

North Carolina
DEPARTMENT OF TRANSPORTATION

Pavement Marking Life Cycle Cost Analysis

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Overview

- NC pavement markings include paint, spray thermoplastic, extruded thermoplastic, cold applied plastic and polyurea.
- The data was gathered by the NCDOT Signing & Delineation Unit through various sources.
- Based on cost-benefit ratio, these results can be used to assist in the selection of pavement marking materials for roadways based on ADT and needed service life.
- The replacement of pavement markings is based on retroreflectivity. We believe markings should be replaced at 100 mcd/lux/m².

History

- First set of data taken on new markings installed around 2000 until the markings were replaced.
- Additional data came from Wide Line Project readings and other data collection readings.



What do we do with the data?

Parameters & Equations

- Equations
 - Extruded Thermoplastic
 - The Extruded Thermoplastic models used are shown below:

Yellow: $R_L = 190 + (0.39 * R_{L \text{ Initial}}) - (2.09 * \text{Time}) - (0.0011 * \text{AADT}) - 39.7$

White: $R_L = 190 + (0.39 * R_{L \text{ Initial}}) - (2.09 * \text{Time}) - (0.0011 * \text{AADT}) + 39.7$

Parameters & Equations

- Paint
- The model for paint is as shown:

$$R_L = 55.2 + (0.77 * R_{L \text{ Initial}}) - (4.17 * \text{Time})$$

- Equations came from NCSU report “Pavement Marking Performance Analysis” by Dr. Joseph Hummer, et. al.
- In this study data collected from NC roads was used to create degradation models for extruded thermoplastic and paint.

- Notes for Equations

- R_L – Final Retroreflectivity in mcd/lux/m²
- $R_{L\text{ Initial}}$ - Initial Retroreflectivity in mcd/lux/m²
- Time - Time since installation in Months
- AADT - Annual Average Daily Traffic in Vehicles Per Day
- Data used to develop the paint model has an average AADT of 1300

Parameters & Equations

- Initial Retroreflectivity Values
 - The initial retroreflectivity values are based on the minimum standards for each material from the NCDOT Standard Specifications for Roads and Structures.
 - Higher initial retroreflectivity values increase life to a certain point
- Values Used in Research Study
 - Paint: 200 mcd/lux/m²(Yellow) and 225 mcd/lux/m²(White).
 - Extruded Thermoplastic with Standard Beads: 250 mcd/lux/m²(Yellow) and 375 mcd/lux/m²(White).
 - Polyurea with Highly Reflective Elements: 250 mcd/lux/m² (Yellow), 375 mcd/lux/m² (White)

Material Cost

- Extruded Thermoplastic
 - 4" X 90 Mil - \$0.65 (Std)
- Paint
 - All - \$0.20 installed per coat
 - Permanent paint markings require 2 coats (\$0.40)
- Polyurea
 - \$1.00 (Std)
- Spray Thermoplastic
 - \$0.40

Assumptions for Cost Analysis

- The following analysis is based on these criteria:
 - NCDOT replacement retroreflectivity (R_L) value used is 100 mcd/lux/m²
 - Replacement retroreflectivity value based on information from AASHTO, MUTCD subcommittee, and Paul Carlson (TTI) study.
 - On roads with high ADTs and/or moderate to heavy snowplowing, paint pavement markings will not last as long as shown in the charts.
 - Yellow center lines wear quickest due to color and location in roadway.

Chart Explanation

- The charts show cost per mile on a 2 lane road for five different materials at four different AADTs based on time.
- Materials shown:
 - Paint with Standard Beads
 - Extruded Thermoplastic with Standard Beads
 - Polyurea with Standard Beads
 - Hot Spray Thermoplastic with Standard Beads
 - Cold Applied Plastic (CAP)

Paints with Standard Beads

Recommended Uses

Temporary Pavement Marking For Work Zones

Projects that will be resurfaced in the next year

Not a Long Life Marking

- Traffic Paint used on NCDOT roads must meet current Federal Specification No. TT-P-1952
- Unless installed as an interim marking, must be installed in two separate coats at a minimum 15 mils each with glass beads on each coat. Interim markings require glass beads.
- Initial retroreflectivity requirements:
 - 225 White
 - 200 Yellow
- Time Frame
 - Depending on ADT a few months -2 year



Hot Spray Thermoplastic

Recommended Uses

Maintenance (in lieu of paint)

