SNAP4CITY

KM4CITY

UNIVERSITÀ DEGLI STUDI FIRENZE

DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

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https://www.disit.org
https://www.Snap4city.org
*https://www.Snap4Industry.org*

Intelligenza Artificiale (IA) e Machine Learning:

- algoritmi per computare
  - predizioni, classificazioni, riconoscimento di pattern, pattern
- X prendere decisioni e migliorare le operazioni e pianificazione.
- Fornire
  - Suggestion
  - Prescription
  - ottimizzazioni
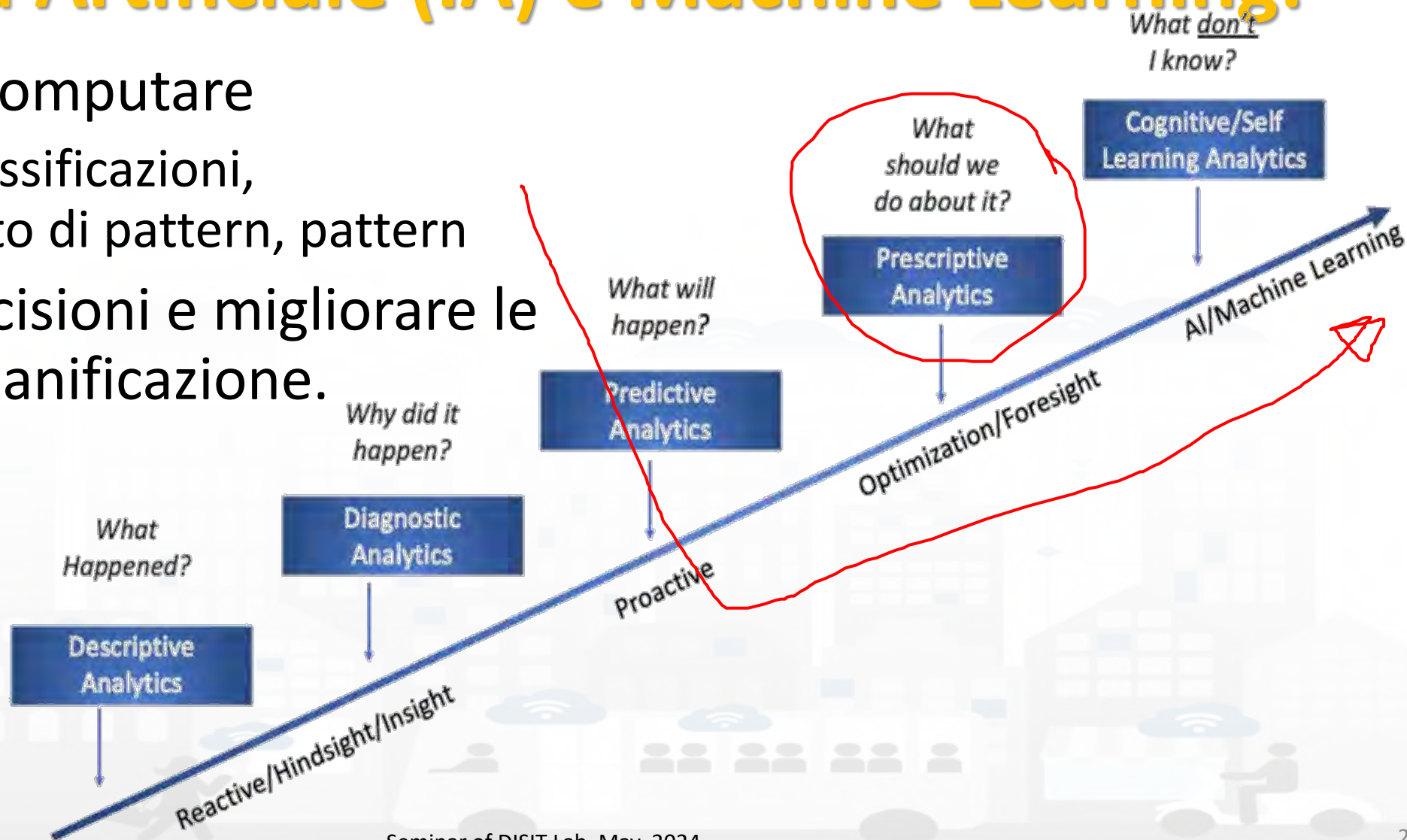
- **Artificial Intelligence** usually also includes
  - Code, learn and reasoning
  - Semantic computing, Knowledge Bases
  - Neuro-symbolic reasoning
  - Decision Support Systems
  - Problem solving
- **Machine Learning** usually includes
  - Learn without coding
  - Predictions, decisions (classifications)
  - Supervised or not
  - NLP, vision, pattern recognition
- **Deep Learning** usually includes
  - Capability to learn complex patterns on huge amount of data
 - Specialized ML solutions
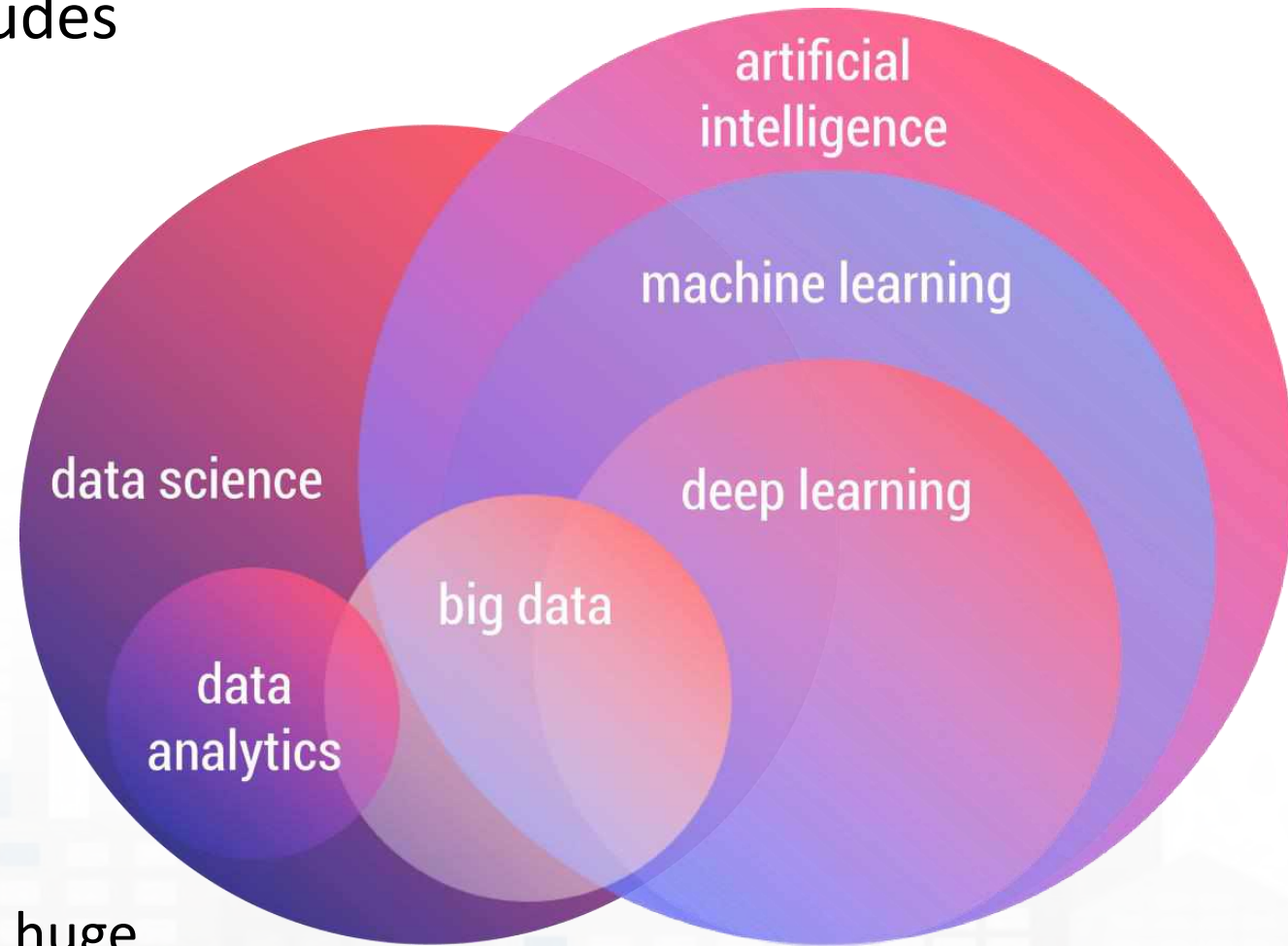
Main Tasks

