A Performing Manufacturer Mitigates Risk by Using Performance Information Systems

Dhaval Gajjar, PhD, FMP, SFP
Clemson University
South Carolina, USA

Isaac Kashiwagi, PhD
Kashiwagi Solution Model, Inc.
Arizona, USA

A manufacturer initially approached the researchers to identify how to use the performance information of their high-performance urethane coating system to increase quality. The research project used the construction industry structure to identify owners who understood the high risk and transactions caused by low bid practices. Intelligent owners understood that value was delivered by expert contractors using high performance products rather than warranties. However, during the economic downturn, high performing contractors reverted to the low bid practices of using warranties to win work rather than performance. To create a high-performance environment, the manufacturer again approached the researchers to mitigate the risk caused by their warranties. The research identified that risk was not mitigated by warranties, but by transparency and performance information. A structure was developed that mitigated risk caused by a change in paradigm that resulted in a “win-win” result in a test case that involved the school district. As the system was installed, the performance of contractors increased, and the sprayed urethane foam contractors became the only roofing contractors at the school district to consistently maintain their installed roofs and mitigate the risk to the client at their own cost without using the manufacturer's warranty.

Keywords: Manufacturer, Performance, Risk, Roofing, SPF.

Introduction

A manufacturer was introduced to the Research Group in 1996. Since that time, the Alpha Program (1996 - 2015) was the longest running sprayed polyurethane foam (SPF) roofing program. The aromatic polyurethane coating developed by the subject manufacturer has the proven performance and durability as identified by the performance of the roofing system in heavy hail areas (Gajjar et. al. 2014, Gajjar et. al. 2015, Kashiwagi et. al. 2016; Kashiwagi et. al. 2017). The Alpha SPF roofing system is the only system that was proven to withstand the FM-SH test 4470 (Kashiwagi & Pandey, 1997).

A school district had been using the manufacturer’s Alpha roofing system since 1996 due to the characteristics of the SPF Alpha roofing system:

1. High performance; the oldest performing roof was 26 years old.
2. Monolithic, lightweight (4 PCF), high compressive strength of SPF (50 psi), very high insulating value (R7 per inch of SPF and hail resistant).
3. Could be installed over an existing BUR or SPF roof system.
4. Encapsulated the existing roofing system, saving the cost of removing and disposing of other roofing systems.
5. The overall cost of the SPF Alpha system lower than the removal cost of the existing roof system and the installation of some of the other traditional roofing systems.
In the five years during the economic downturn, the contractors started to bid low and use warranties to win projects, while material prices increased. The school district identified that performance of roofing contractors has decreased, and the risk for the client has increased as they have been unable to enforce the manufacturers’ warranties to get the expected roofing performance (Smith, 2011).

The school district wanted a system that mitigated this risk of roofing projects. The school district had the following constraints:

1. The roofing projects were a part of bond projects awarded to general contractors.
2. General contractors were responding to request for bids, with price the most important factor.
3. The designers of the roofing specifications were not skilled in specifying the roofing projects, many times leaving things out of the specifications.
4. The only real control was the school district roofing manager, who expected the manufacturers to respond to non-performance due to their warranties.

The manufacturer initially gave the school district a "joint and several" warranty, but after analyzing the risk caused by the price-based environment, refused to continue to give the warranty. The warranty initially covered the roofing system from the roof deck to the Alpha SPF roof system which overlaid other roofing system or existing SPF roofing system. This warranty was given with the assumption that the Alpha roofing contractors were doing their due diligence to maintain their performance regardless of the specifications. However, under the pressure of price, and with the downturn in the economy, the Alpha roofing contractors began reverting back to low bid practices. The school district wanted the manufacturer to manage their contractors by eliminating contractors who did not perform and issuing a warranty that protected the school district. The manufacturer thought the risk was too high and refused to protect the school district.

Problem

The school district wanted the Alpha roofing performance but wanted the manufacturer to manage its contractors. The manufacturer wanted the contractors to increase their performance, and if they did not, the risk to the manufacturer was increased. This paper presents a case study involving a school district and a manufacturer and how a unique industry structure and performance information was used to solve the issue of low performance.

