ANAS Smart Road:

transition from *traditional civil work* to *interactive technological infrastructure*

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20th December 2022

OUTLINE

- **Introduction**

  Network needs analysis

- **Pavement maintenance strategy**

  Approach to maintenance activities

  Technological & digital support

- **Monitoring**

  Current picture

  - Road visual inspection
  - Pavement Management System – Anas

  Future works

  - Road Asset Management
  - Instrumentation of Anas service vehicles
  - Building Information Modeling

- **Anas Smart Road**

  - ANAS Vision
  - The future of European Mobility
  - Technological Infrastructure
  - Green Island
  - C-ITS Services
  - Innovation Projects
  - Trial sections & in situ experience

- **Conclusions**

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Introduction

Network needs analysis

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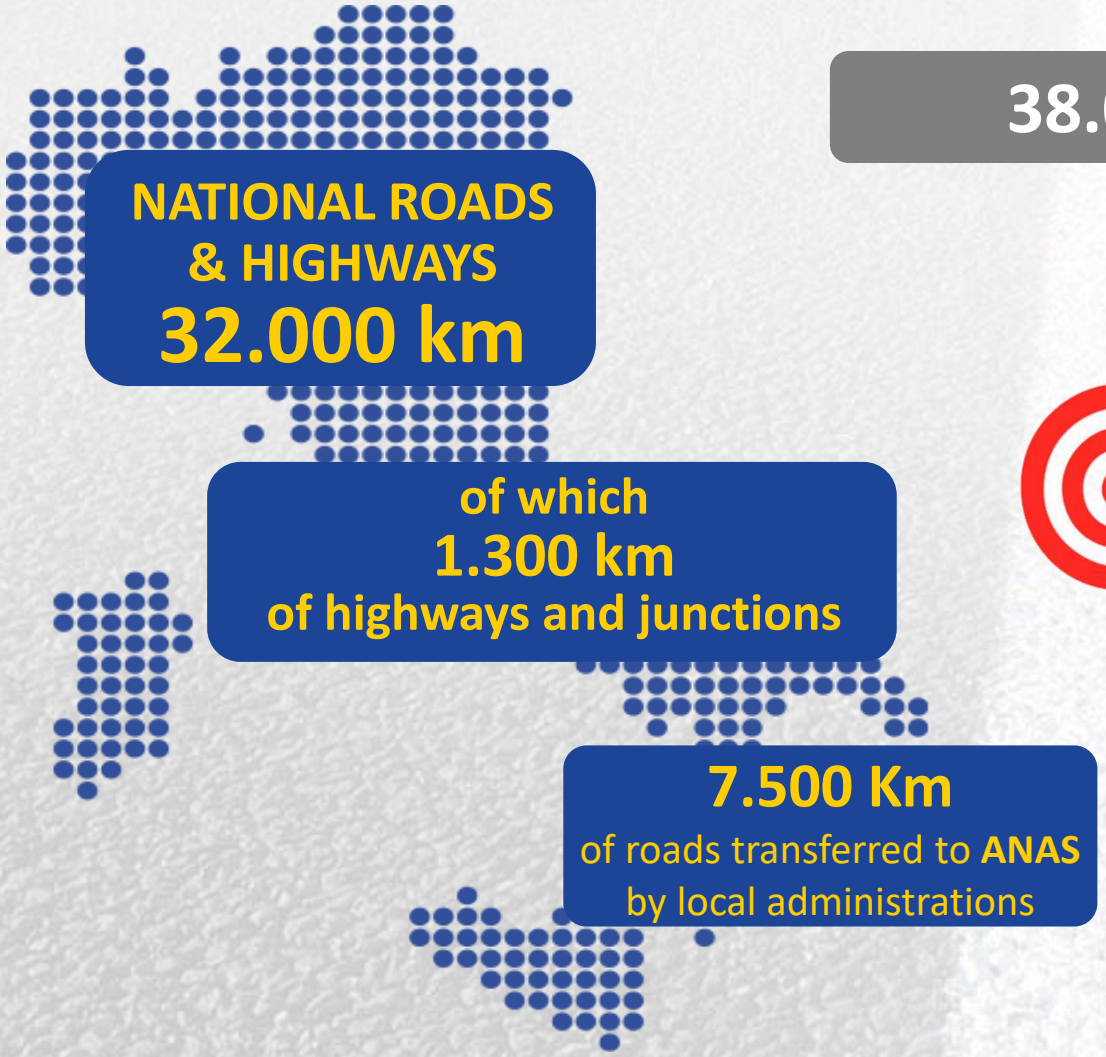
NETWORK NEEDS ANALYSIS



38.000 km (2018-2022) of paved lines

- ***Managing and processing the large amount of data*** *available about pavement conditions*
- *Uniforming* ***quality and safety standards*** *on the entire road network under management*

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INVESTMENT CHANGE MANAGEMENT

Funding | Design | Contract | Production | Check

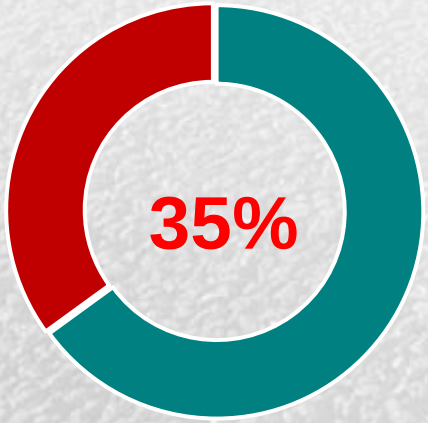
Program Agreement MIT – ANAS (2016 -2020)

5,1 billions €
for planned maintenance

→ **PA 21-25** *work in progress*

MULTI-YEAR BASIS

Road pavements



around 1,8 billions for road pavements

Other fundings (≈ 1,5 miliardi €):

- Local roads
- Extra-plans of planned maintenance
- Infrastructure Fund
- Budget law 21-24
- FSC (funds for development and cohesion)

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INVESTMENT CHANGE MANAGEMENT

Funding | Design | Contract | Production | **Check**

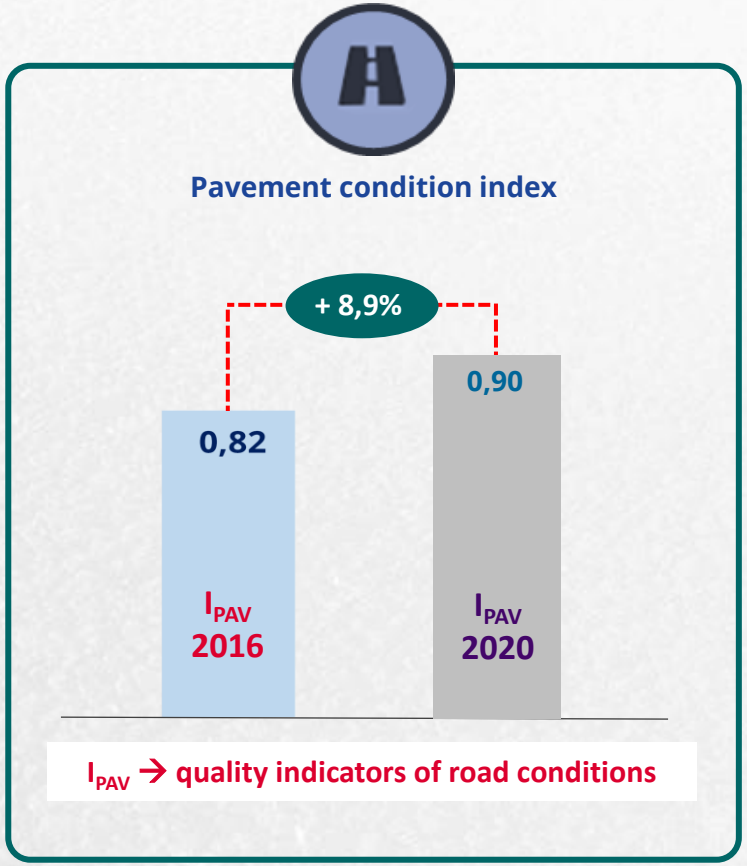
The interventions on pavements are controlled in terms of quality and quantity by the Ministry of Infrastructure and Transport, because of the strategic nature of the work in relation to user safety and comfort.

QUALITY CONTROL:

- Penalties
- Less fundings
- Reputation loss

$$I_{PAV} = 0{,}6 * I_{CAT} + 0{,}4 * I_{IRI}$$

function of adhesion (CAT) and roughness (IRI)



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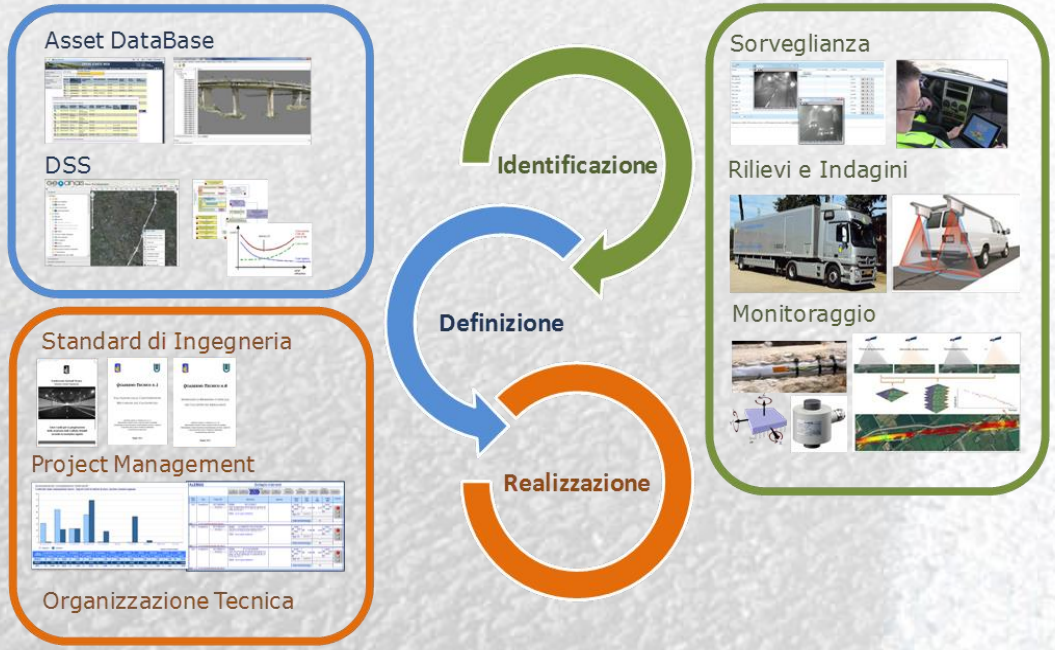
Pavement maintenance strategy

APPROACH TO MAINTENANCE ACTIVITIES

EXTRAORDINARY MAINTENANCE » **PLANNED** MAINTENANCE » **INDUSTRIAL PREDICTIVE** MAINTENANCE



PMS

Goal:

- ***end of emergency logic***
- ***multi-year planning***

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IDENTIFICATION OF MAINTENANCE NEEDS

Maintenance approach

REACTIVE APPROACH:

maintenance works only after the occurrence of pavement distresses

PRO-ACTIVE APPROACH:

action is taken before deterioration appears thanks to specific studies of pavement performance characteristics

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IDENTIFICATION OF MAINTENANCE NEEDS

Maintenance approach

How is it possible to obtain the necessary information for a PRO-ACTIVE approach?

