Mission Critical Communication
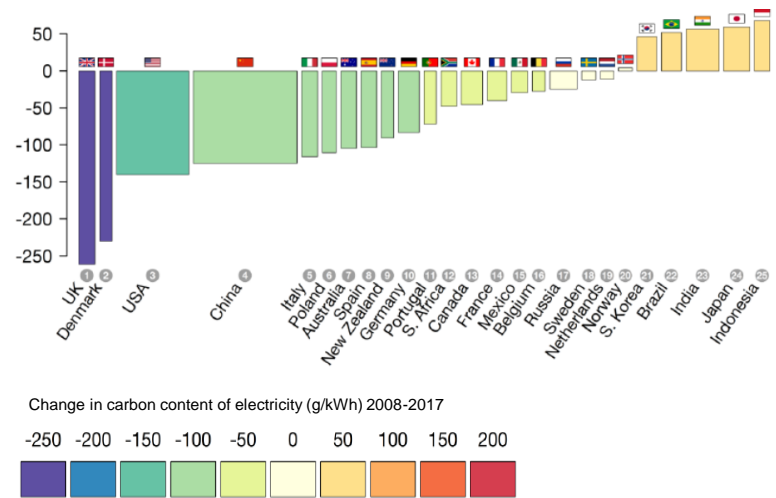
Load Balancing & Power Quality Business Case

Bo Nilsson, Business Development Director

Utility example: Digitalization is a key enabler of achieving decarbonization and decentralization goals

Decarbonization



Change in carbon content of electricity (g/kWh) 2008-2017

Achieving decarbonization goals requires additional investments in:
- Utility-scale renewables (wind, solar)
- Transmission and energy storage capacity
- Electrification of transportation and buildings

Decentralization

Denmark, 1990   **Denmark, 2014**

- Central power stations
- Local CHP plants
- Wind turbines
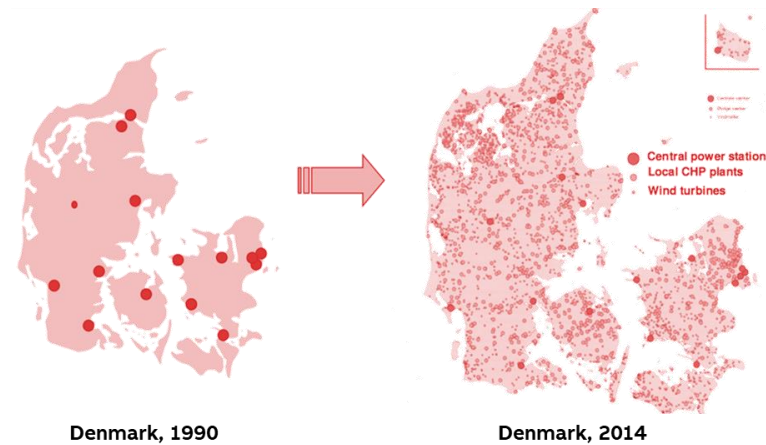
Continued decentralization will require:
- Tighter integration of transmission, distribution and the DERs (rooftop PV, EVs)
- Digital assets at the grid edge
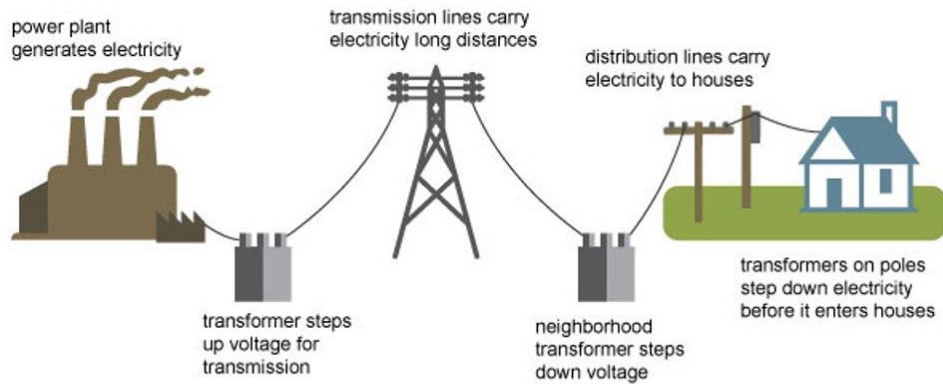- Development of transactive energy markets

