

ASSOCIATION RULE-BASED LCCA MODEL FOR PAVEMENT PROJECTS

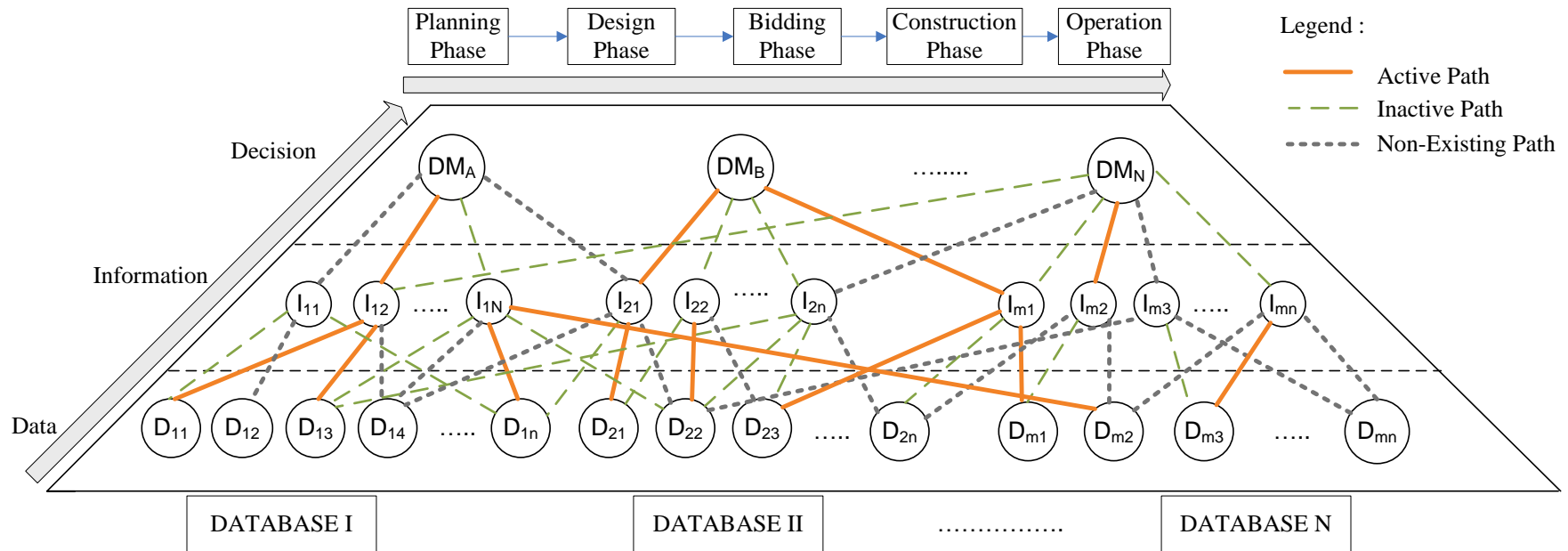
April 16, 2012

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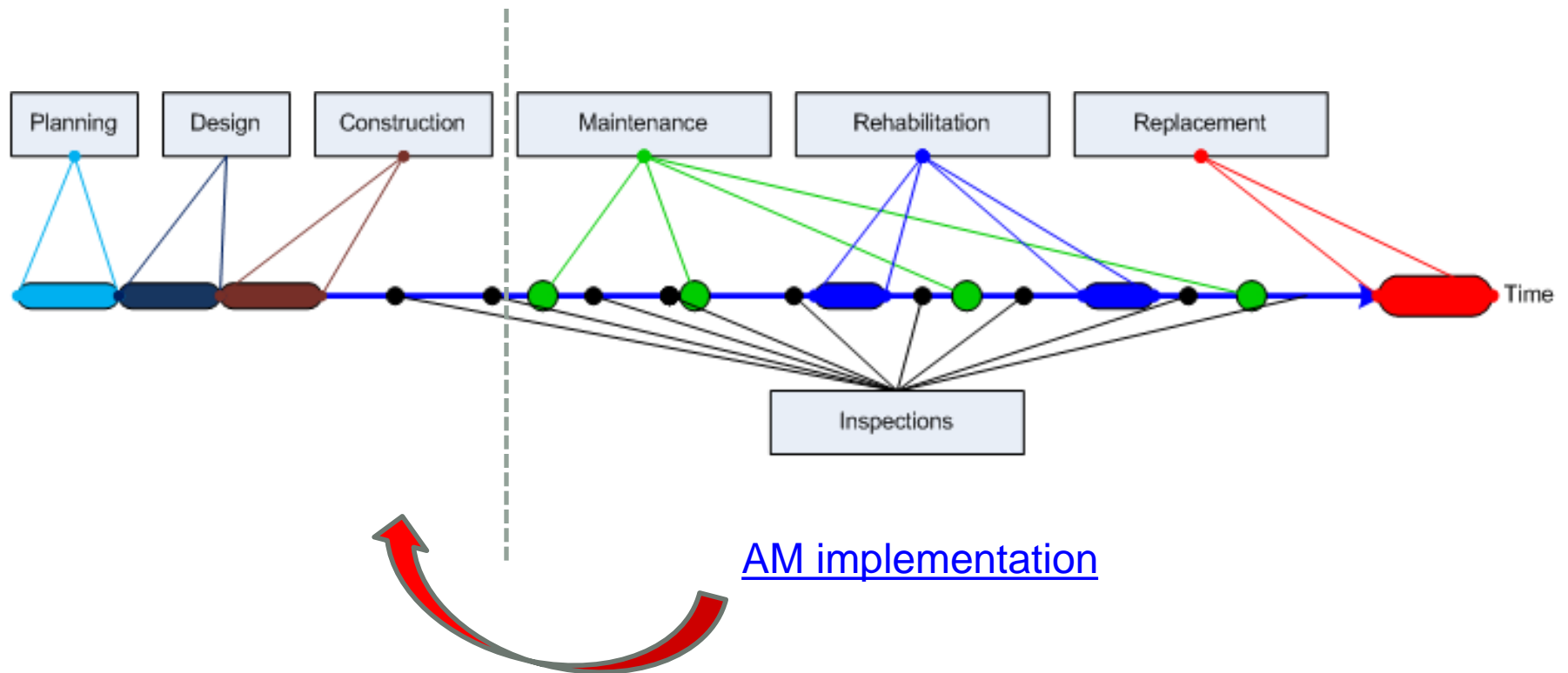
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Data – Information – Decision Making



