

How to Use KPIs in Contracts for Effective Road Construction Project Management^{1, 2}

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ABSTRACT

In the management process of the road construction project, the effective reporting and the performance evaluation of the project outcome throughout the life cycle of the project. In the project performance measurement process, clarifying the KPIs attributes that meet the requirement of both two parties is the key to ensure the results can be successfully reported and assessed, which is a complicated and critical step. In order to help contractors and managers to manage projects more effectively, it is necessary to find an alternative dashboard and the corresponding KPIs that best match the attributes of the road construction project.

This paper uses Multi-Attribute Decision-making techniques (MADM) to define and prioritize several dashboards that are required for performance measurement, and to help users understand which are the most critical attributes that should be selected. The paper concludes by recommending alternative solution and providing effective references for the management of road construction projects.

Key words: Key performance indicators, Road construction project, KPIs dashboard, Contract management, Effective project management, Performance metrics and measurement

INTRODUCTION

As contract management becomes a more and more critical success factor in the Road construction industry, the strategic requirements of contract management are getting stronger, and the complexity of the clauses in the contract is higher and higher. The KPIs in dashboard for project performance measurement in the contract also contains a large amount of information and

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management strategies, which makes the risk of project management in the Road construction industry even greater. Inefficient project management represents a large amount of capital loss, time cost, space idle cost and waste of labor costs. Based on the statistic indicating, "70% of all the projects are behind their schedule and over budget, while 52% of the projects finished at 189% of their initial financial budget."³

In the project contracting industry, contract is used as a vehicle for managers to measure projects, monitor processes, and required periodic reports for deliverables that including detailed of the contractor's contributions and accomplishments. However, most of contract administration lacks a tangible tool that presents a clear and operational measurement systems. It enables all the stakeholders to visually capture the performance of the earned value and other values in the project. In addition, this tool can also act as one of the leading indicators, which leads and directs the project to move forward. The tool is called Key performance indicators (KPIs), which is essentially a "dashboard" that is comprised with the relevant standards that the owner and contractor will measure. According to Eckerson's definition: "The KPIs is a metric to measure how excellent the organization or an individual performs tactical, operational, or strategic activities that is critical for the success of the organization now or in the future."⁴ It should be noted that this paper will focus on the specific field that how to use "KPI" in contract rather than use "metric", because the "metric" is generic, however the "KPI" is specific for different project types and scopes.

Contract management is one of the pillars to ensure the success of the Road construction project. KPIs in contract are pragmatic scorecards to measure whether a project is progressing toward predefined project targets or not. However, it can be found that KPIs in Road construction dashboard are complex, there are many factors should be taken into account. Therefore, before creating thesis and statement of purpose, it is necessary to create a Root Cause Analysis (RCA) of the problem. The idea of Root Cause Analysis is to sort out the root cause of KPIs' defect in performance measure dashboard, which led to the ineffective road construction project management. According to the figure (Figure 1) below, the assignment of this thesis is to fully consider all necessary KPI clauses in contract management and to seek a flexible and feasible method to achieve effective Road construction project management.

³ *Measuring Contract Performance Using Earned Value Management* (2018, March). Retrieved from <https://pmworldlibrary.net/wp-content/uploads/2018/03/pmwj68-Mar2018-Yang-measuring-contract-performance-using-evm-student-paper.pdf>

⁴ *Performance dashboards: Measuring, monitoring, and managing your business* (2013). Hoboken, NJ: Wiley.

