Project Diagnostics – Assessing the Condition of Projects and identifying Poor Health

The research described here was carried out by the Australian Cooperative Research Centre for Construction Innovation

John Tsoukas,
Arup Project Management, Brisbane Australia (email: john.tsoukas@arup.com.au)

Abstract

In many cases, construction projects do not achieve the objectives that the project participants set for them. If participants could better understand how their project is performing overall, at various stages of its delivery, then the opportunities to achieve project success would almost certainly be greater.

This paper documents a method of assessing the status of a project, at a point in its design or construction phase, or after completion. The status is assessed in terms of up to seven (7) key success factors. Any evidence of less than adequate performance in these performance areas is scrutinised to seek out the root causes of why this situation is happening. Using these identified root causes of under performance, general suggestions can then be made as to how to return the project to good health.

A software package that assists in assessing the status of the project has been developed. The package is currently being calibrated before commercial release.

Keywords: diagnostics, project status, project performance indicators, root causes

1. Project Diagnostics

1.1 The Gestation for Project Diagnostics

Many projects fail to meet predetermined objectives. This failure is a major issue adversely affecting the construction industry, and more generally, the community. From the need to better understand how to judge the prognosis for a particular project (in terms of its likely performance), the idea of developing a "diagnostic kit" arose.

Project Diagnostics is a research initiative of the Australian Cooperative Centre for Construction Innovation (CRC CI). Arup Pty Ltd (Arup) is a founding member of the CRC CI, and lead this research project. This project was undertaken by a team with industry, government, and academic expertise.

1.2 The Human Health Analogy

Humphreys, Mian, Sidwell, (1) identified parallels between construction project health and human physical health, and proposed that in many ways the "health" of a construction project is analogous to human health. Human health can broadly be thought of as the condition of the body. When physical health is poor, performance or quality of life can be compromised. Poor physical health often has associated symptoms that can be used to help pinpoint the cause of ill health quickly and accurately.

Once the cause has been identified, a remedy can be implemented to assist the return to good health. If symptoms are left unchecked, they can develop into critical situations. In many ways the 'health' of a construction project is analogous to human physical health:

- State of health influences performance
- Symptoms can be used as a starting point to quickly assess health
- Symptoms of poor health are not always present or obvious
- State of health can be assessed by measuring key areas and comparing these values to established norms
- Health changes temporarily
- Remedies can often be prescribed to return to good health
- Correct and timely diagnosis can avoid small problems becoming large.

Project health is synonymous with project performance. If a particular project aspect is not performing as expected it would be perceived as unhealthy, or failing. On the other hand, if it is fulfilling expectations, it would be perceived as healthy or successful. The requirement for rapid, accurate diagnosis leads to the concept of an initial broad health checking mechanism, which could guide further more detailed investigations. More detailed appraisals identify the more fundamental factors contributing to poor health.

1.3 Industry Need

Research during the latter part of 2002 indicated that a reasonably comprehensive tool to assist in the assessment of the state of the existing health of construction projects was not generally available. Ready access to such a tool would significantly enhance the opportunity for an under performing project to be appraised - and then corrected, in a focused and systematic way.

Project Diagnostics has developed such an assessment tool to aid understanding of the current condition of a project. The assessment identifies performance against industry benchmarks for the key success factors. Further analysis of any underperforming areas is carried out – enabling the probable root causes of poor performance to be captured. This diagnosis can then provide a prognosis for the success of the project, or otherwise. The diagnostic toolkit can then point the way to remedial actions that could be taken.

These activities are highly relevant to industry. If project participants are able to confidently compare how a project is currently performing against industry norms, then targeted action can be taken to improve performance, as necessary. The diagnostic toolkit can be then applied again at subsequent stages of the project, to continue to monitor the effectiveness of remedial action taken.

2. Methodology

2.1 Project Methodology

The Project Diagnostics methodology is shown in Figure 1. The following steps outline the methodology and should be read in conjunction with this figure.

