Case Study of a New Construction Research Model

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This is a case study of an alternative/new research model built at Arizona State University in 1994 to perform construction research. The case study includes the changing university environment and requirements, the process of setting up the research group, the strategic and business plan, the funding model, the research area and hypothesis testing, the alignment of research and education, and the business operations. The case study also includes the research scope and breadth, and potential to sustain the research. The case study proposes that the new research model becomes more doable and logical as the university environment moves to a business approach, requiring researchers to become business units with expertise and impact, and the funding should be self generated with soft money.

Key Words: Construction research, education, strategic and business plans, industry funding, alignment of resources

Introduction

A 1992 PhD dissertation titled "*Development of Performance Based Design/Procurement System for Non-Structural Facility System*" made the following observations/proposals about the construction industry:

1. The construction industry structure was unstable.
2. The price based award formed an adversarial structure.
3. Construction/project management as currently practiced by clients/buyers was an inefficient model.
4. The price based delivery system of construction was creating industry problems of poor quality, adversarial structures, and inefficiency.
5. Standards were ineffective in ensuring performance and protecting the construction clients.
6. The client and not the construction industry controlled the level of quality and performance of the construction industry.
7. Performance measurements, which were not being used, were important in identifying the value of construction systems.
8. A best value delivery system which selected contractors on performance and price should replace the current price based delivery system.
9. The industry would benefit in moving from a management and technically oriented approach to construction to a leadership based, supply chain oriented, non-technical delivery system.

An attempt was made to test and implement the proposals of the dissertation in the curriculum and research at the Air Force Institute of Technology (AFIT) located at Wright Patterson, AFB. However AFIT was not opened to the concepts, and resulted in the research moving back to ASU at the Del E Webb School of Construction (DEWSC), under the College of Engineering

and Applied Sciences (CEAS). The reception at the DEWSC was not much different. The concepts faced internal opposition which was manifested in the denial to the researcher of a tenure track position in 1994 by the DEWSC promotion and tenure committee (which was overridden by the DEWSC Director and CEAS Dean, and subsequent denial for early promotion, and promotion by the same promotion and tenure committee) (Badger, 2007).

The environment in 1992 at the Del E Webb School of Construction was:

- There was no research funding for professors.
- Professors were required to teach three classes a semester.
- Research was recommended, but the school was basically a teaching unit.
- The graduate construction management program was just being started.

During the mid 1990s, the CEAS took on a major endeavor to further emphasize the importance of new knowledge by separating the technology areas (education and training areas) from the research programs. They realized that in order to become a world-ranked institution, they must centralize their efforts to (Insight 2005):

- Be known for producing a creative, entrepreneurial and technical work force
- Become a driving force for change and economic growth in the community
- Deliver useful research for the benefit of individuals, companies, institutions, and the environment.

Research became the focus of CEAS and therefore, the focus of the DEWSC. The DEWSC identified the major sources of construction research grants as:

1. Government organizations such as the National Science Foundation (NSF)
2. Large agencies such as Housing and Urban Development (HUD) and Department of Transportation (DOT)
3. Trade organizations (i.e. NECA, SMACNA, MCAA, etc.)
4. Large client/owner groups (or contractor/owner mixes) such as the Construction Industry Institute (CII) and Construction User Roundtable (CURT)

However, these agencies had their own research areas, and addressing the issues of industry structure, inefficiency and ineffectiveness of the client's delivery system, and the use of performance measurements in the procurement of construction services within their research programs would entail tremendous effort. Also, traditional research funding forced a researcher to identify what research areas proposals are being requested, putting together an extensive competitive proposal, waiting for approval, and then doing the research if it was awarded. The following are weaknesses of that approach:

1. The researcher must become an expert in areas that the funding was available.
2. If the funding sources change the interest areas, the researcher's area must change.
3. It is difficult for the researcher to become the expert in a sustained research program over ten or more years if they are forced to change areas of expertise.
4. The researcher must continually compete for research grants.

5. Research findings/products in construction are usually studies/reports that document current practices and may propose new models, procedures, and materials. However, rarely do the research results have a chance for implementation and repeated hypothesis testing.
6. There has been difficulty in implementing the research findings in the industry.
7. At the DEWSC, each professor had to teach three classes a semester. Research was done in the professor's spare time. The professor also had administration duties, which further diluted the professor's research efforts.

Other struggles were taking place within and around the DEWSC. The first struggle was the resistance of the faculty against change and innovative research methods. If one professor became more successful, it put pressure on the other professors to do research and publish. The second struggle was a traditional struggle between the DEWSC and its parent CEAS. The DEWSC did not feel the CEAS was giving them sufficient funding, tenured faculty lines, and research support (Badger, 2007). The counterbalance to this environment of turmoil was a very progressive director of the DEWSC who's only rule was there were no rules. This approach gave an opportunity for a new research model.

