How Technology Convergence is Impacting Radical Innovation in the Energy Sector

Knut H. H. Johansen
CEO eSmart Systems

27th of February 2018

Intelligence First

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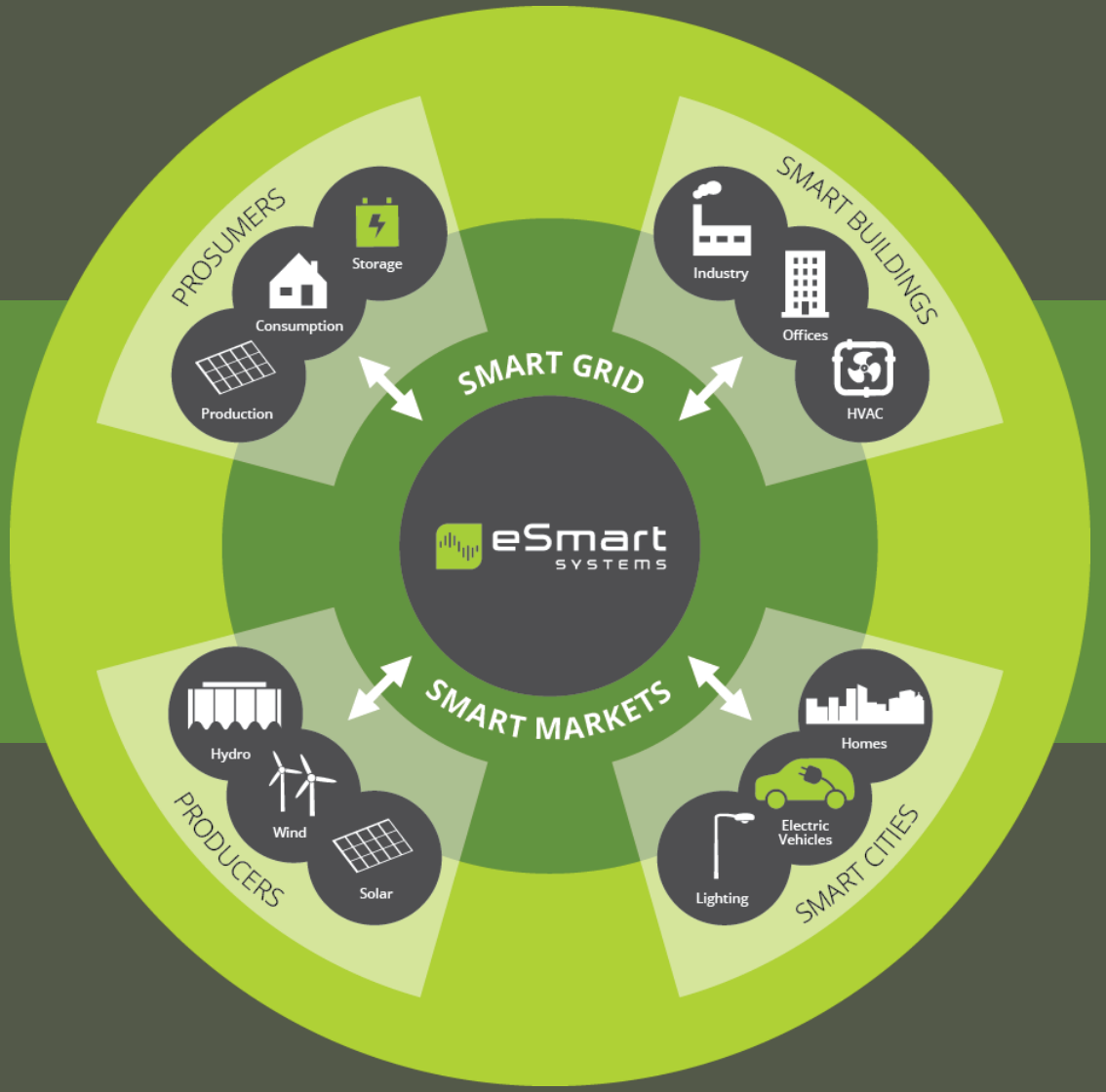
At eSmart our mission is to build digital intelligence to provide exceptional solutions to our customers and accelerate the transition to sustainable societies



Focus on AI


Microsoft
Cortana Intelligence and Machine Learning Blog
Cortana Intelligence and Machine Learning Blog
Connected Drones: 3 Powerful Lessons We Can All Take Away
Connected Drone
(powered by Azure)
Lesson 1: Cloud-Based Solutions Empower Trailblazers Wherever They Are
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We couldn't do it without...
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eSmart Systems Business Areas

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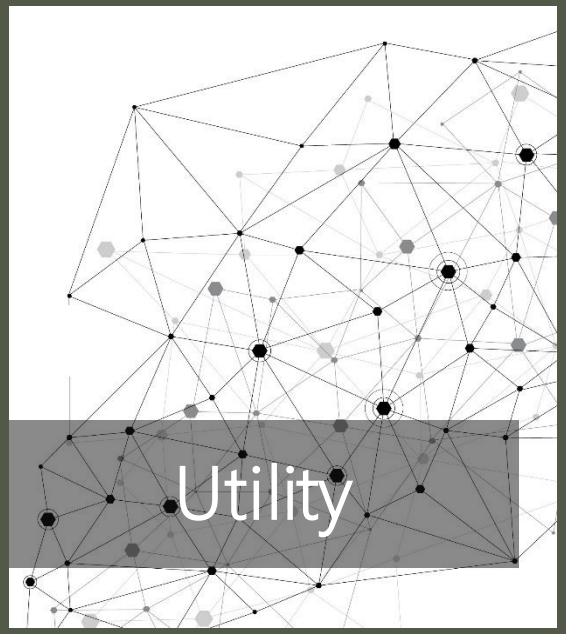

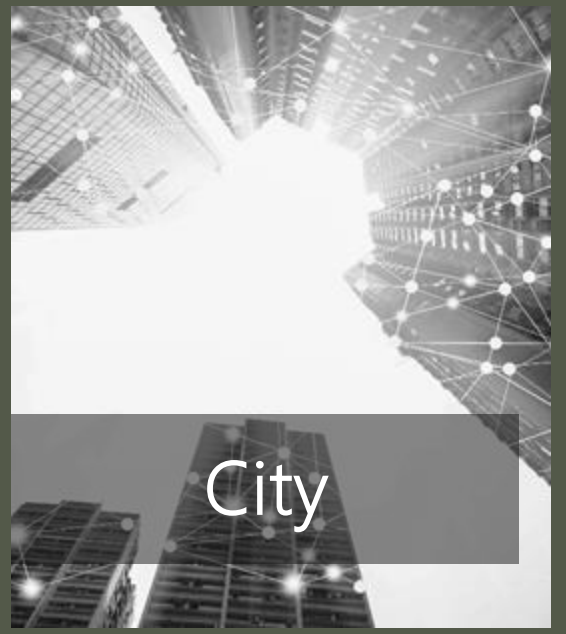

eSmart's foundation

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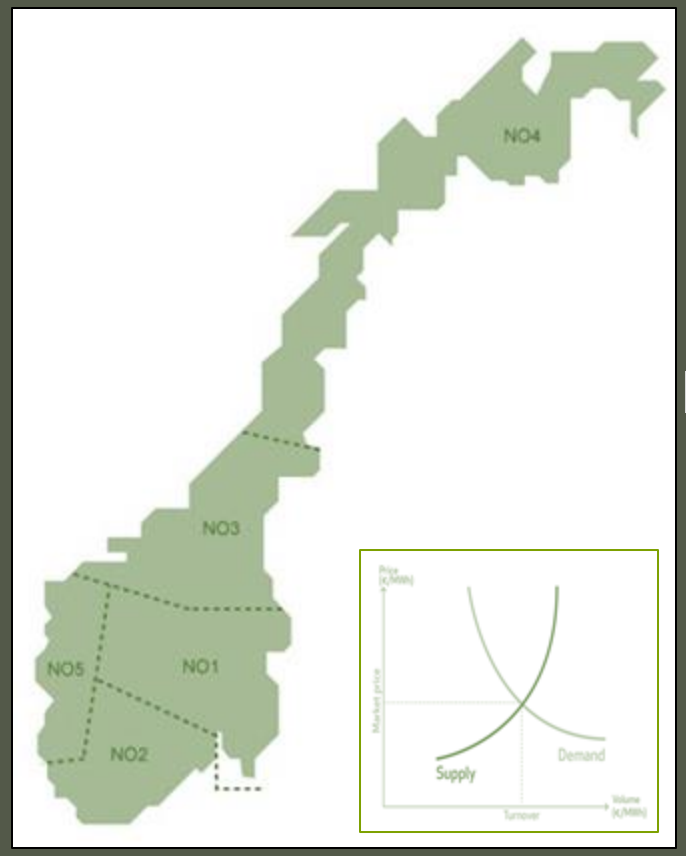
- 20 years of software development for the energy business
- 2 decades of experience with machine learning
- Extensive business knowledge in different markets
- World leading technology vendor
- Long experience with innovation processes
- Generated revenue of 5 billon NOK from innovation

Development of PCR (Price Coupling of Regions)

1991 (Norway)



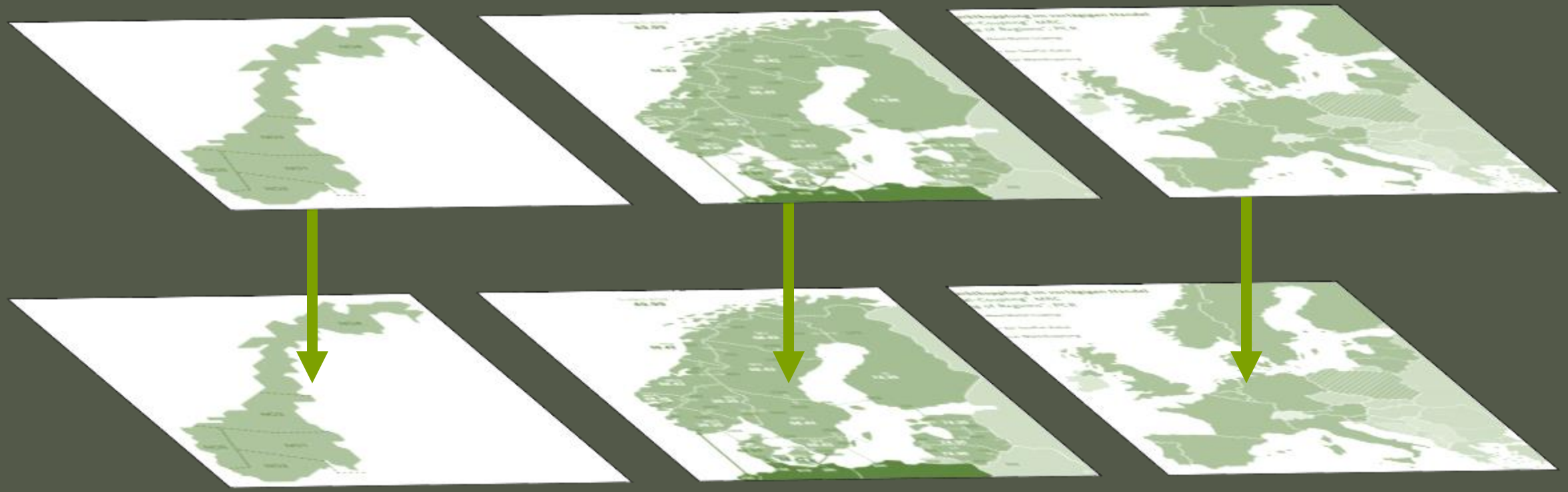
1996 – 2000 (Nordic) 2010 – 2013 (Baltics)

2014 (NWE) -

From the *world's first* spotmarket for electricity to the *world's largest* spotmarket for electricity

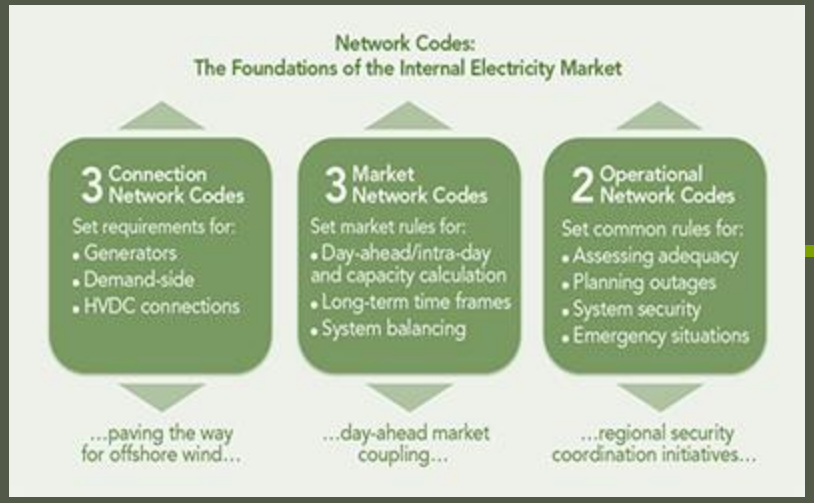
The Internal Electricity Market & Local Electricity Markets

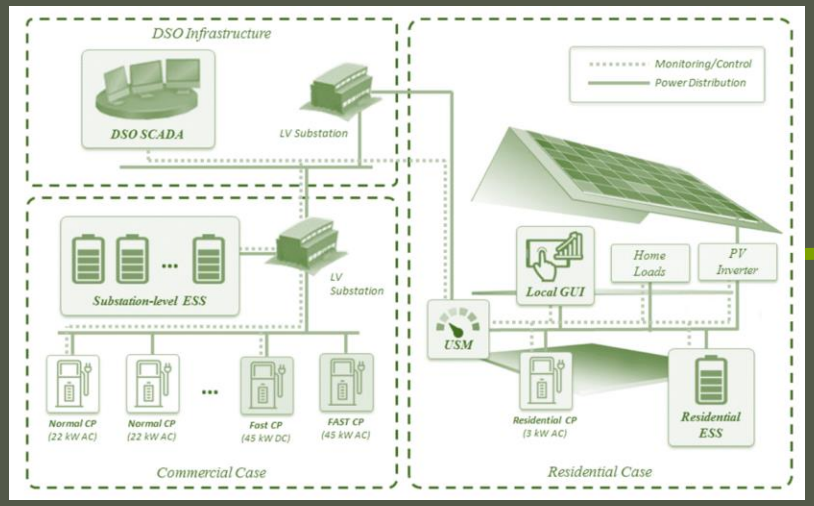
TSO – level: matured market



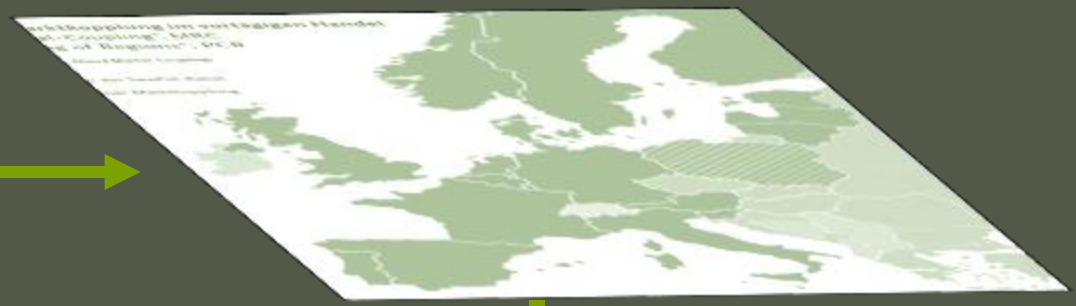
DSO - level: emerging distributed / local markets

The Internal Electricity Market & Local Electricity Markets





TSO – level: matured market



DSO - level: emerging distributed / local markets

EMPOWER

INVADE

An irreversible and dramatic change in human history

Three technologies converge into extreme power

Digital Technology Convergence

Exponential growth in volume [illegible] data

Exponential growth in [illegible] power and storage

Exponential [illegible] development of sophisticated AI algorithms

The Age of Artificial Intelligence

Get Ready To Never Trust Anything On The Internet Ever Again

The rise of fake Everything

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The rise of fake Everything

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Who is speaking?

eSmart SYSTEMS

LYREBIRD

DEMO ABOUT LOG IN

Welcome to the beta version of Lyrebird

Lyrebird allows you to create a digital voice that sounds like you with only one minute of audio.

Create your digital voice

Or log in if you already have an account

This **beta version** allows anyone to create their digital voice with **only one minute** of audio. Simply sign up, record yourself for at least one minute and you will be able to generate any sentence you like with your digital voice.

An irreversible and dramatic change in human history

Will this extreme power lead to technological singularity?