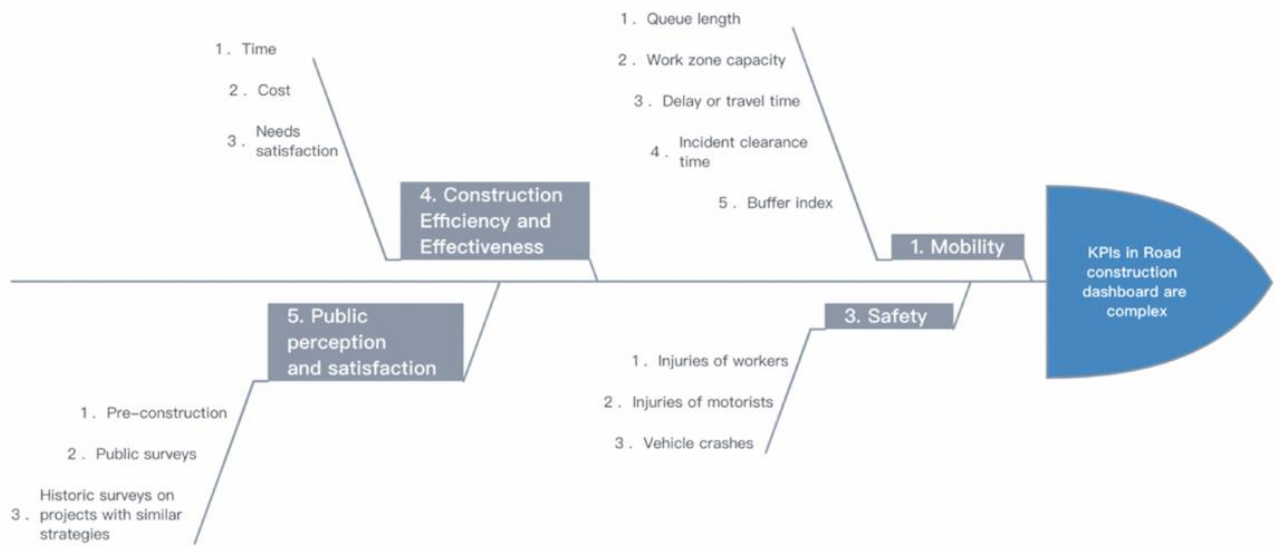


Figure 1: Fishbone Diagram⁵

STEP 1: Problem Definition

Is it the true that the KPIs dashboard that contains all the elements is perfect to ensure the success of road construction project management? *"That's not the case, although "Metric" is too generic to accurately measure project performance, sometimes "KPIs" with too much detail can cause many operational problems due to the difficulty of measuring and counting."*⁶ In most process of project, KPIs are not only used as the performance evaluation tool after the end of the process, *"but also used by some project contractors and managers as the standard to identify if the process should be approved, revised and measure the level of project performance."*⁷ Therefore, KPIs that are specific and closely related with the attributes of road construction project are critical to the success of project management. How did this happen, why did it become like this? Next step, this paper will focus on answering the following questions:

- What kind of dashboard can be used as a standard for accurately measuring the completion level of a road construction project? Which should be closely related to the project content and easy to calculate.

⁵ By the author.

⁶ Project Management Metrics, KPIs, and Dashboards: A Guide to Measuring and Monitoring Project Performance (2017, October 16). Retrieved from <https://www.amazon.com/Project-Management-Metrics-KPIs-Dashboards/dp/1119427282>

⁷ Work Zone Road User Costs Concepts and Applications (2011, December). Retrieved from <https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/fhwahop12005.pdf>

- What KPIs attributes should the road construction project take into account in their contract management?
- The benefit of using KPIs in contract for road construction project?

METHODOLOGY

STEP 2: Feasible Alternatives

This section is to quantify each alternatives solution by using Multi-Attribute Decision-making techniques. According to the Problem Statement from Step 1, the step 2 is going to reviews the attributes of following alternative dashboards, revealing the methods and KPIs of those performance measurement modules. In order to identify the feasible alternative solution to help contractors and Road construction project managers to implement projects efficiently.

- *Guild of Project Controls Compendium and Reference (GPCCaR) Module*⁸
- *DAU Gold Card*⁹
- *NDIA's A Guide to Managing Programs by using the Predictive Measures Module.*¹⁰
- *Performance measures for Ministry of Transport (MOT) Module.*¹¹

Guild of Project Controls Compendium and Reference (GPCCaR) Module

This GPCCaR Modul⁴ (Figure 2) is a very detailed and visible "Dashboard" that uses "S-Curve" from a real programme to show the dynamic results of different project progress throughout the project lifecycle. It also provides a referential metrics ribbon below the chart, giving contractors and project managers a great view of the current state.

⁸ Guild of Project Controls. (2015, October 3). 09.5.3.4 Dashboard reports - Guild of project controls compendium and reference | Project Controls - planning, scheduling, cost management and forensic analysis (Planning Planet). Retrieved December 15, 2018, from <http://www.planningplanet.com/guild/gpccar/project-performance-forecasti>

⁹ Earned value management general reference (Gold Card). (2015). Retrieved from [https://www.dau.mil/tools/t/EVM-General-Reference-\(Gold-Card\)](https://www.dau.mil/tools/t/EVM-General-Reference-(Gold-Card))

¹⁰ National Defense Industrial Association / Integrated Program Management Division. (2014). A guide to managing programs using predictive measures. Retrieved from <http://www.ndia.org/>

¹¹ Work Zone Road User Costs Concepts and Applications (2011, December). Retrieved from <https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/fhwahop12005.pdf>



Figure 21 - S-Curve from a Real Programme

Source: Giammalvo, Paul D (2015) Course Materials Contributed Under Creative Commons License BY v 4.0

In the example above, there are 7 projects in this program and this is the Level 1 Summary Report issued to management showing the overall program status as of the end of Week 7 of a 26 week program. The chart explained:

1. The Budget At Completion for this program was \$833,208
2. The Estimate At Completion using the CPI formula was \$844,128
3. The Estimate At Completion using the CPI X SPI formula was \$823,128
4. Cumulative BCWS to date was \$314,322
5. Cumulative ACWP to date was \$330,826
6. Cumulative BCWP to date was \$328,219
7. Cost Variance (CV) was (\$2,617) meaning we were \$2,617 OVER budget
8. Schedule Variance (SV) was \$13,896, meaning we are \$13,896 AHEAD of schedule in terms of money
9. Cost Performance Index (SPI) is 0.99 meaning we are only 1% worth of work behind schedule
10. Schedule Performance Index (SPI) is 1.04, meaning we are 4% AHEAD of schedule in terms of work completed.
11. Baseline Execution Index (BEI) shows we have FINISHED 3% more activities than we had planned to finish by this date.
12. To Complete Performance Index (TCPI) means we only have to work at 99% efficiency for the remaining time to finish on time and within budget
13. We have spent 39.5% of our money budget; we have earned are 39.2% of our budget and only 37.5% of the time allowed has elapsed.
14. As of the end of Week 7, the projected completion date of this program is Week 23 and the P90 Estimated Cost at Completion is \$865,199

Figure 2: Guild of Project Controls Compendium and Reference (GPCCaR) Module¹²

¹² Guild of Project Controls. (2015, October 3). 09.5.3.4 Dashboard reports - Guild of project controls compendium and reference | Project Controls - planning, scheduling, cost management and forensic analysis (Planning Planet). Retrieved December 15, 2018, from <http://www.planningplanet.com/guild/gpccar/project-performance-forecasti>

DAU Gold Card

The DAU Gold Card gives the definition of terminology for earned value (EV) and related equations. As it's a one-page document, it could easily be adapted into the dashboard and more convenient for managers to review. The DAU Gold Card can be used to clarify the overall status of the road construction project. This one-page dashboard covers lots of information, including schedule variance, cost requirements, project efficiencies, baseline performance and forecasts, etc. This dashboard shows the relationship equations between all relevant data, which is an excellent layout that eliminates many management questions and misunderstandings.

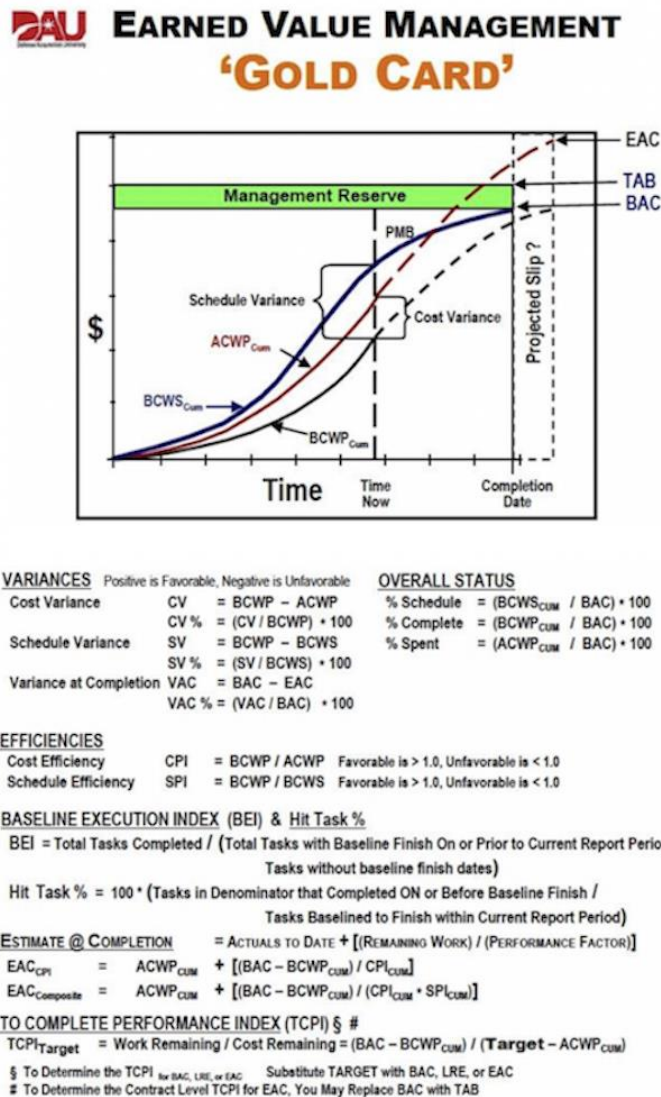


Figure3: DAU Gold Card¹³

¹³ Earned value management general reference (Gold Card). (2015). Retrieved from [https://www.dau.mil/tools/t/EVM-General-Reference-\(Gold-Card\)](https://www.dau.mil/tools/t/EVM-General-Reference-(Gold-Card))

NDIA’s A Guide to Managing Programs by using the Predictive Measures Module

NDIA's "A guide to managing programs by using predictive measures" is a broad dashboard that is more like a guideline. It not only shows the equations contained in the DAU Gold Card, but also include some equations related with: schedule, cost, staffing, risk and opportunity, requirement, technical performance, contract health, supply chain, which brings a more detailed and comprehensive reference scheme for managers.