Proposal

The researchers proposed that the solution was a "win-win-win" for the school district, the roofing contractor, and the manufacturer. The proposed solution was to identify risk caused by all parties and minimize the risk by creating a “win-win-win” alignment.
Construction Industry Structure

The researchers used the Construction Industry Structure (CIS) (Figure 1) to design a solution. The CIS identifies the price-based environment as:

1. The wrong party doing the decision making, directing, managing and controlling the contractor. The expert should be the contractor, and not the designer or the client.
2. The method of winning the award is to be the “low price”.
3. Once the contractor bids a low price, they approach the project as a low risk project.
4. Contractors approach the project as meeting minimum requirements (as directed by the designer).

![CIS Diagram](image)

Figure 1: CIS Solution (Kashiwagi, 2011).

The school district roofing projects had all the above characteristics. They wanted the manufacturer to issue warranties that would cover the risk of poor contractor performance. However, when a roofing project was not performing, the school district did not have the ability to force the manufacturers to pay for the non-performance. This led to a condition where the school district could not manage the contractors and the manufacturers to maintain their roofs once the roofs were installed.

Warranty Issue

The CIS identifies the price-based environment where warranties are the most important. In the roofing industry, warranty is an offer of protection provided by the manufacturer to the buyer (Agrawal et al. 1996). The warranty is written by the manufacturer and their legal representatives (Murthy & Djamaludin, 2002). Warranties contain certain exclusions that, if encountered, will void the warranty (Christozov et al., 2009). Therefore, it is the buyer’s burden to show that they did not do anything to violate the exclusions of the warranty. The manufacturer must then also agree that the buyer did not void the warranty leading to parties blaming each other. The best value environment has the following characteristics:

1. Expert contractors dictate the construction project.
2. Expert contractors do not depend on the warranty but fix their problems. By definition (Figure 1) the best value environment has high performance.
3. Expert contractors identify and mitigate risk that they do not control. Experts do not have technical risk. The only risk they have is risk that is outside of the project scope, the risk that they do not control.

4. Expert contractors identify the risk that they do not control and set up a plan to mitigate the risk before they do construction. They then document any risk and cost and time deviation because the risk is owned by the owner.

5. Because they clearly identify what they cannot control (risk), and clearly lay out to the owner that it is outside of the contract. Being experts, they track the risk and identify when it impacts their scope.

When the contractor has input in writing the contract (what they are delivering and how they are delivering), what they are not delivering is clearly documented in their contract along with their risk mitigation plan (Kashiwagi, 2010). The need for warranties is minimized due to the expertise of the contractors. The request of the school district for the manufacturer to increase the coverage of their warranty shows the following:

1. Win-lose; the school district wins, and the manufacturer loses.
2. Does not assist the manufacturer in mitigating the risk of nonperformance of the Alpha contractors in a low-price award environment created by the general contractors and the price-based environment.
3. The manufacturer cannot manage the general contractors who are awarding the roofing work based on the low price.
4. The manufacturer and the school district cannot control the designers to produce a more accurate specification. The designers are a part of the low bid environment causing them to be reactive (Child, 2010).

The manufacturer would not alter their warranty to joint and several warranty covering the installed Alpha roofing system to the deck including the existing roofing system which may not be installed with their products.

Risk of Non-performance

The system to create a "win-win-win" would require a best value environment. The researchers identified that the system attributes which would reflect the best value environment. The requirements of the new system would include:

1. Roofing contractor in control of the project regardless of poor design and a low bid environment.
2. The school district roofing manager able to give input before the construction started.
3. The manufacturer representative able to give their requirements before construction based on the unique project conditions.
4. Motivate the roofing contractor to perform and study the roof out in detail and identify what they priced out and what they did not due to an incomplete design.
5. Meet all the legal requirements of the school district and their construction delivery system.
The best value requirements would include:

1. Minimization of risk by contractor, especially correction of designer errors.
2. "Win-win-win." Roofing contractor cannot be expected to cost risk that they cannot control.
3. Preplanning.
4. Contractors which understand the client's and the manufacturer's expectation before starting construction instead of by inspections after material has already been installed.
5. Transparency.
6. Measurement of performance.
7. Motivation for contractors to be accountable and perform during and after installation.