- *A number of tools are currently available to determine pavement conditions, both in terms of structural and functional performance.*
- *The new technologies allow a **significant reduction in time and costs required for data acquisition**.*

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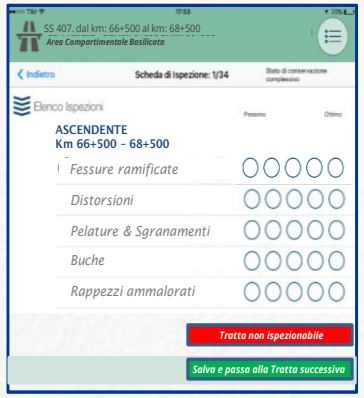
IDENTIFICATION OF MAINTENANCE NEEDS

Daily activities of:

Supervision

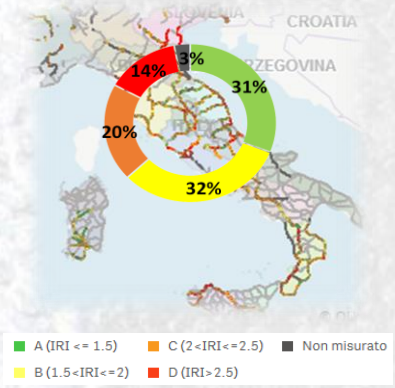
45.000 semestral visual inspections

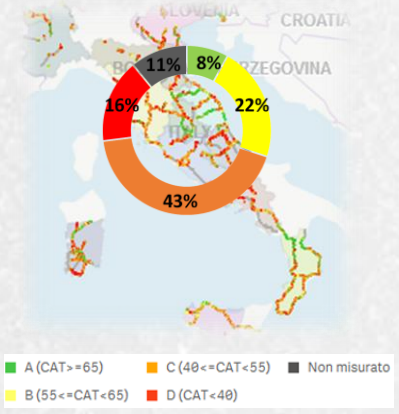


Survey & Detection

High-performance equipment

Analysis and Elaboration





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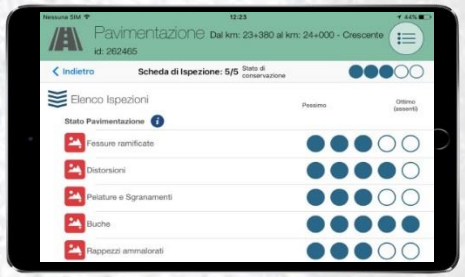
DATA AQUISITION

Pavement distresses detection

Distress category
CRACKING (LONG. – TRANS. – ALLIGATOR)
DEPRESSIONS (RUTS, CORRUGATIONS, BUMPS SAGS)
WEATHERING AND RAVELING
POTHOLES
PATCHING

VISUAL INSPECTIONS

according to codified methods common to all local offices



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Pavement distresses detection – Work in progress

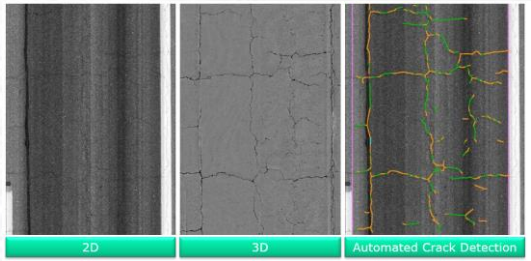
Automatic detection of surface pavement distresses

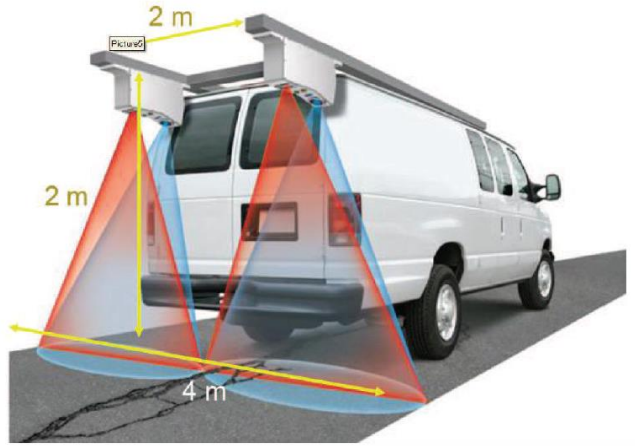
The automatic surface distresses detection system consists of high-resolution and high-frequency laser cameras, installed in the back part of a specific dedicated vehicle.

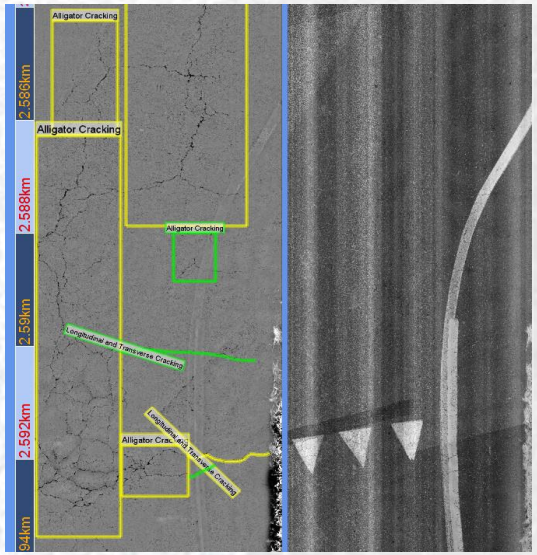
The system is able to acquire:

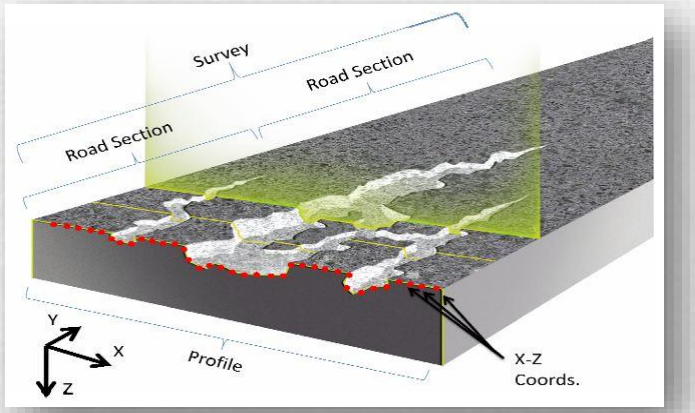
- 2D IMAGES
- 3D PAVEMENT PROFILE

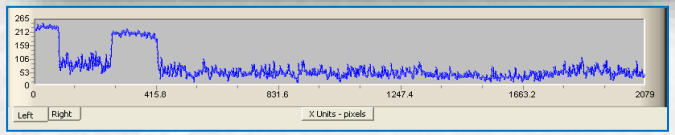
From the analysis of 3D images and scans collected by the cameras, a specific software automatically identifies pavement distresses and classify them on the basis of their **TYPE**, **EXTENT** and **SEVERITY**.











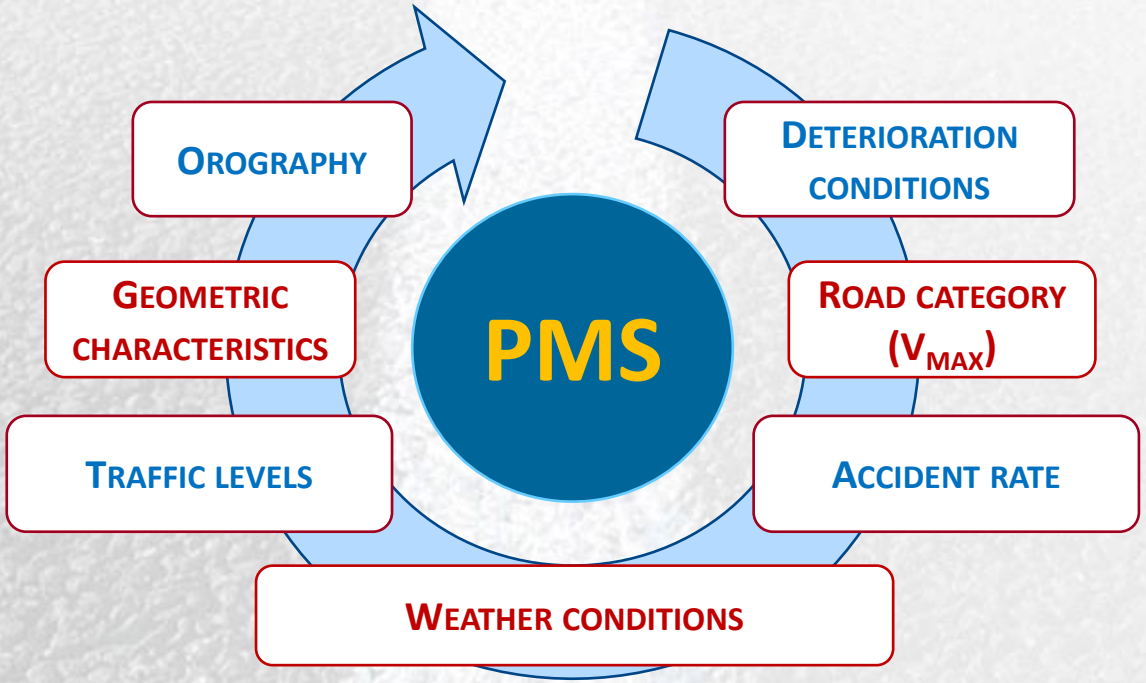
Pavement Management System - ANAS

Conceptual model

Where → **How** → **When** → **How much**

For each direction and each lane (current and historic data)

