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Who Should Read This White Paper?

The target audience for this White Paper is an international audience of infrastructure practitioner or policy maker who are interested in identifying reliable methodologies to create infrastructure performance indicators capable of evaluating how infrastructure is performing in enabling expected outcomes. Additionally, this White Paper will be of interest to anyone concerned with identifying what outcomes society expects infrastructure to play a role in enabling.

Key Messages from the White Paper

These key messages are synthesised from evidence presented in the body of the White Paper.

- Literature on performance management emphasises the importance of understanding the purpose, goals and plans for the system whose performance is being measured prior to designing performance indicators.
- If the purpose of infrastructure (in terms of the outcomes it is expected to enable) is not explicitly stated, it is not possible to design meaningful performance indicators. Therefore, infrastructure performance indicator development ideally begins with identification of a set of the system level outcomes society expects infrastructure to enable.
- To ensure infrastructure performance indicators remain ‘fit for purpose’, regular review of the extent to which performance indicators remain aligned with desired outcomes is required.
- Any process to create performance indicators must record (in written form) the rationale for all decisions taken during the process. Doing so provides a number of benefits; (i) the purpose of the indicators is made explicit (ii) assumptions implicit in indicator design are clearly stated (iii) a full audit trail between purpose and indicator, including the formulae for calculation makes the purpose of the indicator and the significance of changes to the measured value explicit to the indicator audience (iv) indicator design decisions can be retrospectively justified and understood (v) provides a clear evidence base for regular review of whether the indicator remains ‘fit for purpose’.

Abstract

How strategic performance indicators, aligned with those elements of infrastructure performance most valued by the society the infrastructure serves, can be most effectively developed and used to evaluate infrastructure performance is of interest to any country that

aspires to understand and improve the performance of its nation's infrastructure. This White Paper shares an overview of three interim research outputs from collaborative ICIF and iBuild research on the use and design of strategic performance indicators for infrastructure. Refined versions of these outputs will be published shortly in a report to Infrastructure UK and two academic papers

Key Words

Infrastructure, performance, indicators, outcomes, purpose

Connections to Other ICIF White Papers

TBC

Where Can I Find Out More?

For more information please contact Dr Tom Dolan

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The need for this White Paper arose as an outcome of collaborative research between ICIF and iBUILD on behalf of Infrastructure UK. This White Paper draws on material originally presented in a Report 'A Process for the Formation of Outcome-Orientated Infrastructure Performance Indicators' and Academic Paper 'Infrastructure Strategic Performance Metrics – A New Paradigm?'

Strategic Infrastructure Performance Indicators

1 Introduction

Based on infrastructure performance indicator research being currently undertaken in collaboration between ICIF and iBUILD with support from Infrastructure UK (Carhart et al., 2015)(insert 3 x references here), the focus of this White Paper is how to develop a set of performance indicators for national infrastructure that are also applicable at a range of geographical and cross-sectoral scales. The White Paper opens with a set of Key Messages from this Research (Table 1), an overview of the context for this research is given in section 1.1 and key insights from academic and technical literature are given in section 1.2. The body of the White Paper (Sections 2 and 3) introduces a set of guideline criteria for evaluating performance indicator design (Table 2), presents a set of design principles for a process to develop performance indicators (Table 3) and finally outlines a process based on these principles to design performance indicators that satisfy the guideline criteria (Figure 1)

Table 1 Overview of Key Messages

The key messages stated here synthesised from evidence presented in the body of the White Paper.

- Literature on performance management emphasises the importance of understanding the purpose, goals and plans for the system whose performance is being measured prior to designing performance indicators.
- If the purpose of infrastructure (in terms of the outcomes it is expected to enable) is not explicitly stated, it is not possible to design meaningful performance indicators. Therefore, infrastructure performance indicator development ideally begins with identification of a set of the system level outcomes society expects infrastructure to enable.
- Any process to create performance indicators must record (in written form) the rationale for all decisions taken during the process. Doing so provides a number of benefits; (i) the purpose of the indicators is made explicit (ii) assumptions implicit in indicator design are clearly stated (iii) a full audit trail between purpose and indicator, including the formulae for calculation makes the purpose of the indicator and the significance of changes to the measured value explicit to the indicator audience (iv)

indicator design decisions can be retrospectively justified and understood (v) provides a clear evidence base for regular review of whether the indicator remains ‘fit for purpose’.

