ASECAP DAYS
ISTANBUL 2023

Celebrating 50 YEARS OF Successful TOLL ROAD PROJECTS

# E-PMS: EVOLUTIVE PAVEMENT MANAGEMENT SYSTEM


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autostrade per l'italia


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ICA
YAVUZ SULTAN SELİM BRIDGE AND NORTHERN RING MOTORWAY

# E-PMS: EVOLUTIVE PAVEMENT MANAGEMENT SYSTEM

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## Autostrade per l'Italia Group

### The largest highway operator in Europe

- **~ 3.000 km** motorway network
- **~ 320 km** tunnels
- **~ 4200** bridges and viaducts
- **4,6 M** daily customers
- **2,7 M** daily vehicle transit


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- **MOVYON** — Technology, R&D
- **TECNE** Sustainable Engineering — Engineering and implementation
- **AMPLIA** INFRASTRUCTURES — Construction and related services
- **ELGEA** Space for Energy — Energy from renewable sources
- **FREETOX** Sostenibilità. Innovazione. Mobilità — Services for travellers

- around ***3.000 km*** of highway managed
- ***4,6 million*** customers travel along the network every day

***8 million square meters*** of surfaces area through our pavement maintenance activities

***Pavement maintenance plan***

- Improving **preventive maintenance**
- **Maximise** the effects of interventions
- Evaluate **sustainability** of maintenance activities

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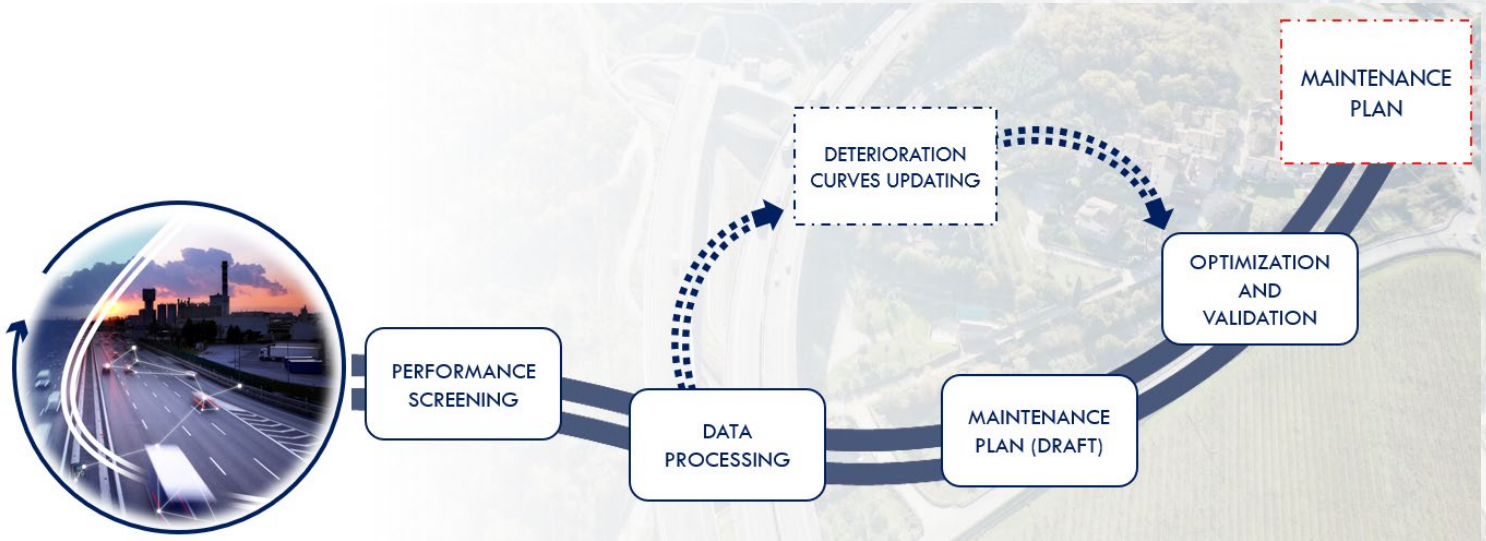
# E-PMS: EVOLUTIVE PAVEMENT MANAGEMENT SYSTEM

ASPI E-PMS is an innovative and strategic tool developed by MOVYON with the technical supervision of UNIVERSITÀ POLITECNICA DELLE MARCHE which is already used for the defining and actuating optimized maintenance plans.