Digitalization
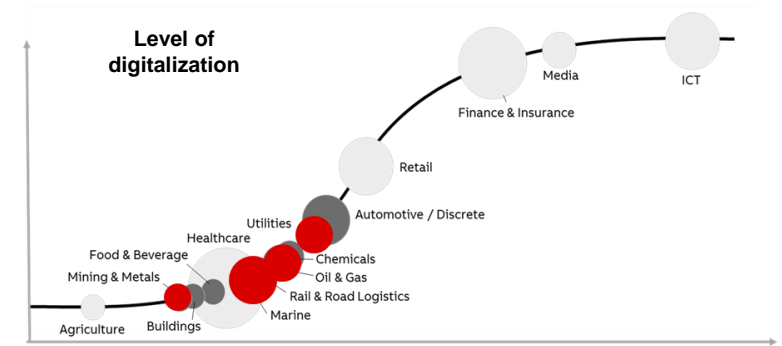
Digitalization enables decarbonization and decentralization by:
- Utilizing data and analytics to enable the operation of transmission grids with high penetrations of renewable energy
- Enabling higher hosting capacity for DERs on distribution networks while supporting the development of transactive energy markets

Hitachi Energy
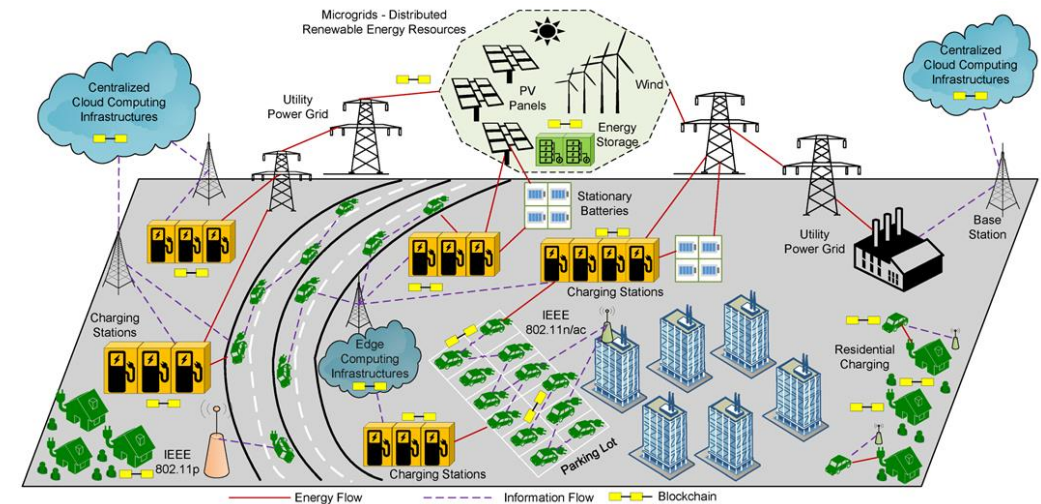
Electric Grids are in a Massive Transition

- Centralized Highly Predictable / Controllable generation

- Forecasted generation on a second-by-second basis

- Forecasted load with 98%+ accuracy

- Decentralized / Variable generation

- Sudden new appearance of generation

- Sudden decrease in load

- Mobile load increases demand uncertainty

Electricity generation, transmission, and distribution

power plant generates electricity

transmission lines carry electricity long distances

distribution lines carry electricity to houses

transformer steps up voltage for transmission

neighborhood transformer steps down voltage

transformers on poles step down electricity before it enters houses

Source: Adapted from National Energy Education Development Project (public domain)

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Why Wireless Communication?