- Regular review of whether the performance indicator remain aligned with strategy as the external environment changes is important if infrastructure performance indicators are to remain ‘fit for purpose’
- To make explicit the trade-offs involved in achieving any performance target, to inform discussions of relative priorities and to identify potential perverse incentives arising from performance indicators, the performance indicator for any desired outcome, should comprise a set of component indicators from which progress toward that headline outcome indicator can be measured.

1.1 Research Context

Infrastructure UK (I-UK) have since publication of the first National Infrastructure Plan (NIP) in 2011 published an annual set of performance indicators for Infrastructure (“National Infrastructure Plan 2014,” n.d.). With the aim of improving these performance indicators Infrastructure-UK initiated a research project in partnership with ICIF and iBUILD to investigate the use of performance indicators in Infrastructure. This White Paper is an output from the above project, and the content of this white paper is sourced from an interim project report (Carhart et al., 2015) and a pair of academic papers currently under preparation (refs to be inserted prior to white paper publication)

The guideline criteria shown in Table 2 of this White Paper were derived from an industry workshop on performance indicators for Infrastructure held by ICIF, iBUILD and Infrastructure UK on 2nd March 2015, over 20 operational and strategic experts from infrastructure utilities, professional bodies and research attended the workshop. Subsequent to the workshop a report of findings from the workshop, in-depth literature review and consultation with I-UK was produced (Carhart et al., 2015).

The principles and process presented here (Table 3 and Figure 1) arose as outputs from research into how to operationalise the guideline criteria (Table 2) to create a process for

infrastructure performance indicator development. At time of writing this research is ongoing it is envisioned the process will be applied to propose alternate performance indicators for the NIP and the process will be further refined to give greater emphasis to systemic performance indicators.

1.2 Insights from Academic and Technical Literature

Greater depth on the literature reviewed as part of this research is available (Carhart et al., 2015), in this section we share selected insights from this literature

Performance Management Literature

Literature on performance management emphasises the importance of understanding the purpose, goals and plans for the systems whose performance is being measured prior to designing any performance indicators (Alegre and International Water Association, 2007; Behn, 2003; Hatry, 2006; Lebas, 1995; Parmenter, 2010), in particular, Lebas (Lebas, 1995) identified five general reasons for measuring performance, namely to understand: (i) where have we been; (ii) where are we now; (iii) where do we want to go; (iv) how are we going to get there, and; (v) how will we know when we get there? This approach demonstrates that performance measurement can help establish a continual cycle of performance improvement to be established by understanding current and past performance and setting measurable targets to which future performance aspires

Literature on Performance Indicators in Infrastructure

On the purpose of performance indicators for infrastructure, US National Research Council (1995) observe *“Infrastructure is a means to other ends, and the effectiveness, efficiency, and reliability of its contribution to these other ends must ultimately be the measures of infrastructure performance.”* (p5)

In a comprehensive report produced on behalf of National Infrastructure Unit in New Zealand (Covec and Beca, 2013), make a number of important points, these include. (i) Infrastructure enables other activities, therefore the flow of welfare created by the infrastructure stock can be used to measure performance (ii) infrastructure indicators must be interpreted with regard to trade-offs, as it is not always possible to increase one indicator without reducing one or more others (iii) Performance indicators must facilitate decisions that help with 'Better use of existing infrastructure' and 'Better allocation of new investment' and (iv) specific characteristic of infrastructure should play a role in dictating the type of infrastructure performance indicator chosen for that system

Sharp et al. (Sharp et al., 2015) makes an important distinction between four characteristics of infrastructure systems that performance indicators can measure, namely, (i) Inputs (for example, the level of capital investment) (ii) Outputs (the specific infrastructure built) (iii) Outcomes (the stated reasons for the output) (iv) Impacts (factors occurring as an indirect result of the ii and iii). They argue that because service performance is critical, performance indicator sets should be designed to measure Outcomes. In particular they identify four groups of outcomes that affect quality of service to system users and develop indicators under these heading for the infrastructure sectors in Australia