## Monitoring

High-performance vehicles able to know the performance characteristics of the slow lane;

## Knowledge

History of the planned operations and the existing state of the pavements and over 20 years of data collection;

## Flexibility

Decay curves can be customized due to the variety of traffic spectra, weather conditions and construction characteristics of different road sections;

## Sustainable

Balance between performance and environmental impact of maintenance activities (Enviromental Asphalt Rating);

## Evolutive

Real time analysis of data from connected infrastructures;

# E-PMS: EVOLUTIVE PAVEMENT MANAGEMENT SYSTEM

## Performance Screening

Maintenance plan definition process

PERFORMANCE SCREENING

SKID RESISTANCE - ROUGHNESS


- ***CAT (Coefficiente di Aderenza Trasversale)***
- ***MPD (Mean Profile Depth)***
- ***IRI (International Roughness Index)***
- Measures under traffic
- Measurement step: 10 metres

BEARING CAPACITY


- ΔV (Deflection velocity of the road surface) -> deflections (micron) -> ***SCI300 (Surface Curvature Index)***
- Measures under traffic
- Measurement step: 10 metres
- Thickness measurement by Georadar

# E-PMS: EVOLUTIVE PAVEMENT MANAGEMENT SYSTEM

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## Performance Screening

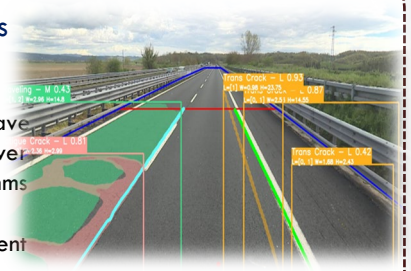
E-PMS innovations

**DATA ACQUISITION**
**Vehicle-Infrastructure Connection**

Real time analysis ⟷ E-PMS ⟷ Maintenance plan

### ✓ Automatic deteriorations analysis

Knowing the real-time conditions of the network is crucial because we might have sections that are subject to very rapid decay. These algorithms allow the identification of deterioration of the pavement from the images. The images come from vehicles constantly moving on the network.



### ✓ Embedded Sensors

A monitoring technology, integrated into the pavement, capable of acquiring "undisturbed" measurements of the main physical characteristics inside the bounded layers (ex. temperature, humidity). It allows to improve the predictive models of the bearing capacity.

PATENT PENDING

### ✓ Smart Tyres

The interaction between the vehicle and the pavement takes place through the tire, which contribute decisively to the amount of grip avaible and to the noise produced. (especially at high speeds).

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# E-PMS: EVOLUTIVE PAVEMENT MANAGEMENT SYSTEM

## Data Processing

### Traffic Data

### Homogeneous sectioning

DATA PROCESSING

- rapid development in the deterioration of motorway pavements led to customised procedure to normalise the traffic effects
- a study of traffic spectra led to the redefinition of Load Equivalent Factors
- traffic data available from tolling system **(close network)**
- The platform creates homogeneous sections for each parameter (IRI, CAT, SCI300)
- Bridges have been considered as independent homogeneous sections
- The process adopted in the E-PMS starts from a preliminary clustering in function of the traffic. These data are subsequently analysed through a statistical process

| LEF (ESAL/vehic) | Motorway Type |
|---|---|
| 5,11 | 4 lanes – high traffic |
| 5,06 | 3 lanes – high traffic |
| 4,94 | 3 lanes – medium traffic |
| 3,95 | 2 lanes – low traffic |

| 1st lane | 2nd lane | Motorway Type |
|---|---|---|
| 68% | 32% | 4 lanes – high traffic |
| 83% | 17% | 3 lanes – high traffic |
| 86% | 14% | 3 lanes – medium traffic |
| 97% | 3% | 2 lanes – low traffic |


Definition of homogeneous sectioning

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## Data Processing

### Deterioration curves

DATA PROCESSING

- Prediction models and deterioration curves represents a crucial aspect of any Pavement Management System due to many combined influences of traffic, environment, pavement structure and maintenance strategies adopted;
- For this reason, parametric deterioration curves have been implemented within the E-PMS;
- This allows to customize the platform by setting different parameters in each traffic-section of the entire network.

| | |
|---|---|
| [1] Skid Resistance | $CAT_{20,5-mis} = A - B \ln(t)$ |
| [2] Roughness | $\theta_i = a \cdot \left(SCI300_{r,50}\right)^b$ |
| [3] Bearing Capacity | $\varepsilon_{t,max}^r = a \cdot \left(SCI300_{r,85}\right)^b$<br>$E_r = c \cdot \left(\varepsilon_{t,max}^r\right)^d$<br>$N_{100}^r = 0{,}0795 \cdot \left(\frac{1}{\varepsilon_{t,max}^r}\right)^{3{,}291} \cdot \left(\frac{1}{E_r}\right)^{0{,}854}$ |

[1] Marchionna, A. P. (1994). Decadimento dell'aderenza sulle pavimentazioni autostradali. Autostrade.