- The electric distribution grid increasing in complexity at an accelerating rate
  - New energy assets are added to the grid by actors inside and outside of the utility
    - Roof top solar
    - Electric vehicles
  - Demand (Load) is now mobile
    - "Houses and apartments" driving around the city
    - Grid load balancing is more complex and expensive

- The individual consumer impacts grid operations more than at any time in the past
- Increasing complexity has impacted operational and performance demands on distribution utilities
- The only path forward for the distribution grid is to exponentially increase the operators' visibility

- Communication technology provides critical visibility
  - Wireless communication technology is the most cost-effective enabling technology of the intelligent grid
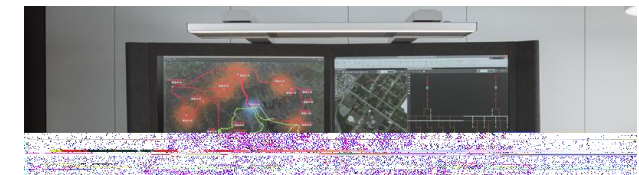
"The use of wireless networks in grid edge applications is significantly less developed than wired." - Cambridge Consultants

Hitachi Energy

Why Wireless Communication?

- Wireless is ideal to provide the following use cases at a significantly lower total cost of ownership

LTE

- AMI backhaul
- Transmission / Distribution SCADA
- Line Devices
- Lines Switches
- Volt/VAR management
- Environmental Monitoring

Narrowband IoT

- C&I Metering
- Lighting Control
- Pole Sensors (Tilt & Sag)
- Transformer Monitoring
- Environmental Monitoring

Private LTE

- Router SCADA controller
- Infrared Video
  - Monitor Transformer heat
- Intruder Detection
- Transformer Hydrogen Monitoring
- RTU monitoring
- Physical Access Control

Hitachi Energy

The Challanges

Every DNO and DSO is looking for a way forward …

Challenged that DNO / DOS will need to address

- Power generation injection at the DNO / DSO level will increase

  - Implement logic in the grid edge that turn uncontrolled black outs into controllable brownouts

  - implement logic that can handle the off grid / on grid scenarios – like EV Charger island in remote locations

- Need for implementation of massive IIoT - both digital twins and real time digital twin's sensors. The DNO / DOS need better / full visibility to the grid applications and related services. Start with a grid application profiling.

- Wireless Coverage and Reach in the UK – Public & Private Wireless Service (410 MHz band 87 PoC in UK)

  - How to build a "hybrid" wireless infrastructure

  - The impact of 5G in the utility DSO / DNO market

- New Cybersecurity Regulation (NIS-2) - are we ready

The Environment We Serve !

