Pavement Life Cycle Cost Analysis

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What is LCCA?

- Life-cycle cost analysis is a process for valuating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs, such as maintenance, user, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment.

Source: Transportation Equity Act for the 21st Century

How is it typically done?

- Calculate the initial cost and expected future costs in current dollars.
- Discount the future costs to present value.
- Add it all up.
- Subtract the salvage value of the pavement if the alternatives have different remaining life at the end of the analysis period.
- What is left is the life-cycle cost.

What key factors affect the outcome?

- What standard do you design to?
  - Lowest first cost?
  - Lowest LCCA?
- What will the future costs be?
  - How will the pavement perform?
  - At what point do you do work on pavement?
  - What do you do to it?

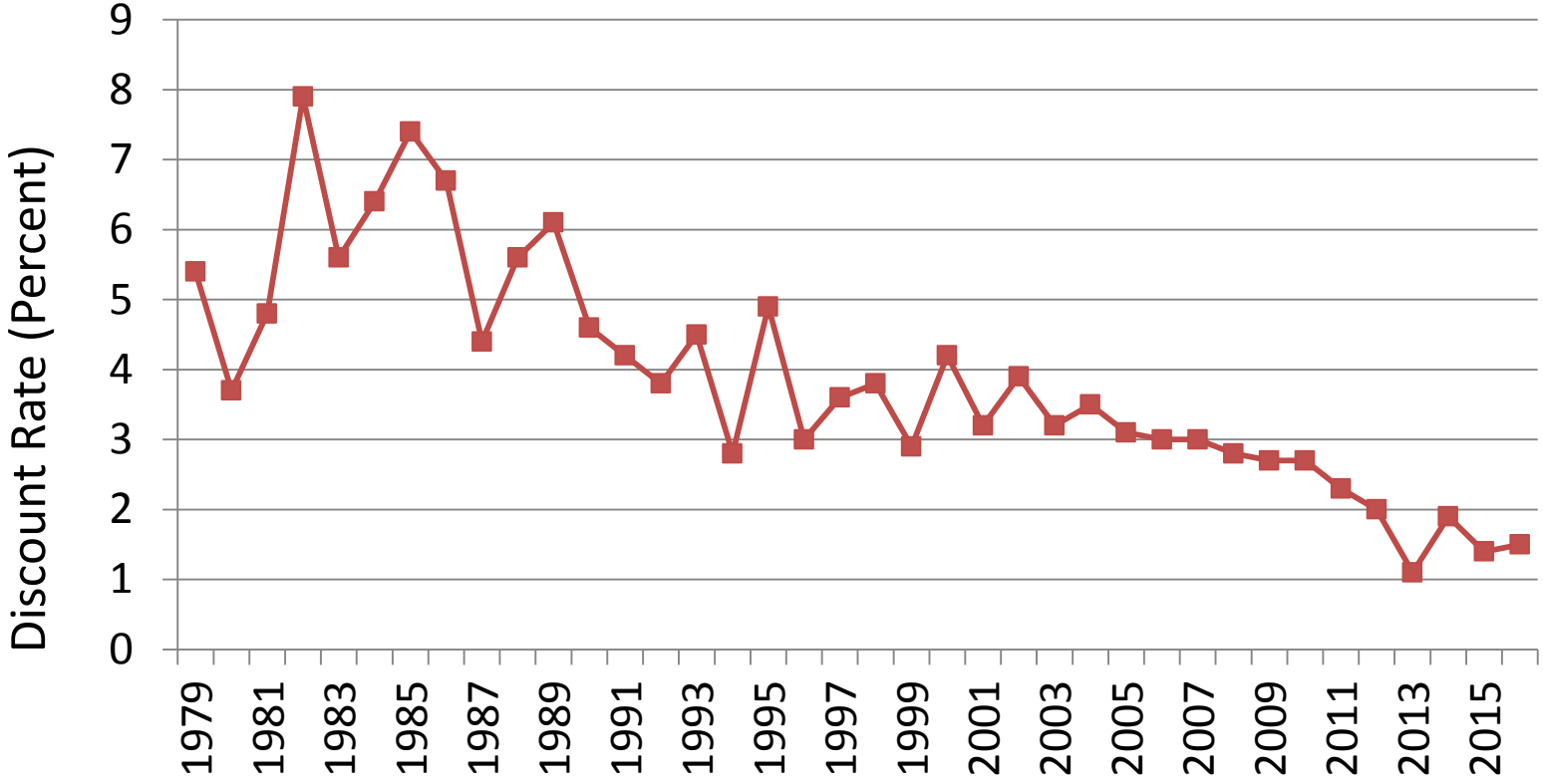
What key factors affect the outcome?

