DIGITAL TWIN & BIM applications

SESSION 3: Predictive maintenance

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Final Event

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INTRODUCTION

EXISTING CONTEXT

- Reactive maintenance strategies deficiency
- Minimize the costs of repetitive tasks
- High costs and disruption

MAIN GOALS

- Predictive maintenance
- Predicting future behaviors through sensor data collection (Maintenance schedule Prediction)
- Prioritization of mitigation actions based on the identification of the current situation

MOTIVATION AND OBJECTIVES

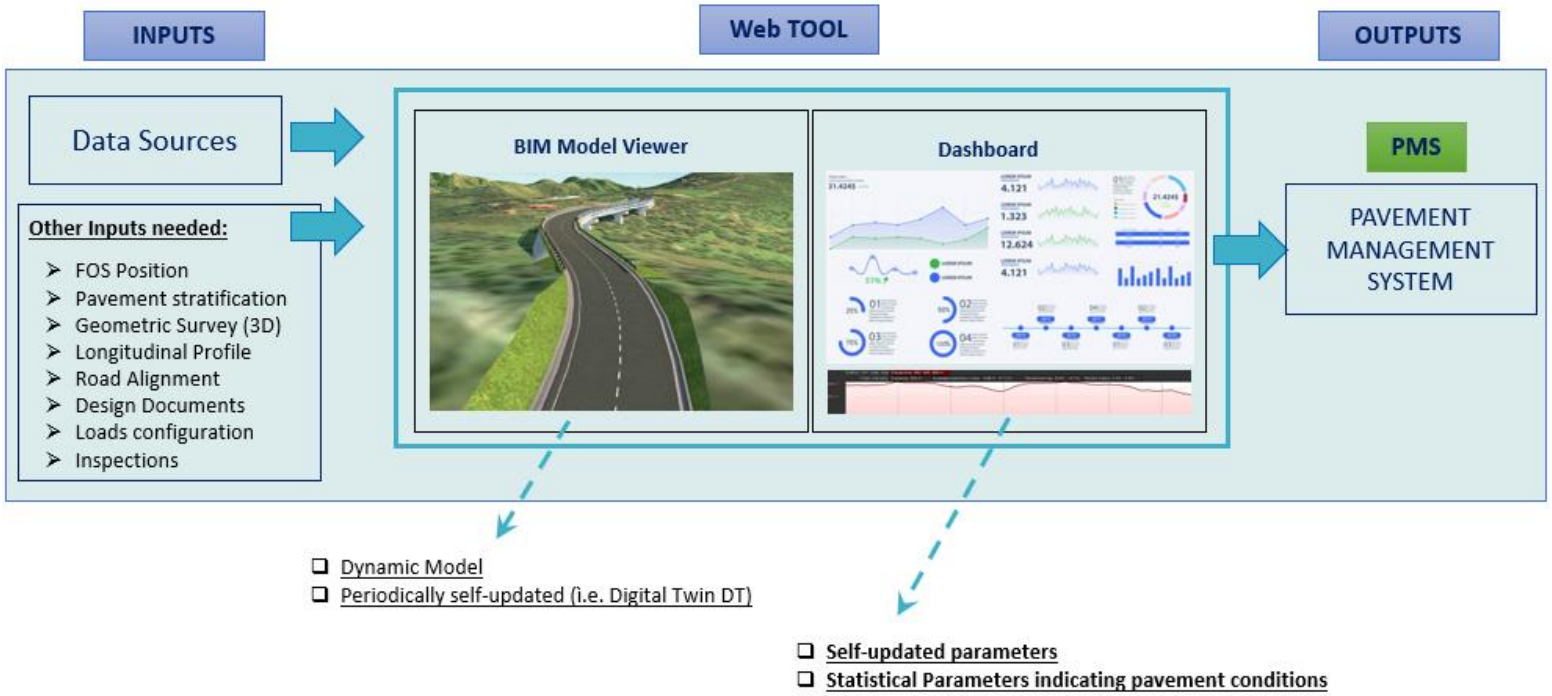
SOLUTION: WEB BASED APPLICATION acting as a DIGITAL TWIN plug-in for Pavement Management System

- **Digital Twin**: virtual replication of a critical Road Segment and its processes

COMPONENTS

- BIM Model: serves as the foundation for creating and enriching Digital Twins – Physical component of the DT – Geometric information
- DASHBOARD: Valuable data and insights for effective pavement conditions management
- SENSOR DATA: Pavement Condition Indices assessment - Maintenance schedule Prediction – Weather information