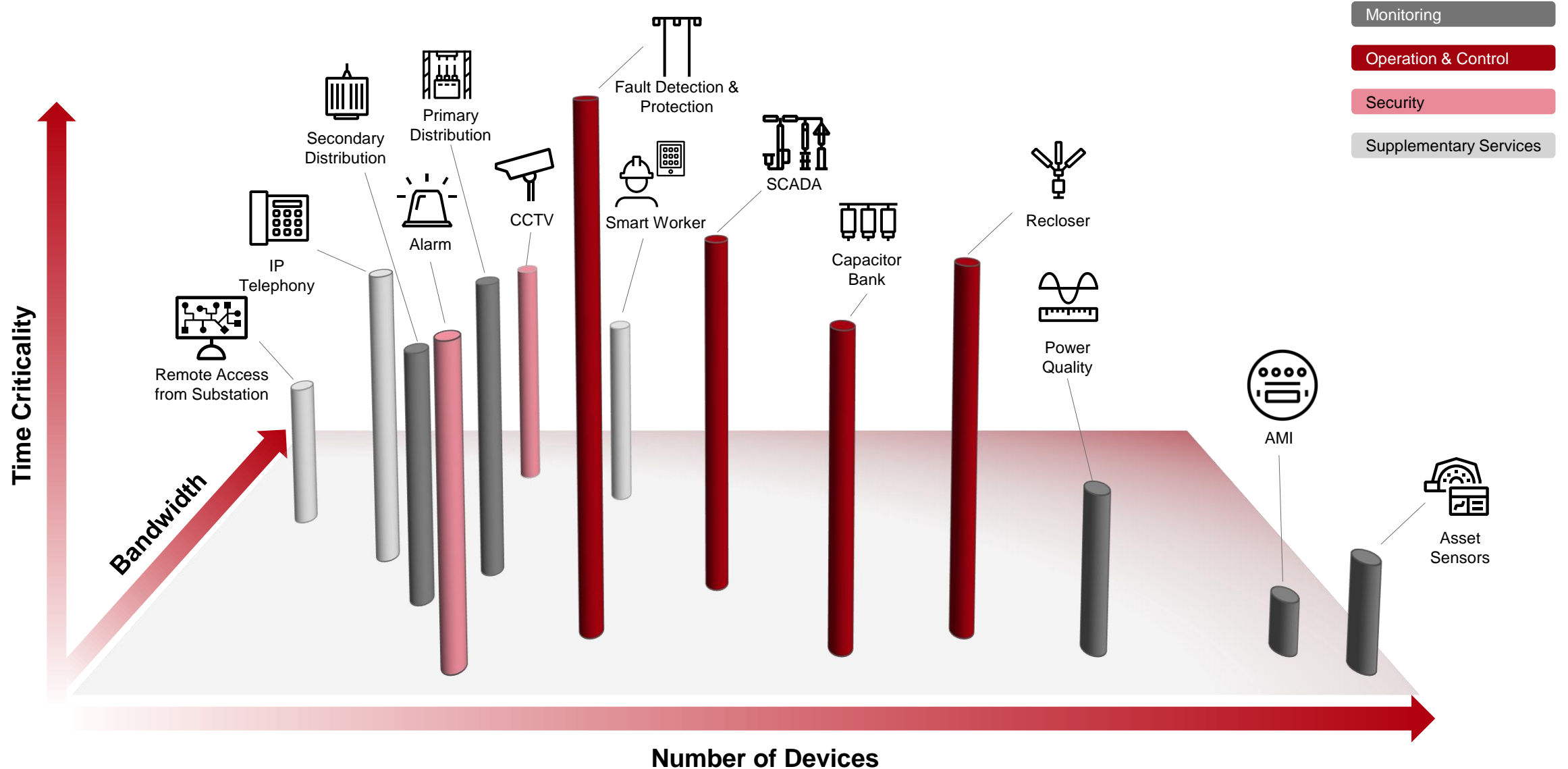# Comms equipment for Grid & Heavy Industry is not always friendly…

Applications Profiling

How to start the process for planning to implement a hybrid infra….

Application vs Requirements

Utility Use Cases vs. TRO fit

Monitoring
- Asset Sensors
- AMI
- Power Quality
- Secondary Distribution Equipment
- Primary Distribution Equipment

Operation & Control
- SCADA
- Capacitor Bank
- Recloser
- Fault Detection & Protection

Security
- Alarm Equipment
- Video Surveillance

Supplementary Services
- IP Telephony
- Remote Access from Substation
- Smart Worker

