

### Development of New Life Cycle Cost Modeling

OTE

*<u>The University of Oklahoma</u>* Dominique Pittenger, AC Doug Gransberg PhD, PE \*\*

Musharraf Zaman, PhD, PE Caleb Riemer, PE \*\* Currently with Iowa State University



### **Project Objective**

- Conduct a comparative field evaluation of common methods to restore skid resistance
  - Surface treatments

- Mechanical methods
- 23 asphalt and concrete test sections
  - Monthly testing of skid and macrotexture
  - Result will be deterioration models for each treatment
- Complete a life cycle cost analysis of each method in the study

### **Test Section Sponsors**

- Blastrac, Inc. Edmond, OK
- Penhall Diamond Grinding, Anaheim, CA
- JLT Corp. Cushing, OK

- Ergon Emulsions and Materials, Austin, TX
- Skidabrader, Inc. Ruston, LA
- Polycon, Madison, MS
- Haskell Lemon & Hall Brothers, OKC, OK
- Pathway Services, Tulsa, OK
- Calumet Lubricants, Shreveport, LA



# **Background and Motivation**

- ODOT latest APP: transportation system preservation - critical part of mission
- Economic Analysis: vital transportation decisionmaking component (sustainability)
- Substantial issues with LCCA theory when applied to preservation.



Sustainability - Triple Bottom Line, (AASHTO, 2009)



### **Current LCCA in Transportation**

Recommended by FHWA

- Limited application due to complexity
- Very sensitive to discount rate & analysis period
- Limited at project/implementation level
- No specific LCCA/PPT adapted tool
- Network-level LCCA tool (FHWA CASE STUDIES):
   not applied to PPT or needs to be customized for PPT
- Economic analysis tools still being developed (FHWA, 2007)
- No consensus among SHAs
- SHA to develop own tools (Hall et al, 2003)
  - PPT alternatives, SL, cost and productivity data







 Treatment cost-effectiveness evaluation based on engineering economic principles

#### FHWA LCCA procedures:

- 1. Establish design alternatives [and analysis period]
- 2. Determine [performance period and] activity timing
- 3. Estimate costs [agency and user]
- 4. Compute [net present value] life cycle costs
- 5. Analyze results
  - 6. Reevaluate design strategies



#### **OTC** Net Present Value AP Selection Methods

- 1. Establish [PPT] alternatives and analysis period: NPV: analysis period = a common period for all alternatives
- set AP equal to the shortest life among alternatives
- set AP equal to the longest life among alternatives
- set AP equal to the least common multiple of the lives of the various alternatives
- use a standard AP, such as 10 years
- set the AP equal to the period the best suits the organization's need for the investment
- use an infinitely long AP

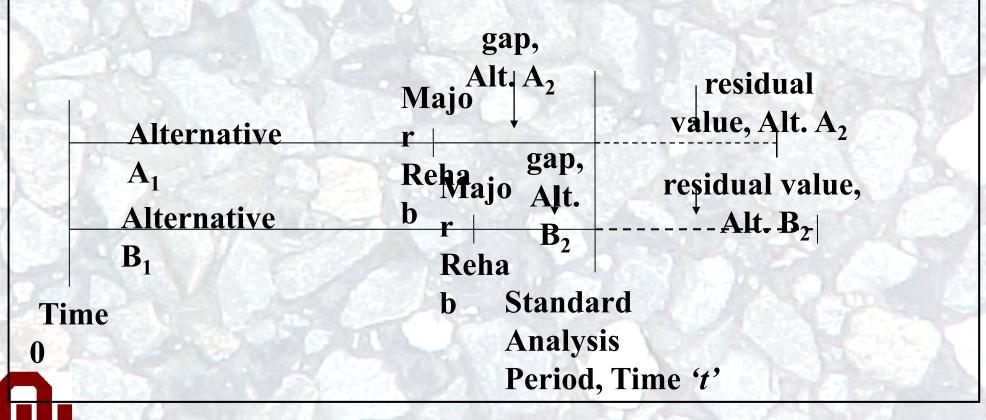
(White et al, 2010)



### FHWA LCCA procedure

1. Establish design alternatives [and analysis period]

OTE



Standard Analysis Period, One Major Rehabilitation Accommodated

### LCCA



### adapted to PPT alternative evaluation

Equivalent Uniform Annual Cost LCCA procedures:

- 1. Establish design alternatives
  - [SL<sub>alt</sub> = analysis period<sub>alt</sub>]
- 2. Determine [performance period and] activity timing [SL<sub>alt</sub> = MIN{microtexture, macrotexture, expected}]
- 3. Estimate costs [agency and user]
- 4. Compute [EUAC] life cycle costs