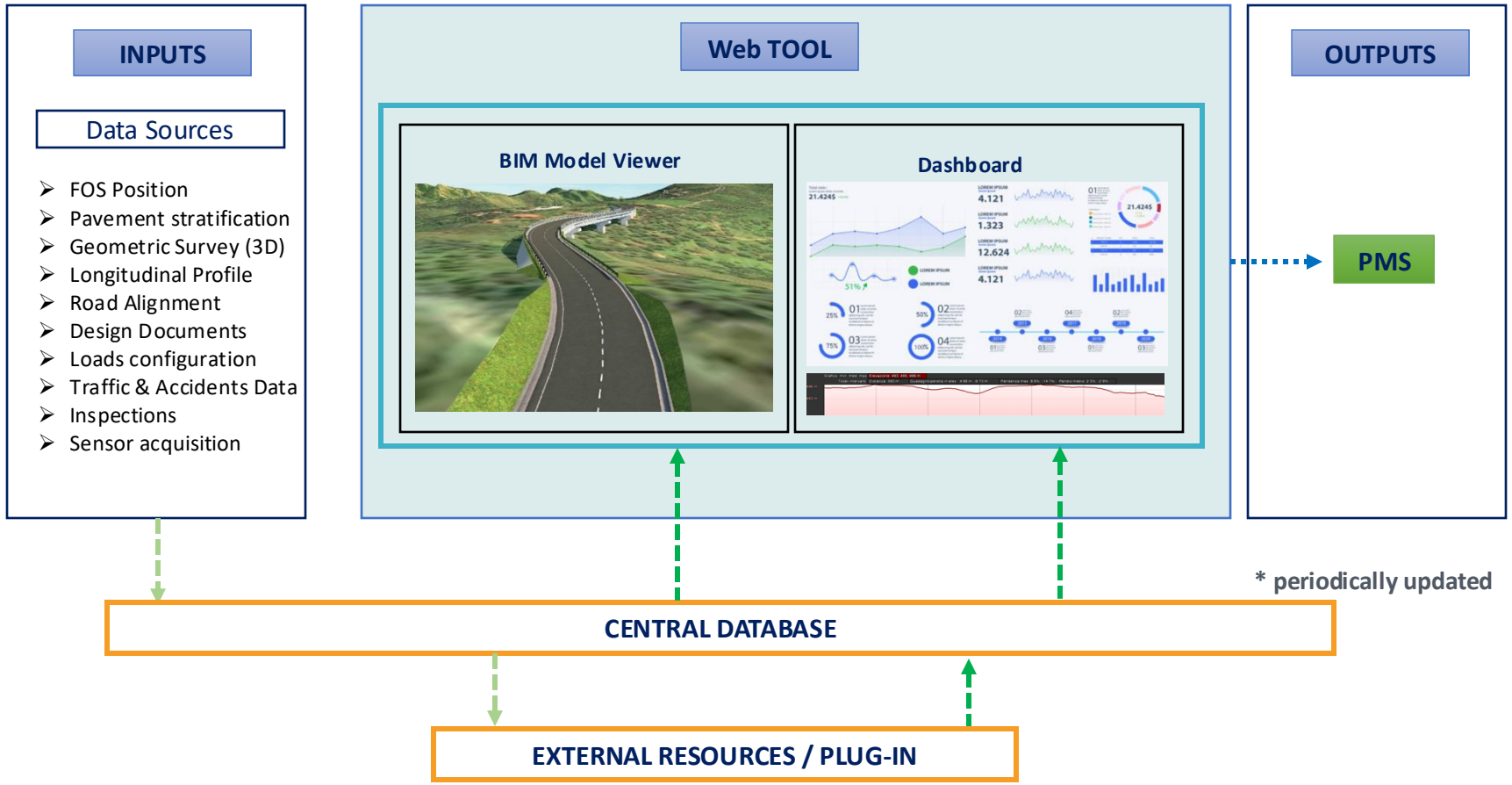
MOTIVATION AND OBJECTIVES



This Application can retrieve inputs from multiple data sources and integrating them into a BIM model developed for the specific road section under analysis. BIM model is enriched with information related to the infrastructure/pavement status, gathered at specific time intervals.

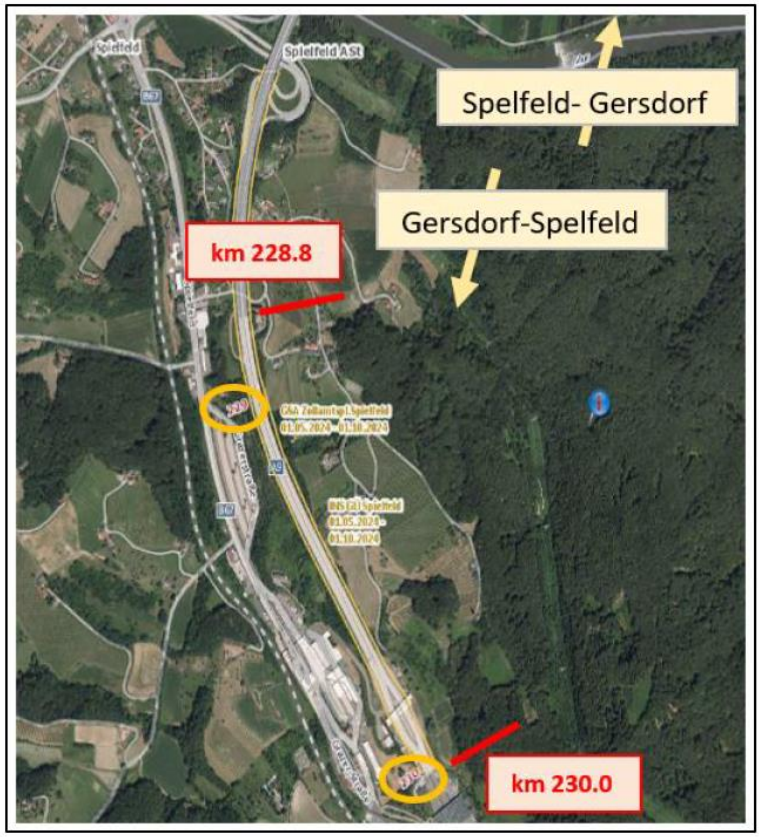
→ This will render the model dynamic and periodically self-updating (i.e., a Digital Twin)