INVENTORY DATA



CONDITION DATA

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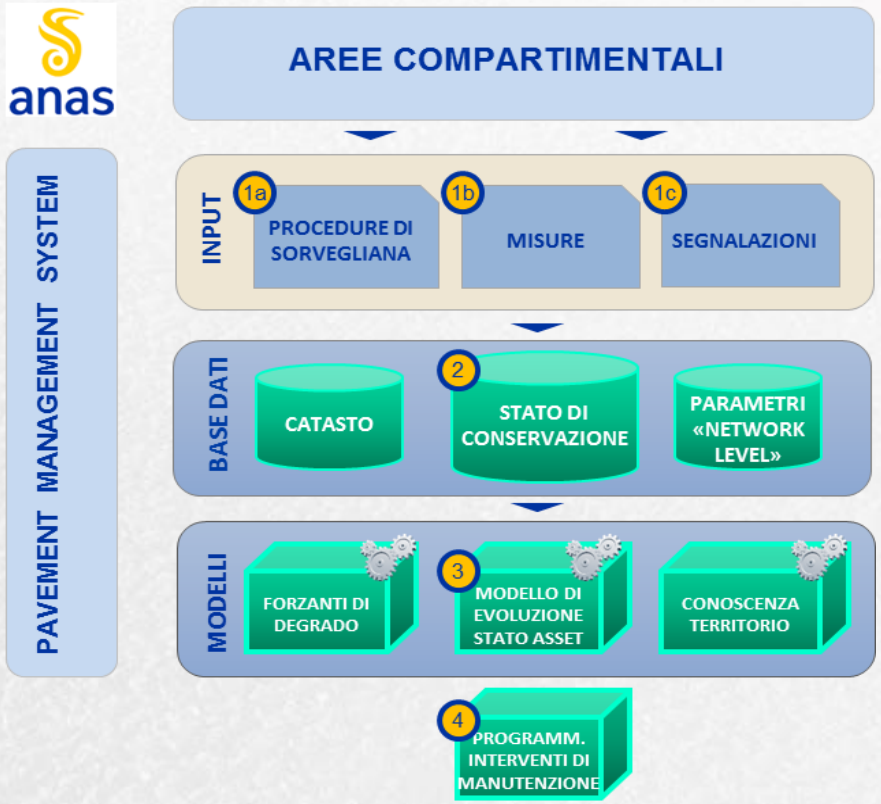
Pavement Management System - ANAS

Conceptual model

DATA COLLECTION » **NETWORK STATUS ANALYSIS** » **DATA ELABORATION AND DECISION-MAKING** » **INTERVENTION PLANNING**

1. ***TECHNICAL PARAMETERS ACQUISITION***
   (local and network data): *inspections; monitoring; reports*
2. ***STATE INDECES***
   for each parameter
3. ***GEOMETRIC AND GEOGRAPHICAL INDICATORS, PHOTOGRAPHIC DOC., WEATHER CONDITIONS***
   data georeferencing, archiving and standardized display (SYNTHETIC or DETAILED format)
4. ***PREDICTIVE MODELS***
   calculation and analysis
5. ***IMPOSITION OF BOUNDARY CONDITIONS***
   technical and economic

» ***M&R ACTION PLANS***



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DATA ACQUISITION

Functional and structural performance monitoring and automatic distresses acquisition

ROUTINE EVALUATION OF MACROTEXTURE, EVENNESS AND SKID RESISTANCE

DYNAMIC ROAD SOUND METER

FALLING WEIGHT DEFLECTOMETER

HIGH-PERFORMANCE EQUIPMENT

ROAD MARKINGS

TRAFFIC SPEED DEFLECTOMETER

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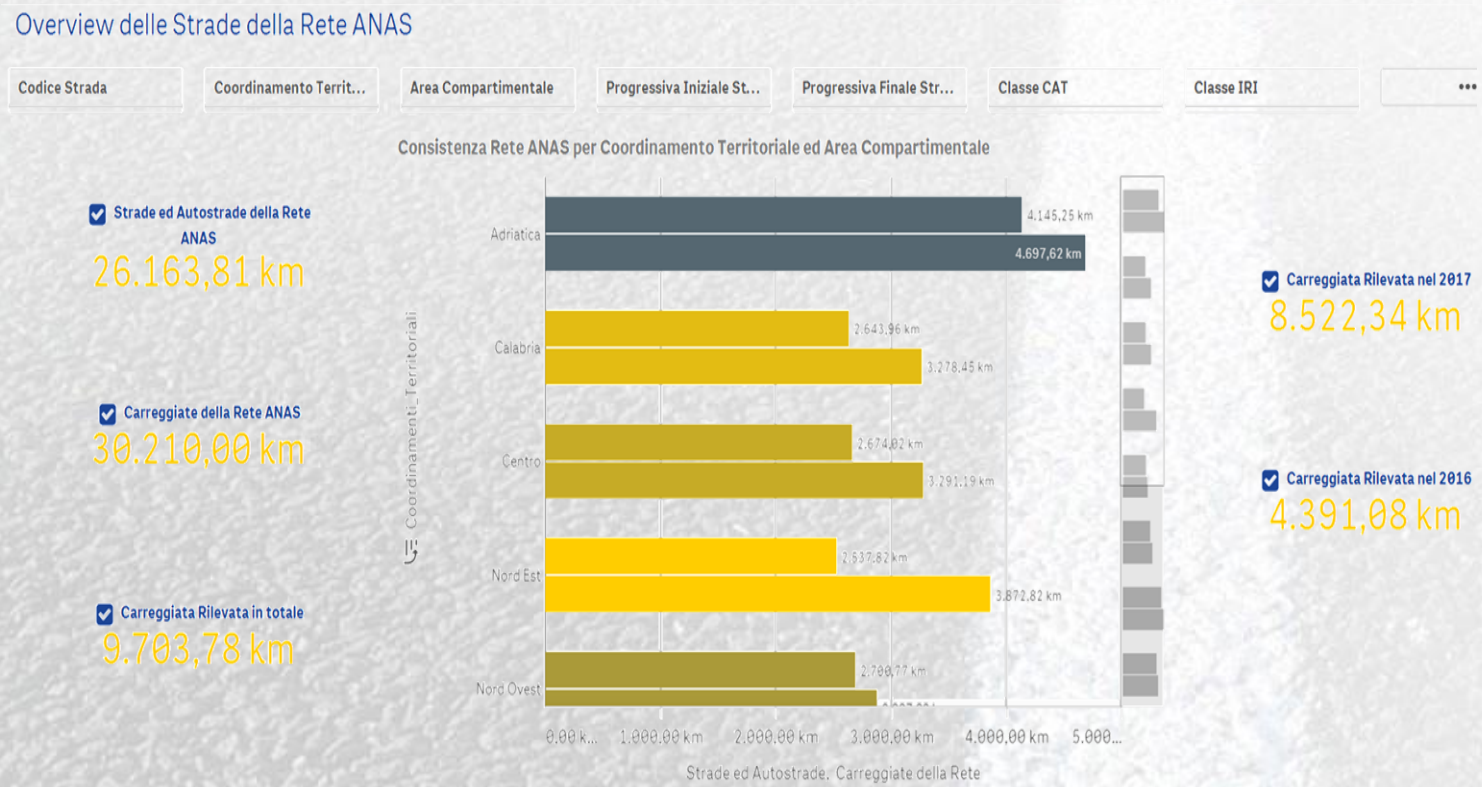
DATA VISUALIZATION