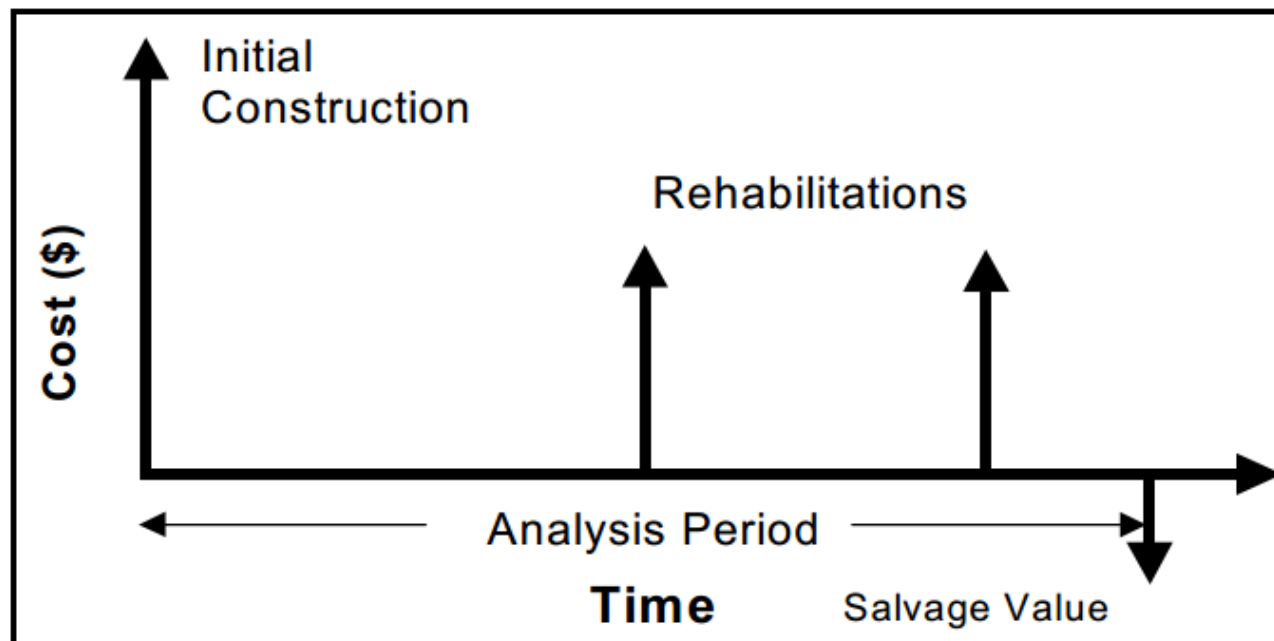
Power to the Owners!



Introduction

What is Life-Cycle Cost Analysis (LCCA)?

- Life-cycle cost analysis (LCCA) is an engineering economic analysis technique for evaluating the total worth of a usable project segment over its life (*Transportation Equity act for the 21st Century*).
- Expenditure stream diagram to calculate Net Present Value.



Why LCCA?

- Which pavement type is the most cost-effective in the long run?

Concrete

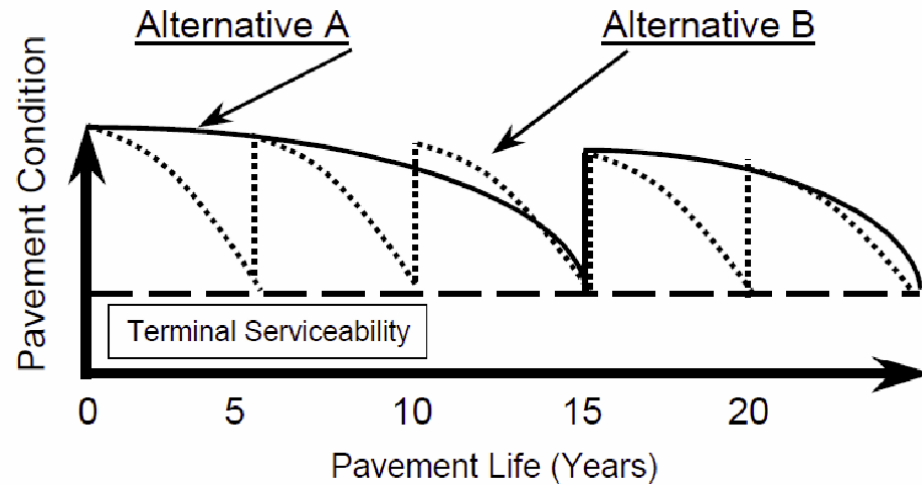


Asphalt



Unknown Future Performance

- Different pavement types have different future performance.



