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Exploring ways to convey the state of transport system performance in a simple non-technical way

Glen D'Este

School of Urban Development, Faculty of Built Environment & Engineering,
Queensland University of Technology, Brisbane 4001, Australia

Email for correspondence: g.deste@qut.edu.au

Abstract

What is the current state of the transport system; what are its key deficiencies; and what are our targets for how well we can reasonably expect it to perform. These seem like simple questions that should be able to be answered in a simple non-technical way. But we often struggle when asked to take the available information about the current performance of the transport system; how it compares over time and to other places; our aspirations for performance levels; and the performance gaps, and distil it into a simple multi-faceted "at a glance" format. One example is the Australian Road Assessment Program (AusRAP) road safety risk assessment and star rating for Australian highways. Another approach is the Intelligent Transport Maturity Model which has been applied to Singapore and Brisbane. This paper reviews standard and emerging approaches to presenting the results of a transport system performance assessment; and discusses a criterion-referenced approach that links condition to comparisons to objectives/aspirations across a range of criteria at a glance. The proposed approach is flexible enough to be adapted to different modes or aspects of the transport system; to other sectors of the economy; and for cross-sectoral comparisons.

1. Introduction

A question that is often asked is "how well is the transport system performing". Generally when this question is asked, the preferred response is not a weighty report full of statistics, but instead a performance assessment that is expressed in familiar, non-technical terms and can be understood "at a glance". This seems like a simple request but more often than not, it proves difficult to fulfil. We often struggle when asked to take the available information about the current performance of the transport system; how it compares over time and to other places; our aspirations for performance levels; and the performance gaps, and distil it into a simple multi-faceted "at a glance" format.

This paper does not address the issue of how to measure transport system performance. Instead it assumes that measurement has already been done and the challenge is how to condense the key messages from the data and represent it clearly and in a way that can be understood quickly and easily without the need for in-depth technical knowledge. The paper

starts by reviewing a range of approaches to presenting the results and then discusses a suggested criterion-referenced approach that links system performance to relevant criteria, performance standards and targets at a glance.

2. Representing performance levels

Many different methods are used to convey the results of performance assessment. These methods include:

- textual: description, commentary;
- tables: numbers, qualitative ratings (high, medium, low), etc;
- symbols: stars ratings, “Harvey Balls” (○ ◔ ◑ ◕ ●), etc;
- charts and graphics: bars, pies, dashboards, barometers;
- map-based: line colour, line width, shading, graphics, etc;
- formal structures: balanced scorecard, maturity model, etc;

All of these methods have a range of advantages and disadvantages as illustrated by the following examples, which are mostly drawn from the transport sector.

2.1 Examples

2.1.1 AusLink corridor strategies

As part of the planning process for second tranche of AusLink projects (now part of the Nation Building program), corridor strategies were prepared for all corridors of the National Land Transport Network (NLTN) (DOTARS 2007). These strategies assessed the current performance of each corridor in the context of current and foreseeable needs.

The approach is mostly textual, with a mix of commentary linking performance to AusLink objectives and tables (and maps) identifying corridor deficiencies. The approach provides a wealth of information for planners and decision-makers and meets most of the desirable criteria for performance assessment, but it is not easy to comprehend overall corridor performance or to compare different corridors “at a glance”.

2.1.2 Australasian New Car Assessment Programs (ANCAP)

ANCAP rates the level of occupant protection provided by vehicles in serious front and side crashes. Each vehicle is crash tested and then rated on a scale of 1-5 stars with more stars indicating better performance.

The aim is to distil the complex results of the crash tests into a format that is easily understood by consumers “at a glance”. A similar approach is used for many other consumer goods, for instance in relation to energy efficiency.

This approach has the advantage of simplicity and ease of comparison, but without extensive accompanying explanation, it is difficult to fully understand what the stars actually mean, other than that more stars indicates superior performance. As a result, simplicity is both an advantage and a disadvantage of this type of approach.

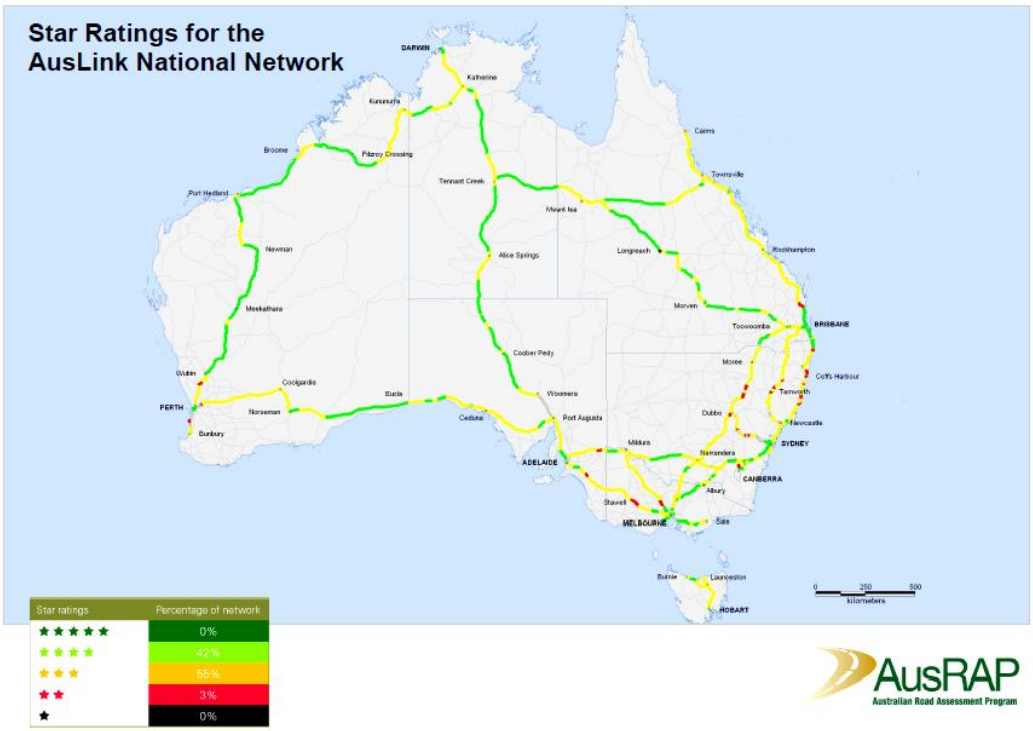
2.1.3 Australian Road Assessment Program (AusRAP)

