Strategic Research

PROGRAM

Developing a Performance-Based Contracting Mechanism for Crash Reductions

November 2014
DEVELOPING A PERFORMANCE-BASED CONTRACTING MECHANISM FOR CRASH REDUCTIONS

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This research effort evaluated the potential of a new contracting mechanism that focuses on incorporating safety performance measures into highway maintenance activities. The contracting process would include an incentive-based program that rewards a contractor for exceeding specific safety roadway performance goals (i.e., crash reductions) along the maintained corridors. This document includes a review of potential availability payment strategies, candidate treatments, safety assessment approaches, and barriers to implementation. This report concludes with a draft specification and presentation slides used to facilitate discussion at an asset maintenance conference.

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Developing a Performance-Based Contracting Mechanism for Crash Reductions

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ACKNOWLEDGMENT

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EXECUTIVE SUMMARY

The research described in this report evaluates the potential of a new contracting mechanism that focuses on incorporating safety performance measures into highway maintenance activities. This process would include an incentive-based program that would reward a contractor for exceeding specific safety goals along the maintained corridors. This document includes a review of potential availability payment strategies, candidate treatments, safety assessment approaches, and barriers to implementation. This report concludes with a draft specification and presentation slides used to facilitate discussion at an asset maintenance conference.
DEFINING THE PROBLEM

Introduction

The inclusion of effective safety strategies as key components in transportation construction or improvement projects typically consists of deploying the safety treatment, opening the facility to traffic, and then responding on an as-needed basis to additional safety concerns. This reactive approach to safety can result in additional crashes and introduce substantial and potentially preventable costs as part of maintenance or infrastructure rehabilitation efforts. There is a need to proactively maintain facility safety in a manner similar to common maintenance contracts for transportation facilities. This research effort explored a potential contracting mechanism for establishing performance-based safety initiatives that will result in expected crash reductions. Karen Dixon and Paul Carlson worked with established maintenance contractor, DBi Services, to explore ways that a conventional transportation maintenance contract could be expanded to incorporate safety metrics.

Approach

The mission statement for almost every transportation agency includes a reference to the safe and efficient movement of people and goods, yet these agencies struggle with the best way to accomplish this safety objective. Documents such as the American Association of State Highway Transportation Officials (AASHTO) Highway Safety Manual (HSM) have been recently developed to promote and support quantitative analyses of highway safety performance. These emerging techniques can be used to reasonably estimate the predicted number of crashes that can be eliminated through the use of strategic safety countermeasure treatments. The structure of a safety-based contracting mechanism can vary and would most directly impact the contracting agency and their maintenance contractor; however, this type of initiative creates two distinct opportunities for the Texas A&M Transportation Institute (TTI). First, any performance-based contract, particularly one that is incentive based, will need to include a third party safety assessment to determine opportunities for safety improvements (prior to maintenance) and approximate reduction in crashes (during and following maintenance activities). A second opportunity for TTI is enhanced collaboration with industry professionals that may ultimately result in future research opportunities. This project specifically combined the strengths of TTI and DBi Services to develop and explore a potential new long-term business opportunity for both organizations.

Performance-based contracting is a growing trend within the United States. Performance-based contracts typically deal with routine maintenance activities such as vegetation management, sweeping, and herbicide treatments. Performance thresholds are set by the respective department of transportation (DOT) and contractors assume responsibility and risk associated with maintaining specific assets to the performance levels established by the DOT. DBi Services is one of the largest contractors in the United States that provide performance-based contracting services and so is an ideal collaborative partner to TTI for assessing ways to expand safety into the routine highway maintenance process.
PROBLEM EVALUATION

Methodology

TTI researchers Paul Carlson and Karen Dixon worked with DBi Services to develop a model specification for a Performance-Based Contract for Crash Reductions (see appendix). The collaborative team explored various options for candidate incentive clauses that would help reward a maintenance contractor for a reduced number of facility crashes and/or establishing routine safety performance measurement procedures for a specific corridor. To explore this opportunity, the collaborative team of TTI and DBi Services conducted several conference calls, met in person on two occasions, and ultimately presented the concept to select DOT and maintenance professionals at a maintenance conference. This latter event included a discussion session that generated considerable excitement about this concept. The presentation slides for the conference are also included in the report appendix.

In general, DOT feedback about the concept varied but was generally positive. Key issues to be resolved are summarized in the following section.