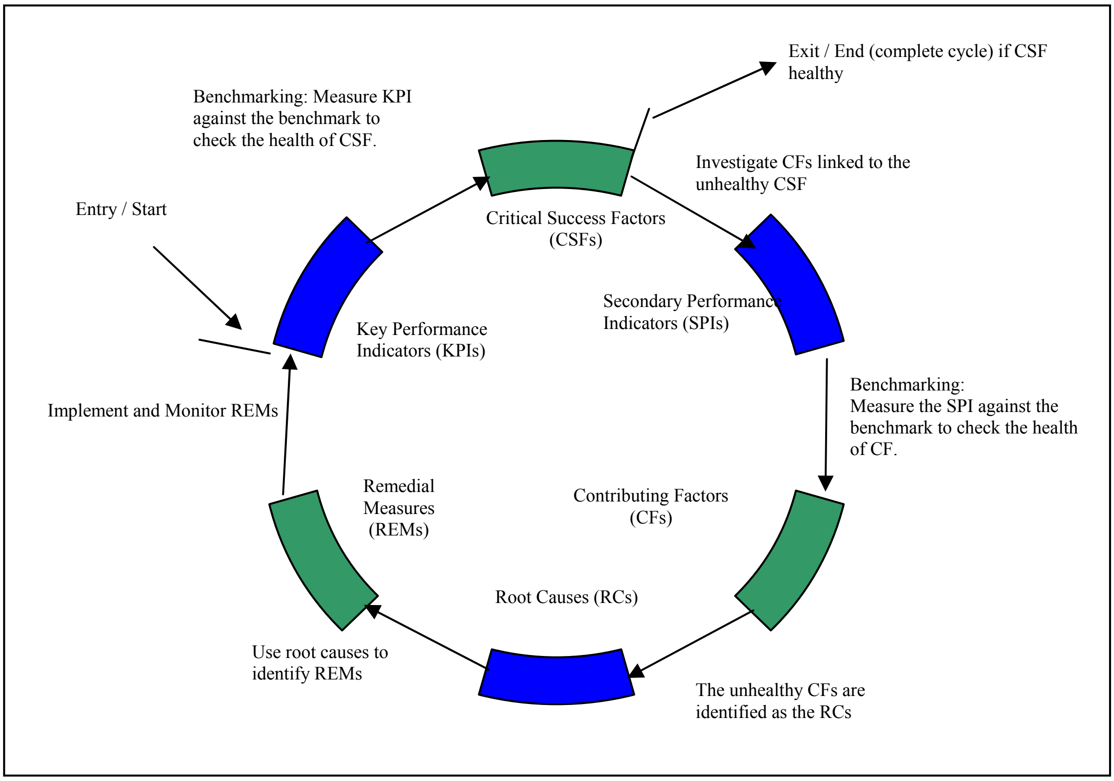

Figure 1

2.2 Critical Success Factors (CSFs)

Research carried out in the last decade provides many sources of success and failure measures, totalling more than 120 different relevant measures. The measures have been split among different stages of a project. In order to make these extensive lists more manageable to work with, and to help analyse the interactions, they are represented by seven main measures of success. These are termed Critical Success Factors (CSFs).

The factors used for the assessment of current health of the construction project are:

- Cost
- Time
- Quality
- Relationships
- Safety
- Environment
- Stakeholder value

As is the case with human physical health, these measures are critical areas that can facilitate a broad evaluation of project health; they need to be investigated in order to ascertain project health.

2.3 Key Performance Indicators (KPIs)

The seven CSF themes represent critical areas of construction project health. In order to use these CSFs as indicators, they need to be properly assessed. This task was achieved by developing an associated series of Key Performance Indicators (KPIs) for each CSF.

The KPIs are used to measure the degree of acceptability of CSFs. Their value is compared to benchmarks, to check status. The aggregation of CSF status information provides an indication of the project health. This process involves collecting data from the project under scrutiny, calculating the KPIs, and comparing them with benchmarks.

The use of KPIs to assess the performance of the main CSF themes allows the model to be applicable to most (if not all) of the project stages and a majority of the procurement methods. To facilitate the KPIs application to assess the performance of the CSFs, they were calibrated using benchmarks from Australia (Coles 2003, (2)), UK (CBPP 2003 (3)) and USA (CII 2003 (4)). Calibration makes the model applicable to a project regardless of generally how the performance target was arrived at.