PIV Software

DATA FROM VISUAL INSPECTION

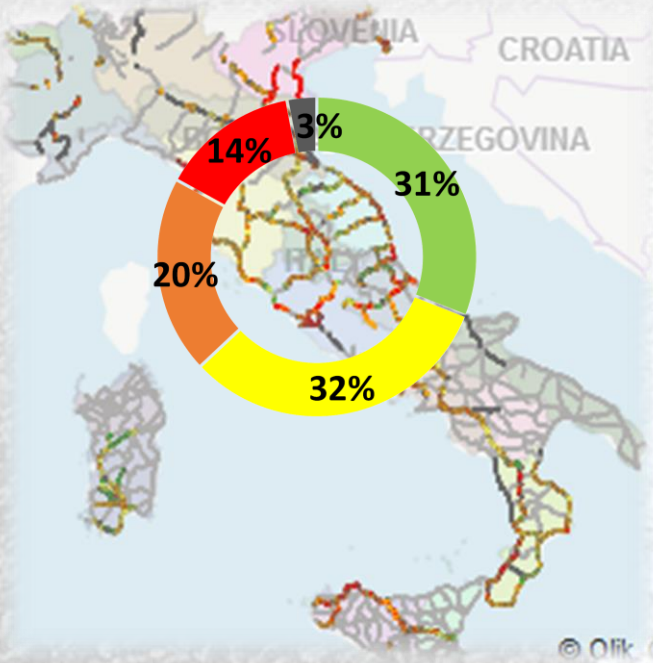


DATA VISUALIZATION

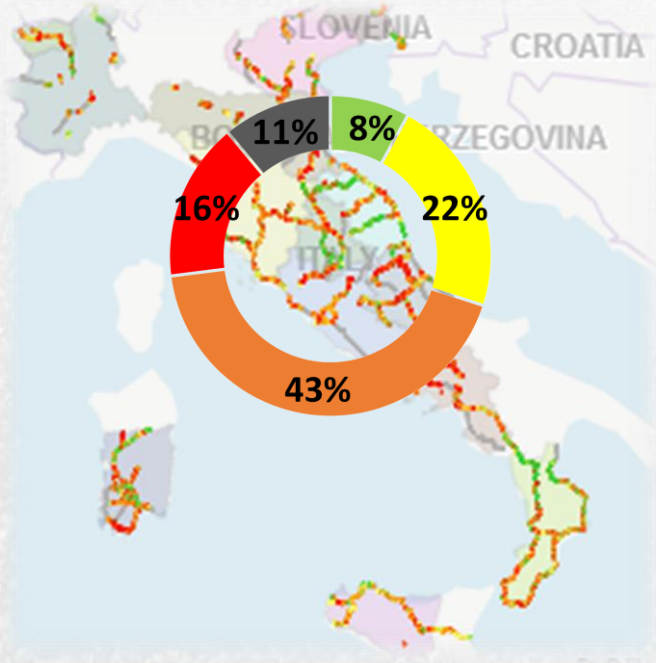
PIV Software

DATA FROM HIGH-PERFORMANCE EQUIPMENT

% km rilevati per Classe IRI



% km rilevati per Classe CAT



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DATA ELABORATION & ANALYSIS

SIGMA Software

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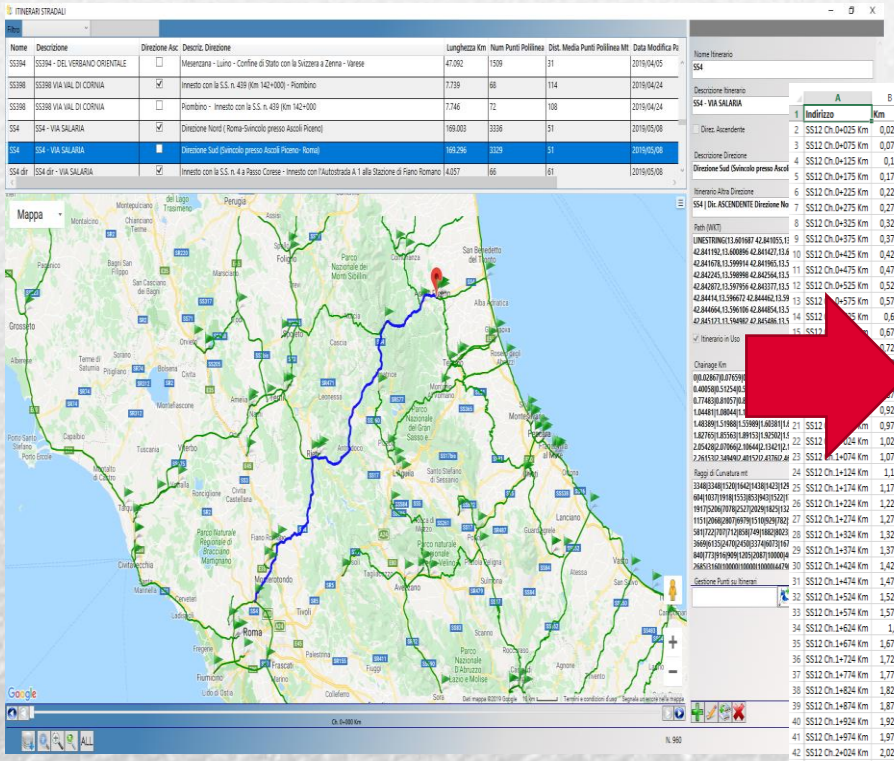
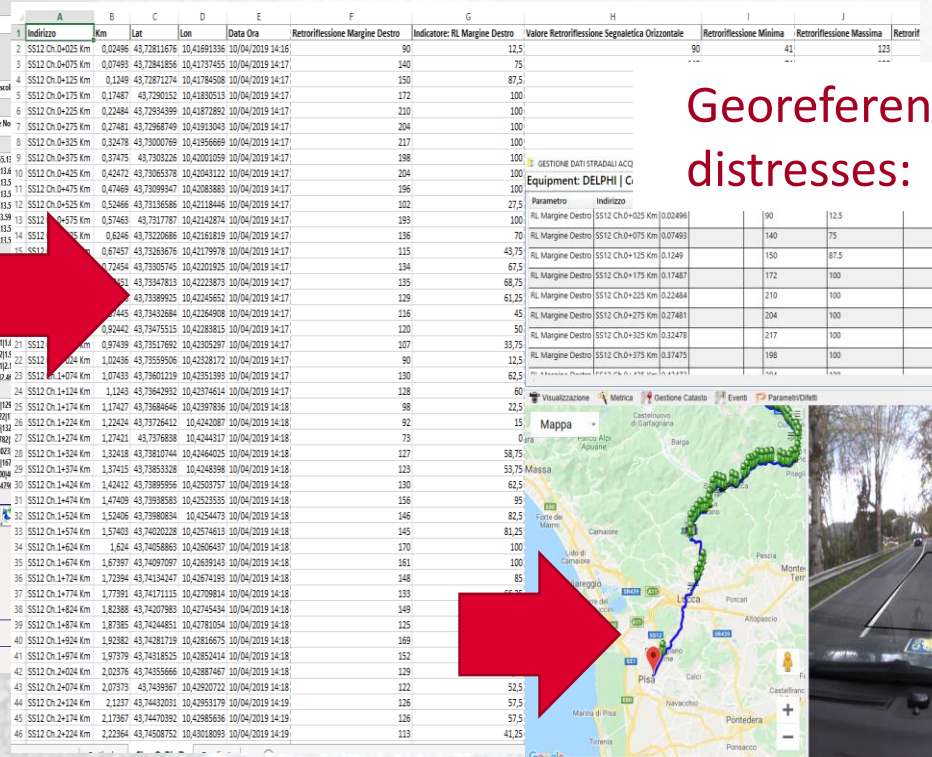
DATA ELABORATION & ANALYSIS

Uploading e data visualization

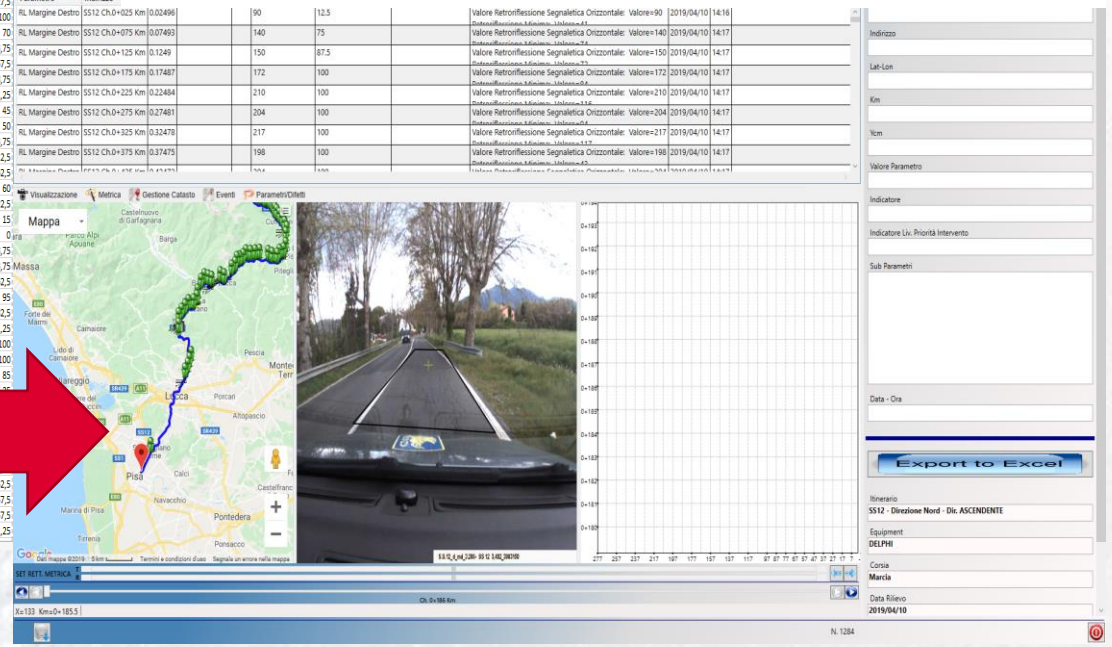
Itinerary and data uploading:



Data downloading in .xls format:



Georeferencing and correlation with local distresses:

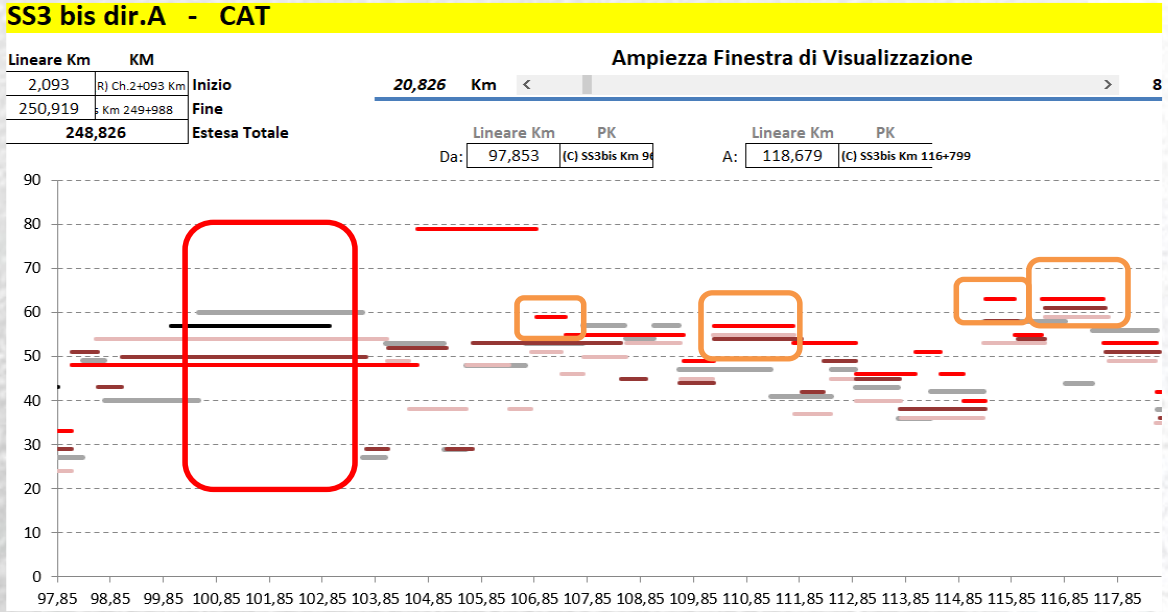


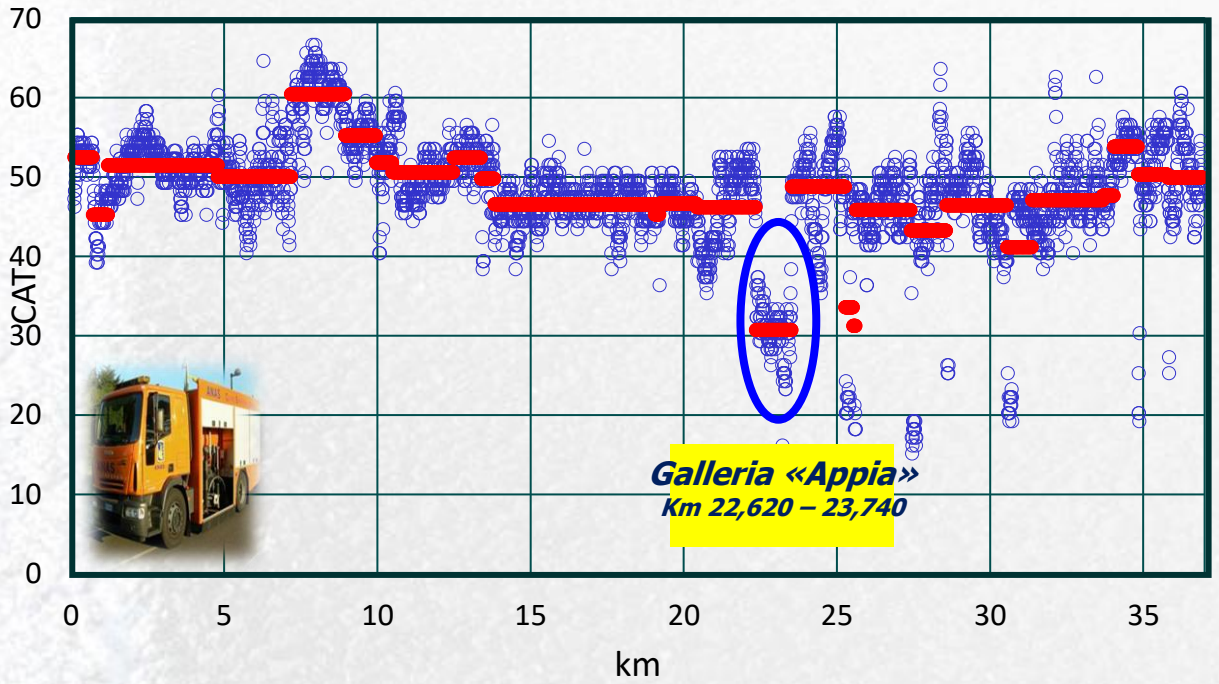
DATA ELABORATION & ANALYSIS

Homogeneous sections

Comparison homogeneous sections 2015 → 2019 (determination of potential CAT decreases)