The New Research Model

A new research model was required to develop the best value concept at ASU. The requirements of the model included:

1. Research office that was self funded through industry funding.
2. Research area that had all three phases of research, long term potential, impact and value.
3. Research funding.
4. A strategic plan/business model.
5. A time management model that allowed research. A professor had teaching and administrative duties that were as important as the research.
6. Research phases: theoretical, prototype testing, and implementation had to be accomplished.
7. Marketing of research capability to industry groups to sustain research efforts.
8. Meet the requirements of promotion and tenure.
9. Publications in refereed conference papers and journals.
10. Validation of research results.

Research Office

The research office for the research was called the Performance Based Studies Research Group (PBSRG). The name was selected for the following reasons:

1. Performance Based. The main focus of the research would be performance based procurement/systems using performance information and measurements.
2. Studies. The name studies was used to deflect attention from ASU sponsored projects group which would charge overhead (33-50%) on any research being conducted. If it

was called studies, it would be considered free of the sponsored projects overhead rate. Initially PBSRG could not afford to pay the high overhead rate.
3. Research Group. Research was used due to the requirement for promotion. If PBSRG just did studies, detractors would say the research has no value, that it is merely studies and consulting.

The formulation of PBSRG needed no approvals. CEAS and the DEWSC were not interested because there was no funding and no perceived impact. In a very bureaucratic environment, it was amazingly simple to innovate and setup PBSRG, as long as it didn't require anyone else's effort or funding. PBSRG is now a fixture in the DEWSC and in the CEAS. We receive no university funding, no CEAS funding, and no DEWSC funding. We follow all university rules. In the last two years (2005-2007) there has been a shift from the ASU president who is trying to form the New American University. It is a very business oriented model. This new model fits PBSRG growth and development.

Research Area/Expertise

The research area had to be something that was logical and sound, involved theoretical development, prototype testing, implementation and hypothesis testing in each phase, potential in other industries, and bring value (profit, quality, and performance (on time, on budget, less effort, and high customer satisfaction)) to the construction industry. The following was identified as primary research targets based on the current status and needs of the construction industry:

1. The procurement of construction services that would bring higher value, quality, and performance to the construction client/buyer. This is the best value procurement or Performance Information Procurement System (PIPS).
2. The restructuring of the construction industry to create a more efficient delivery system, increase the value and need of technical training.
3. The education of contractors in how to maximize profits.
4. Educate manufacturers/suppliers of high performance products on how to differentiate their products to maximize their profits.
5. The integration of high performance clients, contractors, professional services, and researchers to create the next generation models.

Strategic Plan/Business Model

The PBSRG strategic plan included the following:

1. PBSRG would become the world leader in best value delivery in construction.
2. PBSRG would concentrate more on hypothesis testing to determine new models instead of existing industry concepts which were not supported by hypothesis testing results.
3. PBSRG would use simple deductive logic models. Models that were not logical, for example management based models which use direction, control, and inspection cannot lead to efficiency (Deming 1982).

4. PBSRG would not seek funding from research sources. PBSRG would seek operational funding from industry clients who could use the research to add value to their operations. This would become a self imposed filter, because if the research did not add value, the research client would not return. This puts PBSRG at risk. This research model is very akin to a free enterprise model.
5. The industry funding model placed a constraint of time of delivery for the research results. Results would have to be easily quantifiable, dominant, and easily explained.
6. Due to the progressive nature of the research and funding model, PBSRG would work only with research clients who were ready for the change. PBSRG would address other research clients as a different group, working with them as it became economically feasible. An example of this is if we were testing the concept of a FM becoming an outsourcing, leadership based FM using performance information, we would not test the concept with a FM who did not see the value of outsourcing.
7. The strategic plan is modified every year.

The business plan included the following guiding principles:

1. The concepts are "out of the box," innovative, and potentially "before their time." Start with small tests and work to larger tests.
2. Research clients could offer several different forms of compensation: research funding, research opportunity to test a very progressive hypothesis, exposure to other high performance participants, research tests, and opportunity to fulfill university tenure/promotion requirements such as publications.
3. Survival is the first objective, strategic planning the second objective, sustainability and proliferation the third objective.
4. Theoretical research, prototype testing, and implementation of concepts would have to be cyclical, always improved, and done simultaneously.