Singulatity

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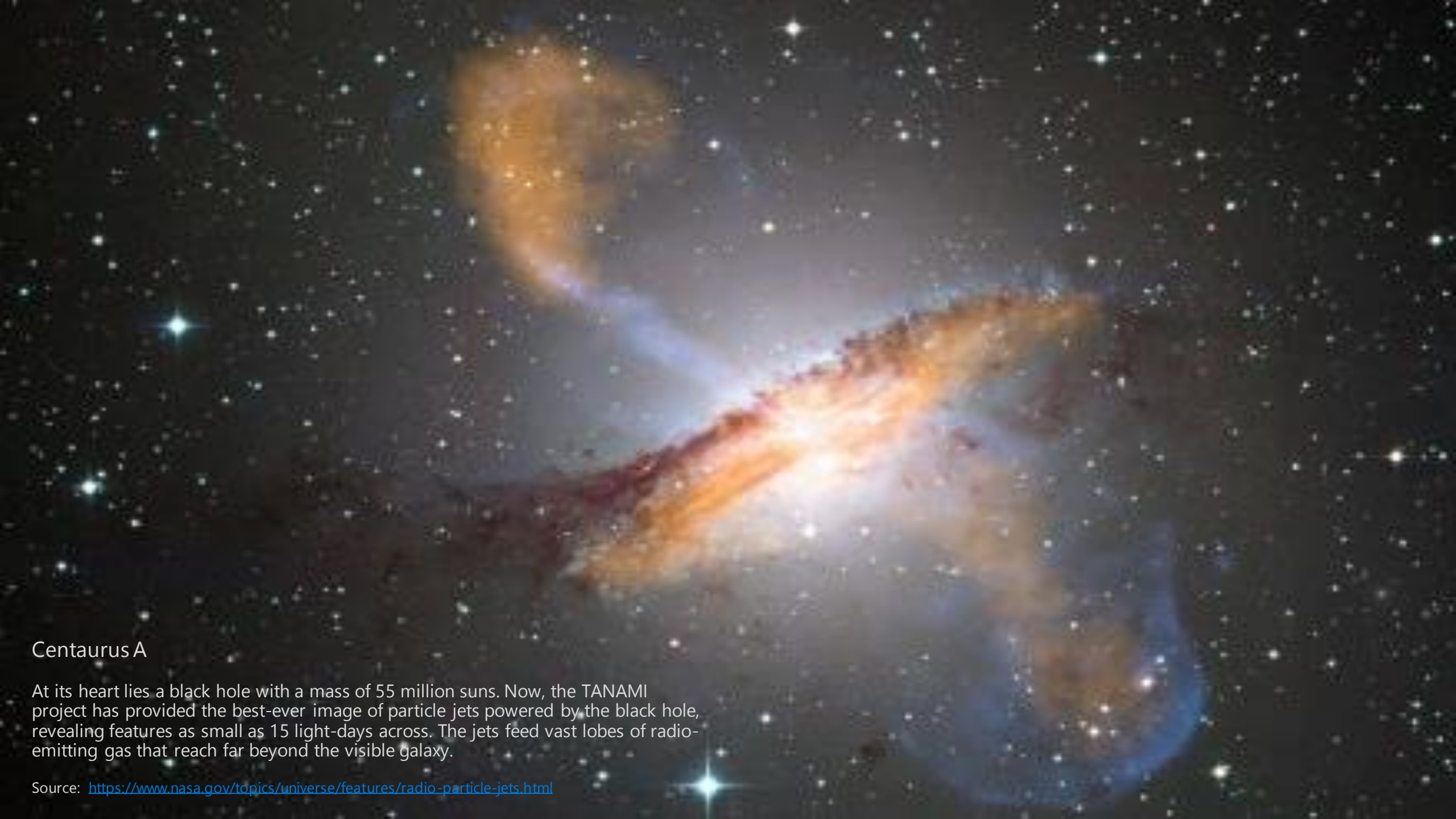
$$f(x) = \frac{1}{x}$$

$$x = 0$$

$$f(0) = \infty$$

Mathematical singularity, a point at which a given mathematical object is not defined or not "well-behaved", for example infinite or not differentiable

$x = 0$ gives ***essential singularity***, a singularity in which the function exhibits ***extreme behavior***



Centaurus A

At its heart lies a black hole with a mass of 55 million suns. Now, the TANAMI project has provided the best-ever image of particle jets powered by the black hole, revealing features as small as 15 light-days across. The jets feed vast lobes of radio-emitting gas that reach far beyond the visible galaxy.

Source: https://www.nasa.gov/topics/universe/features/radio-particle-jets.html

Technological Singularity

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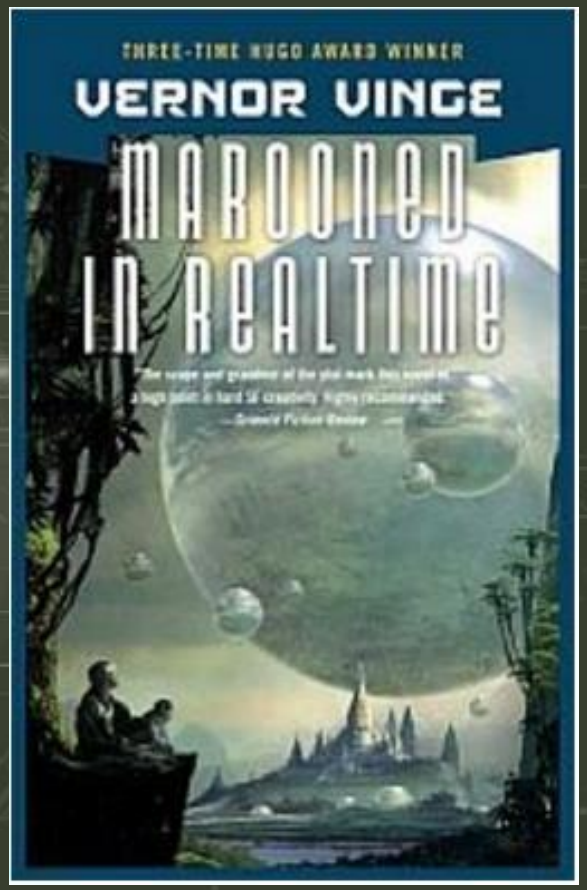
Vernor Vinge introduced the term Technological Singularity in his science fiction novel Marooned in Realtime (1986) and later developed the concept in his essay the Coming Technological Singularity (1993).

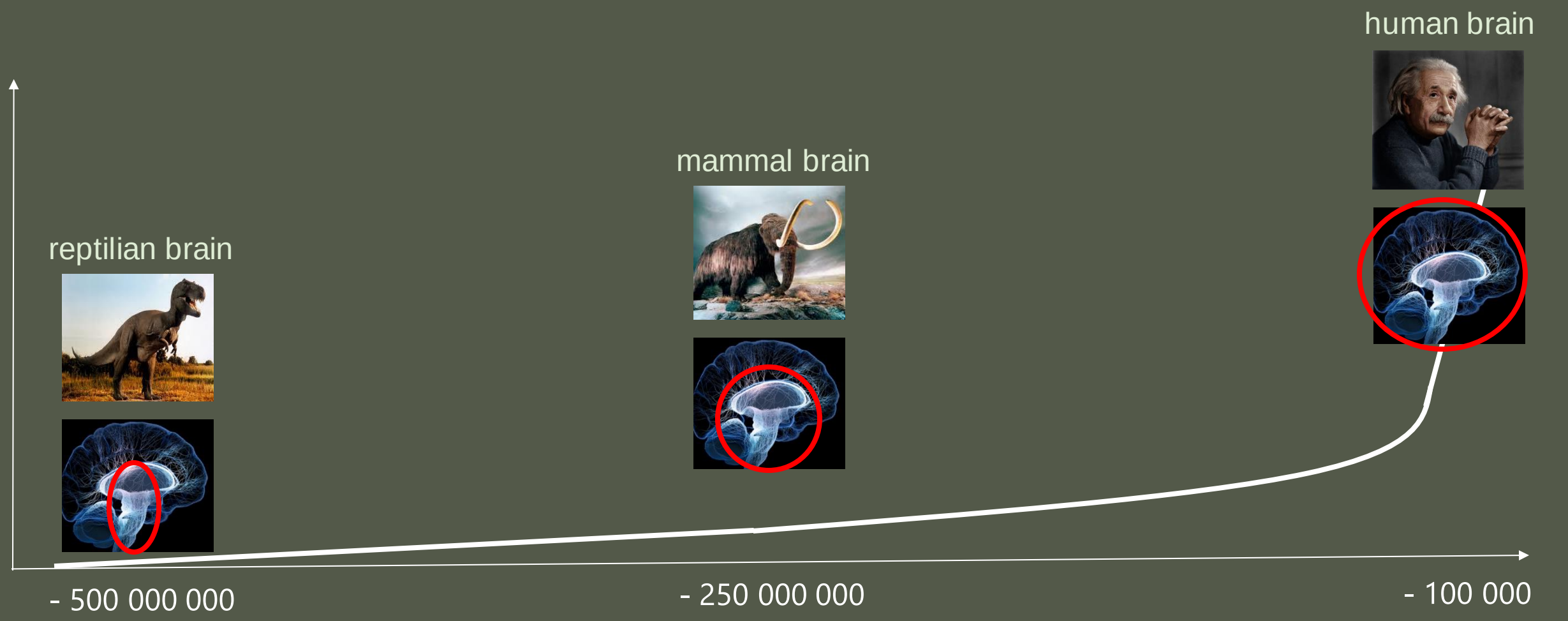
His definition of Singularity is widely known as the event horizon thesis and in essence says that trans or post-human minds will imply a weirder future than we can imagine:

"Within thirty years, we will have the technological means to create superhuman intelligence. Shortly after, the human era will be ended. [...] I think it's fair to call this event a singularity. It is a point where our models must be discarded and a new reality rules.

As we move closer and closer to this point, it will loom vaster and vaster over human affairs till the notion becomes a commonplace. Yet when it finally happens it may still be a great surprise and a greater unknown."



Cognitive Singularity



From First to Fourth Industrial Revolution

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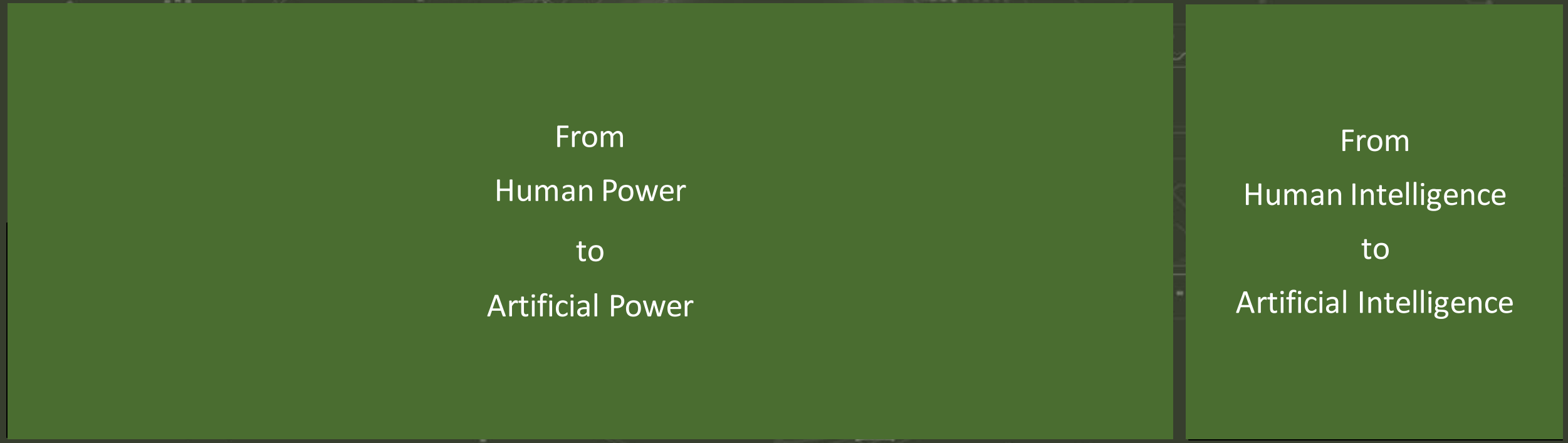


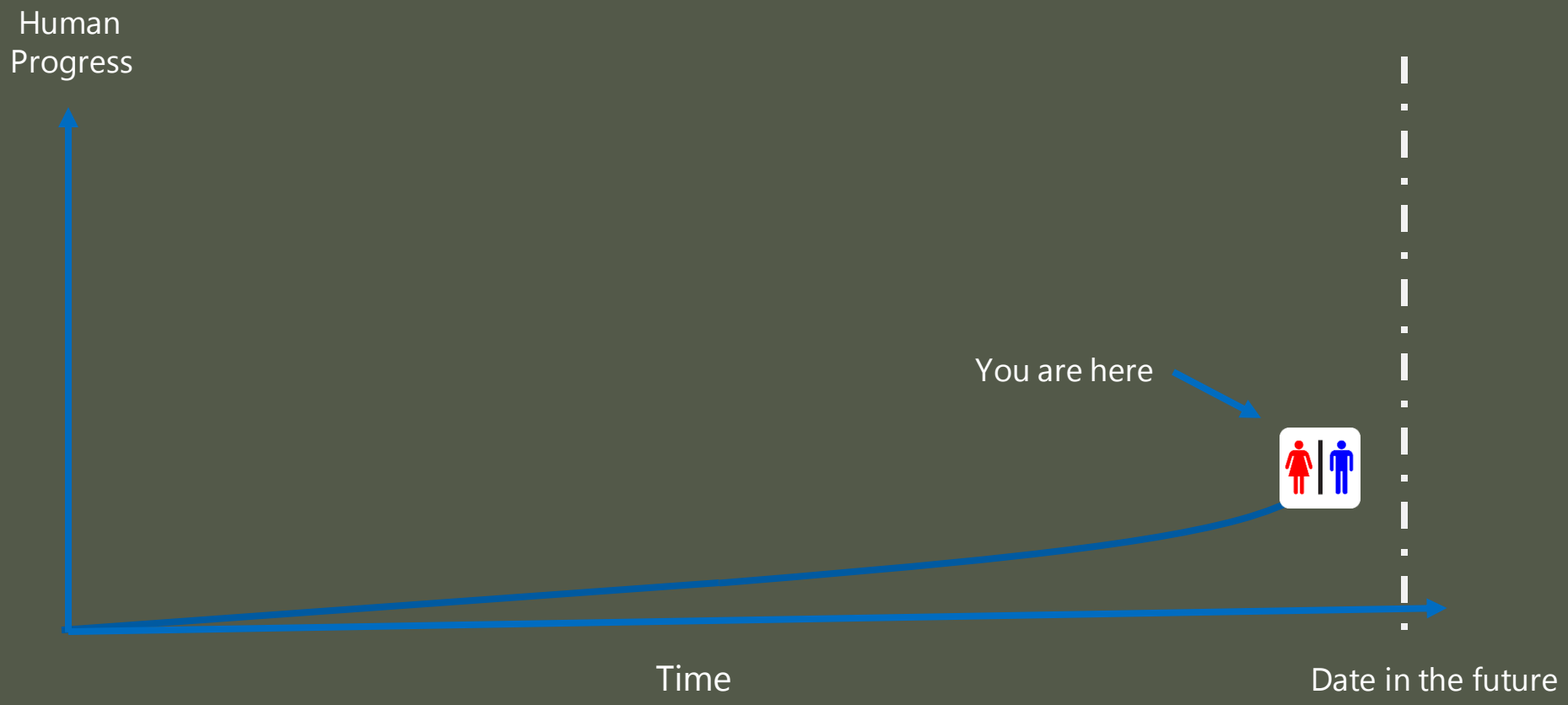
First mechanical loom, Edmund Cartwright's Water Power Loom 1784