2	Schedule Metrics	4
2.1	Schedule Performance Index (SPI) ^[1]	5
2.2	Baseline Execution Index (BEI) ^[1]	9
2.3	Critical Path Length Index (CPLI) ^[1]	14
2.4	Current Execution Index (CEI) ^[1]	18
2.5	Total Float Consumption Index (TFCI) ^{[1][3]}	22
2.6	Earned Schedule (ES) ^[6]	27
2.6.1	Time-Based Schedule Performance Index (SPI _t) ^[6]	28
2.6.2	SPI _t vs. TSPI _{ed} ^[6]	32
2.6.3	Independent Estimated Completion Date – Earned Schedule (IECD _{es}) ^[6]	35
3	Cost Metrics	38
3.1	Cost Performance Index (CPI) ^[5]	38
3.2	CPI vs. TCPI _{ac} ^[5]	42
3.3	Range of IEACs (Independent Estimates at Completion) ^[4]	45
4	Staffing Metrics	48
4.1	Staffing Profile	48
4.2	Critical Skills Key Personnel "Churn"/Dilution Metric	51
4.3	Critical Resource Multiplexing Metric	55
5	Risk and Opportunity Metrics	59
5.1	Risk & Opportunity Summary	59
5.2	Risk/Opportunity (R/O) \$ vs. Management Reserve (MR) \$ ^[14]	63
5.3	Schedule Risk Assessment (SRA)	66
5.3.1	SRA Histogram (Frequency Distribution Graph)	67
5.3.2	SRA Sensitivity (Tornado) Graphs	72
5.4	Schedule Margin Burn-Down	75
6	Requirements Metrics	78
6.1	Requirements Completeness ^[11]	78
6.2	Requirements Volatility	81
6.3	TBD/TBR Burn Down	84
6.4	Requirements Traceability ^[6]	86
7	Technical Performance Measures (TPMs)	90
7.1	Technical Performance Measure Compliance	90
8	Contract Health Metrics	94
8.1	Contract Mods	94
8.2	Baseline Revisions	96
8.3	Program Funding Plan	98
8.4	Program Funding Status	100
8.5	Contract Change Value	102
8.6	Research, Development, Test, and Evaluation (RDT&E) Actual Billings vs. Forecast Billings	105
9	Supply Chain Metrics	108
9.1	Parts Demand Fulfillment	108
9.2	Supplier Acceptance Rate	111
9.3	Supplier Late Starts	115
9.4	Production Line of Balance ^{[6][10]}	118
10	Rayleigh Estimator ^[12]	122

Figure 4: NDIA’s A Guide to Managing Programs by using the Predictive Measures Module ¹⁴

¹⁴ National Defense Industrial Association / Integrated Program Management Division. (2014). A guide to managing programs using predictive measures. Retrieved from <http://www.ndia.org/>

Performance measures for Ministry of Transport (MOT) Module

Performance measures for Ministry of Transport (MOT) Module (Figure 5) is the collection of performance measures of Work Zone Road Project, which is quantifiable and definable, results-based response times or conditions for performance, procedures, and evaluating policies of work zone. The focus of performance measurement is to achieve goals, not how to achieve them. This MOT module included four main KPIs of work zone performance: construction congestion and mobility, construction’s efficiency and effectiveness, satisfaction and public perception, and safety. Figure 5 below presents the content of work zone performance measurement module by using the MOT analysis method for all the performance categories.

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2.1	Schedule Performance Index (SPI) ^[1]	5
2.2	Baseline Execution Index (BEI) ^[1]	9
2.3	Critical Path Length Index (CPLI) ^[1]	14
2.4	Current Execution Index (CEI) ^[1]	18
2.5	Total Float Consumption Index (TFCI) ^{[1][3]}	22
2.6	Earned Schedule (ES) ^[6]	27
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6.4	Requirements Traceability ^[8]	86
7	Technical Performance Measures (TPMs)	90
7.1	Technical Performance Measure Compliance	90
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9.2	Supplier Acceptance Rate	111
9.3	Supplier Late Starts	115
9.4	Production Line of Balance ^{[9][10]}	118
10	Rayleigh Estimator ^[12]	122

Figure 5: Performance measures for Ministry of Transport (MOT) Module¹⁵

¹⁵ Work Zone Road User Costs Concepts and Applications (2011, December). Retrieved November 20, 2018, from <https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/fhwahop12005.pdf>

STEP 3: Development of the Outcomes

First Alternative: Guild of Project Controls Compendium and Reference (GPCCaR) Module

The GPCCaR Module is the dashboard with the most comprehensive and detailed KPIs. As GPCCaR refers to DAU and NDIA, where there is a KPI in DAU or NDIA dashboard, there is also a corresponding KPI in GPCCaR. Not only that, *“but GPCCaR also contains KPIs that DAU and NDIA do not have, for example in the aspect of cost, GPCCaR has a unique IEACs KPI measurement formula: $IEAC5=ACWP+((BAC-BCWP)/(EV/AC))$ ”*¹⁶, which provide a more accurate forecast and as another way to improve the level of confidence in cost forecast. In addition, in terms of the profile related to the resource, GPCCaR also includes the unique KPI of Direct Workforce Profile Planned vs Profile Actual. This is a visual graphic KPI of daily/weekly/monthly “Direct” resources, which is the contractor is required to achieve the goals and targets. If the project is resourced as the schedule, there will be a clear indication, and if not, this graphic will clarify what alternative actions need to be taken to achieve progress.