After careful scrutiny, a total of 33 KPIs were chosen. As an example, the KPIs for the "Cost" CSF follow:

Table 1:

CSF	Key Perf Indicators	Explanation of Indicator
Cost	CPI (Cost Performance Indicator)	CPI = BCWP / ACWP Where: BCWP = budgeted cost of work actually performed. ACWP = actual cost of work actually performed. CPI ≥ 0.85 indicates a healthy project. CPI < 0.85 indicates an unhealthy project. The benchmark is based on an average value of cost overrun of 15% from survey of 375 general building projects in the Giles Royal Commission (1992) into the productivity of building industry in NSW. This indicator provides a snapshot of the project cost at a particular point in time. The source for gathering ACWP would be the progress claims of the consultant/contractor showing the approved amount at that point of time. This will be compared with the BCWP at that time - can be sourced from the contractor/consultant cost plan. The budgeted cost should include approved variations.
	PJCI (Projected Cost Indicator)	PJCI = BAC / EAC Where: BAC = budgeted cost at completion. EAC = actual cost at completion (i.e. actual cost to date plus updated estimate of work remaining). PJCI ≥ 0.85 indicates a healthy project. PJCI< 0.85 indicates an unhealthy project. The rationale behind the above benchmark is the same as the CPI. This purpose of this indicator is to check the health of a project at completion based on the forecast from the particular point in time chosen for the snapshot for CPI. In order to check the health of a project as far as cost is concerned, the CPI & PJCI are considered together in terms of the following conditions: CPI < 0.85 & PJCI < 0.85 indicates an unhealthy project. CPI < 0.85 & PJCI ≥ 0.85 indicates an unhealthy project. CPI ≥ 0.85 & PJCI < 0.85 indicates a healthy project. CPI ≥ 0.85 & PJCI ≥ 0.85 indicates a healthy project. The CPI and PJCI are applicable to all stages of a project from planning to hand over.

It was necessary to validate the robustness of these KPIs by testing them on actual projects. Table 2 provides an explanation of how the indicator was used in testing.

Table 2: Example Cost Performance Indicator (CPI)

CSF	**Indicator**	**Explanation of Indicator**
Cost	CPI	Definition: CPI = BCWP / ACWP Where: BCWP = budgeted cost of work actually performed ACWP = actual cost of work actually performed Benchmark: CPI ≥ 0.85 indicates a healthy project CPI < 0.85 indicates an unhealthy project This provides a snapshot of cost performance on the day of health check.

For all relevant CSFs (up to seven), the results are then analysed and the overall health of the project is able to be assessed. If the results indicate a healthy project the cycle ends. Otherwise, the use of the toolkit proceeds to the next step.

2.4 Contributing Factors (CFs)

CSFs that were found to indicate project performance as being less than industry benchmark levels were used as the focus of a more detailed investigation. Factors leading to poor levels of performance against benchmarks were assessed; these factors are called the Contributing Factors (CFs). There is a direct relationship between CFs and the root causes of poor project performance.

A list of Contributing Factors associated with each CSF was developed in consultation with industry through pilot studies. Pilot interviews were conducted on projects identified by the industry partners from the research team. These interviews were conducted using a structured questionnaire. The respondents included clients, consultants, contractors and sub contractors. A total of 28 interviews were conducted. The questionnaire was designed to allow identification of CFs and to allow them to be ranked in terms of relative importance using a numeric scale. This list of CFs was augmented with CFs identified from a literature survey.

The CFs were further validated using a Delphi type approach using industry partners as specialists.

The overall ranking of the identified CFs for each unhealthy CSF from the pilot questionnaire was calculated, using a statistical frequency analysis.

Table 3 shows the rank and importance index for CFs for "Cost" as an example. The indexes are ranked in descending order.