PBSRG was handled as a business unit. There was no control over PBSRG finances by either DEWSC or CEAS. PBSRG maintained a six month window of operation where funding was already secured. PBSRG found ways to minimize overhead rates to survive in the early years. PBSRG negotiated with the then Dean of the CEAS to use the foundation accounts with a minimal overhead rate of 7% to do the early research. It was not until United Air Lines research project which brought in $180,000 /year did the university sponsored projects group become very interested. Due to the longevity of some of our research clients sponsored projects has granted a 33% overhead rate for much of the research. PBSRG, due to the unique research technology (simplicity, deductive logic, and the Information Measurement Theory (IMT), used students at all levels to support the research. Unlike other university research groups which depended heavily on PhD or masters students to run the research and publish the results, PBSRG is heavily dependent on the major researcher/professor as the hub and the students as the spokes.

In 2003, PBSRG hired its first full time marketing/coordination specialist. In 2005, PBSRG was augmented by a second full time assistant professor. And in 2005, PBSRG was augmented by a third critical piece, the former director of the DEWSC, who possessed considerable expertise in leadership. In 2006, PBSRG launched its own Facility Management/Project Management masters degree.

Off of the five areas of PBSRG research/expertise, the following entities in their prioritized order were targeted for funding and research participation:

1. Construction clients. They were not receiving high performance construction. They wanted better value, with less effort.
2. High performance contractors/manufacturers. Objective was to gain a competitive advantage for high performance/value systems. Attracted by a client base who wants high performance/value.
3. High performing industry participants. Participants who are naturally efficient, want to add value to others, and who want change.
4. Unions, training groups, safety groups. Participants who want the industry better trained, who want to see trained entities gain a competitive advantage.
5. Groups seeking change and continuous improvement. This includes researchers, industry advocates, industry groups (International Facility Management Association (IFMA), National Institute of Government Purchasing (NIGP), International Council for Research and Innovations in Building and Construction (CIB) and the Institute of Supply Chain Management (ISM), and Project Management Institute (PMI).)

The most difficult task was to start the research effort, gaining the initial funding. The initial procurement model was used to convince the client/buyers to run tests in the local community to gain funding. A package was put together showing the potential value of the first generation Performance Based Procurement System (PBPS). Due to the deductive logic and simplicity of the PBPS and its theoretical foundation, the Information Measurement Theory (IMT), and the potential dominant results (minimization of FM efforts and increased value of procured product) the following cycle of results occurred:

1. Presentations were given at IFMA chapters and national meetings.
2. Local organizations (Motorola, Intel, Honeywell, IBM, International Rectifier, and McDonnell Douglas) participated with testing out the procurement systems (roofing, janitorial services, and landscaping services)
3. The interest from the client/buyers attracted attention from high performance contractors and manufacturers who saw a "win-win" and an escape from the low price mentality.
4. The synergistic impact of the research partners led to larger projects, new modifications to the theoretical research, and modification to the best value processes.
5. It led to more presentations and interest (IFMA, ISM, CIB, PMI, and NIGP).

Time Management Model

PBSRG's most valuable resource was time. The researcher has to find a way to free up time to conduct research. Treating PBSRG like a business, the researcher needed a method to accomplish the DEWSC professors' tasks, but still be able to do the research. The following steps were taken:

1. A strategic goal was set to teach only courses that were in the expertise of PBSRG. The final goal was to develop a masters program around the technology, which was accomplished in 2006.
2. The first goal was to hire undergraduate students to do all of the administration work of PBSRG.
3. The second goal was to hire the best students in the undergraduate classes to come back after finishing the class, and have them administer tests, give study sessions, answer questions, and give some of the easier lectures. These students were hired from the research funding of the research clients.
4. The third step was to buy out the undergraduate class, and teach a graduate class on the PBSRG technology.
5. The fourth step is that PBSRG researchers will do only research in the best value area.

This model of aligning the expertise of PBSRG with the education and research duties, and buying out any other activities that are not in alignment has led to sustainable research effort that has spanned 14 years, and almost $7M. In the course of doing the research all the requirements for tenure would have to be met:

- High teaching performance ratings.
- Teaching existing and new classes.
- Service to the DEWSC, CEAS, and University.
- Service to the industry.
- Research expertise.
- Known worldwide for research expertise.
- Publications in refereed conferences and journals.
- Research funding.

The strength of PBSRG researchers is research. In research related issues (funding, publications, worldwide recognized expertise, service as a reviewer and sit on editorial boards of journals), PBSRG researchers are dominant. In the other areas, the numbers are very good. PBSRG has a mentoring methodology that looks out for the best interest of PBSRG staff. As new individuals come in, the research goes to the next level in terms of scope, breadth, and theoretical development.