APPROACH FOR ACHIEVING RESULTS

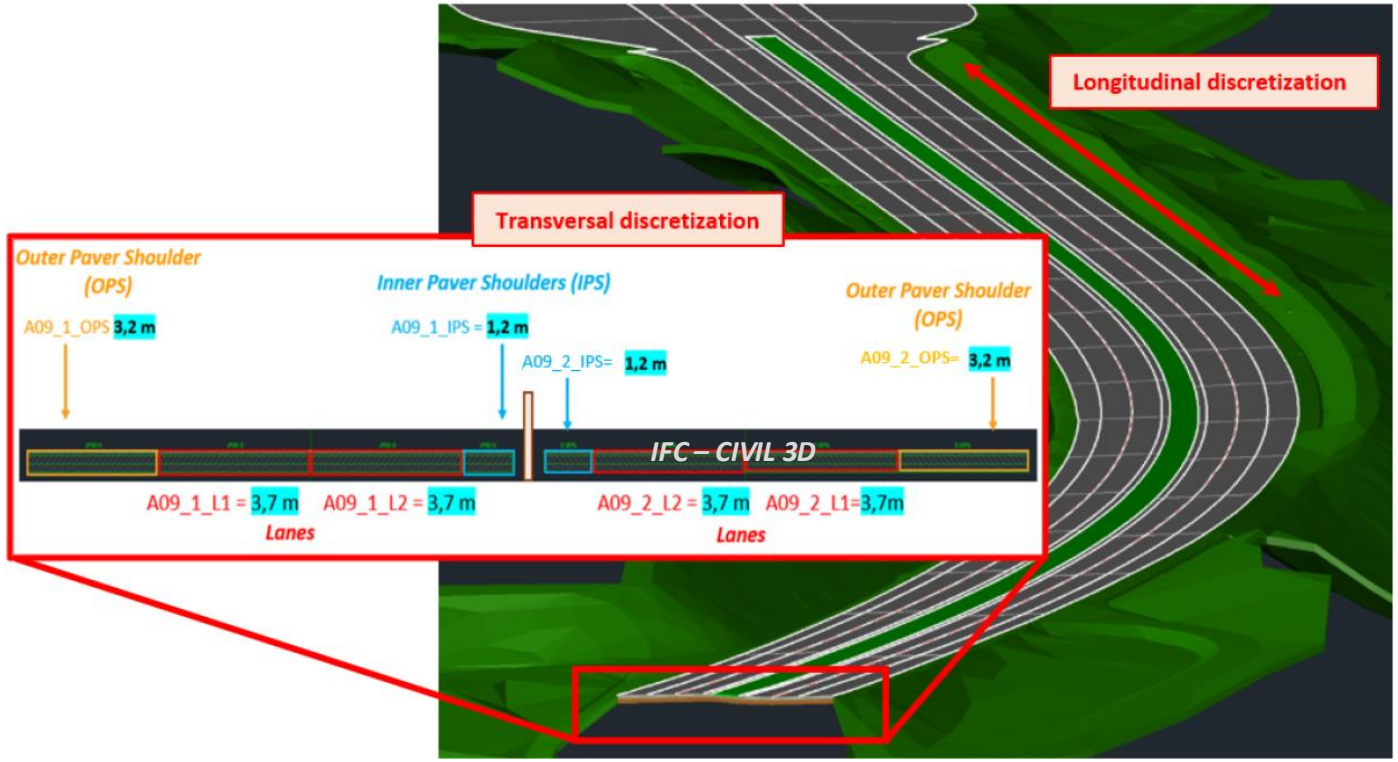


APPROACH FOR ACHIEVING RESULTS

SHOWCASE: Road Section in Spielfeld [Austria]

