W117 Performance Information in Construction:
2018 Research Roadmap Report

International Council
for Research and Innovation
in Building and Construction

Foreword

The CIB Working Commission W117, "Performance Measurement in Construction," is one of the more innovative and productive research-based commissions in CIB. It focuses on the utilization of performance metrics in the delivery of construction services. The home for W117 is the Performance Based Studies Research Group (PBSRG) at Mesa, Arizona, where W117 and PBSRG hold their annual Best Value Conference in conjunction with KSM Inc. From its start in 2009, W117 was led by Prof. Dean Kashiwagi (PBSRG), and his group of innovators (Dr. Jacob Kashiwagi, Dr. Jake Gunnoe, and Dr. Alfredo Rivera) and co-coordinator, Professor Charles Egbu, (Glasgow Caledonian University). In 2016, W117 was joined by Co-Coordinator Prof. Sicco Santema, (University of Technology, Delft, Netherlands) the visionary who led to the proliferation of the W117 technology in the Netherlands.

W117 aims to change construction procurement and stakeholder organizations worldwide through the use of the information-based Best Value Approach (BVA). As such, it differs from most CIB Commissions that are more science driven, while W117 is more concept and impact driven. It has been one of the most successful CIB Commissions in bridging the gap between the construction industry practice and academic research. It has been prolific in publishing and running research tests with industry partners. W117 and PBSRG have published over 384+ papers and generated licensed technology (61 licenses from Skysong Innovations, the licensing body of Arizona State University for intellectual property rights). It is the most licensed technology from the most innovative university in the U.S. (as rated by U.S. News and World Report (2016-2018).

W117 is responsible for the development and continuous testing of the following technologies:

1. Best Value Approach (BVA).
2. Best Value (BV) Intellectual Property (IP) technology.
3. Performance Information Procurement System (PIPS).
4. Performance Information Risk Management System (PIRMS).
5. Information Measurement Theory (IMT) and Kashiwagi Solution Model (KSM) and related models such as Spectrum of Observation.
6. Industry Structure model.
7. A new project management model based on IMT.
8. definitions of Risk, Expert and movement of Project Management by management, direction and control (MDC) to Project Management by simplicity, alignment of expertise, language of metrics and transparency.
9. A new risk management model that focuses on the risk that the expert vendor does not control.

The activities of WII7 are responsible for the following impacts of the Best Value Approach (BVA) concepts on the delivery of construction:

1. Rijkswaterstaat, the largest user of construction services in the Netherlands, won the 2012 Dutch Sourcing Award (DSA) for the successful completion of a $1B infrastructure project called "fast-track projects" using BV-PIPS.
2. NEVI, the Dutch procurement professional organization, has licensed the Best Value technology from ASU and has identified the approach as a mainstream approach to the delivery of services, educating and certifying procurement professionals in the delivery of construction and other services.
3. Dutch visionary and author Sicco Santema, and his protégé Jeroen Van de Rijt, published a Best Value Procurement (BVP) book, using Dutch test cases to show the BVA technology was compliant with European Tender Law (12,000 books sold). Other books (in Dutch) were also published for the contractor community.
4. RISNET, a Dutch risk management association, licensed the Best Value Approach in order to increase the use of the risk-based project management in the construction industry.
5. W117 BVA certification system was developed, which certifies competence of BV professional practitioners.
6. W117 introduced the BVA into Canada, resulting in $3M research grants for the delivery of construction services in 25 different universities and government organizations.

7. W117/PBSRG Best Value signed a sole source agreement with the National Association of State Procurement Officials (NASPO) and their subsidiary, the Western States Contracting Association (WSCA), to allow all states to utilize the W117/PBSRG technical expertise by "sole source." This has led to tests in 33 different states.
8. Introduction of BV into Malaysia in 2012, into the Project Management Master's Program, led by Dr. Fah Choy Chia at Universiti Tunku Abdul Rahman (UTAR).
9. Introduction of BV into India in 2014 resulting in the noted engineering school, SJCE, adopting the curriculum into their engineering school.
10. Introduction of BVA into Norway in 2014, through the FIR, the construction engineering association. FIR translated the Dutch book into Norwegian, going public on June 20, 2016, during a three-day event to include the first certification of Best Value professionals in Norway. The first BVA testing occurred in 2016 (award made in 2017), with five additional tests scheduled in 2017. The first large BVA certification testing sponsored by W117, occurred in 2017 in Trondheim, Norway. Earlier individual certifications occurred in 2014 and 2016.
11. Introduction of BV into Poland with a three-day conference in Krakow in March 2016, with the publication of the translated Dutch Best Value Procurement (BVP) book into Polish. The first W117 sponsored certification training occurred in April 6, 7th 2017 with the licensed Polish BV Foundation. The next BVA CIB sponsored training will be in October 2017.
12. Introduction activities in Switzerland, Denmark, Finland, Hungary, Germany and Saudi Arabia in 2015 and 2016.

These research efforts have led to the following future research and development opportunities:

1. Development of the language of metrics in the delivery of construction services.
2. The development of a new risk management and project management models.
3. Opportunity to test the sustainability of innovation in traditional environments.
4. Opportunities to test the innovative concepts in different countries.
5. Opportunity to identify and test the sustainability of testing new theoretical concepts in the industry without the traditional extensive academic research literature search and investigations.

W117 has successfully utilized the CIB Platform to impact the construction industry performance worldwide with the information based academic research. Its drive to make a difference is to be applauded and this Research Roadmap (for consultation) is one more example of its high quality and high impact deliverables.

Dr. Wim Bakens
Secretary General for CIB
July 2017

Towards a CIB W117 Research Roadmap

In 2005, the CIB Program Committee organized TG61 "Benchmarking Construction Performance Data," for the purpose of identifying the performance of the construction industry based on performance information or metrics. TG61 produced a report based on a comprehensive literature research on the use of performance metrics in the construction industry. It identified a lack of impactful research based on actual industry research tests (Egbu et. al., 2006). As a recommendation of TG61, the CIB Program Committee established a Working Commission, W117, on the *Use of Performance Information in Construction* in 2009, and appointed Dean Kashiwagi (PBSRG) and Charles Egbu (Glasgow Caledonian University) as co-chairs. In 2016, Charles Egbu was replaced by Sicco Santema (Delft University of Technology).

W117 Objectives and Scope

The objectives and scope of W117 is to document and explore the potential use of performance information to improve the state of all stakeholders and their organizations in the construction/services industry supply chain. It also includes to change the research vehicle and working commission structure to assist W117 to increase the success of implementing performance information in the construction industry. This includes:

1. To establish W117/PBSRG as the worldwide center of excellence in both the construction and other services industries and in academic research in the documenting of case study tests, doing theoretical, prototype testing, and implementation research and the testing of performance information to create transparency and the mitigation of risk in the construction and other industries.
2. To identify collaborators who could assist the W117 in documentation, testing and research of the use and implementation of performance information in the industry.
3. To improve the supply chain performance and the performance of all stakeholders in the construction industry through research and testing.
4. To advocate the use of performance metrics in the acquisition and delivering of construction work and other services.
5. To advocate for new approaches to performance metrics that improves the construction industry performance.
6. To study different countries and cultures to identify how the use of performance metrics can improve the performance of construction and other services in their respective countries.
7. To document the use, research and testing of performance metrics in the delivery of services in the *Journal for the Advancement of Performance Information & Value*.
8. To quickly and accurately get the W117 research results to the industry and stimulate even more research in the area of performance metrics by utilizing the W117 journal.
9. To apply different approaches of research to validate outcomes from different angles. Approaches include literature search, discussion among the industry and academic researchers, and analyzing the opinions of individuals interviewed on the concept of using deductive logic and common sense and hypothesis testing. All of which are validated by immediate testing in practice.