- Fair environment for competition.



Alternate Bidding Model

- Incorporates the LCC of alternative types into the bid competition.

$$\text{Total Bid Price} = A + L$$

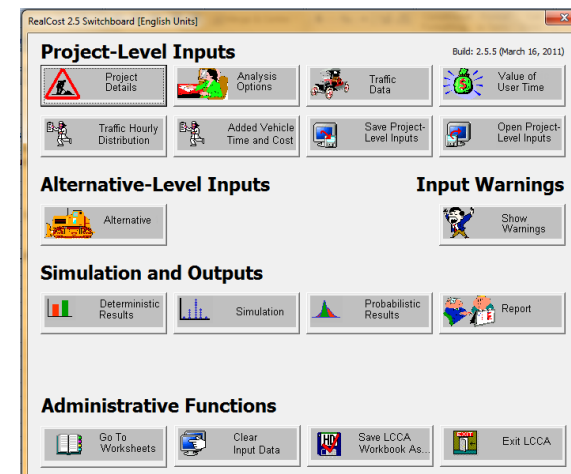
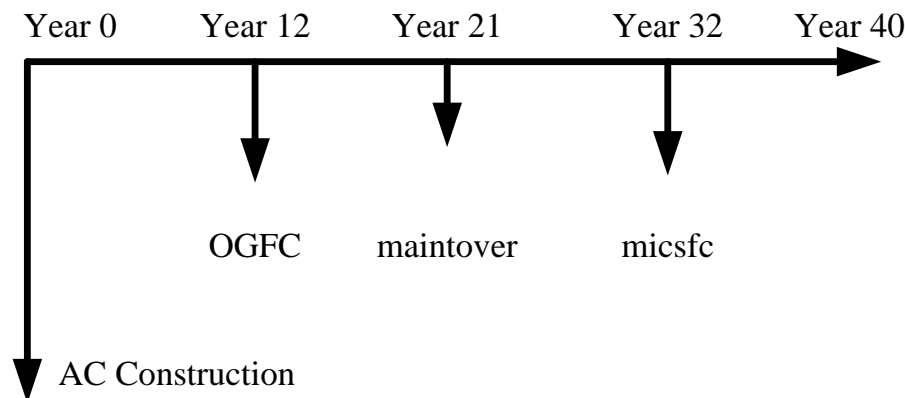
Contractor's base bid

Represents the life cycle
cost of the alternative

Calculated by the Agency

Current LCCA Practice

- Typically, State Highway Agencies perform LCCA using RealCost software.
- Only one treatment strategy can be defined for LCCA.
- Even though the uncertainty in the timing of and associated costs of treatments can be incorporated in the analysis, the sequence of activities is fixed.



Motivation to Develop a New LCCA Model

- Life-cycle cost is critically important during pavement type selection process.
- There is no consensus between industries on the current LCC models.
- “Past behavior and performance, predicts future behavior and performance.” (http://www.uwec.edu/career/online_library/behavioral_int.htm)
- Historical sequential patterns in pavement treatment dataset are utilized to develop a realistic LCCA model.

Association Rules Mining

- Expressed by “if-then” statements, show the attributed value conditions that occur frequently together in a given data set.
- Specify which events are likely to occur together.

Is bread typically purchased with bananas?

Is Ketchup purchased when charcoal and lighter are purchased together?



What should be in the basket but is not?