The current process at the school district is:

1. Roofing contractors submit bids to general contractor.
2. General contractors compete, and the winner has an Alpha subcontractor.
3. Roofing subcontractor goes to preconstruction meeting.
4. Roofing subcontractor installs roof.
5. School district roofing manager, general contractor and roofing consultant inspect roof and identify problem areas.
6. Roofing contractor fixes the roof.

The problems that are occurring include:

1. General contractor pre-construction meeting does not address roofing issues. There are too many sub vendors and professionals.
2. Alpha roofing contractors are bidding what is specified, and many times it is confusing. Some Alpha contractors are including non-specified work into their bids based on previous knowledge of what the school district expects, and some contractors are not.
3. The general contractors do not want to approach the school district on change orders.
4. Problems are identified at the end of job inspection that force "win-lose" situations due to the amount of resources and material installed on the roof.

The school district blames the manufacturer for not controlling their Alpha contractors and wants a more inclusive warranty. The manufacturer states that the designers are at fault, and that the contractors should have higher bids to cover the discrepancies, and the contractor is blaming the school district for not having better designers and the manufacturer for not supporting them when issues occur. The resulting environment conclusion is:

1. The manufacturer will not give a more inclusive warranty and risks losing the school district work that amounted to 3M+ SF.
2. School district will lose its best roofing system based on performance and price.
3. Alpha contractors need the school district work to survive as school district is one of the major clients of the Alpha system in the Dallas-Fort Worth area.
4. The Alpha SPF system will get poor publicity as a system that does not perform due to contractor nonperformance.
Solution

The warranty is depended on most in the price-based environment where work is strictly based on price and the length of the warranty. The manufacturer should understand that risk is mitigated by the contractor in a proactive approach; therefore, the manufacturer should assist in requiring a meeting with the Alpha contractor before construction to assist the contractor in understanding the project risks. The client should also have a representative who attends the pre-construction meeting to identify and answer issues that the Alpha contractor may have. The school district representative should understand the following:

1. The Alpha contractors are being picked on low price and not best value.
2. The designers have incomplete specifications.
3. The school district cannot expect best value delivered Alpha system results.
4. The school district needs to be fair, "win-win" and identify and agree to change order issues that result from incomplete or irrational specifications. If the price is too high for the change orders, school district should discontinue using the Alpha roofing system.
5. Contractors should not price risk items that are not in the specifications. This will ensure that the bids are competitive, and the risk items will be priced at the preconstruction meeting.
6. The school district system of project managers, designers, selecting contractors in a price-based environment and general contractors picking roofing contractors to do school renovations which includes the roofing work is not an optimized system which has for the past 10 years has not been corrected. School district should treat the system as a non-optimized system and put in activities which increase the value and minimizes the risk of nonperformance.

The only point of contact at the school district is the roofing manager. He is responsible to select the roofs for reroofing; controls the school district specifications and he is responsible for maintaining the roofs after installation. He should minimize his effort but participate at the right time to ensure his overall effort in managing specifications, inspecting roofs and managing the maintenance of the roofs is minimized. His goal is to assist the entire supply chain to minimize cost and every participant’s effort while increasing the performance of the installed Alpha roofing system.

The manufacturer must do its utmost to motivate the best SPF contractors to minimize risk and maintain their installed Alpha roofs without coming back to the manufacturer for further material or assistance in maintaining the roofs within the warranty period. This required the manufacturer to have a program that identifies the contractors who can install an Alpha roof system, and which motivates the contractors to stay in the program. The Alpha roof program included the following requirements (Gajjar et. al. 2013):

1. Annually turn in all roof applications for a customer satisfaction check.
2. Every other year have a roof inspection of the 25 roofs which has the greatest risk of not performing. This is coupled with a survey completed by the owners to identify which roofs may have risk.
3. Keep a 98% customer satisfaction rating, and 98% roof performance rating.
4. Any Alpha contractor’s client can call the Alpha program administrator and identify their roof as leaking (nonperforming) and the client as being not satisfied, and the contractor must rectify the problem to stay in the 98% requirement. In the 15 years of the Alpha program, there have been less than 10 disputes, which were all resolved.