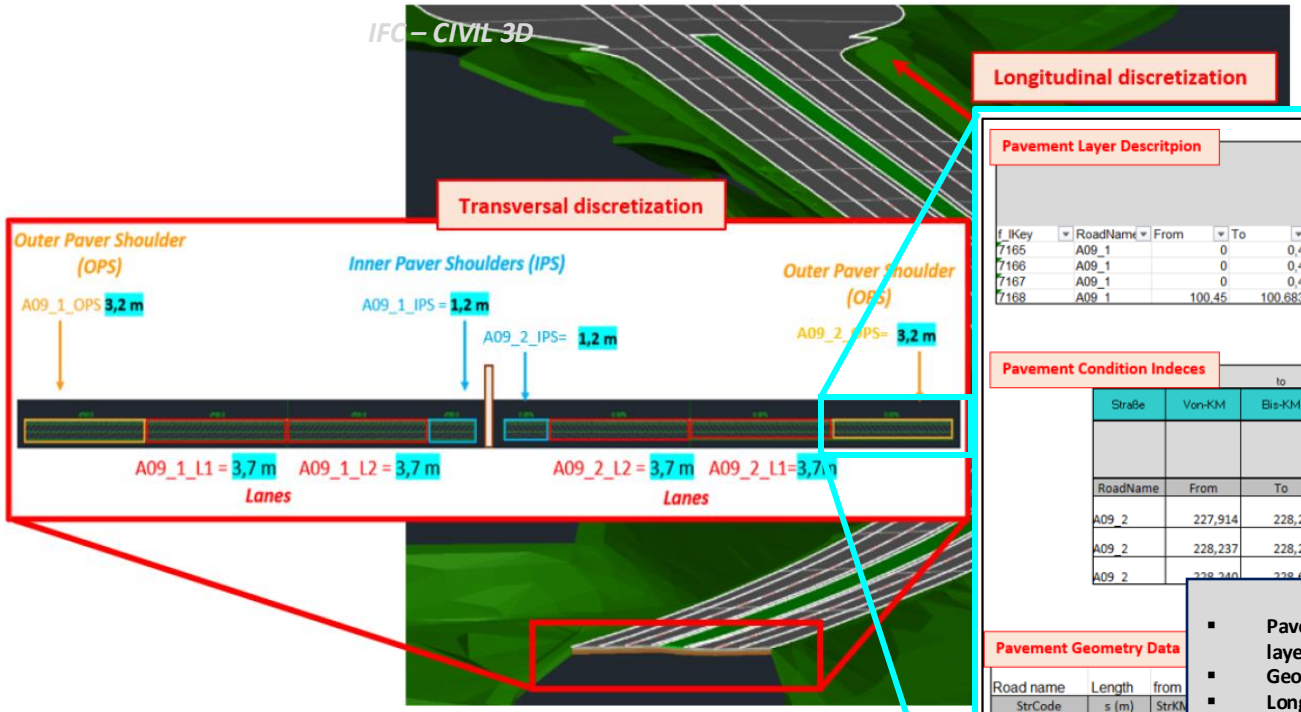


BIM MODEL: Longitudinal and Transversal discretization



APPROACH FOR ACHIEVING RESULTS

BIM MODEL: Longitudinal and Transversal discretization



CENTRAL DB: Longitudinal and Transversal discretization

Pavement Layer Descritpion

f_IKey	RoadName	From	To	Length	Lane	Type of the pavement struvture (old name) Bautyp	Type of the pavement structure new Bautyp_Ne	flexible or rigid Bauweise	mixture for noise reduction Belag_laer	ErhIV	Total tickness of the bound layers Gesamtdic	Total tickness of the pavement structure Gesamtdic	HJ_theoretical HJ_theoret	AADLT (Annual average daily load traffic) JDTLV_akt
7165	A09_1	0	0,4	0,4	0	BT14_D	AS1	ASPHALT	FALSO	3	21	78	1992	2391
7166	A09_1	0	0,4	0,4	1	BT14_D	AS1	ASPHALT	FALSO	3	21	78	1992	2391
7167	A09_1	0	0,4	0,4	2	BT14_D	AS1	ASPHALT	FALSO	3	21	78	1992	2391
7168	A09_1	100,45	100,683	0,233	1	BT14_D	AS1	ASPHALT	FALSO	2	27,5	79,5	1997	2357

Pavement Condition Indeces

Straße	Von-KM	Bis-KM	Structural index SI (top layers) SI_Decke HFS_F Main driving lane	SI_Decke NFS_F Secondary lane	Structural index SI (bearing capacity) SI_Tragfähigkeit HFS_F Main driving lane	SI_Tragfähigkeit NFS_F Secondary lane	Structural Index SI SI HFS_F Main driving lane	SI NFS_F Secondary lane	Comfort Indec GI Komfort HFS_F Main driving lane	GI Komfort NFS_F Secondary lane
RoadName	From	To							ZU_ZW_SI_NFS	ZU_ZW_GI_Komfor
A09_2	227,914	228,237	2,23	2,21	1,00	1,00	2,23	2,21	3,06	3,53
A09_2	228,237	228,240	2,21	2,21	1,07	1,02	1,48	1,44	3,90	4,13
A09_2	228,240	228,690	1,14	1,11	1,05	1,00	1,21	1,11	2,10	1,96