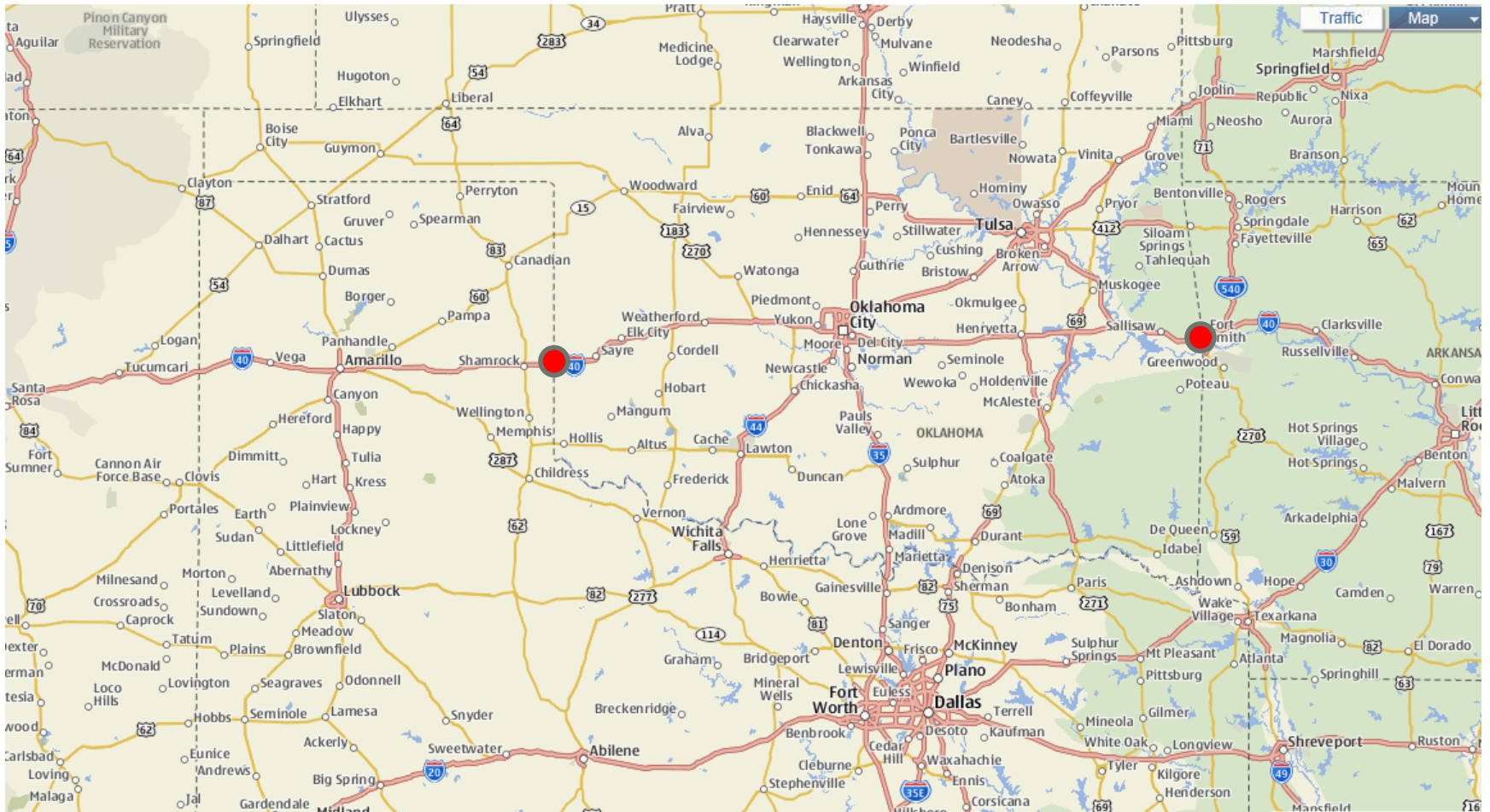
How do the demographics of the neighborhood affect what customers buy?

Research Questions

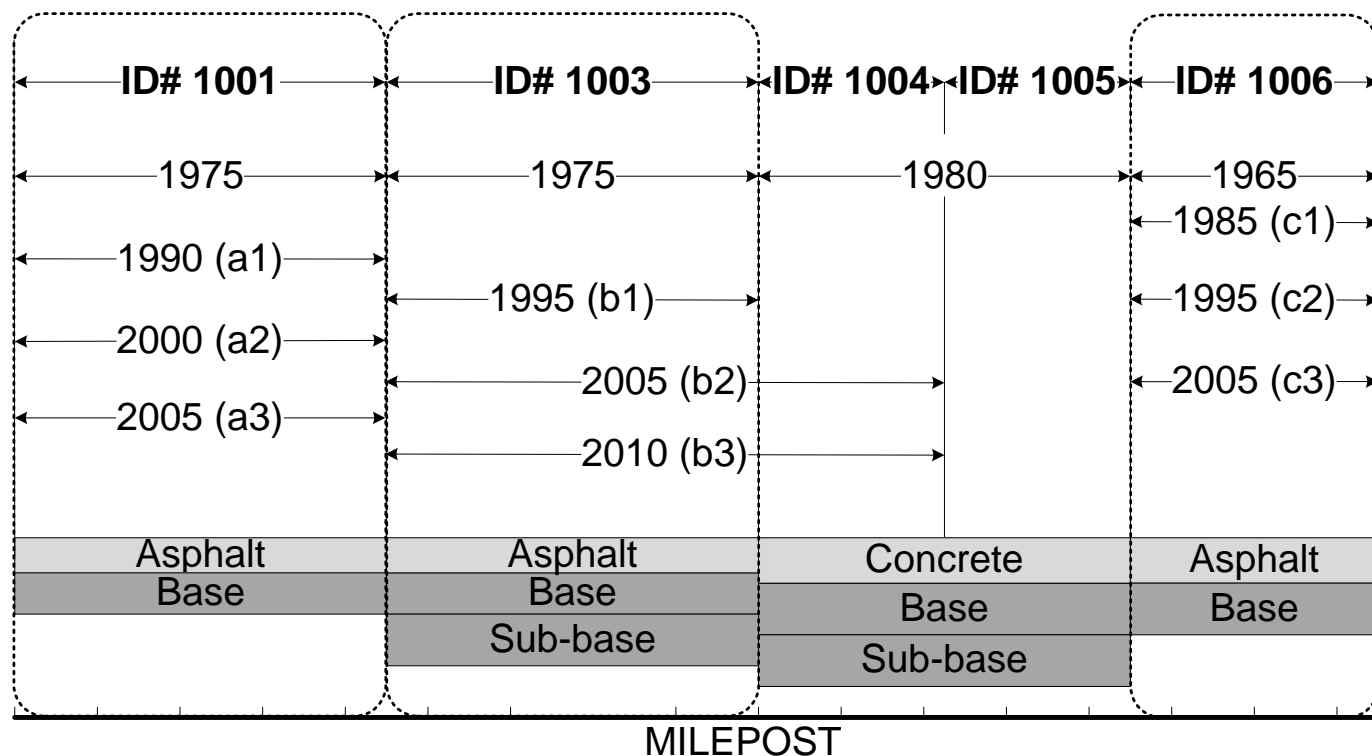
- What types of treatment are likely to occur together?
- When a highway is treated by OGFC, what type of treatment is likely to occur next?