10. To analyze the success of W117 in creating theoretical concepts, testing the concepts, implementing the concepts into the industry, and documenting the implementation of the test results.
11. If the speed of implementation of performance information is not meeting W117 expectations, the W117 objective will include to change the W117 approach by modifying the mechanism/structure that W117 is currently operating with.
12. The changing of the W117 research structure could be to go private instead of depending on the university to lead and support the W117 operations. This would be a test to change not only the concepts that are being implemented into the industry but applying the same concepts to the W117 research structure. This would be identifying the performance information concept a recursive concept.

W117 Work Program

The W117 Work Program includes:

1. Conduct research on the use of performance information in the construction industry to develop state of the art practices that increase construction performance and value, minimize risk and resolve longstanding issues in the construction industry.
2. Test all visionary information concepts in academic research/industry tests. The use of research/industry test results to validate W117 concepts to change the way research is perceived by the industry.
3. Publishing a CIB preferred journal to document the use and impact of performance information in the construction industry and quickly disseminate to the industry and research community by using open source journal platforms such as Research Gate.
4. Hold annual CIB W117 meeting, to discuss the latest results of research in the use of performance information in construction.
5. Do CIB W117 webinars, podcasts and post presentations on YouTube to proliferate the exposure of the use of performance information concepts in the construction industry.
6. Attend and participate in international conferences to stimulate expert discussion on the use of performance metrics in the construction industry.
7. Partner with different research groups and industry experts to proliferate research on the use of performance metrics.
8. Educate and run academic/research tests in different countries to the use of performance metrics in the delivery of construction.
9. Hold W117 meetings to assist different countries in implementing performance metrics in the delivering of construction services.
10. Hold meetings with industry stakeholders to help bridge the gap between academic research and industry practices and encourage the industry to sponsor academic research testing on their own projects.
11. Generate research funding to do research in the use of performance metrics in the construction industry.
12. Create partnerships with active research groups and the CIB to self-fund CIB W117 activities and research and can be self-sustainable without CIB funding.
13. Use the developed information concepts of the Best Value Approach (BVA) intellectual property (IP) to modify the structure and research areas of W117.

Concluding Invitation

The W117 commission is a leader in innovation. It is the first commission to have a very focused goal of implementing academic research/industry testing to impact the construction industry. The research is constantly evolving and impacting the direction, scope and speed of evolution of performance metrics, transparency, mitigation of risk and the improvement of the supply chain stakeholders. However, this is not the only thrust and value of W117. The W117 is looking to change the definition of successful and impactful research from traditional academic/industry research. It will change what is recognized as valuable and impactful research. This Research Roadmap is the latest document, as of June 2018, and will be continually changed in the coming years. W117 welcomes all other working commissions and industry visionaries to join in the effort towards improving the construction industry.

W117 Supporters & Staff
December 2018

W117 Roadmap Architects

Dean Kashiwagi, PhD, P.E.
Fulbright Scholar, IFMA Fellow
W117 Co-chair, Editor of the W117 Journal
Director | Performance Based Studies Research Group
Director | KSM Inc.

Sicco Santema, PhD, MSc Law, MSc W117 Co-chair Director | Scenter, a consulting firm to the construction industry Professor of Marketing and Supply Management | Delft University of Technology	Jacob Kashiwagi, PhD W117 Journal Coordinator Research Director | Performance Based Studies Research Group Chairman of the Board | Leadership Society of Arizona
Alfredo Rivera, PhD W117 Roadmap Contributor Co-Director | Leadership Society of Arizona	Jake Gunnoe, PhD W117 Roadmap Contributor Co-Director | Leadership Society of Arizona
Joseph Kashiwagi, MS W117 Roadmap Contributor Program Manager | KSM Inc.	Isaac Kashiwagi, MS W117 Roadmap Contributor Program Manager | KSM Inc.

Administrative Assistance

David G. Krassa,
W117 Project Manager and Administrator

Under the authority of CIB:
Dr. Wim Bakens (Secretary General)
The CIB Board

W117 Performance Information in Construction: 2018 Research Roadmap Report

Introduction

The CIB Secretariat has created a CIB Roadmap (see Figure 1) that will assist the working commissions to create their own roadmaps, to become successful, sustainable, focused on a strategic plan and assist the improvement of the worldwide construction industry, see Figure 1. The CIB research roadmaps provide authoritative guidance and support for national and international research bodies and funding agencies.

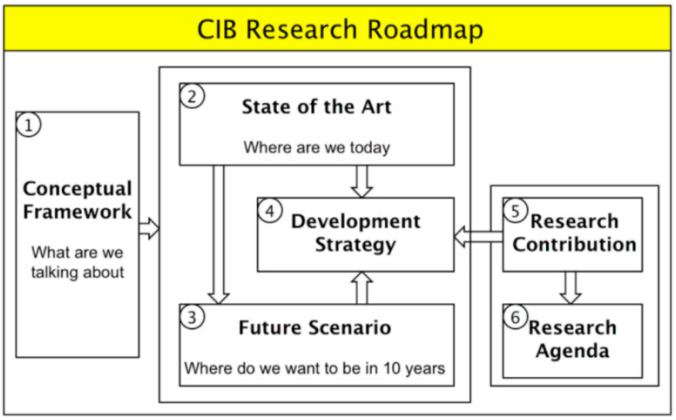

Figure 1: CIB Research Roadmap.

As Figure 1 indicates, creating a CIB 117 Research Roadmap requires the following questions to be addressed:

1. Conceptual Framework:
   What are we talking about? This question includes the typical: What are the issues, how are these interrelated, what influences all of this, who are the stakeholders, what are the relevant areas of expertise, what are the characteristics of relevant systems, processes, and technologies? This is addressed in the *Conceptual Framework* section.

2. State of the Art:
   Where are we today? This question includes: State of technology, best practices, international variations, perceived problems and the world's leading centers of expertise. The state of the art is elaborated in the section *State of the Art in the Utilization of Performance Information*.

3. Future Scenario:
   Where do we want to be in five years? The stakeholders' vision is described in section *Future Scenario: Where Do We Want to Be in Five Years?*

4. Development Strategy:
   This section includes: what is needed in terms of knowledge, information, tools, concepts and applications to enable the respective systems, processes and technologies to be developed over time? These subjects will be described in the section *Development Strategy*.

5. Research Contribution:
   In section *Research Contribution*, we describe how W117 research contributes to the development strategy and what the requirements for research are in order to make that contribution.

6. Research Agenda:
   Section *Research Agenda* concludes with the agenda for W117 research worldwide. That will include areas of science and technology development, required sequences of development, priorities, international cooperation within the research community, cooperation between research and practice.