- Once the strategy is decided, a discount rate must be selected to calculate the present value of future costs.
- For many years, most states used 3% to 4% to represent the value of money above inflation.
- This was a reasonable assumption for many years.

What key factors affect the outcome?

- FHWA advises the states to use the current 30-year discount rate issued by the federal Office of Management and Budget (OMB).
- OMB publishes the rate in Circular A-94, which is updated annually.

OMB A-94 30-year discount rate



Simple LCCA example

- Tire A
  - Costs $290
  - Typical Life – 60,000 miles
  - $4.83 per thousand miles
- Tire B
  - Costs $155
  - Typical Life – 30,000 miles
  - $5.16 per thousand miles

Simple LCCA example

- Plan to keep the car for eight more years.
- Annual mileage = 7,500
- Which tire is the better deal?
- Tire A will last until the car is replaced.
- Tire B will require replacement after four years.

Simple LCCA example

- Life-cycle cost of Tire A = $290
- Life-cycle cost of Tire B=
  - Initial cost $155
  - Present value of $155 four years from now at a discount rate of 3.5% = $134.78
  - Life-cycle cost = $155 + $134.78 = $289.78

Problems

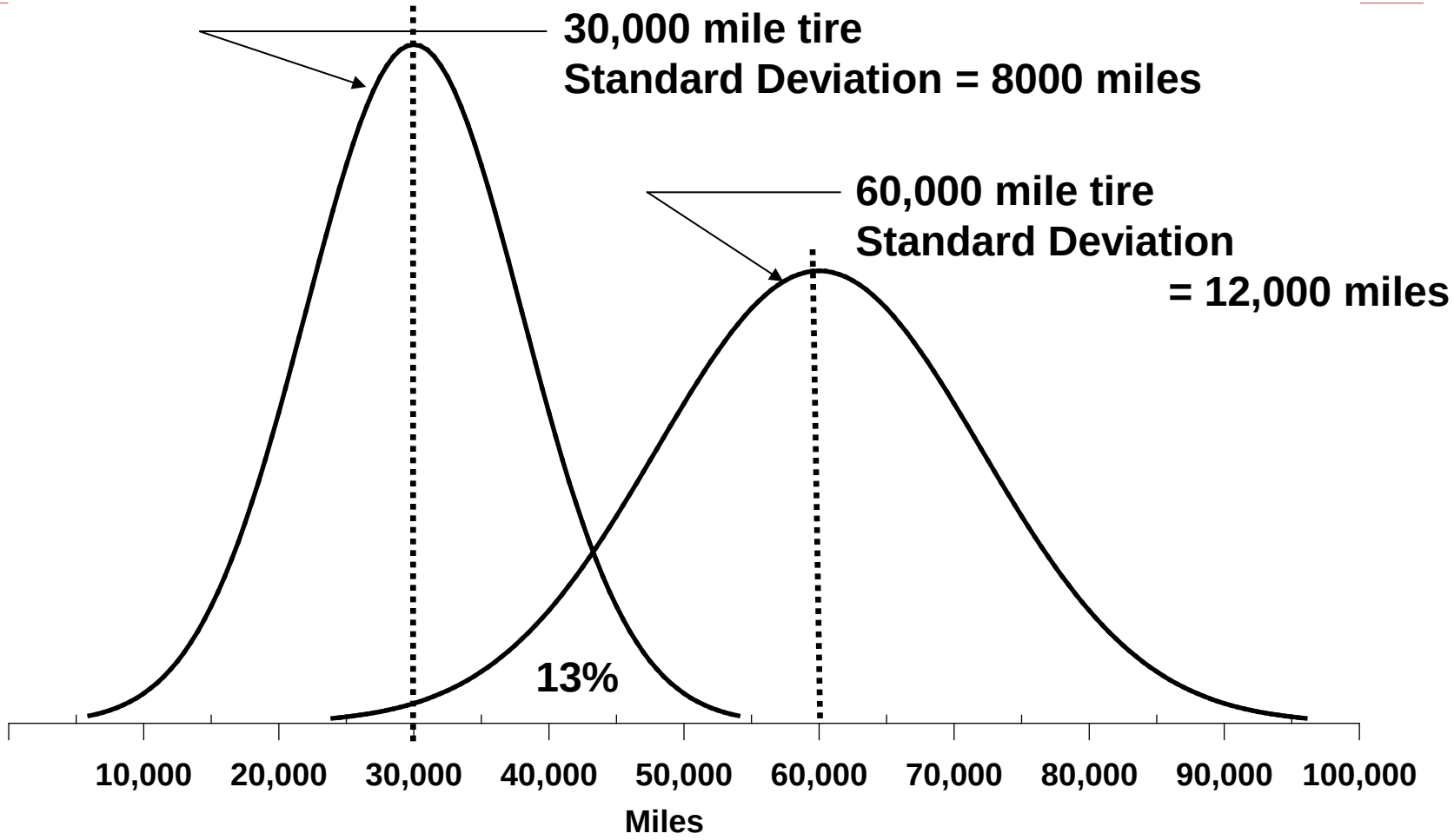
- Will we get *exactly* 60,000 and 30,000 miles of use out of the alternatives?
- How do we define when the tire is worn out?
- Are we sure we aren't going to replace the car sooner or keep it longer than planned?
- Do we have enough money in the bank to afford Tire A?
- Will our annual miles driven remain constant?
- Will our investments earn 3.5% above the inflation rate?
- Will the cost of tires in the future be higher or lower?
- Does Tire A or B offer intangible benefits (better fuel economy, more traction, less noise)?