- **Controlling Status: management, and operational**
  - Monitoring via KPI
  - Computing predictions data from the field and KPI
  - Anomaly detection
  - Early warning on critical conditions
- **Making plan: tactic and strategic, medium and long range**
  - Optimisation: Prescriptions, suggestions
  - Risk assessment
  - What-if analysis on scenarios
    - Simulation and predictions
  - Resilience
- **Be ready for Unexpected Unknows**

- **Controlling Status: management, and operational**
  - Monitoring via KPI
  - Computing predictions vs KPI
  - Anomaly detection
  - Neuro-Symbolic analysis
  - Risk assessment
  - Early warning on critical conditions
- **Making plan: tactic and strategic, medium and long range, micro/macro**
  - Simulation & predictions
  - Generative AI Prescriptions, scenarios
  - Resilience to Unexpected unknows
  - What-if analysis wrt scenarios
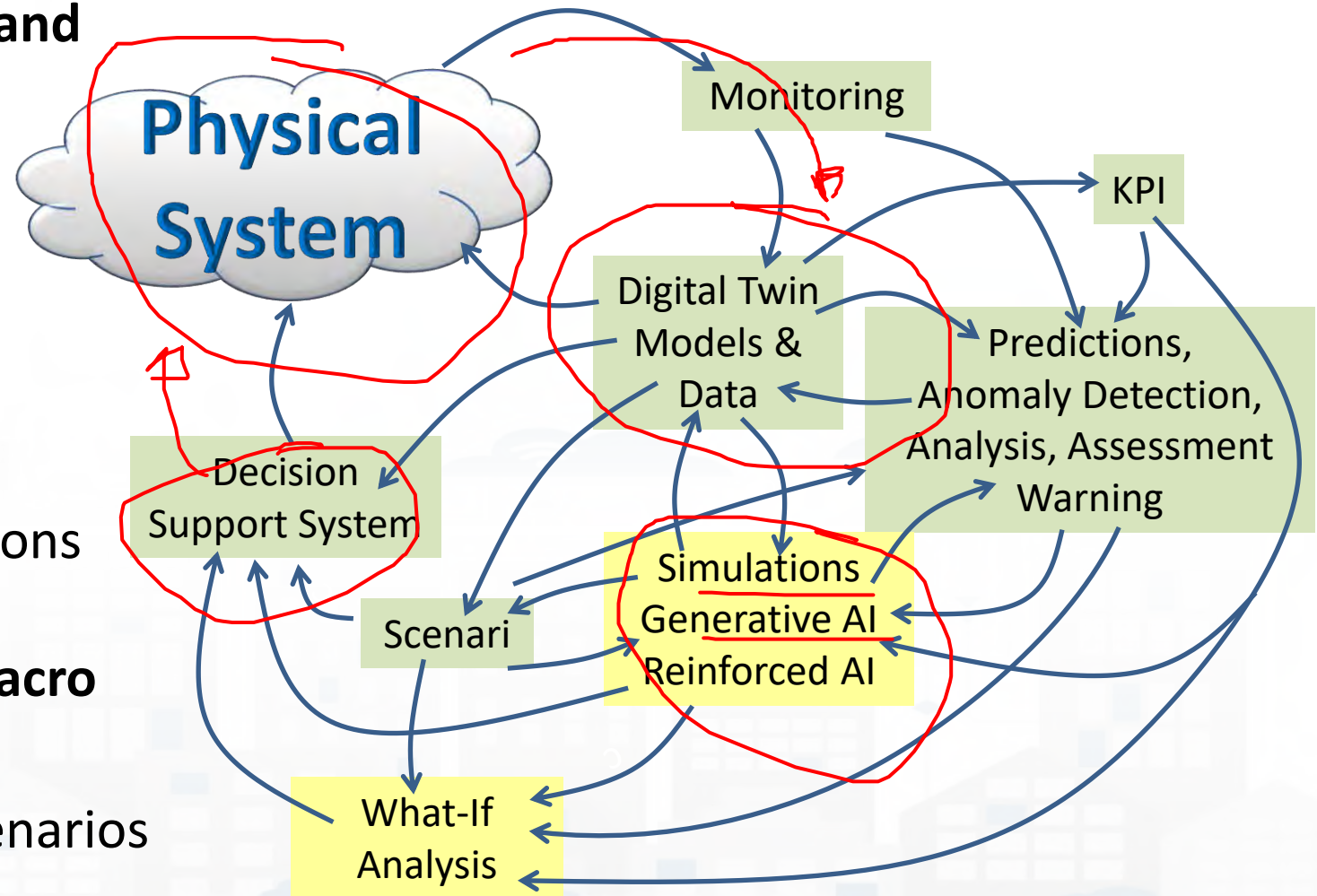
Available AI Solutions at DISIT Lab

https://www.snap4city.org/997

- **Mobility and Transport**
- **Environment, Weather, Waste, Water**
- **City Users Behaviour and Social analysis**
- **Energy and Control, Security, …..**
- **Tourism and People**
- **Industry applications**
- **Security and Safety**

- **Decision Support Solutions**
  - **Asset management**
  - **Resilience and Risks Analysis**

