acciona
Energy

pervasive
technologies

Google Cloud

An AI approach to control and monitor wind farm assets using satellite imagery

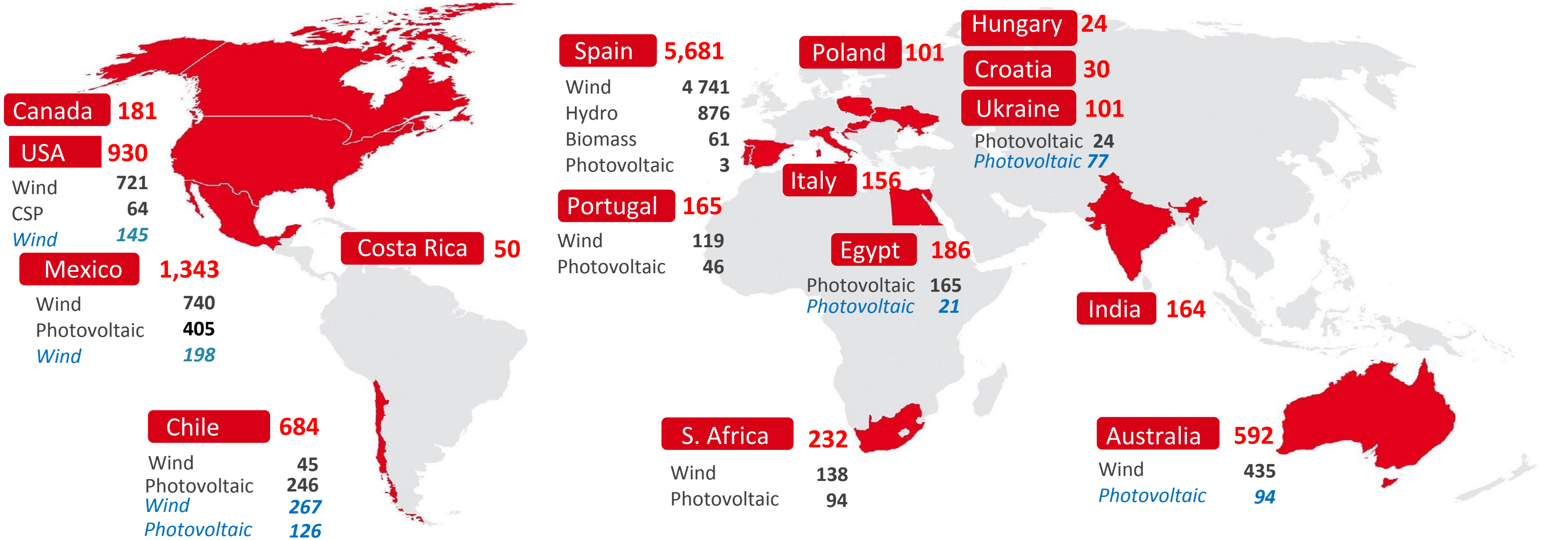
Thought Leaders' Forum

WindEurope
CONFERENCE
& EXHIBITION
2019 2-4 APRIL
BILBAO

www.pervasive-tech.com

A GLOBAL COMPANY

WITH OWNED ASSETS IN SIXTEEN COUNTRIES, FIVE CONTINENTS



Canada	181

USA	930
Wind	721
CSP	64
Wind	*145*

Mexico	1,343
Wind	740
Photovoltaic	405
Wind	*198*

Chile	684
Wind	45
Photovoltaic	246
Wind	*267*
Photovoltaic	*126*

Costa Rica	50

Spain	5,681
Wind	4 741
Hydro	876
Biomass	61
Photovoltaic	3

Portugal	165
Wind	119
Photovoltaic	46

Poland	101

Italy	156

Egypt	186
Photovoltaic	165
Photovoltaic	*21*

S. Africa	232
Wind	138
Photovoltaic	94

Hungary	24

Croatia	30

Ukraine	101
Photovoltaic	24
Photovoltaic	*77*

India	164

Australia	592
Wind	435
Photovoltaic	*94*

● Owned facilities. Where the technology is not stated it is wind power.
Installed capacity in MW (MWp in photovoltaics) as of 31.12.2018
Capacity under construction in 2019

TOTAL INSTALLED + CONSTRUCTION: 10,618 MW

IN THE MAIN TECHNOLOGIES

DEVELOPMENT FOCUSED ON WIND AND PHOTOVOLTAIC SOLAR

INSTALLED CAPACITY IN RENEWABLE ENERGIES

(Cumulative data in MW)

	Wind	Photovoltaic	Hydro	CSP	Biomass	Total
Installed	7,643	983	876	64	61	9,627
Construction	767	224				991
Total	8,410	1,038	876	64	61	10,618

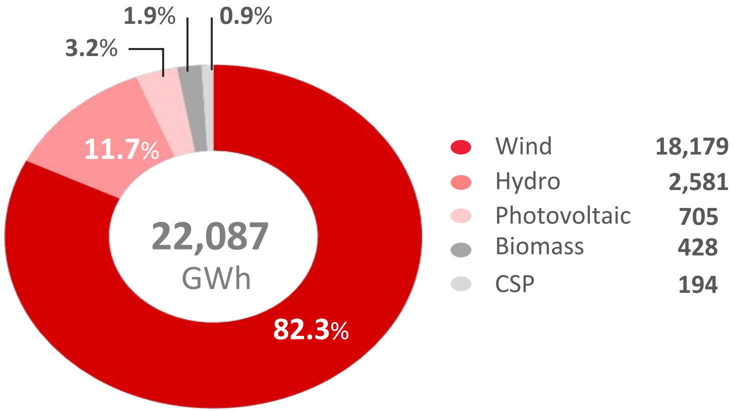
Installed capacity as of 31.12.2018. Capacity under construction during 2019.

100% RENEWABLES

CLEAN ENERGY EQUIVALENT TO THE CONSUMPTION OF OVER 6 MILLION HOMES

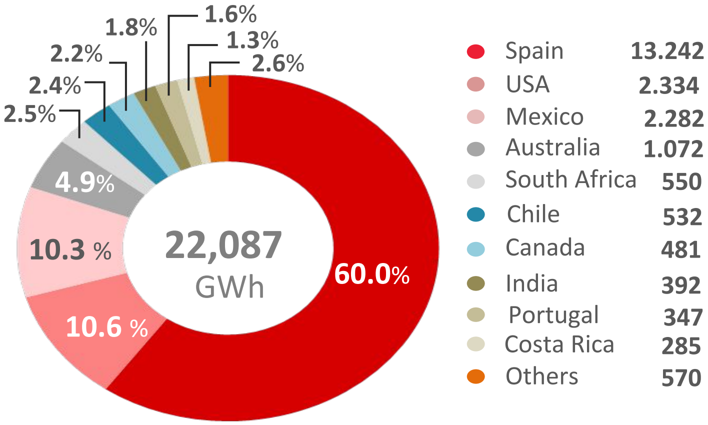
GENERATION BY TECHNOLOGY 2018

(percentage and total)



GENERATION BY COUNTRY 2018

(percentage and total)

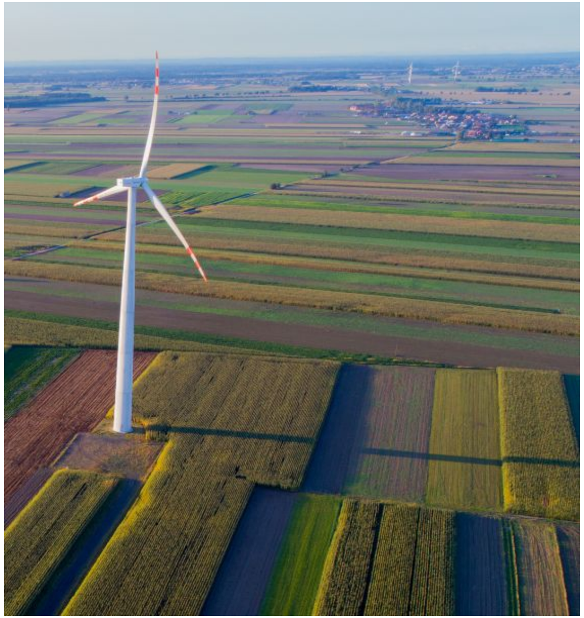


*Others: Italy, Poland, Croatia and Hungary

Data as of 31.12.2018

WIND POWER

IN WORLD TOP-10 BY OWNED ASSETS(1)



7,643 MW INSTALLED
located in 14 countries

222 WIND FARMS
with 6,137 wind turbines

18+ TWh GENERATED
per year on average

10,000+ MILLION EUROS
accumulated investment

(1). Chinese operators excluded. Data as of 31.12.2018

WIND POWER

FLAGSHIP PROJECTS

Oaxaca Wind Complex
Oaxaca, México

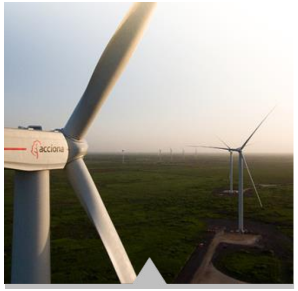
- 306 MW in three wind farms
- 1,300 GWh annual production
- Turbines: 204 AW70/1500
- Steel tower
- Energy for 700,000 homes
- 1.25 Mt CO2 avoided a year
- Start-up: 2011