Realistic Life-Cycle Cost Models

I40 - Oklahoma



Data Preparation (1)



Interstate 40 Structural Pavement History Dataset

- Original pavement type
- Original pavement construction year
- Treatment history

Data Preparation (2)

- Developing a dataset in transaction format

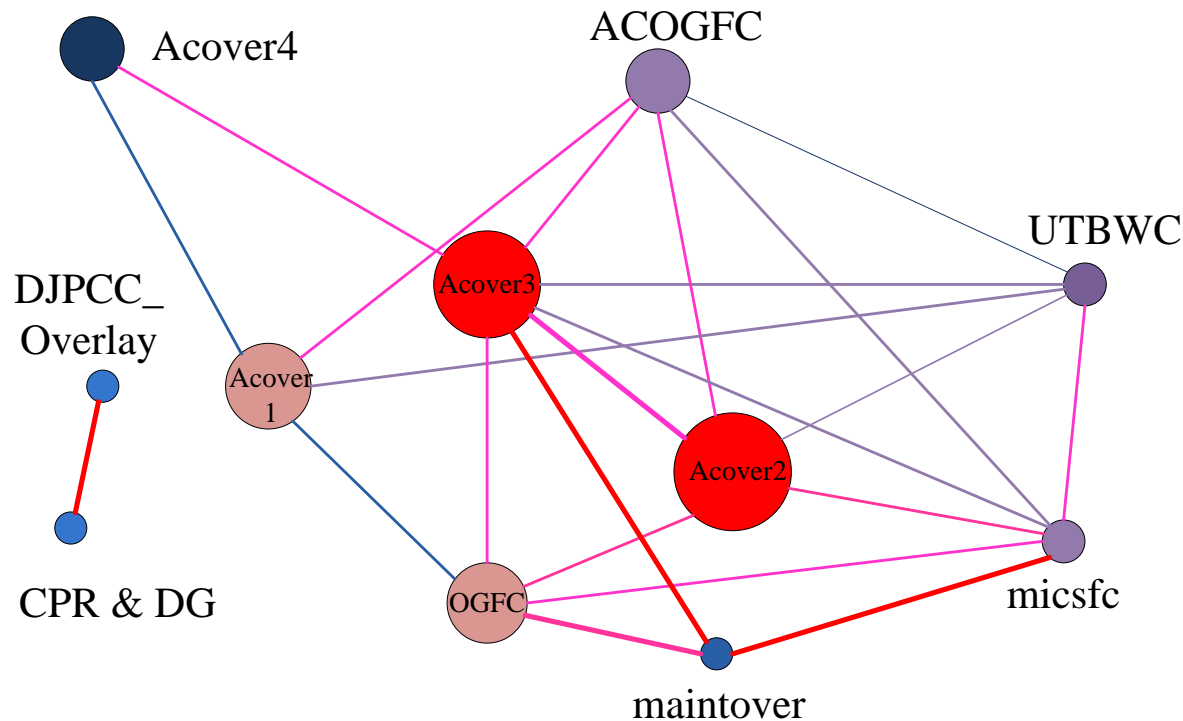
ID	Treatment Type	Sequence
1001	Treatment a1	1
1001	Treatment a2	2
1001	Treatment a3	3
1002	Treatment b1	1
1002	Treatment b2	2
1002	Treatment b3	3
1003	Treatment b1	1
1003	Treatment b2	2
1003	Treatment b3	3