First assembly line Cincinnati slaughter houses, 1870

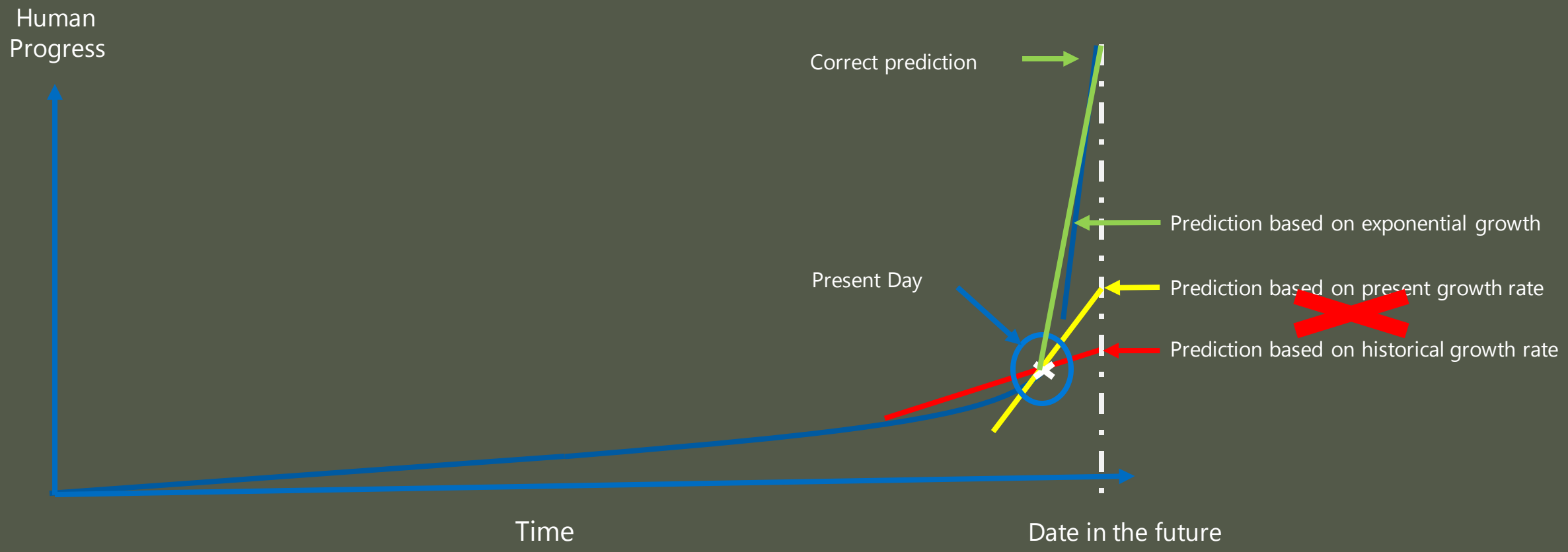
First Programmable Logic Controller (PLC), Modicon 084, 1969

Development and use of Cyber-Physical Systems

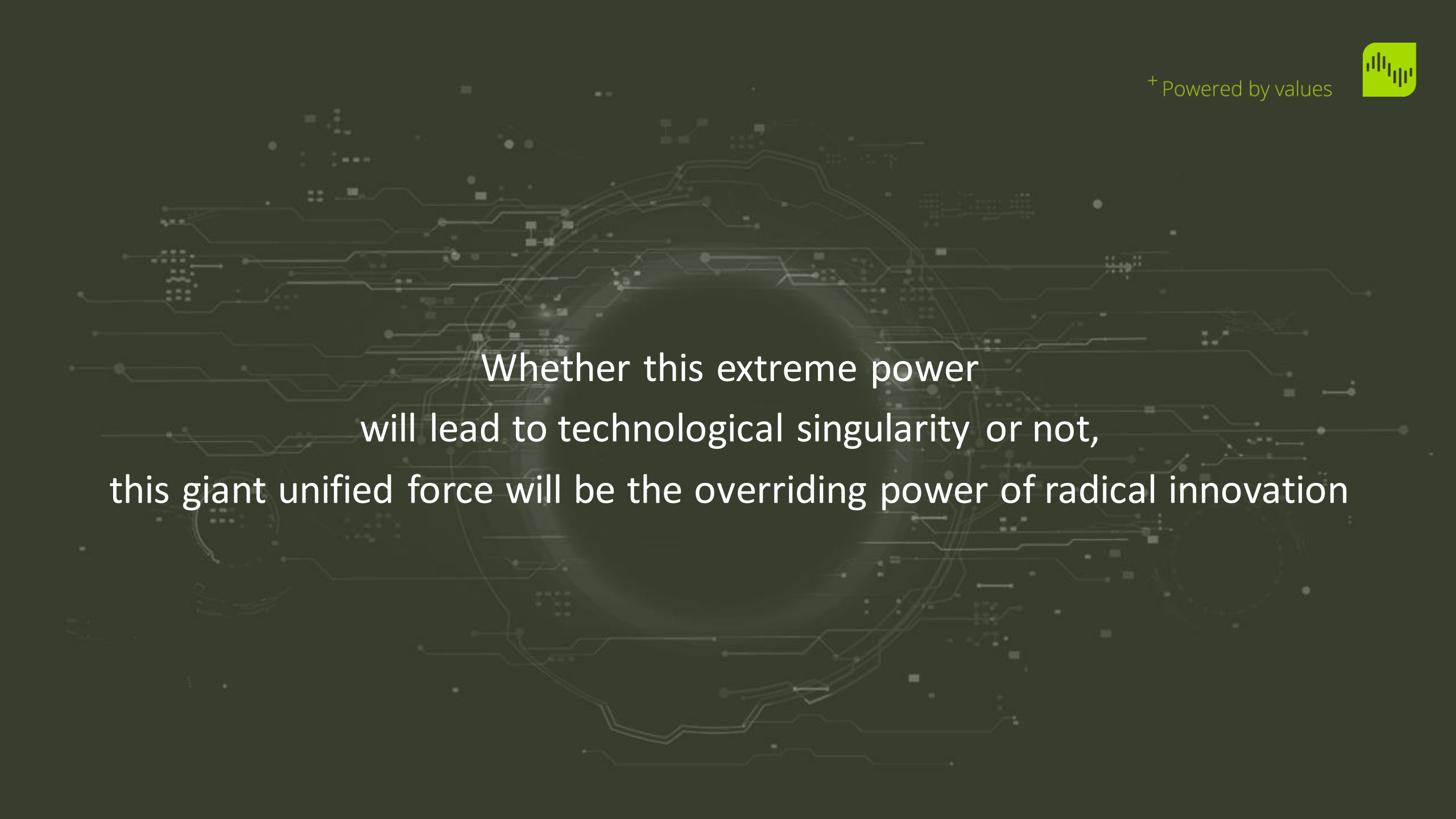
The Far Future - Coming Soon



The Far Future - Coming Soon




But if the technological
Singularity can happen, it will.
Vernor Vinge



Whether this extreme power
will lead to technological singularity or not,
this giant unified force will be the overriding power of radical innovation

Neuralink – will **turbocharge** brains

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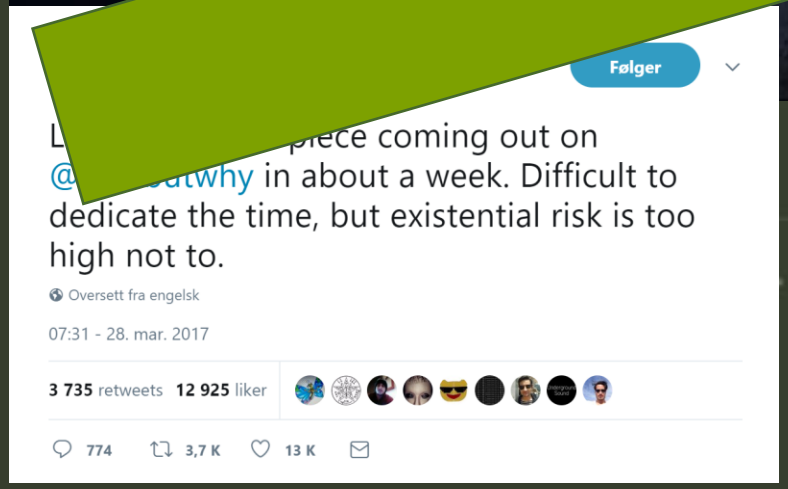
Develops technology to connect computers to our brains – merger of biological intelligence and machine intelligence

Image: Oliver Burston

Radical Innovations need Radical Ideas



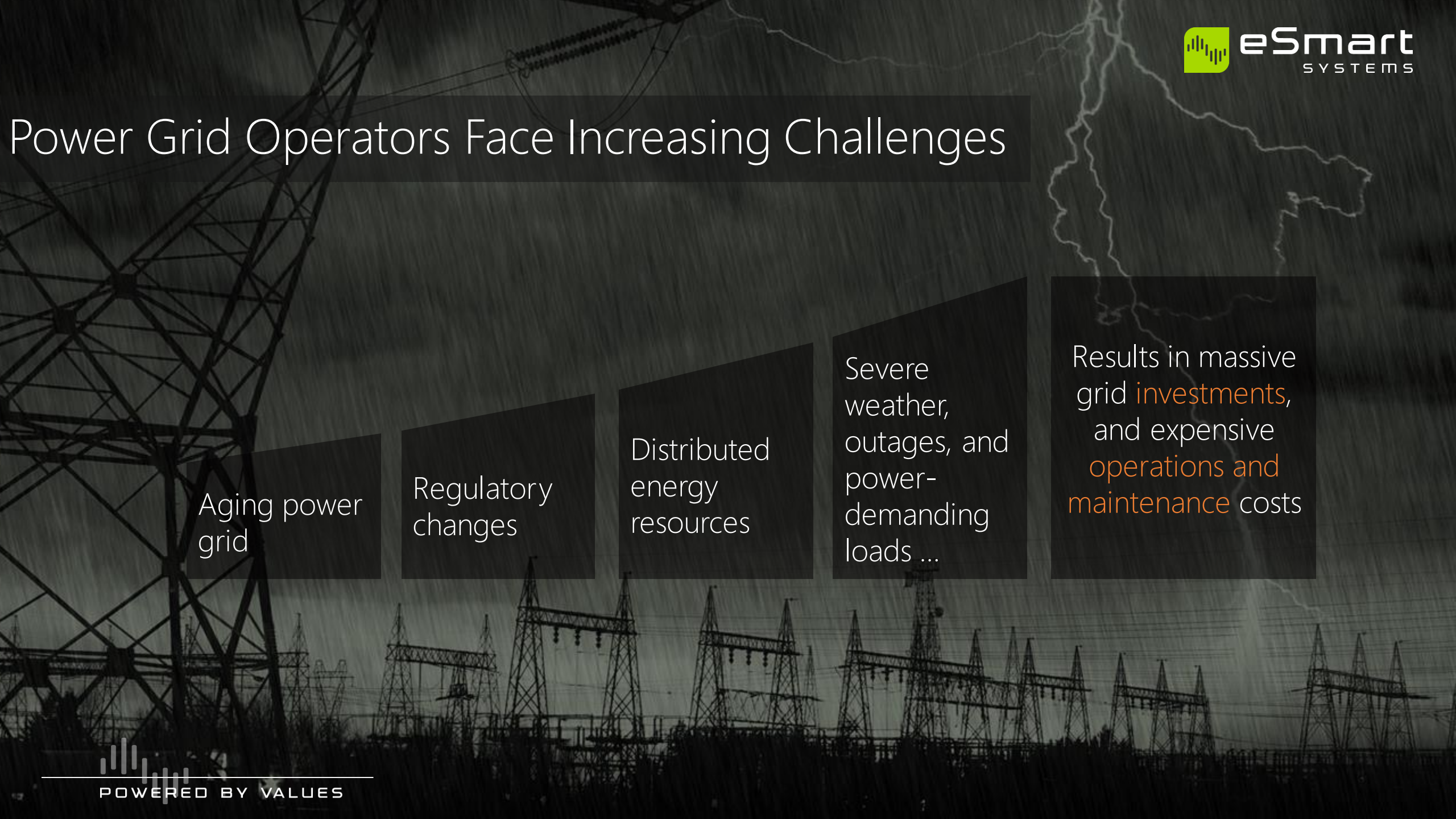
Neuralink has the potential to rapidly accelerate the development of mind-machine interface via its "neural lace" which is a digital layer above the cortex that could work well and symbiotically with the human brain"

Neuralink's ultimate goal is to develop a *"whole-brain interface," which would be a device that is completely integrated into the brain, and give the brain the ability to connect wirelessly with the cloud, and all other people and their computers with the same interface.*

The Economist

Renewable energy

A world turned upside down


eSmart SYSTEMS
Power Grid Operators Face Increasing Challenges
Aging power grid
Regulatory changes
Distributed energy resources
Severe weather, outages, and power-demanding loads ...
Results in massive grid investments, and expensive operations and maintenance costs
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Technology changes drive market changes

- DER technology development and price drop
- Electricity market changes
- ICT and analytics development
  - Internet of energy
  - Time series data
  - Microsoft Azure cloud
  - Real-time analytics
  - Artificial intelligence and deep neutral networks

Digital Platform

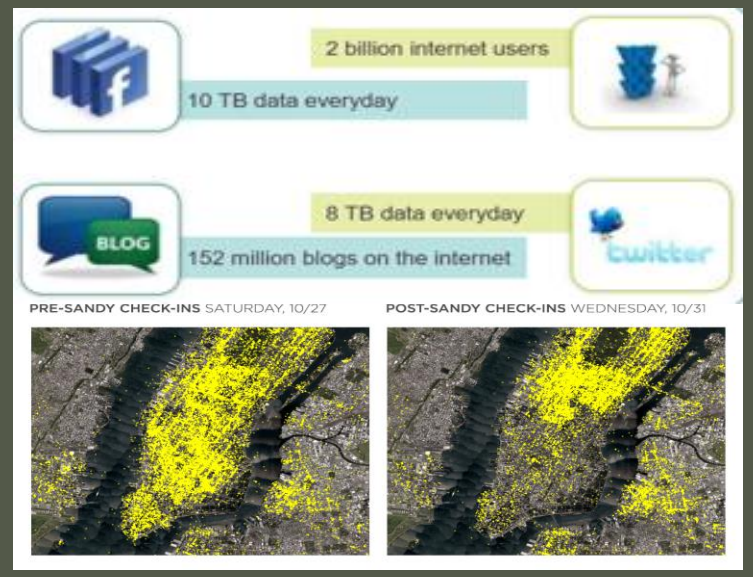
Internal Data

Legacy data systems and traditional data warehouses are not designed to handle the amount & type of data generated by newer internet-scale technologies

Big Data Technology bridges the gap

Big Data Technology will be crucial for the competitive advantages

External Data



90% of the data is coming from net-new data sources – mobile, social media, web and machine-generated data – and this will increase

Rob Bearden CEO - Hortonworks

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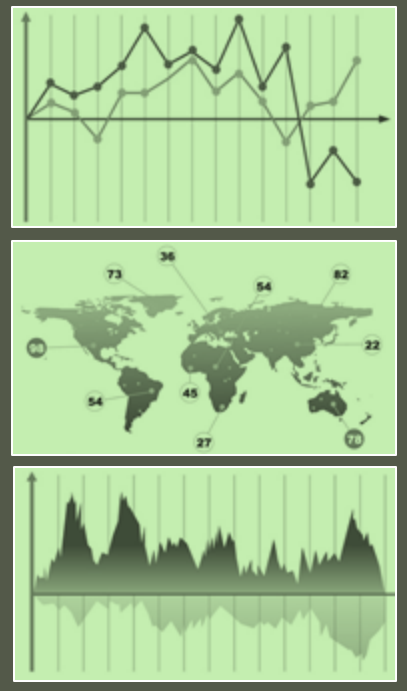
IoT Big Data Real Time Analytics Visualization

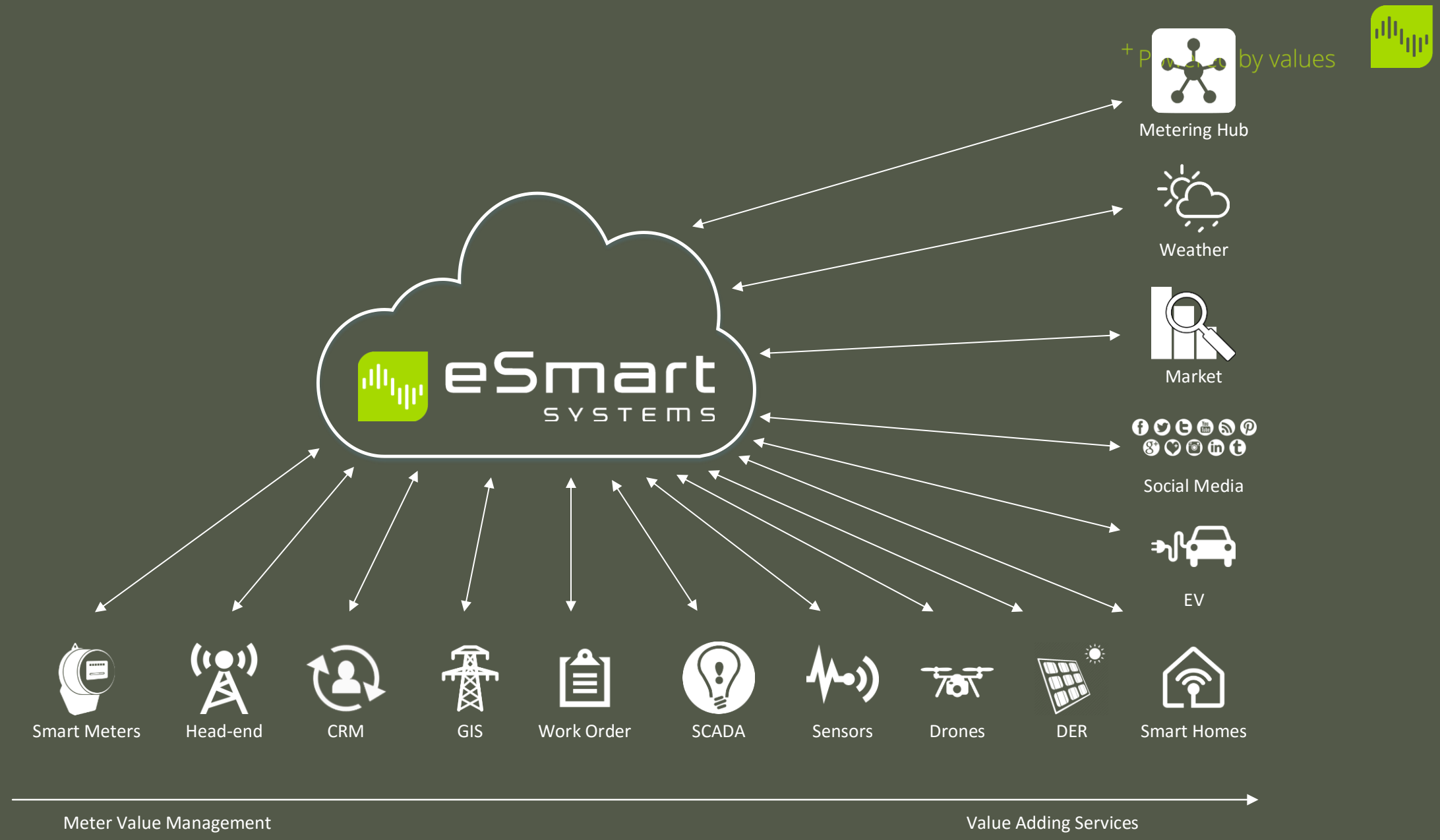
- Volume
- Velocity
- Variety
- Veracity



Turning Big Data into Value

The “datafication” of the world gives us unprecedented amounts of data.