At the same time, the manufacturer is responsible for assisting the contractors at the right time (before construction) on their expectations to issue a warranty at the end of the project. The manufacturer cannot be changing their requirements during the project.

The Alpha contractors need to understand that the solution in maximizing their profit is to implement the best value environment characteristics in the low bid environment. They must understand the following:

1. They cannot be reactive.
2. They must ensure that they act in the best interest of all supply chain participants.
3. They cannot be pricing in risk items that are outside of the scope of the specifications. This is the major problem and is causing confusion among contractors who are hoping to have a relationship with the school district for taking care of risk items that are not specified.
4. They must hold a roofing preconstruction meeting where the school district roofing manager, the manufacturer representative, the general contractor and the roofing designer or professional attends. All risk items that were not identified in the specifications or were ambiguous should be identified and change orders should be issued on those items.
5. All deviations to project cost and time should be documented by the Alpha contractor. The contractor is responsible to identify the risk that caused the deviation. If the source of the risk was the contractor, the contractor should fix the problem at their cost.
6. The contractor is responsible for maintaining the roof for the length of the warranty period. They should respond to the owner in a reasonable time to rectify the problems. This has been a problem as the contractor with the most work, also has the most maintenance to complete.

Supply Chain Solution

The researchers propose that the solution must be a supply chain solution as well as a best value solution. Therefore, it is a paradigm shift more than changing the legal constraints of the delivery system. The following were the major components of this solution:

1. The manufacturer had to ensure that the Alpha program contractors are meeting the simplistic requirements of 98% customer satisfaction and roof performance.
2. The school district needed to determine when a roof requires maintenance repairs based on performance information of the roofs, and the duration of time that the contractor has to fix the roofs. If they do not, school district must give a dissatisfied response, and the contractor will not be allowed to do further work due to being ejected from the Alpha program due to not meeting the 98% customer satisfaction and roof nonperformance requirements. All school district roofs are inspected once a year to identify nonperforming issues. The school district also has an internal reporting system for nonperformance issues such as leaking or blistering (major issue with SPF roof systems.)
3. The Alpha contractors cannot be pricing risk items that are not listed in the specification. The school district roofing manager was asking for a "freebee" which led to relationships and non-transparency. This is a silo-based action that leads to contractors to form relationships with the school district manager that affected the maintenance of the roof. A contractor with a relationship, did not repair their roofs in time, thus putting the school district roof manager at risk of defending why he was specifying the Alpha SPF system if the roof required maintenance.

4. A weekly risk report be sent to all Alpha contractors with the performance information of the contractors.

5. A roofing pre-construction meeting to be held that identifies the risk and change orders required to meet school district’s requirements. Everyone must understand that the delivery system is not optimized, and the system has not been corrected for the past ten years, and instead of putting the effort in to change the existing conditions, a simple meeting with the supply chain participants can rectify the problem.

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**Performance Data of the School District Alpha Applications**

School district roofs were inspected every year for a total of three years. As the solutions have been implemented, the roof performance has been analyzed. The school district has four million square feet of Alpha Roofing on 87 projects. Table 1 compares the blistering, leaking and repair rates of the Alpha Contractors. Table 2 compares the blistering, and repair rates by year.