Mt Gellibrand Wind Farm
Victoria, Australia

- 132 MW installed capacity
- 429 GWh annual produc tion
- Turbines: 44 AW125/3000
- Steel tower
- Energy for 66,000 homes
- 412,000 t CO2 avoided a year
- Start-up: 2018

Punta Palmeras Wind Farm
Coquimbo, Chile

- 45 MW installed capacity
- 124 GWh annual production
- Turbines: 15 AW116/3000
- Steel tower
- Energy for 51,000 homes
- 119,000 t CO2 avoided a year
- Start-up: 2014



San Roman Wind Farm
Texas, USA

- 93 MW installed capacity
- 357 GWh annual production
- Turbines: 31 AW125/3000
- Steel tower
- Energy for 30,000 homes
- CO2 avoided as 250,000 cars
- Start-up: 2016

INNOVATIVE

CECOER: THE BIGGEST RENEWABLES CONTROL CENTER IN THE WORLD

acciona
ÓRDENES MÁQUINA

13,600+ MW MANAGED
for AE and customers in 20 countries

30 TWh+ RENEWABLES PRODUCTION
managed by the control center

8,000+ MULTI-TECHNOLOGY WIND TURBINES
and more than 100 facilities in other technologies

97% AVAILABILITY RATE
24/365 surveillance

EXCELENCE IN OPERATION AND GRID INTEGRATION
with the highest quality and safety

INNOVATIVE

A PERMANENT COMMITMENT TO THE GENERATION OF KNOWLEDGE IN THE BUSINESS

ACCIONA's wind + storage plant certified by DNV GL

€73 M€ IN INNOVATION IN 2018

100% directly linked to the business

OBJECTIVE: OPERATIONAL EFFICIENCY

- **Turbine for life**: working life extension of wind assets
- **Max Power**: increase in the energy produced by assets
- **Advanced technologies in wind and FV**: aerial thermography, 3D printed components, inspection with drones
- **Energy storage** with wind and PV solar power
- **Blockchain**: Energy origin certificates
- **Microgrids**: Design technological solutions

BIG DATA AND DIGITAL CONVERSION

- Big data management, process digitalization, mixed reality

PIONEERS IN GRID INTEGRATION

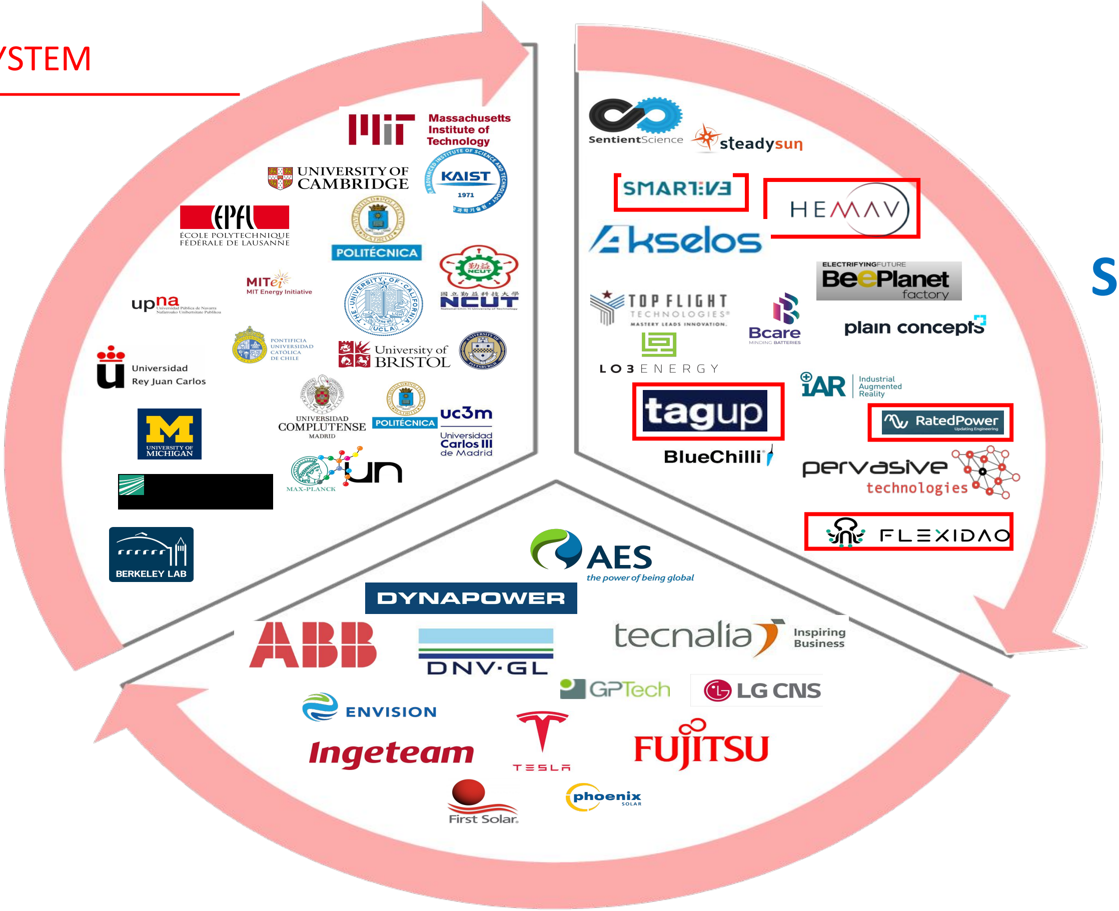
- Over 4,000 MW qualified in balancing services in Spain (3,737 MW in wind and 700 MW in hydro)

INNOVATION ECOSYSTEM

Academy (50)

USA EUROPA

CHILE CHINA


Massachusetts Institute of Technology
UNIVERSITY OF CAMBRIDGE
KAIST
EPFL ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
POLITÉCNICA
NCUT
MITei MIT Energy Initiative
upna
THE UNIVERSITY OF CALIFORNIA UCLA
PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE
University of BRISTOL
Universidad Rey Juan Carlos
UNIVERSIDAD COMPLUTENSE MADRID
POLITÉCNICA
uc3m Universidad Carlos III de Madrid
UNIVERSITY OF MICHIGAN
MAX-PLANCK
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BERKELEY LAB
SentientScience
steadysun
SMARTIVE
HEMAV
Akselos
ELECTRIFYINGFUTURE BeePlanet factory
TOP FLIGHT TECHNOLOGIES
Bcare
plain concepts
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GPTech
LG CNS
ENVISION
TESLA
Ingeteam
FUJITSU
First Solar
phoenix SOLAR

Startups+Partners (234)

USA EUROPA

acciona

BUSINESS AS UNUSUAL

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We help our customers to transform and optimize their business using the power of data and AI technologies

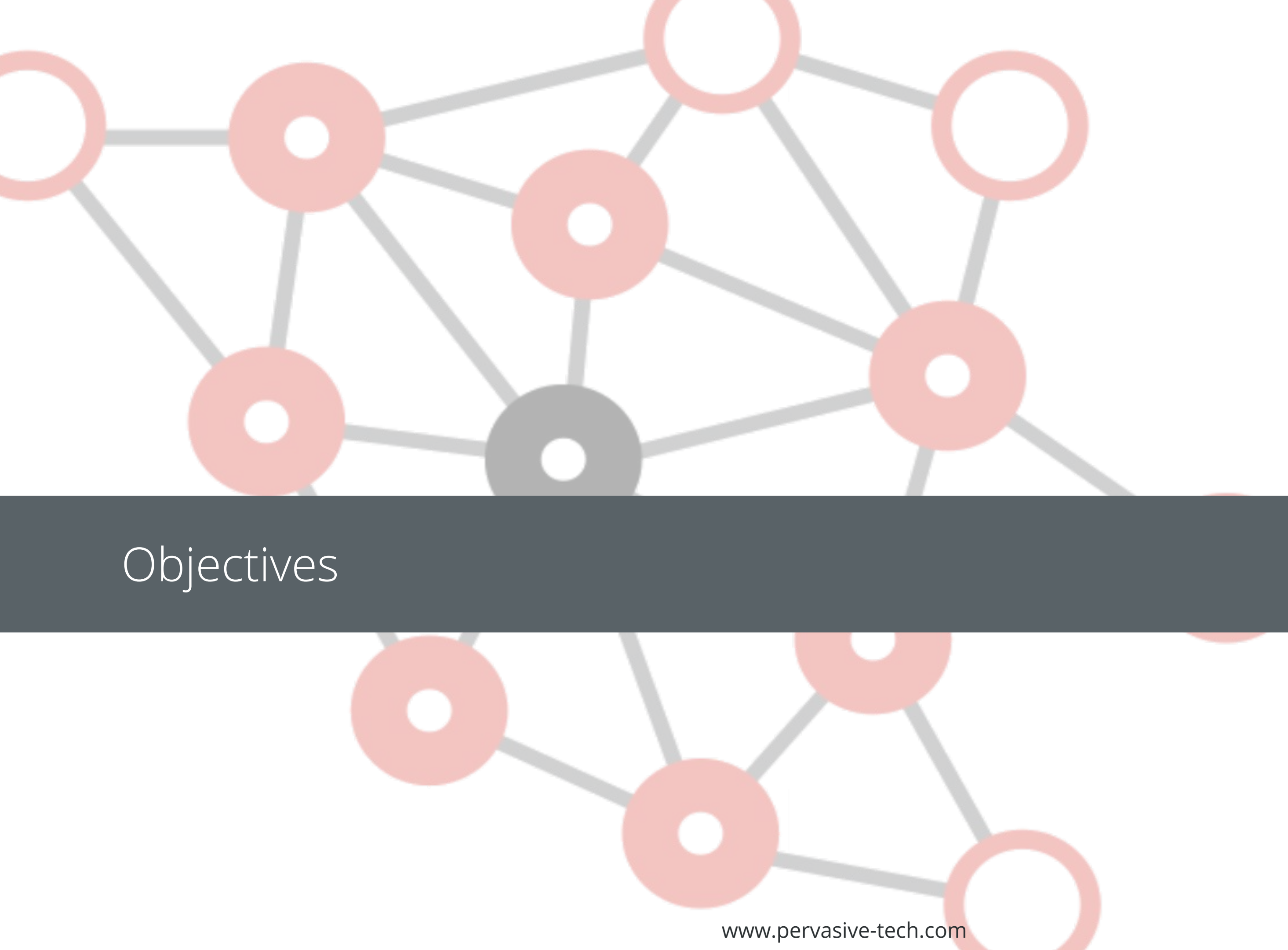
- Tailored Business Value oriented AI – ML Modules
- Own methodology
- Heureka, own platform for deployment.
- Local Analytics, High Talented Expertise
- Strong Partnership with Google Cloud
- Long Term relationship with customers as partners
- Passionated Team