Projects planned for resurfacing or rebuilt in a few years

Lower volume roads

- Applied at 50 mils
- Contains intermixed beads that add life to the marking. Compared to Extruded (90 mils) reduces life of marking
- Not considered a long-life marking- but better than paint
- Time Frame average 3 years can be longer depending on road ADT

Extruded Thermoplastic

Recommended Uses

On any asphalt roadway (if used on concrete, sealer required)

Long life marking used in low to moderately snowplowed areas

Preferred application for majority of roadway system

- Applied at 90 mils, must have intermixed beads and drop on beads
- Initial retroreflectivity requirements:
 - 375 White
 - 250 Yellow
- Considered a long life marking



Polyurea

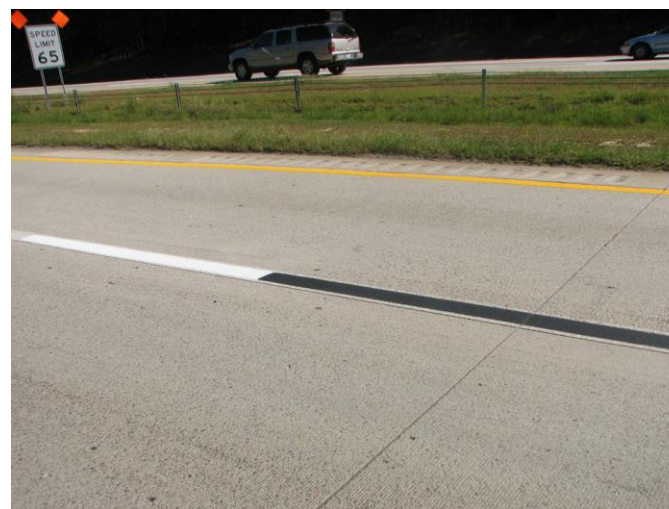
Recommended Uses

On any asphalt or concrete roadway

Sprayed 2-part plural component marking

Applied 30 mils lower profile for snowplowing

- Normal curing time between 5 and 10 minutes
- Initial retroreflectivity requirements with standard beads:
 - 375 White
 - 250 Yellow
- Considered a long life marking