TRO610

TRO620 Cat4

TRO620 Cat12

TRO620 – 5G

Broadband Mesh

* Not a use case we actively promote with wireless, 5G lacks maturity and cost effectiveness today. But it may be a use case for the future.
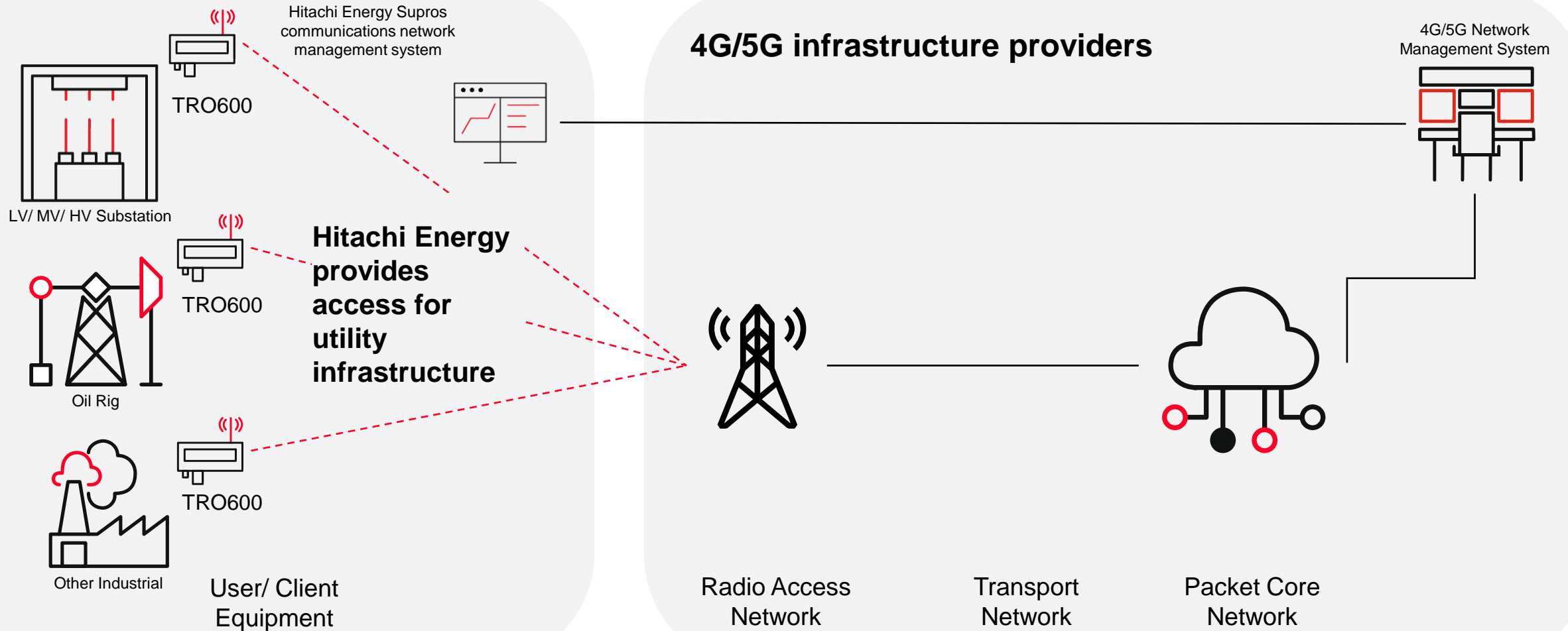
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How to build a hybrid Mission Critical Infrastructure

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4G/ 5G network in an utility application – where do we play?