The latest technology together with the latest software and analysis approaches allow us to leverage all types of data to add value.



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IoT

The Explosion of Connected Devices

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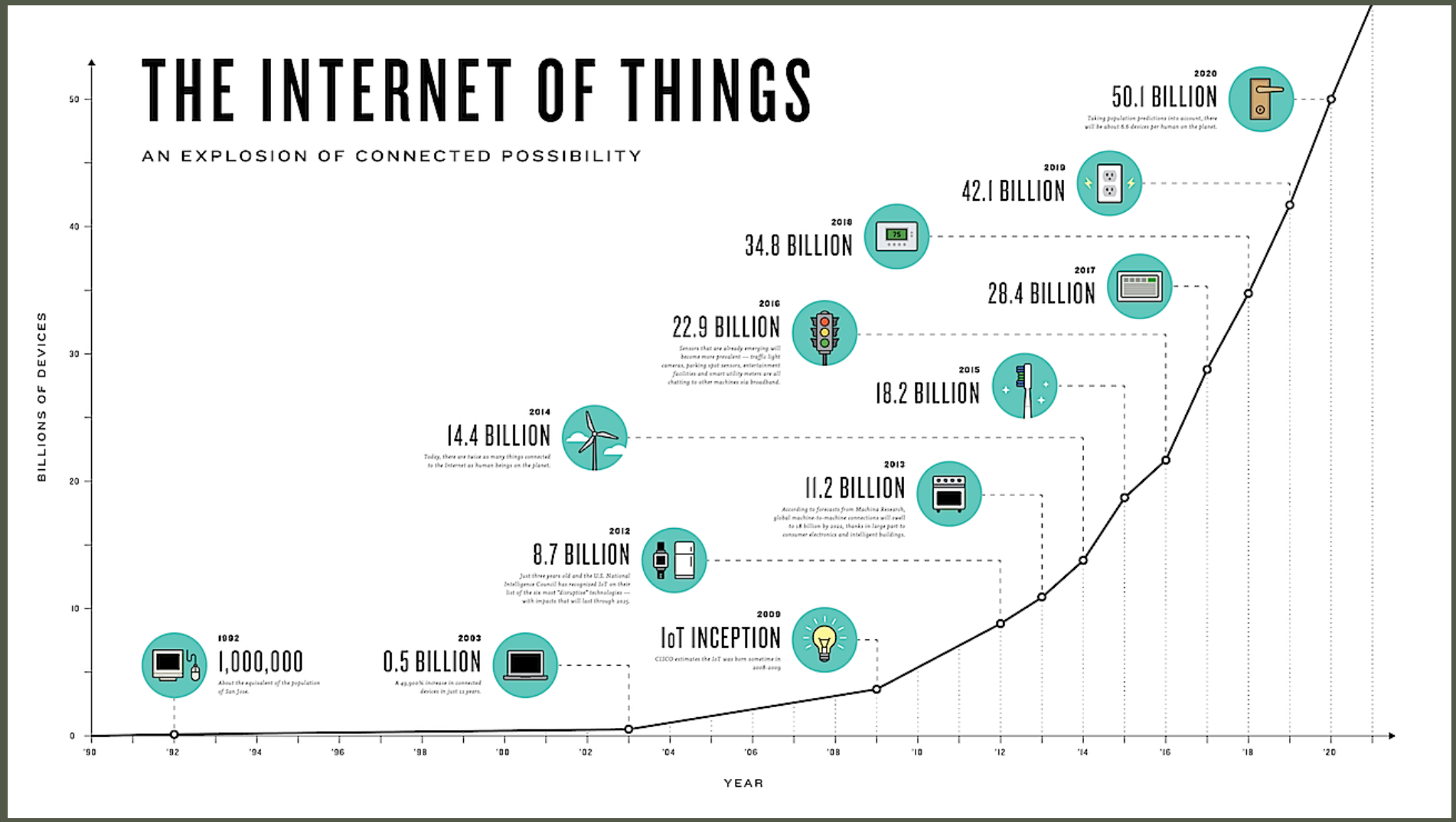

Source: The Internet of Things – infographic The Connectivist based on Cisco data


eSmart
SYSTEMS
EMPOWER
MAIN DASHBOARD
ALL ZONES
15:00 20.09.2016-19:00 20.09.2016
16480 kWh
6340 kWh
17325 kWh
ZONE MAP
14760 kWh
10760 kWh
4760 kWh
Tjeneste-
tilbyder

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Big Data

''There are a lot more people
who know how to move data around than
who know what to do with it"

The FOUR V's of Big Data

From traffic patterns and music downloads to web history and medical records, data is recorded, stored, and analyzed to enable the technology and services that the world relies on every day. But what exactly is big data, and how can these massive amounts of data be used?

As a leader in the sector, IBM data scientists break big data into four dimensions: **Volume, Velocity, Variety and Veracity**

Depending on the industry and organization, big data encompasses information from multiple internal and external sources such as transactions, social media, enterprise content, sensors and mobile devices. Companies can leverage data to adapt their products and services to better meet customer needs, optimize operations and infrastructure, and find new sources of revenue.

By 2015

4.4 MILLION IT JOBS

will be created globally to support big data, with 1.9 million in the United States

Volume

SCALE OF DATA

40 ZETTABYTES

[43 TRILLION GIGABYTES]

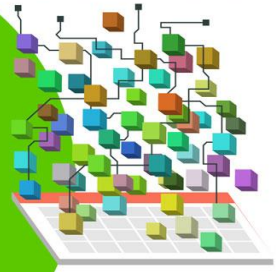
of data will be created by 2020, an increase of 300 times from 2005

It's estimated that

2.5 QUINTILLION BYTES

[2.3 TRILLION GIGABYTES]

of data are created each day



6 BILLION PEOPLE

have cell phones

WORLD POPULATION: 7 BILLION

Most companies in the U.S. have at least

100 TERABYTES

[100,000 GIGABYTES]

of data stored

Variety

DIFFERENT FORMS OF DATA

As of 2011, the global size of data in healthcare was estimated to be

150 EXABYTES

[161 BILLION GIGABYTES]

30 BILLION PIECES OF CONTENT

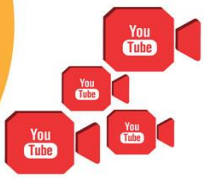
are shared on Facebook every month

By 2014, it's anticipated there will be

420 MILLION WEARABLE, WIRELESS HEALTH MONITORS

4 BILLION+ HOURS OF VIDEO

are watched on YouTube each month



400 MILLION TWEETS

are sent per day by about 200 million monthly active users

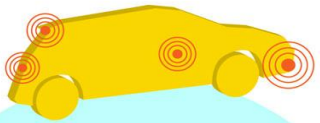
Velocity

ANALYSIS OF STREAMING DATA

The New York Stock Exchange captures

1 TB OF TRADE INFORMATION

during each trading session



Modern cars have close to

100 SENSORS

that monitor items such as fuel level and tire pressure

By 2016, it is projected there will be

18.9 BILLION NETWORK CONNECTIONS

– almost 2.5 connections per person on earth

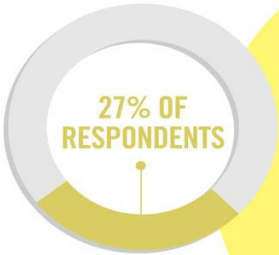
Veracity

UNCERTAINTY OF DATA

1 IN 3 BUSINESS LEADERS

don't trust the information they use to make decisions

27% OF RESPONDENTS



in one survey were unsure of how much of their data was inaccurate

Poor data quality costs the US economy around

$3.1 TRILLION A YEAR

Sources: McKinsey Global Institute, Twitter, Cisco, Gartner, EMC, SAS, IBM, MEPTEC, QAS

IBM

- Some Big Data trivia

  - More data has been created in the past 2 years than in the entire previous history of the human race

  - By the year 2020, about 1.7 MB of new information will be created every second for every human being on the planet

1.7 MB

1.7 MB/s * 7 000 000 000 = 11.9 Petabytes/sec

1 Zettabyte per day

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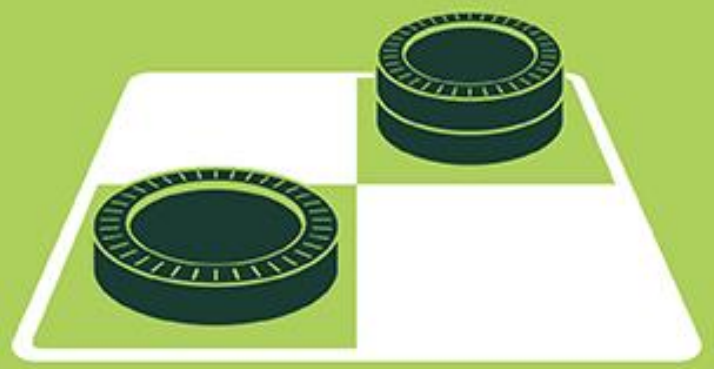
AI

ARTIFICIAL INTELLIGENCE

Early artificial intelligence stirs excitement.



MACHINE LEARNING

Machine learning begins to flourish.

DEEP LEARNING

Deep learning breakthroughs drive AI boom.

1950's 1960's 1970's 1980's 1990's 2000's 2010's

Processing power development

NVIDIA Titan X GPU
250W
26cm x 11cm x 4cm

NEC Earth Simulator

Worlds fastest supercomputer from 2002 to 2004

Used 6.4 MW of power (plus air conditioning)

Housed in a two-story building
65m x 50m x 17m

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“Machine learning – the science of building computer programs that improve through experience”

Question/purpose

Data and examples

Learning algorithm

Predictive model

... contains the answer to the questions

... answers the question on new data

Today less than 0.5% of all data is analyzed

Digital intelligence in energy management solutions

+ Consumption and production predictions
+ Segmentation of customer data
+ Optimal switching
+ Market behavior predictions
+ Risk monitoring
+ Fault detection
+ Automated image analysis
+ Predictive maintenance
+ Intelligent asset management

Condition Monitoring & Predictive Maintenance

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- Jacksonville, Florida – smart metering (AMI) of water and electricity – 300 000 customers
- 7500 truck rolls a year to check zero consumption meters - 80% are wasted
- Advanced analytics to estimate likelihood of broken water meters
- 86.5 % prediction accuracy
- Net value for JEA over three years $2.1 million

eSmart SYSTEMS

Leveraging smart meter (AMI) data to improve operations and recover lost revenues


THE ZERO CONSUMPTION
PROJECT

Local Energy Markets and Demand side flexibility

+ Powered by values

"Develop and verify a local market place and innovative business models to encourage active participation of prosumers, exploiting the flexibility created for the benefit of all connected to the local grid"

- EUR 6 million budget
- Project period 2015-2018
- Three pilot areas
  - Hvaler, Norway
  - Wolpertshausen, Germany
  - Malta
- Platform provider and technology development partner in the project is eSmart Systems

EMPOWER ©

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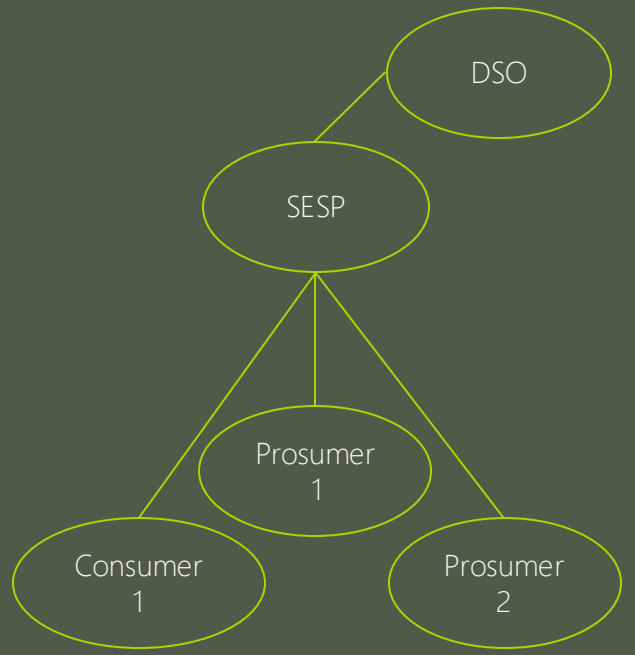
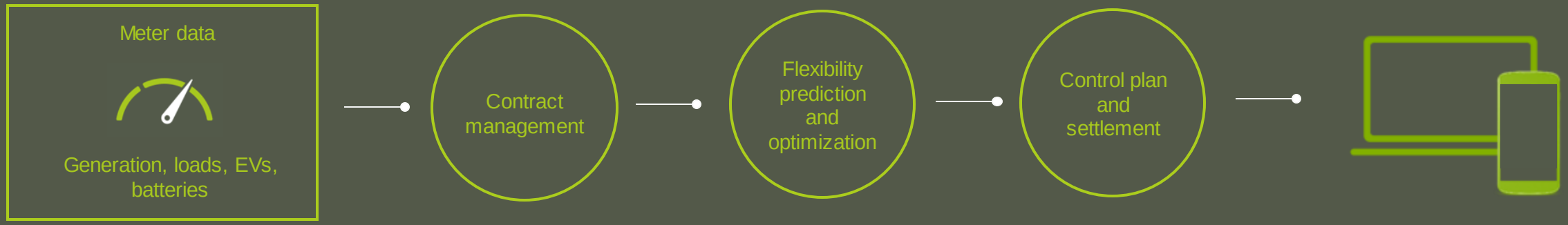
The Energy Flexibility Concept in EMPOWER

- SESP = smart energy service provider (aggregator)
- The SESP and DSO enter contract for flexibility services
- The SESP enters flexibility contracts with flexible consumers and prosumers
  - Up: Increased generation, decreased load, storage discharging
  - Down: Decreased generation, increased load, storage charging



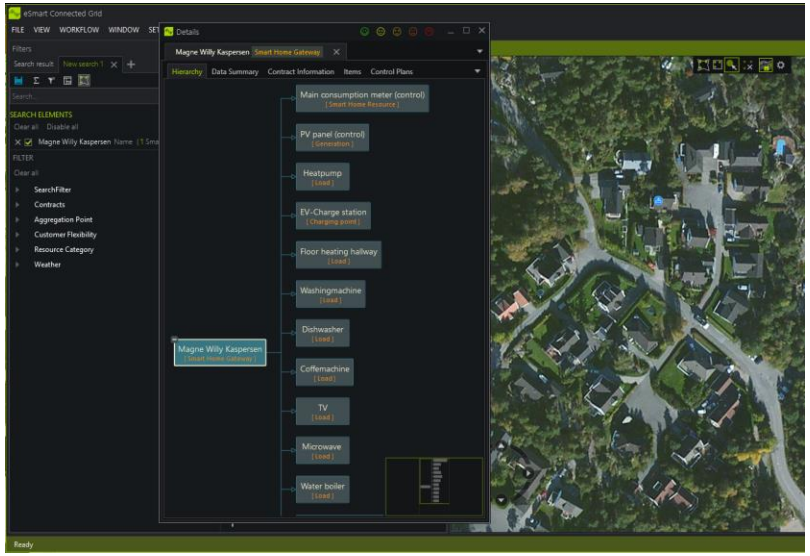


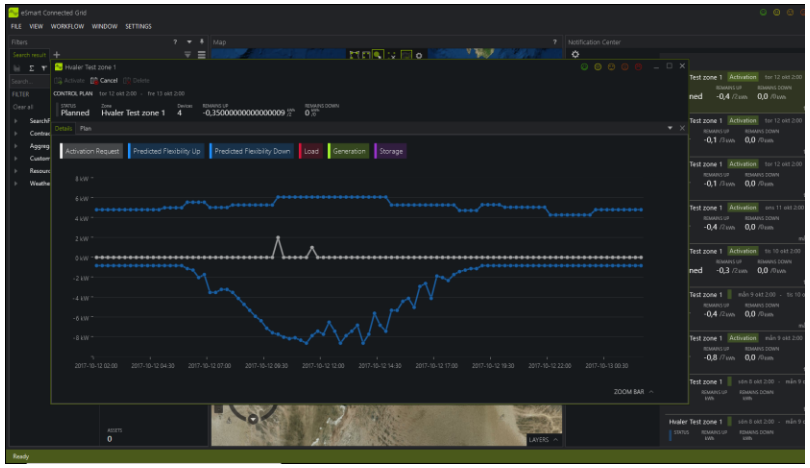
Connected Prosumer –energy flexibility control and trade

The concept is developed with the partner consortium in H2020 project EMPOWER, and is built on the Connected Platform. Target is to exploit local flexibility to solve local problems for the DSO.