Second Alternative: Performance measures for Ministry of Transport (MOT) Module

The MOT module is one of the most relevant dashboard of the road construction project in four dashboards. Although the MOT is different from the other three dashboards, it does not measure the performance of project management by formula calculation. However, the MOT contains many unique KPIs of road construction project, which makes the project performance easier to be observed and recorded. First, the MOT's dashboard contains KPIs related to schedule and cost that are mentioned in the other three dashboards, which are crucial KPIs. *“In addition, MOT has some unique KPIs for measuring the performance of road construction projects, such as mobility, workers and motorists' safety, construction effectiveness and efficiency, public perception and satisfaction.”*¹⁷ And those attributes are really necessary and suitable for road construction project.

Third Alternative: NDIA's A Guide to Managing Programs using Predictive Measures Module

NDIA is a broad dashboard that is more like a guideline. *“It has almost show all the equations contained in the DAU Gold Card, such as CPLI (Index of Critical Path Length), CEI (Index of Current Execution), TFCI (Index of Total Float Consumption), SPIT (Index of Time-Based Schedule*

¹⁶ Best in Class – Dashboards for Oil and Gas Projects (2017, October). Retrieved from <https://pmworldjournal.net/wp-content/uploads/2017/10/pmwj63-Oct2017-Paterson-Best-in-Class-Dashboards-for-OG-Projects.pdf>

¹⁷ Work Zone Road User Costs Concepts and Applications (2011, December). Retrieved November 20, 2018, from <https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/fhwahop12005.pdf>

Performance), and so on.”¹⁸ In addition, NDIA also include some unique equations related with: staffing, risk and opportunity, requirement, technical performance, contract health, supply chain, which brings a more detailed and comprehensive reference scheme for managers. However, NDIA has some additional KPIs, which are more related with US Government project and these are not been considered for inclusion in the dashboard of road construction type project.

Fourth Alternative: DAU Gold Card

As DAU is a one-page dashboard, which is really easily for managers to review. And DAU clarify the overall status of the road construction project really clear in its layout. “DAU has cover lots of KPIs in the aspect of schedule and cost, such as Schedule Performance Index(SPI), Schedule Variance(SV), Index of Baseline Execution(BEI), Index of Cost Performance(CPI), the Cost Variance(CV), etc.”¹⁹ However, DAU missing more detailed and more related KPIs of road construction project, “such as KPIs address to resource, risk, contract health, mobility, safety and construction effectiveness”,²⁰ which is not enough to adapt to the changing and dynamic road construction project industry.

STEP 4: Selection of the Criteria

In order to better and more accurately evaluate each alternative solution and link them to the road construction project, we will evaluate them by identifying if the following KPIs attributes are take into account in their dashboard:²¹

1) Schedule (Time control)²²

KPIs of schedule include Schedule Performance Index (SPI), % schedule, Baseline Execution Index(BEI), etc. This type of KPIs can show a clear indication if the project or process are being finished on time.

¹⁸ National Defense Industrial Association / Integrated Program Management Division. (2014). A guide to managing programs using predictive measures. Retrieved from <http://www.ndia.org/>

¹⁹ Earned value management general reference (Gold Card). (2015). Retrieved from [https://www.dau.mil/tools/t/EVM-General-Reference-\(Gold-Card\)](https://www.dau.mil/tools/t/EVM-General-Reference-(Gold-Card))

²⁰ Best in Class – Dashboards for Oil and Gas Projects (2017, October). Retrieved from <https://pmworldjournal.net/wp-content/uploads/2017/10/pmwj63-Oct2017-Paterson-Best-in-Class-Dashboards-for-OG-Projects.pdf>

²¹ Work Zone Road User Costs Concepts and Applications (2011, December). Retrieved November 20, 2018, from <https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/fhwahop12005.pdf>

²² Work Zone Road User Costs Concepts and Applications (2011, December). Retrieved November 20, 2018, from <https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/fhwahop12005.pdf>

2) Cost

This attribute presents the assessment of cost management, if the dashboard estimated for cost forecasting specific and appropriate formula or not.

3) Safety

Safety KPIs is the estimates of crash-related work zone RUC, which includes the clauses related to injuries and vehicle crashes of workers as well as motorists.