Campus, Regional Context

Hitachi Energy Supros communications network management system

TRO600

Hitachi Energy provides access for utility infrastructure

LV/ MV/ HV Substation

TRO600

Oil Rig

TRO600

Other Industrial

User/ Client Equipment

4G/5G infrastructure providers

4G/5G Network Management System

Radio Access Network

Transport Network

Packet Core Network

Hitachi Energy

What are our options ? For Secondary Substation Connectivity

Campus, Regional Context

Hitachi Energy Supros communications network management system

TRO600

LV/ MV/ HV Substation

TRO600

Oil Rig

TRO600

Other Industrial

User/ Client Equipment

Hitachi Energy provides access for industrial infrastructure
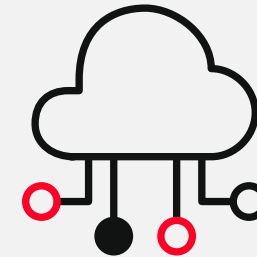
4G/5G Network Management System
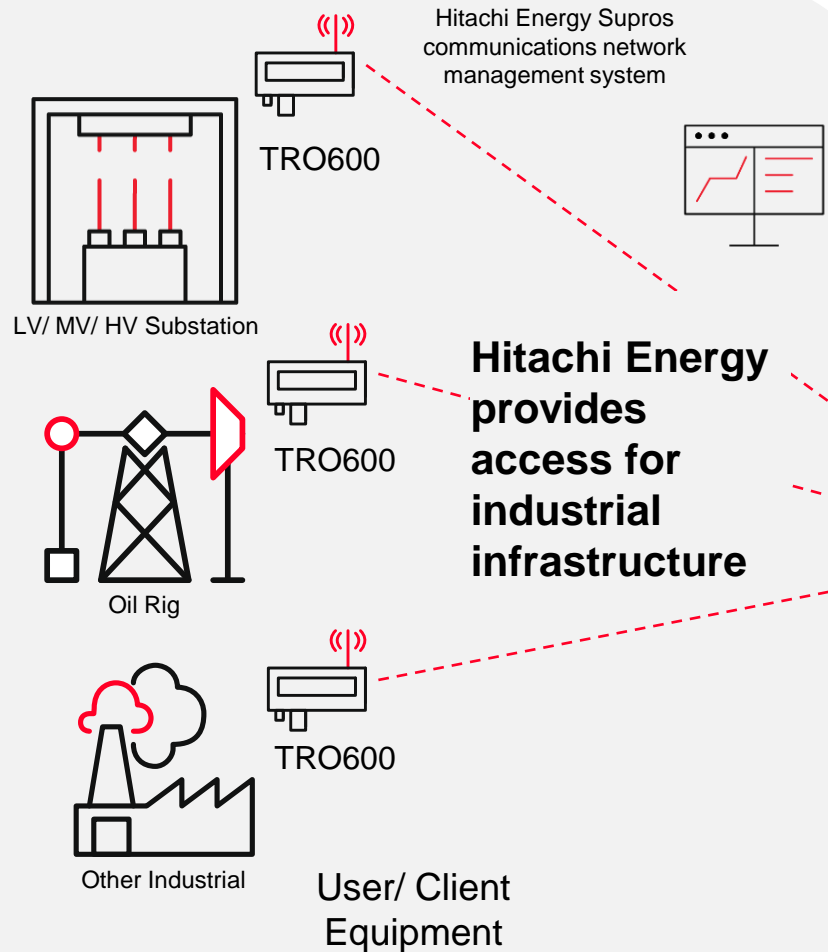
4G / 5G infrastructure providers are now our partners:

1) **Public mobile operators:** Vodafone, O2
2) **Virtual/ Dedicated Networks:** Arqiva or 410 MHz
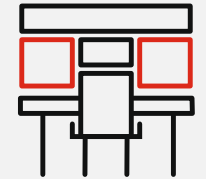3) **Private Networks:** RAN & Core vendors