AGGREGATOR/SERVICE PROVIDER'S CLIENT

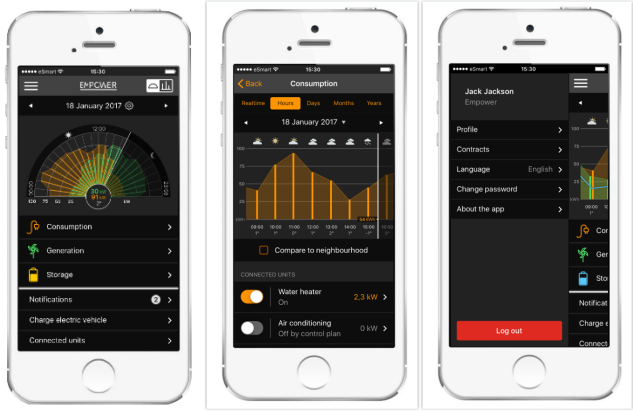
- Aggregator and DSO enter contract for flexibility services
- Aggregator enters flexibility contracts with
  flexible consumers and prosumers
- Screenshot A illustrating the appliances connected to the grid by one of the pilot customers at Hvaler, in Norway.
- Screenshot B illustrating a request for flexibility from the DSO, represented by the white, dotted line.
- The blue dotted lines represent the available flexibility aggregated by the prosumer contracts that the SESP has in the affected area





PROSUMER'S ENERGY CONTROL CENTER

- Real-time visualization of energy production and consumption
- Participation in market trade with energy and flexibility
- Monetary overview of purchase and sold energy and flexibility
- Overview of additional services with service provider



Prosumer App

PROSUMER'S ENERGY CONTROL CENTER

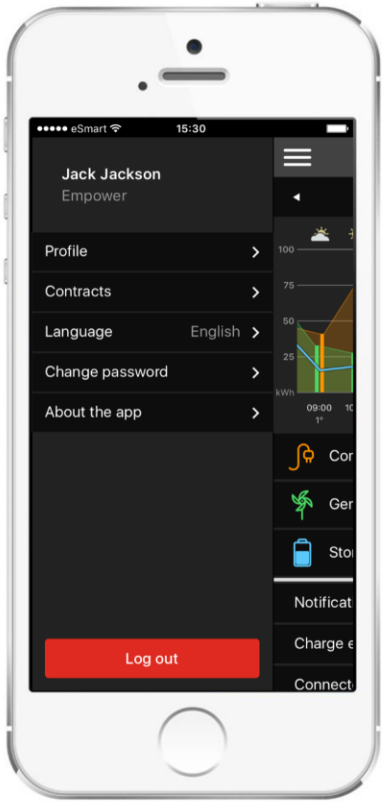
+Visualization of energy resources, both single devices and summarized, historical values and predicted

+The opportunity to decline participation in a control plan

+Contract information on

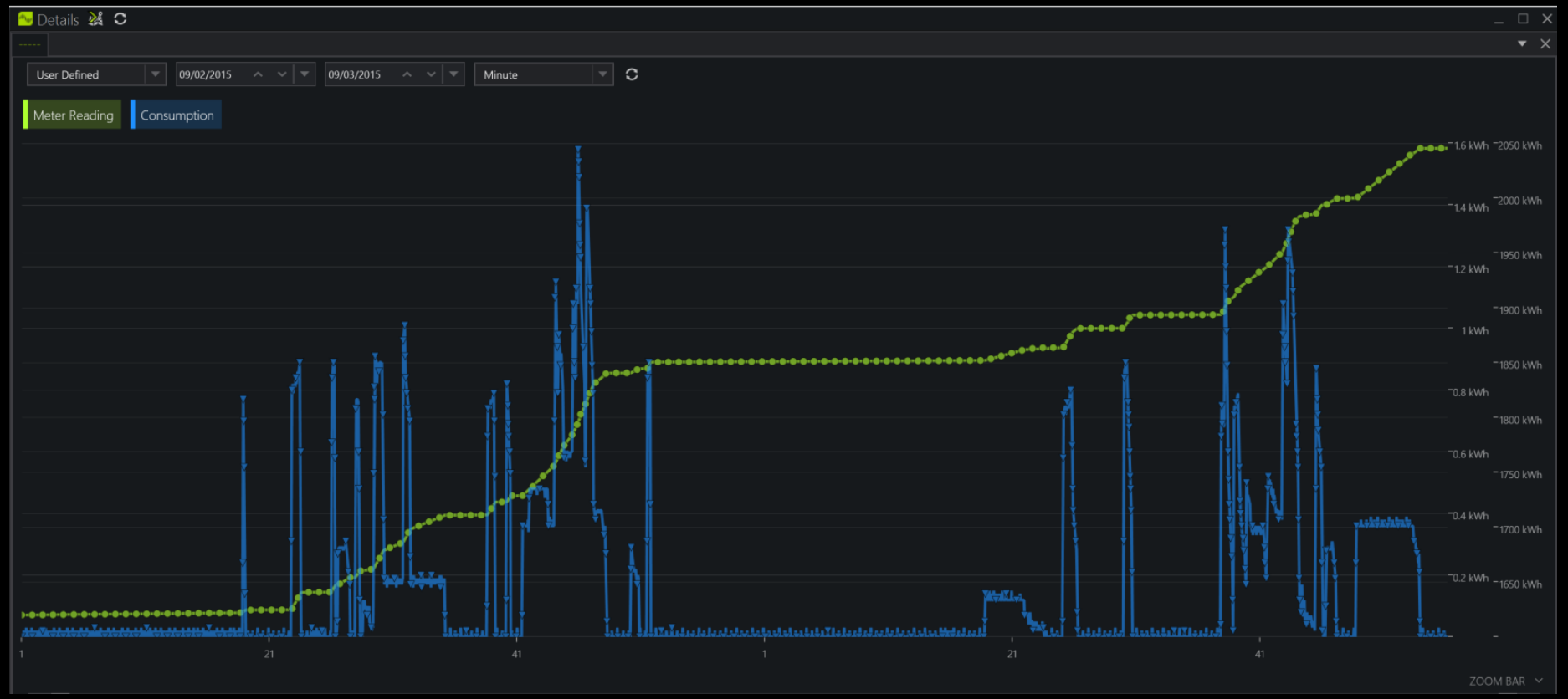
- +Energy contracts
- +Flexibility contracts
- +Service contracts

+Monetary balance overview. Net value from participation of control plans, economic values, and overview of purchased and sold energy



EV Charging

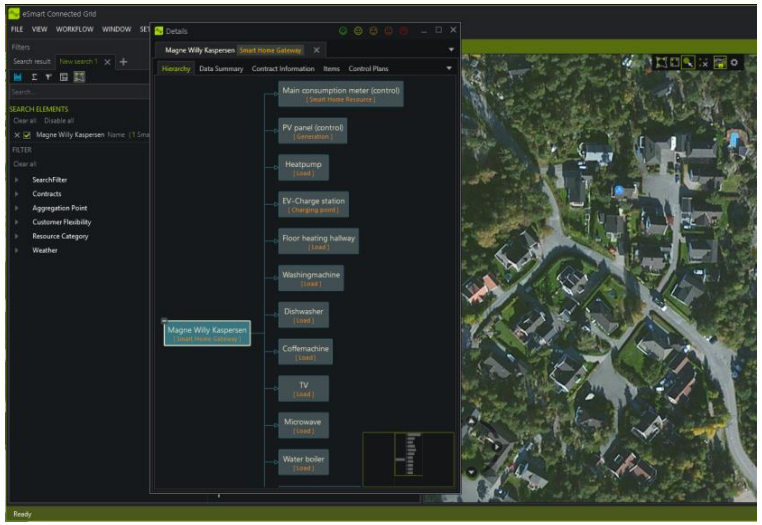
EV Charging Station Load Forecasting

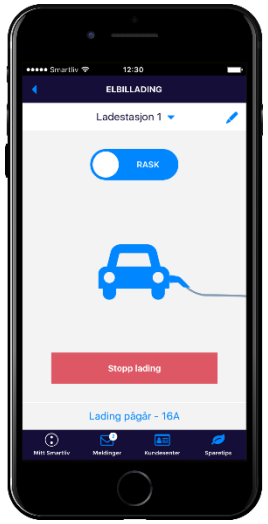


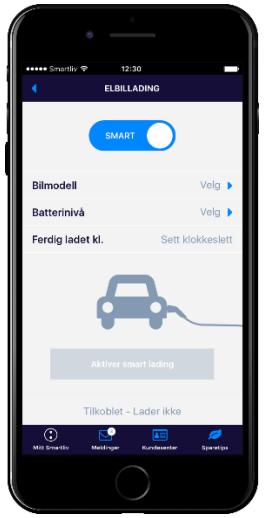
- One minute resolution reading from EV charging station with 16 outlets
- High day-to-day variability
- Predicting actual profile is challenging
- Focus on predicting near term peaks

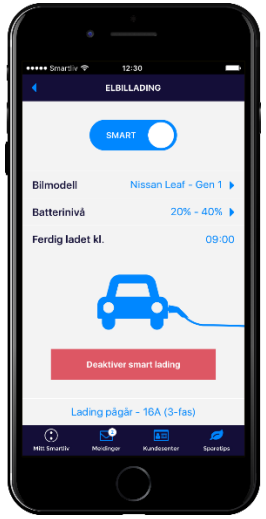
Charging infrastructure asset management, control and optimization

EV charging station monitoring and asset management – optimization of capacity utilization, avoided capacity investments, and intelligent management based on predictions and artificial intelligence







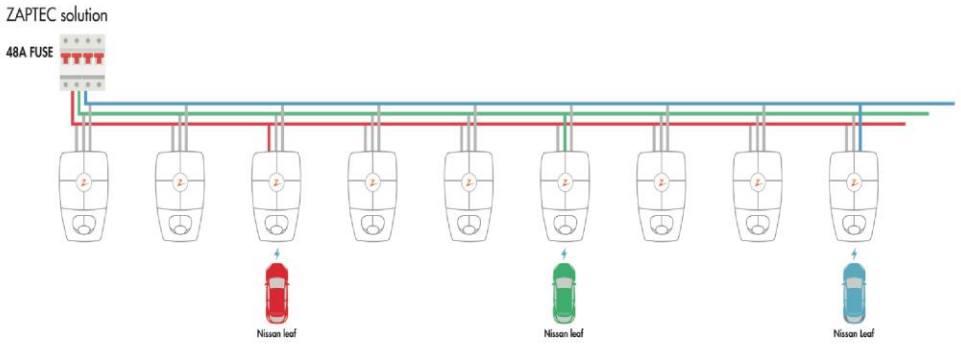


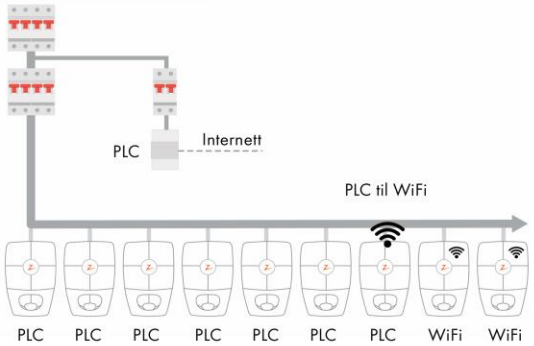
PARTNERS

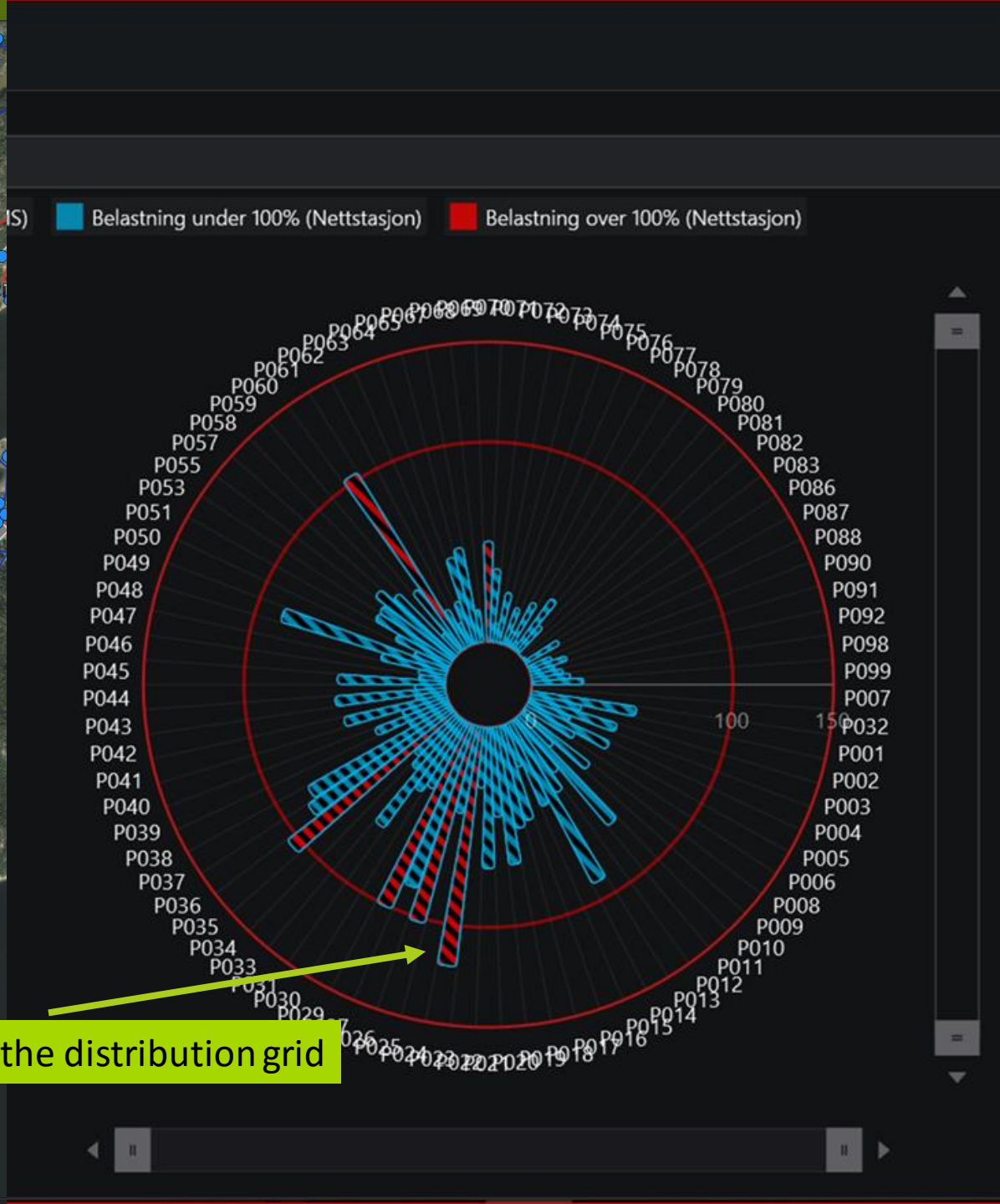
+ eSmart solutions for monitoring and management are vendor-independent
+ Integrations are put in place for all relevant hardware suppliers
+ Zaptec and Schneider are both existing partners on EV charging solution deliveries

FUNCTIONALITY

+ Asset management
+ Phase and load balancing
+ Work flow and error management
+ Flexibility control and optimization based on building, plan or grid input
+ Integrated booking, payment and energy system functionality







