Identifying Transport Corridors With Systems Engineering
Melissa Jovic, Principal Manager, Corridor Development
Introduction

TfNSW’s CORE business is delivery of transport services. System Engineering Management as a consequence of this:

- Planning for transport services takes a long time
- Planning requires an appropriate process supported by Systems Engineering:

  1. Strategic Integrated Planning
  2. Corridor Identification
  3. Transport Mode Clarification
     - Heavy Rail (including metro)
     - Light Rail
     - Active (cycle / walkways)
     - Bus
     - Road
     - BRT
  4. Transport Corridors Development
  5. Transport Corridors Protection

June 2016
SE In Early Stages In Transport for NSW

Deputy Secretary
Freight Strategy & Planning

Executive Director
Transport Networks

Program Development
Road Transport Strategy
Corridor Preservation
Rail Transport Strategy
Active Transport Planning
Transit Network Strategy

Rail Demand Ops Assessment
Network Strategy
Asset & System Strategy
Corridor Development
Rail Projects

June 2016
Sydney’s Rail Future 2012 -2036

CRITERIA FOR ASSESSMENT

The way in which new capacity is added in the coming years will fundamentally shape the rail network’s long-term evolution. To ensure that investment in new services and new infrastructure meets long-term performance requirements, the four key options outlined in Figure 8.1 have been assessed against five key criteria:

1. Customer focus
   Delivery of high-quality, customer-centric services that prioritise timeliness, safety and security, and comfort.

2. Network capacity
   Provision and management of capacity to match future population growth and meet increased demand for passenger rail travel where it is needed most.

3. Network resilience
   Improvement of on-time running performance and sectorisation, and reduction of incident occurrence risk.

4. Delivery risk
   Feasibility of construction, and risks in implementation.

5. Cost effectiveness
   Delivery of value for money, taking into account capital costs and whole-of-life costs, including operations and maintenance.

1. Operational efficiencies

- Timetable overhaul to introduce standardised and regular “peakface” stopping patterns, more express services
- Significantly improved fixed management, with better management of dwell closure
- Platform de-cluttering to allow clear passenger entrance and exit
- Better incident recovery management through improved operational processes.

2. Network efficiencies

- Completion of South West Rail Link, station upgrades and Rail Clearways projects
- Introduction of even simpler timetables across the network
- Introduction of Automatic Train Operations
- Transition to dedicated fleet types for some lines
- Track infrastructure enhancement
- Platform re-design.

3. New rapid transit system

- Rapid transit trains are used to offer a comfortable, frequent, fast and high capacity link to busy inner areas
- Completion of the North West Rail Link and procurement of rolling stock for the new rapid transit line, single-deck train system initially operating between the North West and Chatswood, with a cross-platform interchange to suburban services for those customers travelling to the CBD
- There will be a train from Chatswood to the CBD every three minutes in peak periods
- In line with the North West Rail link, upgrade of the Epping to Chatswood Rail Link to a high capacity rapid transit system.

4. Second Harbour Crossing

- Completion of a new tunnel under the Harbour and a new Sydney CBD link, allowing services from the North West Rail Link to extend directly to the Sydney CBD
- The second Harbour Crossing will create the largest increase in capacity to the Sydney rail network for 80 years
- Unravelling the CBD enables major capacity increases on the Western line.

5. Southern sector conversion

- Extension of the new single-deck service to Bankstown and Hurstville
- Continue major timetable changes to the existing suburban services to continue major capacity increases to the South West and Western Sydney
- Better express services introduced due to separation from rapid transit.
Indicative Vehicle Capacity By Mode

Source: Sydney’s Light Rail Future December 2012
Sydney’s Urban Growth History

Source: Bureau of Transport Statistics Small Area Population (or employment) Forecasts 2009
Employment vs Population Forecast

Strategic Transport Planning

Stakeholder Management
Risk Based Management
Value Realisation

June 2016
Transport Planning Process

**Triggers for Strategic Transport Planning:**

- State Significance
- Sustainable Growth
- Land Protection
- Time Window

**Land use analysis**

**Analysis of population and employment growth**
- Extended global influence such as:
  - Immigration
  - Trade
  - Global economy
  - Resource boom/bust

**Identification of best suited mode for the transport task**

**Demand modelling**
- For new lines: Alignment Study
- For existing lines: Train Service Planning

**Operational resource requirements to service timetables**
Strategic Planning Initial Steps

Assess - concept dimensions

Identification – new potential corridors or modify existing

Services – provision of what the customer wants

Opportunities – base for growth and city shaping

Capabilities – to support services
Strategic Needs Confirmation – Inputs

We are taking in accounts all inputs as:

• Legislation – Commonwealth, State/NSW, City and Council
• Strategies – Long Term Transport Master Plan, Metropolitan & Regional Land Use, Freight & Ports, Modal (rail, light rail, buses, ferries, etc.)
• Connectivity – Strategic level and performance level articulating need for network expansion
• Economics
• Demographics / migration / housing
• Freight import / export (commodities / containers).
Demand Analysis Methodology

- Input to design of services
- Confirmation of service design

Diagram:
- Train Plans
- Future Transport Provision
- Land Use Forecasts
- Observed Station to Station Matrix
- PTPM: Public Transport Project Model
- STM: Sydney Strategic Travel Model
- Factored Station to Station Matrix
- ETCM: Enhanced Train Crowding Model
- Network Line Loads & Train Crowding
- CBD Station Demand Analysis

Legend:
- Input
- Model
- STM/PTPM Output
- Process
- Output
Mode-agnostic Corridors
- Problem Identification

- **Function** of mode-agnostic corridors is to connect population, freight and employment growth centres while enabling interchanges.

- **Flexibility** of initial corridor in order to cater for different modes in different time e.g. buses in first 20 years, heavy rail later.

- **Service** required from the transport network needs to be assessed from all different aspects as:
  - Capacity – corridor, vehicle & interchange/station/stop (taking in account the unique characteristics of each service mode)
  - Quality – components required for service delivery
  - Performance – service patronage, operational performance & customer feedback
  - Geographical Coverage – direct or linked service for cross-city and cross-regional journeys
‘Why’ At The Front End

“The weakness in so many of these long-term strategic processes is that few governments or project owners really stop to ask why they are doing what they are doing. The more effort that government can put into debating the ‘why’ at the front end, the better the outcomes of their decisions will be.”

- Sir John Armitt
  Former Chairman, Olympic Delivery Authority & CEO of the UK’s Network Rail

We are aware that strategy & planning is “the cheapest place” in the whole investment life cycle to address the problem and solution.
Key Drivers For Systems Engineering

• Very complex system operating in a always changing complex environment
• Multitude of competing inputs from a long list of stakeholders with many opinions
• Long time for development and delivery of investment
• Long asset life
• Traceability from the very beginning to the very end

“It is critical that long term planning be supported by the right governance structure that includes precise responsibilities across the public and private sector.”
Systems Engineering – The Holy Grail?

Research has shown that:

- 18% of cost savings can be achieved by avoiding over-engineering
- 30% of cost savings can be made by employing best practice program management and Systems Engineering approaches

<table>
<thead>
<tr>
<th>The challenge is directly proportional to the:</th>
<th>Problem novelty and complexity</th>
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<td>Solution novelty and complexity</td>
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<td></td>
<td>Technological complexity</td>
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<td></td>
<td>Diversity of stakeholders</td>
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<td>Number of stakeholders</td>
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<td>Scale of operational demands</td>
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<td>Logistics challenge</td>
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Problem Assessment

Strategic assessment of multiple options:

• To achieve Government corridor objectives based in different time frame

• Within a set of defined land-use transport corridors

• Is based on a consistent and structured approach (external and internal stakeholders consultations)

• Evidence based benefits and costs, organised on the level of early information flexible enough to provide platform for next stage.
What We Do Well
(In Early Application Of System Engineering)

Sensitivity tests and understanding of needs through justification translated as **Operational Concept Definition**

This is an initial answer to question “why” which leads to a corridor area establishment including desktop or lessons learned impact analysis (environmental, economical, social, etc.)

As in good practice of System Engineering, OCD format is less important than internal stakeholders consultations
What We Are Learning
(In Early Application Of System Engineering)

1) **Internal Stakeholders landscape**
   - The land of “million” parties occurring as ever evolving matrix structure

2) **Our response**
   - **Workshops** with structured tasks and clearly communicated outcomes as risk registers, hazard logs, etc.
   - **Iterative** process to build consensus

3) Progress from the problem statement and develop the service (Operational Concept) before designing the solution
Next Steps Towards Transport Mode Identification

External Stakeholders landscape

The service need identified further consideration

This review is based on:

• Documentation available at this stage which should support the identification of service need and the consideration of the resources required to develop a strategic business case
• As soon as possible we specify first draft of BRS and MCD
• In the same time with more inputs from stakeholders our OCD is having next revision
Which Is The Best Transport Mode?