Findings

The TTI/DBi Services collaborative team evaluated a variety of key issues that would impact the success of a performance-based safety maintenance contract. These issues can best be summarized as the following four key topics:

- Candidate maintenance treatments.
- Safety assessment parameters.
- Incentive techniques.
- Potential barriers to implementation.

Each topic is briefly reviewed in the following paragraphs.

Candidate Maintenance Treatments

The focus of this effort was to explore implementing treatments that have known safety improvements and also fall within the boundaries of a highway maintenance contract. Though maintenance contract scopes may vary by jurisdiction, in general they include roadside maintenance, select pavement improvements (generally minor rehabilitation), and traffic control device maintenance and repair. Consequently, a limited number of candidate countermeasures should be considered for the initial scoping of a performance-based safety maintenance contract. Upon review of potential treatments, the collaborative team identified the following list of items that have known safety effects while also following within the purview of a maintenance contract:

- Guardrail or guide rail.
- High friction surface treatments (at horizontal curves and intersection locations).
- Rumble striping.
- Rumble strips.
- Signage.
- Striping.

**Safety Assessment Parameters**

The assessment of safety for a performance-based contract requires two key components: (1) a triage of the existing corridors and prediction of the expected number of crashes based on known road type performance and historic (observed) crashes, and (2) a subsequent assessment of the number of reduced crashes following implementation of select safety countermeasures.

For the initial contracting approach, the collaborative team recommended that a specific road type, such as the rural two-lane or multilane highways, be the target facilities for this analysis. These rural highways have a known high frequency of single vehicle, run-off-road crashes. Consequently, the preliminary triage assessment can be practically performed and the rural (non-freeway) highway will have substantial potential for crash reductions (the second stage of the assessment).

The procedures for the safety assessment would be consistent with those presented in the AASHTO HSM. These quantitative and data driven techniques provide tools for assessing a specific corridor and determining the expected number of crashes along the corridor. Subsequent evaluations would then compare the crashes to what can normally be expected to have occurred so that the added benefit of the new safety treatments could be directly measured.

The target crashes for this assessment would primarily focus on fatal and injury crashes; however, one potential contracting model could use weighting factors for less severe crashes and thereby consider total crash reduction in addition to the fatal and severe injury crash reduction. DBi Services staff expressed concern that sometimes a crash occurs that is atypical for the location. This could be due to a catastrophic crash (such as a bus crash) or due to careless behavior by an impaired driver. The safety assessment criteria, therefore, should be robust enough to screen out these unusual events so as to determine a realistic cause and effect assessment for the safety treatments.

**Incentive Techniques**

When this innovative contracting mechanism was initially presented to transportation agency professionals, a common comment was that they already invest in safety treatments followed by the question of how this approach would differ. The goal of the safety-based performance maintenance contracts is to provide systemic safety treatments that the agency may not have budgeted and absorb the risk of this effort. In the event the safety performance is much less than expected, the transportation agency would have greatly reduced investments. Alternatively, the maintenance contractor would have availability payments that would mature over time. The draft specification included in the appendix of this report presents two candidate options for incentive payments.

In addition, discussions with representatives of the Florida DOT indicated that any incentive techniques should be easy to calculate and understand.
Barriers to Implementation

During the development of this contracting mechanism concept, the collaborative team attempted to identify potential barriers to implementation of this contracting approach. Some of these have been listed in the previous sections but, in general, the expected barriers are summarized as follows:

- Deploying a contracting mechanism of this nature while still retaining the competitive bidding structure.
- Creating an incentive structure that makes this approach beneficial and that can be easily understood by all parties.
- Identifying atypical crashes that should be excluded from the analysis.
- Determining which treatments and to what extent new safety enhancements should be deployed (this could vary dramatically by contractor).
- Developing an unbiased safety performance measure procedure that will satisfy the contracting agency and the contractor.

Several transportation professionals at the state and national level indicated that this contracting mechanism has promise and is an important new direction for maintenance contracts; however, refining how to address the individual perceived barriers can be a daunting task that could best be addressed by implementing a pilot study for a select number of corridors.
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Overall, the concept of the performance-based safety contract received positive feedback and the collaborative team developed a draft specification for two optional incentive plans (see appendix). The actual implementation of this contracting mechanism, however, requires some refinement that can only be accomplished through field testing of the concepts incorporated in the contracting specification. At the conclusion of this strategic research initiative, therefore, the collaborative team had developed the basic concept and DBi Services is currently working with representatives of Florida DOT to identify a potential set of corridors where the concept can be tested.