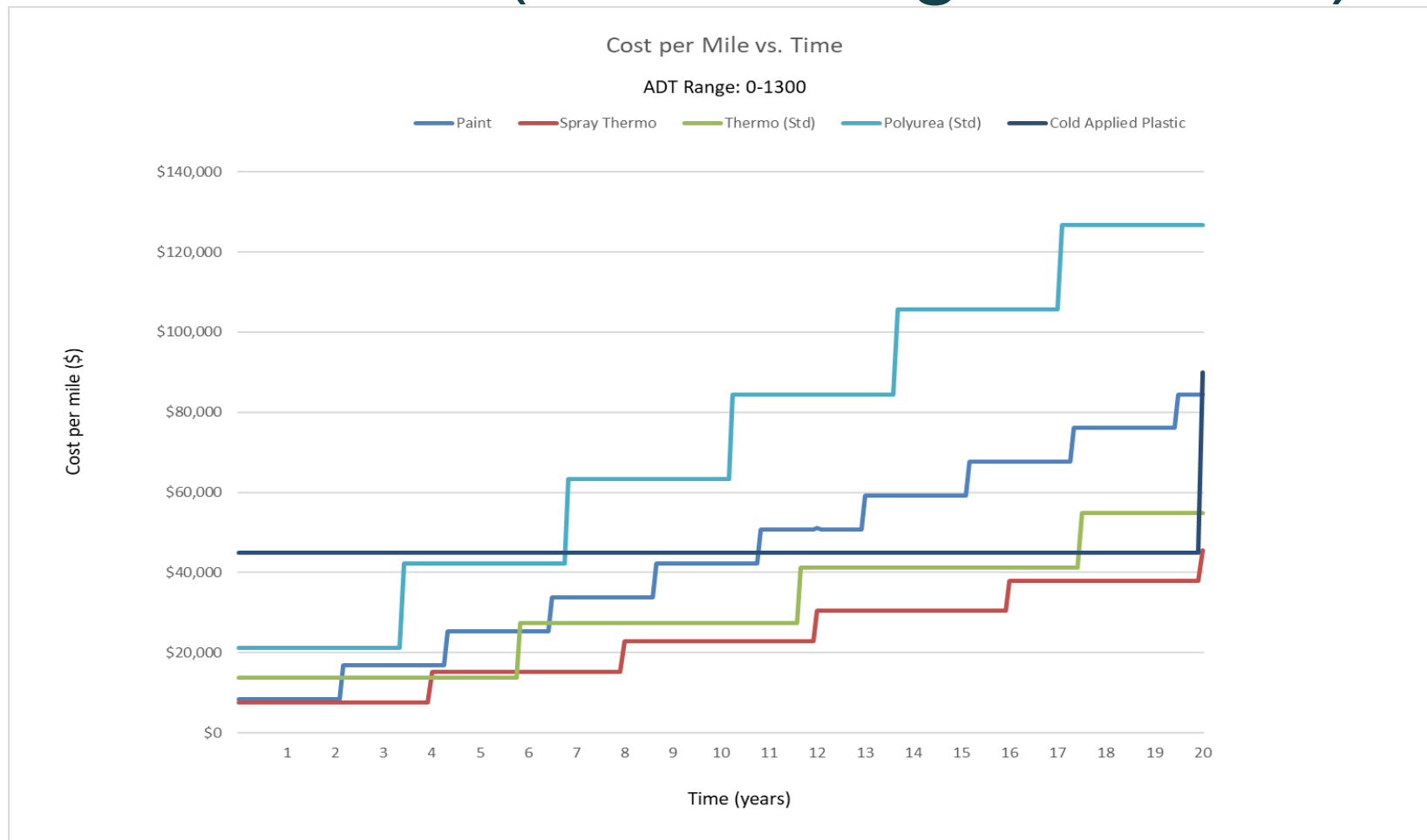


Cold Applied Plastic (CAP) – “TAPE”

- Manufactured product with an adhesive back that is applied to pavement.
- Four types in NC
- Very durable product but cost prohibitive
- Can be applied to asphalt or concrete with proper preparation