4) Mobility

It's the KPIs about estimates for travel time, vehicle operating costs and delays.

5) Construction Efficiency and Effectiveness

This is about the KPIs of needs satisfaction, which present adjectival if the related issues of the road construction were addressed.

6) Public's perception and satisfaction

This KPIs is to compare the customer satisfaction index of pre-construction and after.

7) Visibility²³

This attribute concern about whether the layout of the dashboard is clear and visibility enough for managers to review.

8) Buffer index

*"Buffer Index is a key KPIs of the calculated of the reliably travel service as one ratio between the difference of the average travel time, and the 95th percentile travel time, divided by the average travel time, respectively."*²⁴

²³ Best in Class – Dashboards for Oil and Gas Projects (2017, October). Retrieved from <https://pmworldjournal.net/wp-content/uploads/2017/10/pmwj63-Oct2017-Paterson-Best-in-Class-Dashboards-for-OG-Projects.pdf>

²⁴ Work Zone Road User Costs Concepts and Applications (2011, December). Retrieved November 20, 2018, from <https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/fhwahop12005.pdf>

Attributes	GPCCaR	DAU	NDIA	MOT
Schedule	EXCELLENT	EXCELLENT	EXCELLENT	GOOD
Cost	EXCELLENT	GOOD	EXCELLENT	GOOD
Safety	GOOD	FAIR	GOOD	EXCELLENT
Mobility	FAIR	POOR	POOR	EXCELLENT
Construction Efficiency and Effectiveness	FAIR	FAIR	POOR	GOOD
Public perception and satisfaction	FAIR	POOR	POOR	EXCELLENT
Visibility	EXCELLENT	EXCELLENT	POOR	FAIR
Buffer index	POOR	POOR	POOR	EXCELLENT

Figure 6: Multi-Attribute Decision making models-analysis of the dominance of each alternative²⁵

To distinguish the importance and weight of these criteria, we are going to evaluate and compare them and give them a rating to find out which is the most important criterion for the alternatives.

²⁵ By the Author.

	Schedule	Cost	Safety	Mobility	Construction Efficiency and Effectiveness	Public perception and satisfaction	Visibility	Buffer index	Ordinal ranking
Schedule	x	1	0	1	1	1	1	1	7
Cost	0	x	0	1	1	1	1	1	6
Safety	1	1	x	1	1	1	1	1	8
Mobility	0	0	0	x	0	1	1	1	4
Construction Efficiency and Effectiveness	0	0	0	1	x	1	1	1	5
Public perception and satisfaction	0	0	0	0	0	x	0	1	2
Visibility	0	0	0	0	0	1	x	1	3
Buffer index	0	0	0	0	0	0	0	x	1

Figure 7: Comparison of the importance of the attributes²⁶

According to the Figure 7 above, we can easily find out that the performance of each alternative solution based on each criterion.

Following the analysis method through those figures above, which give us date and information to create a relative ranking of the best solution for the topic, basing on the characteristics selected. Following is the outline of the best alternatives by using lexicographical compilation.

Ordinal Ranking	The relative ranking of each alternative based on attribute
8	Safety MOT > GPCCaR = NDIA > DAU
7	Schedule GPCCaR = DAU = NDIA > MOT
6	Cost GPCCaR = NDIA > DAU = MOT
5	Construction Efficiency and Effectiveness MOT > GPCCaR = DAU > NDIA

²⁶ By the Author.

4	Mobility	MOT > GPCCaR > DAU = NDIA
3	Visibility	GPCCaR = DAU > MOT > NDIA
2	Public perception and satisfaction	MOT > GPCCaR > DAU = NDIA
1	Buffer index	MOT > GPCCaR = DAU = NDIA

Figure 8: Lexicography to choose the best metric²⁷

FINDINGS

STEP 5: Analysis and comparison of alternative

In this section, for giving a recommendation of the best solution, we are going to compare each alternative by using the following figures:

VALUE	FORMULA	DIMENSIONLESS VALUE
EXCELLENT	Relative rank = (4-1)/ (4-1)	1
GOOD	Relative rank = (3-1)/ (4-1)	0.67
FAIR	Relative rank = (2-1)/ (4-1)	0.33
POOR	Relative rank = (1-1)/ (4-1)	0

Figure 9: Dimensionless value²⁸

²⁷ By the Author.

²⁸ By the Author.