The TTI and DBi Services collaboration effort for this project did strengthen the relationship between these two organizations (one of the two anticipated benefits of this strategic research effort). If DBi Services and Florida DOT are successful in their efforts to identify a location and subsequently implement a pilot study, it is likely that TTI will be asked to assist with the safety assessment task. If the pilot study is a success, TTI will be on the ground floor of a new contracting mechanism that is likely to generate future research for TTI in a practice-based area where traditionally TTI does not maintain significant traction. This may then result in an entirely new area of research for TTI staff.

Recommendations

At this time, DBi Services is in the leadership position for continuing this effort. They are proposing exploring this concept as part of a pilot study effort. This exploratory approach will help to refine the process and resolve logistical questions regarding how best to develop future safety-based performance contracts.
REFERENCES

Scope of Work (Option #1)

The intent of this Design/Build/Maintain/Finance (DBMF) initiative is to implement safety countermeasures on selected roadways to yield reductions in crashes. The Contractor will determine the locations and the type(s) of safety countermeasures. To determine locations, the Contractor will use a combination of (1) owner-supplied crash statistics for locations known to have experienced crashes and (2) safety analysis procedures to determine locations that have similar characteristics as those that have experienced crashes prior to this contract, but have no recorded crashes to date. Using this systematic, proactive approach and private funding, the owner will realize improvements in safety more quickly than would have been realized using more traditional project delivery mechanisms.

Example performance-based countermeasures to be used by the Contractor include:

- Guardrail/guide rail.
- High friction surface treatments.
- Rumble striping.
- Rumble strips.
- Signage.
- Striping.

The Contractor will provide the funding to pay for the location analysis, countermeasure design, and construction work performed, which will be completed within two (2) years after financial close. Availability Payments from the owner to the Contractor will be made over a 15-year period, and such amounts will be tied to performance measures as determined below. The maximum amount of work that will be performed over the two-year period will be $15M.

The annual amount of the Availability Payments will be based upon performance measures associated with the total number of crashes per lane mile of roadway, measured against previous experience and adjusted for ADT. An example of how the formula will be calculated is shown below:

\[
X = \text{Average Number of Crashes experienced in the 10-year period prior to the Contract.}
\]

\[
Y = \text{Number of Crashes experienced in a given contract year after safety countermeasures are implemented.}
\]

\[
Z = \text{Average Daily Traffic (ADT) over the 10 years prior to the Contract.}
\]

\[
A = \text{ADT during a given contract year.}
\]
AP = Base Availability Payment.
APX = Calculated availability payment.
\[
APX = \frac{(Y \times A) \times AP}{X \times Z}
\]

Based upon an investment of $15M over two years, the AP range will be as follows.

<table>
<thead>
<tr>
<th>% of Crashes reduced/avoided (as adjusted for ADT)</th>
<th>AP Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum AP 0% or less</td>
<td>$2.5M</td>
</tr>
<tr>
<td>Average AP 0–40%</td>
<td>$3.0M</td>
</tr>
<tr>
<td>Maximum AP Over 40%</td>
<td>$3.5M</td>
</tr>
</tbody>
</table>

At no time will the annual AP be less than $2.5M nor greater than $3.5M during any contract year.

**Scope of Work – Option #2** (essentially the same as Option #1, with two major exceptions: work would be spread over 7 years, and the AP would be over 5 years for each years’ worth of work completed)

This Design/Build/Maintain/Finance (DBMF) initiative is to implement safety countermeasures on selected roadways to yield reductions in crashes. The Contractor will determine the locations and the type(s) of safety countermeasures. To determine locations, the Contractor will use a combination of (1) owner-supplied crash statistics for locations known to have experienced crashes and (2) Contractor-generated analysis to determine locations that have similar characteristics as those that have experienced crashes prior to this contract, but have no recorded crashes to date. Using this systematic, proactive approach and private funding, the owner will realize improvements in safety more quickly than would have been realized using more traditional project delivery mechanisms.

Performance-based countermeasures to be used by the Contractor include:

- Guardrail/guide rail.
- High friction surface treatments.
- Rumble striping.
- Rumble strips.
- Signage.
- Striping.