LCCA resources

Probabilistic LCCA

- The traditional way of performing LCCA is called *deterministic.*
- The new way is called *probabilistic.*
- Probabilistic LCCA assigns variables a probability distribution rather than a single value.

Probabilistic LCCA



How do we handle multiple probabilities?

- Monte Carlo Simulation –
  - Use software to "roll the dice" for each random variable.
  - Repeat hundreds to thousands of times.
  - Observe the distribution of combined outcomes to determine the global probabilities.

FHWA Realcost software

https://www.fhwa.dot.gov/infrastructure/asstmgmt/lccasoft.cfm

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Life-Cycle Cost Analysis Software

Thank you for your interest in the FHWA's pavement design life-cycle cost analysis software product. This software provides a tool to perform LCCA for pavement selection in accordance with FHWA best practice methods. These best practices are outlined in the FHWA's "Life-Cycle Cost Analysis Primer," and the software methodology is fully documented in the FHWA's "Life-Cycle Cost Analysis Technical Bulletin," publication number FHWA-SA-98-079. Both of these documents are available in electronic format on the FHWA's LCCA website (http://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.cfm).

The version currently in production is Realcost 2.5.

The following compressed files contain the setup programs for the described versions of RealCost. These products are in Microsoft Excel spreadsheets with additional Visual Basic for Applications code to provide the graphic user interface. To use this software, you must have MS Excel 2000, or a more recent version. To install this product to your computer:

1. Save the zip file to your hard drive, Version 2.5 (.zip, 7.7 mb)
2. Unzip the file
3. Run the resulting file, LCCA Setup.exe
4. Additionally, **ensure that MS Excel macro security is set to medium or low** - you must choose to allow macros to run for this product to perform properly.

- User's Manual

Contact

- **Siva Sivaneswaran**
  Office of Research, Development and Technology
  202-493-3147
  E-mail Siva

Pavement example

- 4-lane rural highway, new location
- Project length is six miles
- Initial ADT predicted at 11,000, 8% trucks
- 20 year ADT predicted at 16,000

Pavement alternatives

Rigid Alternative

- 9” Jointed Plain PCC
- Geosynthetic Separator
- 6” Cement Treated Base

Flexible Alternative

- 110 psy Open Graded
- 200 psy HMA Surface
- 250 psy HMA Intermediate
- 450 psy HMA Base
- 8” Unbound Aggregate Base

Flexible rehab schedule

- 1 – Initial Construction
- 2 – Mill 1”, Replace OGFC
- 3 – Mill 1”, Replace OGFC
- 4 – Mill 3”, Replace HMA Surface and OGFC
- 5 – Mill 1”, Replace OGFC