Reliability: the ability of the infrastructure to meet normal or current demand (eg. proportion of trains running on time, road congestion in response to normal traffic demand), ***Stability:*** the consistency of the infrastructure service provided (eg. drops in water pressure, surges in electricity), ***Safety:*** the safeness of the infrastructure for those who use it (eg. microbial levels in water, frequency of road accidents), ***Resilience:*** the ability of the infrastructure to respond in the event of unusual demand (eg. road congestion in response to unusual event, internet download speeds)''

The ACI Guide(*Guide to Airport Performance Measures*, 2012) highlights the importance of knowing the purpose of measuring system performance before designing performance indicators for any system and advocates a step wise approach to performance indicator development in infrastructure. Where the first step is to identify key performance areas (KPA) for the infrastructure in question, the second step is define at least one performance indicator (PI) per KPA, and the third step is to use the PIs to evaluate and improve performance and the whole process is iterated through frequent consultation with users and other interested parties.

2 Guideline Criteria for Evaluating Infrastructure Performance Indicators

Following a Workshop with industry stakeholders, critical literature review and evaluation of the performance indicators used in the UK National Infrastructure Plan (NIP), we identified a set of guideline criteria for evaluating performance indicator design (Table 2. Guideline Criteria for Evaluating Performance Indicator DesignTable 2). The Purpose of these guideline criteria is to provide a framework against which to evaluate current indicators, and a framework of points to consider when creating a new set of performance indicators.

Table 2. Guideline Criteria for Evaluating Performance Indicator Design

Characteristic	Description
Meaningful	Indicators should be easy to interpret and unambiguous
Purposeful	Designed for an explicitly stated purpose
Strategic	Designed to provide meaningful feedback on progress toward strategic outcomes
Outcome-focused	Be more than indicators of stock/activity or technical performance; provide meaningful feedback on progress toward strategic outcomes. (Strategic outcomes should be linked to welfare as well as economic growth)

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Future-focused	Designed to measure elements of performance relevant to the future of the infrastructure system in question
Systemic	The purpose of indicators needs to be clearly linked to the system they are measuring, each performance indicator should be part of a meaningful multi-dimensional set that collectively gives a view of system performance. Indicators should not be used in isolation for the purpose of optimising individual system elements.
Transparent	The underlying data source(s) for any indicator need to be declared as do methods and justifications for any calculation/aggregation/normalisation performed to create the indicator. Where an indicator is aggregated from multiple data sources, it should be published alongside the indicators that comprise it.
Relevant Presentation	Relevant information can be hidden by average or normalised values. A range of formats should be considered for publishing indicators such that the indicator meaningfully communicates behaviour linked to its strategic purpose.
Geographical Scale	Indicators should be presented on a geographical scale relevant to decision makers. Where national data is published, appropriate regional data should be made available.
Reviewed frequently	Indicators should be frequently reviewed in terms of whether they remain fit for purpose, and aligned with strategic outcomes. Indicators no longer aligned with these elements should be removed or adapted to ensure the indicator remains meaningful
Not data constrained	Strategic elements of performance or outcomes that need to be measured should be identified before issues of data availability are considered. Where data is unavailable clear justification for the use of alternative metrics should be provided.
Objective and Neutral	Indicators should not create lock-in to particular infrastructure solutions or technologies
Encourage Innovation	Send clear signals to infrastructure industries by being consistent with strategic outcomes
Reflect Stakeholder Needs	The performance indicators should provide relevant information to stakeholder groups who may use them.
Capture Multiple stakeholder perspectives	Indicators should provide measures of performance relevant to a range of infrastructure stakeholder perspectives

2.1 Evaluation of PI criteria using NIP as Case Study

Using the criteria (Table 2) as a guiding framework, evaluation of the current NIP performance indicators allowed a number of observations to be made:

- It is ambiguous what meaningful information decision makers and other infrastructure stakeholders are able to derive from the indicators
- The link between strategic purpose(s) and indicator selection is not specified.
- It is possible to infer the strategic purpose(s) of the performance indicators in the NIP, however this is not clearly stated
- No explanation of the rationale for selecting the performance indicators used in the NIP is given
- The indicators lack the resolution to inform regional decisions
- The indicators are backward focused
- The indicators are sectoral not systemic
- Data availability rather than strategic need appears to have driven the selection process
- The indicators are dependent on secondary data used outside of the context originally intended
- Normalisation of data and no information on how each indicator is calculated increase ambiguity and reduce indicator transparency

3 A Process for Indicator Development

The guideline criteria in Table 2 were distilled into 9 principles (Table 3) in order to operationalise them and incorporate them into the performance indicator development process shown in Figure 1.