PBSRG looks at the research environment in the following terms:

1. Worldwide. PBSRG researchers must be active in the following ways: attend a minimum of two international conferences; publish in at least one worldwide journal per year and a minimum of ten conference papers per year; be associated with at least one CIB TG/WG chair or coordinator; be associated with at least two worldwide journals; be a visiting professor to one foreign university; and be recognized worldwide by professors, graduate students, and industry participants.
2. Nationwide. Cover the US with research presentations (minimum 50 per year), research clients, research tests, and visiting professorships and relations with other major universities.

3. Website. PBSRG website connected to the world.
4. Industry partners/potential tests. Through presentations, PBSRG continually made attempts to get entry into other industries through procurement/contracting, project management, supply chain management, or leadership and management professionals. PBSRG used the theoretical concepts, prototype testing, and implementation in other industries to determine the universal applications of the IMT logic. These tests will give validation to the construction research, while increasing the opportunity to identify the universal applications of the best value technology (Figure 1. PBSRG Research Cycle).

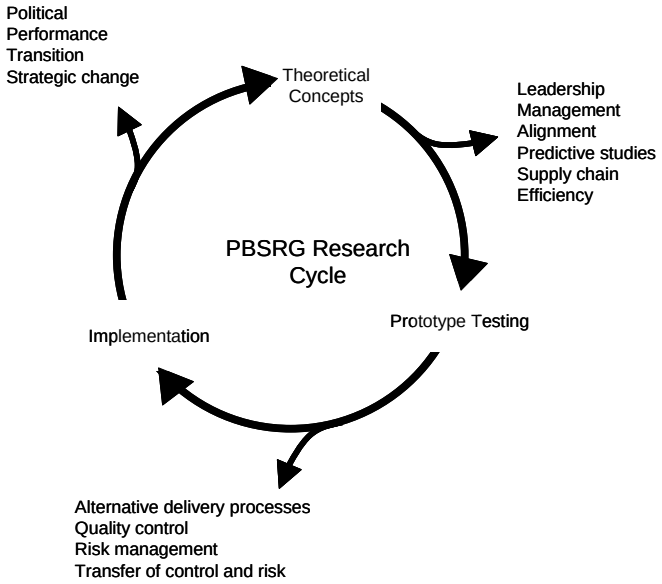

Figure 1. *PBSRG Research Cycle*

PBSRG Research Development

PBSRG has become a professional research group. It now has its own full time marketing/coordinator, three full time researchers/professors, two full time researchers, and three to five research assistants. They are supported by six to ten student workers who do internet web development, data analysis/database maintenance, filming of research presentations, literature searches marketing activities and assisting with administration. PBSRG research activities are closely associated with the FM/PM masters program which currently has 22 students.

PBSRG Research Funding and Test Results

The following are unique characteristics of PBSRG research results:

1. The research has sustained itself over 14 years with significant growth in research funding, value of construction and other service projects, and number of clients (see following Figures 2 through 5)
2. The research has been received worldwide culminating in 2007 by recognition of the Fulbright program, and the potential movement of the education/research program to

Botswana University in Africa to start a cutting edge project management research program for African researchers.

3. The research has received the 2001 Tech Pono Award for the State of Hawaii, 2005 Corenet Global Innovation of the Year award, and two gold Construction Owners of America awards in 2007 for both design and construction projects.
4. The research was recognized in the Engineering News Record in a two page article in April 2005, and will have another entry in March 2008.
5. PBSRG is the co-coordinator for the CIB worldwide effort on studying the impact of performance information.
6. PBSRG was recently tasked by the Arizona State University contracting office to use its technology to assist in transforming the office to a PIPS based contracting office. The first major project was the delivery of the $400M, 10 year food services contract. Increased value and quality, minimized ASU participation, and identified as one of the smoothest transitions of services at ASU resulted in PBSRG applying its technology to the procurement of ASU sports marketing services.
7. The different applications has forced PBSRG to address issues of leadership based structures, supply chain management, leadership vs management practices, and the definition of value and performance.