https://www.snap4city.org/download/video/course/p4/

https://www.snap4city.org/download/video/DPLSNAP4SOLU.pdf

Model/Technique Development/testing

- **Identification of Process goals and Planning (problem definition)**
  - Which goals
  - How to compute, which language
  - Which environment, which libraries
- **Data Discovery and Ingestion (from the general life cycle)**
  - Data Collection, Data Preprocessing if needed
- **Data Analysis: feature engineering, feature selection**
  - Data ethics assessment
- **Data review and preparation for the model, splitting, encoding**
- **Model Identification and building: ML, AI, etc....**
  - Model Training
  - Tuning hyperparameters when possible
- **Model Assessment and Selection (Evaluation)**
  - Validation in testing
  - Assessment on a set of metrics depending on the goals: global relevant and feature assessment
  - Assessing computational costs
  - Impact Assessment, Ethic Assessment and incidental findings
  - Global and Local Explanation via Explainable AI techniques
- **Model Deploy and Final Validation**
  - Optimisation of computation cost for features, if needed reiterate
  - Solution on Production (security, scalability, etc.)
- **Monitoring and Maintenance on production**
- **Documentation, incremental documentation**
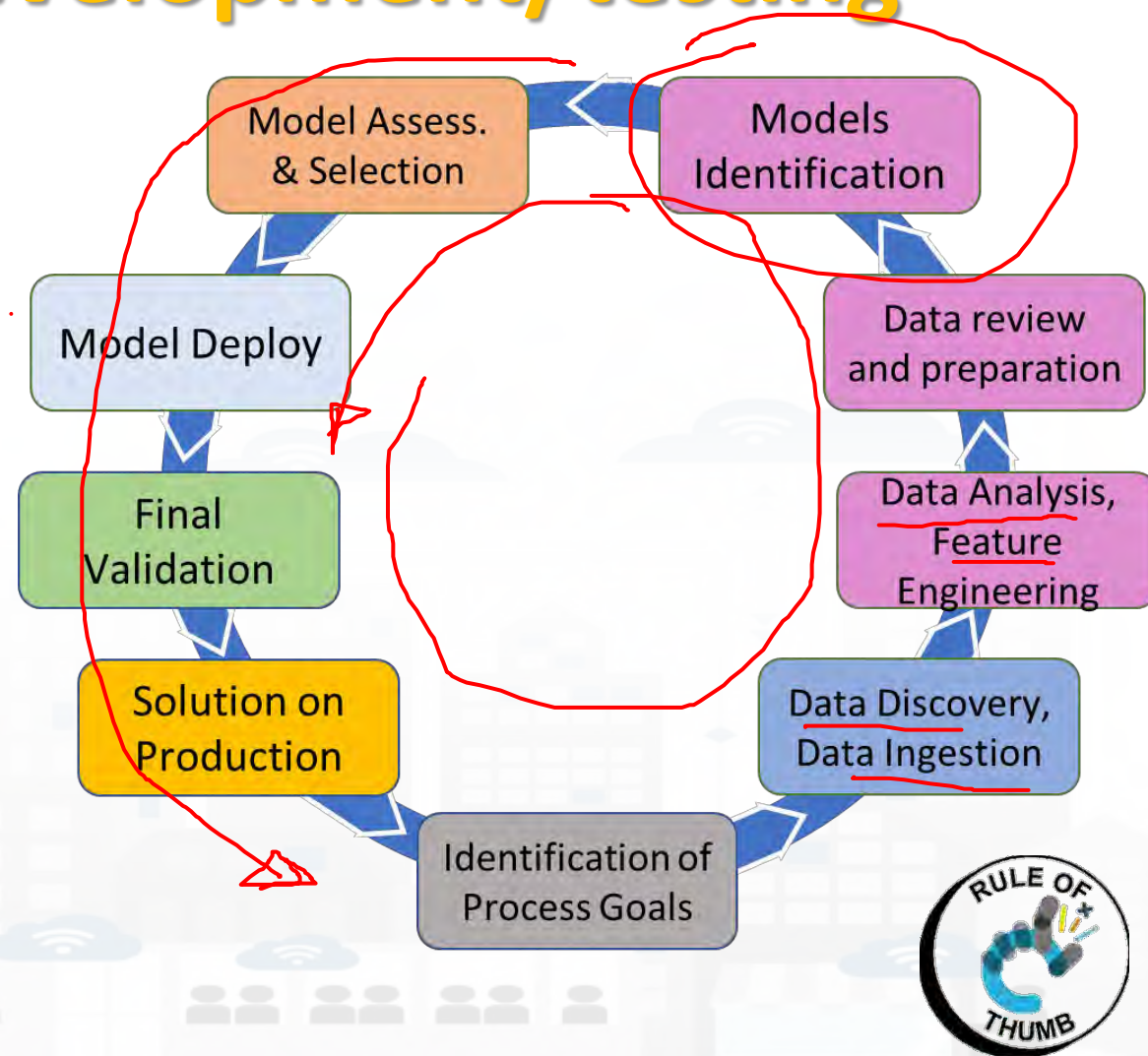
Predictions

- **Computing predictions**
  - **Why?**
  - **They can be always computed?**
    - Time series, time trends, seasonality, etc.
  - **Which data are needed?**
  - **Precision needed and precision which can be obtained?**
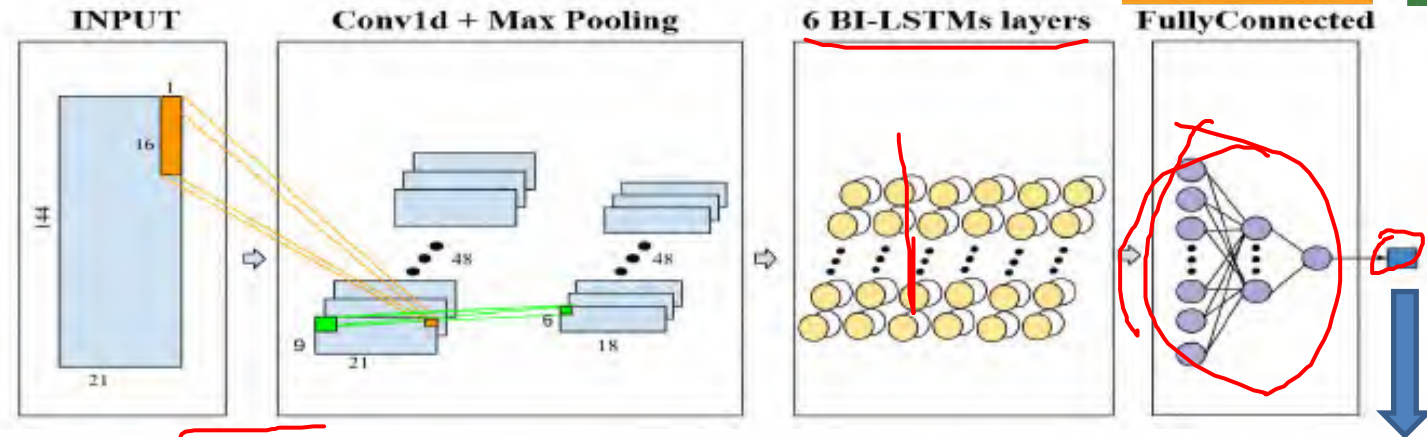 - **Computational costs?**

- **Technically:**
  - **Time range**, in most cases they are defined such as:
    - Short: 5-15 Minutes;   Mid: 30-45 minutes;
    - Long: 1 day, week;   very long: weeks / months / years
  - **Computational Model needed ?**

Management
Tactics/strategy

Short-Term Prediction of City Traffic Flow via Convolutional Deep Learning

INPUT | **Conv1d + Max Pooling** | **6 BI-LSTMs layers** | **FullyConnected**

Urban data:
- Date-time
- Traffic
- Temporal
- Seasonality
- Pollution
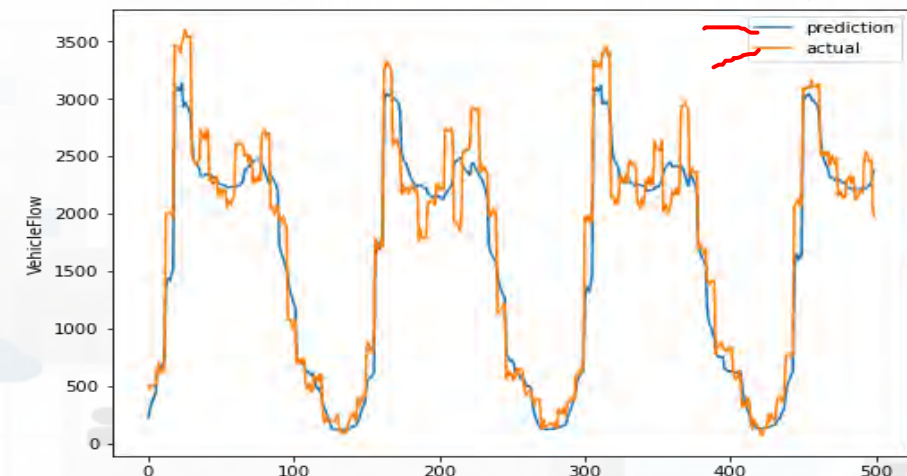- Weather