Flexible service/structural life

Expected Service/Structural Life			
	Low	Expected	High
Initial Construction	8/16	10/20	12/24
OGFC Replacement	8/8	10/10	12/12
OGFC and Surface Replacement	8/16	10/20	12/24

Flexible delay time

Construction Days			
	Low	Expected	High
Initial Construction	NA	NA	NA
OGFC Replacement	16	20	49
OGFC and Surface Replacement	26	34	80

Rigid rehab schedule

- 1 – Initial construction
- 2 – Patch 2%, grind, clean and reseal joints
- 3 – Patch 2%, grind, clean and reseal joints
- 4 – CPR plus overlay with 510 psy HMA
- 5 – Mill 1”, Replace OGFC

Rigid service/structural life

Expected Service/Structural Life			
	Low	Expected	High
Initial Construction	18/25	24/35	32/45
PCC restoration	8/8	10/10	12/12
Overlay PCC	8/16	10/20	12/24

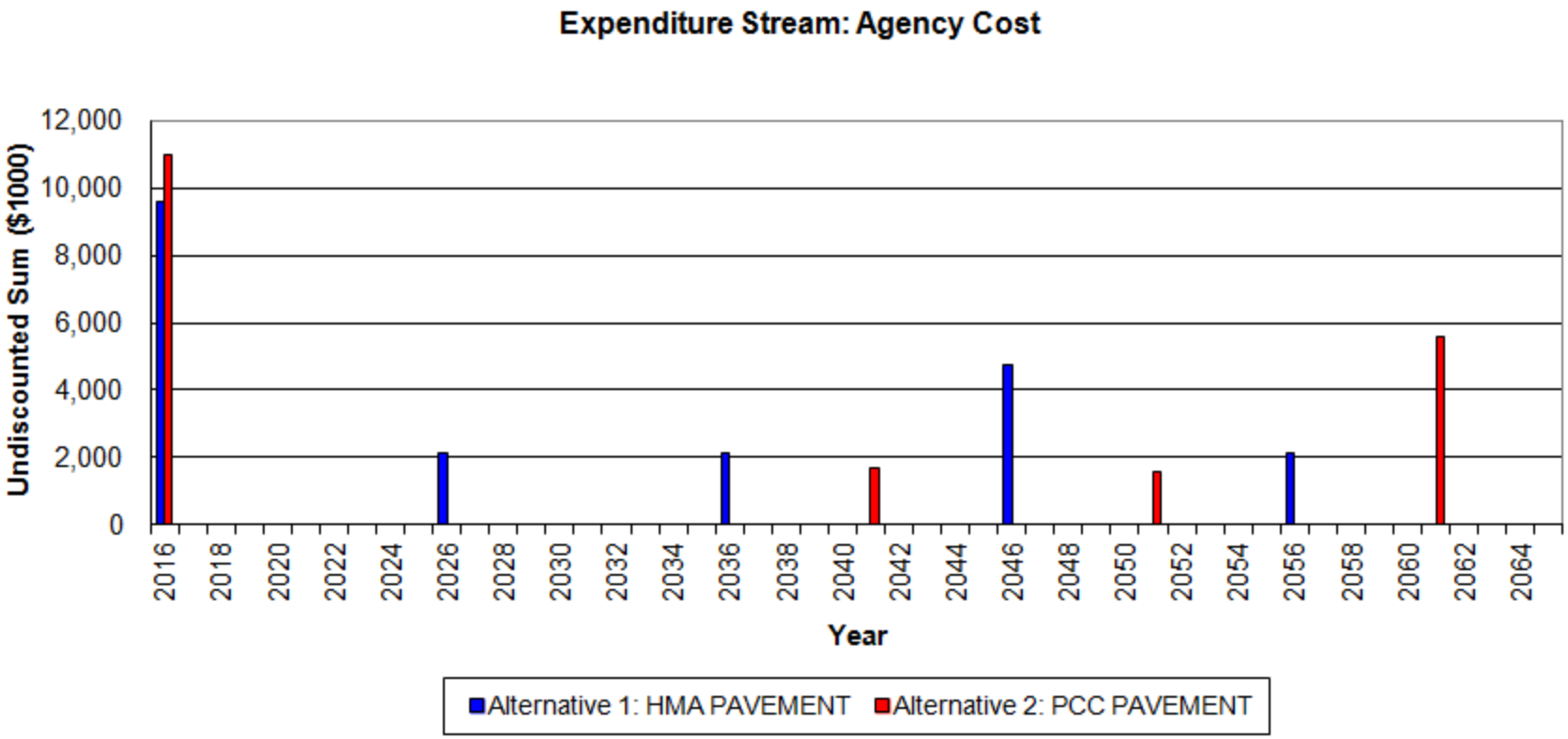
Rigid delay time

Construction Days			
	Low	Expected	High
Initial Construction	NA	NA	NA
PCC restoration	25	30	50
Overlay PCC	42	52	103