3.1 Process Design Principles

Table 3. Design Principles for a Process to Develop Performance Indicators

	Principle Description
Principle 1	The process should generate a full written narrative to justify the rationale for all decisions taken during the process and provide a clear narrative that demonstrates the connection between long term vision/desired outcomes and the performance indicator sets produced.

Principle 2	It is important that performance indicators used in any infrastructure sector reflect both the policy vision for that sector and the outcomes users and society value from that sector. Only by doing so, will performance indicators for the sector create a meaningful picture of sector infrastructure performance.
Principle 3	Because outcomes are often multidimensional, incur indirectly as a result of infrastructure acting as an enabler, and are difficult to measure, Outcomes should be broken into a set of contributing factors before developing performance indicators.
Principle 4	Contributing factors for any infrastructure enabled outcome, these should be framed in a technologically and solution neutral way.
Principle 5	Performance indicator development should be informed by clearly stated long term vision and a set of socially desired outcomes infrastructure is expected to enable, rather than be constrained by current data availability.
Principle 6	Headline indicators to measure performance against each Outcome can only make sense in the context of the indicator set from which the Headline indicator is derived. Therefore, any process to design performance indicators must make these contributing factors explicit and ensure that the headline indicator is stated as part of a package with the contributing factor indicators and the method used calculate the headline from the contributing factors. The purpose of this is to make explicit the trade-offs involved in achieving any performance target and so inform discussions of relative priorities and identify potential perverse incentives arising from performance indicators.
Principle 7	Whenever indicators are published, each indicator should be accompanied by a statement of their intended value to the audience they are designed for, these statements should be an output from the indicator design process.
Principle 8	The final stage of any process is to consider data sources. Where data cannot be obtained, the process should be sufficiently flexible to be revisited and modified in the light of data availability, without modifications affecting the underlying purpose of the performance indicator.
Principle 9	Any process for performance indicator creation needs to be flexible such that it can be applied at any geographic scale, in any sector, and at a cross sectoral infrastructure scale, to allow comparisons between different regions, different sectors (where appropriate) and to promote a systemic perspective that recognises actions in one sector to meet performance indicator can impact on the ability of other sectors to achieve performance indicator

3.2 Performance Indicator Development Process

The process for developing performance indicators (Figure 1) is designed give a transparent stepwise approach to the development of Performance Indicators from identification of long term vision and desired outcomes to the production of performance indicators connected to

those outcomes. Additionally, the process is applicable broadly to Infrastructure, to any Infrastructure Sector, and may be applicable to other contexts where performance indicators derived from clearly stated desired outcomes are required. Furthermore, the process embodies all 9 principles (Table 3) and will produce performance indicators that perform well if evaluated against the guideline criteria (Table 2).

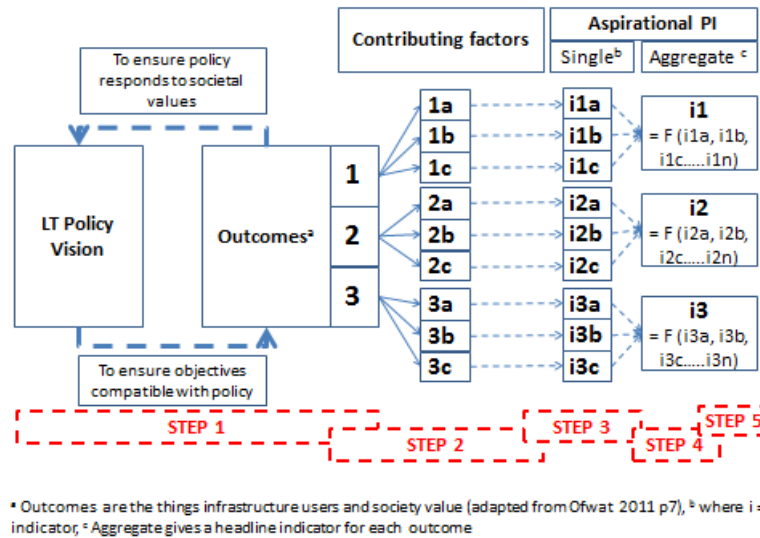


Figure 1 A Process for Developing Performance Indicators

3.2.1 Explanation of Process Steps

Step 1: Laying Foundations

Step 1 requires that both a long term policy vision and a set of desired outcomes are clearly stated prior to undertaking any further work to develop performance indicators. Step 1 acknowledges a two way relationship between long term policy vision and desired outcomes, which of these comes first is unimportant provided the two are sense checked against one another and a set of desired outcomes, with a supporting rationale is the output from Step 1. Step 1 embodies principles 1, 2 and 5.