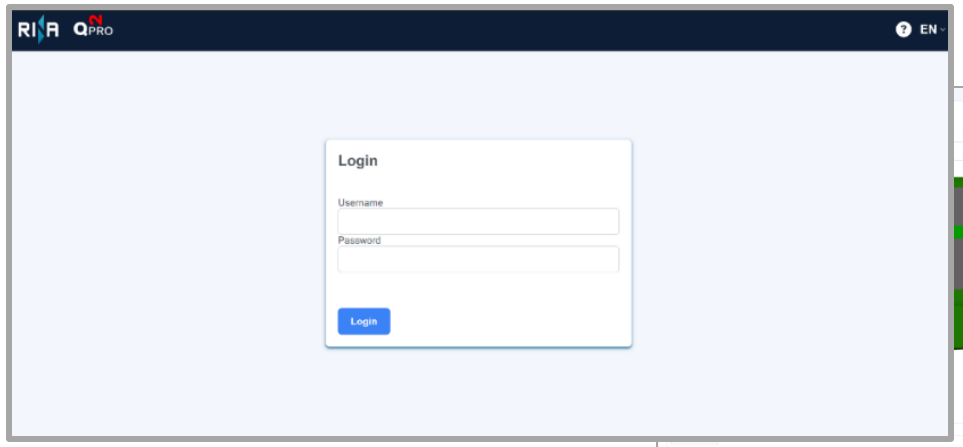
Pavement Geometry Data

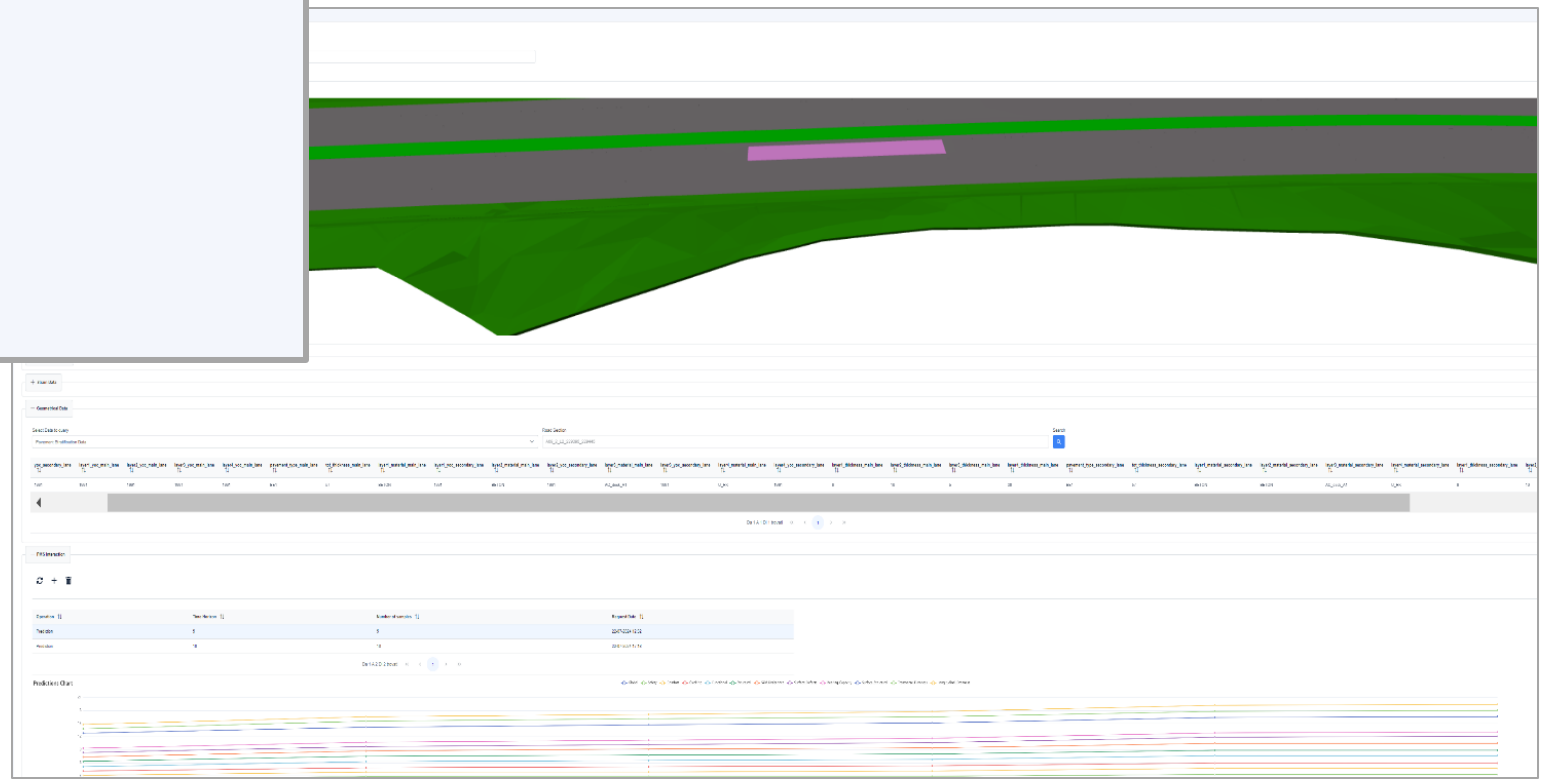
Road name	Length	from										
StrCode	s (m)	StrKM									deltaWLP (mm)	sigmaWLP (mm)
01 A09L1-QPB	25	KM 22									73,1	8,8
01 A09L1-QPB	75	KM 22									73,1	8,8
01 A09L1-QPB	125	KM 22									73,1	8,8
01 A09L1-QPB	175	KM 22									73,1	8,8
01 A09L1-QPB	225	KM 22									73,1	8,8
01 A09L1-QPB	275	KM 22									73,1	8,8
01 A09L1-QPB	325	KM 22									73,1	8,8
01 A09L1-QPB	375	KM 229,5+144	229,59	229,644	576633,077	313075,436	0,67	22	0,4	1,7	18	3,5
01 A09L1-QPB	425	KM 229,5+94	229,54	229,594	576606,442	313117,27	0,67	22	0,4	2	23,9	4,4
01 A09L1-QPB	475	KM 229,5+44	229,5	229,544	576579,763	313159,138	0,67	22	0,4	2,1	27,7	4,6

- Pavement stratification containing the fully description of the different layers (such as material, year of construction, thickness etc.)
- Geometric cartography
- Longitudinal profile
- Design documents
- Images and photos
- Catalogue of the performed inspections
- Sensor's position and configuration

