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Stochastic prediction of short-term friction loss of asphalt pavements: a traffic dependent approach

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Stochastic prediction of short-term friction loss of asphalt pavements: a traffic dependent approach

Structure of the presentation

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2. Objective
3. Methodology
4. Results
5. Discussion aspects
6. Concluding Remarks

Maria POMONI
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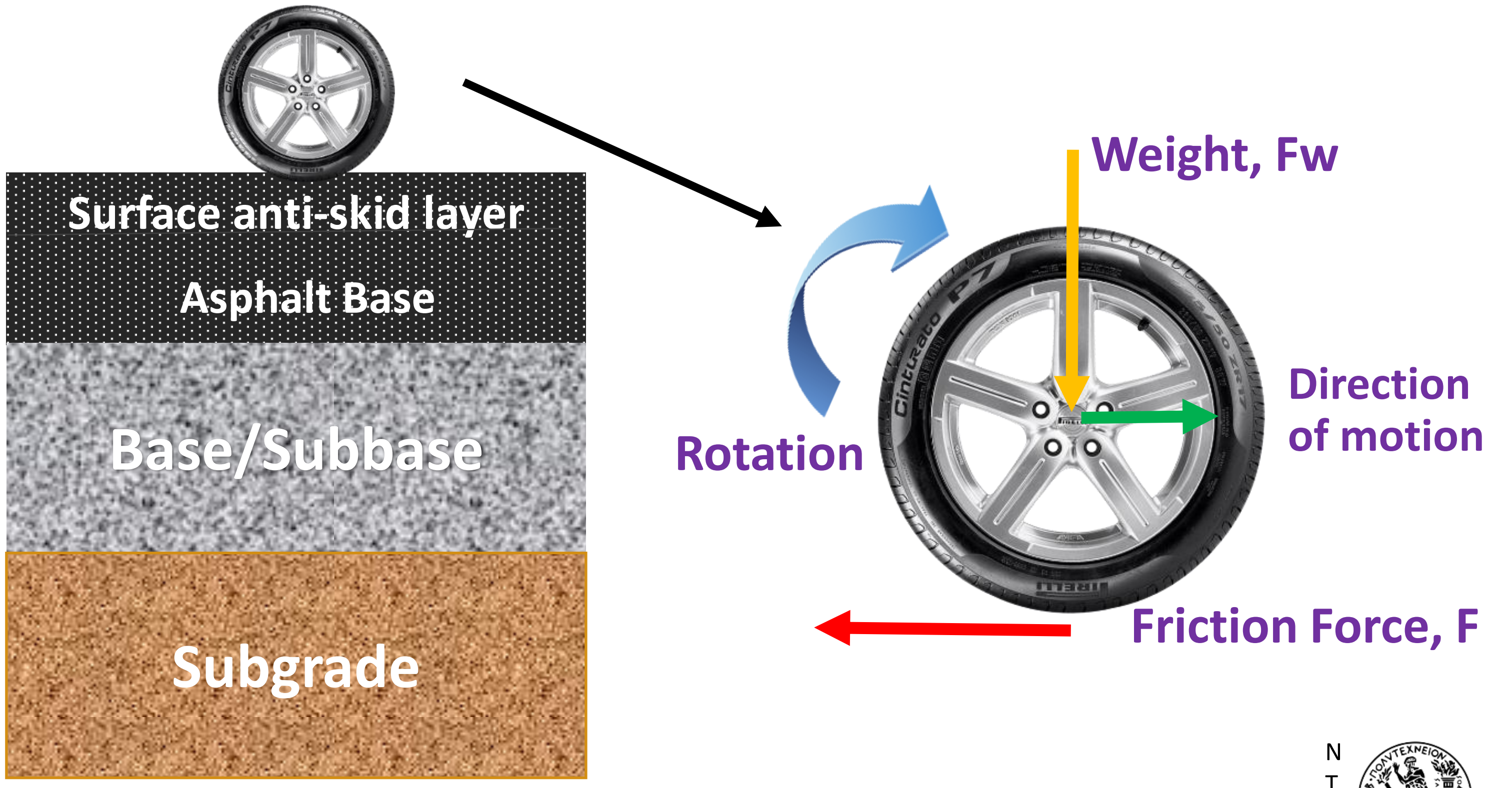
1. Introduction