Pavement Section

Treatment Types

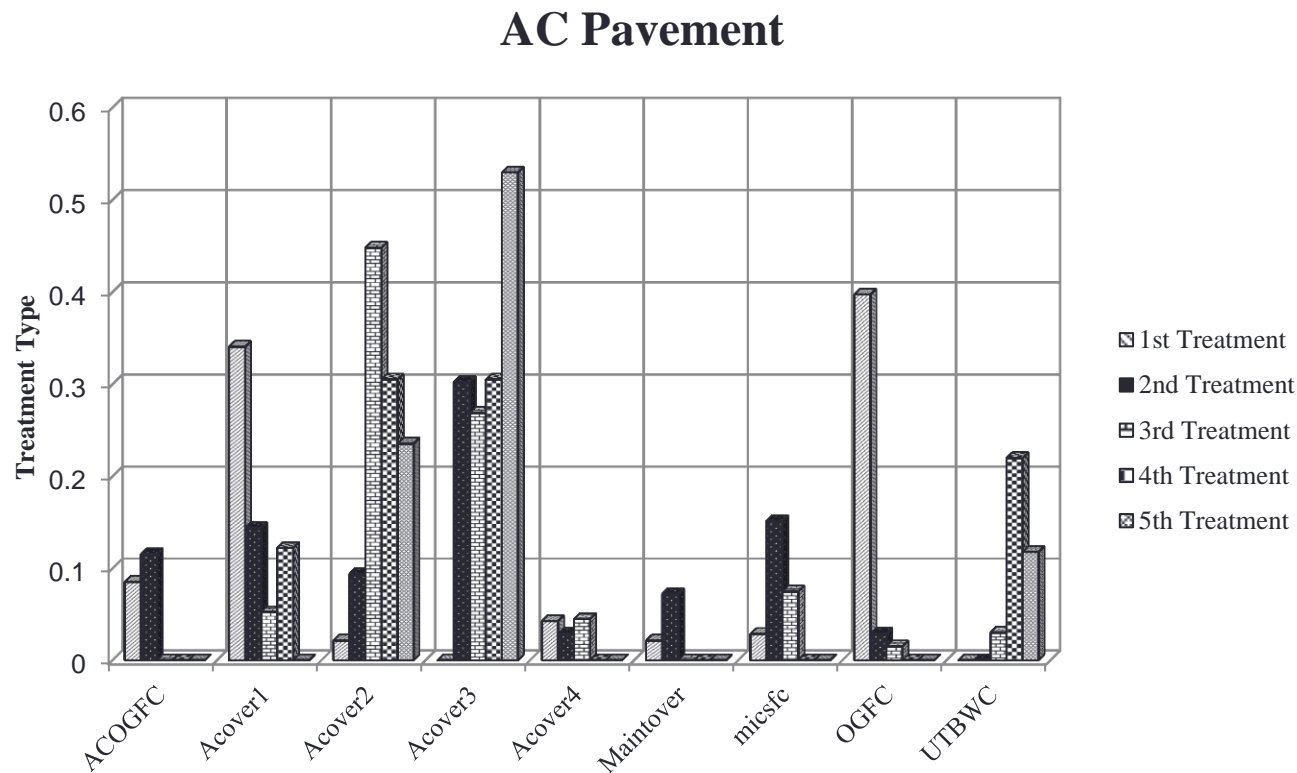
Sequence of Treatment

Link Graph of Association Rules



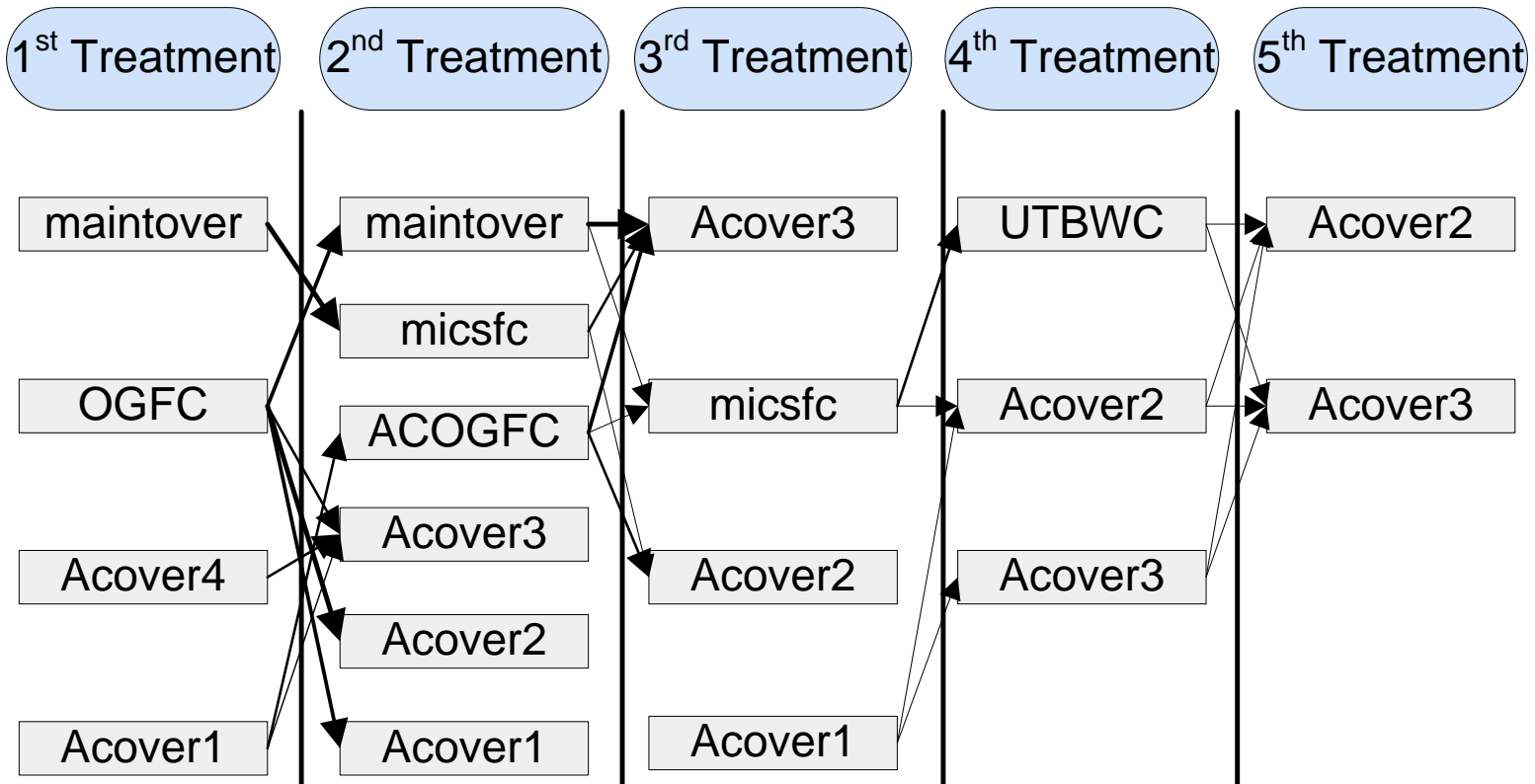
- Acover2, Acover3, OGFC, and Acover1 are the major treatment activities.
- Association between “maintover and micsfc”, “maintover and OGFC”, “maintover and Acover3”, and “Acover2 and Acover3” are strong.