[2] Regression curve obtained from field data.

[3] F. Canestrari, L. I. (2022). Assessing the remaining structural life of motorway pavements at the network level from Traffic Speed Deflectometer measurements. submitted to International Journal of Pavement Engineering.

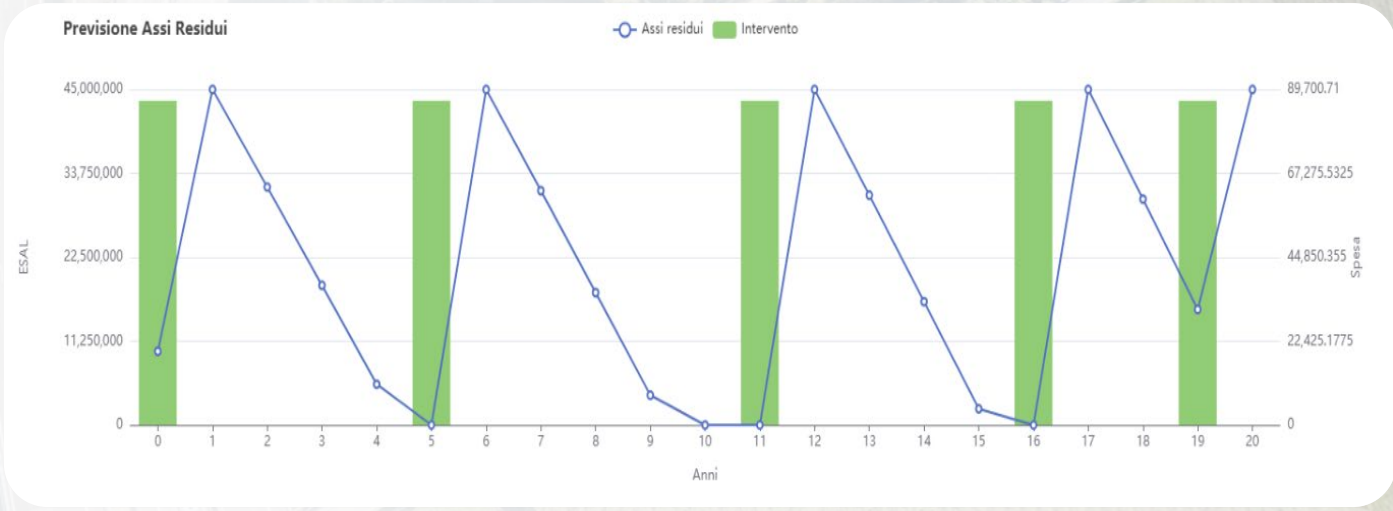
# E-PMS: EVOLUTIVE PAVEMENT MANAGEMENT SYSTEM

## Data Processing

### Deterioration curves

DATA PROCESSING

- An example of a homogeneous sections decay curve;
- The purpose of the decay curves is to estimate the residual service life for each hom.sec., therefore of the entire network;
- Thanks to the use of deterioration curves we can predict how often we need a maintenance activities;
- We can define a scenario according to the quality parameters (skid resistance and roughness);
- For each homogeneous section we can predict the maintenance for a short, medium and long period.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## Maintenance Plan

Maintenance plan definition and optimization

OPTIMIZATION AND VALIDATION

**Bering capacity**

- **Residual service life < trigger value** → Analysis of the adjacent sections (Fuzzy tolerance) → Verification of the distance between construction sites

**Roughness**

- **Residual service life < trigger value** → Structural anticipation →Analysis of the adjacent sections (Fuzzy tolerance) → Verification of the distance between construction sites

**Skid Resistance**

- **Residual service life < trigger value** → Analysis of the adjacent sections (Fuzzy tolerance) → Verification of the distance between construction sites