Road safety

- A crucial factor that combines road condition and functional performance in terms of safety is the level of **friction** of the wearing course

Pavement friction

- Resistive force developed when tyre is prevented from rotating and instead skids along the pavement surface



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1. Introduction

New pavement

Traffic effect, mainly affects friction as wears the surface aggregates

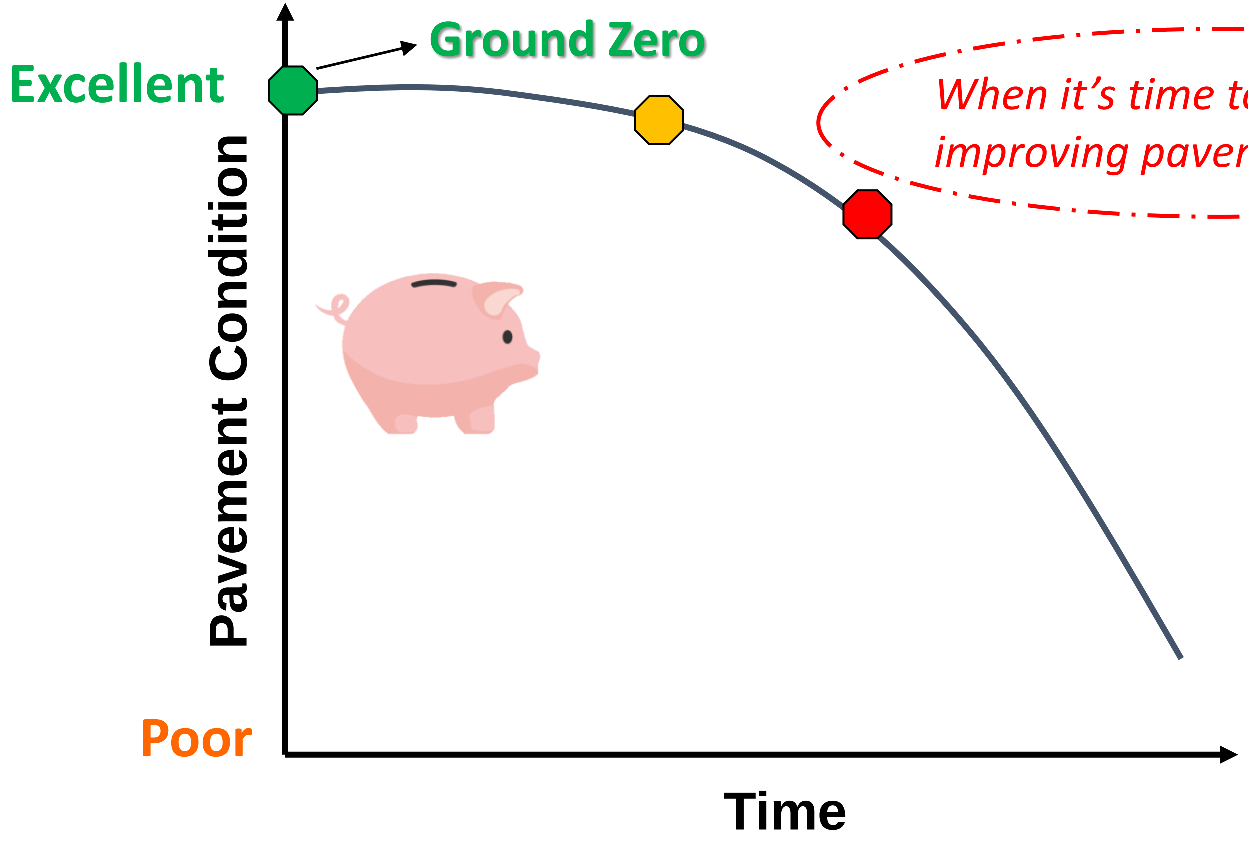
Fluctuations may occur mainly due to the weather effects

After traffic polishing

Friction deterioration

Maria POMONI NTUA

1. Introduction



When it's time to intervene for improving pavement condition?