Problem

Acciona’s difficulties to monitor wind farm assets

Goal

Automatic and remote monitoring of assets with high precision using satellite imagery



Objectives

Objectives

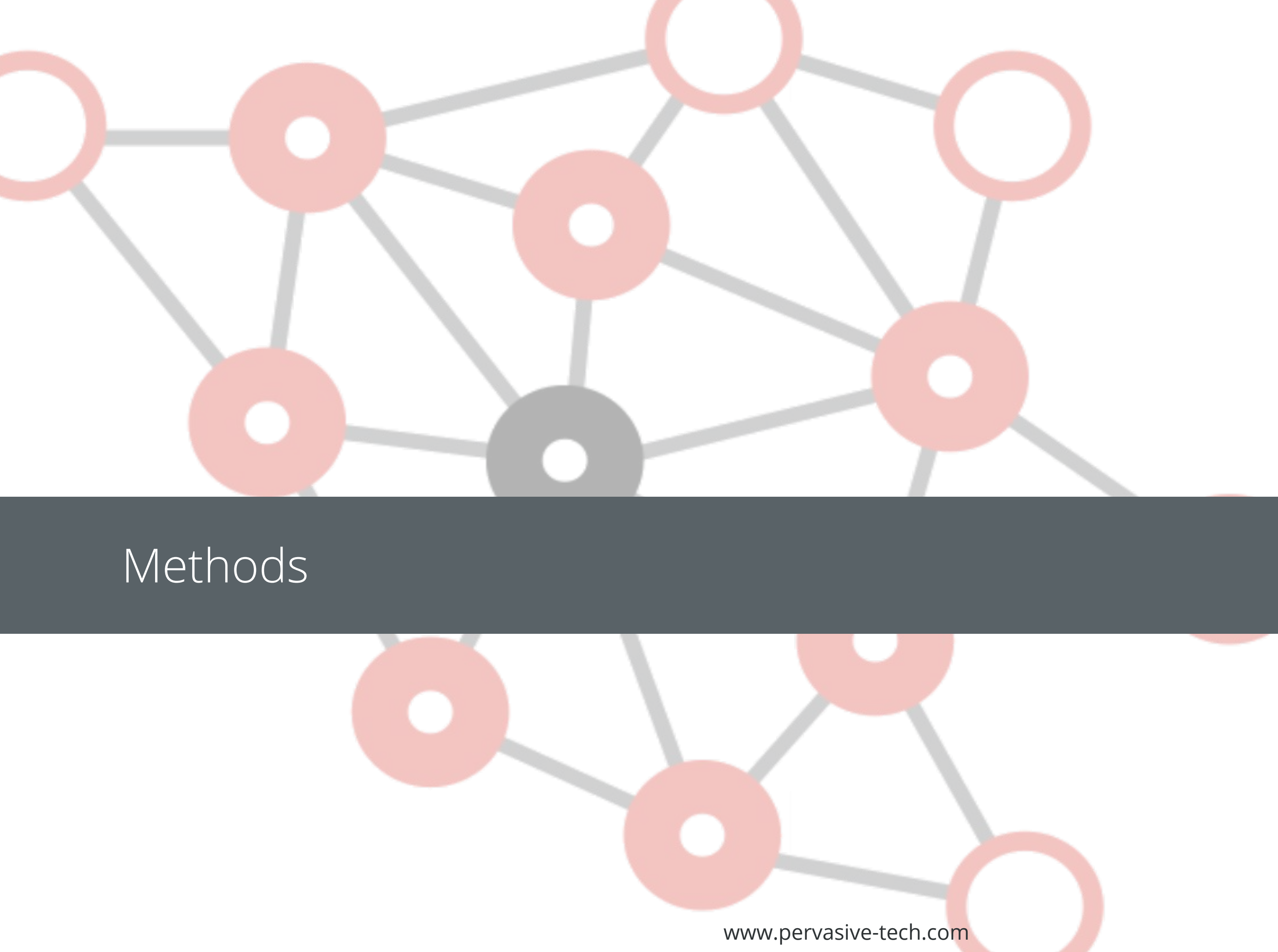
Main goal:

Autonomous and remote system for regular monitoring of assets using satellite images.

- Reduce operational costs
- Increase monitoring recurrence

Steps:

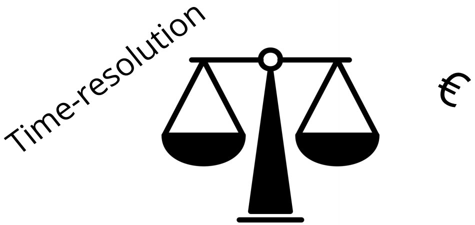
1. Acquire periodical satellite images of the area of interest
2. Apply semantic segmentation to get structured information
3. Compute analytics to estimate risks related to the assets



Methods

Methods

- Acquire periodical satellite images (weekly or monthly)
    - Trade-off between time-resolution and image cost



- Semantic segmentation using AI
    - Detect a pre-defined set categories pixel-wise
    - Distributed infrastructure for huge models

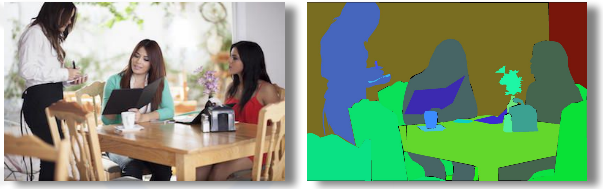
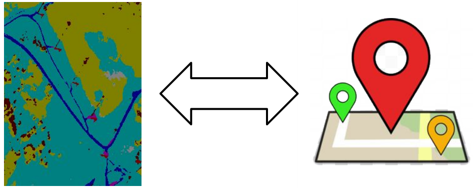
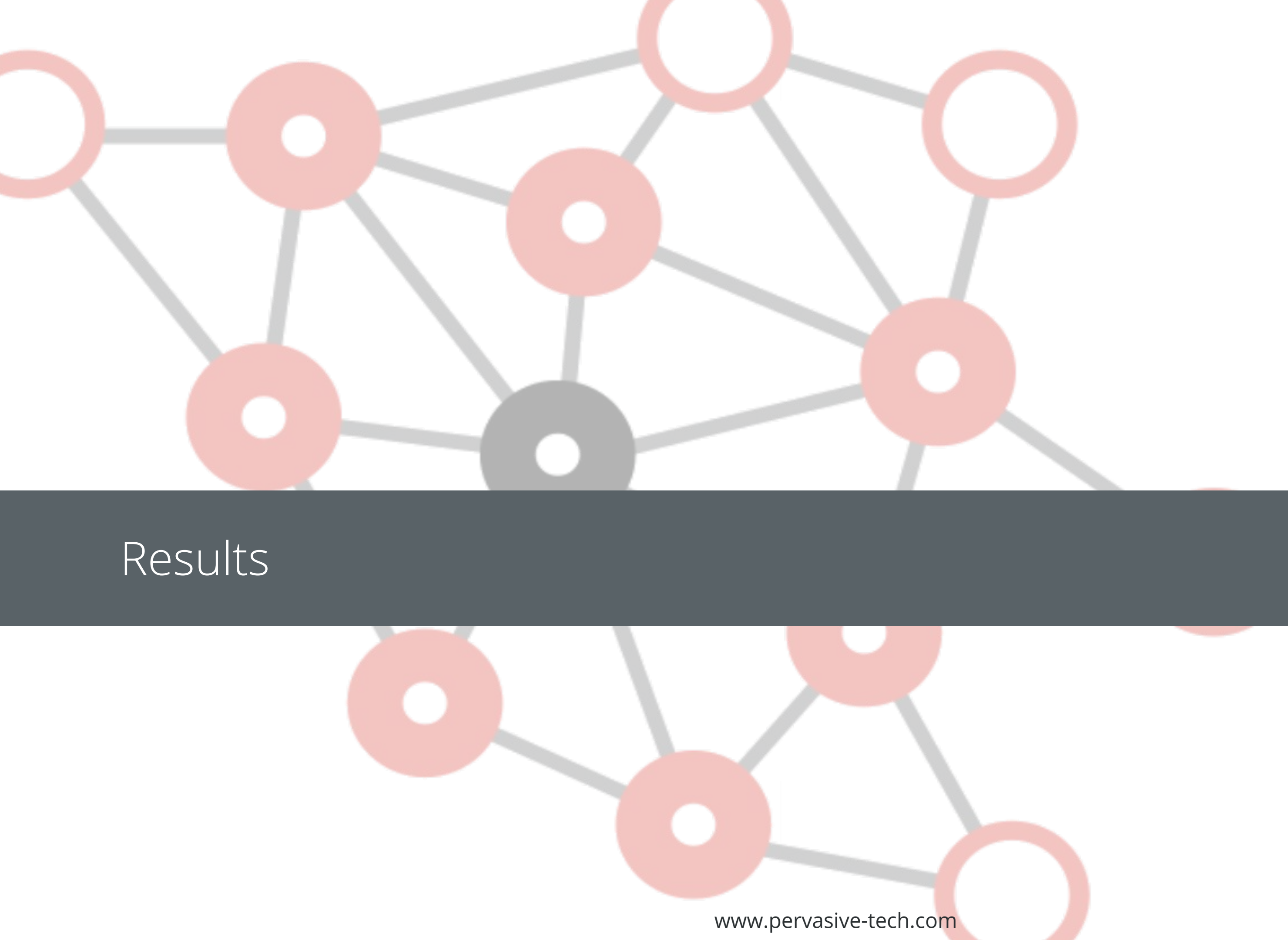