RF
XGBOOST
DNN
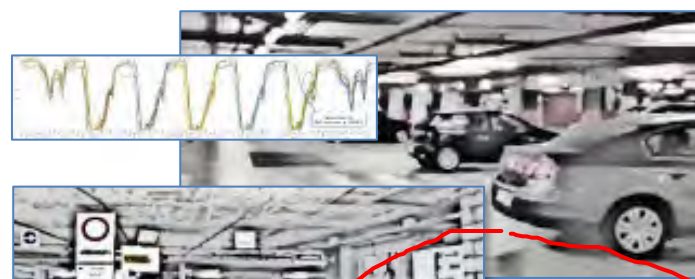LSTM
BI-LSTM
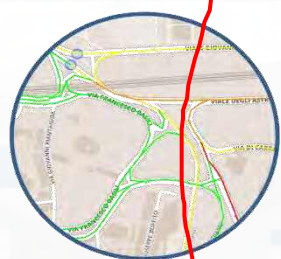Autoencoder BI-LSTM
Attention CONV-LSTM
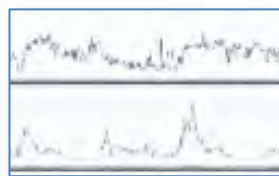CONV-BI-LSTM
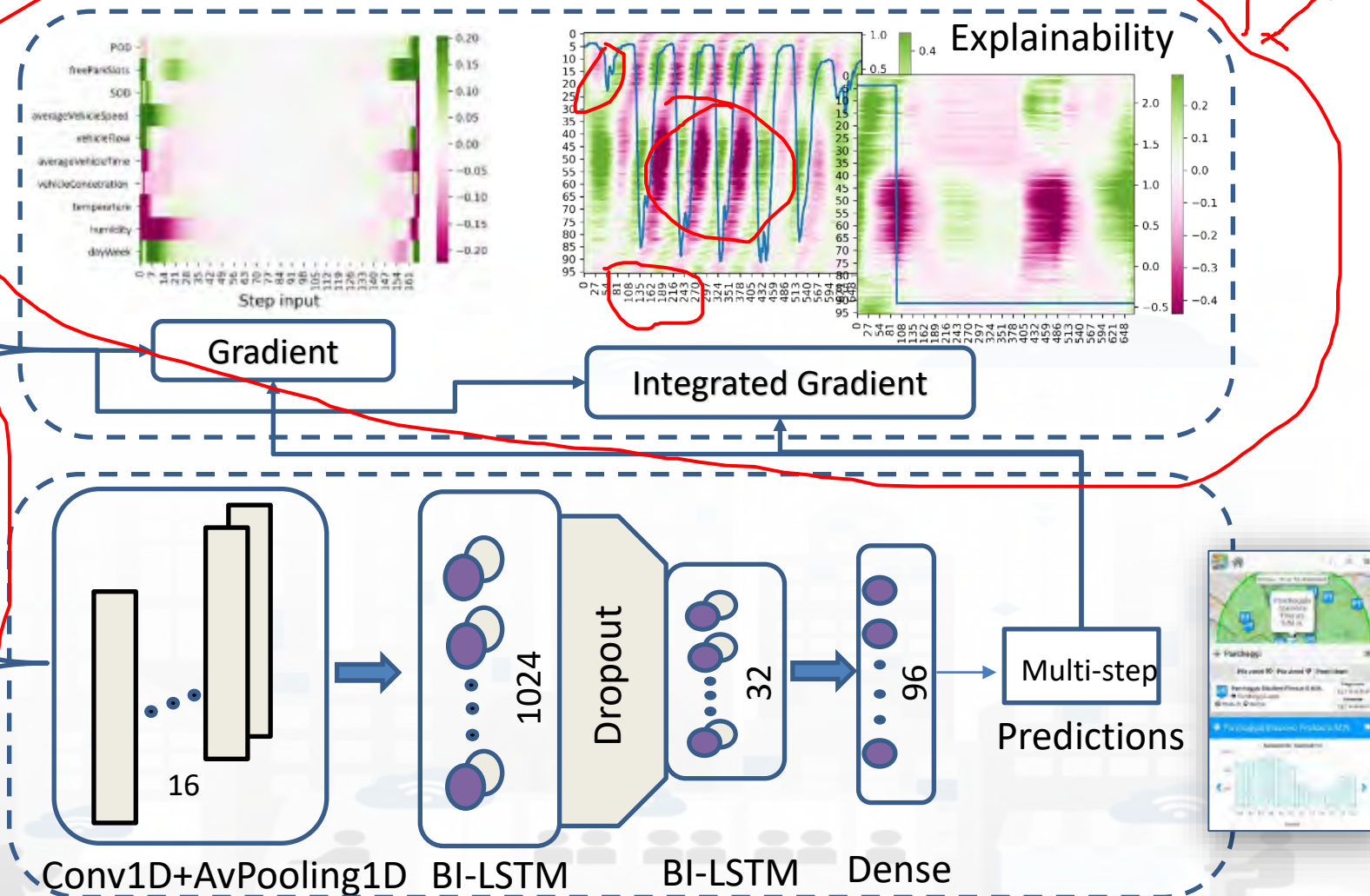
CONV-BI-LSTM

Deep Learning AI to surely Park!