Pavement Monitoring System

- ✓ Data Collection
- ✓ Appropriate Analysis Tools

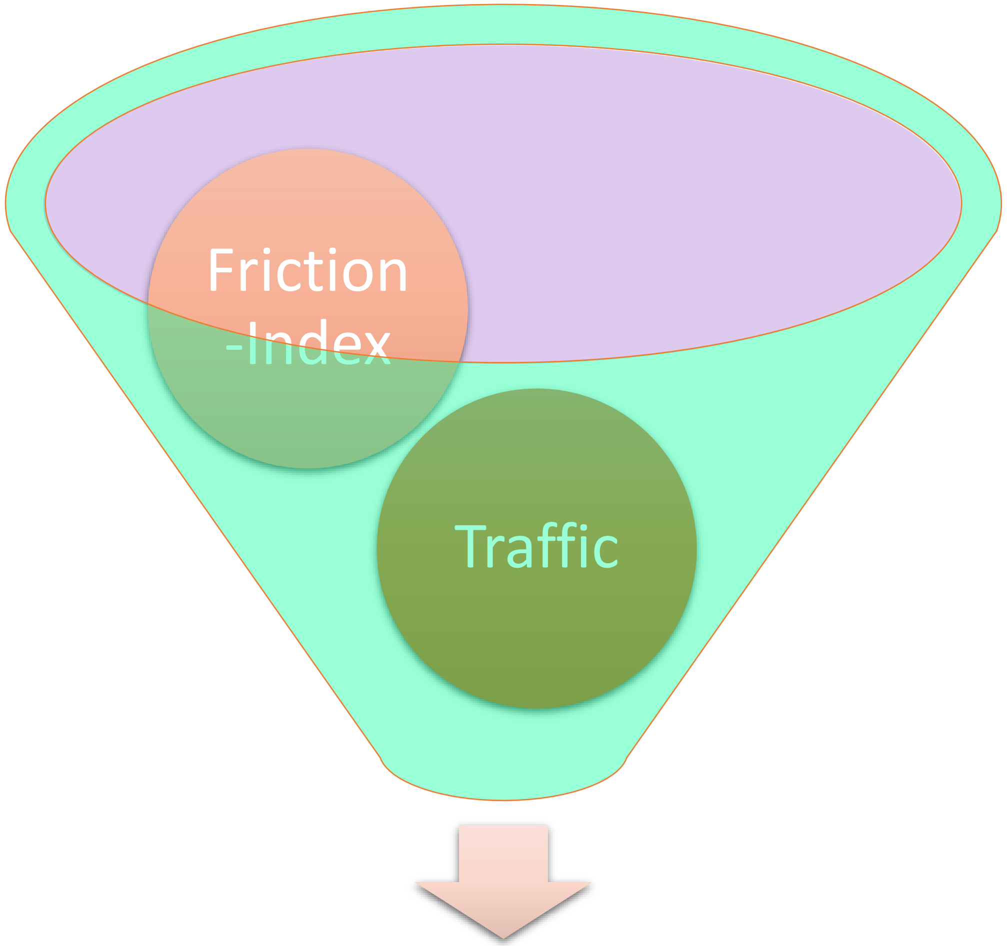
2. Objective

To propose a useful and practical approach for road agencies with the view to assessing friction condition through Kaplan - Meier survival analysis (deterioration trend)

Given this, a stochastic approach for the prediction of short-term friction loss is followed based on real friction data from an in-service asphalt pavement.

Road authorities may appropriately schedule and allocate funding for potential upcoming maintenance actions

2. Objective



2-variable friction model

3. Methodology

Site Characteristics and Data Collection

- ✓ Urban highway which has been divided into 32 sub-sections depending on their direction, location, traffic volume and structural characteristics

- ✓ Surface layer: HMA, O-5 mix designation, ASTM D3515

Friction: GripTester

Grip Number: **GN**

Measurements from the outer right wheel path
- Faster deterioration

Measurements after the wet period (an extended rain period)
-Limit the effect of the remaining summer contaminants

Traffic: AADT

Annual Average Daily Traffic

3. Methodology

Survival probability – Kaplan Maier curve

- ✓ **Kaplan-Meier method to calculate the probability distribution of the survival random GN variable**