Table 3: Rank and Index of Contributing Factors

CSF	Contributing Factors (CFs)	Index	Rank
Cost Overrun	Variations	14.7	1
	Inaccurate cost estimate	6.0	2
	Rework	3.3	3
	Lack of client decision making	2.7	4
	Competitive nature of market	2.3	5
	Poor quality of design and documentation	2.3	5
	Approvals	2.0	7
	Contractor / Sub-contractor work efficiency	2.0	7
	To manage project simultaneously a large component of work was done in another city branch office	2.0	7
	Poor workmanship	1.3	10
	Work sequencing with other trades	1.3	10
	Audit testing	1.0	12
	Change of management	1.0	12
	Emissions and under measures in documentation	1.0	12
	Lack of completeness of contract documents	1.0	12
	Limited resources	1.0	12
	Lack of architect higher management interest	0.7	17
	Productivity of workforce due to traveling involved due to remote location of project	0.7	17
	Relationship workshop	0.7	17
	High quality product required	0.3	20
	Higher management direct involvement	0.3	20
	Programming issues causing pressure on contractors	0.3	20

The importance index and rank for each CSF was found by calculating the average index for the rank 1 to 4 of contributing factors within each CSF. Table 4 shows the index and rank of the overall CSFs.

Table 4: Rank and Index of CSFs

CSFs	**Index**	**Rank**
Cost	6.68	1
Time	3.86	4
Quality of documentation - increase in RFI	3.20	8
Quality of construction - increase in rework	4.65	2
Safety	3.60	5
Relationships	4.15	3
Environment	3.40	7
Stakeholder value	3.43	6

As mainly successful projects were evaluated in pilot studies, the list of CFs was not considered comprehensive. Augmentation with CFs identified from a literature survey occurred. The CFs were further validated using a Delphi type approach using industry partners as specialists. Thes team members added CFs to the list obtained from pilot studies so as to achieve a comprehensive list. A second round of feedback on CFs was instituted with the research team. Finally they were discussed in a workshop attended by the same specialists to get a final list, based on the consensus of these specialists.

2.5 Secondary Performance Indicators (SPIs)

Like CSFs, the CFs needed to be assessed to pinpoint the areas most likely to be causing poor project health. This task was accomplished with a series of Secondary Performance Indicators (SPIs) for each CF. A number of key criteria, similar to those used for selecting KPIs, were also used for choosing SPIs. A sample of "Cost" SPIs follows:

Table 5: Example showing "Cost" SPIs

CSFs	**Contributing Factors**	**Secondary Performance Indicators**
Cost Overrun	Inaccurate estimating of cost	To measure the reliability of cost estimates, actual design or construction cost is needed and estimated design or construction cost; and using the formula: Performance Percentage Predictability = (Actual design or construction cost – Estimated design or construction cost) / Estimated design or construction cost and plotting this value on the Predictability - Cost curve indicates the performance level.

	Consultant / contractor lack of appropriate experience	Profile is an indicator - has consultant or contractor successfully completed a similar project in terms of size, locational restrictions, complexity etc. This indicator however needs benchmarking.
	Inflation	Magnitude has direct impact on cost estimates.
	Lack of trust in contractors and consultants by client	The policy adopted by the client may lead to teams' protecting their own position, resulting in loss of focus or reduced productivity.
	Adoption of inappropriate contract type	An inappropriate contract type (eg, Fixed, or Cost Plus, when scope is not well defined), can lead of cost overruns.

Potential SPIs associated with each CF were identified from the literature. As with the KPIs, these SPIs needed to be benchmarked. Benchmarks were identified through a literature review of research material from the UK, the USA and Australia. In addition, results from four projects of the project team members were used to validate the results. The results weer further reviewed in a workshop with industry research partners.

2.6 Root Cause Identification

Knowledge of the particular CFs failing to meet the target (benchmarked) values, provide the necessary insight to confidently identify root causes of poor performance. For example, if the relevant "Cost" CF was the use of an inappropriate contract type (as highlighted by the SPI), then the relevant root cause becomes almost self evident. In some cases, the CF and its root cause are quite similar. In other cases, such as the relevant "Cost" CF being inaccurate cost estimating, then the specific root cause needs further review; is the inaccurate cost estimating due to poor project scoping, or inadequate resources, or lack of skills, or some other basic cause? It is here that the experience of the project participants, and/or external professionals, comes into play.

Once the root causes were acknowledged, remedial measures associated with each of them were able to be identified: based on lessons learnt from the industry partners, through case studies, and from another literature search.