Parking data

Traffic sensors data

Weather Features
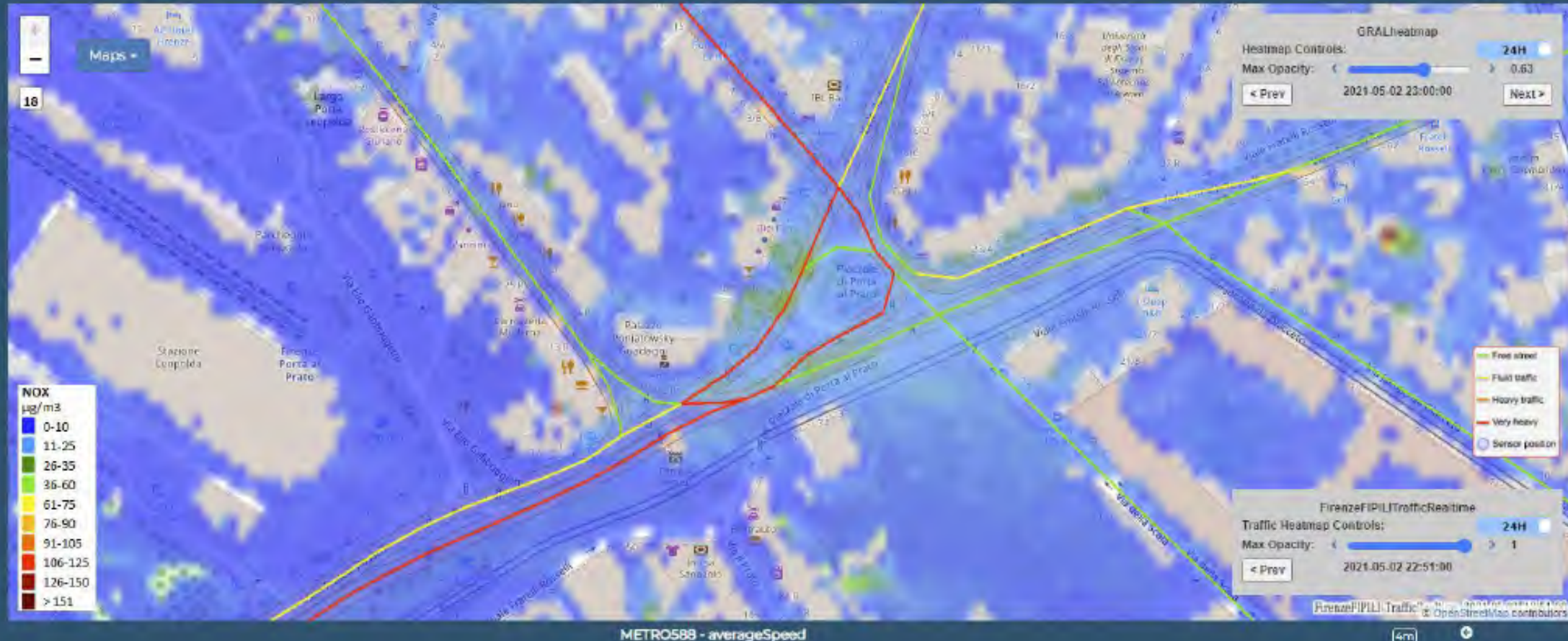
Explainability

Gradient

Integrated Gradient

Step input

Conv1D+AvPooling1D   BI-LSTM   BI-LSTM   Dense

16   1024   Dropout   32   96

Multi-step Predictions

Traffic Flow Manager on multiple cities

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzEyNg==

Predicting Land slides

24 hours in advance
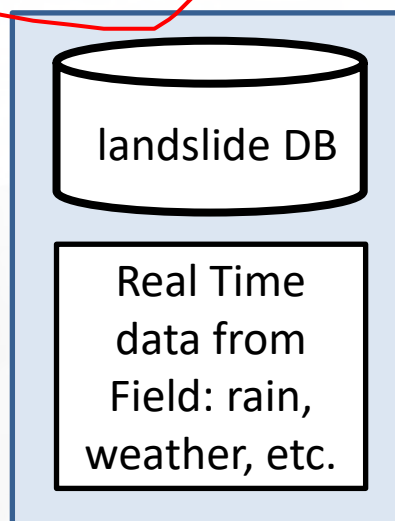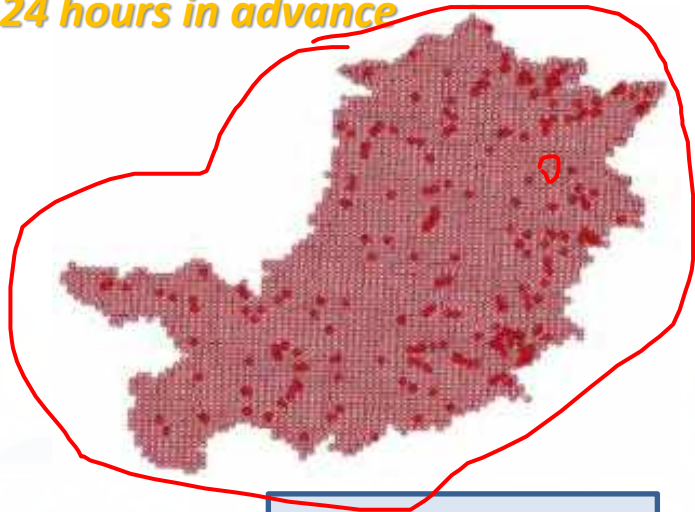
Dataset Construction

Previsional Model

Dataset Construction

Model training And validation

Model

Data

SNAP4City Advanced APIs

landslide DB

Real Time data from Field: rain, weather, etc.

Processes

Ingestion

Big Data Storage and KB

Predictions

Model execution Shap Assessment

Data Analytics IOT App Management

predictions

Snap4City Servers and Tools: Dashboard manager, Heatmap manager, GeoServer, Smart City API.

Dashboards and Mobile Apps

Day3
MaxTemperature
Humidity
LevelSIRFre
LevelSIRIdr
PrecipSIR
MaxTempSIR

21-12-2019

SHAP Values

day

Predicting EC's KPI on NO2 months in advance

Deep Learning Long Terms Predictions of NO2 mean values, From 30 to 180 days in advance

- The features used as input for the predictive models are:
  - **Month**
  - **dayOfTheYear**
  - **NO2**
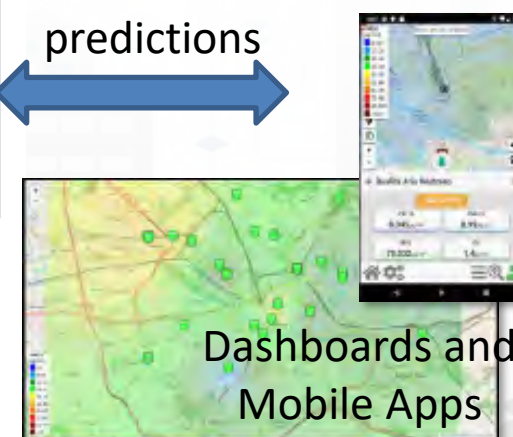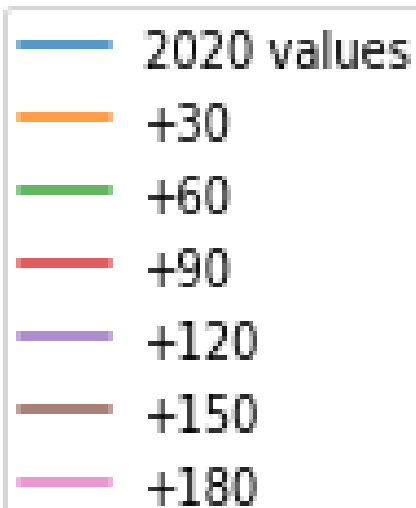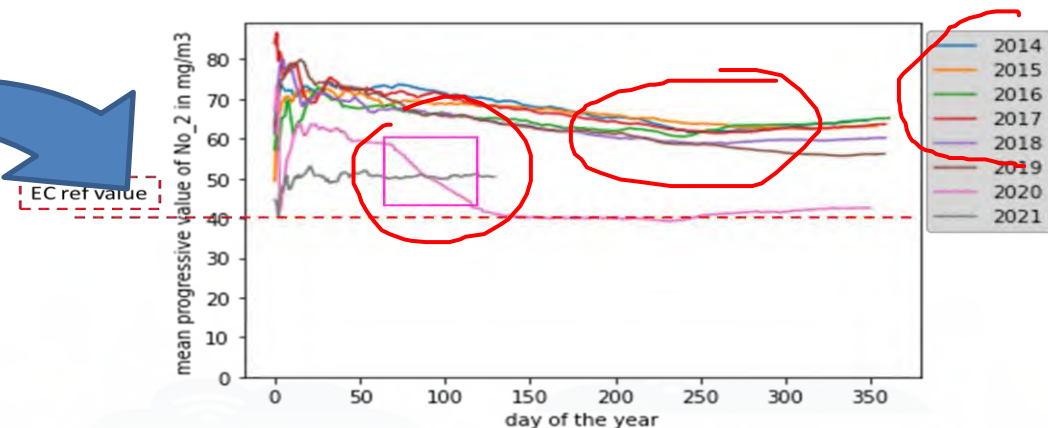 - **Tmean**
  - **Humidity**
  - **windMean**
  - **NoxDomestic**
  - **numberOfVehicles**
  - **NO2cumulated**
  - **NO2progresseveMean**
  - **numberOfVehiclesCumulated**

Legend:
- 2020 values
- +30
- +60
- +90
- +120
- +150
- +180

Pollutant	Averaging period	Air Quality Directive			WHO guidelines	
		Objective and legal nature and concentration		Comments	Concentration	Comments
PM$_{2.5}$	One day				25 µg/m³ (*)	99ᵗʰ percentile (3 days/year)
PM$_{2.5}$	Calendar year	Target value, 25 µg/m³		The target value has become a limit value since 1 January 2015	10 µg/m³	
PM$_{10}$	One day	Limit value, 50 µg/m³		Not to be exceeded on more than 35 days per year.	50 µg/m³ (*)	99ᵗʰ percentile (3 days/year)
PM$_{10}$	Calendar year	Limit value, 40 µg/m³ (*)			20 µg/m³	
O$_3$	Maximum daily 8-hour mean	Target value, 120 µg/m³		Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m³	
NO$_2$	One hour	Limit value, 200 µg/m³ (*)		Not to be exceeded more than 18 times a calendar year	200 µg/m³ (*)	
NO$_2$	Calendar year	Limit value, 40 µg/m³			40 µg/m³	

Closing the loop
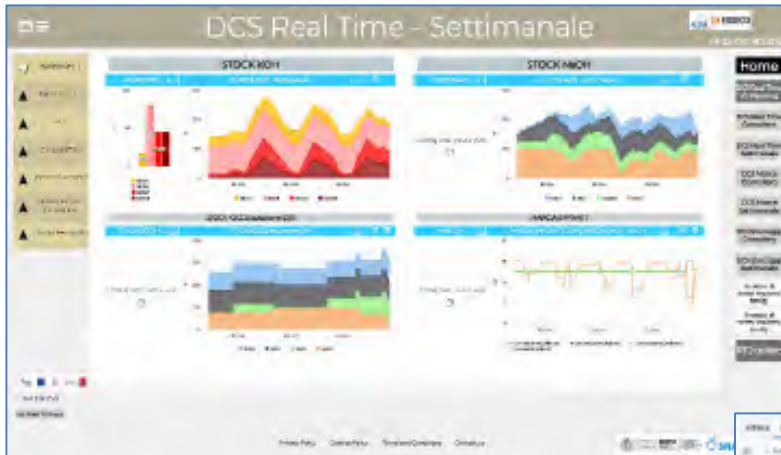
Historical and Real Time Data