Attributes	GPCCaR	DAU	NDIA	MOT
Schedule	1	1	1	0.67
Cost	1	0.67	1	0.67
Safety	0.67	0.33	0.67	1
Mobility	0.33	0	0	1
Construction Efficiency and Effectiveness	0.33	0.33	0	0.67
Public perception and satisfaction	0.33	0	0	1
Visibility	1	1	0	0.33
Buffer index	0	0	0	1
TOTAL	4.66	3.33	2.67	6.34
RANKING	2	3	4	1

Figure 10: Summary of No dimensional scaling results²⁹

ATTRIBUTES	RELATIVE RANK	NORMA LIZED WEIGHT (A)	ALTERNATIVES							
			GPCCaR		DAU		NDIA		MOT	
			(B)	(A)×(B)	(C)	(A)×(C)	(D)	(A)×(D)	(E)	(A)×(E)
Schedule	7	0.19	1	0.19	1	0.19	1	0.19	0.67	0.13
Cost	6	0.17	1	0.17	0.67	0.17	1	0.17	0.67	0.11
Safety	8	0.22	0.67	0.15	0.33	0.07	0.67	0.15	1	0.22
Mobility	4	0.11	0.33	0.04	0	0	0	0	1	0.11
Construction Efficiency and Effectiveness	5	0.14	0.33	0.05	0.33	0.05	0	0	0.67	0.09
Public perception and satisfaction	2	0.06	0.33	0.02	0	0	0	0	1	0.06
Visibility	3	0.08	1	0.08	1	0.08	0	0	0.33	0.03
Buffer index	1	0.03	0	0	0	0	0	0	1	0.03
TOTAL	36	1		0.77		0.56		0.51		0.78
RANKING				2		3		4		1

Figure 11: The additive weighting technique results³⁰

²⁹ By the Author.

³⁰ By the Author.

STEP 6: Selection of the preferred alternative

Concluding the analysis above, we can find that in Figure 6, MOT performs best. After weighing in Figure 7 and Figure 8, MOT it still the best choice while GPCCaR become the second best. From the result of Figure 11 above, MOT is 101% better than GPCCaR ($0.78/ 0.77*100$). However, GPCCaR is still the second choice, which performs better by 137% ($0.77/ 0.56*100$) and 150%($0.77/ 0.51*100$) than DAU and NDIA, respectively. Therefore, we strongly recommend applying the MOT dashboard to deal with KPIs application issues in contract management of road construction project.

STEP 7: Performance Monitoring and Post Evaluation Results

To track the feasibility and performance of the solution we recommended, we will use the Pareto Analysis to keep monitoring the KPIs that have critical impact on road construction project and should be optimized. We will take some factors which cause the performance of the solution decline into consideration and evaluation, such as the frequency of occurrences of Over budget, Schedule delay, Inefficiency, Public dissatisfaction. Monitoring the performance of the KPIs of recommended dashboard by using this method, we are able to find out which factor (causes) should be addressed first from the Pareto Analysis diagram.

The Pareto Analysis method can be divided into six steps. Before using this, we need to:

- 1) Collect data and related data for different analysis factors.
- 2) Form a statistical summary of frequency of occurrences of these factors(causes) as a percentage.
- 3) Prepare the Pareto Analysis table. Line the rows in an order of decreasing importance of the factors

	Over budget	Schedule delay	Inflexibility	Inefficiency	Public dissatisfaction
Frequency	a	b	c	d	e
Percentage of occurrences	v%	w%	x%	y%	z%

Figure 12: Pareto Analysis table³¹

Then we need to draw the Pareto diagram:

³¹ By the Author.

4) Plot the information in the Pareto Analysis diagram.

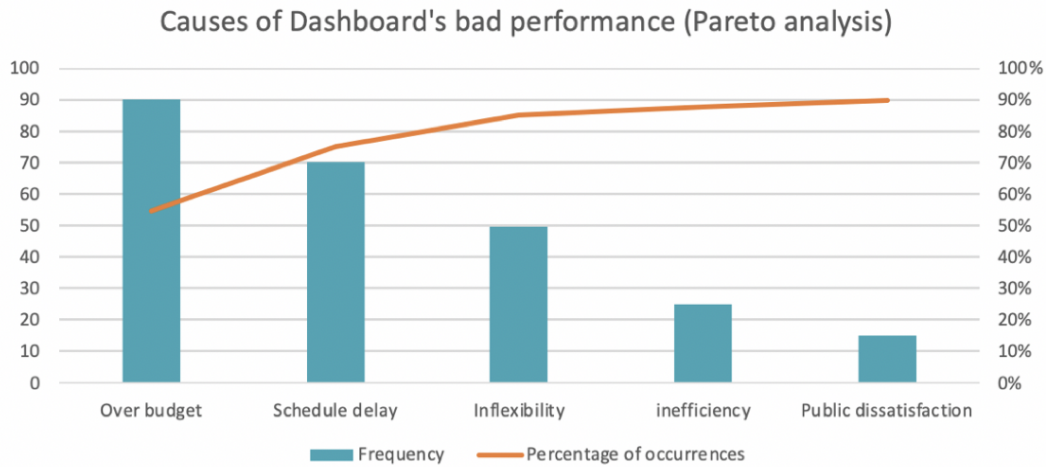


Figure 13: Causes of Dashboard's bad performance (Pareto analysis step 4)³²

5) Identify key factors (causes) that need to be optimized.