Exclusion of sections where **maintenance work** has been carried out on the pavement





DATA ELABORATION & ANALYSIS

List of technical solutions for pavement structure

SOLUTION TYPE

TYPE 1 – Superficial

TYPE 2 – Intermediate

TYPE 3 – Structural

TECHNICAL constraints:

PERFORMANCE INCREASE

PRE-intervention

- CAT_i
- IRI_i
- $Hs_{i,}$
- Residual service-life

POST-intervention

- CAT_f
- IRI_f
- HS_f
- Residual service-life

STRATEGICAL constraints:

BUDGET

Cost 1
€/sqm

Cost 2
€/sqm

Cost 3
€/sqm

Priority index = f(Coeff. of importance; Coeff. of effectivness; Coeff. of use)

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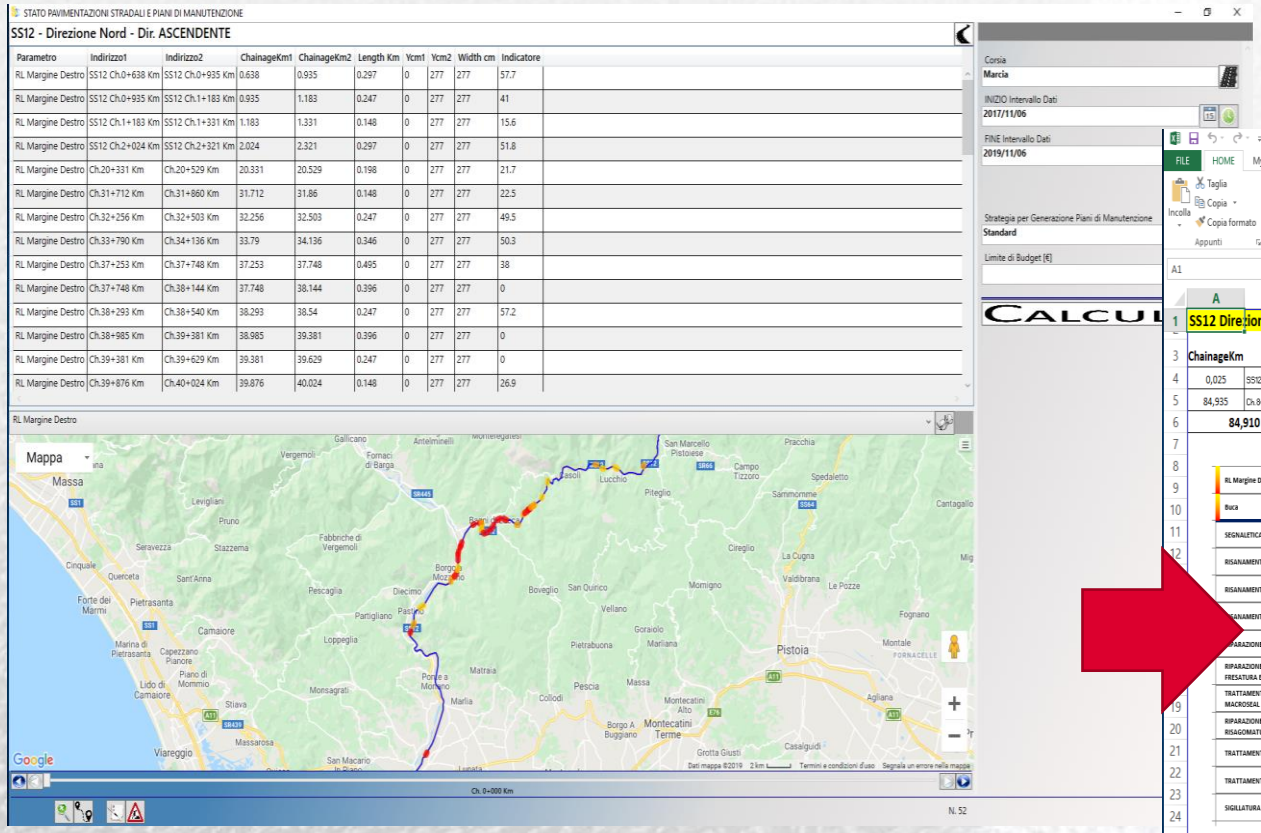
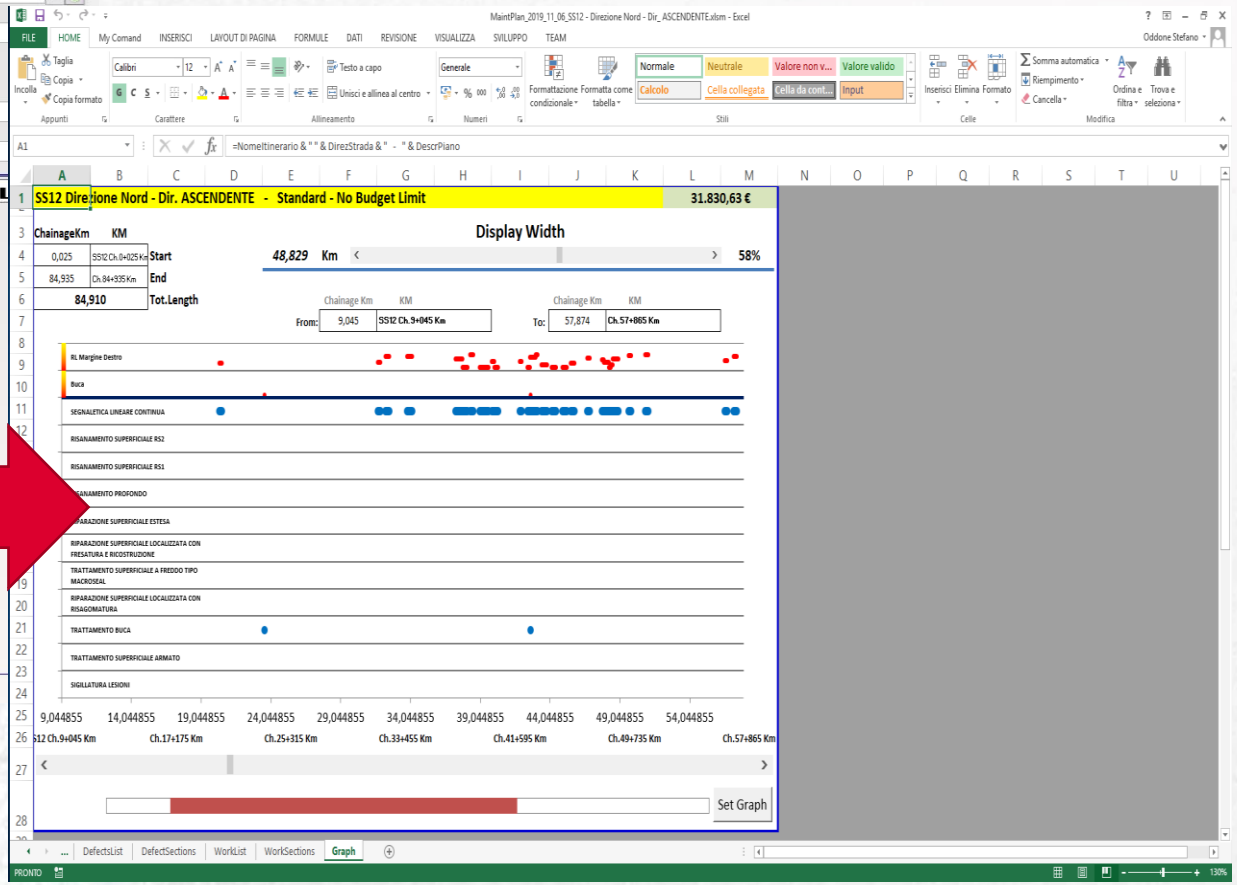
DATA ELABORATION & ANALYSIS

Maintenance plans





Future works

ROAD ASSET MANAGEMENT

Work in progress

Model for the planning and management of maintenance interventions (RAM System) → allows to start a radical transformation of the management and surveillance system of the various network assets

The RAM model can be summarized in a 4-step process:

1. Data collection

- Road infrastructure inventory by Asset
- Identification of environmental conditions
- Identification of boundary conditions

2. Analysis

- Condition of the asset
- Realized and planned maintenance works (maintenance needs identification)

3. Data Elaboration

- Forecast of asset degradation through mathematical models
- Budget available

4. Decision-Making

- Economic value of the asset obtained through the planned maintenance work
- Study of different alternative intervention strategies

OPTIMAL TECHNICAL AND ECONOMIC PLANNING OF OVERALL SCHEDULED MAINTENANCE INTERVENTIONS FOR ALL ASSETS

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Instrumentation of Anas service vehicles

Work in progress

The idea is to *arm Anas service cars* (about 2,000 vehicles) with tires equipped with sensors that are able to accurately detect certain types of pavement distresses (e.g. holes, cracks) through accelerations measurements.