 $[EUAC(i\%)_{alt} = [\Sigma P] [i(1+i)n \div (1+i)n -1)]]$ 

• 5. Analyze results

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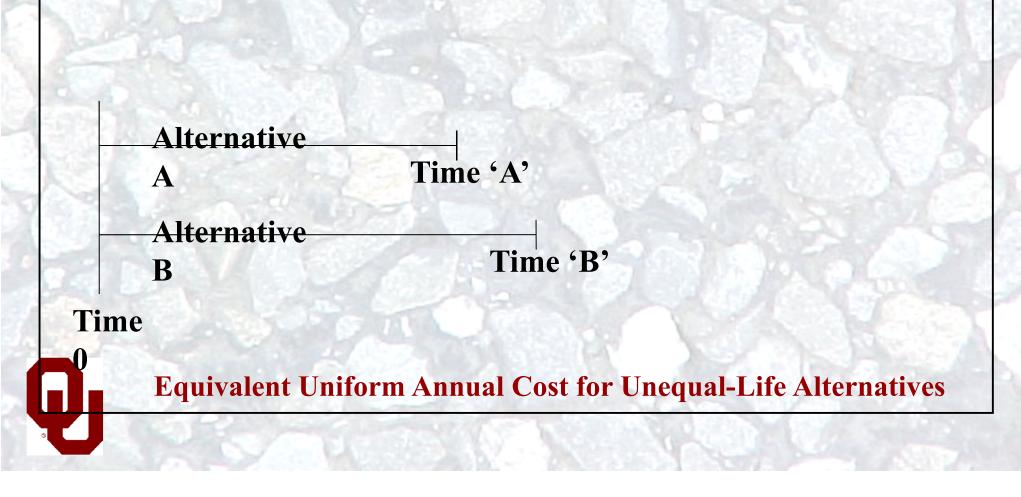
6. Reevaluate design strategies



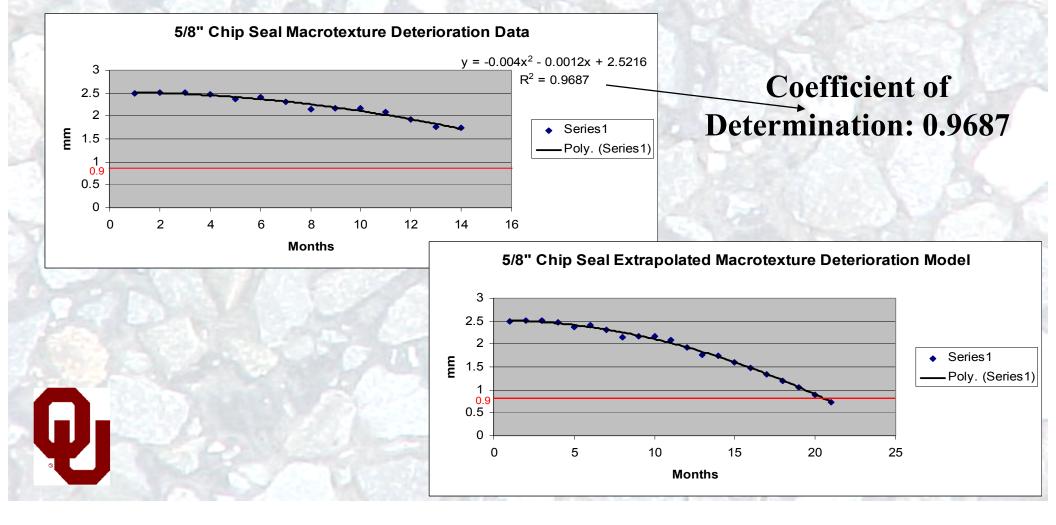
# **OTC** Equivalent Uniform Annual Cost (EUAC)

1. Establish design alternatives

[Analysis period<sub>alt</sub> = SL<sub>alt</sub>]



# CTC Engineering Technical Data 2. Determine [performance period and] activity timing [SL<sub>alt</sub> = MIN{microtexture, macrotexture, expected}] Field Trial Deterioration Models – Macrotexture, chip seal



### **EUAC for PPT evaluation**

2. Determine [performance period and] activity timing [SL<sub>alt</sub> = MIN{microtexture, macrotexture, expected}]

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		Service	Life (years)	
<b>Pavement Preservation Treatment</b>	Microtexture	Macrotexture	ODOT & Lit. Review	Minimum
1" Hot Mix Asphalt Mill & Inlay (HMA)	> 10	N/A	10	10
Open Graded Friction Course (OGFC)	> 10	5.3 years	10	5.3
5/8" Chip Seal	3.8	1.8	5	1.8
Pavement Retexturing, Abrading	>5	N/A	2	2
Pavement Retexturing, Shotblasting	>5	N/A	2	2

**Treatment Service Life Based on Extrapolated Field Data** 

### **PPT EUAC Model**



### 4. Calculate EUAC, (Continuous Mode) [SL<sub>alt</sub> = MIN{microtexture, macrotexture, expected}]

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### **OTC** EUAC (Continuous Mode) Sensitivity Analysis



### 4. Calculate EUAC, (Continuous Mode) [SL<sub>alt</sub> = MIN{microtexture, macrotexture, expected}]

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#### EUAC (Continuous Mode) Sensitivity Analysis



