Consequences and Probabilities:
Using *Risk* to justify decisions

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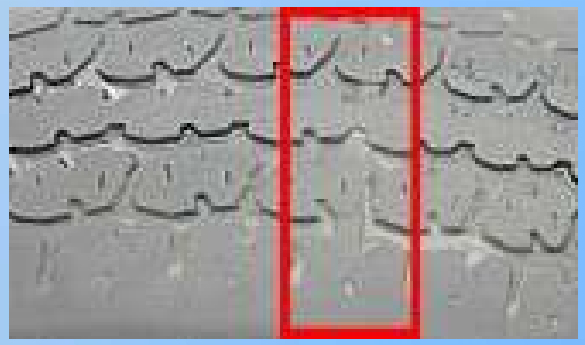


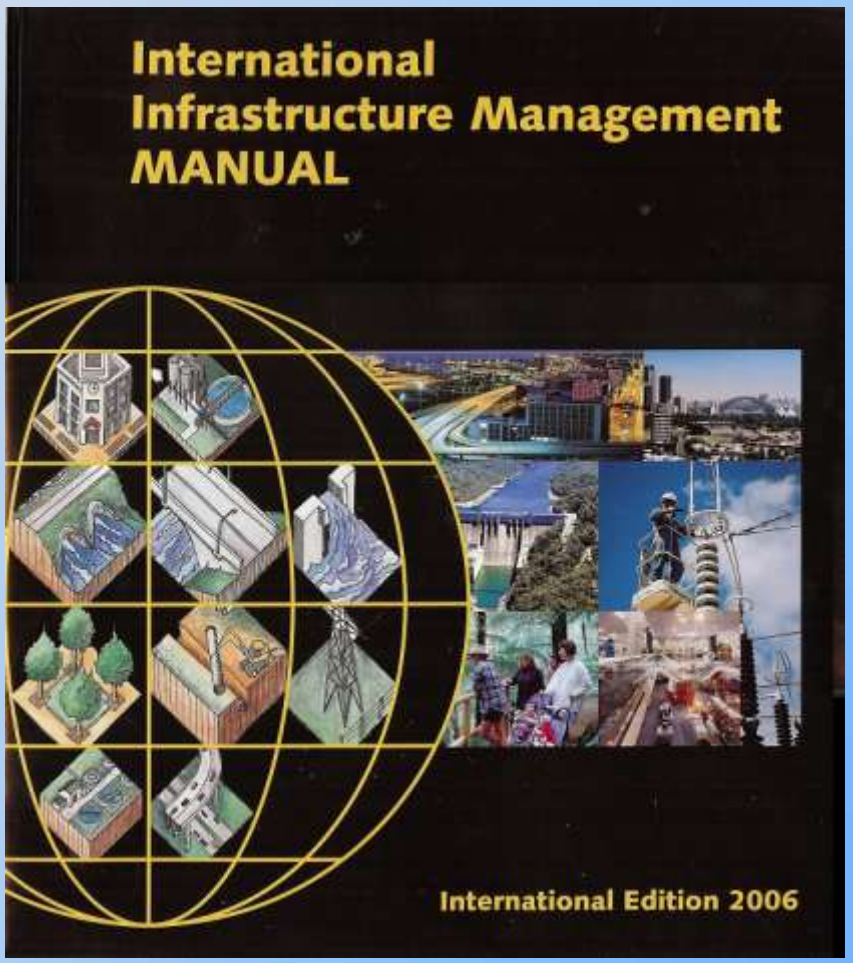
What we will cover today

- Define Risk in the world of Physical Asset Management
- An example of Risk with the Family Car
- Application of Risk with GIS Data

Tools of the day:

PowerPoint and VUEWorks with GIS data

Risk is a core component of Infrastructure Asset Management



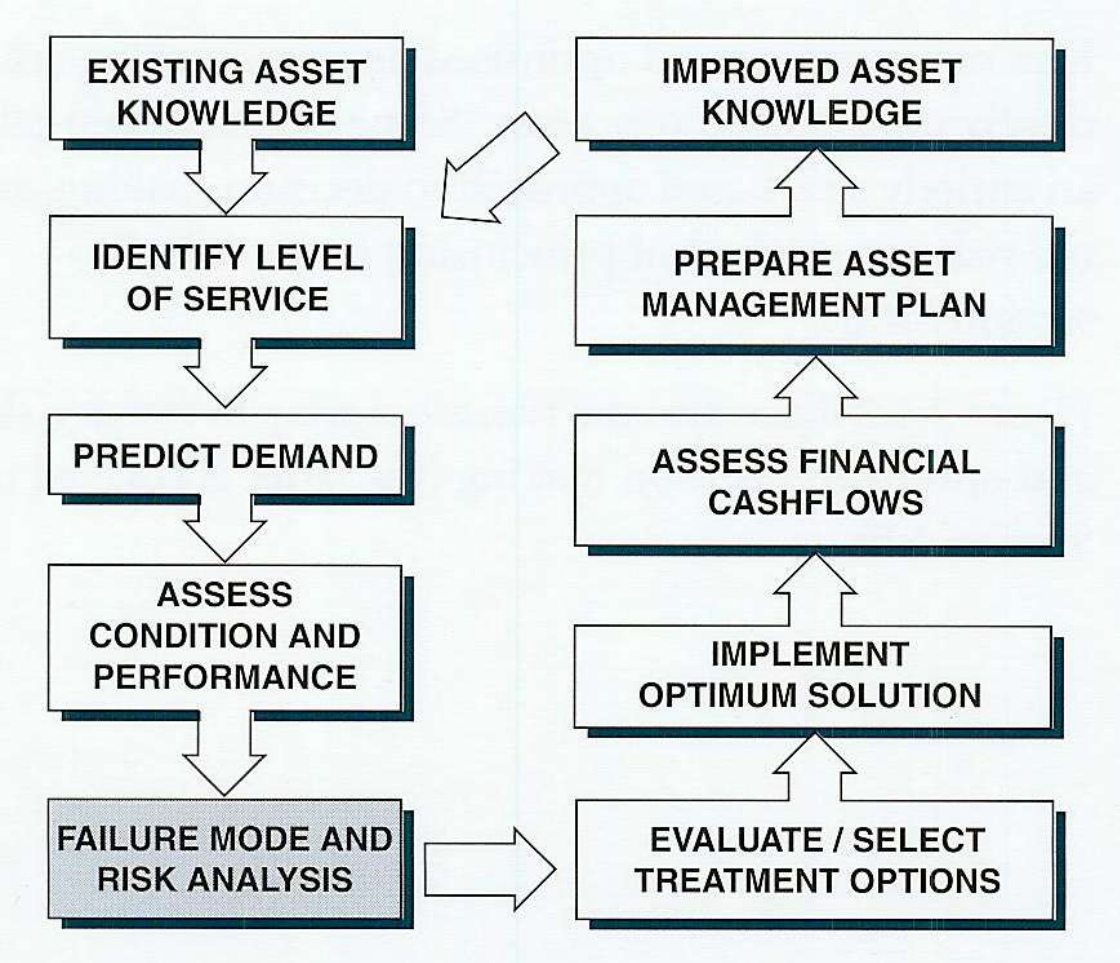
What is Physical Asset Management

A business process that utilizes and maintains asset information including physical attributes, condition, performance, failure modes, and work history to deliver expected levels of service while minimizing life cycle costs.

Some key components of Asset Management

- Asset Management Strategy
- Target Levels of Service - Asset Purpose
- Inventory - Attributes - Expected Life
- Criticality
- Asset Failure Modes
- Condition and Performance
- Identify & Prioritize O&M and Capital Projects
- Develop short and long range plans \ budgets

Risk in the Physical Asset Management framework



2006 International Infrastructure Management Manual

Risk is a core component of Physical Asset Management

Risk management is increasingly being viewed as a core business driver that influences all decision making, rather than an activity undertaken as an isolated process. -2006 International Infrastructure Management Manual

Risk is used as a basis for decision making to prioritize assets for O&M and Capital activities.

A Model for Assessing Risk

Using the Family Car as an example we will develop a model to assess Risk – a key part of Asset Management that is instrumental for prioritizing work and capital projects.