Frequency Distributions vs. Order of Occurrence



- What is the order of OGFC occurrence? Does it occur as the 1st, 2nd, 3rd, 4th, or 5th treatment?

Final Results

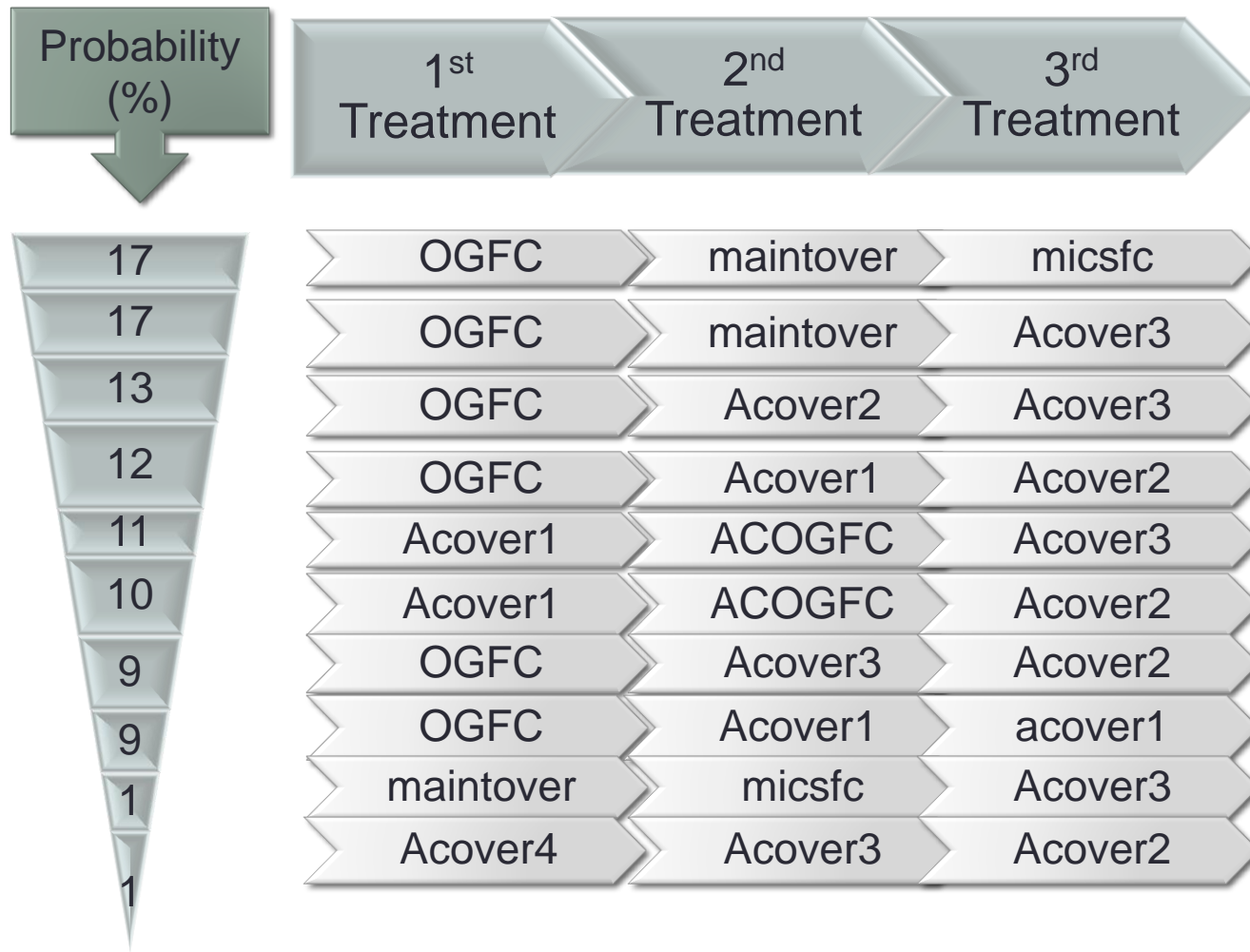


- Significant AC pavement treatment strategies

Realistic LCCA Model (1)