A similar approach has been adopted by the AusRAP program (AusRAP 2010). The purpose of AusRAP is to provide a safety rating for roads across Australia. AusRAP has two components

- risk mapping, based on a road's history of casualty crashes and traffic flow. Metrics for crash risk, such as average annual casualty crashes per km, are then colour-coded by risk level (Low to High) and tabulated and mapped; and
- star ratings, which "involve an inspection of a number of design elements such as lane and shoulder width and the presence of safety barriers, which are known to have an impact on the likelihood of a crash and its severity. Between 1 and 5-stars are awarded to road links depending on the level of safety which is 'built-in' to the road." (AusRAP 2006). Figure 1 shows an example of star rating of the NLTN.

The AusRAP approach provides an excellent overview of the safety performance of the national road network, but again, there is so much information distilled into the star ratings that it is difficult to understand what the stars actually mean. Also the star ratings do not convey a sense of what needs to be done to achieve better performance.

Figure 1: AusRAP Star Ratings for the National Land Transport Network



2.1.4 Criterion-referenced assessment

Criterion-referenced assessment (CRA) is a generic term for an assessment framework in which performance is referenced back to predefined criteria and generally to levels of achievement or standards within those criteria. For example, CRA is a favoured approach to assessment of student grades in many Universities. In this context, CRA involves defining

- a set of criteria for each assessment task – these criteria relate to the goals of the course and reflect the range of concepts, skills or knowledge being assessed; and
- a set of standards which should be achieved on each criterion, for instance with each level corresponding to a different grade.

CRA can be contrasted with norm-referenced assessment which compares performance against others in the test population and yields a ranking or measure of performance relative to the "average", rather than to a standard of achievement that is set in advance.

CRA can take many forms and has been applied broadly for performance assessment in many contexts. A version of CRA that has appeared in the transport field and illustrates the components of the CRA approach is the *maturity model*.

Figure 2: Intelligent Transport Maturity Model

		Level 1 Single mode	Level 2 Coordinated modes	Level 3 Partially integrated	Level 4 Multimodal integration	Level 5 Multimodal optimized
Governance	Strategic planning	Functional area planning (singe mode)	Project-based planning (single mode)	Integrated agency-wide planning (single mode)	Integrated corridor-based multimodal planning	Integrated regional mulitimodal planning
	Performance measurement	Minimal	Defined metrics by mode	Limited integration across organizational silos	Shared multimodal system-wide metrics	Continuous system-wide performance measurement
	Demand management	Individual static measure	Individual measures, with long-term variability	Coordinated measures, with short-term variability	Dynamic pricing	Multimodal dynamic pricing
Transport network optimization	Data collection	Limited or manual input	Near realtime for major routes	Realtime for major routes using multiple inputs	Realtime coverage for major corridors, all significant modes	System-wide realtime data collection across all modes
	Data integration and analytics	Limited with ad hoc analysis	Networked but periodic analysis	Common user interface with high-level analysis	Two-way system integration and analysis in realtime	Extended integration with multimodal analysis in realtime
	Network operations response	Ad hoc, single mode	Centralized single mode	Automated, single mode	Automated, multimodal	Multimodal realtime optimized
	Incident management	Manual detection, response and recovery	Manual detection, coordinated response, manual recover	Automated detection, coordinated response, manual recover	Automated pre-planned multimodal recovery plans	Dynamic multimodal recovery plans based on realtime data
Integrated transport services	Customer relationships	Minimal capability, no customer accounts	Customer accounts managed separately for each system/ mode	Multichannel account interaction by mode	Unified customer account across multiple modes	Integrated multimodal incentives to optimize multimodal use
	Payment systems	Manual cash collection	Automatic cash machines	Electronic payments	Multimodal integrated fare card	Multimodal, multichannel (fare cards, cell phones, etc.)
	Traveler information	Static information	Static trip planning with limited realtime alerts	Multichannel trip planning and account-based alert subscription	Location-based, on-journey multimodal information	Location-based, multimodal proactive rerouting

Source: IBM Global Business Services analysis.