Figure credit from ade20k dataset

- Compute analytics
    - Match semantic predictions and geospatial information

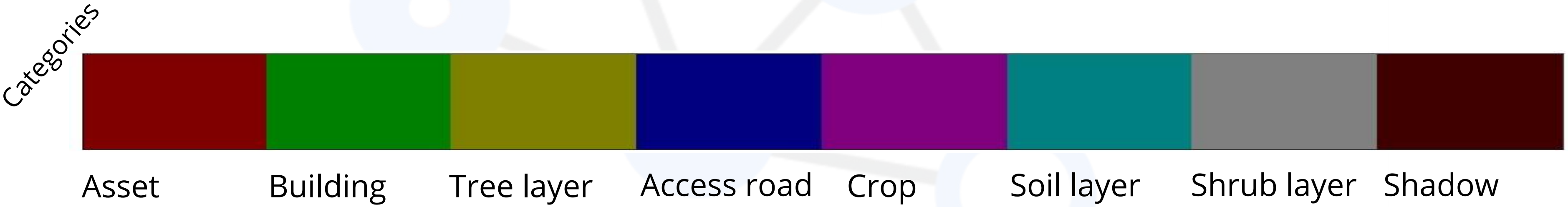




Results

Results description

- Validated with two wind-farms
- Accuracy vs human performance on satellite imagery 85-92 %
- Eight pre-defined categories for semantic segmentation:
  - Asset category stands for objects of interest with clearly defined boundaries: wind turbines, power sub-stations and electricity towers
  - Building category represents human-made structures, such as buildings and ruins
  - Access roads include dirt roads, paved roads, highways...

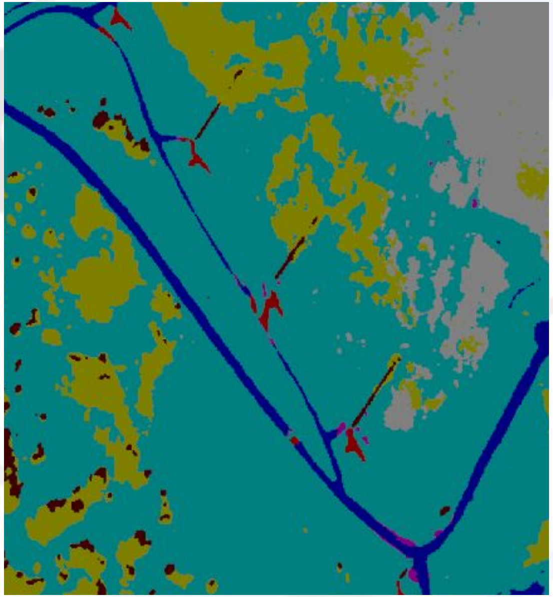

Categories
Asset
Building
Tree layer
Access road
Crop
Soil layer
Shrub layer
Shadow