The Risk Equation

Risk =

Consequence of Failure X Failure Probability

The information we need

1) The car's purpose (mission statement)
2) Parts it is made up of (Inventory)
3) How parts may fail (Failure Modes)
4) How likely it is for a part to fail (Failure Probability)
5) How part failure affects the mission (Consequences)

Step 1: Define the Car's Purpose

In simple terms

- To transport people and their things from one place to another

The committee version

- To safely, comfortably, and reliably transport people and their belongings from one location to any other location within an expected time period at an affordable cost with minimal environmental impact – and do it in style

Step 2: Create a List of Parts

Some Major Parts of a Car (Inventory)

Engine
Transmission
Suspension
Body
Axles
Wheels
Brakes
Brake lines
Master cylinder

Tires
Windshield
Windows
Rear window
Doors
Hub caps
Fuel Tank
Steering wheel
Ignition

Chassis
Radiator
Rear view mirror
Side mirrors
Vanity mirror
Air Bags
Floor mats
Seats
Stereo

Head lights
Brake Lights
Running lights
Turn signals
Interior lights
Windshield wipers
Windshield washer
Heater / defroster
Air Conditioner

Step 3: How Parts might Fail (Failure Modes)

TIRES

- Number of Miles (% Life Left)
- Tread wear
- Pressure
- Structural Condition
- Performance Rating

Step 3: How Parts might Fail (Failure Modes)

ENGINE

- Miles (% Life Left)
- Lubrication
- Tune up
- Coolant
- Condition
- Fuel

Step 3: How Parts might Fail (Failure Modes)

BRAKES

- Miles (% Life Left)
- Amount left on Brake Pads
- Brake Fluid level
- Sound
- Pulling
- Stop distance

Step 3: How Parts might Fail (Failure Modes)

Vanity Mirror

- Age (% Life Left)
- Glass break
- Hinge condition

Step 4: Likelihood of Failure

TIRES

Failure Modes	Assessment	Failure Probability
Miles (% Life Left)	30,000 miles - Rated at 40,000 (25% Left)	40%
Tread Wear	Even wear – about 1/16” left	80%
Pressure	Last checked months ago	65%
Structural Condition	Some small cracks in sidewalls – no noticeable deformations	50%
Performance	Rated for 120 Mph - Our driving is within tire performance rating	5%

Step 4: Likelihood of Failure

ENGINE

Failure Modes	Assessment	Failure Probability
Miles (% Life Left)	100,000 miles - hope to get 150,000 (33% Left)	30%
Lubrication	Last oil change was 10,000 miles ago	80%
Tune up	Last tune-up was at 60,000 miles (recommended every 60,000)	10%
Coolant	Last changed 2 years ago	50%
Condition	Sounds Fine	20%
Fuel	About an 1/8 tank	70%

Step 4: Likelihood of Failure

Brakes

Failure Modes	Assessment	Failure Probability
Miles (% Life Left)	100,000 on car – 10,000 on Brakes	20%
Brake Pads	Plenty left – just replaced 10,000 miles ago	5%
Brake Fluid	Recently checked – filled to line, no leaks	5%
Sound	No abnormal sounds	5%
Pulling	No Pulling	5%
Stop Distance	Very Good on dry surfaces	10%

Step 5:
How Part Failure affects the Mission
(Identify Consequences)

Back to the Mission statement…..

To safely, comfortably, and reliably transport people and their belongings from one location to any other location within an expected time period at an affordable cost with minimal environmental impact - and do it in style

Use Mission Statement to identify Consequences of Failure

Identify Consequences of Failure

Mission:

Provide Reliable Transportation

Implies these Consequences of Failure:

- **Temporary Loss of Service**
- **Total Loss of Service**

Identify Consequences of Failure

Mission:
Safety

Implies these Consequences of Failure:

- **Loss of Health and Life**
- **Property Damage**
- **Fails Inspection**

Identify Consequences of Failure

Mission:

Occupant Comfort

Implies this Consequences of Failure:

- **Occupant Discomfort**

Identify Consequences of Failure

Mission:

Affordable Cost

Implies this Consequence of Failure:

- **High Cost to Operate**

Identify Consequences of Failure

Mission:

Within expected time period

Implies this Consequence of Failure:

- **High Cost to Operate**

Identify Consequences of Failure

Mission:

Minimal environmental impact

Implies this Consequence of Failure:

- **Causes pollution**
- **Fails Inspection**

Identify Consequences of Failure

Mission:

Do it in Style

Implies this Consequence of Failure:

- **Perception Factor**

Prioritize Consequences of Failure

Consequences of Failure	Priority
Loss of Health and Life	100
Property Damage	75
Total Loss of Service	70
Temporary Loss of Service	50
High Cost to Operate	40
Occupant Discomfort	40
Causes Pollution	35
Fails Inspection	30
Perception Factor	25

How much impact could Tire Failure have on these Consequences?