Typical city *Global leading practice*

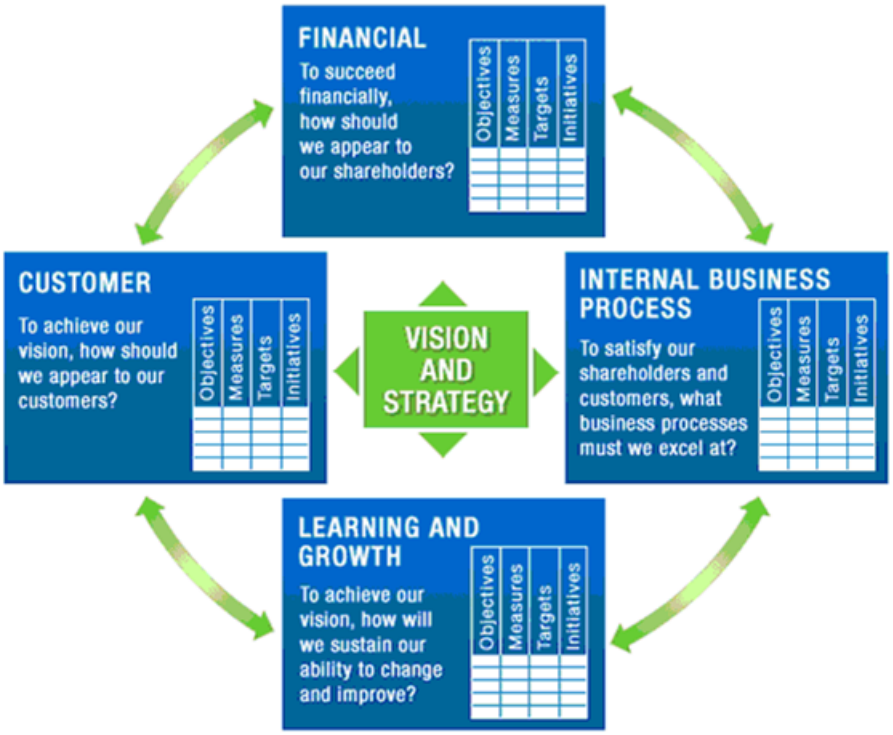
2.1.5 Maturity models

Maturity models come in many forms and have been used in a wide range of applications. It is difficult to pinpoint the origin of this approach, but many recent applications can be traced back to the Capability Maturity Model (Humphrey 1988) developed to assess the capability of software contractors. The basic concept is that performance is assessed against a list of criteria, with performance generally rated on a multi-level scale (usually five levels) which represent a "growth" from an initial level to *maturity*. A common starting point for defining the levels is the concept of "evolution" of the management approach through stages from *Ad hoc* to Engaged, Structured, Managed to Optimised.

A notable example of the use of the maturity model concept in transport is the IBM Intelligent Transport Maturity Model (IBM 2009). The IBM maturity model was originally developed as a way of measuring and comparing the "maturity" of a city's transport planning and service delivery (see Figure 2) and has also been applied more specifically to the state of Intelligent Transport Systems (ITS) development in a city. As shown in Figure 2, this approach is criterion-referenced in the sense of defining performance criteria and standard levels of achievement and assessing performance against these criteria. The assessed current level of performance is then overlaid as a line on the table – the pink line on Figure 2. The IBM model also has elements of the norm-referenced approach in that it also shows "Global leading practice" (blue line) as a comparator.

The maturity model variant of CRA has several strong features. It provides a visual format that represents the performance against a range of criteria simultaneously and also provides a concise definition of what each level means. The disadvantages are that it becomes less manageable and easy to understand as the number of criteria grows, and it seems implicit in this approach that the goal is always to reach "maturity" at the top level of the scale.

Figure 3: Balanced Scorecard



Source: Learn.com

2.1.6 Balanced Scorecard

Although there is less evidence of the use of Balanced Scorecard (BSC) in the transport sector in Australia, it is an approach that has gained widespread use in business and industry over the last 10-20 years. Like the maturity model approach, this approach developed from a range of sources and it is difficult to pinpoint its origin. However its recent popularity appears to have been influenced by the publication of Kaplan and Norton (1996).

BSC has many variants and derivatives, but in essence, it is a strategic planning and management tool which aims to present a balanced overview of performance in terms of a mixture of key financial and operational measures with each compared to a "target" value within a single concise format. The results are displayed in a range of possible tabular, graphical or "dashboard" formats. Figure 3 shows a typical BSC framework.

The BSC framework was predominantly developed as a tool for strategic planning tool and regular (even day-to-day) monitoring of performance. From a transport planning and performance assessment perspective, a key feature of BSC is its linking of *objectives* to *measures* (criteria) to *targets* to *initiatives* (responses).

2.2 Overview

These examples provide an overview of methods ranging from words to tables/graphs to visual to highly structured methods. Some observations that flow from the examples are:

- commentary supported by tables and graphs can provide a comprehensive picture of system performance, but can have too much detail and not provide the "at a glance" summary that is needed for some purposes;
- visual methods such as star ratings provide a very compact and compelling representation of performance, but in the process of distilling multi-faceted performance data down to a star rating, an understanding of the underlying factors that lead to the rating may be lost;
- highly structured methods, such as CRA and BSC, can provide a multi-faceted picture of performance "at a glance" but run the danger of trying to cram too much information onto the page; and
- few of the methods show targets as well as current performance, or they imply that the target is always to reach the highest level on the assessment scale.

Overall, the examples demonstrate how difficult it is to get the balance right between simplifying and over-simplifying while providing sufficient information to very quickly gain a sufficient understanding of overall performance.