If decision makers and stakeholders are in agreement after facilitation process which has given the proper consideration of trade-offs – transport mode is chosen

If rail mode is justified development starts with Strategic Merit Test and Economic appraisal

Service options
Train plans are modelled assessing new line operational integration to the existing system.

Integrated public transport service planning
A number of train specific guidelines that need to be considered as part of the integrated planning process.

Train network design hierarchy
Metro and suburban train services as mass and/or intermediate transit networks.
Transport Mode Initial Definition

Strategic Merit Test

- Problem Statement
- Operational Concept Definition (OCD) - first revision
- A multi-criteria analysis framework
- Alignment with strategic government objectives
- Stakeholder support, risks and implementation
- Successful delivery based on economically efficiency

Strategic Business Case

- Operational Concept Definition (OCD) - next revision
- Maintenance Concept Definition (MCD)
- Business Requirement Specifications (BRS)
- System Engineering Management Plan (SEMP)
- Requirements Management Plan (RMP)
- Safety Change Management Plan (SCMP)
- Configuration Management Plan (CMP)
- Assurance & Governance Plan (A&GP)
Lead Business Initiation

- **Strategic Business Case development at the beginning of the program life cycle**

- **Apply System Engineering approach to program set-up i.e.:**
  
  **Safety Case**
  - Required by ONRSR (Office of National Safety Regulator)
  - A process that can be relied upon by a duty-holder to realise their obligation to ensure safety

  **Justification for Investment**
  - BRS is required for Strategic Business Case
  - Provides evidence to justify decisions

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**Strategic Business Case Documents**

**Investment Management**
1. Preliminary Financial Appraisal
2. Preliminary Economic Appraisal
3. Options Summary Report
4. Value Management Study
5. Preliminary Financial Plan
6. Benefit Realisation Register
7. Asset Strategy
8. Business Case Cost Estimates

**Program/Project Management**
9. Preliminary Project Management Plan
10. Preliminary Environmental Impact Assessment report
11. Preliminary Risk Management Plan

**System Engineering**
13. Outlined Change Management Plan
14. Supporting studies such as safety management plan
15. Business Requirement Specifications

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Investment Gateway 1 – Strategic Business Case
Source: Investment Gating and Assurance Guidelines – July 2013 v1.3
BRS Content - Today & Tomorrow

• **BRS today** – Describes existing bottom up approach

• **BRS tomorrow** - Will specify more holistic top down approach:
  - Customer – Future customer value proposition
  - Operations – Future design targets for service punctuality, reliability and availability
  - Infrastructure (assets, rolling stock, communications, etc.) – Future proofing for new technologies deliverability as innovative regime
  - Environment & Sustainability – Environmental impact in accordance to climate change targets, etc.
  - Safety – Future safety assurance baseline
  - Supportability
Operational Concept Definition - Today & Tomorrow

- **OCD today** – Describes the service operations enabled with specific assets

- **OCD tomorrow** – Specifies normal, degraded, emergency, possession modes etc. Achieve a balance between:
  
  - *Service hours of operation* and *time/ cost for preventive maintenance possessions*
  
  - *Proposed capital cost* of additional assets and long term *maintenance cost* (and possessions)
  
  - *Operations with innovative assets* with fewer possessions and traditional operations with usual assets/maintenance regime
Maintenance Concept Definition - Today & Tomorrow

- **MCD today** – Describes usual maintenance regime enabled with specific assets

- **MCD tomorrow** – Proposes maintenance performance from the beginning to the end of asset life:
  - Preventive maintenance to achieve reliability targets (possessions)
  - Reactive Maintenance to restore services due to asset (response time, maintainability)
  - Assessments to determine equipment types, required possessions, response time, maintainability, etc. must include associated OPEX costs
SE Documents - Process To Assure Cohesion Delivery From End To End
Cost Benefits Analysis And BRS

<table>
<thead>
<tr>
<th>Evaluation of the net benefit</th>
<th>On the basis of a clear rationale for investment.</th>
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<tbody>
<tr>
<td>Cost-benefit analysis</td>
<td>Assess whether a proposed public infrastructure corridor / project will deliver benefits to the community (social and environmental) that exceed its costs, and Make comparisons to prioritise projects.</td>
</tr>
<tr>
<td>The life of the project</td>
<td>Much of cost of new infrastructure occurs up front during design &amp; construction</td>
</tr>
<tr>
<td>Users/business benefit</td>
<td>Over the life of the asset (all benefits and costs are converted into common dollars using a discount rate)</td>
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System Architecture As The Investment Assurance