**EAR**

- **EAR (Environment Asphalt Rating)** → EAR is an innovative index for assessing the environmental impact of pavement maintenance operations on the motorway network

**Materials and production processes as sustainable as possibile**

| PRODUCTION PHASE | | | REALIZATION PHASE | |
|---|---|---|---|---|
| Extraction of raw material | Transport to the production site | Production | Transport to the worksite | Realization |
| A1 | A2 | A3 | A4 | A5 |


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# E-PMS: EVOLUTIVE PAVEMENT MANAGEMENT SYSTEM

## Maintenance Plan

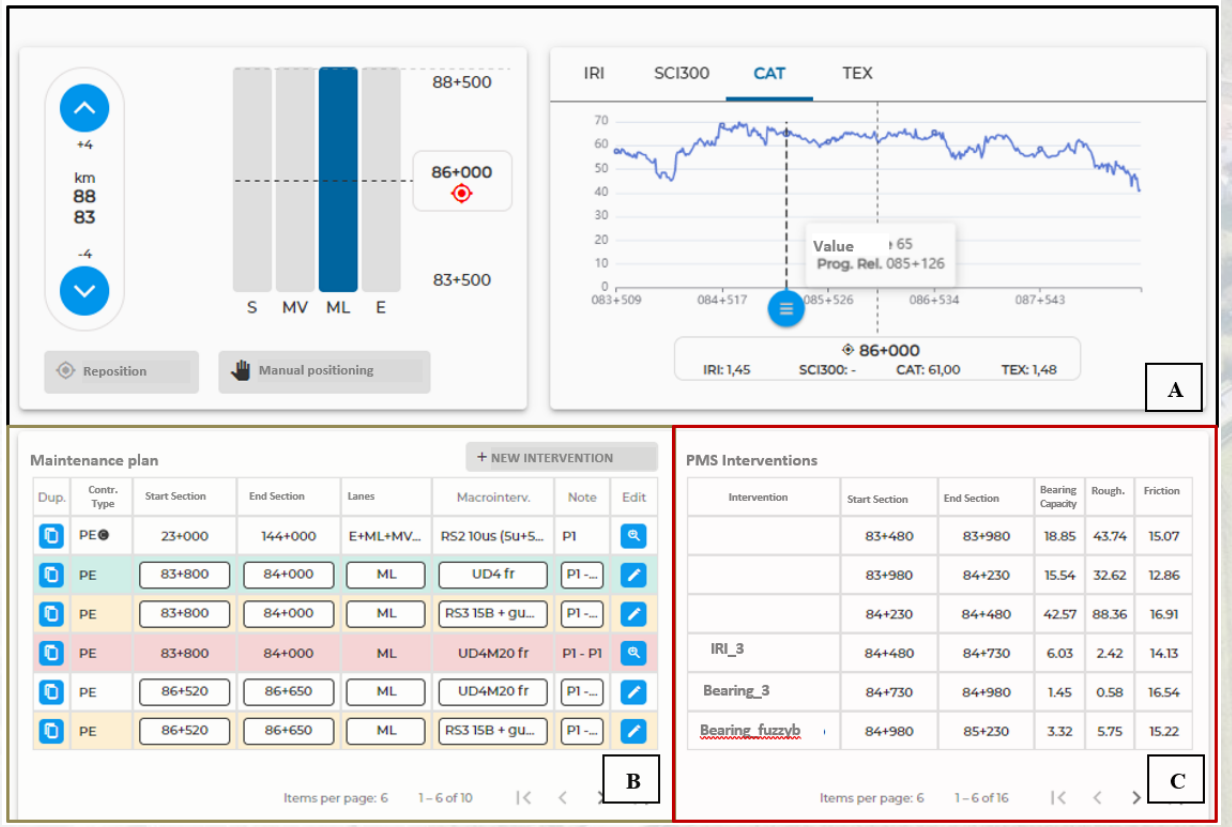
Maintenance plan on site validation

MAINTENANCE PLAN

Navigation Section

Maintenance Plan

PMS Integrations



## Conclusion

The *"Evolutive"* concept of Autostrade per L'Italia's solution is based on asset management in continuous progress thanks to the use of data.

Through the use of data we are able to adopt a planning and therefore a much more precise and detailed maintenance of the pavement.

This way of working certainly leads to optimization of maintenance costs and a lower use of natural resources.

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# THANK YOU

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