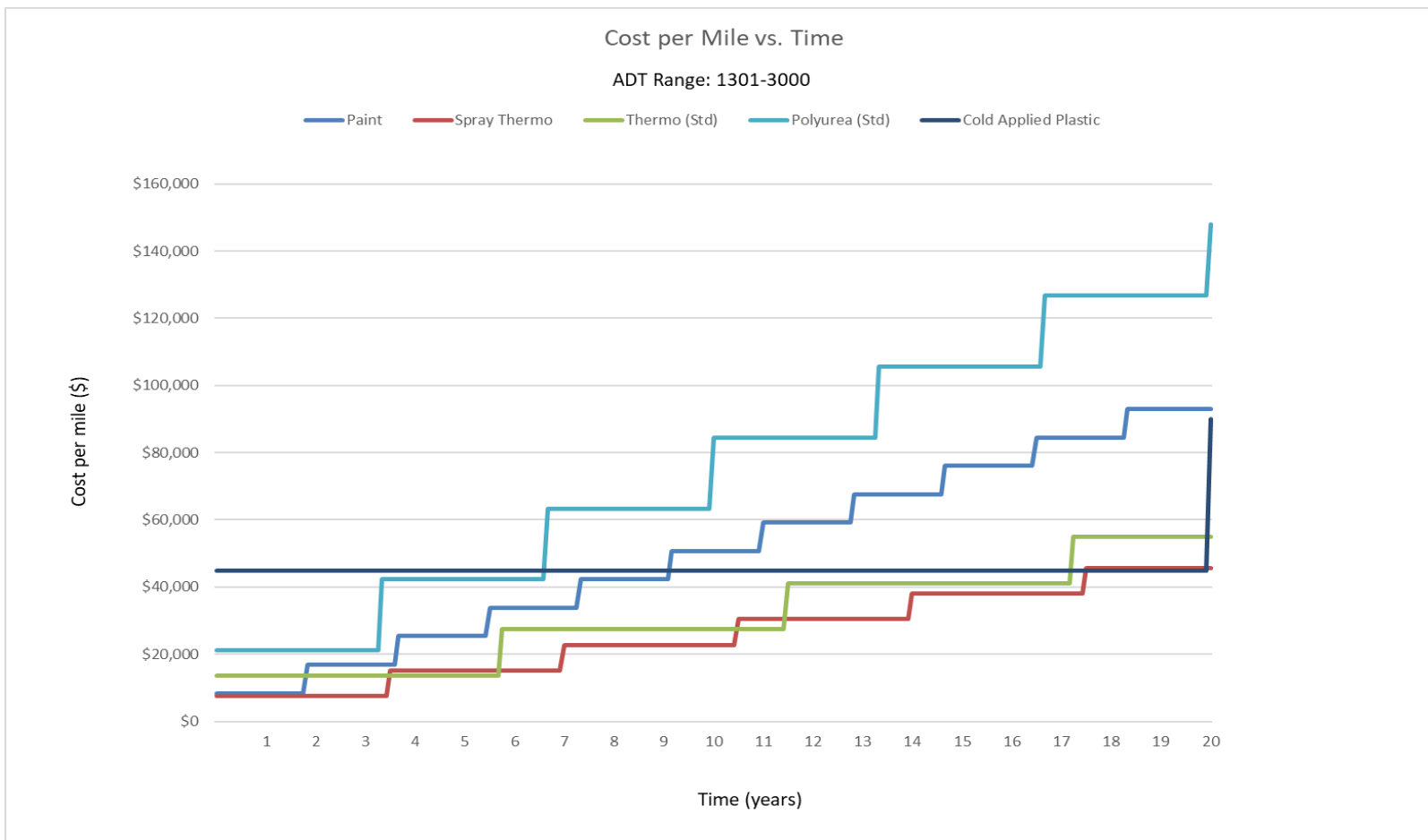


Results (ADT Range 0-1300)



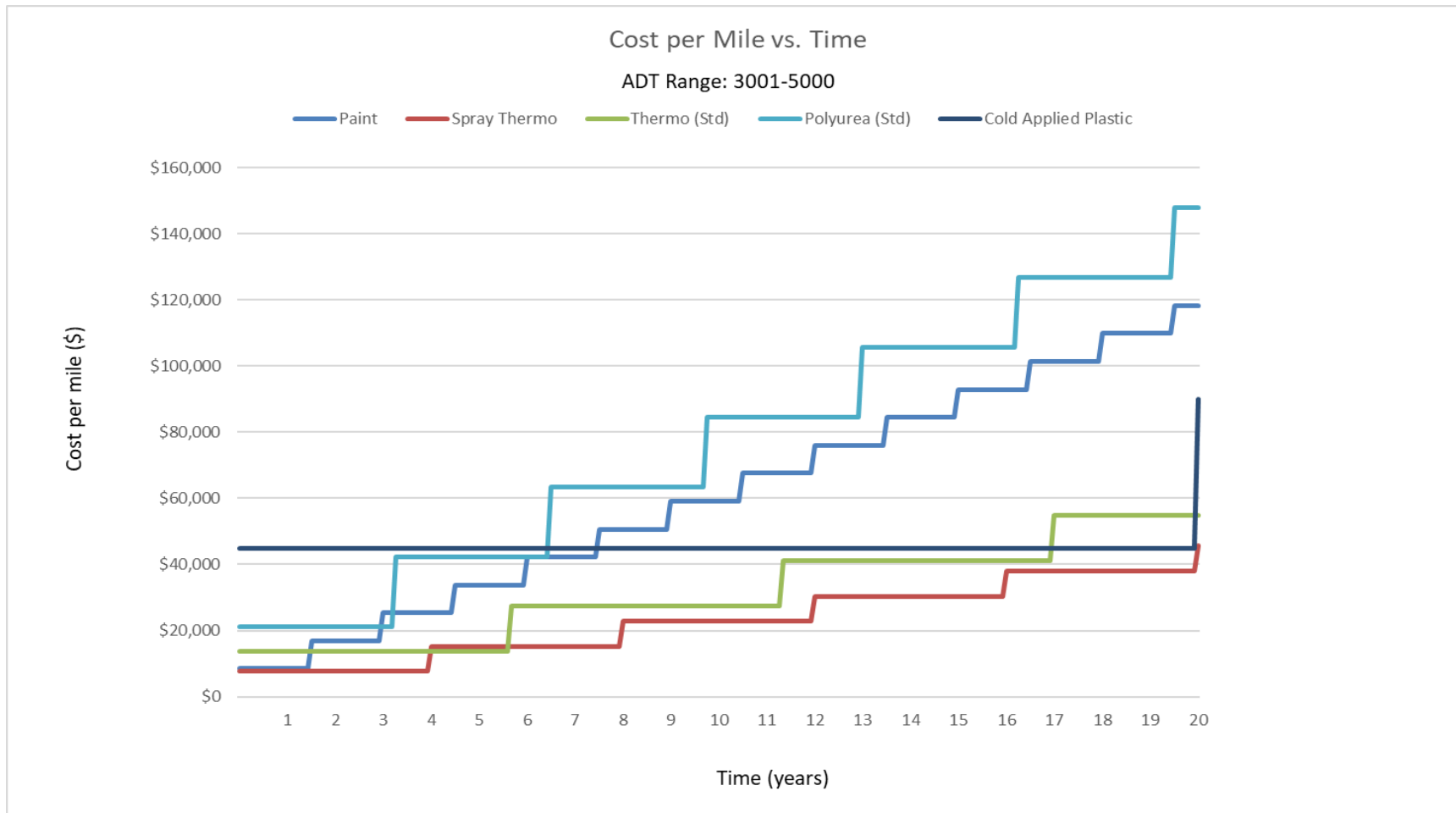
*Spray thermoplastic based off six segments from Division 13 – five NC routes, one secondary route.

