non-proprietary industry standard web services technology allowing multivendor deployment.

The C2C interface consists of the Central C2C Interface Hub (Enterprise Service Bus/Middleware) and the Nodes being both motorway and NSW Government agencies' control systems. The C2C Hub and some Nodes software is being reused or extended for additional functionality and services

To harmonise the data format the C2C interface used the Canonical Data Model (CDM) (the international standard for Traffic Management Data Dictionary (TMDD) developed by ITE/AASHTO). The customisation of the TMDD for NSW implementation has been carried out in strict conformance with the rules provided in the standard. Road agencies in Australia and New Zealand are currently considering adoption of the current NSW TMDD data set.

Network Management

Austroads has commenced the '*AB1935 Harmonised Asset Data'* project, to develop a common meta-data standard and taxonomy across Austroads member agencies. The Asset Standards Authority within Transport for NSW is working with Austroads on this project.

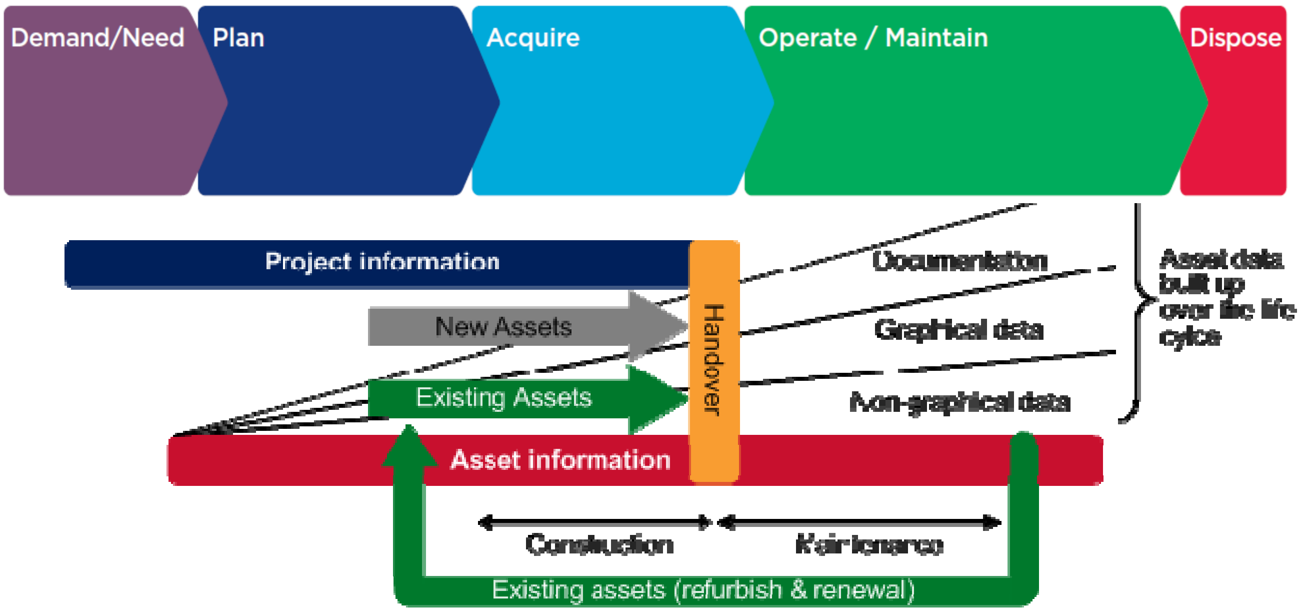
Critical Infrastructure and Security

The NSW Attorney General's Department maintains the Critical Infrastructure Program for Modelling and Analysis (CIPMA). CIPMA uses a vast array of data and information to model and simulate the behaviour of critical infrastructure systems and how they interrelate.

The implementation of any new geospatial and design technology should consider the release of generated data to the Attorney General's Department Critical Infrastructure Program for Modelling and Analysis (CIPMA) to allow analysis of incident impacts at a localised level and across sectors. Compatible data formats and consistency will enhance the effectiveness and accessibility of information to and from CIPMA for network resilience and incident management planning by all agencies.

Asset Management

Transport for NSW's Asset Standards Authority has recently published an Asset Information Management Standard with guidance and processes guiding users with the theme that asset information is an asset in itself that needs to be managed across the whole asset or infrastructure life cycle:



Configuration control over the asset data is vital to maintaining current and meaningful asset information.

The Transport for NSW Configuration Management Plan and guiding documents, published by Asset Standards Authority, provides the model for infrastructure life cycle practitioners to manage and provide evidence or justified confidence to assure Transport for NSW customers that infrastructure assets are fit for purpose, safe, reliable, maintainable, sustainable and cost effective.