Correct and timely identification of contributing factors along with accurate assessment of SPIs, generally allowed an effective remedy to be prescribed, through insight into root causes of concern. The role of the subsequent remedies is to return the project to good health. Recognising the potential effect early and taking the proactive steps necessary to avoid unwanted consequences, can achieve this.

2.7 Remedial Activity

The practical nature of construction suggests that a suitable approach for development of a suite of remedies for a range of health problems would be based on the experiences of the project participants, but focused on the specific results of the CF/ SPI analyses. A combination of the Project Diagnostics specifics, and a broad industry understanding is a powerful project improvement tool. In some cases, it may be appropriate to introduce independent industry professionals to assist the project team in this process.

One of the limitations of using lessons learnt is that remedies tend to be dependent on personal experience. This means that remedies for a given contributing factor or identified root cause, may vary from person to person – and potentially in conflicting ways. The approach for this model will be to develop a set of remedies that have proved historically to be workable and can achieve results.

However, it needs to be understood that each project is unique, with its own set of issues and most appropriate ways of restoring it to good health.

For this reason, remedies nominated in Project Diagnostics can be generic remedies only – and should only be seen as such, until and unless the particular project dynamics are clearly understood.

It is possible that single or multiple remedial measures will be associated with each of the contributing factors for the specific unhealthy CSF. The implementation of the measures may require the coordination of multiple project participants or stakeholders. Once implemented, time may be required time to restore the project to good health.

As necessary, the KPIs for relevant CSFs are able to be measured again later, to check if the cause of poor performance has been remedied. The cycle can iterate until the project health is considered to be satisfactory.

3 Software Development

3.1 Toolkit

The aim of Project Diagnostics was to develop a Toolkit that enables the user to:

- Investigate the health of a construction project
- Identify the root causes of poor health
- Give an indication of remedial measures which could be implemented to improve project performance and outcomes.

This toolkit has both the potential to be used as required when clients or other project participants feel that a project is not performing according to their expectations; and at regular intervals as a ‘health check’ during the delivery of the project.

The toolkit is designed to have integrated benefits that include identifying areas of poor project health, pointing to the probable root causes and suggesting possible remedial measures. It is envisaged that the use of the toolkit will be very cost effective for clients and stakeholders as compared with the costs associated with the adverse impacts of failing projects. These include cost and time overruns, inadequate build quality, poor project relationships, loss of reputation, public clamour and legal disputation.

The software development is well advanced. As at January 2005, commercial arrangements for the finalisation of the software toolkit are being finalised.

3.2 Validation

Further validation of the KPIs, CFs and SPIs, and linkages to case studies are required, before the package is ready for commercial release. To date, four case studies during the later stages of development of the toolkit have been used to validate the model and refine the parameters used. Ten pilot projects were used earlier in the initial development of the approach used in the software.

Comprehensive validation of the software package is intended to be complete by early 2006. The package will then be available for commercial use. Expectations are high for the benefits that Project Diagnostics will bring to the entire industry.

4. Conclusions

Project Diagnostics aims to bring the benefits of industry knowledge and experience, built up over many years, to project participants. By assessing the state of critical success factors for construction projects, at various stages of progress, it is possible to gain a confident view as to the likely prognosis for success of the project.

The software toolkit automates this assessment. The toolkit facilitates the identification of areas of project under performance. Use of the toolkit will assist in setting appropriate remedial measures, to facilitate the restoration of the project to good health.

5. Acknowledgements

Thanks are owed to the Project Diagnostics Project Team, comprising Arup, CSIRO, Department of Main Roads (Qld), Department of Public Works (Qld), John Holland Constructions Pty Ltd, and Queensland University of Technology. The significant role of the CRC CI in sponsoring and guiding this project, is also gratefully acknowledged.

6. References

(1) Humphreys, Mian, Sidwell, (2004) identified some parallels between construction project health and human physical health and proposed that in many ways the “health” of a construction project is analogous to human physical health, Australia.

(2) COLES (2003), Australia

(3) CBPP, (2003), ‘Construction Industry Performance Indicators’, UK.

(4) CII / ECI, ‘Contractor questionnaire version 7.0 ‘on http://www.cii-benchmarking.org/