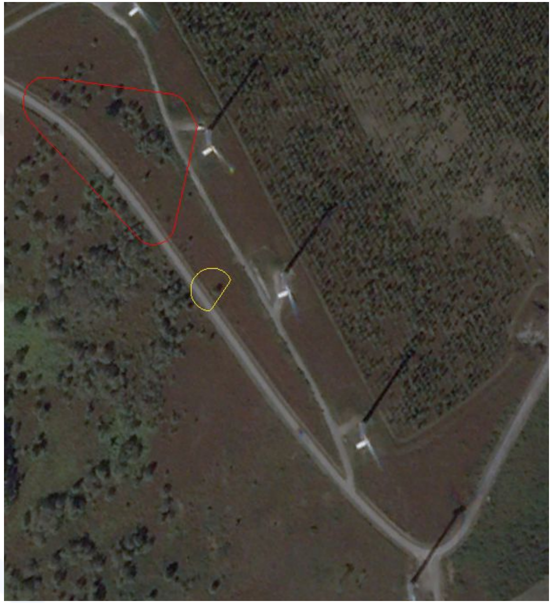
Access roads boundary alarms

Satellite image acquisition

Semantic segmentation

Analytics



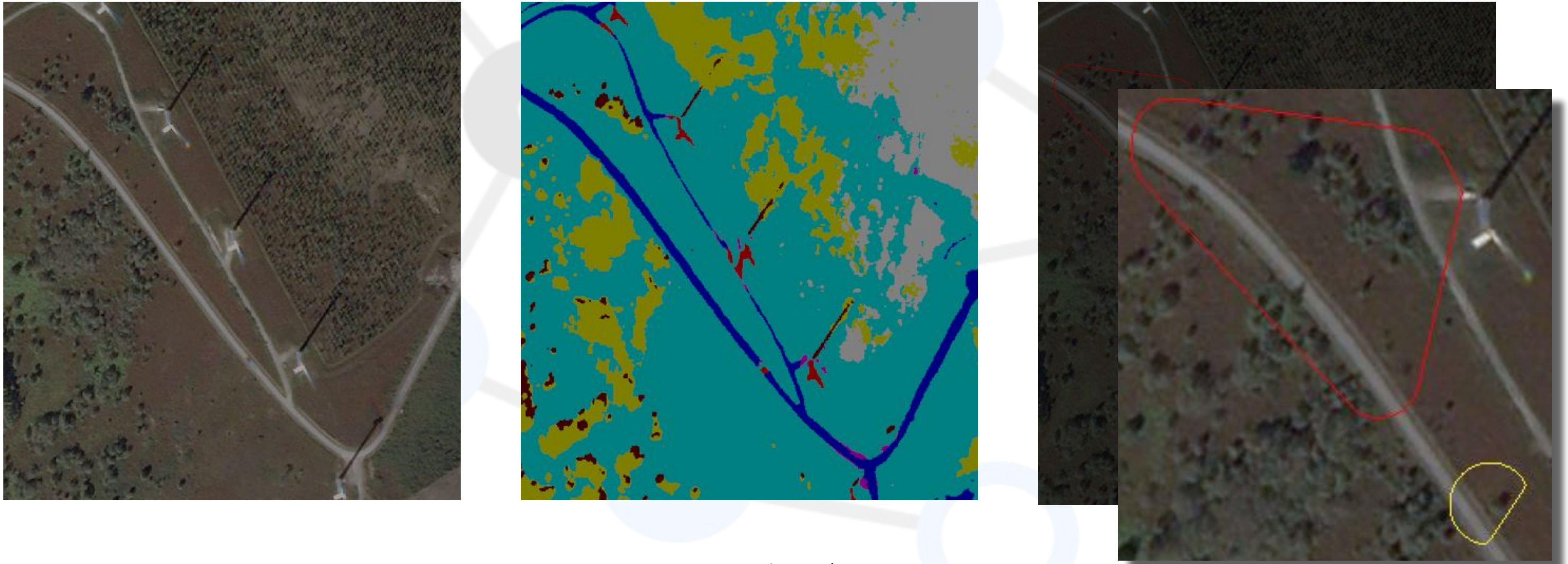


Access roads boundary alarms

Satellite image acquisition

Semantic segmentation

Analytics

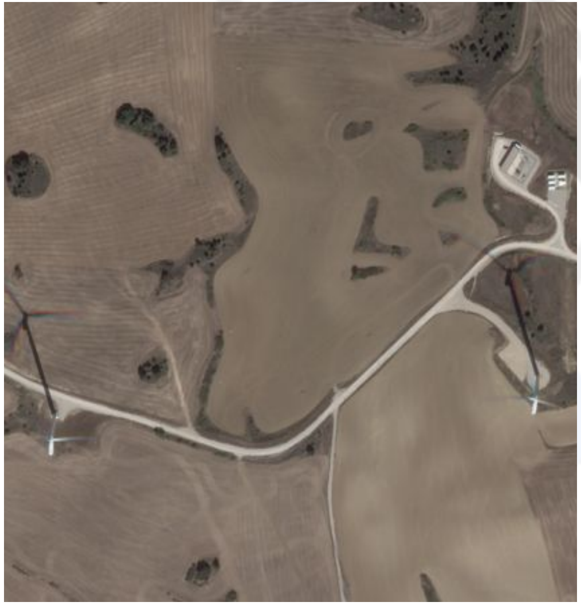


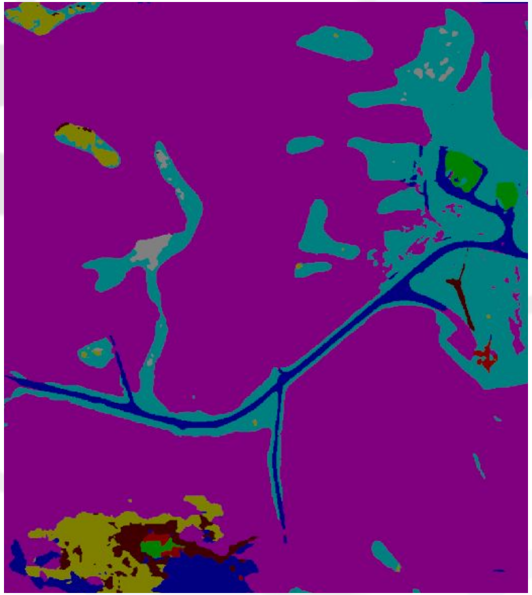
Access roads boundary alarms

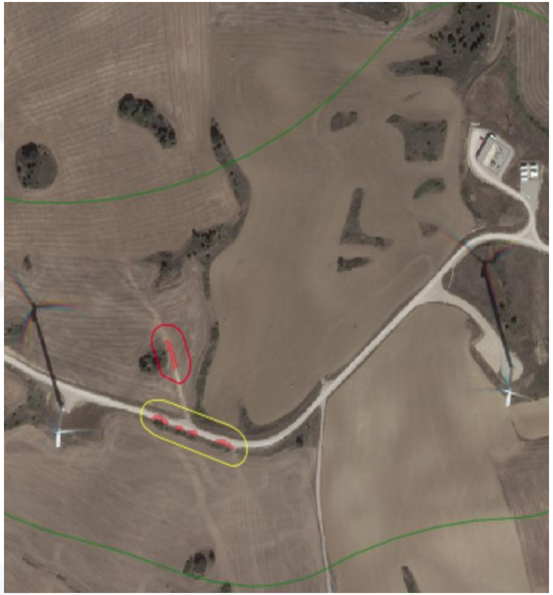
Satellite image acquisition

Semantic segmentation

Analytics





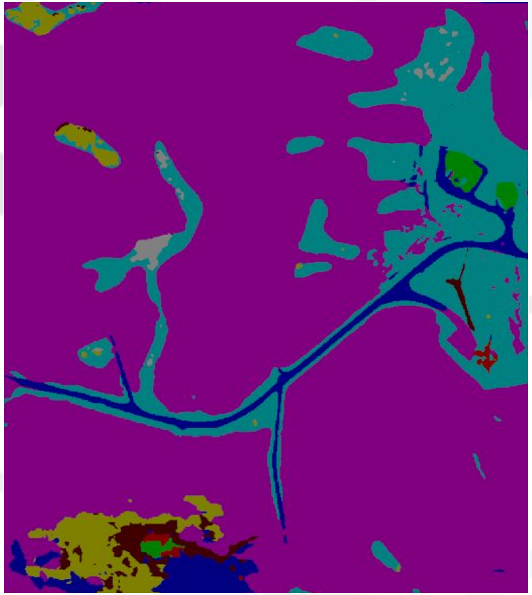


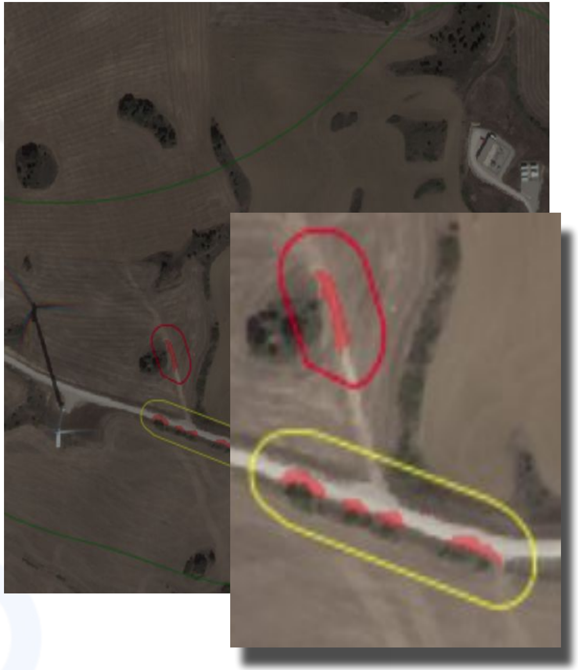
Access roads boundary alarms

Satellite image acquisition

Semantic segmentation

Analytics



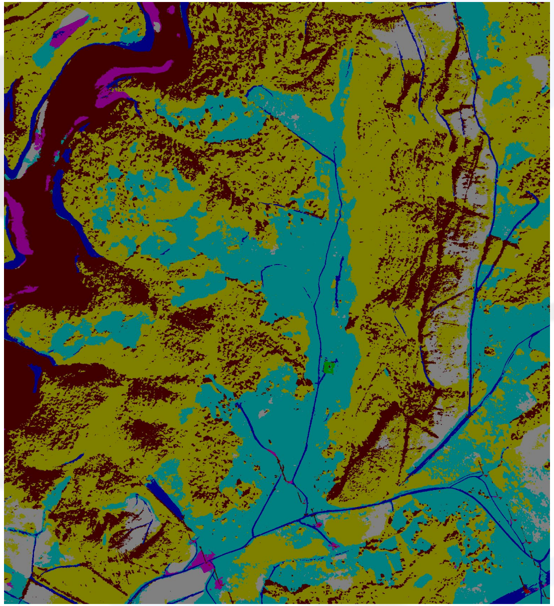


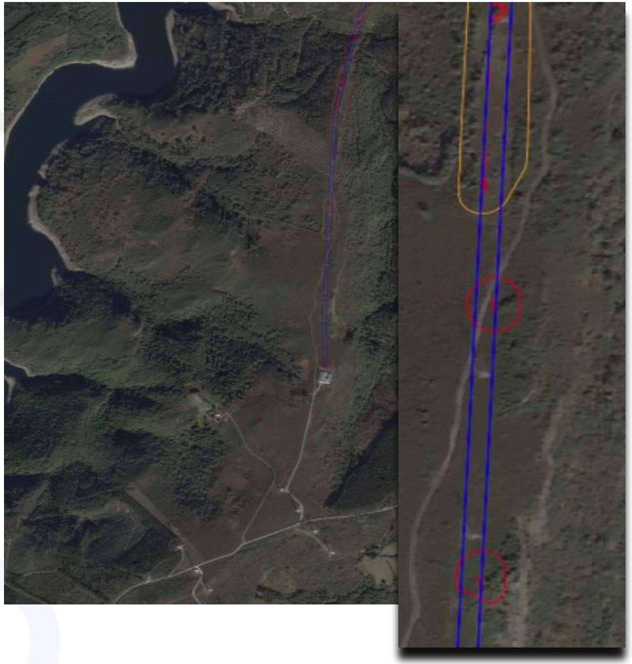
Power lines boundary alarms

Satellite image acquisition

Semantic segmentation

Analytics