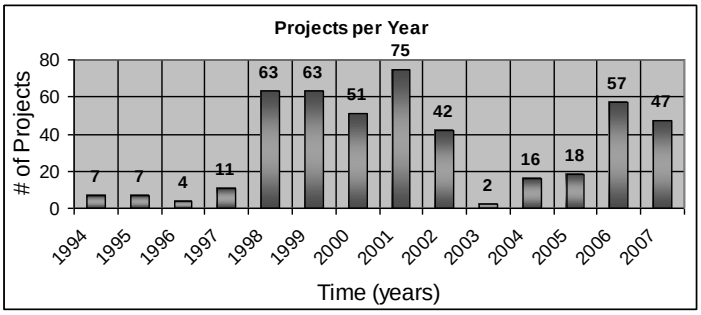

Figure 2. *Number of projects from 1994 to 2008*

Figure 3. *Number of research clients*

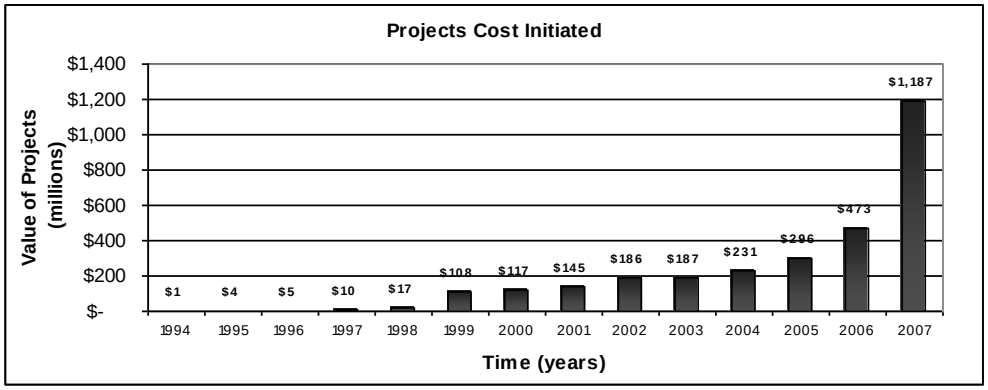

Figure 4. *Size/scope ($) of projects*

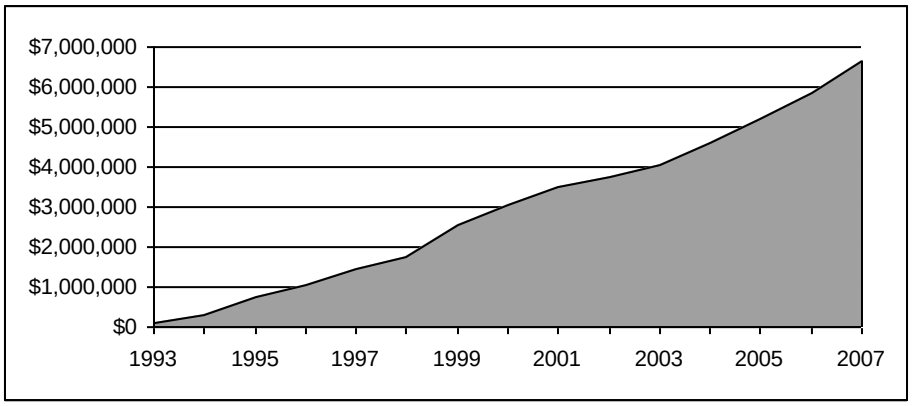

Figure 5. *Cumulative research funding*

Conclusion

This case study shows the development of an alternative research model at the DEWSC, CEAS, at Arizona State University. The differences between the traditional model and this model included:

- Funding by the industry using operational monies.
- No research funding assistance from the university, college, or school.
- Research phases of conceptual theoretical concepts, prototype testing, and implementation are performed simultaneously.
- Research windows for hypothesis testing are shorter than conventional research grants.
- Research group is organized and run as a business.
- Research program and the graduate research program are intertwined and aligned.
- Research program has sustained itself over 14 years, shows exponential growth, focused in the area of best value, constantly modifying the technology, and entering into other academic research areas such as supply chain, contracting/procurement, project management, and design processes.

PBSRG proposes that some of the techniques and concepts can be used at other universities to increase the amount, value, and impact of construction research.

References

ASU Insight (2005, March) Fulton School makes progress on lofty goals. ASU Insight, Volume 25, Number 32.

Badger, W.W. "Faculty Pipeline is Running on Empty," Engineering New Record, McGraw-Hill, New York, NY, Oct 22-29, 2007

Deming, W. E. (1982). *Out of the Crisis*. Cambridge, MA: Massachusetts Institute of Technology.

Kashiwagi, D.T. (1991) "Development of Performance Based Design/Procurement System for Non-Structural Facility System.", *Dissertation for Doctor of Philosophy, Industrial and Management Systems Engineering*; Arizona State University, Tempe, AZ (December 1991).

Kashiwagi, D T., (2003). *Best Value*. Tempe, AZ: Performance Based Studies Research Group (PBSRG).

Website: http:/www.pbsrg.com