In developing this framework, Transport for NSW has identified the need of a common infrastructure language and Master Data. Transport for NSW is moving toward standardising asset information Master Data requirements – this will define format, asset and location coding but not mandate the electronic data format. Data must be held in a consistent manner that will allow it to be extracted for analysis.

The Asset Standards Authority, on behalf of Transport for NSW, is developing standards to set the requirements of data standardisation. These can be viewed at: http://www.asa.transport.nsw.gov.au/ts/asa-standards

Recommendations

5. That COAG or TIC oversees the development of a National Standard for Infrastructure Asset and Location Classification.

6. That COAG or TIC oversees the development of a National Standard for infrastructure data formats and data exchange protocols, based on Industry Foundation Classes (IFC).

7. That COAG or TIC oversees the development of a National Standard for object based design, with the aim of creating a national library of design objects.

8. That COAG or TIC establishes guidelines and principles for establishing a Common Data Environment structured in accordance with the above three Australian Standards.

Identifying international best practice in the use of smart ICT in the design and planning of infrastructure

Best practice and Digital Engineering

Around the globe, rapid developments in smart ICT continue to improve the way infrastructure is now planned and delivered. Contractors seeking to gain a competitive edge are adopting digital engineering practices on their projects with an aim to increase productivity, reduce waste and achieve greater certainty of project outcomes.

It has been recognised that the countries with the most technologically advanced industries have typically been led by governments setting clear targets for digital engineering implementation and use.

This strategic approach in many of the world's leading economies has led to collaborative reforms across their respective construction and transportation industries, driving competitiveness and professional development opportunities across sectors.

More examples of government leadership are now appearing around the globe, through the implementation of digital construction strategies and Building Information Modelling (BIM) mandates.

Nation	BIM Mandate	Target
UK	Mandate for 'fully collaborative 3D BIM' on all publically procured projects	2016
USA	General Services Administration (GSA) mandated BIM as part of project minimum requirements	2006
Singapore	Target for 80% of construction industry using BIM	2015
South Korea	BIM compulsory for all public sector projects	2016
EU	Encouraging all 28 member states to mandate BIM for publically funded projects	2016
Finland	Mandated for all state property services projects	2007

The United Kingdom is recognised to be the world leader in transforming their construction sector and securing public spending savings. In 2011, the UK released their Construction Strategy, outlining a number of reforms to digitally transform the construction sector. The resulting five year plan aimed to achieve a 20% saving in capital expenditure on publically procured projects, and an overall reduction in carbon output.

A key part of this strategy was the ambitious 2016 mandate, requiring industry to develop and provide collaborative 3D object based models (with all project and asset information, documentation and data being electronic) on all publically procured projects.

The response to this mandate has been significant, leading to considerable investment and up-skilling of industry throughout the local supply chain in the past four years. The resulting impacts are already retaining benefits, with the UK government reporting a 20% savings in capital construction costs over a three year period, creating an overall reported saving of approximately

£840 million. In the long-term it is expected these savings will be realised many times over, due to improved efficiencies for operations and maintenance over the life of the new assets.

The UK Government has now commenced the next stage of their strategy, which is to export their skills globally, under the banner of “Digitally Built Britain”. If Australia is to remain competitive when bidding for global mega-projects, we must ensure our local industry continues to drive innovation and are not left behind.

Case Study 1: Crossrail (UK) - £15 billion rail project in London to be completed in 2018

- Embedded DE processes, including a standardised classification system, common file format and secure cloud based common data environment, ensuring consistency of information through design and delivery
- Up skilling supply chain free of charge through formal training provided by in-house BIM Academy
- Creating a structured digital asset for optimal operations and maintenance.

Case Study 2: Network Rail (UK) - National Rail Operator

- Established and funded ‘Offering Rail Better Information Services’ (ORBIS), embarking on a 6 year, £325 million programme to create a new business unit, transforming data and information management to improve overall asset performance
- Developed in-house mobile tools to enable site staff to make faster and more informed decisions.

Transport for NSW has seen early signs that local industry is beginning to apply digital engineering lessons from overseas on our projects. Our suppliers are now showing a willingness and capacity to innovate their businesses, up-skill their workforce and transform how they deliver our projects; all underpinned by digital engineering principles.

Road Network Operations

Use of smart ICT is a key focus for many countries and authorities as it can deliver real benefits including in the design and planning of infrastructure. Roads and Maritime Services analyses national and global experiences to identify best practices to address the challenges and opportunities within the NSW road network.