Synoptics for real time monitoring
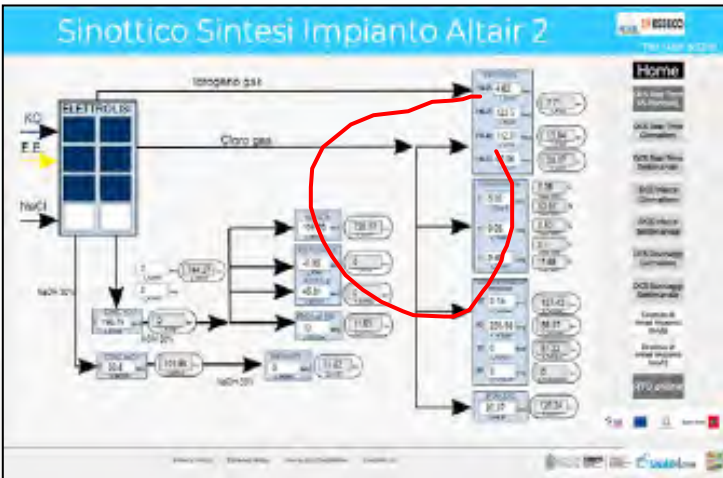
Map and 3D BIM modelling to:
-- represent the details
-- associate physical elements
with data
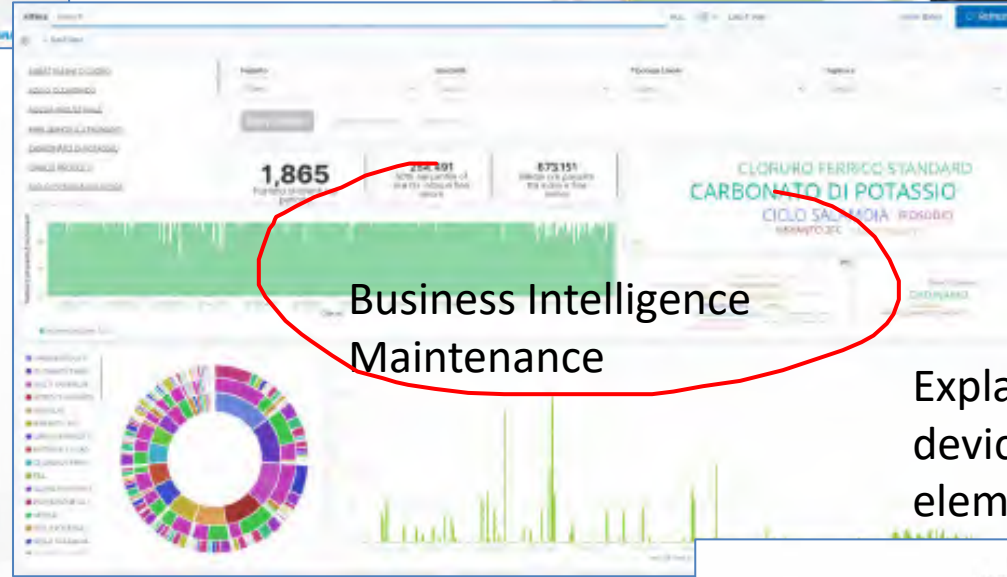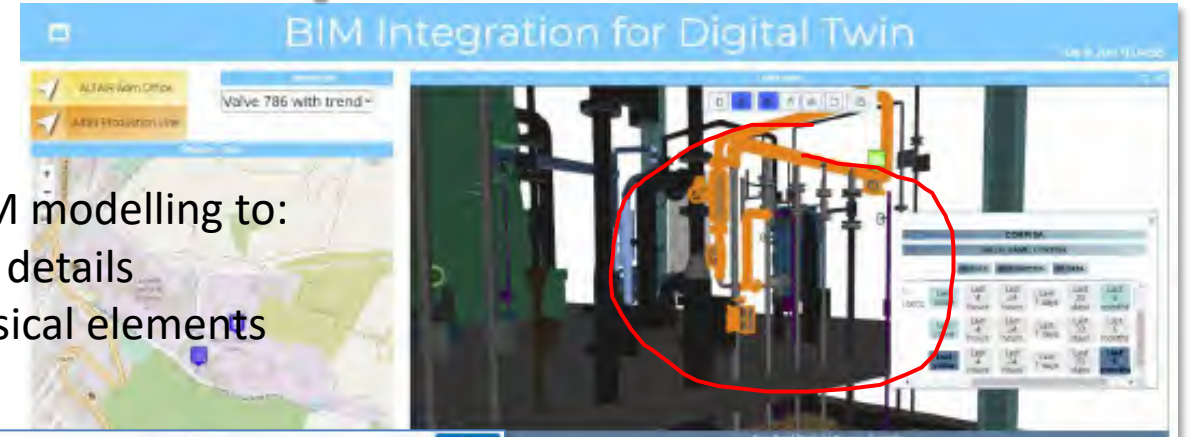
Business Intelligence
Maintenance

Explainable AI to map critical values of
devices and detection to physical
elements in the plant

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzA1NA==
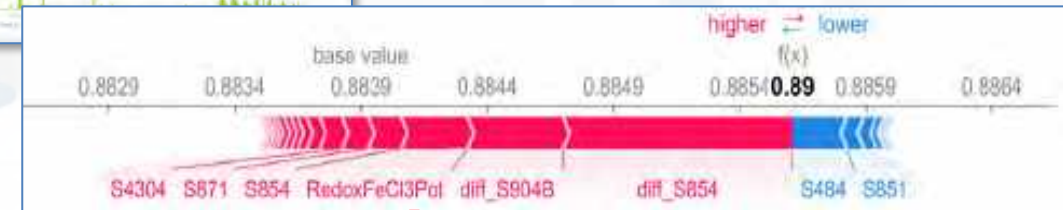
Explainable/XAI - CNN-LSTM (SHAP)