Then draw a horizontal line to intersect the curve at 80% from the y-axis. Then draw a vertical line from the point that cross with the x-axis. Finally, on the left side are those important factors separated by the vertical line, while the trivial Factors is on the right.

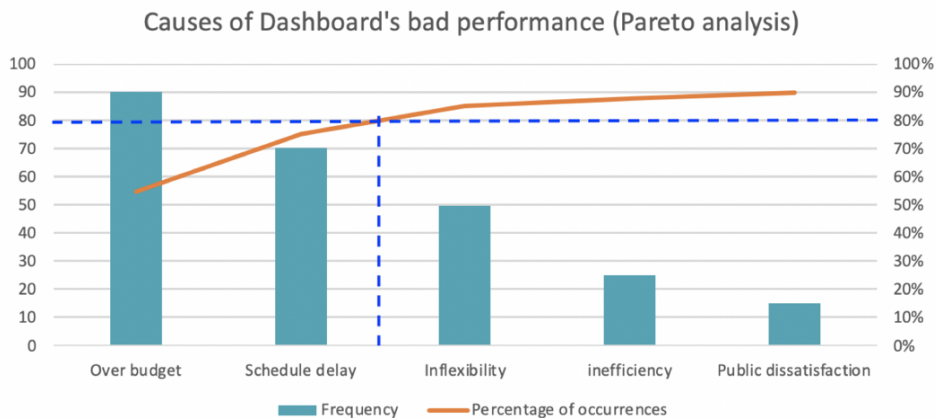


Figure 14: Causes of Dashboard's bad performance (Pareto analysis step 5)³³

6) Design solutions based on identified key factors to optimize the ODR.

³² By the Author.

³³ By the Author.

After the Pareto Analysis, we can clearly review the diagram to make sure that at least 80% of those factors for the problems are captured, which is key factors that we should pay attention to improve it and can give us some hints to optimize our solution.

CONCLUSION

We can now answer to the questions asked at the beginning of this research:

- What kind of dashboard can be used as a standard for accurately measuring the completion level of a road construction project? Which should be closely related to the project content and easy to calculate.
- What KPIs attributes should the road construction project take into account in their contract management?
- The benefit of using KPIs in contract for road construction project?

We have developed four different alternatives. They are GPCCaR, DAU, NDIA, and MOT. To choose a suitable measurement alternative, we compare them to eight attributes and minimum acceptance criteria. In the end, none of them are eliminated, each of them has different advantage which could be suitable for difference road construction project depend on difference context. All of them can be excellent. However, if a road construction project team need to choose one performance measurement dashboard for contract management, then using the MOT dashboard is more suitable. MOT contains many unique KPIs of road construction project, which makes the project performance easier to be observed and recorded. *“Such as mobility, workers and motorists’ safety, construction effectiveness and efficiency, public satisfaction and perception.”*³⁴ And those attributes are really necessary and suitable for road construction project. In addition, MOT also has KPIs related to schedule and cost that other dashboards have, which are crucial KPIs.

The benefit of using KPIs in contract for road construction project management is obviously. All the stakeholders including contractors, project managers, and owners are able to review and measure the performance of the road construction clear and to capture the indicators they want immediately. This would be really helpful for contractor to report and present the project outcome, and also make the project results of road construction more visible for all the stakeholder.

In general, *“Choosing meaningful and justifiable solution involves weighing quantifiable performance indicators and policy directives to make sure that project-specific needs and institution are incorporated into decision-making. Measure tools for decision analysis provide a*

³⁴ Work Zone Road User Costs Concepts and Applications (2011, December). Retrieved November 20, 2018, from <https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/fhwahop12005.pdf>

structured system framework for organizing, gathering and evaluating the information to make informed options."³⁵

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³⁵ Work Zone Road User Costs Concepts and Applications (2011, December). Retrieved November 20, 2018, from <https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/fhwahop12005.pdf>

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Yuanmiao Wang is Chinese, 24 years old, majoring in Project and Programme Management & Business Development (PPMBD) at SKEMA Business School in Paris, France. She graduated from Guangdong University of Finance and Economic in China and held a Management Bachelor diploma. From 2015-2016 she has established a startup project as the founder, which focus on products manufacturing and delivering processes optimization. At the end of 2015, she designed an innovative business model that combines online and offline and use her Business Plan won the 1st Prize of the 3rd Canton Youth Entrepreneurship Competition by conducting a commercial roadshow as a key speaker. In September 2016, she established her own company: Guangzhou Simple Life Semi-Finished Food Co. LLC., and won the 1st Prize of College Students 'Internet+' Innovation Entrepreneurship Competition and the 8th Canton Students' Entrepreneurship Competition. In addition, she also has internship experience related to project management of import and export trading company. Yuanmiao WANG has good project management experience during the time that she operated her own entrepreneurial projects and internships in project management positions. She has the potential to become a competitive project manager.

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