For example, Roads and Maritime Services is planning the deployment of Smart Motorway technology with the first implementation on the M4 Western Motorway. Smart Motorways includes a significant investment in ITS to improve the operation and level of service of motorways. In developing the strategies suitable for NSW RMS reviewed and assessed national and international experiences and best practice.

Asset Management

Transport for NSW is aligning its Asset Management Framework to the ISO 55001, the international standards for Asset Management. The standard has seven specific elements as demonstrated by its framework concept model:

ISO 55001 – seven specific elements

The creation and success of several international bodies and initiatives provide examples of best practice Smart ICT or asset information management methods:

- UK Building Information Modelling (BIM) Academy
- Industry Foundation Classes (IFC) developed and maintained by 'buildingSMART'
- Infrastructure limited asset classifications – e.g. Uniclass, Omniclass.

Infrastructure or asset information should be considered an asset in itself and can be managed more efficiently and effectively using smart ICT.

Value will be achieved through the application of smart ICT across the whole asset life cycle, from supporting decisions based on demand and need, to planning the right asset to build, building that asset and then operating and maintaining the asset.

The challenge for government is to ensure that the smart ICT systems not only serve the efficient and effective delivery of projects but the effective and efficient delivery of ongoing services. Key to this is the avoidance of cost and incompatibility in the transfer and integration of data from the smart ICT used by the construction and consultant industry with government owned systems.

Considering the use of smart ICT in related fields, such as disaster planning and remediation

The use and uptake of smart ICT infrastructure is constantly expanding, as industries find new ways to apply technologies to address societal issues. Disaster planning and remediation is a relatively new field for smart ICT, however various case studies have emerged in recent years that have assisted efforts for humanitarian work in both planning for and responding to disasters. More details on these are provided below.

Unmanned Aerial Vehicles (UAVs) or Drones

In 2013, Typhoon Haiyan was one of the strongest tropical cyclones ever recorded and left more than 6,000 people dead. This humanitarian disaster zone also destroyed vast swaths of infrastructure, including whole neighbourhoods and roads - making it impossible for aid workers to reach people stranded in remote locations.

To resolve this issue UAVs (or drones) were deployed to quickly survey the landscape, locate missing persons and create 2D and 3D maps to help community leaders understand the hardest hit areas. Since then, drones have been used in a number of other disaster areas for a broad range of applications beyond mapping, such as:

- Nepal Earthquake (2015) – Drones were fitted with high powered thermal imaging cameras to detect survivors in remote locations.

- Papua New Guinea (2014) - Médécins Sans Frontières used drones to transport medical samples in Papua New Guinea.

The role and application of drones is set to expand in this field, with the recent establishment of the Humanitarian UAV Network, rostering 300+ aviators for global response to future disaster relief.

Within NSW, Sydney Trains (part of the Transport cluster) has trialled the use of drones fitted with a high definition camera to inspect and record data on assets in hard to reach or high risk locations

Rebuild Coordination

In 2010, Christchurch was devastated by an earthquake that left 85 dead, destroying much of the CBD and surrounding infrastructure including approx. 1000km roads, 50km of water mains and over 30% of the sewerage system.

In response to this devastation, a massive $40 billion program is currently underway to rebuild the city and associated infrastructure. This has effectively transformed the CBD into a city-wide construction site, with multiple construction companies undertaking significant building and infrastructure work at the same time, in close proximity.

Coordination of works is essential, to ensure the numerous contractors can proceed unhindered, while still maintaining accessibility for commuters and residents of the city.

To address this challenge, the local government has developed an online tool called Future Viewer.

This tool uses a collaborative form of GIS, enabling contractors to enter in consistent, critical details about their works including scheduling, deliveries and access points. This provides the capability to detect clashes between projects, and opportunities for program optimisation.

It also has enabled recovery agencies, public and private sector users a shared online view of linear infrastructure repair, planned buildings and other construction.

Future Viewer has provided a significant return, with the local government reporting approximately $4 million (NZ) in cost savings as of 2014, and projecting more than $20 million (NZ) by the end of 2016.

Virtual Cities

Beyond disaster relief, governments around the world are beginning to implement smart ICT strategies to improve disaster planning, with significant developments using digital engineering for city precinct planning and management.

Work is underway in a number of global cities, such as Singapore, Seoul and Vancouver, to break down existing data silos and improve access to current and accurate information for town planners and emergency services. The development of these precinct wide information models, or Virtual Cities, provide a trusted digital representation that can be re-used for response and scenario training, feed real-time monitoring data (video, audio, etc) to emergency vehicles, identify access roads, egress points, highlight underground utilities, etc.