3. A suggested hybrid approach

Before describing an approach which brings together some of the best features of the methods described above, it is important to recall that its purpose is to convey the state of transport system performance in a simple non-technical way. In most cases, what we want to know is

- what are the key performance measures (criteria);
- what is the current level of performance against those criteria;

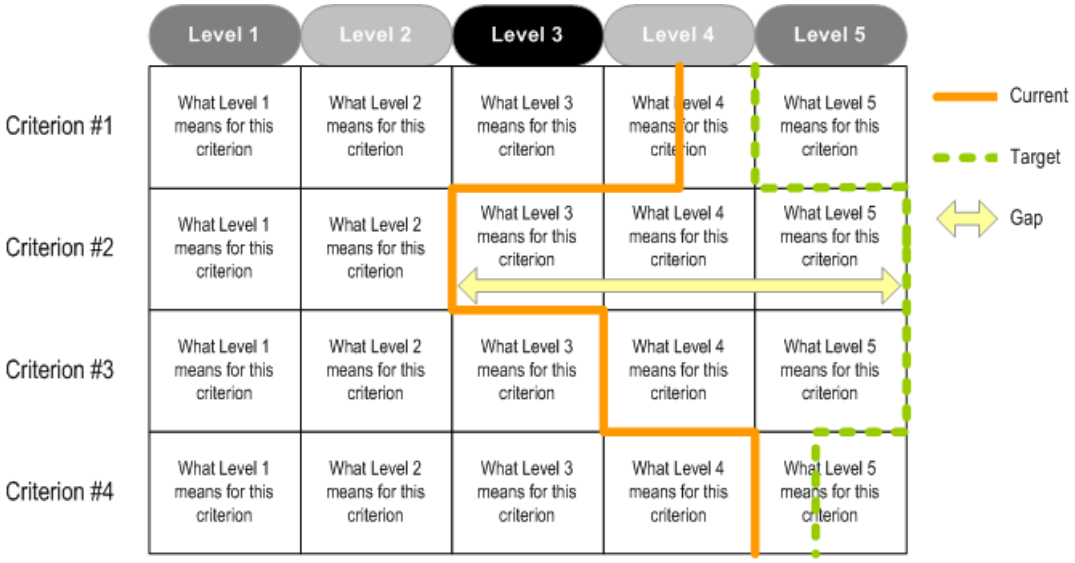
- how has performance changed over time and/or how does it compare to other locations;
- what is our reasonable expectation for the level of performance, for instance in terms of a satisfactory level of performance or “target”;
- how big is the gap between current and target performance; and
- which of the performance criteria are lagging and most need attention.

Preferably a format for conveying the state of transport system performance should address these questions and also:

- have a clear link between the performance criteria and the objectives for the transport facility or service;
- be valid and reliable, in terms of measuring what it is intended to measure; and be internally consistent and stable over time;
- strike a balance between not being overly complicated but at the same time not over-simplifying;
- be self-contained to the extent that it contains all the information that the reader needs to understand what it means; and
- be easy to understand and able to be interpreted “at a glance”.

The suggested hybrid format is consistent with most of these principles. It is a variant of the CRA/maturity model approach that also brings in a sense of targets and gaps that are a key feature of the BSC method. Following the CRA/maturity model approach it combines an underlying tabular format with an overlay of graphics. As shown in Figure 4, the underlying table shows the performance criteria and levels and explains what each level means, and the overlay shows the current performance, target and gaps.

Figure 4: Suggested performance assessment format



The following examples illustrate how the proposed framework can be applied in a variety of transport contexts.

3.1 Examples

3.1.1 Australian National Land Transport Network

The first example goes back to the Australian National Land Transport Network (NLTN). It is based on performance assessments contained in the corridor strategies for representative sections of the NLTN prepared for the AusLink planning process (DOTARS 2007).

The performance criteria were selected to reflect the NLTN objectives which as stated in the corridor strategies are to "support national economic growth by developing sustainable transport solutions that

- increase its efficiency and infrastructure handling capacity;
- improve its safety and security;
- improve transport productivity on its nationally strategic and export-oriented freight corridors
- improve the reliability of travel on interstate and inter-regional corridors; and
- are consistent with viable, long-term economic and social outcomes, and with the obligation to current and future generations to sustain the environment."

For the purposes of the following assessment tables, these objectives have been translated into the following criteria:

- **capacity** of the infrastructure in terms of ability to cater for current and future demand;
- **safety** using the ANCAP star rating system;
- **reliability** based on an assessment of the length and severity of road closures; and
- **productivity** in terms of the extent and sophistication of traffic management systems in place to provide smooth traffic flow and provide information about road/traffic conditions.

The following examples relate to two different generic types of road conditions existing in many locations on the NLTN.

<u>Rural/remote highway</u>

The first example applies the framework to a lightly trafficked highway section of the NLTN in a rural/remote area of northern Australia where safety and flooding problems are the main issues. These factors are reflected in Figure 5 by

- a target line that has a high expectation regarding safety but is realistic in accepting that it is not cost-effective to completely flood-proof the road and automated traffic management is not required;
- performance against the capacity criterion which is sufficient for the foreseeable future and already ahead of the realistic target of sufficient capacity for the next 15 years; and
- the major gaps are in the safety and reliability criteria.

As well as providing an "at a glance" indication of system performance, this format also provides a way of conveying the expected outcome of a proposed intervention or investment. For instance, Figure 6 shows the expected impact on performance levels of a proposed bridge project which addresses a severely flood-prone section of highway.