Step 2: Identify and Analyse Contributing Factors

The desired outcomes identified in Step 1, will in most cases be multidimensional (comprised of more than one contributing factor) and occur indirectly as a result of infrastructure operation. Step 2 is the task of identifying a set of uni-dimensional contributing factors for each outcome. The required output from Step 2 is a clearly stated set of contributing factors for each outcome, with supporting rationale as to why the contributing factors are relevant to the outcome, and why they have been framed in the way they have. Additionally, all contributing factors must be framed in a technologically and solution neutral way.

Completion of Step 2 provides greater clarity regarding the meaning of each outcome and breaks each outcome into a measurable set of contributing factors. Identifying contributing factors should be a team activity that promotes debate and collaboration between those likely to be affected by the performance indicator. Critical examination of the output from Step 2 by external experts is recommended before moving to Step 3. By building on earlier steps, Step 2 embodies principles 1, 2, 3, 4 and 5.

Step 3: Translate Contributing Factors to Indicators

Step 3 is the act of proposing indicators for each of the uni-dimensional contributing factors identified at Step 2. At Step 3 the key question is how can each contributing factor be measured? The required output from Step 3 is a set of decisions (with supporting rationale) for each contributing factor to identify the data needed to measure each contributing factor and to state the calculation by which the indicator will be produced. As with Steps 1 and 2, Step 3 should be undertaken before considering data availability, the purpose of the early stages of this process is to identify what do we need to measure and why. Decisions taken at Step 3 can be revisited during Step 5, if it turns out the required data is not available and cannot readily be sourced. By building on earlier steps, Step 3 embodies principles 1, 2, 3, 4, 5.

Step 4: Produce Aggregate Indicators

Step 4 is the creation of a headline indicator for each desired outcomes identified in Step 1. Headline indicators are calculated from the contributing factor indicator set produced at Step 3. The expected output from Step 4 is clear justification of how to weight each of the contributing factors when calculating the headline indicator and a clearly stated formula to calculate the headline indicator. All decisions, even a decision to weight all factors equally must be justified at Step 4. Similar to step 2 it is important that weighting decision are a team activity that promotes debate and collaboration between those likely to be affected by the performance indicator. Critical examination of decisions taken during Step 4 by external experts is recommended before moving to Step 5. As with Step 3, decisions taken for Step 4 can be revisited during Step 5, if it turns out the required data is not available and cannot readily be sourced. By building on earlier steps, Step 4 embodies principles 1-6.

Step 5: Evaluate Data Gap

Steps 1 -4 are independent of data availability, the aim of this is to ensure indicators measure what needs to be measured not what data allows to be measured. Step 5 evaluates data availability and using the evidence base developed in Steps 1-4 puts in place strategies to address data shortages. Where a data shortage cannot be addressed, it may be necessary to revisit and redesign Steps 3 and 4, provided this process does not change decisions at Steps 1 and 2, data shortages can be addressed with changing the underlying purpose of the Performance indicators.

The required output from Step 5 is a clear linking of each contributing factor indicator to available data with a justification of whether data is 'fit for purpose'. Where current data is not 'fit for purpose' a business case for data collection of additional primary data is required.

If appropriate additional data cannot be sourced, Steps 3 and 4 need to be revisited for the indicator in question.

The question of scale of application is dependent on the data, the indicators developed through Steps 1-4 can be applied to any geographical scale provided data can be acquired. Therefore, it is data availability that affects ability to calculate the indicators at different geographical resolutions. Therefore Step 5 needs to investigate the range of scales at which data is currently available and assemble a business case for additional data collection if data at the required resolution is not available. By building on earlier steps, Step 5 and the process as a whole embodies principles 1-9.

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