Typical SC 2015 prices (YMMV)

Item Number	Bid Item	Unit	Wt. Avg Mean	StdDev	Low Bid	High Bid	Low	High
3081090	8" GAB	SY	$ 8.00	$ 6.00	$ 7.50	$ 12.00	$ 7.50	$ 12.00
3100310	HMA Base Type A	Ton	$ 54.00	$ 22.00	$ 33.00	$ 68.00	$ 33.00	$ 68.00
4011004	PG 64-22	Ton	$ 450.00	$ 86.61	$ 225.00	$ 1,000.00	$ 276.78	$ 623.22
4011008	PG 76-22	Ton	$ 649.00	$ 35.00	$ 640.00	$ 685.00	$ 640.00	$ 685.00
4013200	Mill Asph. 2"	SY	$ 1.50	$ 3.09	$ 0.85	$ 18.50	$ 0.85	$ 7.68
4013010	Surface Plane 1"	SY	$ 1.20	$ 2.16	$ 0.90	$ 7.25	$ 0.90	$ 5.52
4030320	HMA Intermediate Type B	Ton	$ 46.93	$ 25.73	$ 34.00	$ 66.00	$ 34.00	$ 66.00
4030340	HMA Surface Type C	Ton	$ 44.27	$ 32.22	$ 32.04	$ 225.00	$ 32.04	$ 108.71
4030310	HMA Surface Type A	Ton	$ 55.99	$ 19.50	$ 49.00	$ 76.00	$ 49.00	$ 76.00
4092000	OGFC	Ton	$ 74.50	$ 14.93	$ 55.00	$ 92.35	$ 55.00	$ 92.35
	9" PCC	SY	$ 37.00	$ 7.00	$ 28.00	$ 45.00	$ 28.00	$ 45.00
	Drainage Fabric	SY	$ 2.50	$ 1.00	$ 1.50	$ 3.50	$ 1.50	$ 3.50
3050106	CSAB 6"	SY	$ 15.00	$ 2.30	$ 13.00	$ 19.00	$ 13.00	$ 19.00
5021025	FD Concrete Patch - 9"	SY	$ 175.07	$ 65.03	$ 97.59	$ 275.00	$ 97.59	$ 275.00
5032000	Diamond Grind	SY	$ 1.33	$ 1.28	$ 1.00	$ 3.51	$ 1.00	$ 3.51
5041100	C&S Long. Jts.	LF	$ 0.71	$ 0.39	$ 0.55	$ 1.10	$ 0.55	$ 1.10
5041300	C&S Trans. Jts.	LF	$ 1.21	$ 0.45	$ 0.65	$ 1.73	$ 0.65	$ 1.73