→ to ***"READ" in REAL TIME*** road pavement conditions along the network of competence

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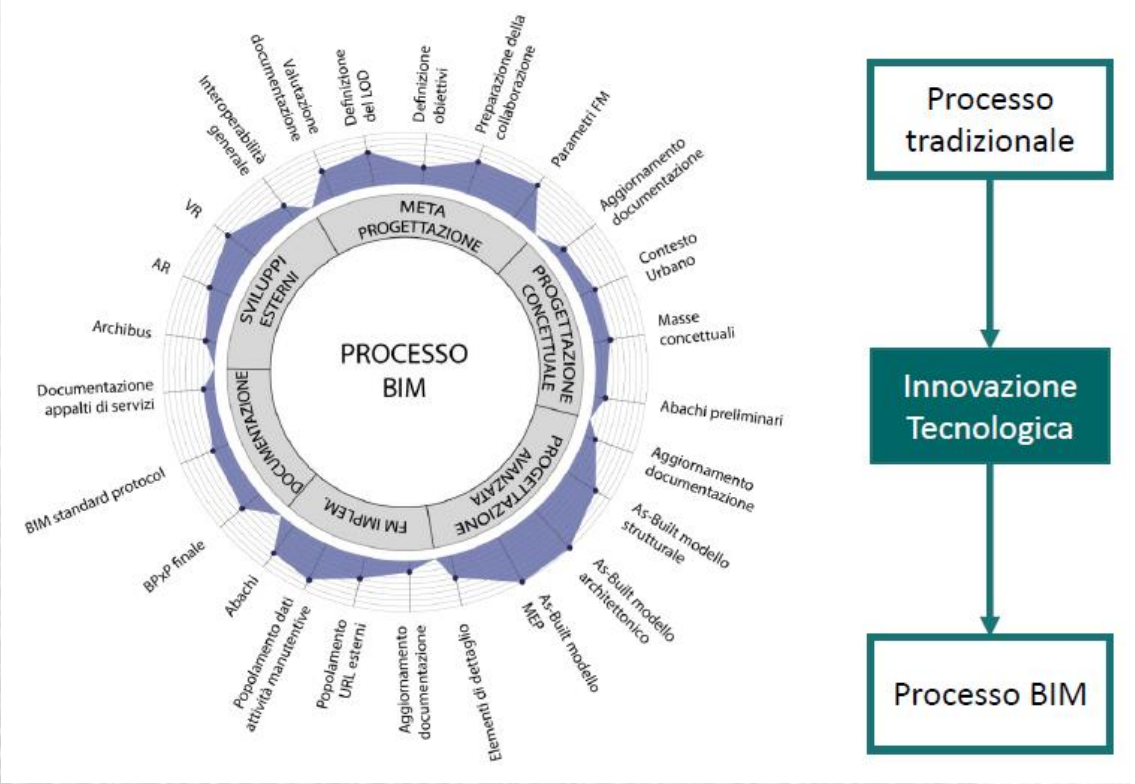
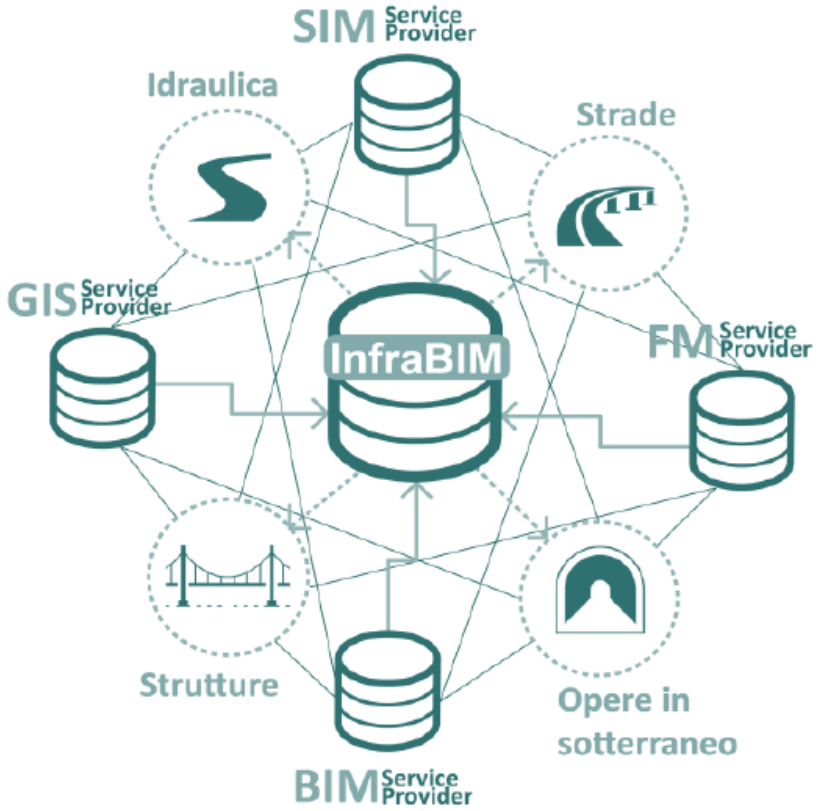
Building Information Modeling

Work in progress





BIM: methodology for digitalizing the management process of road infrastructure

- Digitalizzazione del processo
- Immediata condivisione dei modelli informativi
- Collaborazione continua tra i soggetti responsabili
- Unico ambiente di lavoro in cloud (ACDat)

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ANAS Smart Road

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What's «*Anas Smart Road*»?

The vision

Anas has been fully embracing **digital transformation** so as to meet growing road network management requirements and users' needs since time out of mind; **the "*Anas Smart Road*" Program**, established in 2016, has been conceived to promote **a new mobility paradigm** aimed at assuring safety, connectivity, innovation and paving the way for autonomous driving by putting road users at the heart of the Company's operations.

Benefits

Road Operator

«*Anas Smart Road*» provides **powerful road management tools** by means of which both **traffic** and **maintenance** can be steadily **monitored** and **controlled**

Users

«*Anas Smart Road*» provides **users** with helpful **services** aimed at enhancing **driving experience** and increasing **safety**

Sustainability

«*Anas Smart Road*» is meant to make roads fully **sustainable** by yielding and conveying **renewable energy**

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Technological Infrastructure

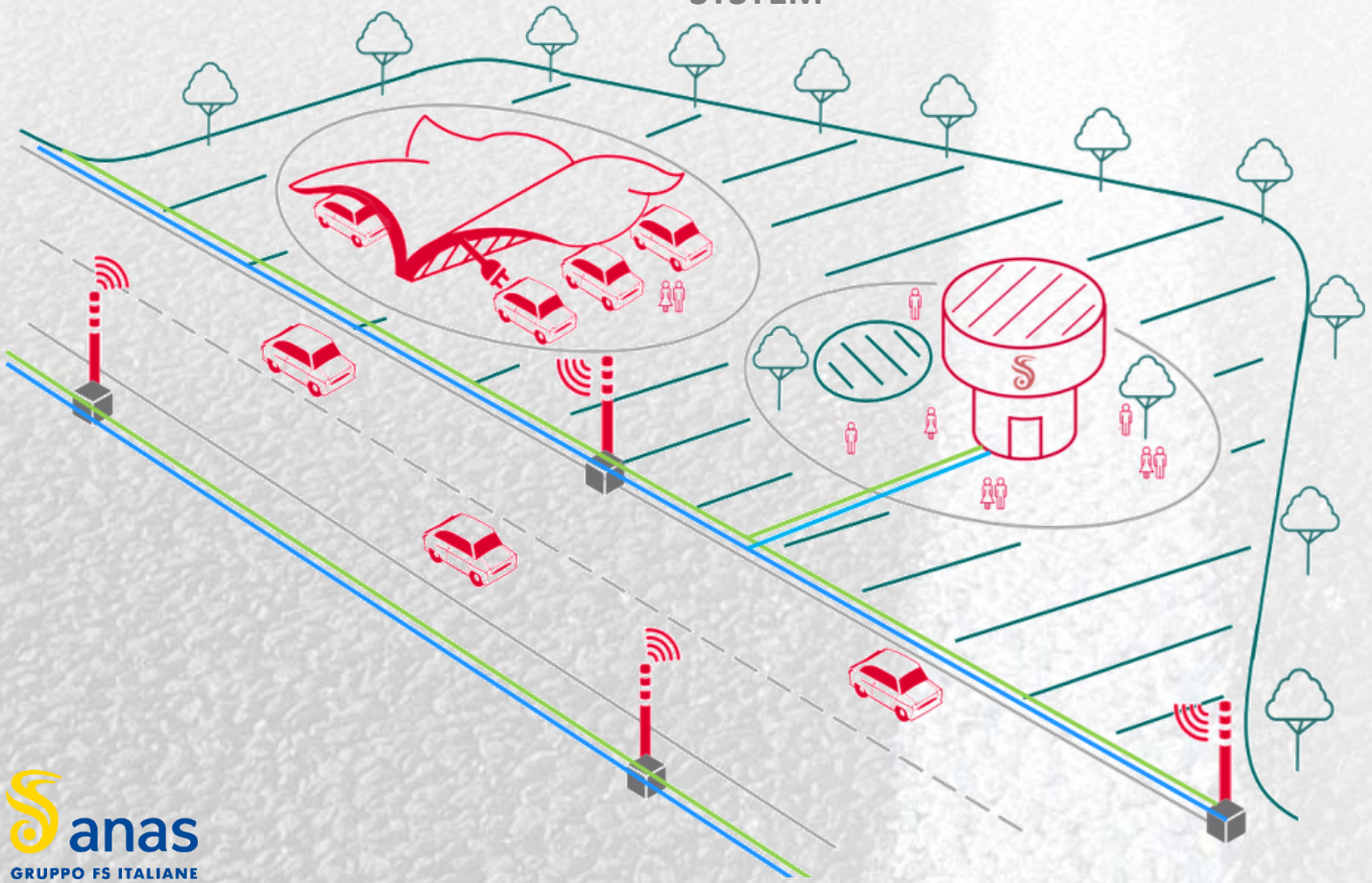
The challenge of digital revolution

CONTROL ROOM

INTELLIGENT CENTRAL SYSTEM

GREEN ISLAND

INFRASTRUCTURE



ENERGY SYSTEM

DATA SYSTEM

MULTIFUNCTIONAL POLE

TECHNOLOGICAL CUBE

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Technological Infrastructure