Results (ADT Range 1301-3000)



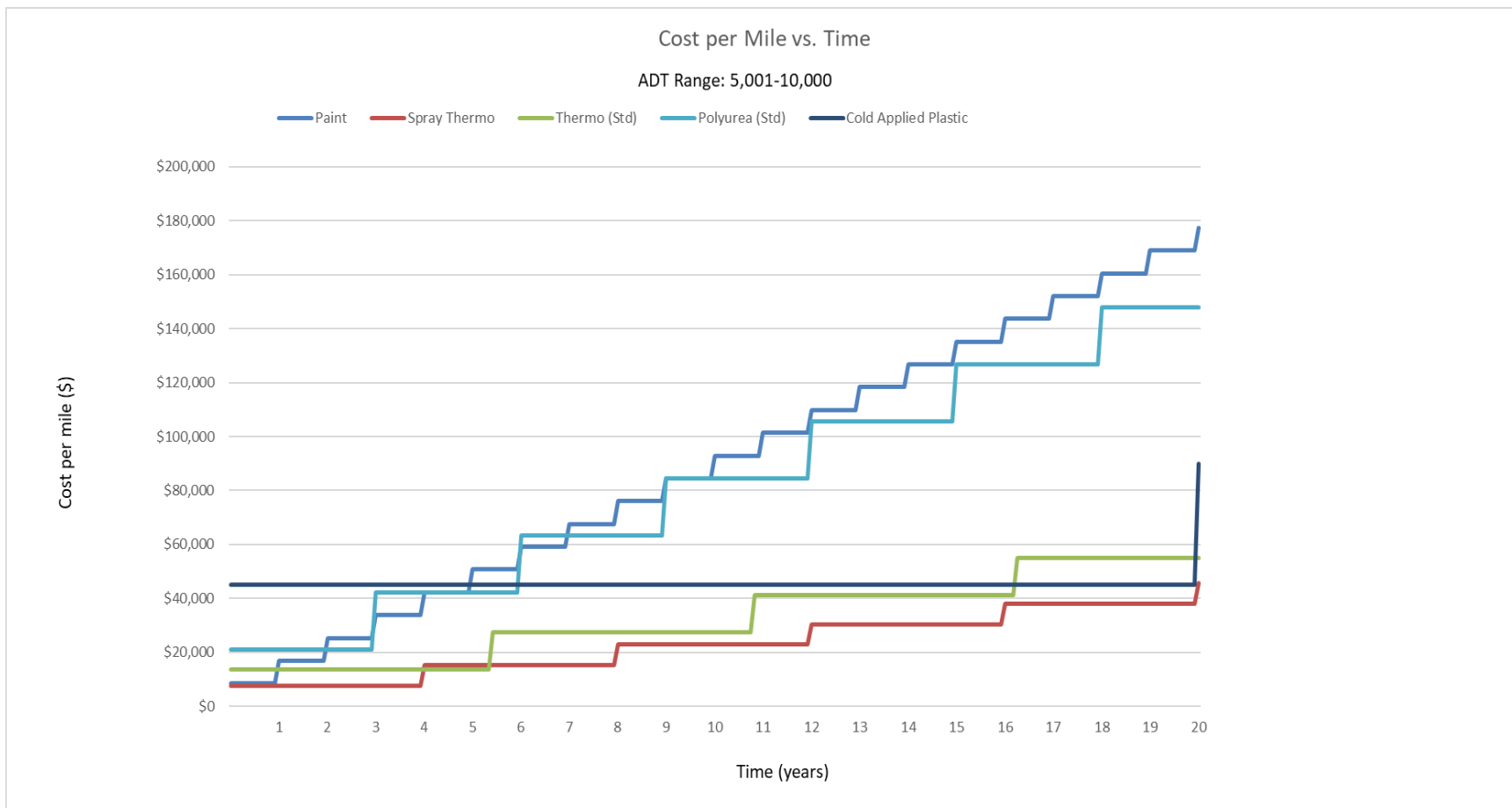
*Spray thermoplastic based off two segments from Division 13 – one US route, one NC route

Results (ADT Range 3001-5000)



*Spray thermoplastic based off three roadway segments in Division 13 – one NC route, two US routes.