Congestions in the distribution grid

Statnett and eSmart Cooperation – Demand Response

Large scale demand response in Northern Norway

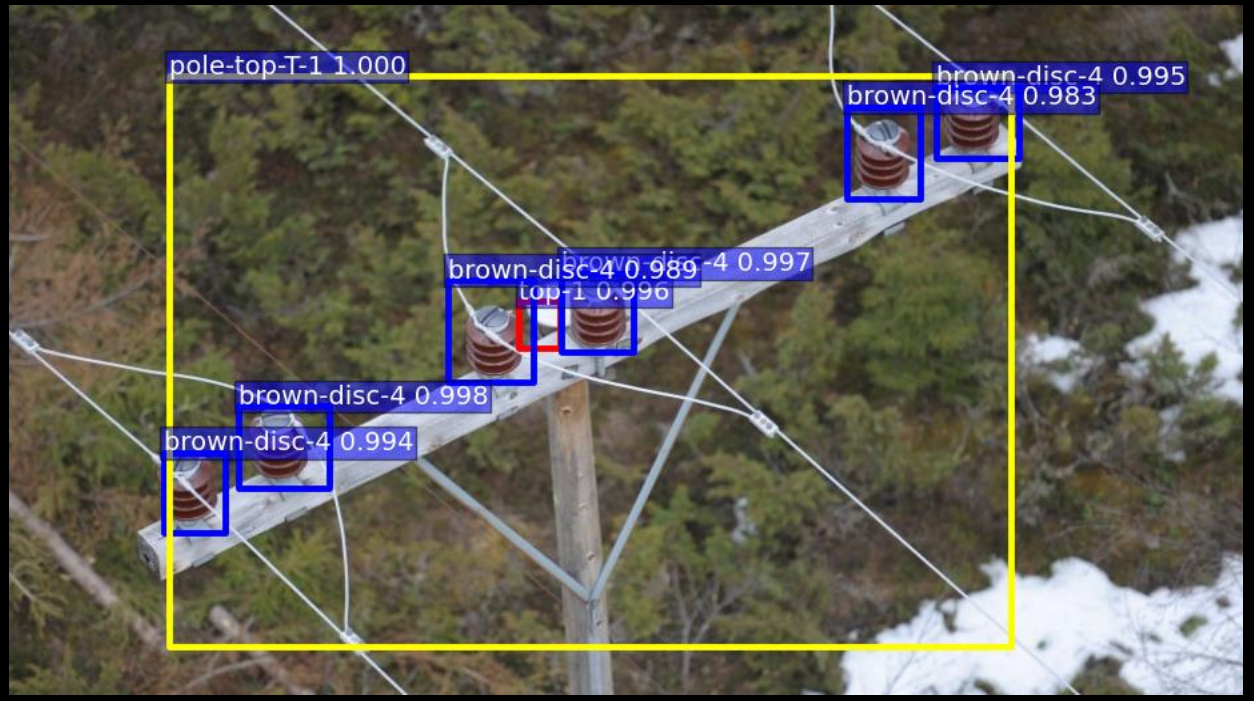
+ Powered by values

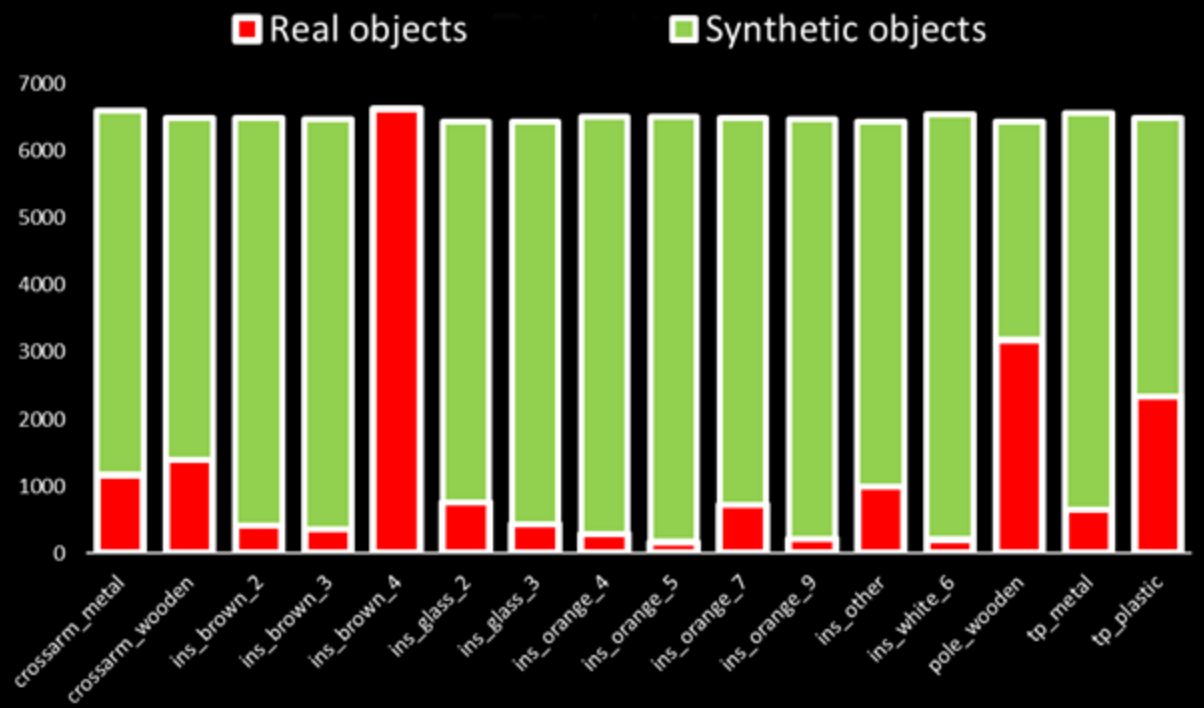
The Intelligent Assistant

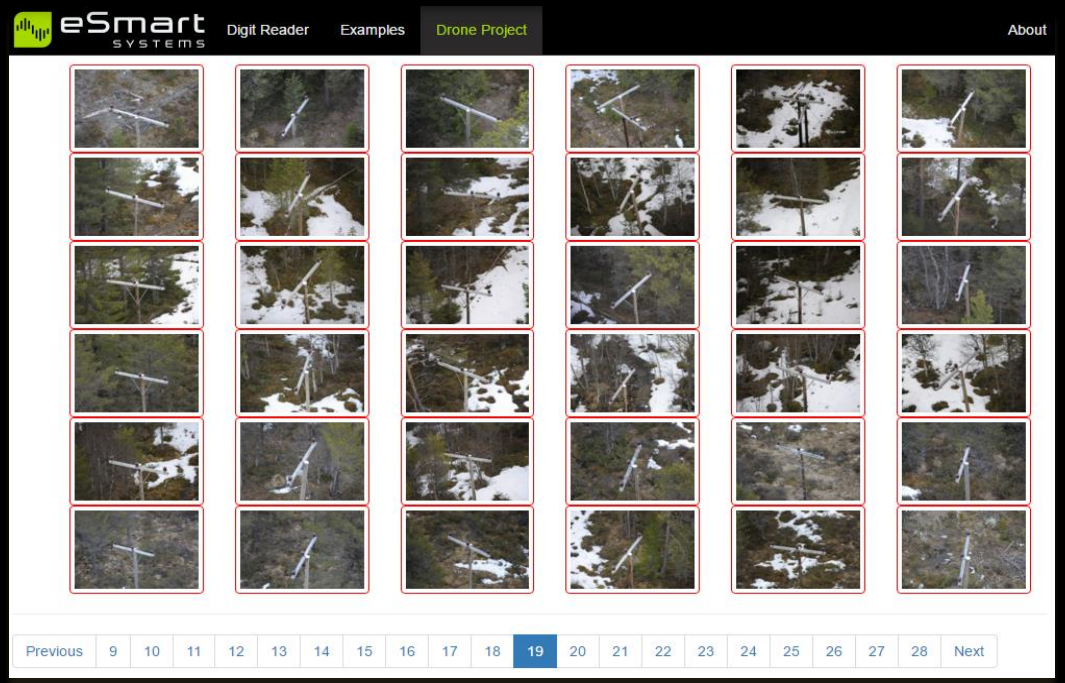

disc-2 0.780
disc-2 0.995
top-1 0.991
disc-2 0.426
brown-disc-4 0.709
brown-disc-4 0.760
disc-2 0.992
top-1 0.943
disc-2 0.984
disc-2 0.992


tp: 0.7
tp: 0.64
insb4_other: 0.66
insb4_other: 0.56
pole: 0.51
pole: 0.57


insb4_other: 0.72
insb4_other: 0.8
cr: 0.95
pole_woodpecker: 0.95
mast: 0.99


pole-top-T-1 1.000
brown-disc-4 0.995
brown-disc-4 0.983
brown-disc-4 0.997
brown-disc-4 0.989
top-1 0.996
brown-disc-4 0.998
brown-disc-4 0.994


Real objects
Synthetic objects
7000
6000
5000
4000
3000
2000
1000
0
crossarm_metal
crossarm_wooden
ins_brown_2
ins_brown_3
ins_brown_4
ins_glass_2
ins_glass_3
ins_orange_4
ins_orange_5
ins_orange_7
ins_orange_9
ins_other
ins_white_6
pole_wooden
tp_metal
tp_plastic


eSmart SYSTEMS
Digit Reader
Examples
Drone Project
About
Previous
9
10
11
12
13
14
15
16
17
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19
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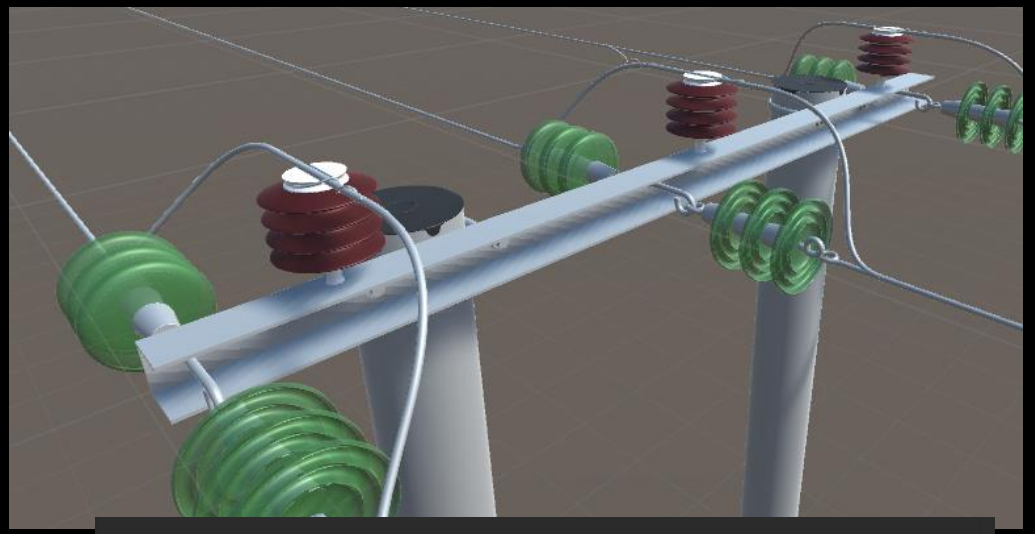
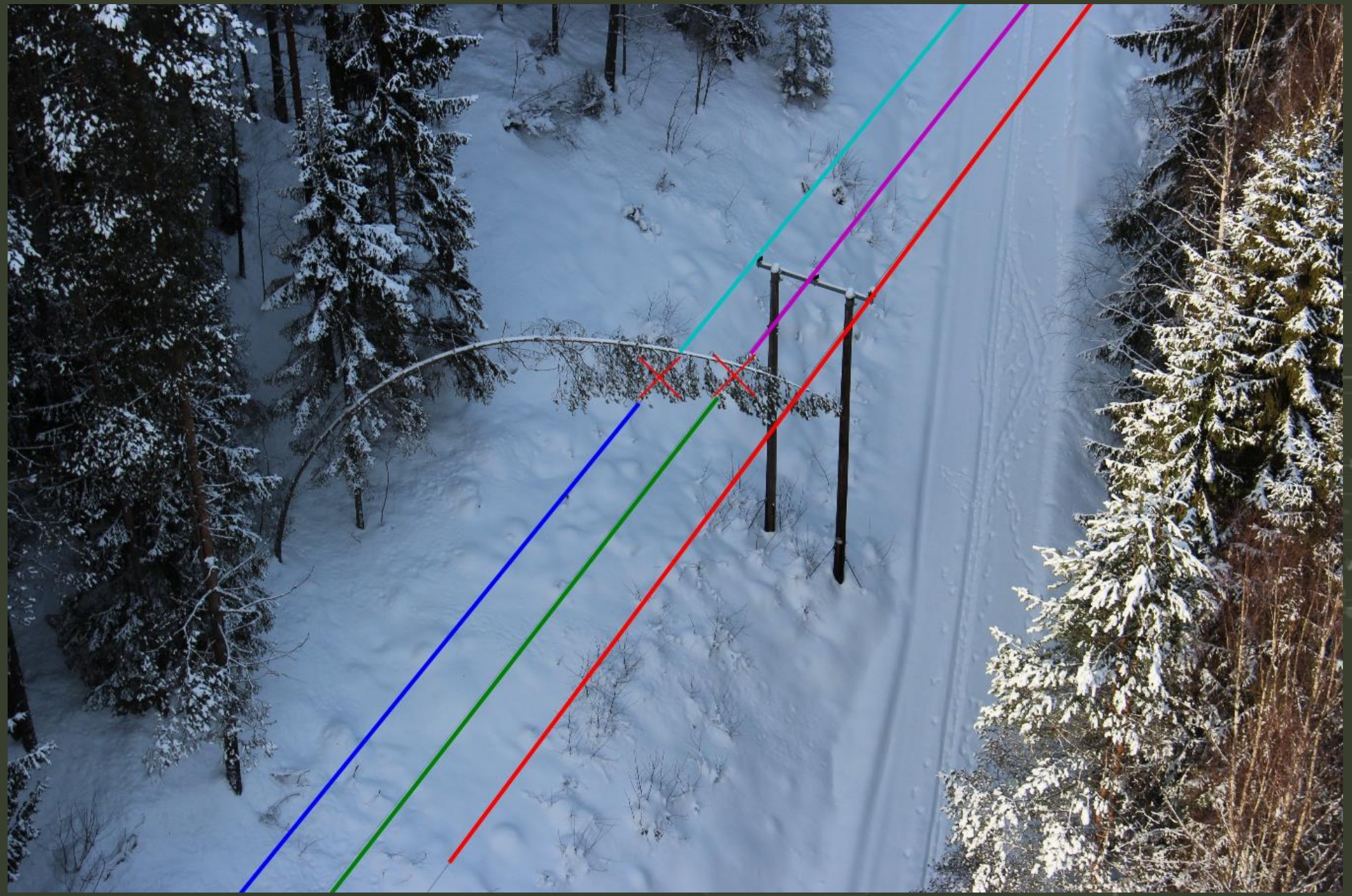
21
22
23
24
25
26
27
28
Next




+ Powered by values



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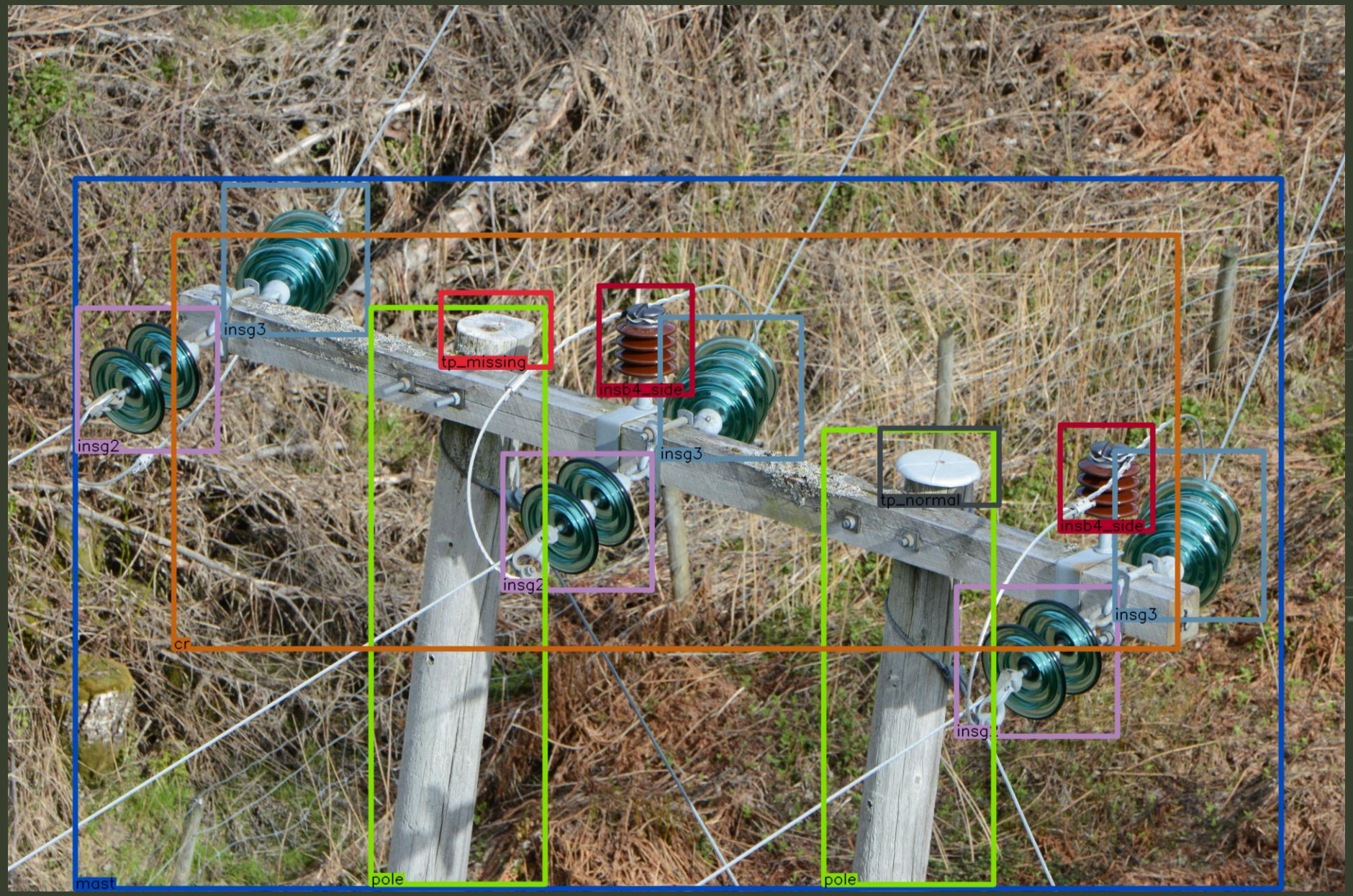


+ Powered by values


insb4_top: 0.68
insb4_top: 0.56
tp_normal: 0.63
tp_missing: 0.55
insb4_top: 0.82
cr: 0.99
mast: 1.0
pole: 0.96

+ Powered by values

ThunderCloud Drone System

THUNDERCLOUD

THE INTELLIGENT MOBILE OPERATION CENTER

eSmart Systems proudly presents Thundercloud. Thundercloud contains the best tools for analysis, visualization and communication.