Conceptual Framework

W117 Research Technology: The Use of Performance Metrics in the Construction Industry

The conceptual framework for TG 61 and W117 was created (2005) by co-chair Dean Kashiwagi (PBSRG) and supported by Charles Egbu (Glasgow Caledonian University) and later, Professor Sicco Santema (Delft University of Technology). Professor Dean Kashiwagi is a researcher in the area of performance metrics, the language of metrics and the use of metrics to simplify and improve the construction industry performance. He has had research test responsibilities for more than 25 years. His expertise is defined by 335 publications, over 2,000 research tests and delivery of $6.6B of services. He also has been involved with education and research testing in 13 countries (United States, Canada, Finland, Botswana, Democratic Republic of the Congo, Netherlands, Malaysia, India, Norway, Poland, Vietnam and China) and 34 states in the United States. This led him to being named as an original co-chair of W117 and resulted in the conceptual framework for W117 research. Professor Charles Egbu gave W117 tremendous support in exposing the performance information technology in the UK academic conferences. Professor Sicco Santema has been the latest visionary to support the worldwide effort.

Co-chair, Dean Kashiwagi, has gone through multiple cycles of finding new researchers in the area of utilizing performance metrics for the improvement of construction services. The cycles were needed because many of the participating researchers, after a certain time period, did not sustain or receive enough funding in the W117 research area to stay active in this narrow field of W117 research. Dr. Dean has been successful in recruiting new W117 members within the same area of expertise to replace those who moved on to other research areas. The new members are being recruited not only from academia but also from industry, many who are running research tests in different countries. The research tests are continually improving and developing the *technology of performance metrics* (Best Value Approach, language of metrics logic called Information Measurement Theory, procurement, project management and risk management processes).

Worldwide construction research was mainly focusing on the documentation of problems. This included the documentation of Key Performance Indexes or KPIs. However, the research community has failed to show how the KPIs increased the performance of construction services. For example, many industries use KPIs but do not know how to apply the metrics to improve construction performance. Each country also has their own perception of the cause of the construction industry non-performance.

In 1993, ASU/PBSRG identified a potential solution. It had the following unique characteristics:

- Based on deductive logic identified as Information Measurement Theory.
- Simplification of the environment and creation of transparency.
- Identification of industry experts who could immediately test the hypothesis.
- PBSRG maintains a high level of control over the industry tests.

Issues in the Construction Industry Worldwide

Worldwide, the construction industry has had performance issues for the past 30 years. It appears to be a low performing industry; clients are unhappy and construction projects do not finish on time or on budget and construction companies finish projects at a loss. Over the last 30 years the assertions were validated by numerous landmark studies. The first major study was a breakthrough study conducted in 1994 by Sir Michael Latham (1994), who identified how significant non-performance was attributing to the continued failings within construction in the United Kingdom. He was one of the first researchers to expose that construction non-performance has been existent for the past 30 years. Interestingly, Peter Goff, of the International Project Management Association (IPMA), shares a similar argument by identifying that, despite the hundreds of millions of dollars invested by private enterprises and government to increase education and training of project managers, there has been no major increase in performance to back up its validity (Goff, 2014). In all, Latham identified current business practices of management, direction and control as the causes of an inefficient environment, and non-performance on construction projects (1994).

Due to the continuous efforts of resolving construction non-performance, the industry was still not improving. In 1997, the United Kingdom commissioned John Egan to develop a task force to perform another study on the performance of the industry. Like the first study, Egan identified a lack of leadership in business practices and integration of standard processes and teams (Egan, 1998). Although both studies have motivated industry and academia to improve the industry performance, the construction industry has seen minimal improvements moving into the 2000's to present day (Chikuni & Hendrik, 2012; Oyedele et al., 2012; Georgy et al., 2005; Bernstein, 2003).

The construction industry has continued to struggle in the 2000s, though some improvement has been documented. The UK, from 2000 to 2011, saw an increase in customer satisfaction from 63% to 80%, but its projects were still only completing on time 45%, and met budgets 63% of the time (UK, 2011). In the U.S., productivity has decreased by 0.8% annually (Adrian, 2001). Construction companies have the second highest failure and bankruptcy rate of 95% (Associated General Contractors, 2006). Over 90% of transportation construction jobs are over budget, and almost 50% of time is wasted on job sites (Lepatner, 2007).

According to a recent Construction Industry Institute (CII) study published in 2015, 2.5% of projects are defined as successful (scope, cost, schedule, and business), 30% of projects completed within 10% of planned cost and schedule, 25 to 50% is wasted due to coordinating labor on a project, and management inefficiency costs owners between $15.6 and $36 billion per year (Lepatner, 2007; PWC, 2009; Yun, 2013).

In 2008, TG61 did a comprehensive literature review of all research efforts worldwide to identify:

1. Research groups who identified the issue of construction nonperformance and ran academic/industry research tests to confirm their hypothesis.
2. Research groups who ran repeated academic/industry research tests to validate their hypothesis to increase construction performance.

The study filtered through more than 15 million articles and reviewed more than 4,500 articles. The study found only 16 articles with documented performance results. The Best Value Approach (BVA) was one of three construction methods found in those articles, and the Best Value Approach was found in 75% (12 of 16) of the articles (Egbu, et al., 2008; Michael, et. al., 2008). The BVA was identified as the only research concept with repeated performance metrics.

For the past five years, W117 has been attempting to identify all construction delivery systems with documented performance information. W117 has sifted through hundreds of papers, websites, and personal industry contacts, and found similar results to the first study. Thus far, the only approach with documented performance is the BVA and PIPS. (Thomas, and Napolitan, 1995; Odeh, and Battaineh, 2002; Hsieh et al., 2004; Assaf, and Al-Hejji, 2006; Arain, and Pheng, 2006; Lo et al., 2006; Sambasivan, and Soon, 2007; Al-Kharashi, and Skitmore, 2009; Mahamid, et al., 2011; PBSRG, 2016)

In one promising study, Sanvido and Konchar identified that the design-build approach was significantly better. However, five years later, a follow-up and more comprehensive study identified that there was no significant evidence that one approach was better to any of the other approaches (Leicht, 2015; Konchar, 1998).

A conceptual framework was proposed by Kashiwagi (1991) that has remained as the foundation of the efforts of W117 (Figure 2).

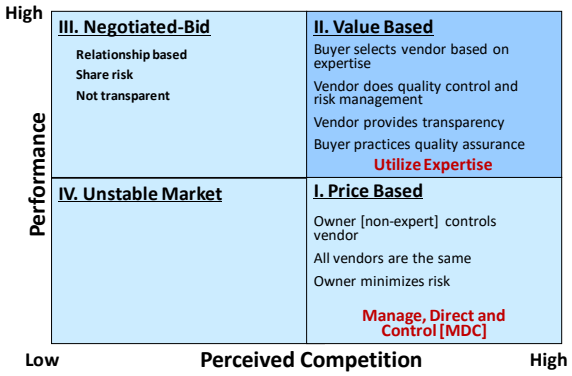

Figure 2: Conceptual framework of the construction industry structure.

The Construction Industry Structure identifies the following:

1. Poor performance is caused by owners using management, direction and control (MDC) to minimize the risk of construction nonperformance.
2. Risk is caused by non-expert stakeholders and not contractors (over 90% of all project cost and time deviation (US Army Medical Command study, State of Minnesota study and Rijkswaterstaat fast track projects)).
3. Risk cannot be transferred by means of contracts.
4. When MDC is utilized to mitigate risk; risk, cost and nonperformance increases.
5. High-performing construction is delivered by utilizing construction expertise instead of MDC.