Road Network Operations

Transport networks form a major component of disaster planning and remediation. For this reason, Intelligent Transport Systems (ITS) can play a major role in disaster planning and remediation. ITS solutions are already used extensively in detecting and managing traffic incidents, and in managing major events. This includes the utilisation of smart ICT to detect and manage these scenarios, and also for dissemination of information to affected customers.

Smart ICT is an increasingly important element in the response to security and emergency events and situations. ITS solutions are useful assets for emergency organisations and authorities when dealing with emergency and security scenarios.

Motorway Management

The Operations Management and Control System (OMCS) cover a broad range of smart ICT technologies which are integrated to implement the safe and reliable operation of the tunnel system. To achieve this objective the OMCS includes:

Highest levels of mission critical reliability and security with the latest software technology such as Continuous Availability utilising Disaster Recovery Site (DRS) and distributed computing.

System redundancy is achieved by implementing virtual servers for high availability and fault tolerant operation.

The OMCS servers and operational facilities are provided in both main Motorway Control Centre (MCC) and Disaster Recovery Site (DRS).

Critical Infrastructure and Security

As smart ICT is gradually embedded into road infrastructure, the dependency on power and telecommunications networks for safety and efficiency will continue to increase. The interdependencies between individual assets, transport networks and across sectors (Communications, Energy, Water, Transport etc.) should be considered as a part of any incident, crisis and disaster planning. In many cases, the risks and vulnerabilities for physical and ICT assets are converging.

Smart ICT in itself will contribute to the resilience of local, state and national networks and deliver benefits to customers, including improved fuel efficiency, reduced travel times, avoidance of hazards and better awareness of incident impacts.

Access to smart ICT technologies can provide enhanced situational awareness through monitoring and controlling networks, more rapid assessment and resolution of physical and information network disruptions and better interoperability resulting in collaboration between agencies. A major bridge malfunction provides one example where smart ICT can:

- rapidly identify the location and cause of the malfunction
- alert crews to the pending task and required parts/actions
- notify Transport Management Centre of the disruption
- potentially automatically develop and implement alternate routes or transport solutions
- communicate these through Intelligent Traffic Systems, smart vehicle control systems, GPS alerts/updates, apps, Variable Message Signs and social media.

Recommendations

9. That the Australian Government funds research and development of new technologies for disaster planning, emergency response and humanitarian relief.

10. That the Australian Government funds the establishment of Virtual Cities or Precinct Information Models in Australia.

Considering means, including legislative and administrative action, by which government can promote this technology to increase economic productivity.

Advanced emerging transport technology innovations may require legislative or regulative changes to allow their introduction, and hence to realise their substantial benefits.

In order to achieve a sustained increase in economic productivity, the government must act as the catalyst, by demonstrating leadership and commitment, and directing industry to unite, commit investment and follow. For the digital transformation of the infrastructure industry to be successful, this will require a vision, with clear objectives supported by appropriate policy and funding.

With regards to the Australian Government, it is recommended that lessons are learnt from overseas governments that have successfully implemented mandates for Building Information Modelling (BIM) (or digital engineering). As noted previously, the UK Government is recognised to be the global leader, due to the on-going transformation of its entire construction industry.

The success of the UK program is well documented and may be attributed to the following key drivers:

a) **Government Mandate –** This sent a clear signal demonstrating the commitment by government, and the expectations for industry to respond and transform.

b) **Government Leadership** – This strategy has been led from the top down with the Government's Chief Construction Adviser acting as champion and leading advocate.

c) **Established Working Group** – The government funded UK BIM Task Group established a centre of excellence and advocacy for BIM, providing an open channel for engagement and collaboration with industry.

d) **New Industry Standards** – Since 2011, the UK Government has published a number of new standards outlining the new processes and obligations to meet the requirements of fully collaborative BIM. These standards are now upheld as global best-practice and are currently being re-written as ISO standards.

e) **Standardisation** – The UK Government has invested heavily into standardised asset classification and open file formats, to ensure a common platform for interoperability across industry. See response to Item 4 for further details.

f) **Mega-projects** – In recent years the UK Government has announced a number of mega-projects such as Crossrail and High Speed 2. These projects have been developed to harness the long-term benefits of DE and as such, have provided significant opportunity for large-scale education and upskilling of industry.

The UK BIM Task Group is recognised for playing a pivotal role in the success of the UK strategy. Established in 2011, the group formally aims to "drive adoption of BIM across government". They have now become the public face of the strategy and lead the on-going engagement with industry through their four work streams, as follows:

- **Stakeholder and media engagement** – broadcasting the vision and value through guidance and publications, stakeholder engagement and regional awareness campaigns.

- **Delivery and productivity** – development of standardised file formats, data exchange and business processes.

- **Commercial and legal** – contracts, copyright and IP / PI
- **Training and academia** – Academic forums, construction skills, accreditation and supply strategies.