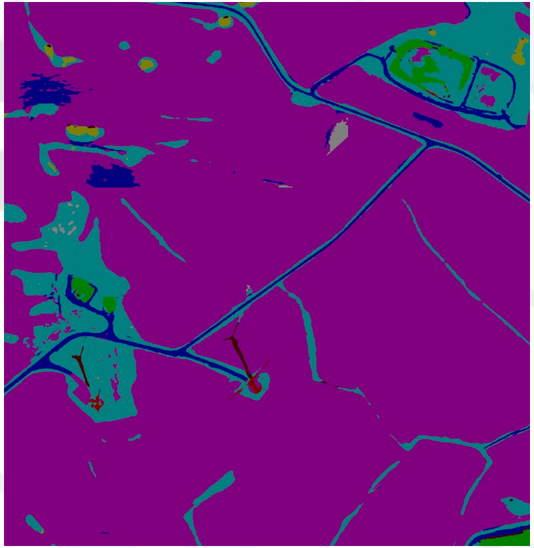


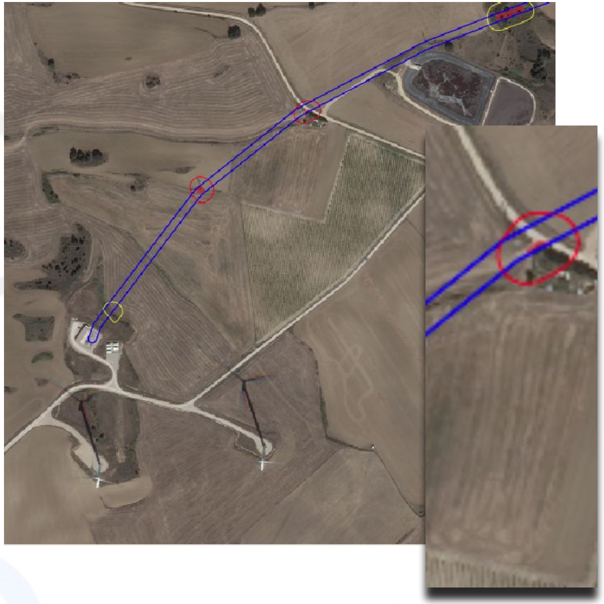
Power lines boundary alarms

Satellite image acquisition

Semantic segmentation

Analytics



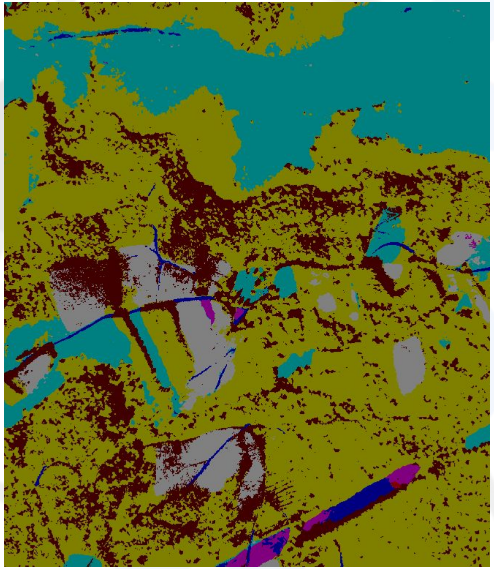


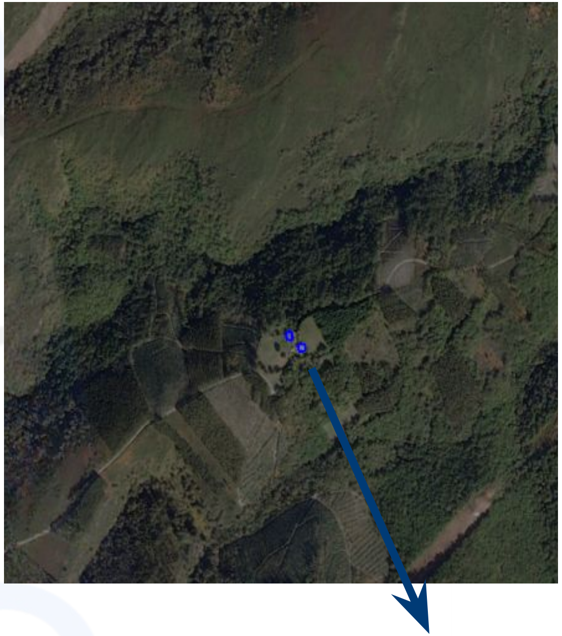
Detection of buildings

Satellite image acquisition

Semantic segmentation

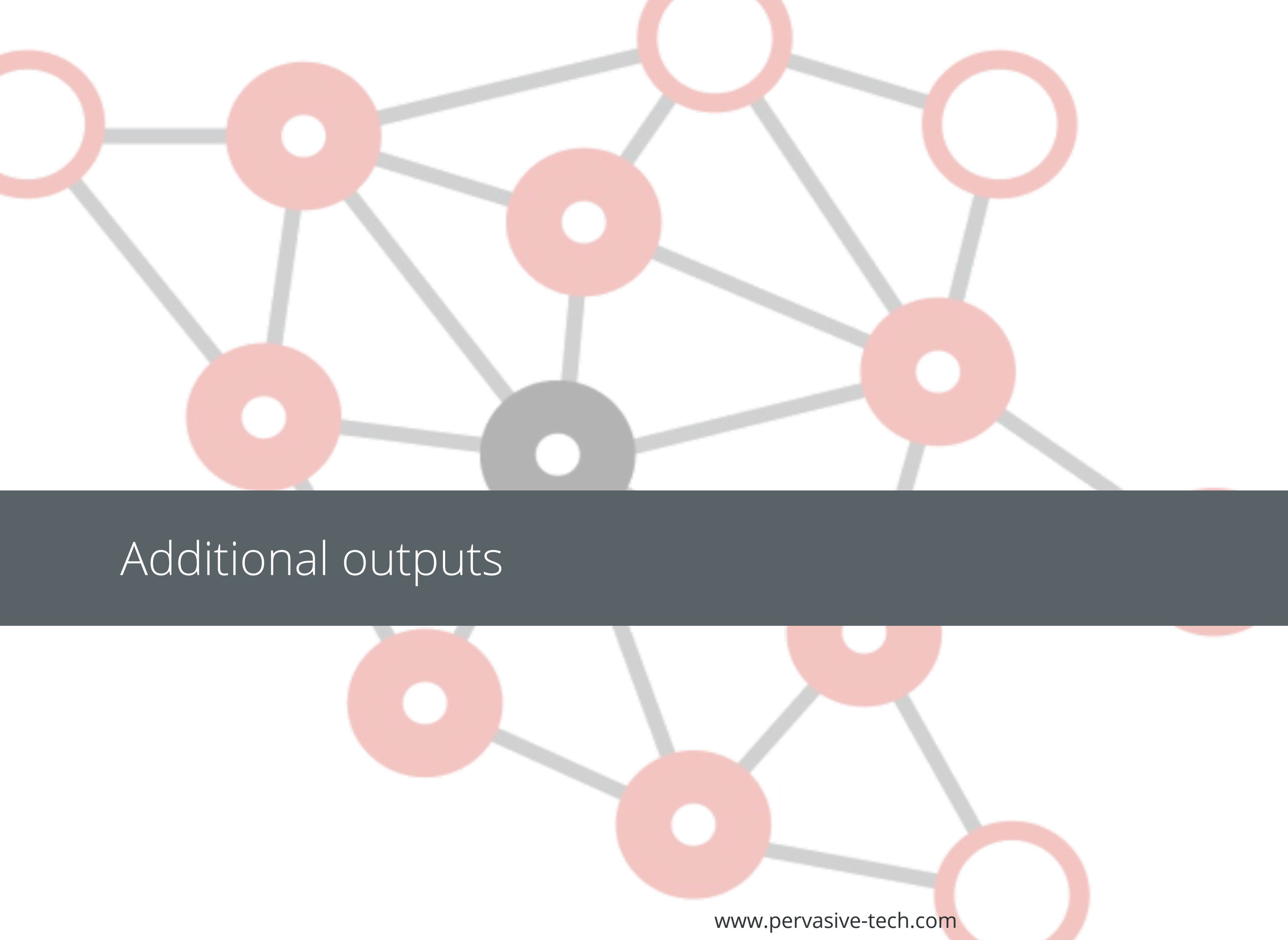
Analytics





Unexpected human-made structures (buildings, ruins…) changes.

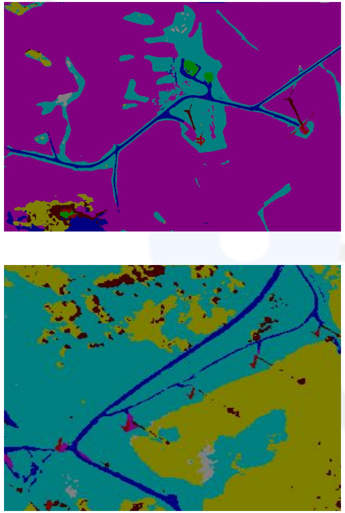
buildings!



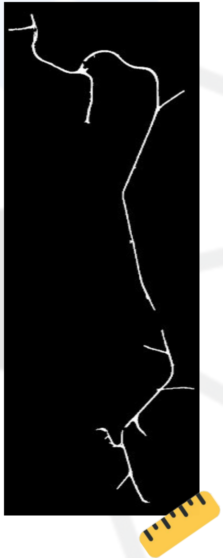
Additional outputs

Additional outputs - Road width

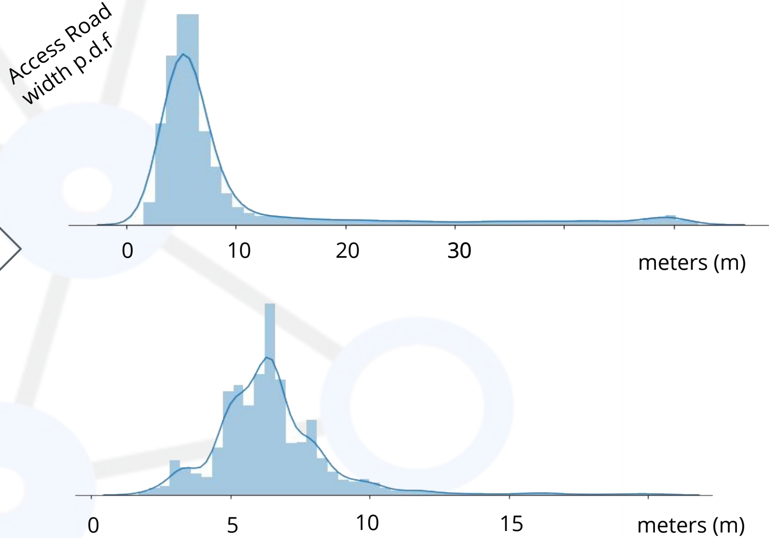
Semantic predictions



Post-processing



Analytics



- Mean access road width: 6 meters
- Time-series analysis to track the evolution of the assets
    - Detect damage in access roads because of rainfalls...
    - Post-disaster analysis