W117 has proposed the following to the construction management research community and the construction industry based on research test results (Kashiwagi J., 2013; Kashiwagi, D., 2016; PBSRG, 2016):

1. The owner or buyer of construction is one of the biggest sources of risk in the delivery of nonperforming construction.
2. Management, direction and control (MDC) by the owner to minimize the risk of construction nonperformance is a major source of nonperforming construction.
3. The lack of utilization of construction expertise by the owners of construction is a resulting problem.
4. The lack of the quantification of construction problems using performance metrics has resulted in the construction nonperformance being a stubborn and lingering problem.
5. There is confusion in the construction industry on the source of construction nonperformance.

W117 conceptualizes the current problem of construction nonperformance with the following characteristics:

1. The construction academic researchers and industry sees the industry as being too complex and has difficulty simplifying the problem and potential solutions.
2. Because of the lack of understanding of the construction industry non-performance, it is very difficult to identify the problem, devise a system/approach to solve the problem, and run tests to validate the proposal.
3. The industry perceives that the problem is a technical problem and is therefore looking for technical solutions such as BIM to solve their problems. W117 research has identified the problem as a non-technical problem, and more related to the supply chain and humanistic characteristics of the supply chain stakeholders.

W117 proposes to solve the problem by using:

1. Deductive logic, natural laws, transparency and simple concepts.
2. Utilizing expertise to lower cost and improve quality.
3. Creating transparency by creating simplicity using the language of metrics.

4. Creating simplicity by changing the definition of risk as what an expert does not control, changing the project management and risk management model (utilizing a weekly risk report (WRR) and Director's Report.

W117 research test results over the past twenty years has validated the following concepts:

1. When transparency is created, there a very few disagreements between stakeholders.
2. When an expert has a plan that includes the functions of all stakeholders, the stakeholders do much better in minimizing the risk that they would normally maximize.
3. When performance metrics are used, there is minimal discussion on someone's level of expertise.
4. An expert who knows what they are doing should always have a lower price than a non-expert. Therefore, the objective is to hire an expert who can lower project costs.

A study was performed, identifying that the Best Value PIPS was the only delivery system with the concept of no-control or minimizing management, direction, and control (Kashiwagi J., 2013). This research also documented the potential impact that implementing the concept of no-control could have on the delivery of construction services (Kashiwagi J., 2013). The study involved 31 construction and non-construction services, among 5 different major buyers in the U.S., comparing the performance of the project when delivered with the Best Value no-control concept and with the traditional management, direction and control techniques (see Table 1). It found the following:

- Cost of services decreased on average by 31%.
- Suppliers were able to offer the buyer 38.5% more value, totaling up to $72.76M.
- The average customer satisfaction of the service being provided increased by 4.59 points on a 1-10 scale (134% greater than the traditional customer satisfaction rating).

Table 1: Traditional Model vs. Best Value Model.

Overall Comparison		
Criteria	Traditional	Best Value
# of Outsourced Services	31	31
Cost of Services	$274,480,342	$189,001,943.00
Added Value	-	$72,762,248.60
Average Customer Satisfaction	3.43	8.02

State of the Art in the Utilization of Performance Information

PBSRG, Kashiwagi Solution Model (KSM) Inc. and W117 have been developing the use of performance information in the construction industry for the past 26 years. However, the center of research and development has been PBSRG under the leadership of Dr. Dean Kashiwagi. As documented in the TG61 and WC117 documents, it is the IP and constant development of the BVA IP which makes W117 research unique.

The state-of-the-art practices, which is the most licensed intellectual property (IP) technology developed at Arizona State University (licensed by Skysong Innovations, the licensing arm of ASU) include:

1. Using the Best Value Approach (BVA) to deliver construction services which results in a very high level of performance. This includes the use of the Performance Information Procurement System (PIPS) and the use of the Performance Information Risk Management System (PIRMS). PIPS has three major phases: Selection, Clarification and Execution. PIRMS uses the low-bid award system as the selection phase, but the clarification and execution phases are identical.
2. The use of the language of metrics to create transparency. The language of metrics minimizes misunderstandings through unified coding.
3. The identification that risk is caused by non-expert stakeholders. Risk cannot be passed. Risk must be mitigated. Performance metrics are used to explain risk to non-experts, thus leading to risk mitigation.
4. The use of Information Measurement Theory (IMT) and the Kashiwagi Solution Model (KSM) to understand human nature, predict future human behavior and utilize these technologies in the selection and alignment of human resources in construction services.
5. The optimization of construction resources using a structure that assists in the optimization of expertise by creating an environment of transparency.
6. Continuous learning from tests and new versions of the methodology. The cycle of learning keeps speeding up as more countries and academics/practitioners are joining the effort.

The W117 sponsored journal "Advancement of Performance Information and Value" captures the latest developments in the use of performance information in the construction and other industries. W117 also keeps a database of published papers in the area of performance information. The W117 committee members are constantly experimenting by using the BVA in new environments (including different industries and countries).

The technology of the Best Value Approach (BVA) is licensed by Arizona State University to 61 organizations and is used by supply chain stakeholders (owners, designers/engineers, facility managers, contractors, subcontractors and material suppliers) and academic researchers.
The BVA has led to a new project management model, a new risk management approach (risk can only be mitigated and not transferred) and a new definition of an "expert" who uses a leadership approach (no influence, minimized decision making, and creating transparency) to optimize the supply chain results. The implementation of these concepts has been challenging. These concepts require more and increased accurate test results and documentation. What may be challenging to construction industry stakeholders is the concept that the BVA IP technology is recursive and defines itself.

The CIB W117 "Performance Information in Construction" working commission, is led by the creator and founder of the BVA (Dr. Dean Kashiwagi) and includes the worldwide experts in both academic research and construction industry practice in the area of using performance metrics in construction projects. W117 is constantly looking for new countries and contributors (both in

practice and in academia) who understand the Information Measurement Theory (IMT) and urge them to participate with W117.

The case of the Netherlands adoption of the BVA took the last ten years. These years included the usage of BVA by Rijkswaterstaat on the $1B U.S. fast track road construction projects, the acceptance of BVA by NEVI (Dutch professional procurement group) and the publishing of the first Dutch Best Value Procurement (BVP) book (by Jeroen van de Rijt and Sicco Santema). This book showed that the methodology was compliant with the European Tender Law. Up to 2016, the book is in its third edition and more than 12,000 copies of that book have been sold in the Netherlands. As an example of continuous development, the fourth edition of the book will be published in 2017, adopting all the latest insights.

In the Netherlands the widespread application of BVP has resulted in the following challenges:

1. Ensuring that the new paradigm is being understood by new practitioners.
2. To ensure proper documentation.
3. To ensure that the contractors/vendors understand the BVA.
4. How to educate the supply chain fast enough to keep up with the demand of Best Value services.

W117 is now faced with the challenge of how to proliferate the BVA in the other European countries. Currently BVA has been moved into Norway and Poland, having the Dutch Best Value Procurement (BVP) book translated into Norwegian and Polish. The BVP label may have set the BVA effort back due to the misunderstanding of the value of the performance metrics that defines the expert vendor's own performance. The BVA has also been exposed to Switzerland, Denmark, Finland and Germany.