Explanation of prediction generated by model for fault

Explanation of prediction generated by model for normality
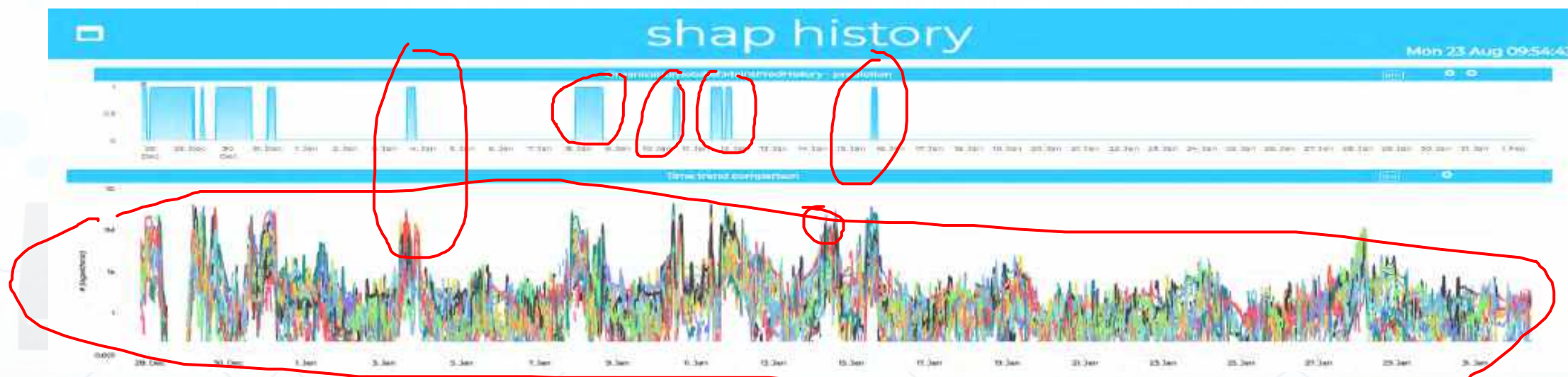
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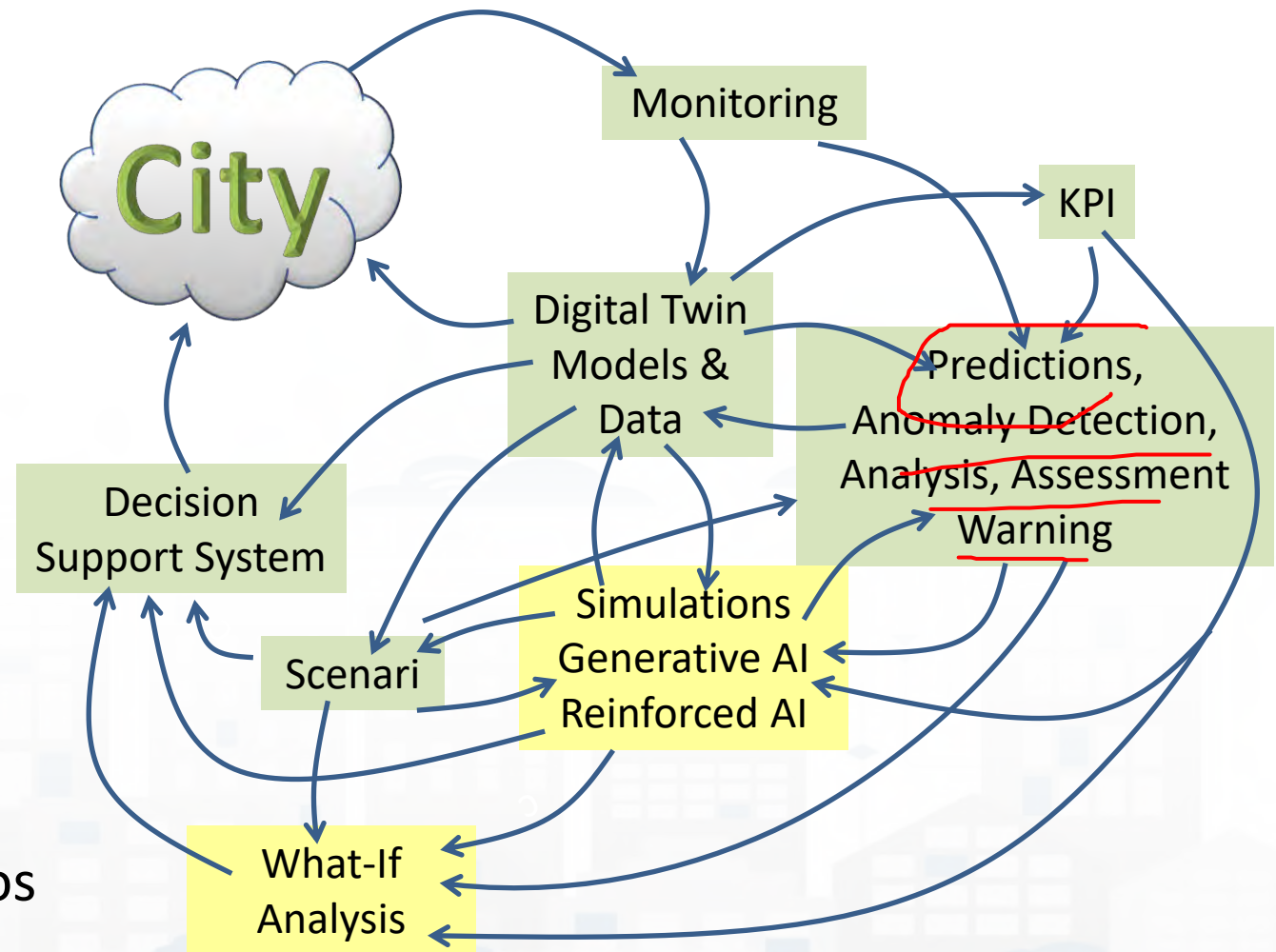
Generative AI

- creates new samples based on learned patterns from existing data

- **Techniques:**
  - **Generative Adversarial Networks**: a Generator and a Discriminator
  - **Variational Autoencoders**: generate samples in the compressed domain…
  - **Transformers**: mainly to generate coherent sequences of elements / text
    - GPT: Generative Pre-trained Transformer → ChatGPT
  - **Recurrent NN, as LSTM**: generate predictions of sequences, use in text and music

- **Applications can be:**
  - Text generation, Code Generation, …
  - Pattern generation: images, sequence of images, time series, etc.
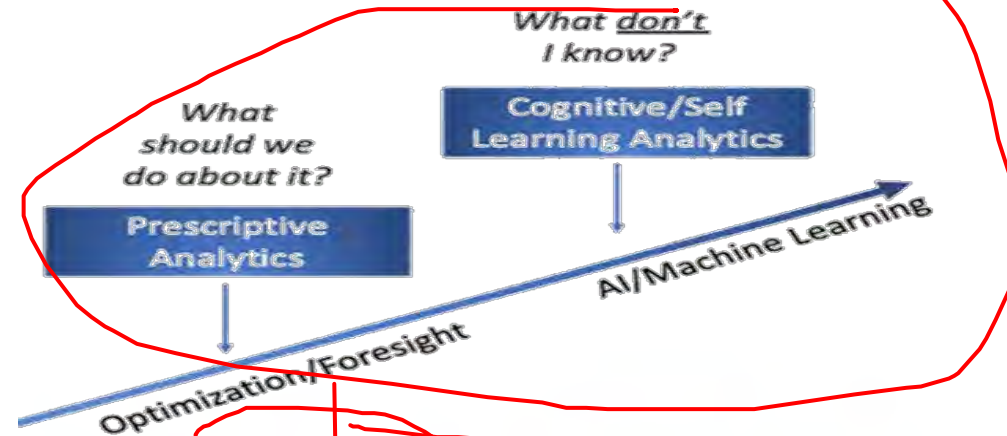
Generative AI in industrial Applications

- **Content Generation…..**

- **Product Design and Prototyping**: suggesting innovative designs.

- **Art and Media Production**: generating music tracks, visual effects, and even entire scenes for movies and games.

- **Virtual Reality and Augmented Reality**: generate realistic textures, environments, and characters, enhancing the overall experience.

- **Drug Discovery and Material Science**: accelerate the drug discovery process and the development of advanced materials.

- **Supply Chain Optimization**: generating demand forecasts, designing efficient transportation routes, and optimizing inventory management strategies.

- **Natural Language Processing (NLP) Applications**: legal, and healthcare, generative AI can be used for generating responses, drafting legal documents, medical diagnosis

- **Creative Collaboration Tools**: generating ideas, concepts, and designs, in brainstorming sessions and design reviews.

Neuro-Symbolic /Hybrid approaches

- Combine NN and Symbolic approaches
  - Refinement, counterpart, etc.