Figure 5: Regional/remote highway

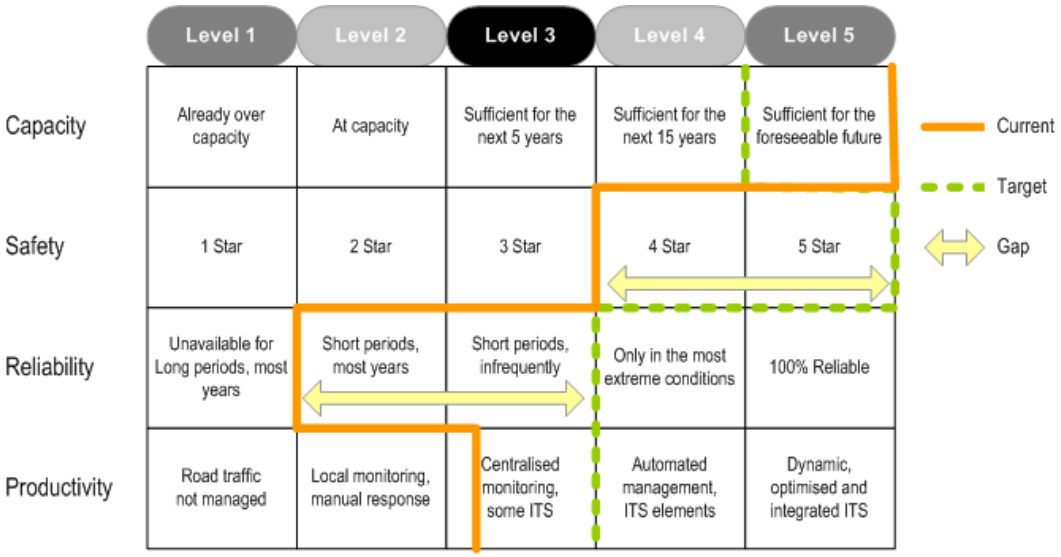
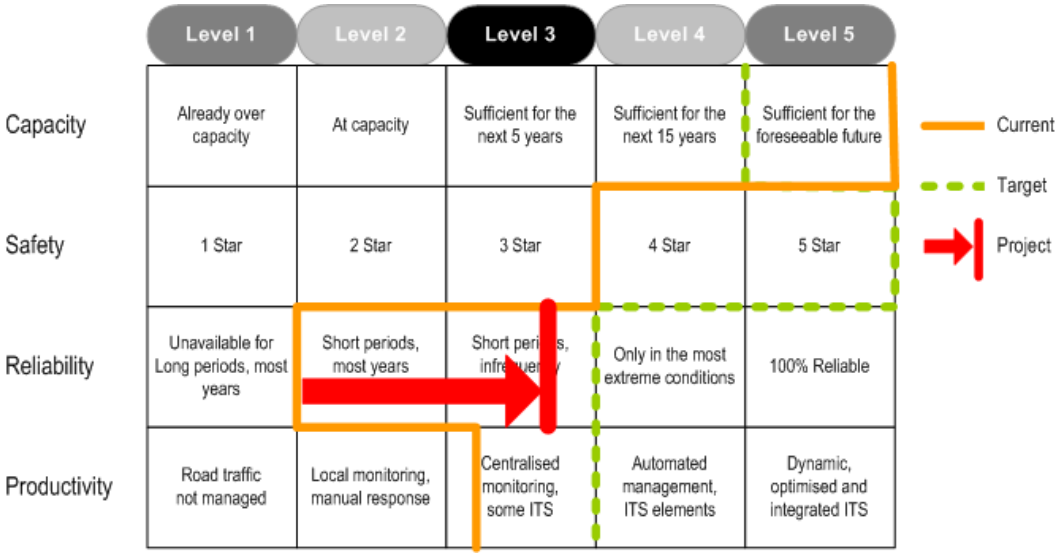


Figure 6: Effect of proposed bridge project

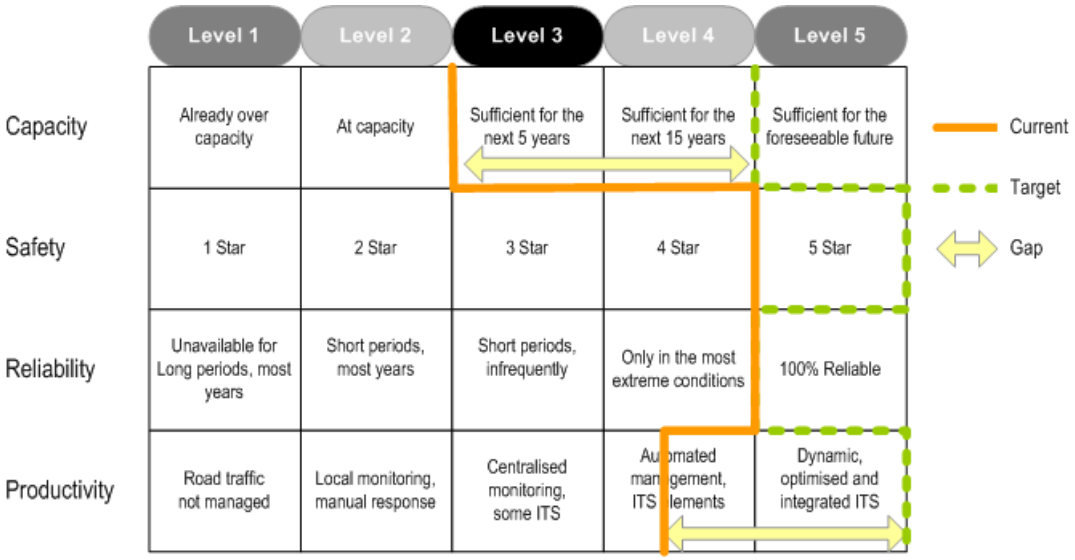


<u>Peri-urban highway</u>

To show how the format can capture the differences in performance and expectations of different parts of the network, the next examples relates to a peri-urban highway section of the NLTN, that is a section of the periphery of an expanding urban area where traffic is growing quickly and is increasingly dominated by commuter travel. In this case, the road is already of a high standard and congestion is the main problem. The performance and expectations for this type of road are shown in Figure 7. The key features are:

- a higher level of expectation (target) in criteria of reliability and productivity compared to the rural/remote highway example;
- significant performance gaps in capacity and productivity; and
- overall, a very different pattern of targets, current performance and gaps compared to the rural/remote example.

Figure 7: Peri-Urban Highway



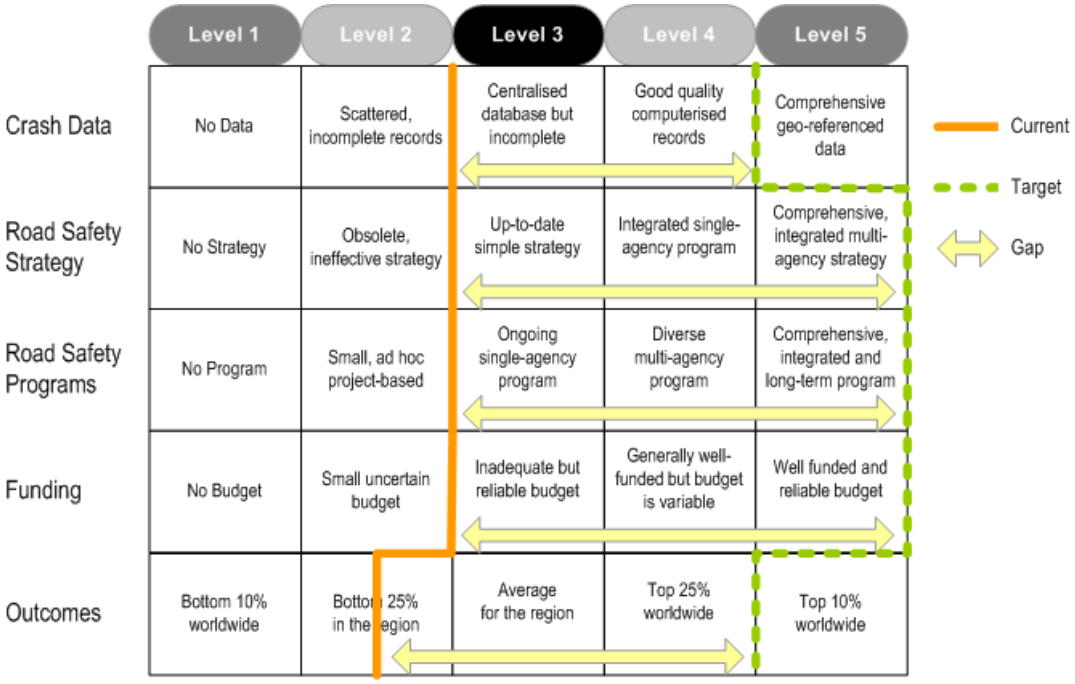
3.1.2 Developing country

The next set of examples illustrate how the suggested format can be applied to several aspects of transport system performance in a hypothetical developing country. They are based on the situation observed in many developing countries of Asia and the Pacific.

Road safety

The first example (Figure 8) relates to a road safety, covering the components that make up a road safety program from crash data through to strategies and programs, funding and outcomes. It shows the likely situation before the commencement of a comprehensive road safety capability building program, with major performance gaps across the board.