The proliferation into other European countries is through the Dutch and European professional engineering groups (in construction) who have observed that their expertise is not being utilized by owners. The Dutch Rijkswaterstaat organization is also exposing the BVA to other infrastructure organizations of other European countries. Also, other consultant organizations exposed to the BVA in the Netherlands and licensed through ASU, are moving it to other European countries where they do business.

Future Scenario of W117: The Next Five Years (2018 – 2023)

The worldwide competitive marketplace is moving toward automation and information systems. The major user of automation is the country of China. Once the user of low-cost labor, the inconsistent results caused by people have forced China to become the world's foremost user of automation. This type of competition is forcing the optimization of supply chains (lower costs and higher performance). W117 has been the leader in the documentation of performance information research and how to utilize the performance information to increase project performance in the CIB.

Dr. Dean Kashiwagi (co-chair) has identified a very aggressive course of the next five years of W117 to address the following:

1. Make the current academic/industry research structure more efficient and effective.
2. Create a research structure that takes the information to the industry through a more effective website, presentations and satellite sites.
3. Create transparency through easy and fast access of information.
4. Change the education/training path to the industry by exposing the information environment to the future generation before they enter the industry.
5. Change the supply chain to take advantage of a more automated risk management and project management model utilizing the theoretical definitions of experts, risk, risk mitigation and project management. Although these concepts were previously identified by W117 research, implementation in the industry has been challenging.

This approach automates the W117 structure and automate the BVA IP technology to make the performance information usage much more successful. By solving both problems by using performance information, W117 will propose that the performance information or BVA IP is recursive, and information is recursive in nature. The data which when analyzed normally identify the equation, will actually be used to replace the equation and thinking and decision making that goes along with the analysis.

W117 Development Strategy

The traditional academic research model for the past 25 years has been where academic research analyzes industry practices and publishes the analysis in academic journals (see Figure 3). The research normally takes 4 – 10 years to create the journal publication. University professors normally participate in a funded system such as the National Science Foundation (NSF), Department of Transportation and other federal grant programs, Construction Industry Institute (CII) or smaller institutes such as the Design Build Institute of America (DBIA), Associate General Contractors (AGC) or other funding group. Researchers then propose on needs of the industry and must continually find and receive grant opportunities to sustain their research. The traditional research professor's success depends on the ability to accomplish the following:

1. Get involved with the granting organizations.
2. Write proposals in the area of industry interest.
3. Be successful in winning a couple of grants.
4. Be promoted to academic administration positions such as director of research, department chair, or dean of the college and manage other young researchers.

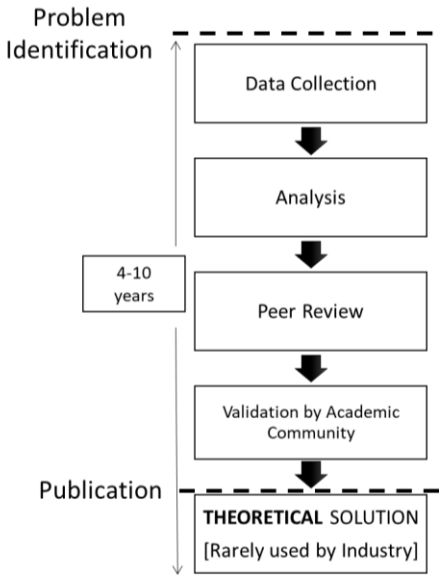

Figure 3a: Traditional Academic Research Model

Academic researchers rarely get the opportunity to become experts in solving industry problems. They cannot drill down into problems and become industry experts. This role is normally left to industry consultants who have the experience to solve industry issues. Academics attempt to differentiate between research and consultation. They have created silos (see Figure 3b) and have concluded that research is more valuable than consultation.

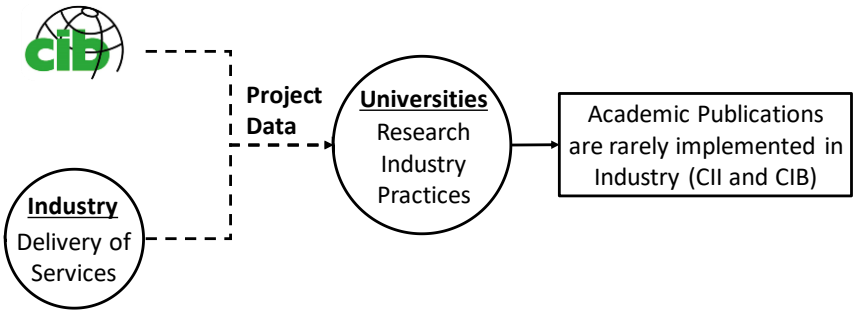

Figure 3b: Traditional Academic Research Model (Silo-Based).

Dr. Dean Kashiwagi (founding co-chair) of TG61 and W117 was one of those individuals who was a research/industry expert (25 years, $17.6M funding, 2,000 tests delivering $6.6B of construction and other services, 9 different countries, and 62 intellectual property (IP) licenses (the most licensed IP developed at ASU), and 360 refereed journal papers, books, and conference presentations). He aligned his expertise with the Performance Based Studies Research Group (PBSRG) at Arizona State University, the W117, and the IP of Information Measurement Theory (IMT), the Best Value Approach (BVA) and the Performance Information Procurement System (PIPS).

However, the inefficiencies of the academic research community (high overhead of university grants, the bureaucratic assignments of the university administration and complex rules of research engagement) encouraged Dr. Kashiwagi to move the research center PBSRG to the private sector to create a more dynamic research model which was more effective and efficient. Dr. Kashiwagi

moved the financial support of PBSRG and leading W117 to KSM (a research consulting organization). It is the first Working Commission in the CIB that is being led by a private sector researcher and research group that has a foundation of concepts that were developed under the umbrella of the CIB. To make this model successful, W117 is attempting to make the following changes:

1. Create a new structure where W117 researchers have full access to the IP and can educate and train others (see Figure 4).
2. Form an international board of industry experts for BVA IP certification to proliferate and development of the technology of performance information (see Figure 5).
3. Increase exposure into more countries by presentations, website, and publications through the creation of an international board of experts in using performance information and the BVA (Figure 5).
4. Increase the number of W117/PBSRG satellite sites that proliferate the technology through licensed and certified educators (see Figure 6).
5. Utilize Arizona State University intellectual property (IP) licensing to maintain successful implementation of the IP technology transfer.
6. Combine "research" and "consultation" to do a mixed methods approach which assumes that the construction industry after 60 years of research and practice, have not understood the major source of the problems in construction, risk and project management (see Figure 7).
7. Minimize the time to publish industry test findings and to immediately "put the information on the street" using free access, public website platform (W117 Journal and Research Gate open platform website) (Figure 8).
8. Test the BVA IP concepts on K-12 (high school students) to prove that the information concept is recursive and can not only be used to solve the industry problems, but also optimize the future generation of professionals' comfort level with automation and information systems (see Figure 4, 9).
9. Implement the testing of BVA IP technology concepts into K-12 grades high school students to prepare the next generation for an information based and fully automated systems environment (Leadership Society of Arizona (LSA)). Implementation of the W117 IP Concepts (see Figure 9).