For more information on the UK Government's strategy and implementation model see the website, www.bimtaskgroup.org.

Recommendation

11. That Australian Governments, through COAG, replicate the UK model, and where possible, utilise and build on the established UK Standards, supporting technologies, training modules, accreditation frameworks and contract models.

    This will allow Australia to leverage off global leaders and ensure we maintain alignment with international best practice.

ROLE OF SMART ICT FOR DESIGN AND PLANNING OF INFRASTRUCTURE
DIGITAL ENGINEERING BENEFITS MATRIX

No.	CORE ELEMENTS: Standardised Classification System	Standardised Open Data Format	Standardised Object Based Models	Common Data Environment	TECHNOLOGIES: Links with Schedule Data (4D)	Links with Cost Data (5D)	Mobile Technology	Augmented Reality / Virtual Reality	3D Printing (components / structures)	Laser Scanning	LIDAR / Photogrammetry	Unmanned Aerial Vehicles / Drones	Plant control by GPS	Robotic construction	RFID tags / QR Codes	Remote Monitors / Internet of Things	CAPABILITY	DETAILS	PRODUCTIVITY BENEFITS
A.	**DIGITAL ENGINEERING CORE ELEMENTS**																		
A.1	Y																**Standardised Classification System**	A Standardised Classification System that defines both Asset Class and Asset Location enables a universal, structured, consistent, logical method for grouping and organising asset information.	This drives significant efficiencies thoughout the asset lifecycle as information can be consistently found, referenced and maintained. This enables information to become machine readible, interoperable between systems and permits business processes to be automated - driving a step-change in productivity.
A.2		Y															**Standardised Open Data Format**	A Standardised Open Data File Format enables a seamless transfer of digital information, regardless of the industry source or software platform by ensuring interoperability across ICT systems	Better collaboration across suppliers, permitting data exchange, object libraries and automated processes. Also enables interoperability between systems, minimising costly data transfer between systems.
A.3			Y														**Standardised Object Based Models**	Standardised Object Based Models enable a consistent digital representation of physical assets, that permits association with metadata and information sources e.g. GIS, Smart 3D Models	Boosts productivity through continued innovation and insights into infrastructure planning, delivery, and operations. Also enables development of standardised libraries of model objects, that can be continually re-used across projects, providing on-going efficiencies and savings.
A.4				Y													**Common Data Environment**	A Common Data Environment (CDE) provides an enterprise level repository for collecting, managing and sharing project asset information, enabling cloud based collaboration across project teams	Single source of information, that facilitates better collaboration between project teams and minimises duplication and mistakes.
B.	**DIGITAL ENGINEERING OVERARCHING BENEFITS**																		
B.1	Y	Y	Y	Y													**Single Source of Truth**	Coordinates disparate information sources into a centralised, current, readily accessible system	Better information exchange, project coordination and interface management. The provides project teams the right information at the right time to make an informed decision.
B.2	Y	Y	Y	Y													**Collaboration**	Enables project teams to develop, manage and share information in a secure, cloud based environment.	Better accessbility to accurate, up-to-date project information. This provides signficant improvements in design coordination, interface management and the ability to share data efficiently without loss, contradiction or misinterpretation.
B.3	Y	Y	Y	Y													**Innovation**	DE creates a Smart ICT platform for governments, asset owners and the supply chain to develop innovative business processes and technologies	Centralised, consistently structured and accessible information provides significant long-term productivity gains. This also enables companies to develop and invest in processes and tools that will provide continued long-term returns.
B.4	Y	Y	Y	Y													**Risk Management**	Enables risks to be linked to design objects and controlled through the assets lifecycle	Enables risk mitigations to be better integrated into the early design phases, resulting in improved safety planning and design.
B.5	Y	Y	Y	Y													**Engineering Management**	Enables better tools for numerous engineering activities, including design traceability, change control, clash detection, checks for assurance and compliance etc.	Provides significant productivity benefits across all engineering functions and activities
B.6	Y	Y	Y	Y													**Quality Management**	Enables better tools for identification, traceability and management of quality issues throughout the asset lifecycle.	Improved quality management through greater control of quality outcomes. Also permits long term analysis of data to make informed decisions of asset quality.
B.7	Y	Y	Y	Y	Y												**Time Management**	Managed with enterprise scheduling platform. Enables program information to be linked objects in virtual models e.g. project schedules, resource planning, site coordination etc	Single source of time information, with standardised data structure for benchmarking. Enables faster, more accurate time estimates, more effecient delivery, coordination of works etc
B.8	Y	Y	Y	Y	Y	Y											**Cost Management**	Managed with an enterprise accounting and cost estimating platform. Enables cost information to be linked to objects in virtual models e.g. Method-of-measurement, unit rates, etc.	Single source of cost information, with standardised data structure for benchmarking. Enables faster, more accurate time and cost estimates e.g. life-cycle cost analysis, projected cash flows etc
B.9	Y	Y	Y	Y	Y	Y											**Commercial Management**	DE gives clients visibility of all decisions, with complete transparency for commercial negotiations of scope, cost and time changes.	Significantly reduces effort required to agree on variations, extensions of time, progress claims, etc.
B.10	Y	Y	Y	Y	Y	Y											**Procurement Management**	Provides standardise tools for procurement of new infrastructure assets	Enables consistent, benchmarked approach to procurement, ensuring faster processes and improved value for money.
B.11	Y	Y	Y	Y	Y	Y											**Benchmarking**	Enables information across projects to be readily collated, grouped and assessed.	Allows benchmarking of project data across industries for a range of measurables e.g. time, cost, quality, carbon etc.
B.12	Y	Y	Y	Y		Y											**Information Management**	Links with other information sources e.g. GIS, Asset Registers etc	Improved efficiency through re-use of government and previously purchased information