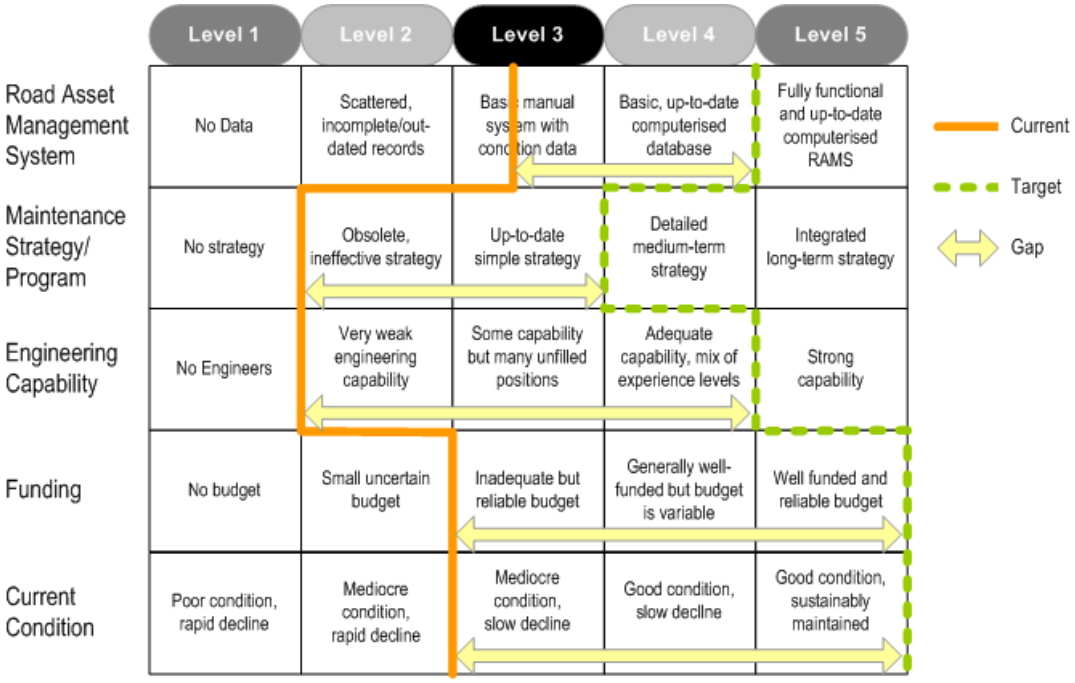
Figure 8: Road safety program



Road maintenance

The next example shows how an analysis similar to the road safety program performance assessment (Figure 8) can be applied to road maintenance. It shows the type of situation likely to be observed in a least developed country.

Figure 9: Road maintenance



Airports

The final developing country example contrasts the situation at the international airport (Figure 10) and a provincial or outer islands airport (Figure 11) in a hypothetical developing country. The performance criteria are capacity (relative to demand), customer experience (a measure of the state of passenger facilities at the airport), safety (navigational aids and rescue and fire fighting capability) and finances (cost recovery and financial self-sufficiency).

For the international airport, targets are set at a relatively high level consistent with traveller and regulator expectations of high standards in international aviation. By contrast, at the provincial/outer islands airport, demand is small, generally with only a few flights per week mostly in small aircraft and a small number of passengers. Under these conditions, basic but appropriate facilities are all that can be justified. This means that even though the criteria and performance levels are the same, the target level for most criteria is set at a lower level than for the international airport. Again this demonstrates that targets must be appropriate to local conditions, capability and expectations. The target is not always to reach the highest level for the criteria.

Figure 10: International airport

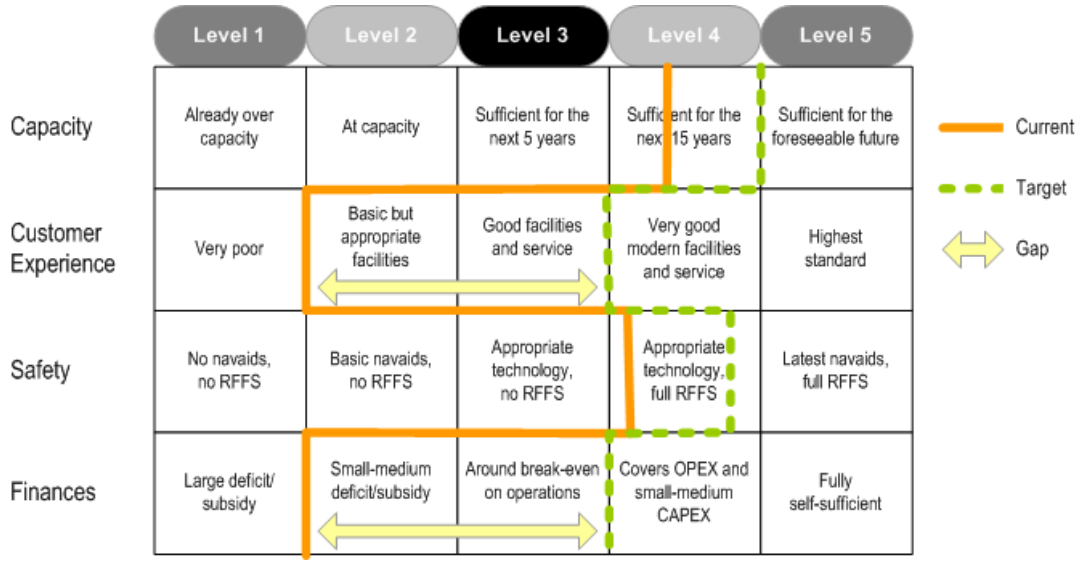
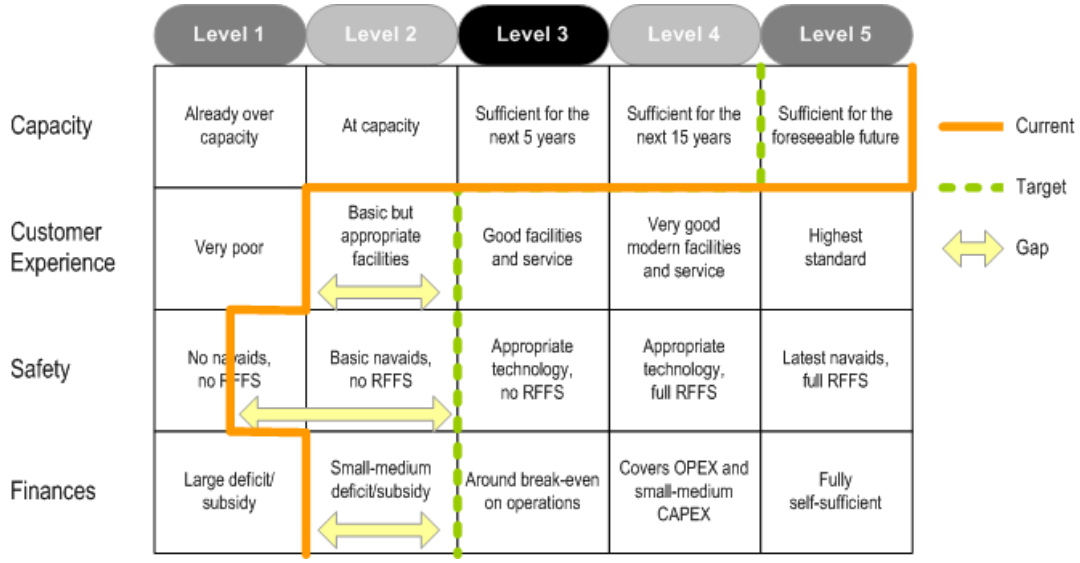