Consequences of Failure	V. Low	Low	Med	High
Loss of Health and Life				X
Property Damage				X
Total Loss of Service				X
Temporary Loss of Service				X
High Cost to Operate			X	
Occupant Discomfort			X	
Causes Pollution		X		
Fails Inspection				X
Perception Factor			X	

Determine the Consequence Factor for TIRES

		Impact				
Consequences of Failure	Priority	Very Low	Low	Med	High	Consequence Factor
Loss of Health and Life	100				10	10.00
Property Damage	75				10	7.50
Total Loss of Service	70				10	7.00
Temporary Loss of Service	50				10	5.00
High Cost to Operate	40			7		2.80
Occupant Discomfort	40			7		2.80
Causes Pollution	35		3			1.05
Fails Inspection	30				10	3.00
Perception Factor	25			7		1.75
				Consequence Factor:		10.00

Out of 10

Tires are highly CRITICAL to our Mission

Determine the Consequence Factor for VANITY MIRRORS

		Impact				
Consequences of Failure	Priority	Very Low	Low	Med	High	Consequence Factor
Loss of Health and Life	100	1				0
Property damage	75					0
Total Loss of Service	70	0				0
Temporary Loss of Service	50	0				0
High Cost to Operate	40	0				0
Occupant Discomfort	40		3			1.20
Causes Pollution	35	0				0
Fails Inspection	30	0				0
Perception Factor	25		3			0.75
				Consequence Factor:		1.20

Out of 10

Vanity Mirrors are NOT CRITICAL to our Mission

Calculate Risk: Consequence X Probability

TIRES

Consequences of Failure	Consequence Factor
Loss of Health and Life	10.00
Property Damage	7.50
Total Loss of Service	7.00
Temporary Loss of Service	5.00
High Cost to Operate	2.80
Occupant Discomfort	2.80
Causes Pollution	1.05
Fails Inspection	3.00
Perception Factor	1.75
Consequence Factor:	**10.00**

Failure Probabilities					
% Life left	Tread Wear	Pres-sure	Condi-tion	Performance	High Scores
40%	80%	65%	50%	5%	
4.00	8.00	6.50	5.00	0.50	8.00

Calculate Risk: Consequence X Probability

TIRES

Consequences of Failure	Consequence Factor	Failure Probabilities					
		% Life left 40%	Tread Wear 80%	Pres-sure 65%	Condi-tion 50%	Performance 5%	High Scores
Loss of Health and Life	10.00	4.00	8.00	6.50	5.00	0.50	8.00
Property Damage	7.50	3.00	6.00	4.88	3.75	0.38	6.00
Total Loss of Service	7.00	2.80	5.60	4.55	3.50	0.35	5.60
Temporary Loss of Service	5.00	2.00	4.00	3.25	2.50	0.25	4.00
High Cost to Operate	2.80			1.82		0.14	1.82
Occupant Discomfort	2.80		2.24		1.40		2.24
Causes Pollution	1.05			0.68			0.68
Fails Inspection	3.00		2.40		1.50		2.40
Perception Factor	1.75		1.40	1.14	0.88		1.40
Consequence Factor:	10.00					Risk Factor:	8.00

Most Concerning Issue: Loss of Health and Life due to Tread Wear
Probability of Failure = 80%