- ✓ Survival analysis is used to determine the percentage of the number of sections for which their average **surface friction level is GN≤ IL** → Risk

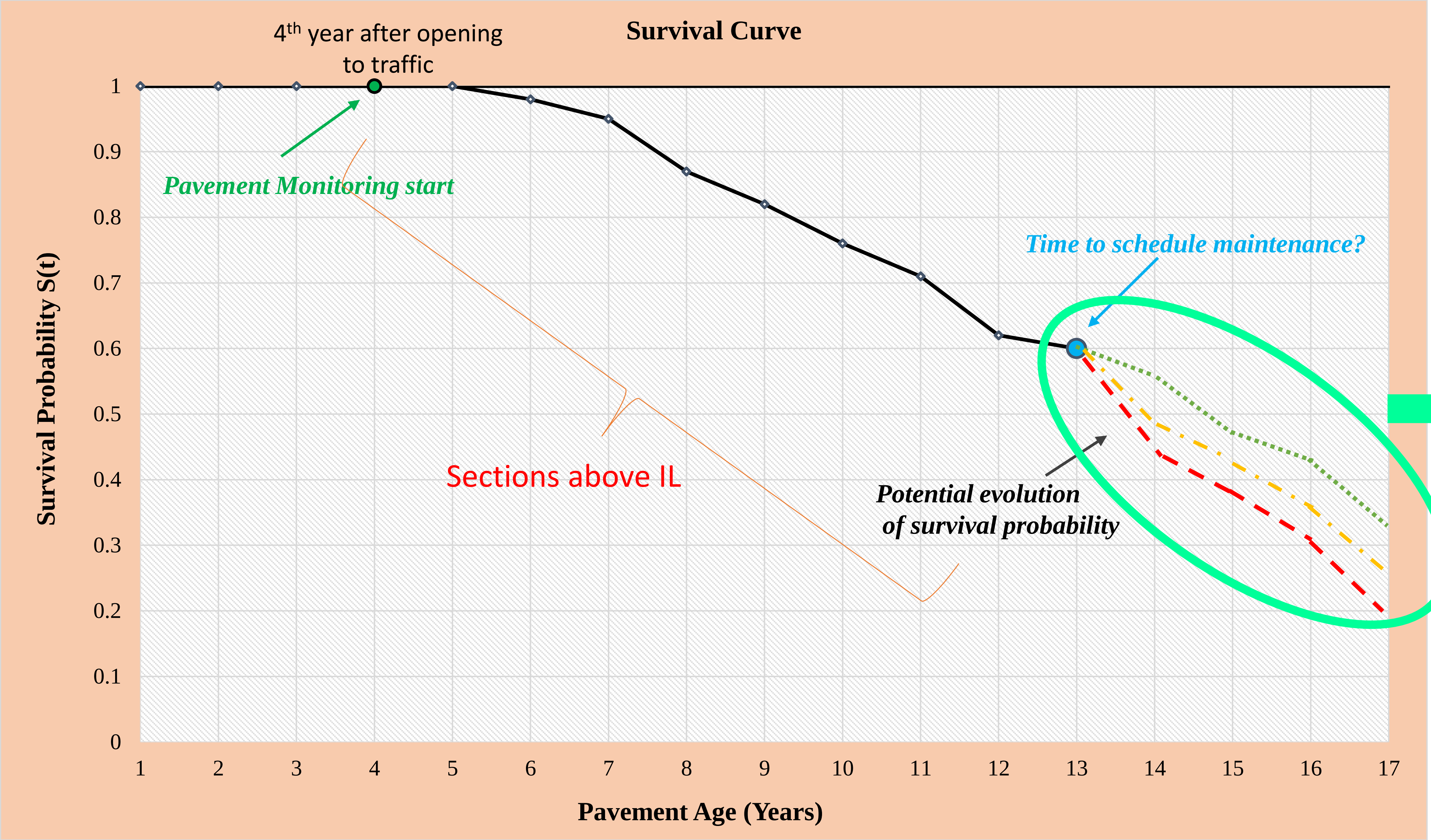
- ✓ This threshold value is an **Investigatory Level (IL) equal to 0.41 GN**

$$p_t = 1 - \frac{\text{Number of pavement sections of GN} \leq \text{IL in interval } t^{th} \text{ year and } t^{th}+1 \text{ year}}{\text{Number of pavements at risk of GN} \leq \text{IL beginning of } t^{th} \text{year}}$$