ROLE OF SMART ICT FOR DESIGN AND PLANNING OF INFRASTRUCTURE
DIGITAL ENGINEERING BENEFITS MATRIX

No.	CORE ELEMENTS				TECHNOLOGIES												CAPABILITY	DETAILS	PRODUCTIVITY BENEFITS
	Standardised Classification System	Standardised Open Data Format	Standardised Object Based Models	Common Data Environment	Links with Schedule Data (4D)	Links with Cost Data (5D)	Mobile Technology	Augmented Reality / Virtual Reality	3D Printing (components / structures)	Laser Scanning	LIDAR / Photogrammetry	Unmanned Aerial Vehicles / Drones	Plant control by GPS	Robotic construction	RFID tags / QR Codes	Remote Monitors / Internet of Things			
B.13	Y	Y	Y	Y			Y										**Knowledge Management**	Enables centralised, searchable and instantly accessible knowledge management	Better use of existing knowledge, saving time and cost in obtaining asset data and communicating business information
1.0	**PLANNING AND STRATEGY**																		
1.1	Y	Y	Y	Y													**Planning**	Provides tools for faster access to asset data and exploring options for project planning	Faster, more holistic planning with improved likelihood of meeting customer expectations and overall project objectives. Also reduces costs by minimising duplication of site investigations and ensures plans are developed based on the most current asset information.
1.2	Y	Y	Y	Y													**Mapping**	Provides platform for presenting geospatial information on maps, presenting the project in context with the surrounds	Improves design, enables rapid optioneering and decision making processes
1.3	Y	Y	Y	Y			Y	Y									**Visual Representation**	Presents clear visual representation of the project early in the design process using virtual models	More effective option assessment, stakeholder consultation and approval
1.4	Y	Y	Y	Y					Y								**Prototyping**	3d printing technology enables rapid creation of tactile models and prototyping	More effective option assessment, stakeholder consultation and approval
1.5	Y	Y	Y	Y						Y	Y	Y					**Spatial Information**	Rapid, cost-efficient collection and management of accurate spatial information	Better input information for strategy development and options assessment
2.0	**DEVELOPMENT**																		
2.1	Y	Y	Y	Y													**Rules-Based Design**	Smart tools enable automated 'rules-based' design. This ensures coordination and compliance is embedded into design process, as opposed to manual checks afterwards.	Automatic clash detection between discplines, ensuring errors are identified and quickly resolved, thereby preventing costly mistakes. Compliance with requirements and standards can also be checked automatically.
2.2	Y	Y	Y	Y													**Design Options**	Enables rapid creation of 'on-the-fly' design alternatives	Faster development of design options for assessment and value engineering
2.3	Y	Y	Y	Y	Y	Y											**Quantity Survey**	Standardised cost benchmarking database linking cost with virtual model objects and scheduling estimates	More accurate quantity take-offs, estimating time & cost, and minimising manual processing.
2.4	Y	Y	Y	Y			Y										**Multidisciplinary Collaboration**	Enables collaboration across design disciplines e.g. Architectural, Structural, Electrical, Mechanical, etc..	Multidisciplinary coordination, improving speed and quality of design process
2.5	Y	Y	Y	Y			Y	Y	Y								**Contextual Design**	Presentation of concept design options within the existing environment	Clearer communication of design intent, resulting in more effective stakeholder consultation
2.6	Y	Y	Y	Y						Y	Y	Y					**Advanced Site Investigation**	Better, more accurate data capture and site investigation techniques reduce the reliance on design assumptions e.g. location of existing utilities, heritage items, etc.	More reliable input information and reduced risk of design errors
3.0	**DESIGN**																		
3.1	Y	Y	Y	Y													**Sustainable Design**	Better tools for calculating project outcomes e.g. energy and carbon use	Better design, with more environmentally friendly and sustainable outcomes
3.2	Y	Y	Y	Y													**Re-use Existing Information**	Better tools for exploiting existing information and standardised library objects	Better re-use of previously purchased and assured information, to minimise duplicated efforts and improve productivity
3.3	Y	Y	Y	Y													**Design Presentation**	Better tools and processes for design development and presentation	Better documentation and output quality
3.4	Y	Y	Y	Y													**Safety and Reliability**	Better tools to visualise, check and manage safety and reliability of design	Safer, more reliable infrastructure, with reduced risk across the asset lifecycle including Construction, Operations, Maintenance and Disposal
3.5	Y	Y	Y	Y	Y	Y											**Time & Cost Estimates**	Standardised cost benchmarking database linking cost with virtual model objects and scheduling estimates	More accurate time and cost estimates, with minimised manual processing
3.6	Y	Y	Y	Y			Y										**Coordinated Design**	Enables more collaborative design processes and automated workflows to ensure multi-disciplinary design coordination	Better interdisciplinary coordination across disciplines - leading to fewer errors, less redesign and less wasteful activities
3.7	Y	Y	Y	Y			Y										**System Engineering**	Better integration of design tools for systems engineering and risk management	Less risk and faster regulation compliance
3.8	Y	Y	Y	Y			Y										**Requirements Management**	Better tools for business and systems requirements management	Better certainty to meet client requirements, and enable higher customer satisfaction
3.9	Y	Y	Y	Y	Y		Y	Y									**Operational Simulations**	Better tools to visualise design and develop operational simulations	Better understanding of design intent, leading to better design outcomes e.g. impacts to existing assets, maintainability of new assets
3.10	Y	Y	Y	Y			Y		Y								**Physical Prototypes**	Better tools to create solid, physical prototypes of design elements	More effective communication of design intent and stakeholder consultation