Deterministic agency expenditure stream



Deterministic results

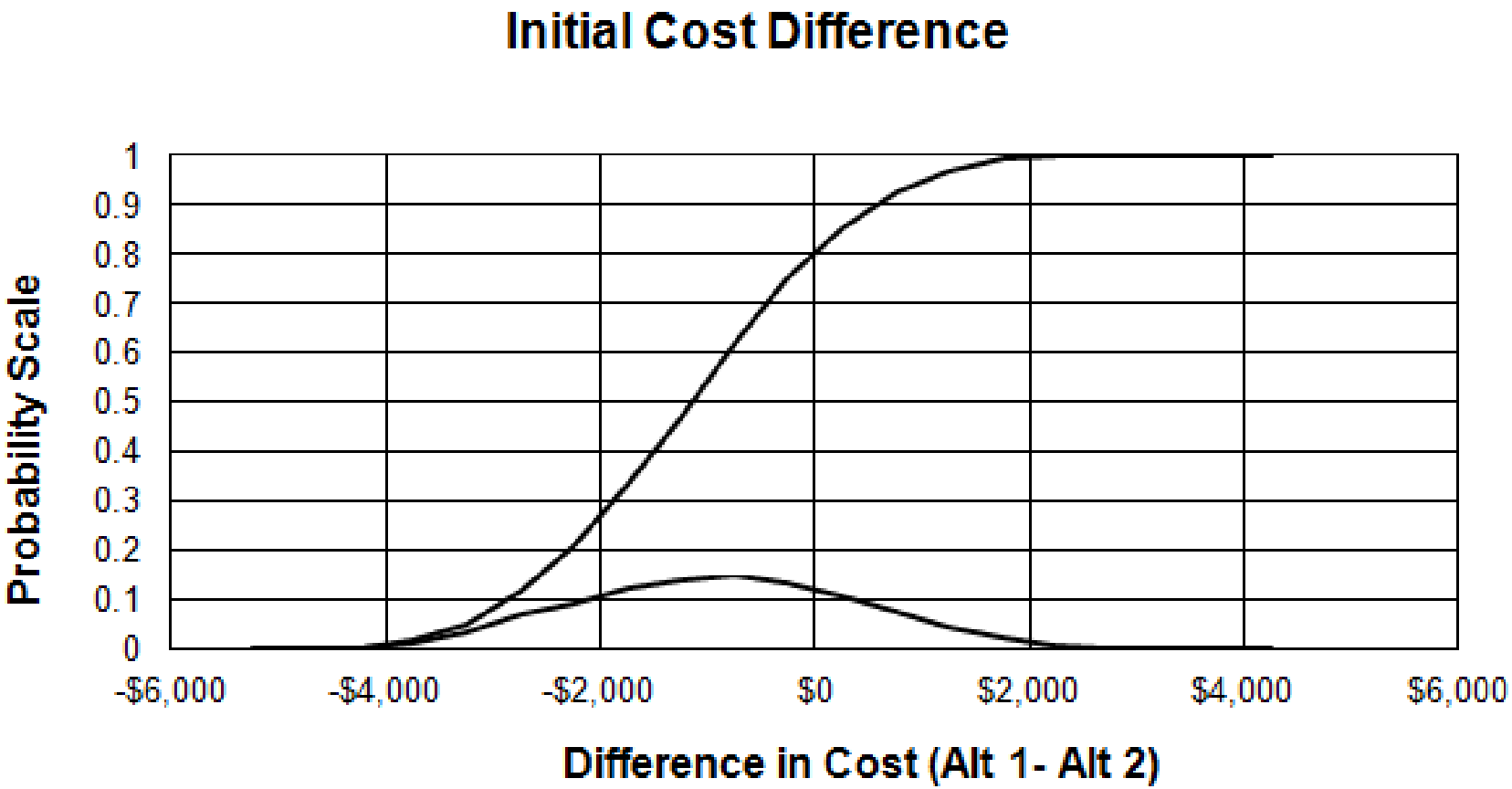
Total Cost	Alternative 1: HMA PAVEMENT		Alternative 2: PCC PAVEMENT	
	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)
Undiscounted Sum	*$20,740.05*	*$895.30*	*$15,613.11*	*$782.19*
Present Value	**$17,227.92**	**$601.17**	**$13,905.13**	**$493.15**
EUAC	$492.23	$17.18	$397.29	$14.09

Lowest Present Value Agency Cost	Alternative 2: PCC PAVEMENT
Lowest Present Value User Cost	Alternative 2: PCC PAVEMENT

Probabilistic results

Probabilistic Comparison						
	Alternative 1: HMA PAVEMENT			Alternative 2: PCC PAVEMENT		
Total Cost (Present Value)	Agency Cost ($1000)	Initial Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	Initial Cost ($1000)	User Cost ($1000)
Mean	$19,030.53	$10,223.65	$516.31	$14,355.05	$11,124.59	$472.80
Standard Deviation	$1,348.12	$817.64	$79.20	$1,187.83	$948.88	$73.49
Minimum	$14,905.56	$8,154.34	$332.19	$11,132.15	$8,825.56	$273.56
Maximum	$23,876.58	$12,474.10	$811.92	$18,080.59	$13,329.86	$716.81