1) Links and interfaces for the life of the investment between:
   - All specifications and documents (BRS, OCD, MCD, SRS)
   - All plans (SEMP, RMP, SCMP, CMP, A&GP)

2) Monitoring, validation and verification

3) The investment impacts
The Race Starts In Parallel In Two Lanes…

A process to identify a preferred alignment for corridor protection - study area defined; Strategic Merit Test passed

Community consultations - Government approves start of public consultations on constraints and opportunities in study area for corridor identification

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Understand the Larger System

“If I had an hour to solve a problem I'd spend 55 minutes thinking about the problem and 5 minutes thinking about solutions.”

– Albert Einstein

Operationalize your process for understanding a system before you operationalize your process for managing it.
Questions?
Translating the Customer Value Proposition into Business Requirements

Dierk Hartmann, Customer Experience Interface Manager
The articulation of customer requirements is the foundation of the service and product specification process and it is not as simple as it might seem!
System engineering requirement:
What does it take to tell the time accurately?

Customer requirement

I want it to tell the time accurately

How to translate a customer requirement to atomic engineering requirements that specify the product?
Certainty of delivery!

How do we know industry is delivering what customers want?
Implied customer requirements:

• Time keeping function unaffected by: motion and weather.
• Minimum battery life of several years

Premium requirements:

• Waterproof;
• Chronometer;
• Self winding /solar, etc.;
• Status enhancing;
• Monitoring fitness, pulse, sleep patterns;
• Needs to go with my dress/suit;
• Display emails;
• Store contacts;
• others
• Customers have diverse requirements
• Customers take the delivery of basic needs for granted
• Once basic needs are delivered, higher order needs gain in importance
• Customer needs evolve with technological advance
• The longer the product or service life, the more products need to anticipate future trends and technology
1870s - 1970s:

01 I want to make and receive calls

NOW

01 Make calls from anywhere
02 Receive calls anywhere
03 Send text messages
04 Communicate by email
05 Take photos
06 Record messages
07 Conduct conferences
08 Watch movies
09 Keep my diary
10 Play games
11 Impress friends
12 access website via voice commands
13 listen to music
14 connect the phone to the car
15 Open and start the car
How does this relate to transport?

• Public transport is a shared service, that needs to fulfil collective needs and preferences
• Different customer segments have different sometimes conflicting needs
• Identical needs require different solutions for different customer segments
The Business Requirements Specification represents the transition from organic customer needs to a structured quantitative engineering process.
**System Engineering:**

- Cannot take any requirement for granted
- Needs to identify and express each requirement atomically;
- Needs to measure each requirement
- Validate delivery against requirements
- Validate benefit realisation
Customer transport requirements are individual, with priority needs mainly falling into four categories:

- **Time**
  - Services arriving and departing as scheduled
  - More frequent trains/reduced waiting time
  - Reduced trip time
  - Better local and suburban connectivity

- **Systems and efficiency**
  - On board free WiFi to use email and browse the web
  - Web and smart-phone app providing real-time timetable and service information
  - Email notification for service disruptions

- **Reassurance**
  - More security staff at night
  - CCTV on train
  - Better lighting and shelter at stations

- **Comfort**
  - Always being able to get a seat on the train
  - Lifts to access the platform
  - Effective air-conditioning and heating on the train

Source: *TfNSW Heavy Rail Services CVP Final Report*, July 2012
Understanding what is important to customers drives planning and design of transport facilities and services.