Thundercloud optimize cloud computing by using edge computing. This enables Deep Learning for the drone, while operating in the air.

Thundercloud consists of six components; Connected Grid, Connected Drone, Broadband Radio Communication, Sensor Package, UAVs and the Mobile Operational Center.

MONITORING AND COMMUNICATION

Connected Grid is the main client operating on top of a big data lake. The client grants access to real time monitoring of all components and objects in the grid, and includes an AI-platform that predicts future outcomes based on numerous inputs.

Thundercloud also includes world class technology that ensures stabile communication under all circumstances.

CONNECTED DRONE

THE INTELLIGENT ASSISTANT

By using Deep Learning, The Intelligent Assistant is capable of identifying components and detecting faults and potential problems.

New intelligent features are defined together with our customers, developed by the Analytics team and deployed to the Thundercloud system seamlessly.

Running on eSmart Systems Connected Platform and Microsoft Azure, The Intelligent Assistant can analyze 180,000 images in less than one hour.

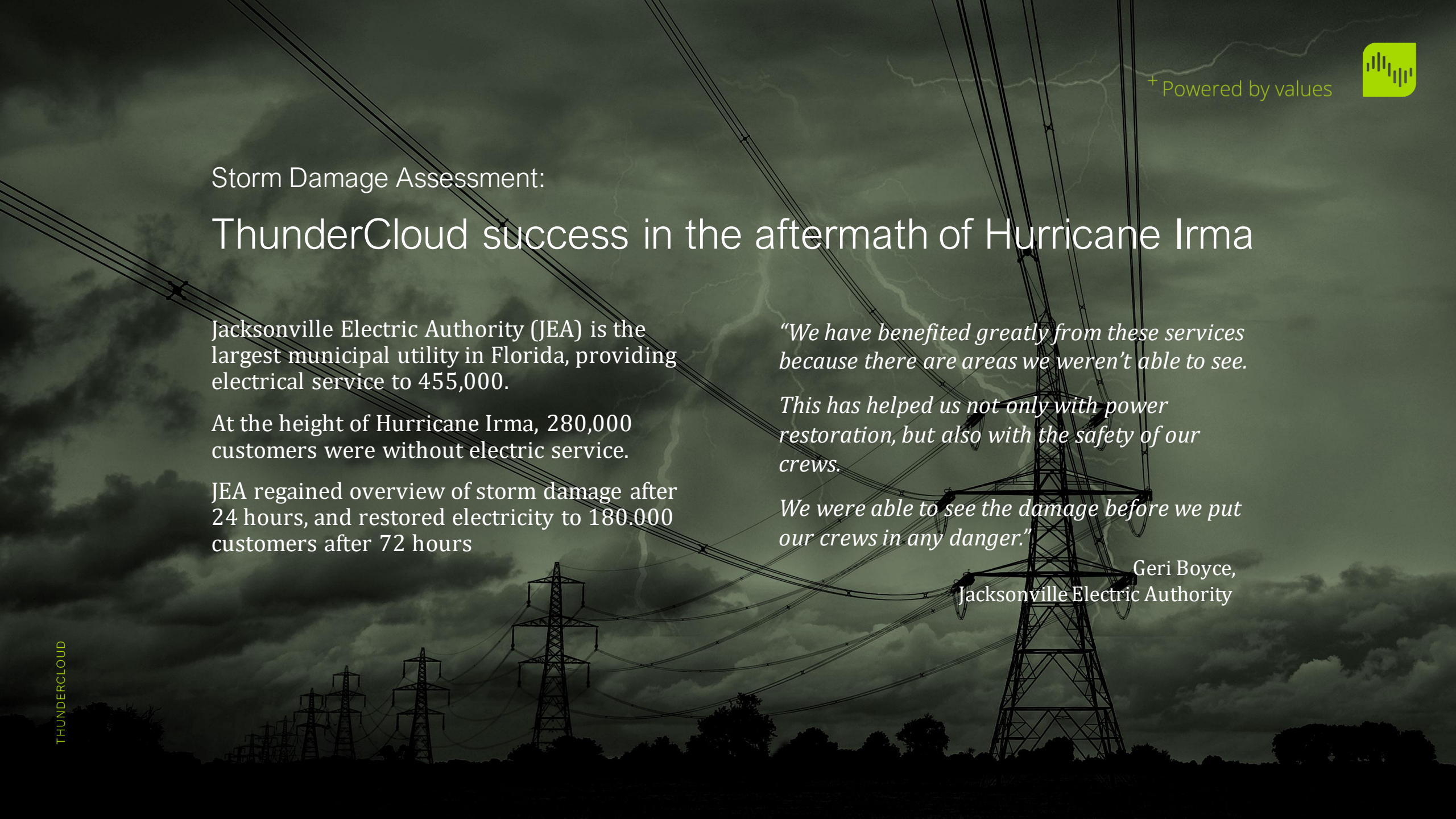
INTUITIVE CLIENT INTERFACE

The results from the analysis is presented through an intuitive and user-friendly client interface, giving the users a fast and efficient tool to view the status of their infrastructure as well as exporting reports as a basis for their maintenance tasks.

Tens of thousand of findings are presented in the matter of seconds, and all data is geotagged and accessible through the interactive map.

QUALITY THROUGH PARTNERSHIP

The Connected Drone's product portfolio is being developed in close collaboration with a number of utilities and our close partners, ensuring world class quality and maximum customer value.



+ Powered by values

Storm Damage Assessment:

ThunderCloud success in the aftermath of Hurricane Irma

Jacksonville Electric Authority (JEA) is the largest municipal utility in Florida, providing electrical service to 455,000.

At the height of Hurricane Irma, 280,000 customers were without electric service.

JEA regained overview of storm damage after 24 hours, and restored electricity to 180.000 customers after 72 hours

"We have benefited greatly from these services because there are areas we weren't able to see.

This has helped us not only with power restoration, but also with the safety of our crews.

We were able to see the damage before we put our crews in any danger."

Geri Boyce,
Jacksonville Electric Authority

THUNDERCLOUD

eSmart Systems engaged in Storm Damage Assessment

- The Energy Authority engaged eSmart Systems in storm damage assessment for their customer JEA
- eSmart Systems and Sky Skopes teamed up with three pilot teams, eSmart ThunderCloud Mobile Operation Center , drones with sensors and an analytics team in Norway
- Live video and data was streamed to JEA Emergency Operations Center
- Data was loaded into eSmart Connected Drone applications for analysis
- Smart Meter data was also imported into the Connected Grid applications for outage overview

ThunderCloud

“This is helping us immensely, we were able to get all of our damage assessments done within 24 hours after the storm left and it was safe to do so.”

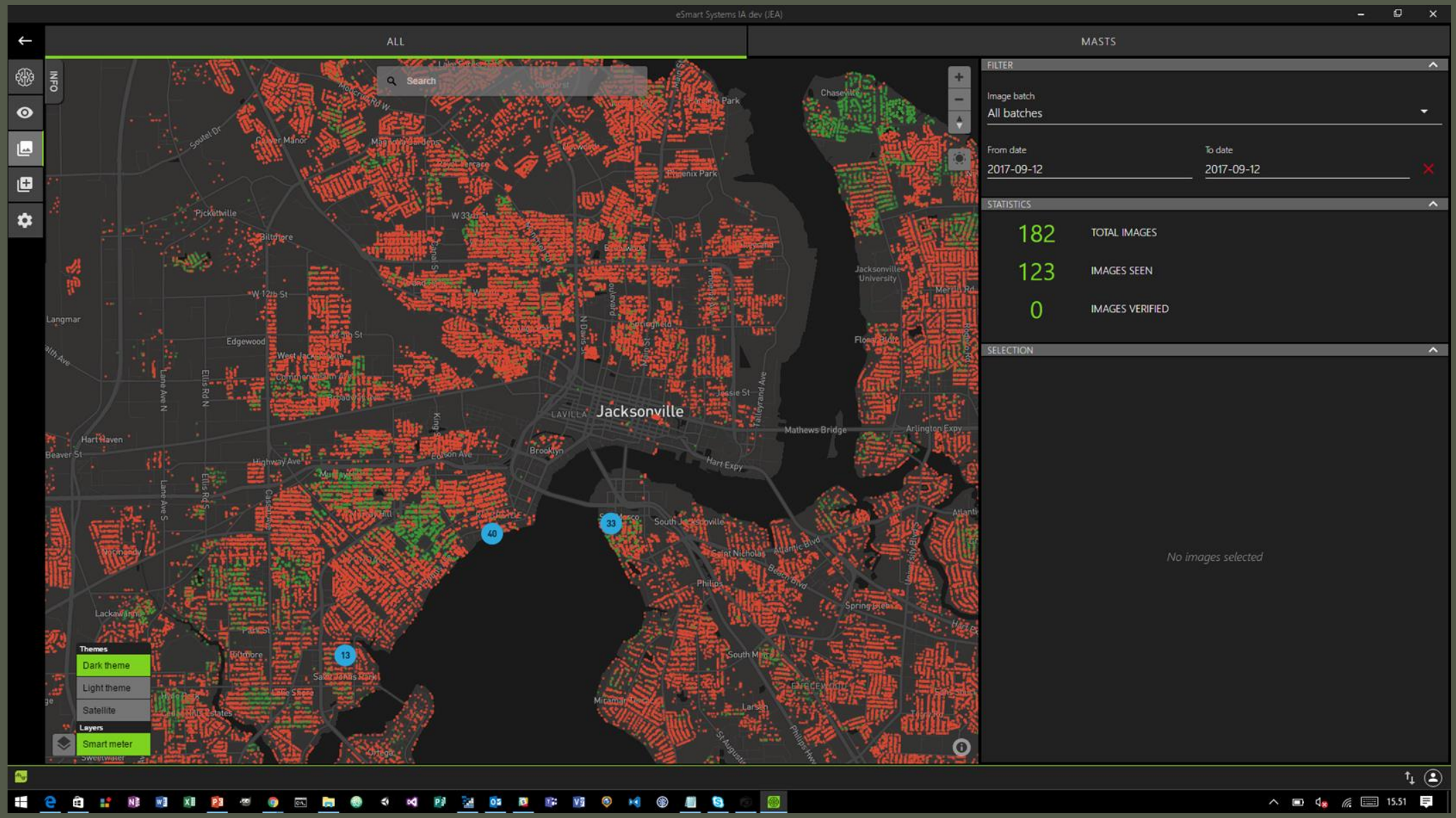
Geri Boyce, Jacksonville Electric Authority

"Because JEA has 745 miles of transmission lines and more than 6,700 miles of distribution lines, the ability to deploy the eSmart mobile operations center and the SkySkopes drones has made an impact."

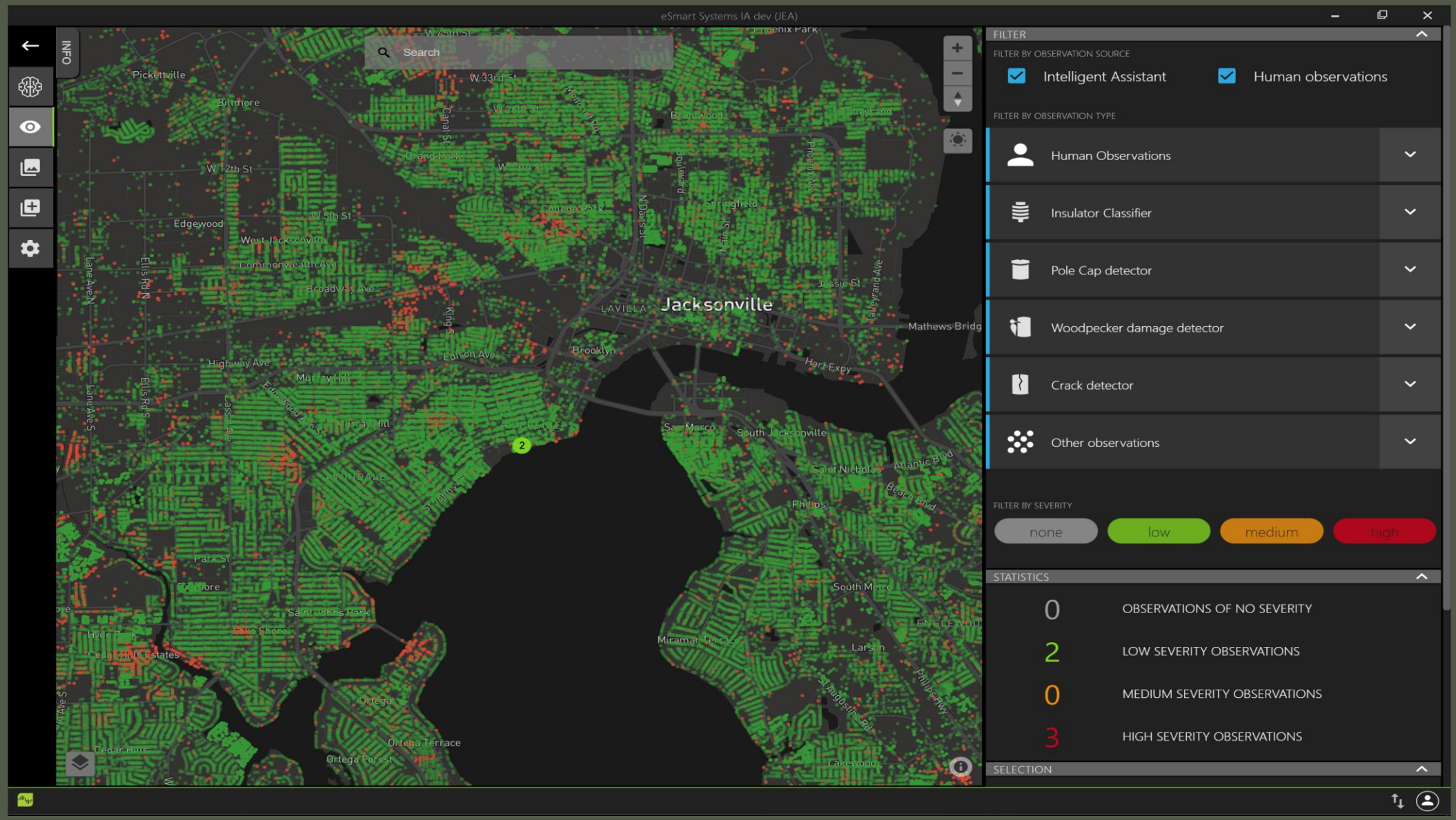
Geri Boyce, Jacksonville Electric Authority