Probabilistic results



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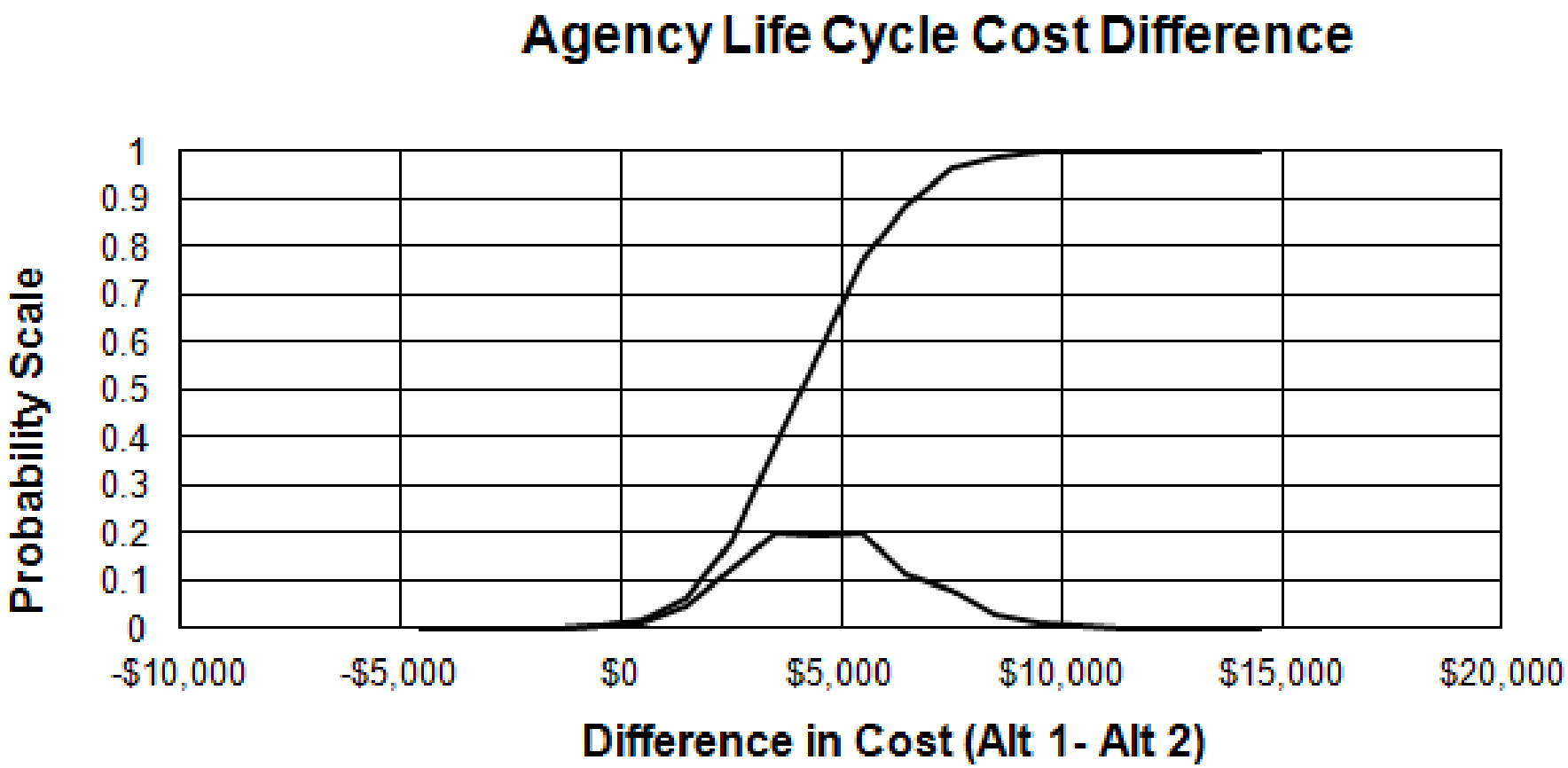

Probabilistic results

Probability Alt 2 LCC Cost > Alt 1	0.2%	Probability Alt 1 LCC Cost > Alt 2	99.8%
Probability Alt 2 LCC Cost > Alt 1 by 10%	#N/A	Probability Alt 1 LCC Cost > Alt 2 by 10%	96.8%
50th Percentile Initial Cost difference	$909.53	85th percentile Initial Cost difference	$2,263.45

Thank you!

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