Results (ADT Range 5001 -10,000)



*Spray thermoplastic based off two roadway segments in Division 13 – one NC route, one US route.

Summary of Analysis

Material Cost Per Mile at 12 Years

AADT	Paint	Spray Thermo	Thermo (Std)	Polyurea (Std)	Cold Applied Plastic (CAP)
1300	\$51,068	\$30,413	\$41,184	\$84,480	\$44,986
3000	\$59,136	\$30,413	\$41,184	\$84,480	\$44,986
5000	\$76,032	\$30,413	\$41,184	\$84,480	\$44,986
10000	\$109,824	\$30,413	\$41,184	\$105,600	\$44,986

Disclaimer:

- **The data for the spray thermo is limited at this time and includes a limited number of roadway segment samples.** It is still not considered as a long-life pavement marking at this time.
- The appropriate pavement marking material for each individual scenario should be used.

Summary of Analysis

Savings per Year Using Long-Life Markings

Division	ADT Range				Total
	0-1300	1301-3000	3001-5000	5001-10000	
Division 1	\$481,923	\$198,594	\$206,262	\$243,178	\$1,129,957
Division 2	\$123,570	\$56,168	\$62,206	\$103,480	\$345,424
Division 3	\$514,875	\$274,822	\$258,646	\$439,790	\$1,488,133
Division 4	\$90,618	\$50,150	\$45,836	\$56,914	\$243,518
Division 5	\$259,497	\$158,474	\$183,344	\$367,354	\$968,669
Division 6	\$480,550	\$262,786	\$258,646	\$388,050	\$1,390,032
Division 7	\$428,376	\$349,044	\$373,236	\$646,750	\$1,797,406
Division 8	\$788,102	\$353,056	\$291,386	\$543,270	\$1,975,814
Division 9	\$65,904	\$50,150	\$52,384	\$93,132	\$261,570
Division 10	\$214,188	\$98,294	\$94,946	\$269,048	\$676,476
Division 11	\$528,605	\$337,008	\$304,482	\$548,444	\$1,718,539
Division 12	\$337,758	\$244,732	\$297,934	\$563,966	\$1,444,390
Division 13	\$503,891	\$300,900	\$225,906	\$486,356	\$1,517,053
Division 14	\$470,939	\$190,570	\$222,632	\$413,920	\$1,298,061
Total	\$5,288,796	\$2,924,748	\$2,877,846	\$5,163,652	\$16,255,042

Notes:

-Total mileage marked from statewide 2014 data.

-Estimated mileage marked in each Division is based on average percent of 4" paint marking from the past 5 years.

-Estimated mileage marked in each ADT range is a weighted percentage of each Division's total mileage in that range.

-Division 11 – 14 have moderate to heavy snowplowing

Requirements & Options

- Anticipated Federal Requirements
 - The next version of the MUTCD will likely have minimum retroreflectivity values for pavement markings.
 - Our current practices will likely not meet these requirements as a whole on our roadway system.
- Options
 1. Spend more money marking roadways or,
 2. Become more efficient with the money we have by using long-life pavement markings.

Recommendations

- The second option proves to be the most cost effective.
- Immediate Actions
 - Use long-life final markings on all TIP and Resurfacing projects, and in all cases where it is cost effective.
- Future Solutions
 - Use long-life markings on all final applications.
 - This would also lessen worker exposure.

Conclusions

- Exposure
 - The costs in this presentation do not include the increased worker and driver exposure with numerous applications of less durable markings.
 - Both of these are a significant safety factor.
- Expected Results
 - Systematically meet minimum retroreflectivity requirements.
 - Save an estimated \$16,250,000 a year statewide.
 - A majority of these savings will be from the Highway Fund – General Maintenance.
- State Forces
 - Eventually minimize or phase out utilization of state forces for pavement marking operations.

Questions / Comments