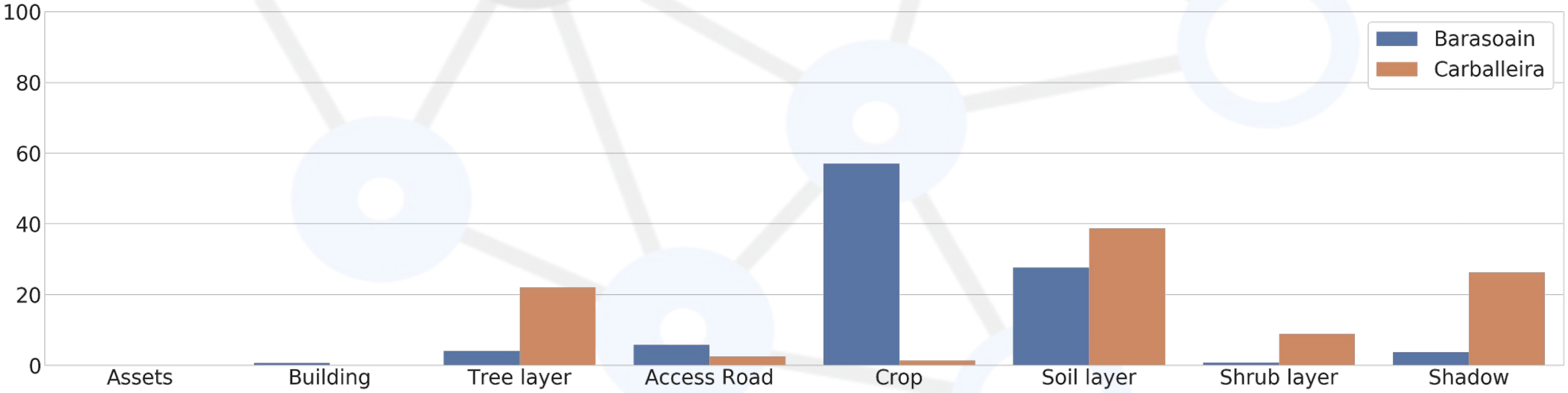
Additional outputs - Land coverage

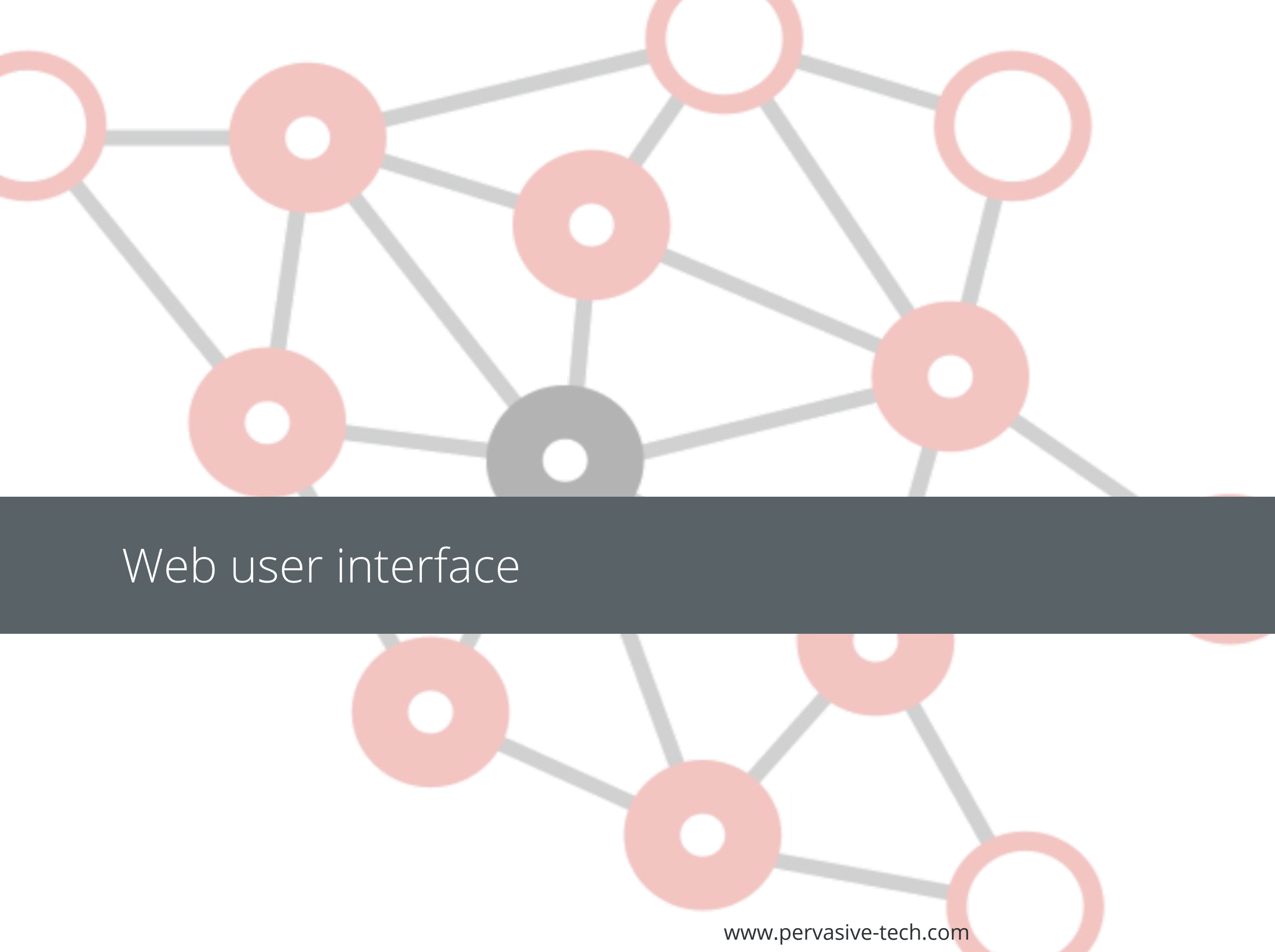
🟦 Barasoain

🟧 Carballeira

Land cover distribution from semantic predictions for:

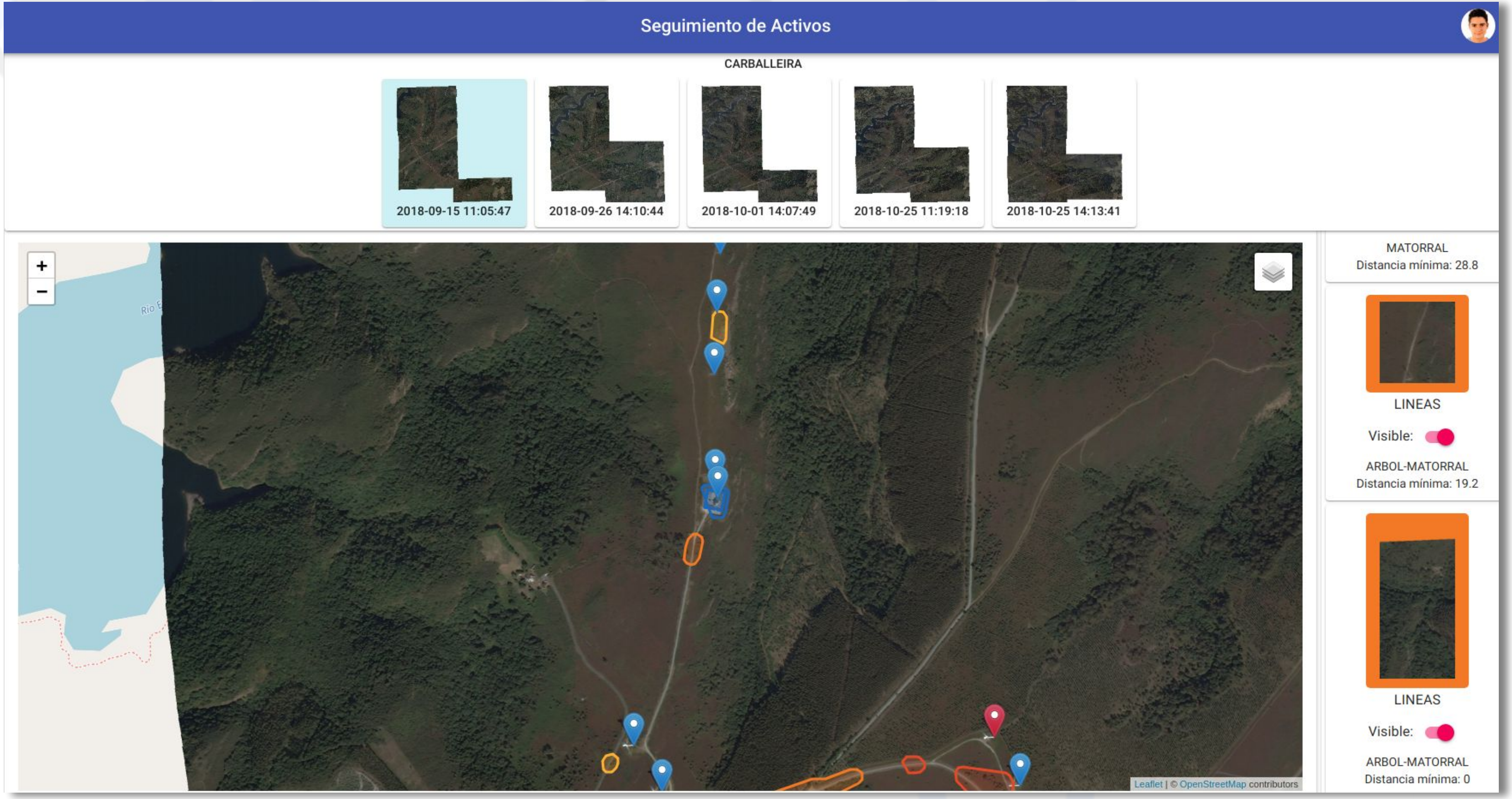
- Terrain characterisation
- Wildfire risk estimation