Multifunctional Pole

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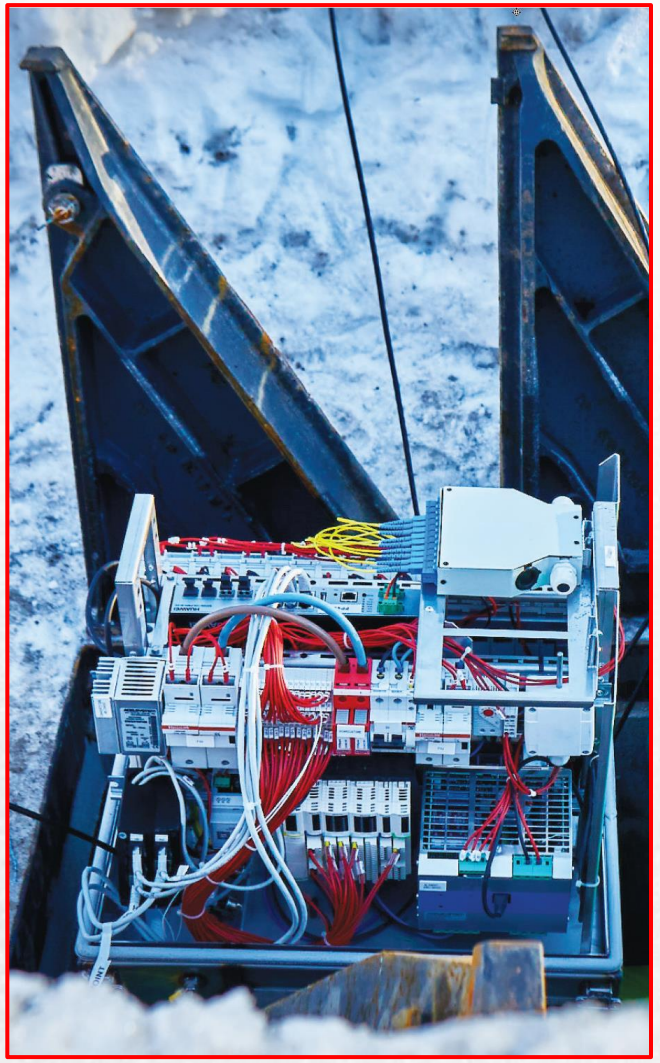
Technological Infrastructure

Technological Cube

"HOSTS SMART ROAD TECHNOLOGIES"

- Switch 10/100 BASE TX - 10G BASE SR - PoE;
- 350 kVA Transformer and DC/DC Converter;
- Battery container;
- IoT Narrowband Gateway;
- UTP Cable Terminal BOX;
- Optical Fibers Terminal BOX.



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The Smart Camera

A watchful eye on user security

AID

- **Stopped vehicle** detection
- **Slow vehicle** detection
- **Traffic** congestion
- **Wrong direction** detection
- **Lane change** recognition
- **Pedestrian** recognition
- **Smoke or mist** on the road
- **Weather** conditions
- Recognition of **dangerous and flammable goods**

WEATHER

Real-time weather detection by video stream processing.

Rain

Severe winter storms

Visibility

Snow and wind

Rainfall

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Green Island as Energy Oasis

The green heart of "*Anas Smart Road*"

- PHOTOVOLTAIC ENERGY EQUAL TO 100.000 kWh/YEAR
- EOLIC ENERGY EQUAL TO 30.000 kWh/YEAR
- ENERGY-SAVING ADAPTIVE LIGHTING
- FREE WI-FI INTERNET CONNECTIVITY FOR USERS
- STOPPING POINTS AND SOLAR ENERGY
- ELECTRIC CHARGING STATIONS
- MONITORING AND INTERVENTION SYSTEM WITH DRONES

The role of the Green Island is to **maximize energy efficiency** and **minimize operating costs**

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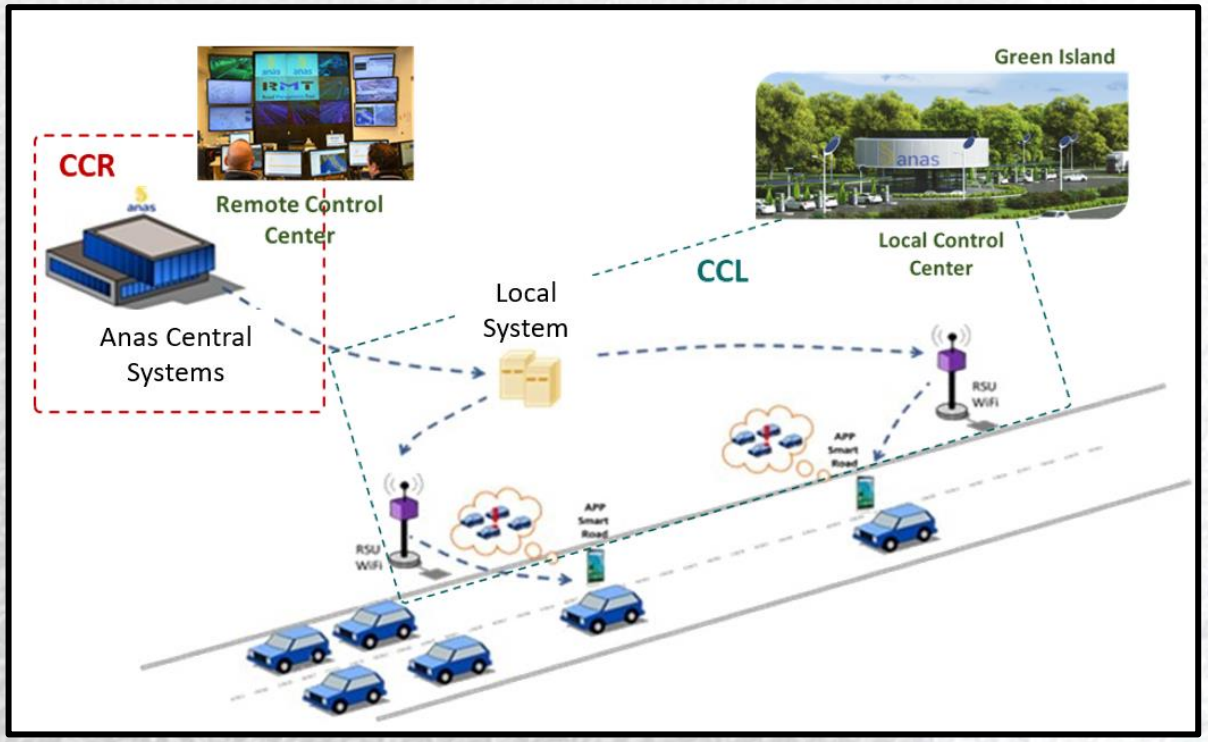
The «*Anas Smart Road*» Control Room

At a glance

The «*Anas Smart Road*» Program can rely on a network of control centers hosting the ICT infrastructure which fully underpins road management and user services. Smart Road uses **two communication standards:**

- **ITS-G5**, based on **IEEE 802.11p** set and proposed by **ETSI**;
- **C-V2X**, based on **LTE-V2X** set and proposed by **3GPP**.



- ***Remote Control Center (CCR)***

A centralized Cloud Data Center where data from the whole set of «Anas Smart Roads» is processed by means of Artificial Intelligence and Big Data algorithms. Additionally, the «CCR» features a Central Control Room gathering video flows from the CCL's all over Italy

- ***Local Control Center (CCL)***

The «Green Island» hosts a computing center where the C-ITS messages exchanged between vehicles and Road Side Units as well as video streams from «Smart Cameras» get processed and shared with the «CCR». Furthermore, the «CCL» is equipped with a Local Control Room for swift responses to road events

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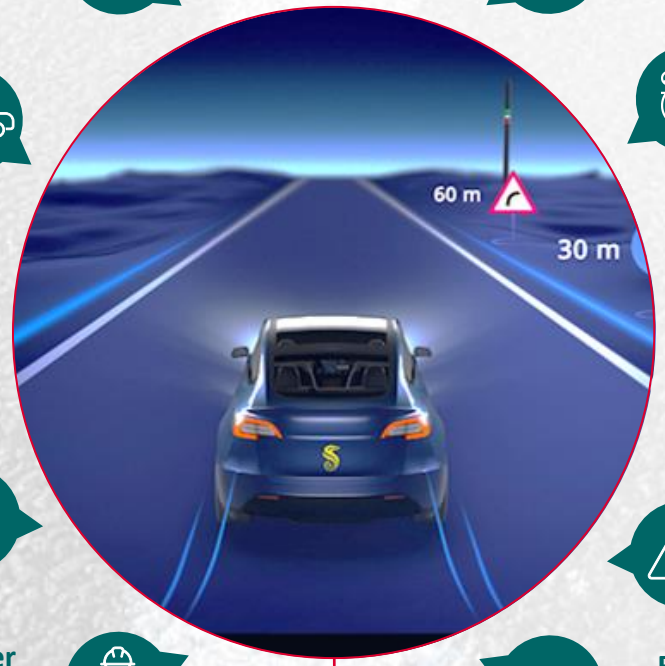
C-ITS Services

Infomobility for safe driving

«*Anas Smart Road*» offers **C-ITS services** supporting and enhancing road users' driving experience. These services fall into the «*C-ITS European framework*» whose guidelines and standards Anas has been strictly sticking to so as to implement and deliver an increasing number of beneficial and helpful **Day 1 and Day 1.5 use cases** over time.



- Slippery Road
- Stationary Vehicle Ahead
- In-Vehicle Speed Limits
- Emergency Braking
- Wrong Way Driving
- In-Vehicle Signage
- Slow Vehicle Ahead
- Emergency Vehicle Approaching
- Lane Closed Ahead
- Obstacle On The Road
- Traffic Jam Ahead
- Vehicle Entering The Lane
- Generic Danger
- Weather Conditions
- Road Closed Ahead
- Animal On The Road
- Road Worker On The Road
- Road Works Ahead
- Traffic Information & Smart Routing (VMS & Infomobility)