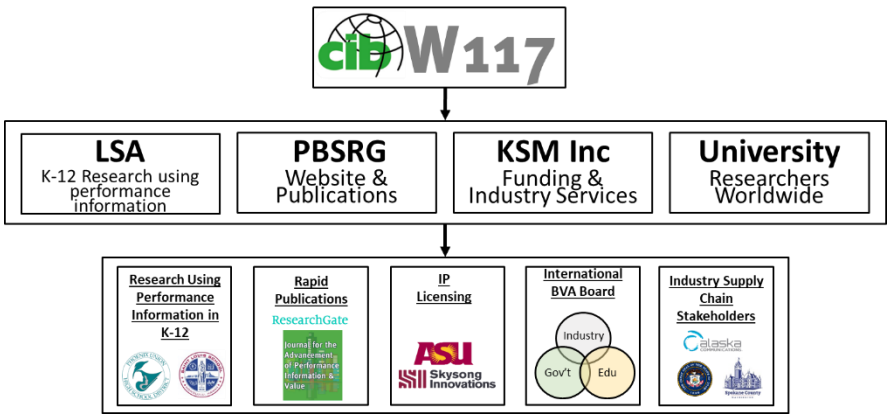

Figure 4: W117 Research Pipeline.

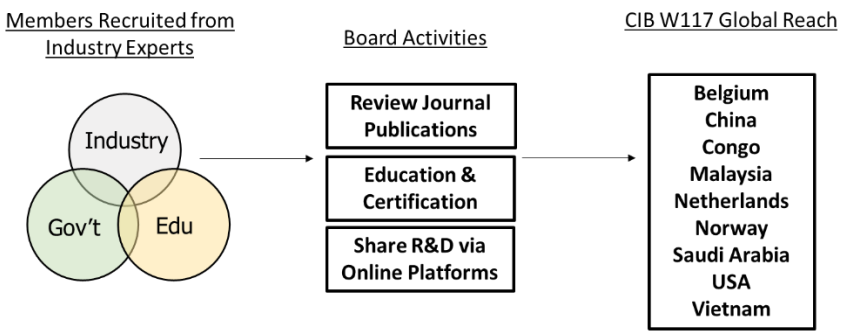

Figure 5: International W117 BVA Board.

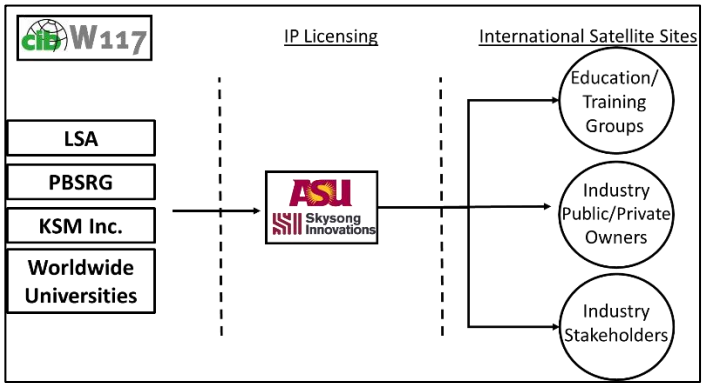

Figure 6: Licensing and Distribution Pipeline.

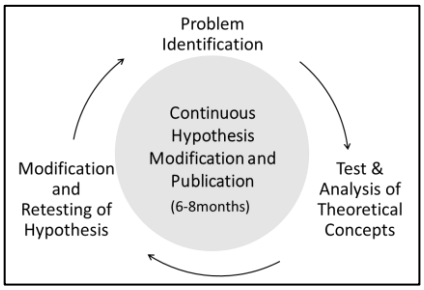

Figure 7: W117 New Research Environment Utilizing Actual Industry Testing.

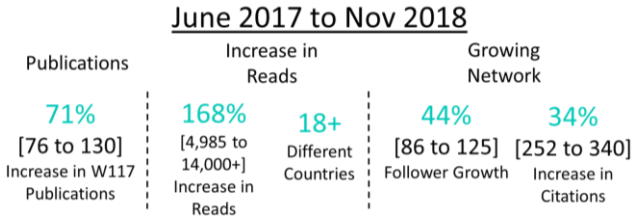

Figure 8: W117 and Research Gate Performance.

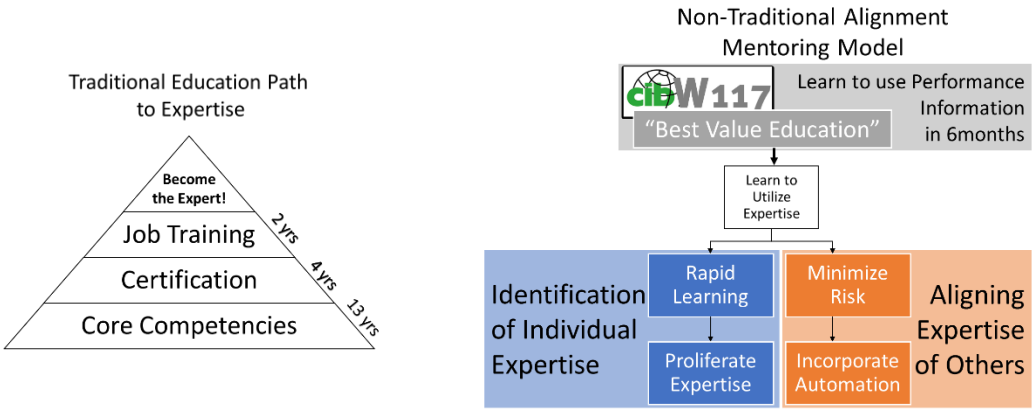

Figure 9: Changing the Education Training Model.

W117 research has identified the following challenges in the implementation of BVA concepts:

1. In the Netherlands, the W117 research activity led to the Best Value IP becoming the mainstream procurement approach. It led to multiple Best Value Procurement (BVP) publications and papers. However, the implementation of the BVA clarification phase and the Weekly Risk Report (WRR) have not met expectations.
2. The Best Value Procurement hybrids have become an issue.
3. The concepts of minimized thinking and decision making in the delivery of services has shown to be difficult to implement.

W117 Research Contribution

As a result of the Dutch experience with the BVA, the following concepts will be redefined, simplified, implemented/tested and retaught to the industry:

1. Move the emphasis from using the BVA technology (performance information) in the procurement function to the project management function (see Figure 10).
2. Semi-automate the procurement function by removing need to think or process and make decisions (see Figure 10).
3. Change the project management model from a management model to a leadership model. Remove management, direction and control from the current project management model (see Figure 11).
4. Redefine risk in simple terms that were previously identified in the Information Measurement Theory (IMT) (see Figure 12).
5. Redefine the definition of an expert to concur with the BVA definition (see Figure 13).
6. Minimize risk and cost by using performance information instead of competition and MDC and negotiation (see Figure 14).
7. Redefine performance information to "machine language" definition (countable and observable or can be verified by robotics) (see Figure 15).