ROLE OF SMART ICT FOR DESIGN AND PLANNING OF INFRASTRUCTURE
DIGITAL ENGINEERING BENEFITS MATRIX

No.	CORE ELEMENTS				TECHNOLOGIES												CAPABILITY	DETAILS	PRODUCTIVITY BENEFITS
	Standardised Classification System	Standardised Open Data Format	Standardised Object Based Models	Common Data Environment	Links with Schedule Data (4D)	Links with Cost Data (5D)	Mobile Technology	Augmented Reality / Virtual Reality	3D Printing (components / structures)	Laser Scanning	LIDAR / Photogrammetry	Unmanned Aerial Vehicles / Drones	Plant control by GPS	Robotic construction	RFID tags / QR Codes	Remote Monitors / Internet of Things			
4.0	**CONSTRUCTION & COMMISSIONING**																		
4.1	Y	Y	Y	Y	Y												**Virtual Construction**	Enables contractors to "build it twice" - once virtually and then physically.	Ensures all aspects of the project can be tested prior to commencing construction e.g. safe working, efficiencies, reduced impacts to public etc
4.2	Y	Y	Y	Y	Y												**Staging Options**	Enables contractor to quickly visualise accurate staging options on-the-fly	Better scenario analysis and optimisation of construction sequence, enabling overall faster project delivery
4.3	Y	Y	Y	Y	Y	Y											**Cost Management**	Standardised cost benchmarking database linking cost with virtual model objects and scheduling estimates	More accurate time and cost management e.g. invoicing, purchase orders, cashflow, variations etc
4.4	Y	Y	Y	Y	Y		Y										**Scheduling**	Captures progress information for realtime tracking and management of project program/schedule	Faster, more accurate programming/scheduling
4.5	Y	Y	Y	Y	Y		Y	Y	Y								**Site Induction**	Better information for staff and visitor site inductions e.g. visualisation, scenarios, real-time data, 3d printed elements etc	Improved learning curve and better worksite safety for workers and emergency services
4.6	Y	Y	Y	Y	Y		Y			Y	Y	Y					**Progress Reporting**	Enables realtime capture of project status using advanced data capture	Better reporting on project progress and performance
4.7	Y	Y	Y	Y			Y		Y				Y	Y			**Prefabricated Construction**	Design for manufactured assembly, enables greater use of off-site construction techniques e.g. prefabricated elements and modular construction direct from the model	Lower construction costs due to improved quality control, reduced shop drawings, less wasted building material, greater cost certainty and typically faster/safer construction techniques
4.8	Y	Y	Y	Y			Y								Y		**Document Control**	Better information management and document control, preventing access to incorrect drawings	Reduced risk of onsite human error
4.9	Y	Y	Y	Y			Y								Y		**Defects management**	Better tools for quality control and defects management	Faster defect rectification, better project quality and improved client satisfaction
4.10	Y	Y	Y	Y	Y		Y								Y	Y	**Delivery Tracking**	Better tracking and management of deliveries of components and materials	Better worksite certainty and efficiencies e.g. just-in-time delivery, site management etc.
4.11	Y	Y	Y	Y			Y						Y	Y	Y	Y	**Worksite Safety**	Better coordination of plant and personnel, including augmented management of machinary	Better worksite safety e.g. automated exclusion zones, fatigue management etc
5.0	**OPERATIONS & MAINTENANCE**																		
5.1	Y	Y	Y	Y													**Network performance**	Network modelling and grouping of asset performance data	Better analysis of network performance, enabling more effective infrastructure investment.
5.2	Y	Y	Y	Y			Y										**Asset Handover**	Better handover of information from Construction to O&M	Seamless transfer of asset information, minimising manual processing and knowledge loss
5.3	Y	Y	Y	Y			Y										**Asset Spatial Information**	More accurate and real-time spatial information of assets	Lower operational costs through improved asset utilisation
5.4	Y	Y	Y	Y			Y										**Configuration Control**	Improved control of asset, system and overall network configuration	Better change control of asset configuration and greater traceability of asset history