RESULTS

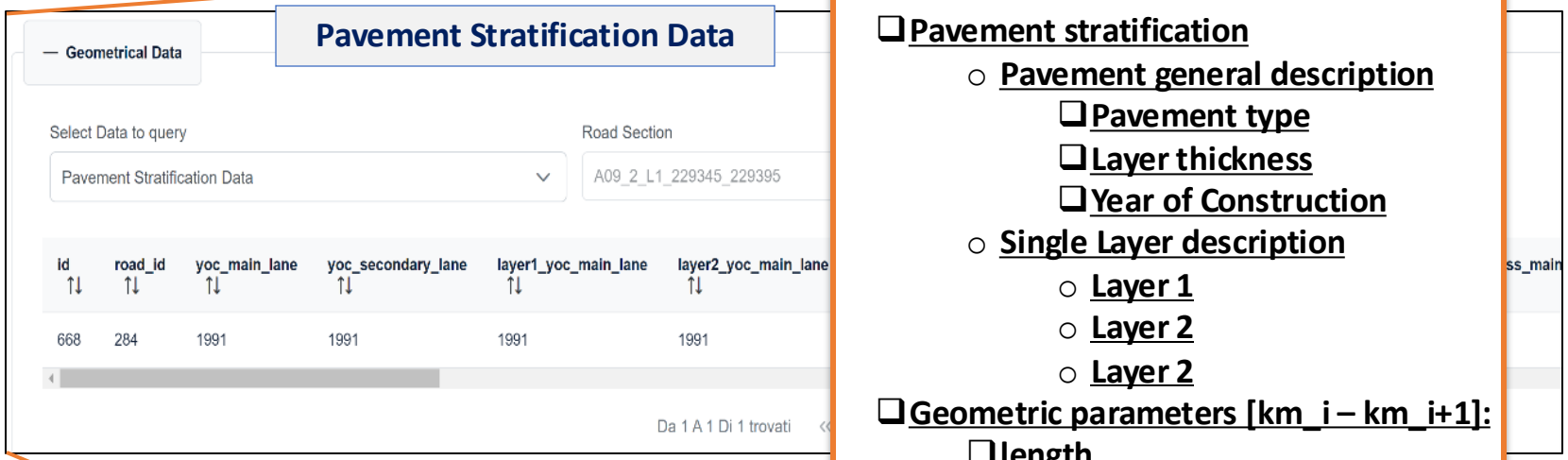
WEB APP: FUNCTIONALITIES





RESULTS

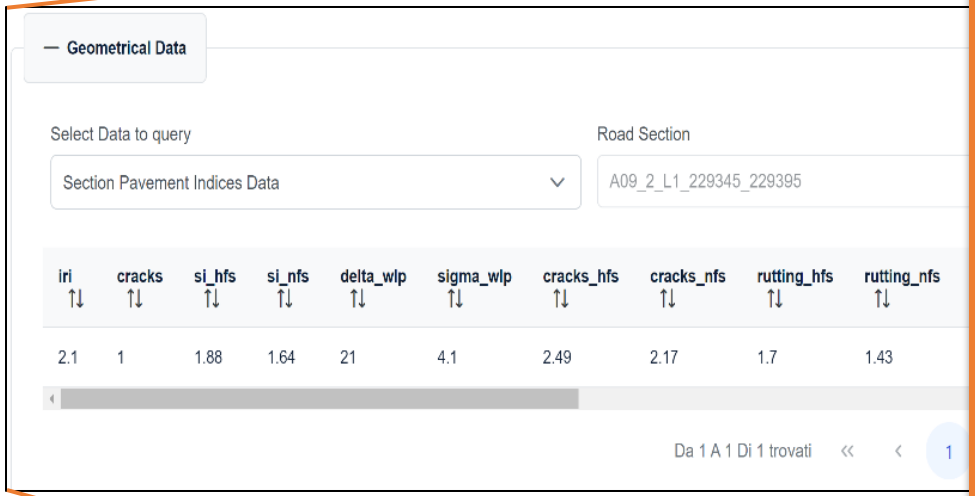
Geometric Data



- ❑ Pavement stratification
  - ○ Pavement general description
    - ❑ Pavement type
    - ❑ Layer thickness
    - ❑ Year of Construction
  - ○ Single Layer description
    - ○ Layer 1
    - ○ Layer 2
    - ○ Layer 2
- ❑ Geometric parameters [km_i – km_i+1]:
  - ❑ length
  - ❑ Number of lanes
  - ❑ Width
  - ❑ Longitudinal slope
  - ❑ Transverse slope
  - ❑ Min. curve radius
- ❑ Sensors positions and data acquisition
- ❑ Temperature data