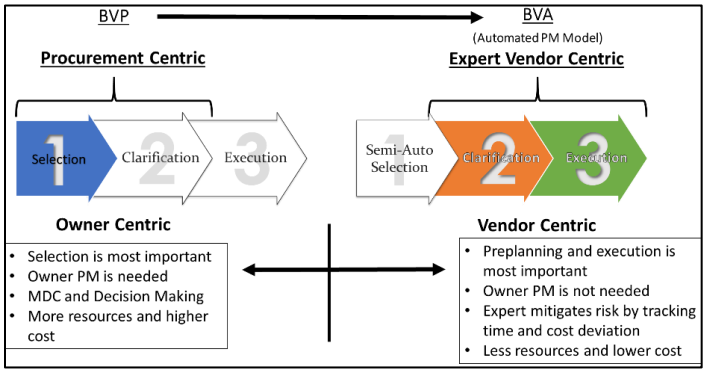

Figure 10: BVP to BVA.

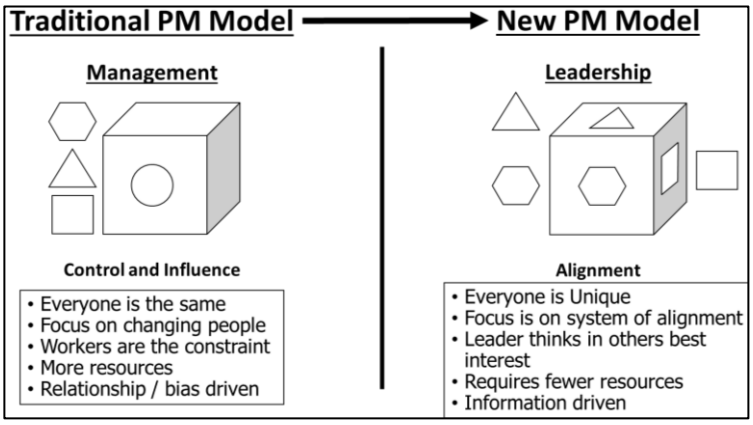

Figure 11: Traditional PM Model vs. New PM Model.

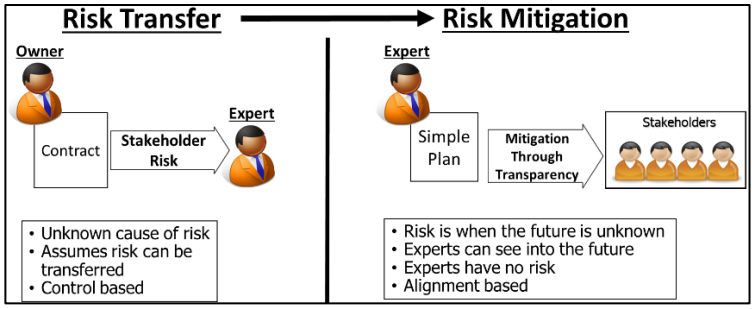

Figure 12: Risk Transfer vs. Risk Mitigation.

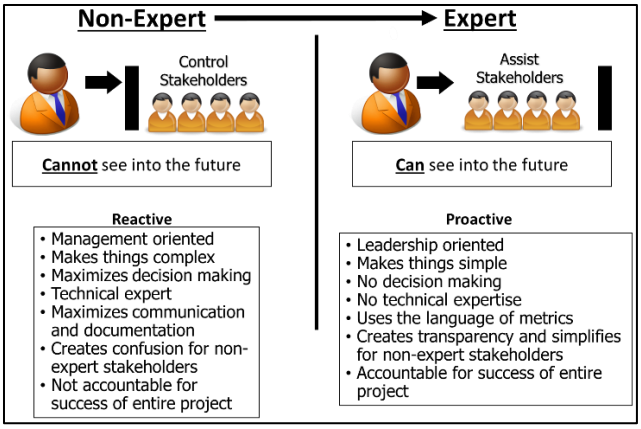

Figure 13: Non-Expert vs. Expert.

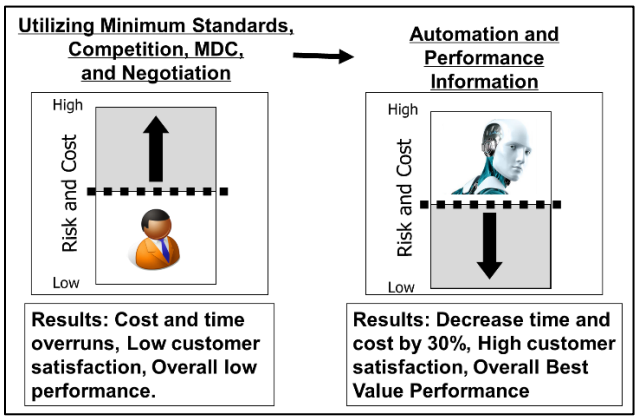

Figure 14: Maximization vs. Minimization of Risk and Cost.

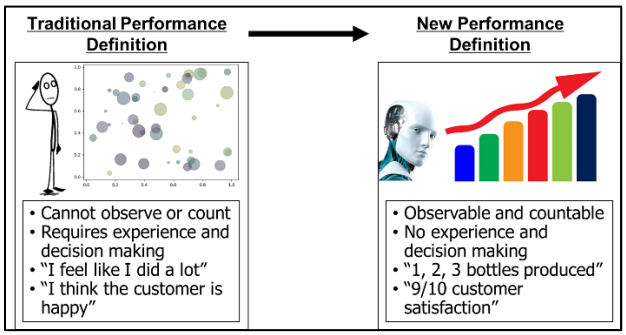

Figure 15: Traditional vs. New Definition of Performance.

W117 will link the past/traditional approaches (procurement, project management and risk) with the future approaches (automation, minimized human thinking and decision making and identification and utilization of expertise and metrics which are observable and countable). W117 is the only organization that has published work on BVA development and has the expertise to link the past BVA concepts to the future concepts that align with automation and information systems. W117 was organized around the expertise of its founder Dean Kashiwagi. As successful as W117 has been in identifying performance, improving performance, and documenting performance, W117 has perceived that a part of the problem in getting to change the industry may be the academic research model itself.

The new W117 research structure eliminates the bureaucracy and limitations that slow down the academic model. In the traditional academic model, research institutions collect data from industry projects, but the data is never applied to industry solutions (see Figure 3). Instead, institutions use the data to write publications with the goal of gaining more research funding. This process involves lengthy review stages and publication restrictions. The goal of the academic-centric model is to receive recognition from highly-praised academic sources.

The new W117 Industry-Centered model subverts the traditional publication process (see Figure 3a). Research data is taken directly from applied projects where it is rapidly published online and

shared with industry stakeholders. This model creates a transparent flow of information between researchers, educators, and industry leaders. This model accomplishes more than publications, its goal is to improve industry performance.

This model achieves the following:

1. Minimizes time to publish research findings on the street using W117 journal and free access, public website platform (see Figure 7).
2. Form international board for BVA certification to proliferate the technology and increase exposure to more countries by presentations, website, and publications (see Figure 5).
3. Increases the number of W117/PBSRG satellite sites that proliferate and maintain technology performance through Arizona State University intellectual property (IP) licensing (see Figure 6).
4. Implements the BVA technology into the education cycle to prepare the younger generation for information based and fully automated systems (see Figure 9).

Accelerate the Change in the Industry Supply Chain Structure to Overcome Industry Challenges

The W117 information technology research implements critical changes in the supply chain structure that can increase project performance. The change in the supply structure has the following facets:

1. Semi-automate the procurement function and transition to a project management focused model (see Figure 10).
2. Redefine project management focus from a management model to a leadership model.
3. Redefine risk management (see Figure 12).
4. Clarify the definition of an expert (see Figure 13).
5. Minimize risk and cost by using performance information instead of competition and MDC and negotiation (see Figure 14).
6. Redefine performance information to “machine language” (countable and observable or can be verified by robotics) (see Figure 15).