- **Symbolic/Hybrid**
  - May provide hints/discriminatory rules on patterns and models Generation
  - Are providing
    - Math models, equations and thus solutions, …
    - Logic solutions, including experts systems, grounded on knowledge base and ontologies
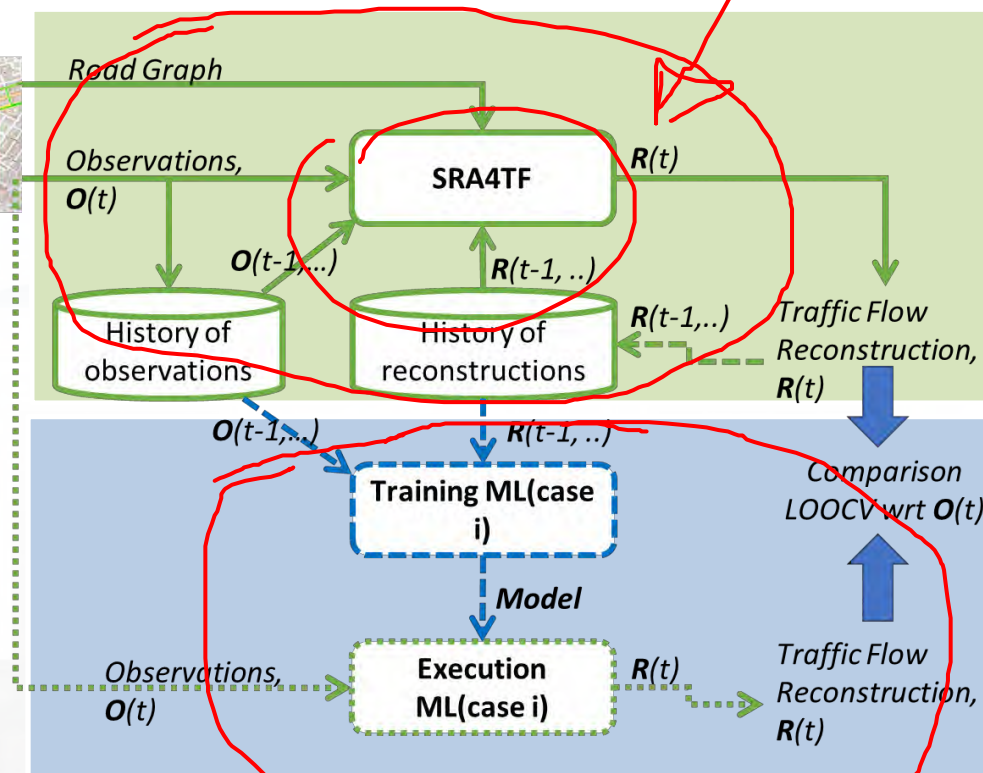
Physics-informed neural networks (PINN)

Solve complex fluid-dynamic problems based on **partial differential equation (PDE)** using neural networks

SNAP4CITY roadmap

2020
- Smart Tourism
- 6 Pilots
- Data Analytics
- Extended platform

Sii-Mobility

JRC EUROPEAN COMMISSION — Contract

Interreg Mediterranean HERIT-DATA

Interreg MARITTIMO-IT FR-MARITIME — MOBIMART
- Smart Mobility
- PISA, PUMS
- Living lab

sssGARDAlike

Km4City 1.6.7

2021

Smart Ambulance (2021-22)

Sii-Mobility

enel x — Contract

JRC EUROPEAN COMMISSION — Contract

PC4City (2020-21) Monitoring Terrain

Winner of Open Data Challenge of enel x

CAPELON
- Smart Light
- Sweden

2022

Enterprise (2021-22) Industry 4.0

ASYMMETRICA URBAN TECHNOLOGY
Asymmetrica Smart City, 2022-23

Almafluida Industry 4.0 (2021-22)

AMPERE (2021-22) Industry 4.0

SYN-RG-AI SmartCity

GRUPPO PRETTO Industry 4.0

uni.systems SmartCity, 2021-23

AXIS COMMUNICATIONS
AXIS collab SmartCity

ITALFERR GRUPPO FERROVIE DELLO STATO ITALIANE
Italferr, Smart City

2023

JRC EUROPEAN COMMISSION — Contract, 2022-23
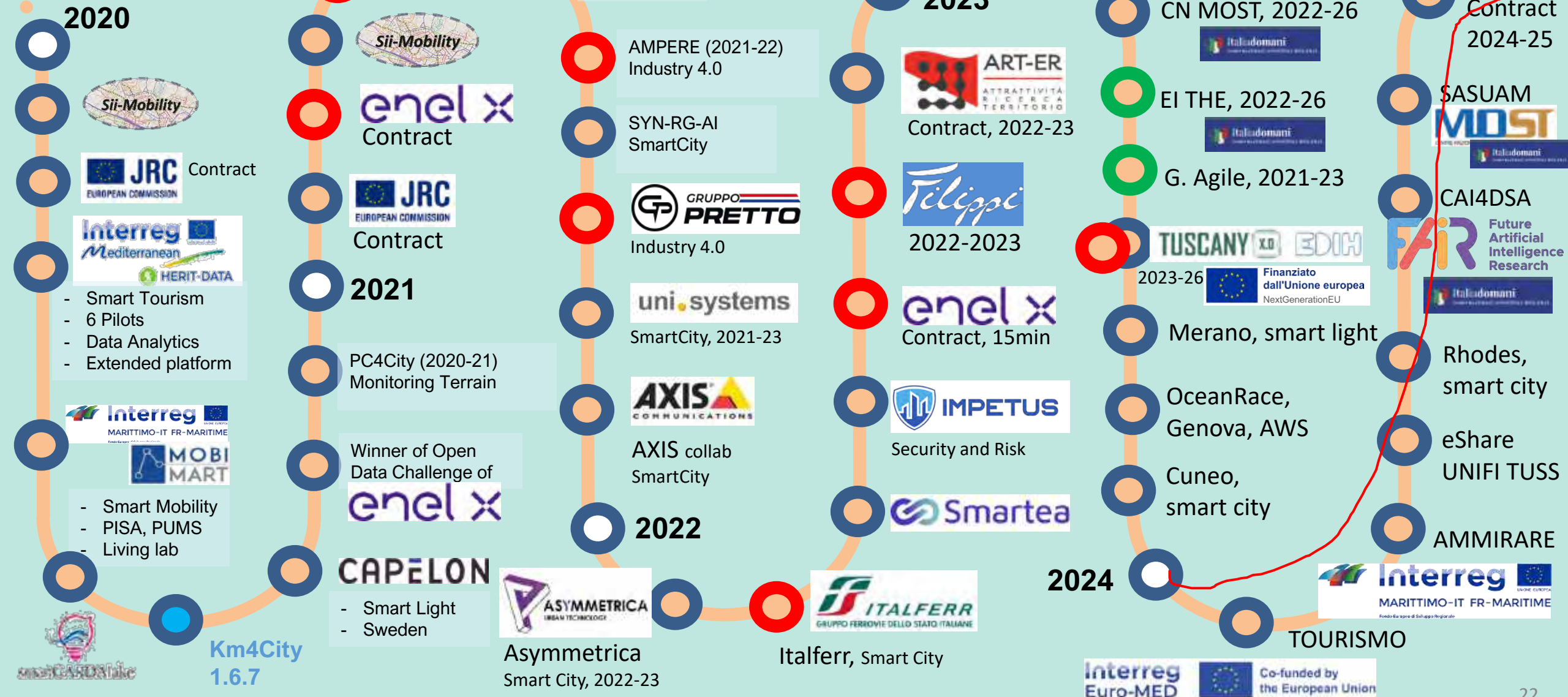
ART-ER ATTRATTIVITÀ RICERCA TERRITORIO
Contract, 2022-23

Filippi 2022-2023

enel x — Contract, 15min

IMPETUS Security and Risk

Smartea

CN MOST, 2022-26

MOST Italiadomani

EI THE, 2022-26

G. Agile, 2021-23

TUSCANY X.0 EDIH
2023-26
Finanziato dall'Unione europea NextGenerationEU

Merano, smart light

OceanRace, Genova, AWS

Cuneo, smart city

2024

Interreg Euro-MED Co-funded by the European Union

TOURISMO

JRC EUROPEAN COMMISSION — Contract 2024-25

SASUAM

MOST Italiadomani

CAI4DSA

FAIR Future Artificial Intelligence Research
Italiadomani

Rhodes, smart city

eShare UNIFI TUSS

AMMIRARE

Interreg MARITTIMO-IT FR-MARITIME

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