Figure 11: Provincial or outer island airport



3.2 Observations

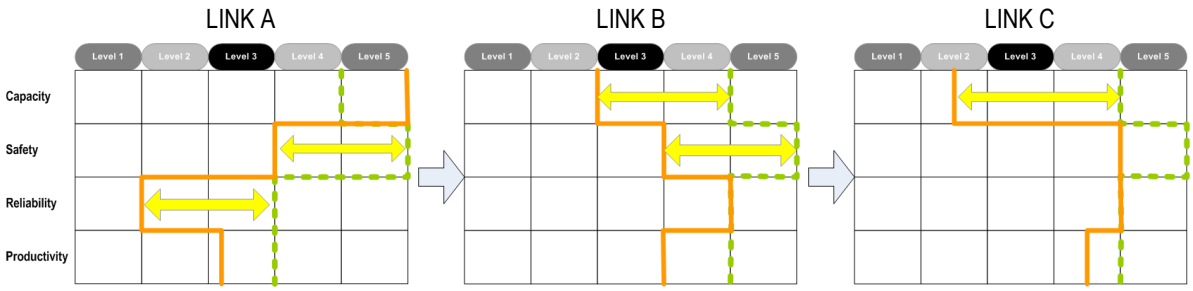
The examples illustrate some of the features of the suggested approach and suggest some guidelines for how to apply it:

- any number of criteria and performance levels can be used but the larger the matrix gets, the difficult it is to take in its meaning “at a glance”. Up to eight levels seems to be a good compromise but any number could be used;
- as far as possible, these criteria should be closely linked to the system objectives as illustrated by he NLTN examples;
- having identified the criteria, defining the performance levels is the trickiest part of establishing the performance assessment framework. The levels should span the range of possible performance from a very low base level to a level of optimised performance

that may not yet be possible but is conceivable. In addition, the levels need to be defined in a way that is meaningful, easy to understand without technical knowledge, and shows a clear and progressive improvement across the range;

- there is no implicit sense of "maturity" or need to reach the top level. Target levels should be realistic and appropriate, so for instance for the airport examples (Figures 10, 11), the performance targets for some criteria are set at a lower level for the provincial airport than for the international airport. The targets should be aspirational but not out of reach;
- however under some circumstances, it is possible to exceed the target level especially where demand is low and supply is lumpy, such as roads and airports (Figures 5, 11) which have a minimum infrastructure size regardless of actual demand;
- the format can be viewed at different levels of detail. For instance, the general pattern of performance can be viewed "at a glance" and then for more detail it is possible to go in to each cell and read the summary definition of what that level of performance means. The approach could also be applied hierarchically with detailed performance assessment tables feeding in to summary tables;
- likewise, the format can be viewed at different levels of magnification. For instance, the format used in the examples could be shown first in full size and full detail, and then reduced to thumbnails to show comparisons across time or location, such as the way that road system performance and key issues vary along the links of a road corridor as shown in Figure 12.

Figure 12: Road system performance along a corridor



4. Closing remarks

There is no one "best" way to convey the performance of a transport system in a simple "at a glance" format. This paper suggests another approach to add to the available toolbox of methods. It is a variant of the CRA/maturity model approach which provides a flexible format for conveying the state of transport system performance in a wide variety of contexts. In particular, the suggested approach brings together and represents the following information in a simple non-technical way:

- performance criteria, performance levels and their definitions;
- the current level of performance;
- the "target" level of performance; and
- the gap between current and target performance.

In other words, where we are now, where we want to be, and where the biggest gaps are.

References

AusRAP 2006, *Star Rating Australia's National Network of Roads*, Australian Automobile Association, www.ausrap.org

AusRAP 2010, *Australian Road Assessment Program (AusRAP)*, Australian Automobile Association, www.ausrap.org

ANCAP 2010, Australasian New Car Assessment Programs (ANCAP), www.ancap.com.au

DOTARS 2007 *AusLink Corridor Strategies*, www.infrastructure.gov.au/transport/publications/auslink.aspx (accessed March 2010)

Humphrey, W 1988, "Characterizing the software process: a maturity framework", *IEEE Software* 5 (2): 73-79.

IBM 2009, *Intelligent Transport: How cities can improve mobility*, IBM Global Business Services, Somers, NY. Available at www-935.ibm.com/services/us/gbs/bus/html/gbs-intelligent-transport-mobility.html (accessed March 2010)

Infrastructure Australia (2010) *State of Australian Cities 2010*. Infrastructure Australia, Sydney.

Kaplan, R.S. and D.P. Norton 1996 *The Balanced Scorecard: Translating Strategy into Action*. Harvard Business School Press, Boston.