**Table 1:** Blistering/Leaking/Repair Rates of Alpha Contractors (PBSRG, 2012).

| No | Criteria                              | Unit | Contractor Code |
|----|---------------------------------------|------|-----------------|
|    |                                       |      | A   | B   | C   | D   | E   | F   |
| 1  | Percent of jobs that do not currently leak | %    | 100%| 100%| 100%| 100%| 100%| 100%|
| 2  | Total blisters                        | SF   | 2,267| 3   | 60  | 1,585| 0   | 0   |
| 3  | Percent of total roof area blistered  | %    | 0.10%| 0.00%| 0.06%| 0.18%| 0.00%| 0.00%|
| 4  | Total repairs                         | SF   | 4,406| 130 | 160 | 10,250| 0   | 0   |
| 5  | Percent of total roof area repaired   | %    | 0.19%| 0.07%| 0.15%| 1.19%| 0.00%| 0.00%|
| 6  | Total job area inspected              | SF   | 2,352,035| 192,000| 108,500| 861,919| 389,250| 75,211|

**Table 2:** Analysis of Percentage of Blistering/Repair Rates (PBSRG, 2012).

| Criteria                              | Year 1 | Year 2 | Year 3 |
|---------------------------------------|--------|--------|--------|
| Total blisters (SF)                   | 4,160  | 4,117  | 3,915  |
| % of total roof area blistered        | 0.15%  | 0.13%  | 0.10%  |
| Average blister size (SF)             | 1.9    | 1.0    | 0.8    |
| Total repairs (SF)                    | 26,696 | 8,721  | 14,946 |
| % of total roof area repaired         | 0.88%  | 0.27%  | 0.38%  |
| Total roof area (SF)                  | 3,023,405| 3,209,733| 3,978,915|

Roof performance increased annually, the number of nonperforming roofs minimized, and the maintenance requirement caused by blisters decreased (Table 3). Also, very few roofs have had leaking. The school district has been impressed with the increase in quality over the last few
years. It is also important to note that the Alpha SPF roof system contractors are the only roofing contractors who have installed roofs at the school district, that have returned and maintained their roofs. The maintenance providing by the contractors is at no cost to the school district. The maintenance repairs have been estimated by the Alpha contractors at over $100K.

Most Alpha roof systems (75%) had less than 0.1% roof maintenance requirements (Table 3). From this analysis, it was determined by school district that any roofs above 0.1% maintenance requirement, or leaking, or having blisters over one foot in diameter, or open blisters would require maintenance within 15 days of notification to avoid a customer dissatisfaction rating on the roof project. This would threaten the Alpha rating of contractor, make them ineligible for future work, and label them as a non-performer for other clients.

Table 3: Category of Risk on Alpha Projects.

| Criteria                                      | Data  |
|-----------------------------------------------|-------|
| Total number of roofs                        | 87    |
| Total number of roofs over .1% blistered     | 22    |
| Total number of roofs that have blisters over 1 foot in diameter | 21    |
| Total number of roofs with open blisters     | 13    |
| Total number of roofs leaked                  | 1     |
| Number of roofs that required maintenance    | 23    |
| Number of roofs fixed by the contractor       | 23    |
| Number of roofs that still need maintenance  | 0     |

Figure 2, Figure 3 and Figure 4 is a screenshot of the Weekly Risk Report (WRR) sent to the school district every week. It shows that the contractor who has done the most work, has formed a relationship with the school district. They are the only contractor who has not met their maintenance requirement. The school district has the option to identify the roofs as non-performing roofs, which may lead to the disqualification of the contractor from future work and ability to install Alpha roofing systems.

| CONTRACTOR | TOTAL JOB AREA (SF) | AVERAGE AGE (YR) | TOTAL BLISTERS (SF) | TOTAL % OF ROOF AREA BLISTERED | TOTAL REPAIRS (SF) | TOTAL % OF ROOF AREA REPAIRED |
|------------|---------------------|------------------|--------------------|-------------------------------|--------------------|-------------------------------|
| A          | 2,352,035           | 6                | 2,267              | 0.10%                         | 4,406              | 0.19%                         |
| B          | 192,000             | 7                | 3                  | 0.00%                         | 130                | 0.07%                         |
| C          | 108,500             | 7                | 60                 | 0.06%                         | 160                | 0.15%                         |
| D          | 861,919             | 7                | 1,585              | 0.18%                         | 10,250             | 1.19%                         |
| E          | 389,250             | 0.2              | 0                  | 0.00%                         | 0                  | 0.00%                         |
| F          | 75,211              | 0.2              | 0                  | 0.00%                         | 0                  | 0.00%                         |