<table>
<thead>
<tr>
<th>Timeliness</th>
<th>Safety &amp; Security</th>
<th>Ticketing</th>
<th>Convenience</th>
<th>Accessibility</th>
<th>Comfort</th>
<th>Cleanliness</th>
<th>Information</th>
<th>Customer Service</th>
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<tr>
<td>Increased reliability of journey time</td>
<td>Safe and secure customer environment (physical design features, service operation, presence of other people)</td>
<td>Ease of purchasing a ticket / Opal card</td>
<td>Convenience of access to transport services</td>
<td>Design and location of stations / termini facilitates use for all customers</td>
<td>Comfortable, well lit, temperature controlled environment</td>
<td>Clean, well maintained customer environment (clean seats, amenities, absence of graffiti and litter)</td>
<td>On-site, on-mode and mobile applications providing simple, accurate effective communication of service and timetable information</td>
<td>Polite, helpful knowledgeable service people</td>
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<tr>
<td>Reduced time to connect between services and modes</td>
<td>Ease of using a ticket / Opal card (how to use it, where to use it, how to top it up, fare rules)</td>
<td>Convenience of interchanging between services and travel modes</td>
<td>Clear and accessible signage that makes navigation easy</td>
<td>Sufficient personal space</td>
<td>Sufficient personal space</td>
<td>Systems that engage promptly and effectively to service requests, issues and feedback</td>
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<tr>
<td>Reduces trip and journey times</td>
<td>Design and location of stations / termini facilitates use for all customers</td>
<td>Amenities where needed</td>
<td>Information and signage enabling simpler navigation</td>
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Consideration must be given to the customer’s experience at stations, on the train and when interchanging between services (or modes) during their end to end journey.
Transport customers do not have a singular requirement such as, “I want to travel from A to B”

Customers have diverse requirements that define their journey experience.
I want to travel from A to B:
• Within 30 minutes
• Depart and arrive on time
• Have a comfortable seat
• In clean stations and carriages
• At 24 degree C
• Using my mobile device
• Being safe
• With an electronic ticket product
• Be informed about delays and travel choices other
## Key points of debate during development of Business Requirements Specifications

<table>
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<tr>
<th>Issue</th>
<th>Challenge</th>
<th>Available approaches</th>
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<tr>
<td>a. Level of detail specified in the Business Requirement Specification</td>
<td>Measuring compliance against qualitatively expressed requirements</td>
<td>Example: Interior vehicle noise level &lt;br&gt;&lt;strong&gt;Qualitative approach:&lt;/strong&gt; Interior noise levels shall allow customers to have a conversation without need to raise their voice at any time during the journey. &lt;br&gt;&lt;strong&gt;Quantitative approach:&lt;/strong&gt; Interior noise level anywhere in the vehicle shall not exceed 78dBA measured 1.5m above saloon floor level at 100km/h in tunnel.</td>
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<tr>
<td>b. Certainty of delivery</td>
<td>Ensuring industry delivers the intended/desired products and services</td>
<td>Multi-disciplinary evaluation teams, consisting of subject matter experts from diverse backgrounds and different but relevant skills and experience.</td>
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<tr>
<td>c. Fair evaluation process</td>
<td>Fair evaluation of tenders that offer different approaches to deliver performance outcomes</td>
<td>Provision of Concept of Operations and Guidance Notes on desired customer experience with the tender. Interactive meetings with tenderers as part of the evaluation process; monitored by probity auditors.</td>
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Customer focused expression of requirements

Trains shall:
• Provide a high level of customer amenity, offering level platform access, high ride comfort, low internal and external noise emissions, high quality passenger information systems and comfortable seating

System engineering interpretation

One bullet = 7 business requirements
1. High level of customer amenity
2. Level platform access
3. High ride comfort
4. Low internal noise
5. Low external noise
6. High quality passenger information system
7. Comfortable seating

Challenges
Definition and measurement of:
• High level customer amenity
• Ride comfort; what is high vs. low ride comfort?
• Low noise levels
• A high quality passenger information system vs. a low quality information system?
• Comfortable seating
• The customer value proposition represents key elements that define the journey experience

• The challenge is to specify the individual elements while:
  – Considering the relevant customer segment
  – Enabling industry to deliver proven product platforms
  – Providing certainty of delivery
  – Providing the ability to verify that the specified outcomes have been achieved (benefit realisation)

• “Soft” customer requirements can be measured
Customer requirements evolve with technological advance

- Technology enhances product and service capabilities
- Customers expect increasing functionality and improved services as a result of technological progress
- Business requirements need to meet today’s customer requirements and anticipate future technologies and evolving customer expectations
Business Requirements must define the desired outcomes, not detailed inputs.

- Focus on meeting customer needs
- Meeting operator and government requirements
- Enable industry to deliver proven, fit for purpose product platforms
- Setting the foundation for achieving certainty of delivery
- Transport infrastructure has a commercial life in excess of 100 years. BRSs must accommodate change and allow flexibility for evolving customer expectations and future technologies.
- Enable verification that:
  - customer outcomes are met
  - operator outcomes are met
  - government commitments are delivered
  - benefits are realised
Where does that lead to?

Today
Majority of services and products on the electric network delivered by one product platform

Future
Increasing product and services differentiation, delivering the right services for the right journey
Questions?