4. Calculate EUAC, (Continuous Mode)

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[SL<sub>alt</sub> = MIN{microtexture, macrotexture, expected}]

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#### (same ranking as NPV, various AP)

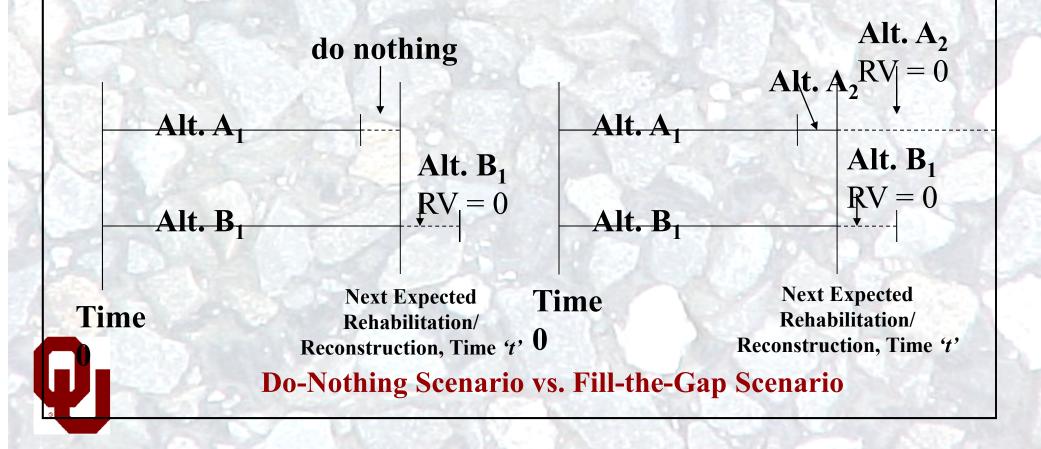
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### EUAC Terminal Mode

#### 1. Establish design alternatives

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[analysis period<sub>alt</sub> = SL<sub>alt]</sub>



### **EUAC**

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#### **Terminal Mode, Expected or Truncated SL**

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2	PAVEMENT TYPE TREATMENT SERVICE LIFE Service Life
4	1 Bituminous A ODOT Standard 5/8" chip seal 5 5
5	2 Concrete B Open Graded Friction Course (OGFC) 10 6
6	C 1" Hot Mix Asphalt mill & inlay (HMA) 10 6
7	
8	
9	
10	
	Construction
11	ALTERNATE # PAVEMENT DESCRIPTION Days**
12	1 : 1 A Bituminous ODOT Standard 5/8" chip seal 0.20 **Days traffic impacted during
13	2 : 1 B Bituminous Open Graded Friction Course (OGFC) 0.20 initial construction project
14	3 : 1 C Bituminous 1" Hot Mix Asphalt mill & inlay (HMA) 0.28 From "Quantity" Worksheet
15 16	4 : 1 D Bituminous 5 : 1 E Bituminous
10	6 : 1 F Bituminous
18	
19	
20	1.18 DISCOUNT RATE = 4 %
21	
-	Years until next Rehabilitation/Reconstruction 6
23 24	
25	
I4 4	NOKPPT \ Setup / UserDelay / Dimension / Quantity / InitialConst. / Bit.Maint. / Bit.Maint. Working Days / Con.Maint. / Con.Maint. Working Days / LifeCycleCost / #
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### OTE



#### Terminal Mode, Expected or Truncated SL

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1			U	U	E	F	
2	ALT #		Maintenance	User Delay	Annual Total		
3							
4	1	2,799	609	243	3,651		
5							
6	2	5,036	517	206	5,759		E
7	3	5,372	517	235	6,124		
8	5	5,572	517	200	0,124		
10							
11							
12							
13							
14							
15							
16 17	ALT #	Description		EUAC	Rank	ifference	
18		Description		20/10		incrence	Intial Cost, SL:
19	1	Bituminous		3,651	1		
20		ODOT Standard 5/8" chip s	eal				Chip seal: \$12.5 k, 5y
21	2	Bituminous		5,759	2	57.73%	
22		Open Graded Friction Cours	se (OGFC)				(expected)
23	3	Bituminous		6,124	3	67.73%	× • /
24		1" Hot Mix Asphalt mill & inla					OGFC: \$26,5 k, 6y
14 4	F HX	UserDelay / Dimension / Quantity / Init	ialConst. / Bit.Maint. /	Bit.Maint.Working Days	/ Con.Maint. / Con	.Maint.Working	Days / LifeCycleCost Alt.Com. / CALCS
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### Conclusions

OTE

- Economic + engineering data can be correlated to produce meaningful, standardized economic and life cycle cost analysis (LCCA) information that would assist pavement managers in selecting an alternative that would yield extended service lives of Oklahoma pavements.
- EUAC is the most efficient, appropriate vehicle for determining PPT (short-term) cost effectiveness

EUAC: treatment-relevant input, pavement managerrelevant output