Figure 2. Weekly Risk Report Showing Contractor Performance.
Table 1. Year 3 Results.

| NO | CRITERIA                                      | UNIT   | YEAR 3 RESULTS |
|----|----------------------------------------------|--------|----------------|
| 1  | Oldest job surveyed                          | Years  | 20             |
| 2  | Average age of jobs surveyed                 | Years  | 6              |
| 3  | Age sum of all projects inspected (doesn't leak, total years combined) | Years  | 506            |
| 4  | Average total repairs on each roof           | Sf     | 172            |
| 5  | % of total roof area repaired                | %      | 0.38%          |
| 6  | Average blister area on roofs               | Sf     | 45             |
| 7  | % of total roof area currently blistered    | %      | 0.10%          |
| 8  | Total existing blisters                     | Sf     | 3,915          |
| 9  | Total job area (of job surveyed and inspected) | Sf     | 3,978,915      |
| 10 | Total number of jobs inspected               | #      | 87             |

Figure 3. Weekly Risk Report Showing School District Alpha Roof System Performance.

Table 2. Comparison of Total SF and SF Blisters.

| NO | ALPHA CONTRACTOR | SCHOOL DISTRICT ALPHA ROOF PERFORMANCE | ALPHA ROOF PROGRAM PERFORMANCE |
|----|------------------|----------------------------------------|--------------------------------|
| 1  | Total sf         | 3,978,915                              | 12,604,280                     |
| 2  | Total sf blisters| 3,915                                  | 2,092                          |
| 3  | % of roof area blistered | 0.10%                           | 0.02%                          |
| 4  | Total sf repairs | 14,946                                 | 790                            |
| 5  | % of roof area repaired | 0.38%                           | 0.00%                          |

Figure 4. School District Alpha Roof Performance vs Alpha Roof Program Performance.

Figure 4 shows that Alpha Contractors servicing the school district had more blisters and repair work than Alpha contractors at other sites. There are unique site conditions; however, the supply chain approach improved the school district roof performance. Other observations from the data in the above tables and figures show:

1. One contractor was getting most of the work.
2. Other contractors with better performance were not getting as much work.
3. The roof system’s performance is increasing.
4. The roof system’s maintenance requirements are decreasing.

The authors proposed the following:

1. There may be a pricing issue, where one contractor may be pricing their work too low or including risk items in their pricing.
2. Over time, there has been a relationship formed between the school district and one contractor which has been detrimental to the Alpha program and the school district.

Conclusion

The school district had a delivery system for installing roofing systems that was not optimal. The Alpha sprayed polyurethane (SPF) roof system had given the school district the best roofing performance. The Alpha program contractors were the only contractors to have their performance measured, their roofs inspected annually, and maintenance done at no cost to the school district. The problem faced by the school district was identified by the Construction Industry Structure model. The difference between the low bid sector and the best value sector is that in the low bid sector all participants in the supply chain are looking after their own interest,
the wrong parties are making decisions, directing, and attempting to control. In contrast, the best value environment has participants in the supply chain act as a supply chain.

This research identifies how a school district increased the value of the Alpha roof systems, overcoming the non-optimized system of their price-based delivery system. It also identifies how the manufacturer-maintained a school district as a client without offering a warranty that they could not support financially. Lastly it identifies how a school district improved the value of their roofs by implementing "win-win-win" activities such as identifying risk at a roofing preconstruction meeting, not expecting more than what was specified, not forming relationships with certain contractors and by using performance information to motivate the contractors to provide maintenance on their installed roofs.

This research identifies the potential impact of implementing best value practices in a price-based environment. It is acting as a supply chain instead of a silo-based approach. It shows the value of understanding the construction industry structure and that the problems in the construction industry are being caused by a system and not individual entities.

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