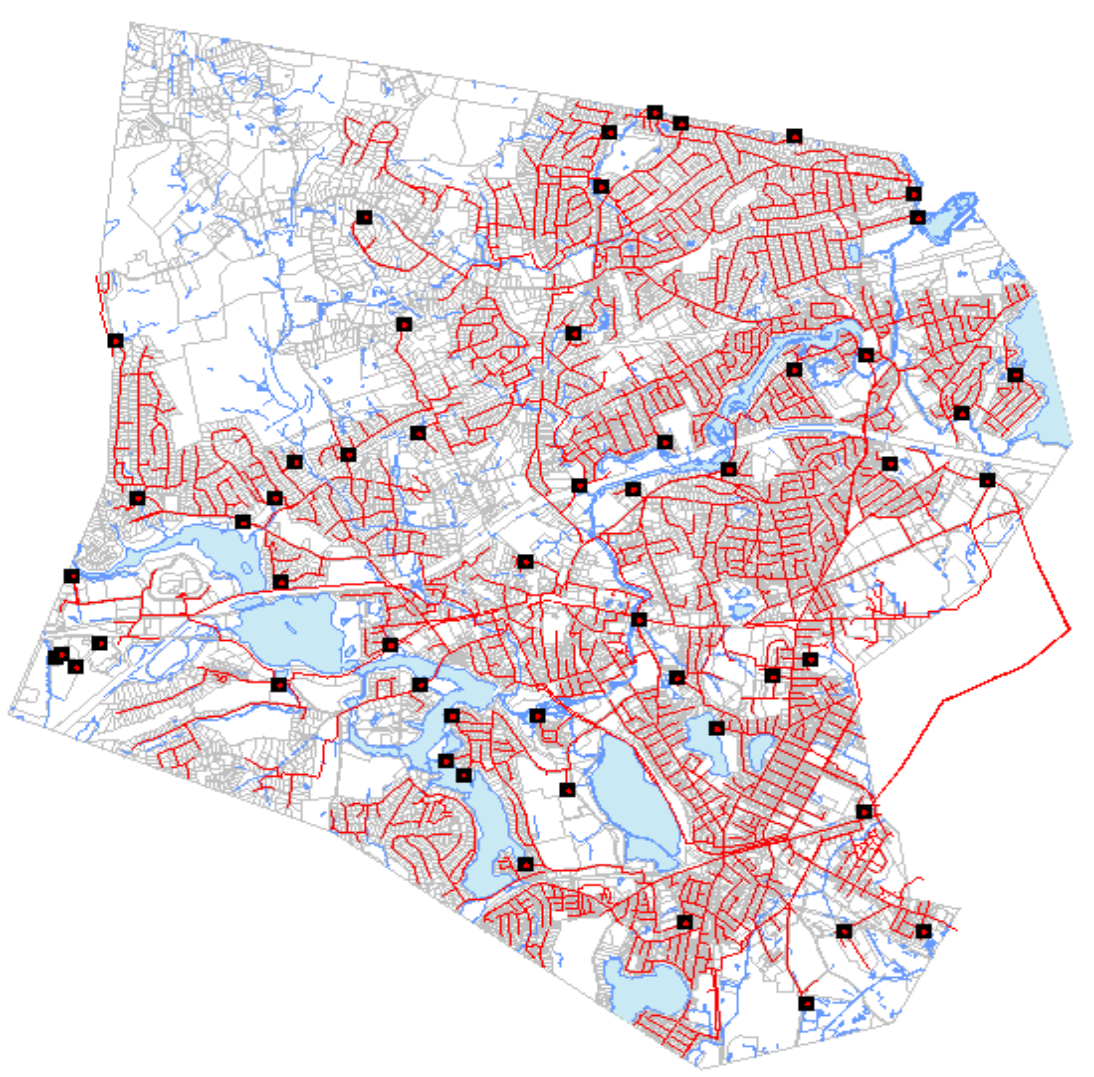
Risk (Priority) Summary

Asset	Consequence Factor	Probability of Failure	Risk Factor	Most Concerning Issue
Tires	10.00	80%	8.00	Loss of Health and Life due to Tread Wear
Engine	7.00	80%	5.60	Loss of Service due to Lubrication
Brakes	10.00	20%	2.00	Loss of Health and Life due to % Life Left
Vanity Mirror	1.20	80%	0.96	Occupant Discomfort due to breaking