RESULTS

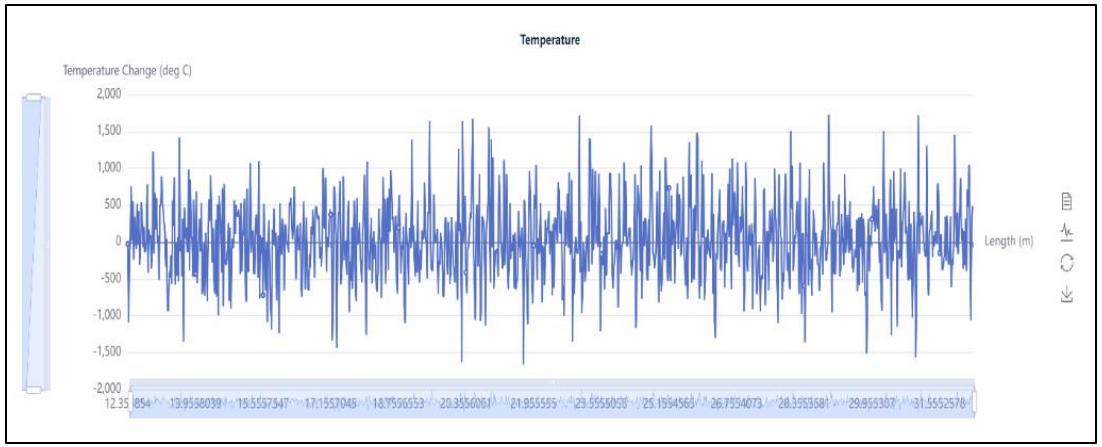
Pavement Condition Indices



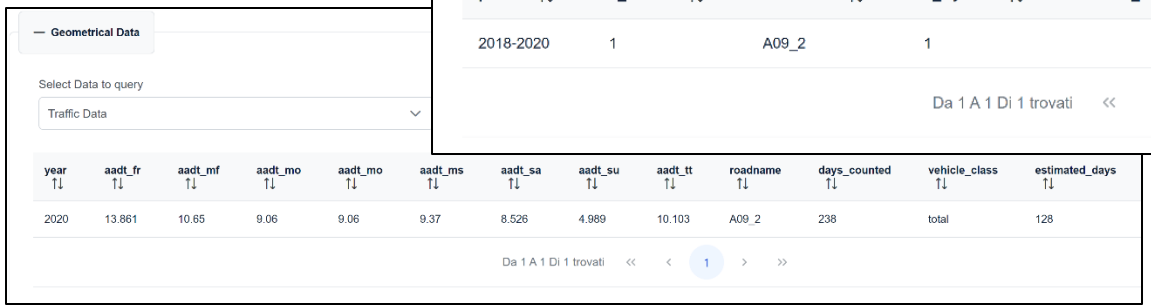
- ***Structural Index (SI)***
  - ***For the principal lane and secondary lane***
- ***Safety Index***
- ***Comfort Index***
- ***Skid resistance***
- ***Synthetic Index***
  - ***Surface defects***
  - ***Rutting (plastic deformation of surface)***
  - ***Cracks***
- ***Specific Index***
  - ***IRI (International Roughness Index)***
- ***Survey Data***