The probability of survival to time t, S(t) is calculated as:

$$S(t) = p_1 \times p_2 \times p_3 \ldots \times p_t$$

3. Methodology



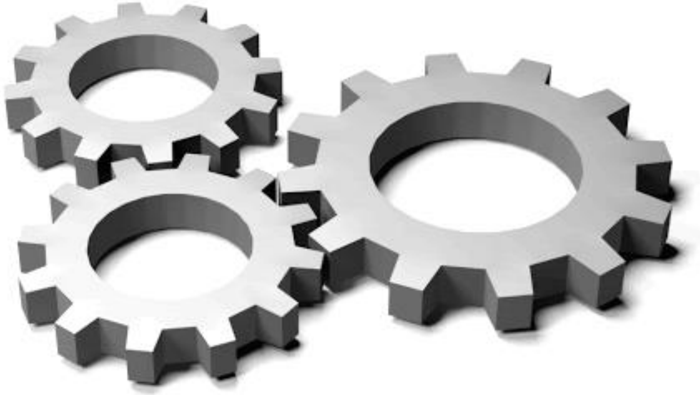
Short-term friction degradation model

3. Methodology

Short-term friction degradation model

- Testing: randomly 60% of the sections (i.e. 19 sub-sections)

2 variable model → GN of the preceding year
2 variable model → AADT of the preceding year

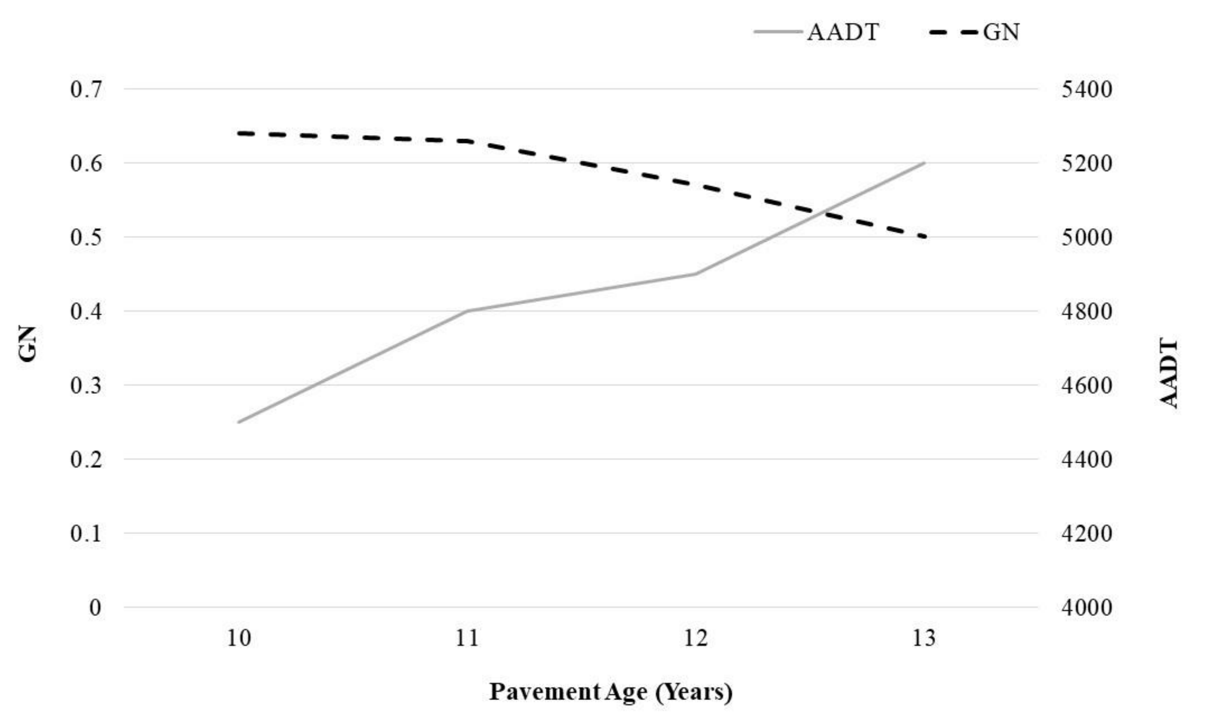


- Validation: the remaining 40% (i.e. 13 sub-sections)