The Contractor will provide the funding to pay for the location analysis, countermeasure design and construction work performed. The contract will cover a 12-year period, with safety countermeasure work being performed at an average rate of $7.5M per contract year across the first seven contract years, with all work being financed by the Contractor. A series of Availability Payments from the owner to the Contractor will be made over an 11-year period, commencing with contract year two and incorporating each year’s work and performance against established performance measures and such amounts will be tied to performance measures as determined below. The maximum amount of work that will be performed over the seven-year construction period will be $52.5M.
The annual amount of the Availability Payments will be based upon performance measures associated with the total number of crashes per lane mile of roadway, measured against previous experience and adjusted for ADT. An example of how the formula will be calculated is shown below:

\[ APX = \frac{Y \times A \times AP}{X \times Z} \]

\( X = \) Average Number of Crashes experienced in the 10-year period prior to the Contract.
\( Y = \) Number of Crashes experienced in a given contract year after safety countermeasures are implemented.
\( Z = \) Average Daily Traffic (ADT) over the 10 years prior to the Contract.
\( A = \) ADT during a given contract year.
\( AP = \) Base Availability Payment.
\( APX = \) Calculated availability payment.

Based upon an investment of $7.5M during each of the first 7 contract years, the AP range against each year work is performed will be as follows.

<table>
<thead>
<tr>
<th>% of Crashes reduced/avoided (as adjusted for ADT)</th>
<th>AP Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum AP 0% or less</td>
<td>$2.25M</td>
</tr>
<tr>
<td>Average AP 0–40%</td>
<td>$2.5M</td>
</tr>
<tr>
<td>Maximum AP Over 40%</td>
<td>$2.75M</td>
</tr>
</tbody>
</table>

At no time will the annual AP be less than $2.25M (one year minimum) nor greater than $13.75M (5-year maximum) during any contract year.
Overview Presentation for Asset Maintenance Conference

On August 26, 2014, Karen Dixon gave a presentation titled *Integrating Safety into the Asset Maintenance Process* at a DBi-sponsored asset maintenance conference in Orlando, Florida. The goal of this presentation was to introduce the concept and facilitate discussion by industry professionals so that ultimately these key industry audience members (affiliated with transportation departments, vendors, and contractors) could openly discuss the overall concept and barriers to implementation. The presentation resulted in a very active discussion where the audience overwhelmingly agreed that integrating safety into the asset maintenance contracting process is the next logical step for performance-based contracts.

The slides from the PowerPoint are shown on the following pages.
Slide 1

Integrating Safety into the Asset Maintenance Process

Karen Dixon, Ph.D., P.E.
August 26, 2014

Slide 2

Presentation Outline

• Defining Safety
• Role of Safety in Maintenance Contracting
• Determining Safety Performance
“Safety is our Top Priority”

What is Safety?

- Number of crashes?
- Number of injuries?
- Level of injury?
Slide 5

Measuring Safety

**SUBJECTIVE SAFETY**
- Perception
- Values vary among observers

**OBJECTIVE SAFETY**
- Quantifiable
- Independent of the observer

Slide 6

Who Pays for Roadway Safety?

- Individual Persons in Crash?
- General Public
- Insurance Company?
- Road Owner?
Slide 7

Performance Based Options

- Performance Based Road Design Gaining Momentum
- Agencies Accountable for Number of Crashes at Their Facilities
- Is Good Road Design Enough? What about 5 years later? 10 years? 20 years?

Slide 8

Scenario

- 5 Mile Long Road Segment had a fatal crash between MP 1 to MP 2 (Vehicle Crashed into a Tree) during wet weather on a rural two-lane road
- Transportation agency decides to improve safety due to crash
- Entire road has similar conditions, but agency does not have money for 5 miles of safety improvements
- What happens? Is the next fatal crash likely to occur between MP 1 and MP 2?
Slide 9

Common Transportation Agency Funding Priorities

- Safety
- Preservation
- Capacity

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Slide 10

Example Activities that Target Safety

- Resurfacing (Improving Pavement Quality)
- Guardrail / Cable Barrier Construction & Maintenance
- Roadside Vegetation Control
- Pavement Markings and Signs
- Drainage Maintenance
Is It Time for Performance Based Maintenance Contracts?

Why?

- Transportation Agencies are Accountable for Road Safety Numbers
- Funds are Limited and Can Only Go So Far
- Road Design, Driver, and Site Condition ALL Influence Safety Performance
Slide 13

How Would a Performance-Based Contract Work?

Possible Funding Techniques:
- DOT requires some minimum level of safety improvements in each contract (already doing this).

- DOT sets aside $$ dedicated to safety projects as needed. These project will be defined by contractor or agent of contractor.

Slide 14

How Would a Performance-Based Contract Work?

Possible Funding Techniques (continued):
- DOT sets aside $$ in contract dedicated to safety but includes a performance-based reward option if corridor exceeds expectations.
How Would a Performance-Based Contract Work?