RESULTS

Sensors Acquisition

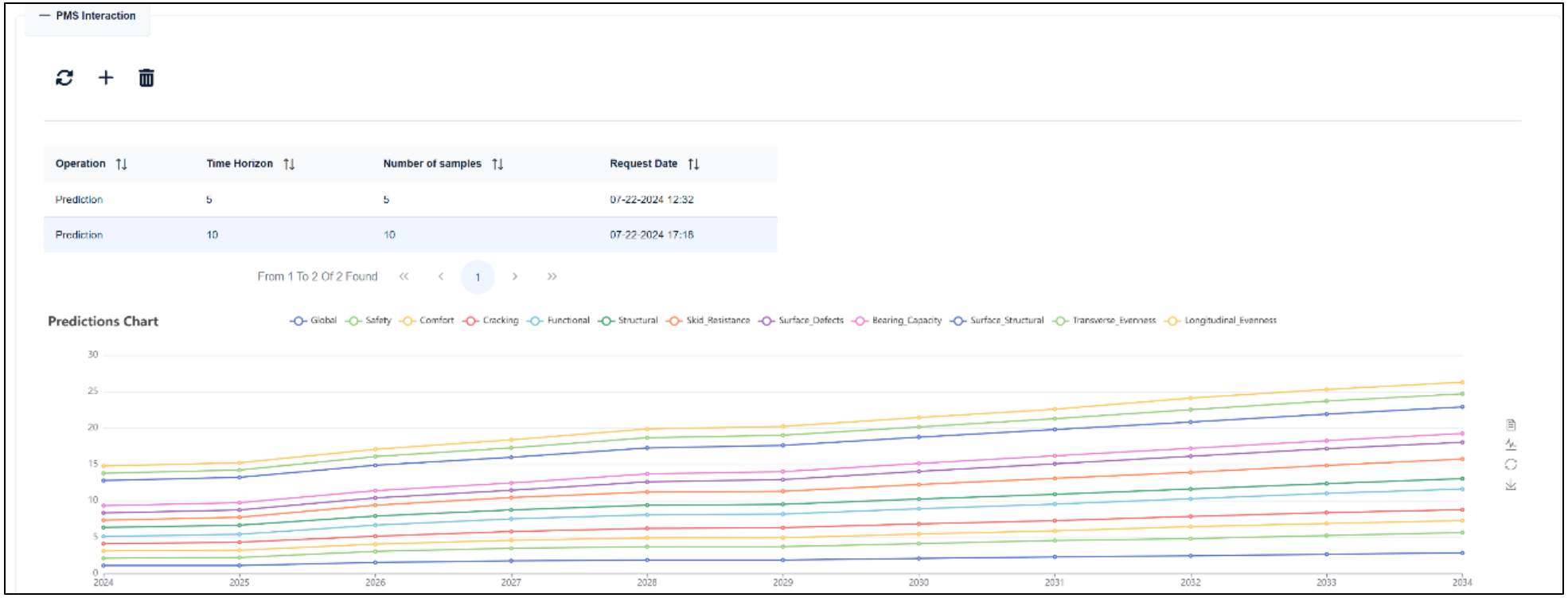


Accidents and Traffic DATA



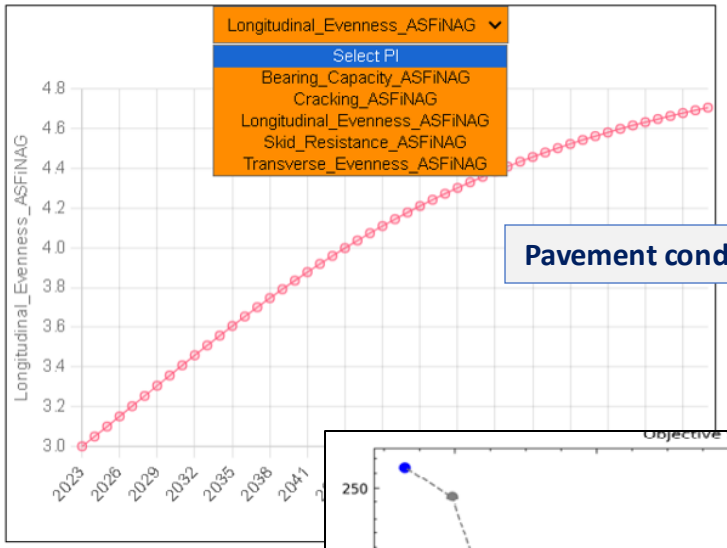
RESULTS

PREDICTION DATA

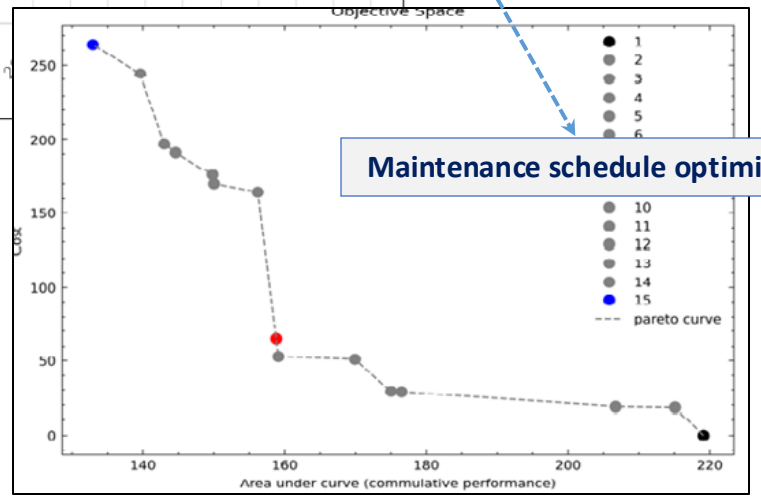


RESULTS

DYNAMIC DATA – PREDICTION DATA

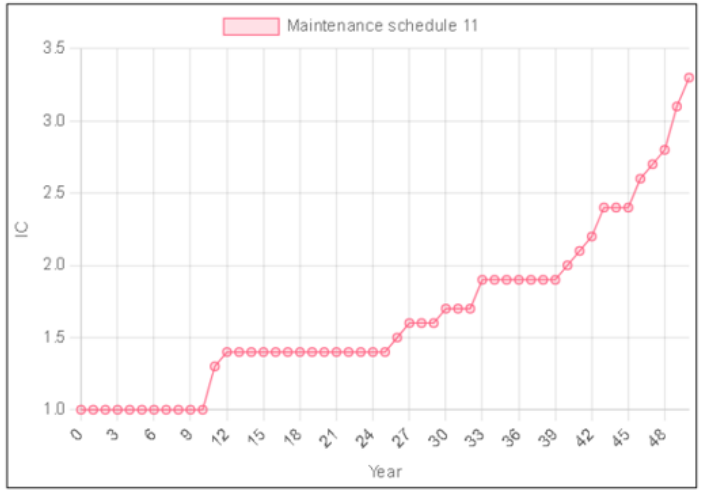


Pavement condition prediction



Maintenance schedule optimization

Maintenance Schedule	
13	Milling (5-10cm) + TC + BC + TC + SC
25	Milling (5-10cm) + TC + BC + TC + SC



Road performance under a specific maintenance schedule

FURTHER DEVELOPMENTS

Integration with additional Data Sources

- Sensor data (e.g. accelerometers) – Traffic sensors (vehicle count)
- Maintenance records (Repair costs)
- Weather data (wind speed – Humidity)

Advanced analytics and Machine Learning

- Image analysis (detect cracks, potholes and other distress automatically)
- Mitigation actions optimization and prioritization based on pavement conditions
- Sensor data processing to monitor pavement response to traffic loads and environmental conditions

Platform expansion and Scalability

- Rising data volume and velocity due to a possible higher number of devices connected
- Computational requirements for complex simulations and analyses

Thank you for your attention

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Infra ROB

Maintaining integrity, performance and safety of the road infrastructure through autonomous robotized solutions and modularization

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