4. Results

Short-term friction degradation model

- ✓ Traffic evolution cannot be considered stable
- ✓ The last four years (from year 10 to year 13) are considered representative to describe the most recent trend of traffic evolution (that of a slight increase)



$GN_i = GN_{i-1} - (AADT_{i-1} * 10^{-5}) / A$

- A=6, (AADT > 30,000)
- A=2, (AADT ≈ 15,000-30,000, with greater heavy traffic volume)
- A=8, (AADT ≈ 5,000)

where:

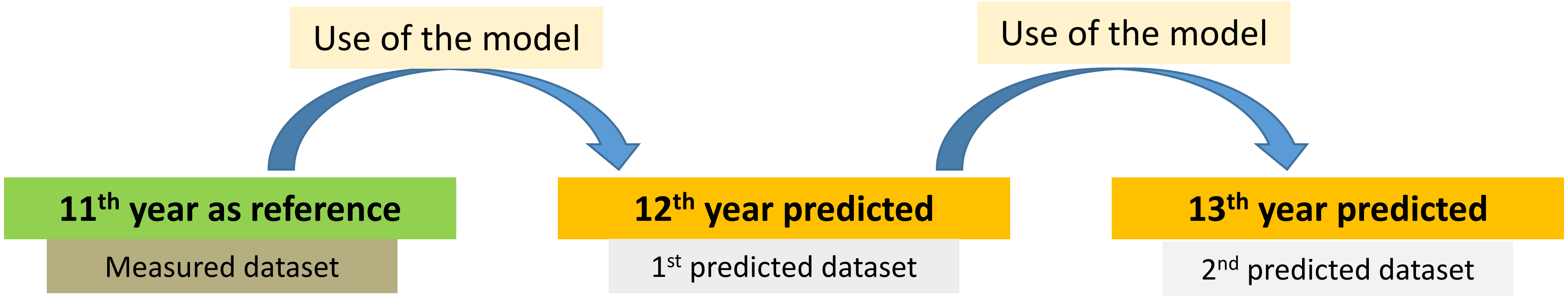
GNi *= predicted GN values for a year (i)*
GNi-1 *= GN values of the previous year (i-1)*
AADT i-1 *= AADT of the previous year (i-1)*
A *= case-adjusted factor*

It is assumed that other factors (i.e. aging) are somehow embodied to GNi-1 and remain stable for a short-term period