HURRICANE IRMA MONSTER STORM

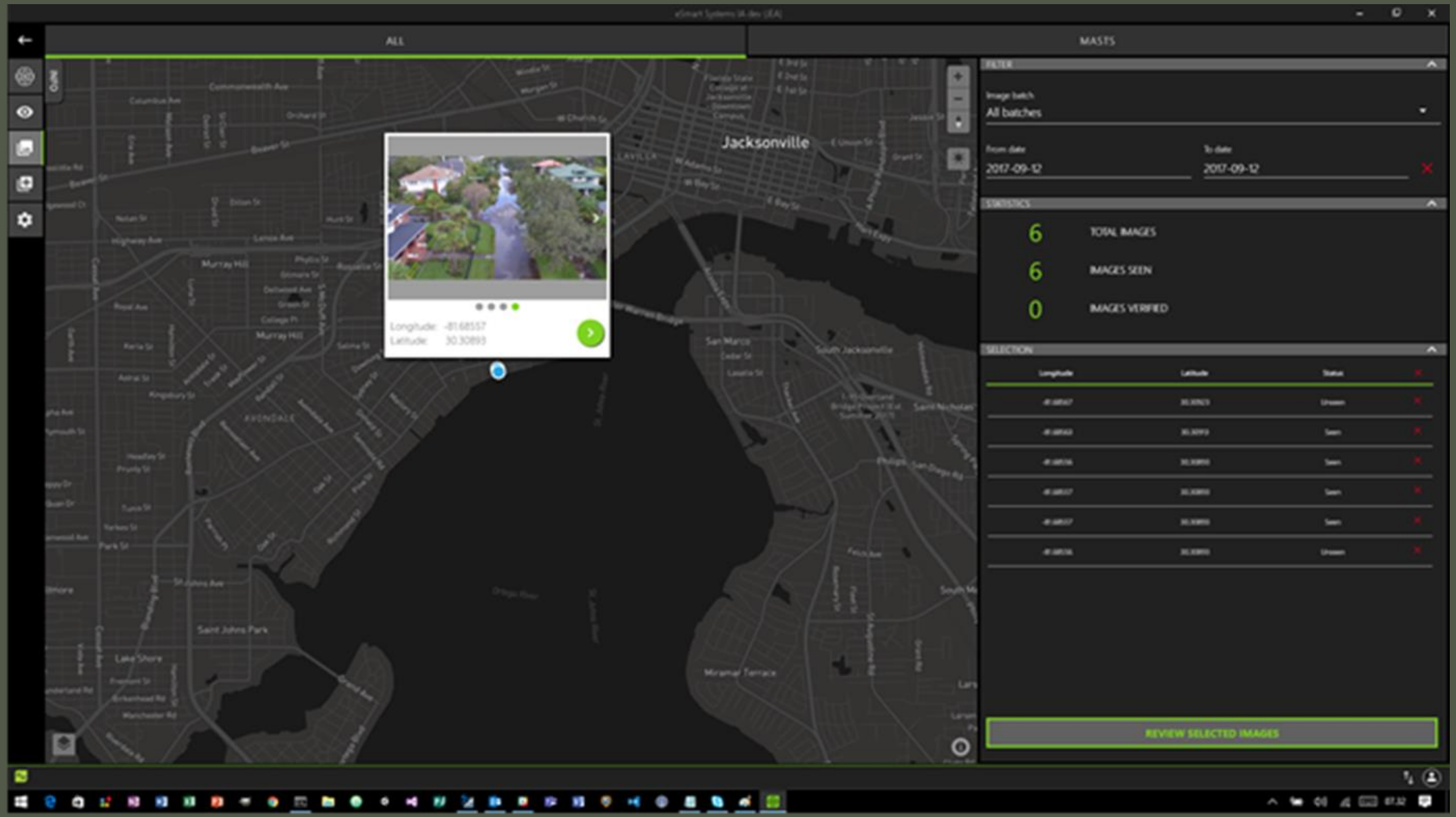
Connected Drone - Grid Outage Dashboard

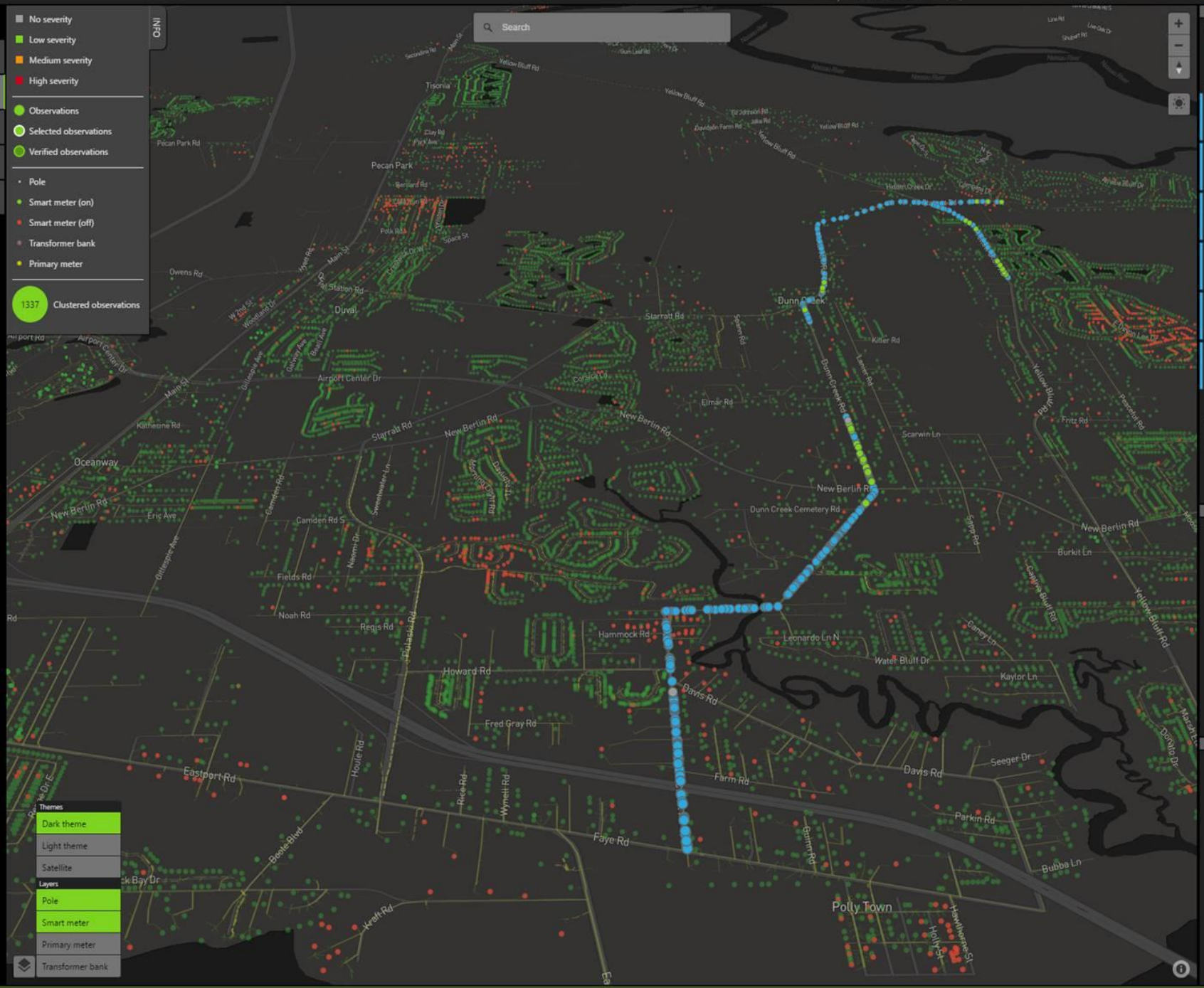


Connected Drone - Grid Outage Dashboard



Connected Drone Intelligent Assistant Dashboard





FILTER

FILTER BY OBSERVATION SOURCE

- [x] Intelligent Assistant
- [x] Manual observations

FILTER BY OBSERVATION TYPE

- Insulator Classifier
- Pole Cap Detector
- Woodpecker Damage Detector
- Crack Detector
- Other Observations
- Components

FILTER BY SEVERITY

none | low | medium | high

STATISTICS

2	OBSERVATIONS OF NO SEVERITY
97	LOW SEVERITY OBSERVATIONS
0	MEDIUM SEVERITY OBSERVATIONS
3	HIGH SEVERITY OBSERVATIONS
3622	IDENTIFIED COMPONENTS

SELECTION

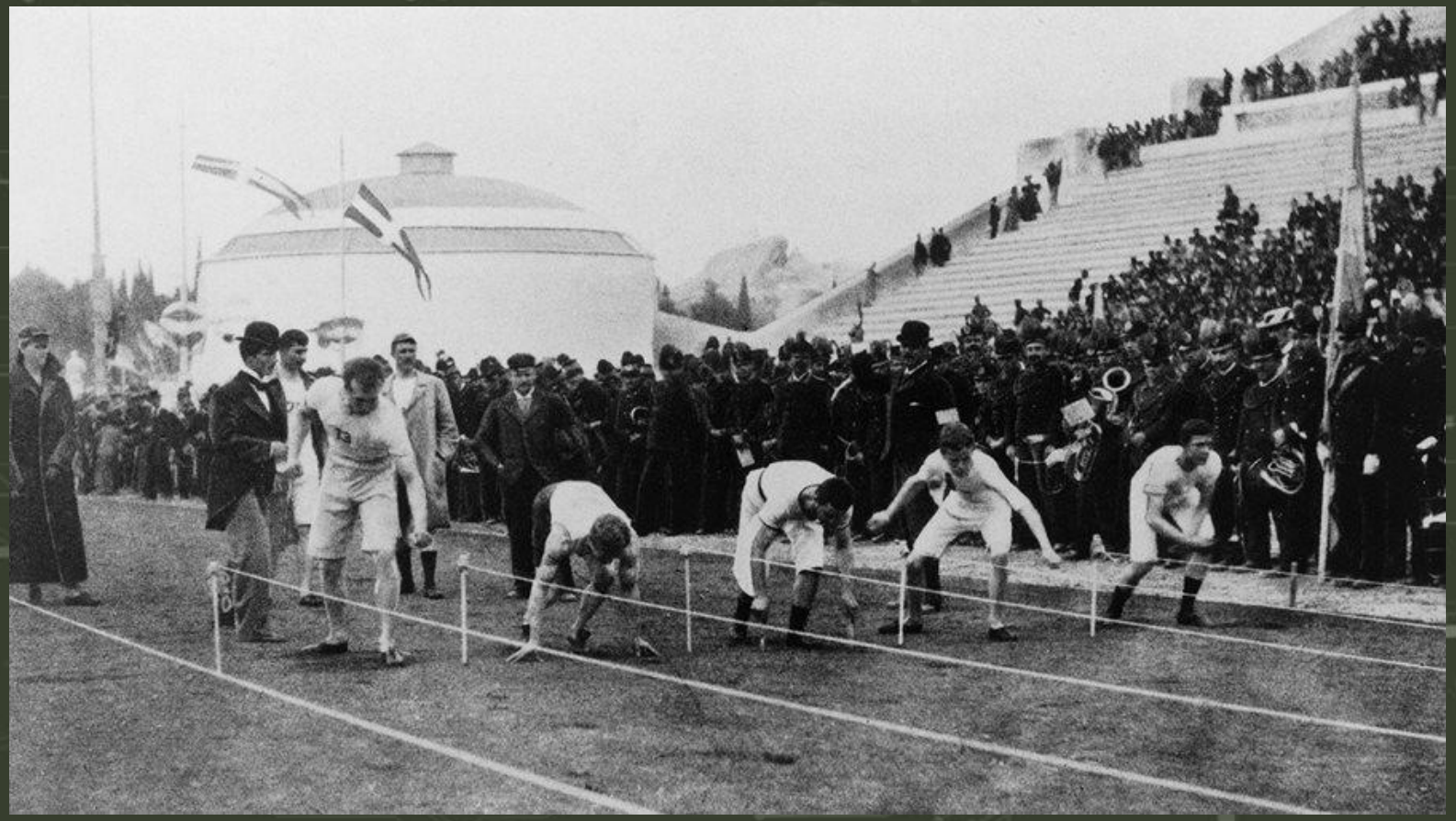
No observations selected

Connected Drone Intelligent Assistant Dashboard

- Safety
  - Better overview of damage and full documentation
  - Field crew has better overview of operation
  - Crew can bring the right tools
- Faster recovery
  - Monday Sep.11 280.000 customers without electricity
  - Within 24 hours JEA has full overview of damages with very good help from three drone crews and the Thundercloud truck
  - Within 72 hours JEA has recovered electricity for 180.000 customers with help from video streams, infra red cameras and analytics data
- Learnings
  - All data from drone operation, mobile uploads, Smart Meters, and operator input is stored in eSmart Connected Drone system
  - Analytics can be run real time on all relevant data

How to start?

+ Powered by values



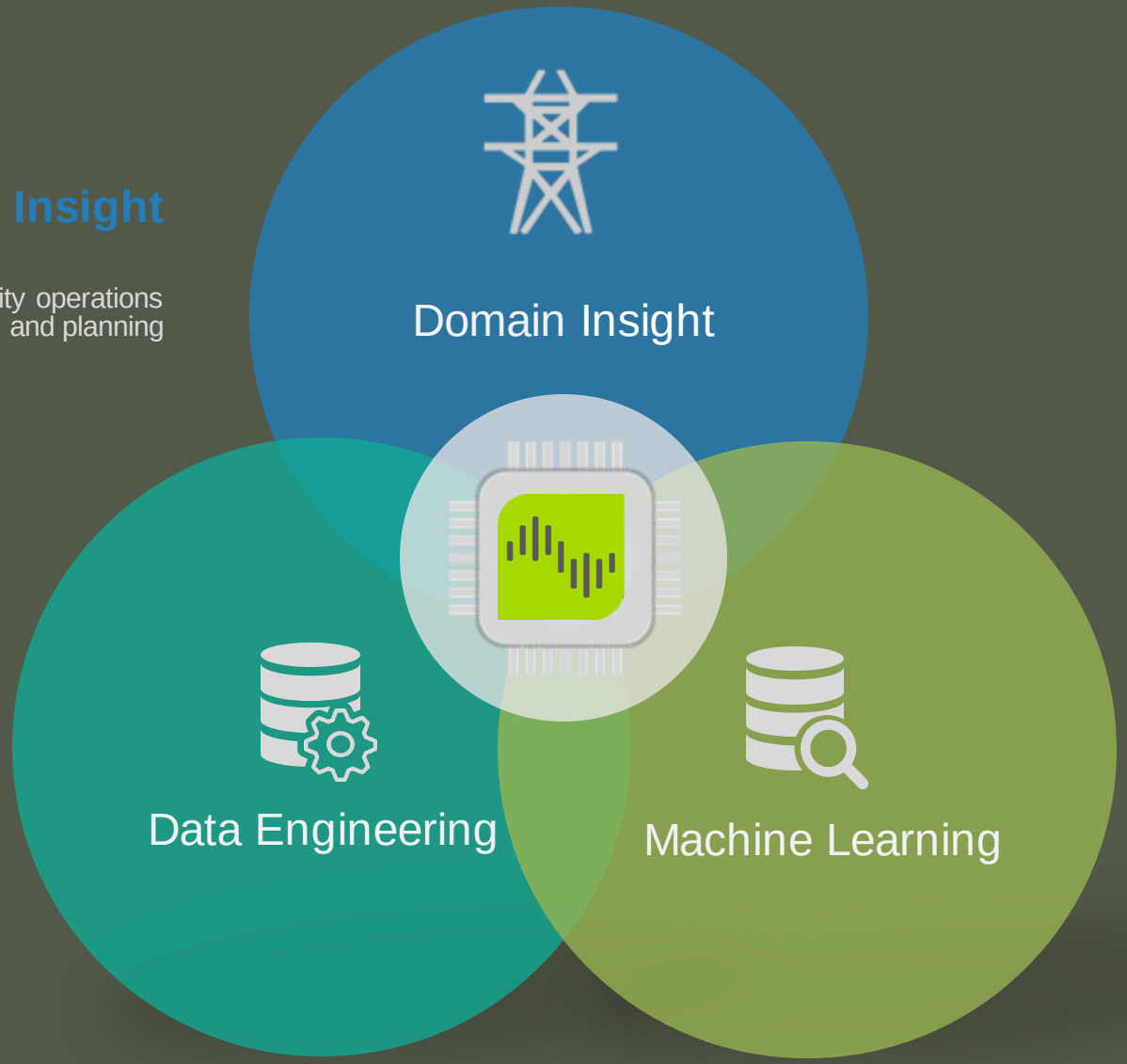
The variety of stances among runners in the 100-meter sprint at the first modern Olympic Games, held in Athens in 1896, is surprising to the modern viewer. Thomas Burke (second from left) is the only runner in the crouched stance—considered best practice today—an advantage that helped him win one of his two gold medals at the Games.

Digital Intelligence

+ Powered by values

Domain Insight

Deep insight in utility operations and planning



Data Engineering

IoT, Storage, Graph, Security, Microservices, CICD

Machine Learning

Deep learning, detection, prediction, segmentation, recommendation