- Each treatment strategy is associated with a probability of occurrence which is obtained by multiplication of frequency and the confidence level.
- NPV for each strategy $NPV = \sum_{j=1}^J P_j = \sum_{j=1}^J F_j \left[\frac{1}{(1+i)^{n_j}} \right]$
- ***Realistic LCC*** $= \sum_{k=1}^K ((Probability)_k * NPV_k)$

Realistic LCCA Model (2)



Example

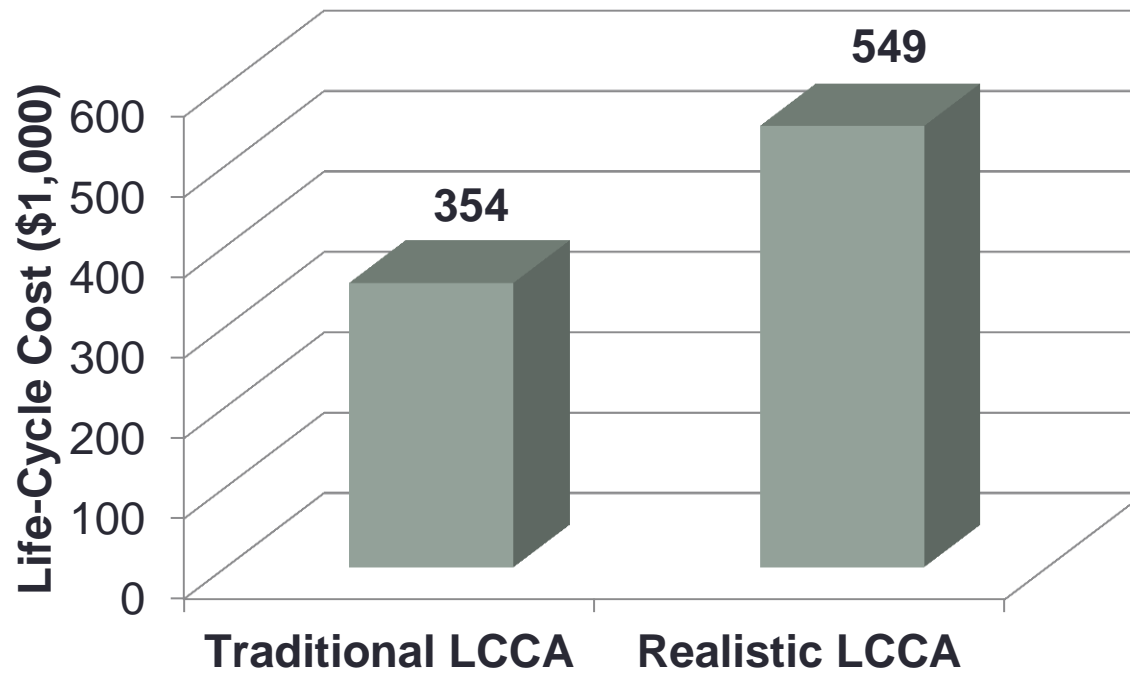
Realistic LCCA

- There are 10 possible treatment strategies for AC pavement.
- Each strategy is assigned a probability of occurrence.
- Summation of probabilities equal to 100%.

Traditional LCC

No.	Treatment Strategy	Probability (%)	1st Treat. Year 12 (\$)	2nd Treat. Year 21 (\$)	3rd Treat. Year 32 (\$)	Net Present Value (\$)	Probability × Net Present Value (\$)
		100					
1	OGFC => maintover => micsfc	17.12	342,000	171,000	228,000	353,645.95	60,559.96
2	OGFC => maintover => Acover3	17.12	342,000	171,000	969,000	564,873.88	96,731.61
3	OGFC=>Acover2 => Acover3	12.84	342,000	456,000	969,000	689,941.46	88,611.56
4	OGFC => Acover1 => Acover2	12.56	342,000	285,000	456,000	468,666.19	58,852.13
5	Acover1 => ACOGFC => Acover3	10.67	285,000	513,000	969,000	679,352.94	72,512.52
6	Acover1 => ACOGFC => Acover2	9.70	285,000	513,000	456,000	533,118.22	51,735.64
7	OGFC => Acover3 => Acover2	9.42	342,000	969,000	456,000	768,828.37	72,411.74
8	OGFC => Acover1 => Acover1	9.13	342,000	285,000	285,000	419,921.28	38,349.21
9	maintover => micsfc => Acover3	0.86	171,000	228,000	969,000	483,081.30	4,136.25
10	Acover4 => Acover3 => Acover2	0.57	456,000	969,000	456,000	840,032.44	4,747.08
Realistic LCC						Total	548,647.70

Traditional vs. Realistic LCCA



Conclusions

Conclusions

- Realistic LCCA is based on the treatment strategies embedded in the historical treatment data sets.
- LCC calculated based on traditional and realistic LCCA models can be significantly different.
- It is expected that the realistic LCC is closer to actual costs than that of the traditional approach.
- Easier for both asphalt and concrete industries to agree on this approach.

Thanks!

Q&A



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