The newest BVA model will be created by semi-automating the procurement model and putting emphasis on the project management model which will also be a semi-automated model using the Weekly Risk Report (WRR) in the BVA model. The WRR will be the structure for the new, leadership-based project management.

The previously identified terms “expert”, “risk”, and “risk mitigation” will be documented in publications. Experts are defined by personnel who minimize their thinking, decision making and can see into the future from the beginning to the end of a project (see Figure 12).
Valid performance information minimizes thinking and decision making. If performance information must be analyzed, BVA does not define it as useful performance information.

W117 Research Agenda

The five-year agenda for the W117 will include the following:

1. Change the structure of W117 (see Figure 4). Take the leadership and operation participants from a university platform to a private sector platform. Create a structure of international experts who are vested in the theoretical area of performance information and the Best Value Approach (BVA). Use the information approach to optimize W117.
2. Have the private organization based W117 identify experts, researchers and university participation.
3. Move primary focus of W117 and research to project management instead of procurement. Identify a project management platform to change the traditional management, direction and control (MDC) PM approach to a leadership-based PM approach that aligns and uses information systems.
4. Increase the number of publications and decrease the time to publish the performance information technology. Make all publications from the W117 journal to the open platform Research Gate (see Figure 8). Continue to double the reads, citations, and research followers.
5. Redefine the terms information, transparency, expert, risk and risk mitigation.
6. Increase the number of presentations of the information based intellectual property worldwide by industry experts.
7. Move into other industries such as services and education to implement the concepts of performance information to optimize the industries.

References

Adrian, J. 2001, 'Improving Construction Productivity', Construction Productivity Newsletter, vol.12, no. 6.

AGC 2005/2006, Associated General Contractors of America, Available from: <http://www.agc.org/inde x.ww>. (7 March 2007).

Al-Kharashi, A., and Skitmore, M. (2009). Causes of delays in Saudi Arabian public sector construction projects. Construction Management and Economics, 27(1), 3-23.

Arain, F. M., Pheng, L. S., and Assaf, S. A. (2006). Contractors' views of the potential causes of inconsistencies between design and construction in Saudi Arabia. Journal of performance of constructed facilities, 20(1), 74-83. Chicago.

Assaf, S. A., and Al-Hejji, S. (2006). Causes of delay in large construction projects. International journal of project management, 24(4), 349-357.

Bernstein, HM. 2003, 'Measuring Productivity: An Industry Challenge', Civil Engineering—ASCE vol. 7, no. 12, pp. 46-53.

Chikuni, A & Hendrik P 2012, 'The Impact of Procurement Systems on the Outcome of Public Projects', Presented at RICS COBRA 2012, Las Vegas, NV.

Egan, SJ 1998, 'Rethinking Construction: The Report of the Construction Task Force to the Deputy Prime Minister, John Prescott, on the scope for improving the quality and efficiency of UK construction.', The Department of Trade and Industry, London.

Egbu, C., Carey, B., Sullivan, K & Kashiwagi, D. 2008, Identification of the Use and Impact of Performance Information Within the Construction Industry Rep, The International Council for Research and Innovation in Building and Construction, AZ.

Georgy, ME., Change, L & Lei Z 2005, 'Engineering Performance in the US Industrial Sector', Cost Engineering, vol. 47, no. 1.

Goff, S. (2014). "IPMA Education and Training Board Series: Closing the Gap between PM Training and PM Performance: Part 2: Closing the Gap." PM World Journal, Vol 3(7).

Hsieh, T. Y., Lu, S. T., & Wu, C. H. (2004). Statistical analysis of causes for change orders in metropolitan public works. International Journal of Project Management, 22(8), 679-686.

Kashiwagi, D. (2016). 2016 Best Value Approach, Tempe, AZ: KSM Inc., 2016.

Kashiwagi, J. (2013). Dissertation. "Factors of Success in Performance Information Procurement System / Performance Information Risk Management System." Delft University, Netherlands.

Konchar, M., & Sanvido, V., 1998, Comparison of U. S. project delivery systems, Journal of Construction Engineering and Management, Nov/Dec 1998, pg 435- 444.

Latham, M., 1994, Constructing the team, HMSO, London.

Leicht, R. M., Molenaar, K. R., Messner, J. I., Franz, B. W., and Esmaeili, B. 2015. Maximizing Success in Integrated Projects: An Owner's Guide. Version 0.9, May. Available at http://bim.psu.edu/delivery.

Lepatner, B.B. 2007, Broken Buildings, Busted Budgets, The University of Chicago Press, Chicago.

Lo, T. Y., Fung, I. W., & Tung, K. C. (2006). Construction delays in Hong Kong civil engineering projects. Journal of Construction Engineering and Management, 132(6), 636-649.

Mahamid, I., Bruland, A., & Dmaidi, N. (2011). Causes of delay in road construction projects. Journal of Management in Engineering, 28(3), 300-310.

Michael, J., Sullivan, K. and Kashiwagi, D.T. (2008) "Leadership Based Project Management Model Tested on Food Services at Arizona State University" 4th Scientific Conference on Project Management (SCPM) & 1st International Project Management Association (IPMA) / Mediterranean Network (MedNet) Conference on PM Advances, Training & Certification in the Mediterranean, Chios Island, Greece, pp.234-238 (May 29, 2008).

Odeh, A., and Battaineh, H. (2002). "Causes of Construction Delay: Traditional Contracts" International Journal of Project Management, Vol. 21 (1), 67-73.

Oyedele, L.O., Regan, M., von Meding, Arinola, J., Olawale, K., Spillane, J. & Konanahalli, A., 'Strategies for Reducing Construction Waste to Landfill in the UK', Presented at RICS COBRA 2012, (10-13 September 2012).

PBSRG. (2016). Worldwide Construction Performance Database. Performance Based Studies Research Group Internal Research Documentation, Arizona State University, Unpublished Raw Data.

PBSRG.com. "Performance Based Studies Research Group." Best Value Procurement & Risk Minimization «. Performance Based Studies Research Group, n.d. Web. Adrian, J. 2001, 'Improving Construction Productivity', Construction Productivity Newsletter, vol.12, no. 6.

PricewaterhouseCoopers (PwC). (2009). “Need to know: Delivering capital project value in the downturn.” Retrieved from https://www.pwc.com/co/es/energia-mineria-y-servicios-publicos/assets/need-to-know-eum-capital-projects.pdf. Accessed September 16, 2015.

Sambasivan, M., & Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry. International Journal of project management, 25(5), 517-526.

Thomas, H. R., & Napolitan, C. L. (1995). Quantitative effects of construction changes on labor productivity. Journal of construction engineering and management, 121(3), 290-296.

UK Construction Industry KPIs - Industry Performance Report 2011, '2011 Industry Performance Report, Based on the UK Construction Industry Key Performance Indicators', pp. 1-30.

Yun, S. (2013). The impact of the business-project interface on capital project performance. The University of Texas at Austin. Retrieved from http://repositories.lib.utexas.edu/handle/2152/22 804.