Possible Funding Techniques (continued):

- DOT agrees to pay a portion of the safety improvements up front (say 50%), but contractor can exceed that amount. If safety performance meets expectations, contractor provides performance-based reward that reasonably exceeds initial full deployment cost (since contractor assuming risk and cost share).

Issues to Consider

- How will the performance be measured (number of crashes, injuries, something else?)
- Who will perform the safety performance analysis – a 3rd independent party?
- How can the performance analysis be free of subjective perspectives?
- What do you do about extreme events (major weather, catastrophic crashes, etc.)
Random Events

Rare Events
Relative Proportion of Crash Events

- Situation with Potential Risk of Crash
- Low Risk of Crash
- Risk of Crash
- Crash Occurs
Slide 19

Contributing Factors

ROADWAY
34% 3

DRIVER
93% 57

VEHICLE
13% 3

Treat, 1979

Slide 20

Expected (Future) Average Crash Frequency

Crash Frequency = Short Term Measure
Slide 21

Data Needs

1. Crash data
2. Facility data
3. Traffic volume data

Slide 22

Crash Evaluation

Effectiveness After Implementation
Crash-Volume Relationship
Can Be Non-Linear

How Do We Measure Safety Performance?

1. Subtract “After” Crashes from “Before” Crashes?
2. What about One-Time Events?
3. Won’t Number of Crashes Vary Each Year?
4. Crashes May be Increasing (Decreasing) Anyway at Site?
Observed Crash Frequency and Crash Rate Methods

• Advantages
  – Intuitive
  – Acceptance

• Limitations
  – Assumes a linear relationship between crash frequency and exposure (probably not the case)
  – Inability to account for changes in road conditions and traffic volumes
  – Cannot use to compare alternative treatments

Natural Variability in Crash Frequency

Expected Average Crash Frequency

Short Term Average Crash Frequency

Years

Observed Crash Frequency
Slide 27

Regression-to-the-Mean (RTM)

RTM Bias
If we do not account for RTM, we cannot say the crash difference is due to the treatment

Slide 28

RTM Example

Site Selected for Treatment due to Short-Term Trend

Observed Crash Frequency

RTM Reduction

BEFORE

AFTER

Perceived Effectiveness of Treatment

Actual Reduction due to Treatment

Expected Average Crash Frequency (Without Treatment)

Years
Crash Rate

Crash Frequency vs Crash Rate Methods

\[
\frac{\text{Number of Crashes}}{\text{Number of Cars}} = \text{Rate}
\]

Example for Crash Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>No. Crashes</th>
<th>AADT</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>13</td>
<td>2,900</td>
<td>2.11</td>
</tr>
<tr>
<td>1989</td>
<td>11</td>
<td>2,900</td>
<td>1.79</td>
</tr>
<tr>
<td>1990</td>
<td>13</td>
<td>3,050</td>
<td>2.01</td>
</tr>
<tr>
<td>1991</td>
<td>23</td>
<td>3,400</td>
<td>3.19</td>
</tr>
</tbody>
</table>

Average Rate = 2.28

Gambling Introduced in 1992

<table>
<thead>
<tr>
<th>Year</th>
<th>No. Crashes</th>
<th>AADT</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>30</td>
<td>10,618</td>
<td>1.33</td>
</tr>
<tr>
<td>1993</td>
<td>30</td>
<td>13,200</td>
<td>1.07</td>
</tr>
<tr>
<td>1994</td>
<td>36</td>
<td>14,300</td>
<td>1.19</td>
</tr>
<tr>
<td>1995</td>
<td>40</td>
<td>13,900</td>
<td>1.36</td>
</tr>
</tbody>
</table>

Average Rate = 1.24

Example Provided by Jake Kononov, Ph.D., P.E., Colorado DOT
Slide 31

Crash Rate Conclusion?

Before Gambling Average Rate = 2.28

Highway Alignment and Typical Cross-Section not Changed

After Gambling Average Rate = 1.24 but the Percent of Alcohol Related Crashes increased 500%

Possible Conclusion: Is Drinking and Driving in Concert with Gambling Good for Safety?

Probably Not but Crash Rates Say Otherwise

Example Provided by Jake Kononov, P.E., Ph.D., Colorado DOT

Slide 32

Safety Performance Function

SPF

Product of Statistical Modeling Process

- Mathematical expression
- Used to estimate predicted average crash frequency
Slide 33

Next Steps

- Explore potential needs and contracting mechanisms
- Develop model for third party safety assessments
- Initiate pilot tests
- Refine process based on lessons learned

Slide 34

Questions?
Comments?