4. Results

Validation process

***Validation*: the remaining 40% (i.e. 13 sub-sections)**

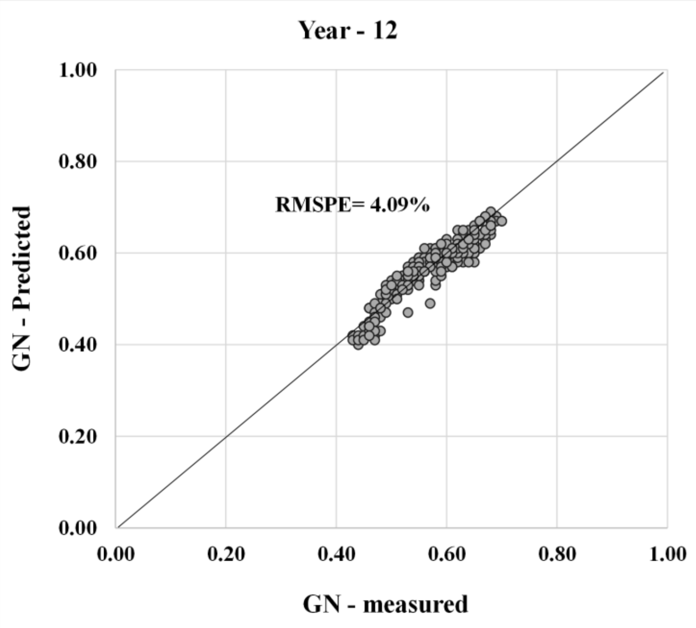


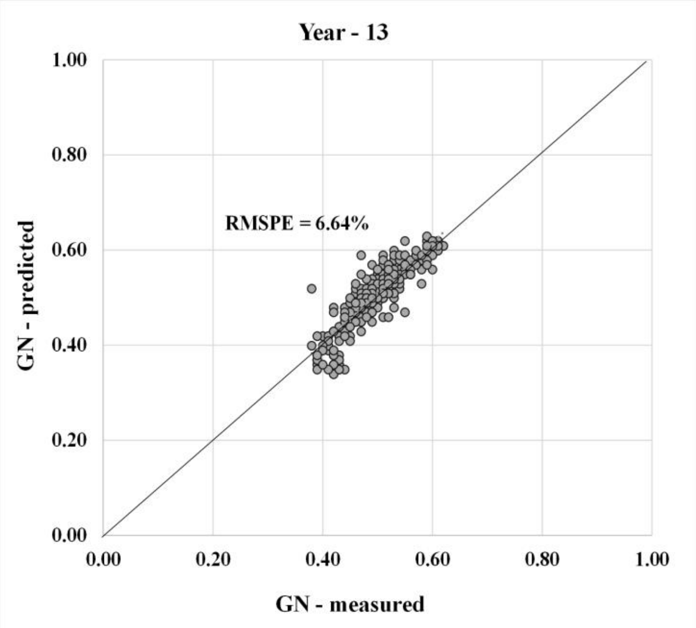
- ✓ AADT is assumed to increase between the years 11-12 and 12-13 with a rational-stable rate
- ✓ The goodness of fit is assessed based on the **Root Mean Square Percent of Error (RMSPE) criterion**

$$RMSPE = \sqrt{\frac{1}{n} * \left[\sum_{i=1}^{n} \left(\frac{GNi^{predicited} - GNi^{measured}}{GNi^{measured}} \right)^2 \right]} * 100$$

4. Results

Validation process





Section	AADT	RMPSE % - year 12	RMPSE % - year 13
1	15000	8.54	9.67
2	20000	14.36	12.28
3	30000	9.02	9.04
4	20000	4.90	7.53
5	30000	4.80	6.10
6	>30000	8.33	9.80
7	>30000	6.07	12.58
8	30000	9.98	10.18
9	30000	12.97	14.74
10	15000	9.48	14.75
11	15000	13.69	14.64
12	15000	8.02	12.43
13	5000	4.09	6.64

5. Discussion aspects

- ✓ A range of factors affect surface friction but road authorities need simple and effective set of tools to draw strategic planning of routine maintenance activities based on rational priorities and budgets assignment

- ✓ However, on a long-term basis the variables assumed to be stable in this approach will not remain constant, while traffic volumes will face changes that may affect the particular case-adjusted factor – A

- ✓ A suggestion could be to define the calibration time based on sharp increases on RMSPE values

- ✓ The proposed model does not consider the effect of intermediate maintenance activities for surface improvement. The consideration of such an issue would raise the complexity of friction modelling

6. Concluding remarks

To sum up…

- *The developed stochastic approach adapted the survival probability analysis in terms of a Kaplan – Meier survival curve and then, a model development was proposed*

- *The presented methodology was considered to predict the degradation in pavement friction and schedule routine maintenance actions*

6. Concluding remarks

- The **effect of traffic volume** was deemed to be critical and was embodied in the developed empirical two-variable model in terms of **AADT**
- The **basic assumption** of the model was that **other factors** that potentially influence the yearly loss of pavement friction within a highway **do not significantly change over a short-period of time**
- It was assumed that the effect of those factors **can be expressed through the level of the friction of the previous year** which was the second variable of the model
- The **different magnitude of traffic volumes** was incorporated through **a case-adjusted factor – A**, which is a traffic dependent parameter
- **Potential improvements** however, may be achieved through **proper adjustments to factor A** in order to consider significant **changes in traffic volume and the heavy vehicle traffic** as well, an issue that seeks further investigation

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Thank you!