Web user interface

Web user interface



Seguimiento de Activos

CARBALLEIRA

2018-09-15 11:05:47
2018-09-26 14:10:44
2018-10-01 14:07:49
2018-10-25 11:19:18
2018-10-25 14:13:41

MATORRAL
Distancia mínima: 28.8

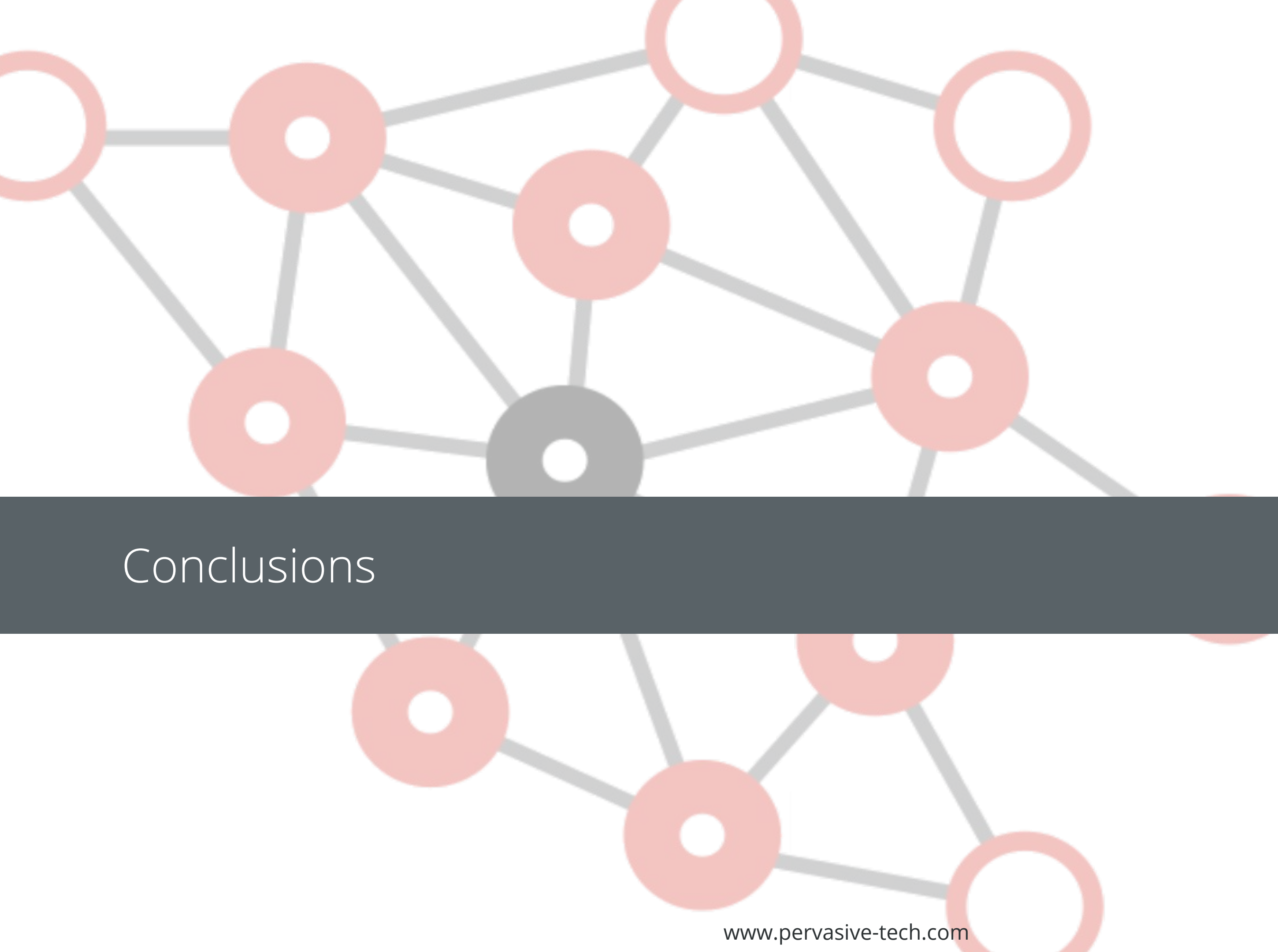
LINEAS
Visible: ●

ARBOL-MATORRAL
Distancia mínima: 19.2

LINEAS
Visible: ●

ARBOL-MATORRAL
Distancia mínima: 0

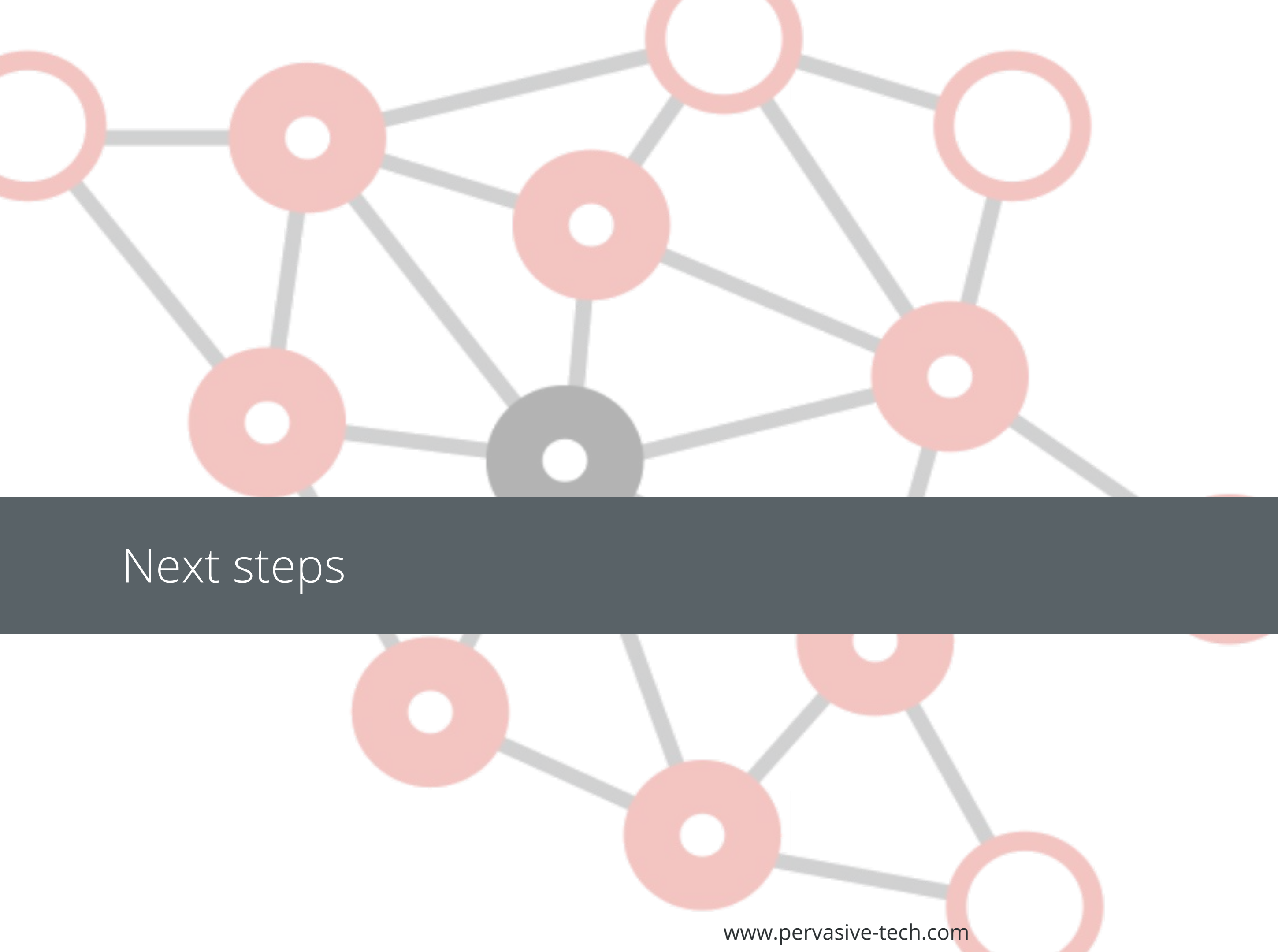
+
−
Rio E
Leaflet | © OpenStreetMap contributors



Conclusions

Conclusions

- Advantages:
    - Fully Automated system
    - Remote monitoring
    - Increase monitoring frequency
    - Reduce operational costs
    - Additional outputs
- Drawbacks:
    - Satellite image cost. It depends on both spatial and time resolution.



Next steps

Next steps

- Wind farm asset surveillance (*)
- Pruning planning based on vegetation growth analysis and prediction (*)
- Pruning audit and certification (*)
- Wind farm wildfire risk estimation and scoring (*)
- New wind farms prospection based on accurate territory analysis (land tipologies, infrastructures, etc...)
- Asset control & surveillance in hydroelectric power plants (pipes and swamps)
- Immediate asset affectation analysis in natural disasters or other risk situations

* Ongoing

Q&A

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