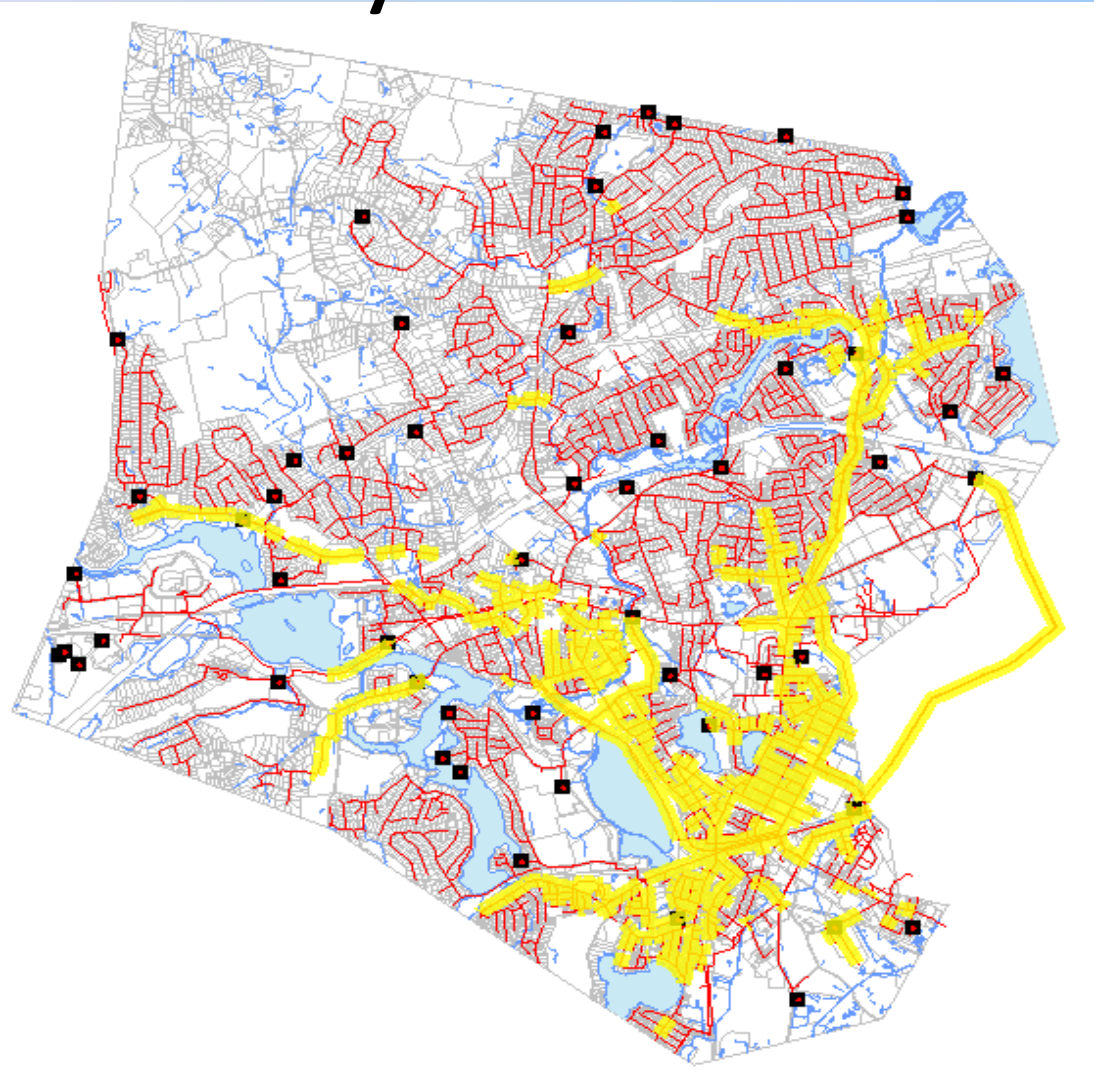
Resulting Decision: Replace the tires and change the oil!

and while you're at it – take a look at other high Risk items

Applicability to Utilities using GIS



Applicability to Utilities using GIS



Conclusions & Recommendations

A good Risk Model should…

- …reflect how you make your decisions
- …bring consistency to your decision making processes
- …maximize the use of your limited resources
- …help you justify decisions to stake holders

- Consider using GIS when you have a lot of assets to manage
- GIS will allow you to look at your assets in variety of ways

Reference

The Basis for the Risk calculation presented here is from the

International Infrastructure Management Manual 2002 and 2006 editions

As well as other Asset Management publications

Contact

For a free Risk Calculator in Microsoft Excel, Contact:

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