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Implemented Services

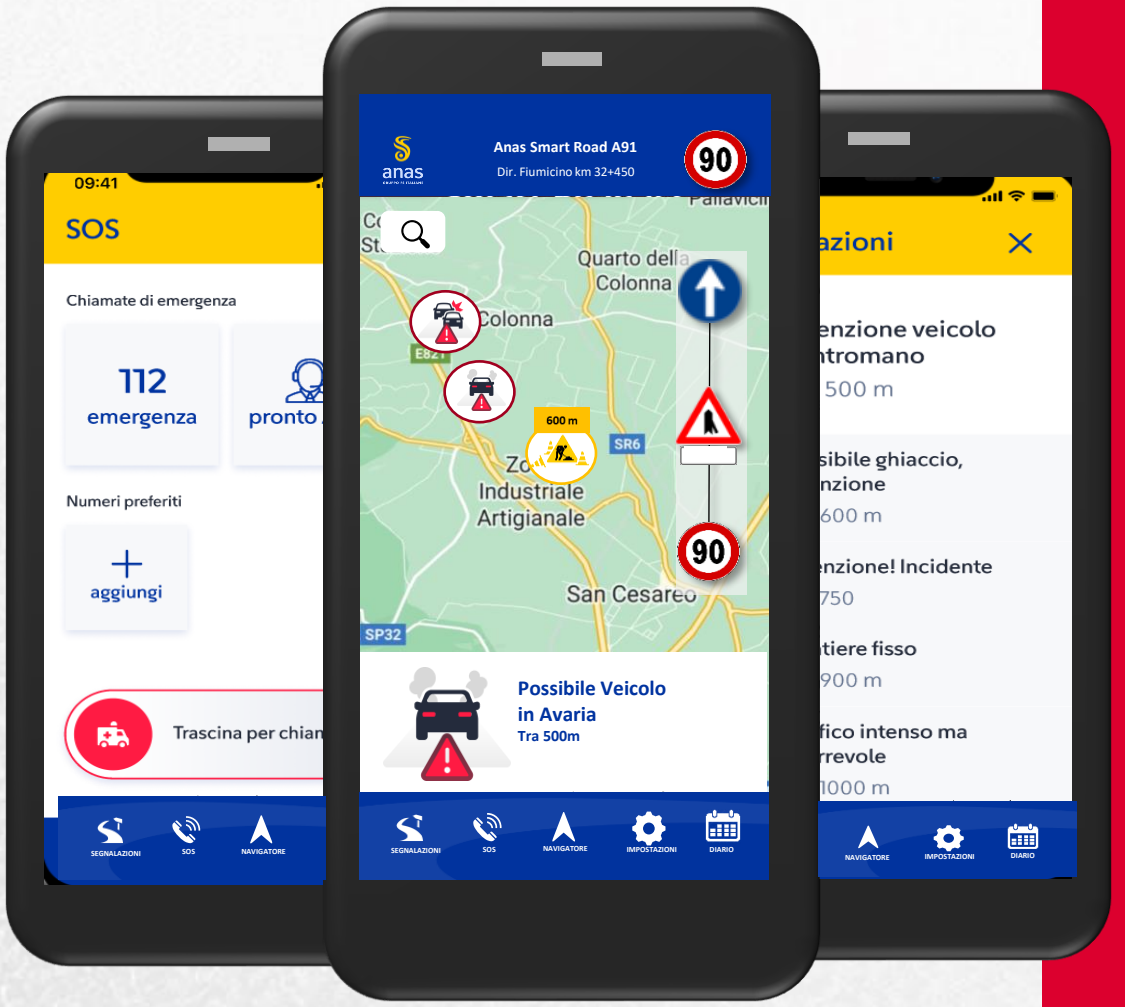
Services on the go

The majority of these «User Services» is delivered by means of a mobile application, aka the «Anas Smart Road App», available for both iOS and Android devices

App Smart Road Anas

User Services

“IMPROVES THE TRAVEL OF USERS ALONG THE SMART ROAD SECTION”



Services and real-time information on road conditions through:

- **IOT (Internet Of Things)**
- **Advanced mobile networks (Wifi in Motion, LTE, 5G)**

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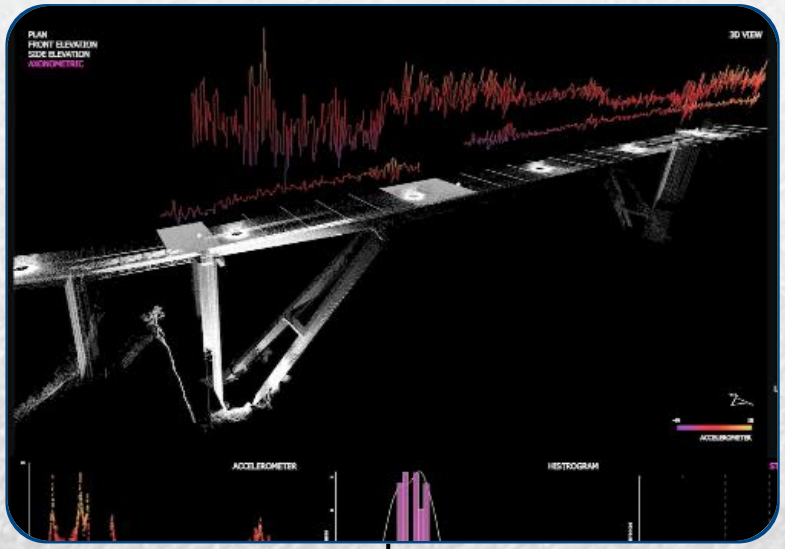
Experimental solutions

Keeping up with progress

«*Anas Smart Road*» opens up **new possibilities** in terms of technological achievements coming up with unique solutions to challenging road management problems: **experimental solutions** can be fully developed and easily integrated thanks to the «*Anas Smart Road*» infrastructure's **scalable nature**.



MIT – Good Vibrations

Smartphone Sensing for data **collection** aimed at bridge real-time **monitoring** and entry level predictive **maintenance**

RWIS – Road Weather Information System

Image processing through AI and machine learning to detect weather and pavement conditions

AREA System

Internet of Things based system designed to steadily keep an eye on **static and moving construction site status**

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The power of expertise

Drawing upon experience to overcome new challenges

The «*Anas Smart Road*» Program started off with the **SS 51 Alemagna** which was exhibited in occasion of the **FIS Alpine World Ski Championships 2021** held in **February** in **Cortina d'Ampezzo**.

80 kilometers

4 tunnels

7 towns

3 Green Islands

336 TAPs

The **A91 RM-FCO**, linking Rome to the FCO Airport, was successfully tested in 2021 along with an innovative **National Control Room** hosted by the **«*Anas Smart Road Center*»**; several experimental projects are currently underway.

13 kilometers

1 Green Island

42 TAPs

Due to the lack of european standards, Anas has developed a Road Side Unit which is able to communicate with vehicles over both DSRC and Cellular-V2X

Anas has been partnering with major car manufacturers so as to ensure its road infrastructure can be fully compatible with On Board Unit-equipped vehicles

«Anas Smart Road» infomobility services have been conceived, designed and implemented to straightforwardly suit road users' needs

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Conclusions

iTECH & AI FOR MANAGING MAINTENANCE ACTIVITIES

PREDICTIVE MAINTENANCE

TECHNOLOGICAL & DIGITAL SUPPORT

MATERIALS & EQUIPMENTS

MONITORING

INTER CONNECTIONS

SMART ROADS ***SMART PAVEMENTS***

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GO BEYOND THE TRADITIONAL CONCEPT OF INFRASTRUCTURE AS A MAJOR MATERIAL WORKMADE OF STEEL, CONCRETE AND ASPHALT

NOT ONLY A TRANSFER SYSTEM, BUT A WAY THROUGH WHICH TO IMPROVE USERS' LIFES

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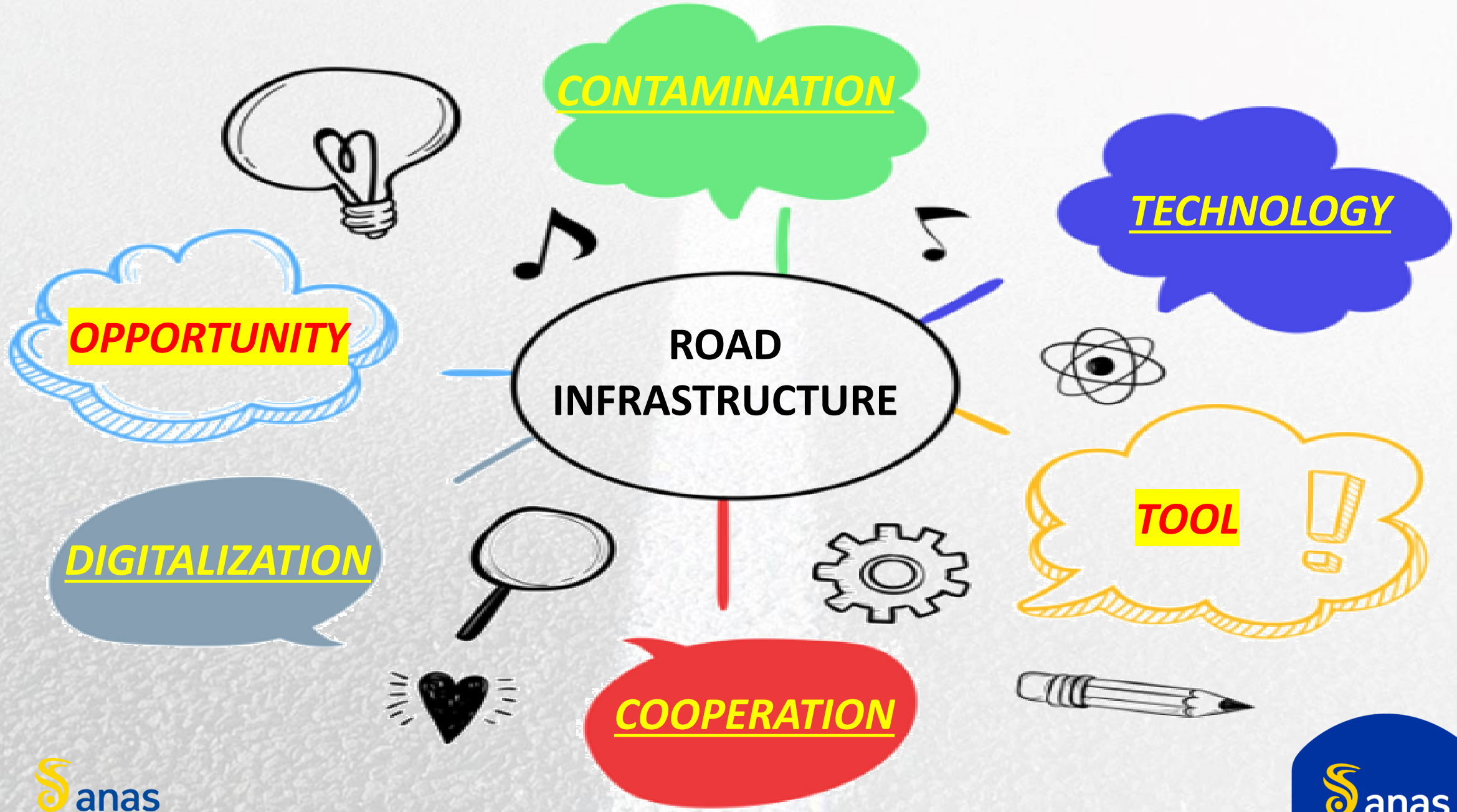
CONTAMINATION
TECHNOLOGY
OPPORTUNITY
ROAD
INFRASTRUCTURE
TOOL
DIGITALIZATION
COOPERATION

Thank you for your attention

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