5.5	Y	Y	Y	Y			Y	Y									**Security and Emergency Services**	Centralised information accessible to security and emergency services	Better safety and crisis management through information accessibility and virtual scenario training
5.6	Y	Y	Y	Y			Y	Y									**Staff Training**	Asset models of facilities or network can be used for virtual training e.g. train driver training etc	Improved safety for staff, through clearer, more effective inductions and training
5.7	Y	Y	Y	Y					Y								**Component Manufacture**	Enables innovative procurement/manufacture of replacement components	Potential for 3D printing of replacement components, creating on-going savings and driving efficiencies
5.8	Y	Y	Y	Y			Y			Y	Y	Y			Y	Y	**Asset Management**	Real-time tracking of operational and asset performance data	Lower operational costs through more efficient asset management and upgrades. This is achieved by more targeted/refined maintenance, extending the life of exiting assets and minimising costly routine works.
5.9	Y	Y	Y	Y			Y	Y							Y	Y	**Automation**	Increased automation of O&M activities e.g. network inspections, asset monitoring, virtual site inspections etc.	Increased savings and improved safety due less reliance on manual labour
5.10	Y	Y	Y	Y												Y	**Predictive Maintenance**	Remote monitoring and management of assets (both fixed and rotable)	Enables predictive maintenance, reducing long-term resourcing and cost through more targetted asset maintenance activities

Appendix B

Alignment of Transport for NSW Strategic Drivers and Enterprise Asset Management software application outcomes

Strategic Driver	**EAM Software Application Outcome**
Increased productivity and economic development	
Increased efficiency and better capacity utilisation across the network	Support decision making by providing evidence of asset condition, portfolio benefits, performance and cost across the whole transport portfolio. Transparency will improve risk management.
Innovation and excellence in transport delivery	
Value for money transport solutions	Drive a consistent approach to measuring asset condition and usage thus determining the Total Economic Value and Total Cost of Ownership. This will support the determination of replacement and maintenance strategies and measure the compliance against these strategies.
	Asset management accounts for a significant proportion of the Transport for NSW budget. Enterprise Asset Management software application will reduce the material, personnel and capital costs associated with delivering transport services.
Successful delivery of innovative and cutting edge projects	Provide a common framework for designing, delivering and commissioning assets. Enterprise Asset Management software application will ensure that the correct projects are undertaken and manage the assets entire lifecycle through a common system.
A safer and more sustainable transport system	
Provide and promote sustainable transport option	Measure the compliance of maintenance and service delivery schedules against the strategies and continuously measure the condition of the asset. This will ensure that assets are always operating within their design specifications.
An agile, high-performing and collaborative business	
Best practice governance arrangements and improved integration of people, systems and processes	Vastly improve maintenance efficiency by integrating maintenance planning with procurement and HR functions. This will ensure that the right service parts and personnel are available to execute the work.
	Manage the various transport assets, agencies and contractors as one transport system.
Improved financial management, resourcing and certainty to better deliver community outcomes	Allow Transport for NSW to evaluate alternative sourcing models by effectively modelling cost and risk for various build, buy, maintain and operate scenarios.