Radio Access Network

Transport Network

Packet Core Network

TRO600 Connectivity Options

Cellular Only

Cellular Only

Broadband Mesh Only

WAN/ Backhaul
Connectivity

Cellular

TRO610

Eth

**Optional
Bluetooth**

Cellular

**Eth or
Fiber**

TRO620

Eth   Serial

Mesh

**Eth or
Fiber**

TRO620

Wi-Fi

Eth   Mesh   Serial

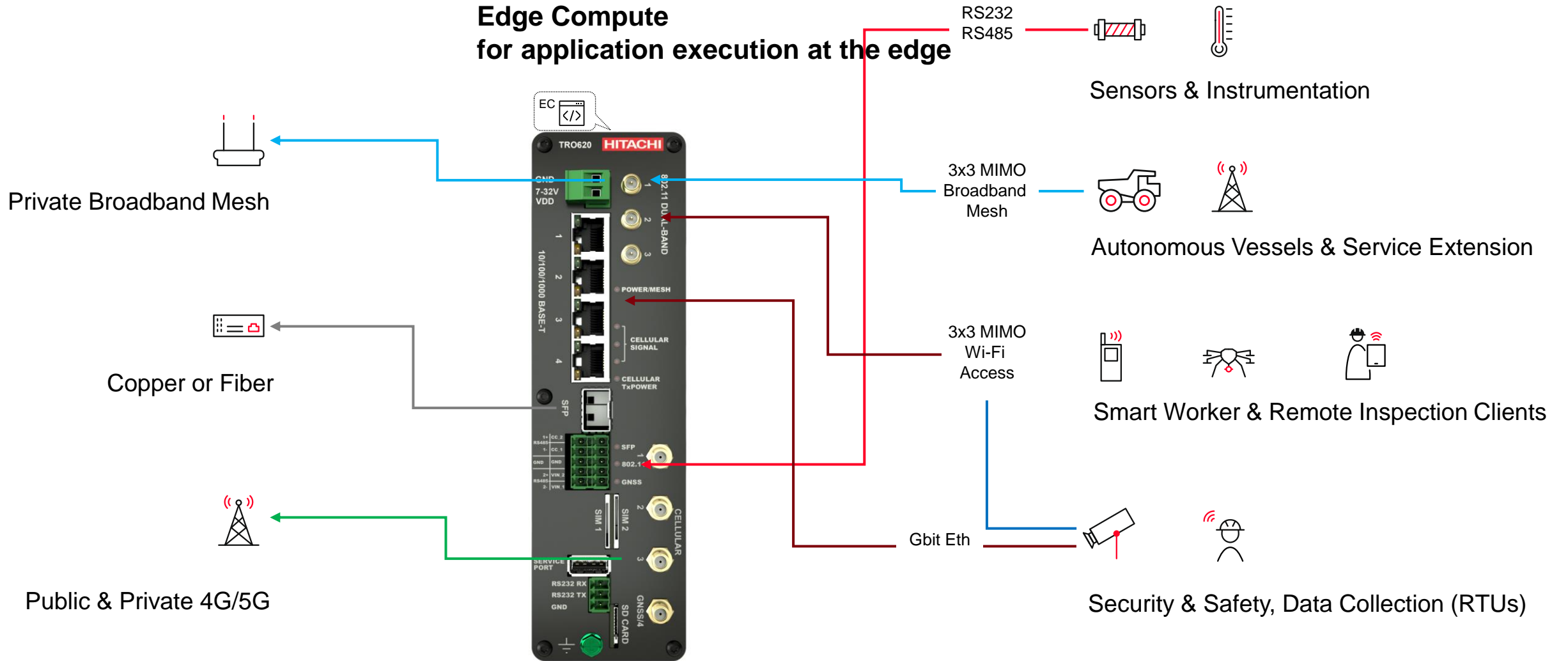**Cellular**

Mesh

**Eth or
Fiber**

TRO620

Wi-Fi

Eth   Mesh   Serial

Client
Connectivity

Managed by Supros Network Management and backward compatible with older generations TropOS

Hitachi Energy

The TRO600 Series

TRO610

A small form factor, ideal for single client connectivity. Cost optimized for large scale industrial IoT deployments, focusing on low power cellular technologies (NB-IoT/ Cat-M).

Industrially certified with mission critical grade cyber security.

Suitable for Massive IIoT 5G.

Variants:
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- Bluetooth (optional local interface)

Available today

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- Cellular (2G, 3G, 4G, 5G - future)
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- Cellular (2G, 3G, 4G, 5G - future)
- Broadband mesh / Wi-Fi Hybrid

Available Q2 2023

Supros

Single Carrier Grade NMS

SuprOS Carrier-Class Network Management

Comprehensive management with powerful visualization tools

– One application to manage the wireless comms network

– Future support for Eth Switch and Fleet management

– Enhanced Security

– Low Touch Provisioning for ease of deployment

– Edge Application Management

– Network-wide visualization tools

– Scalable to >100,000 devices

– North Bound Interface to integration with other management systems

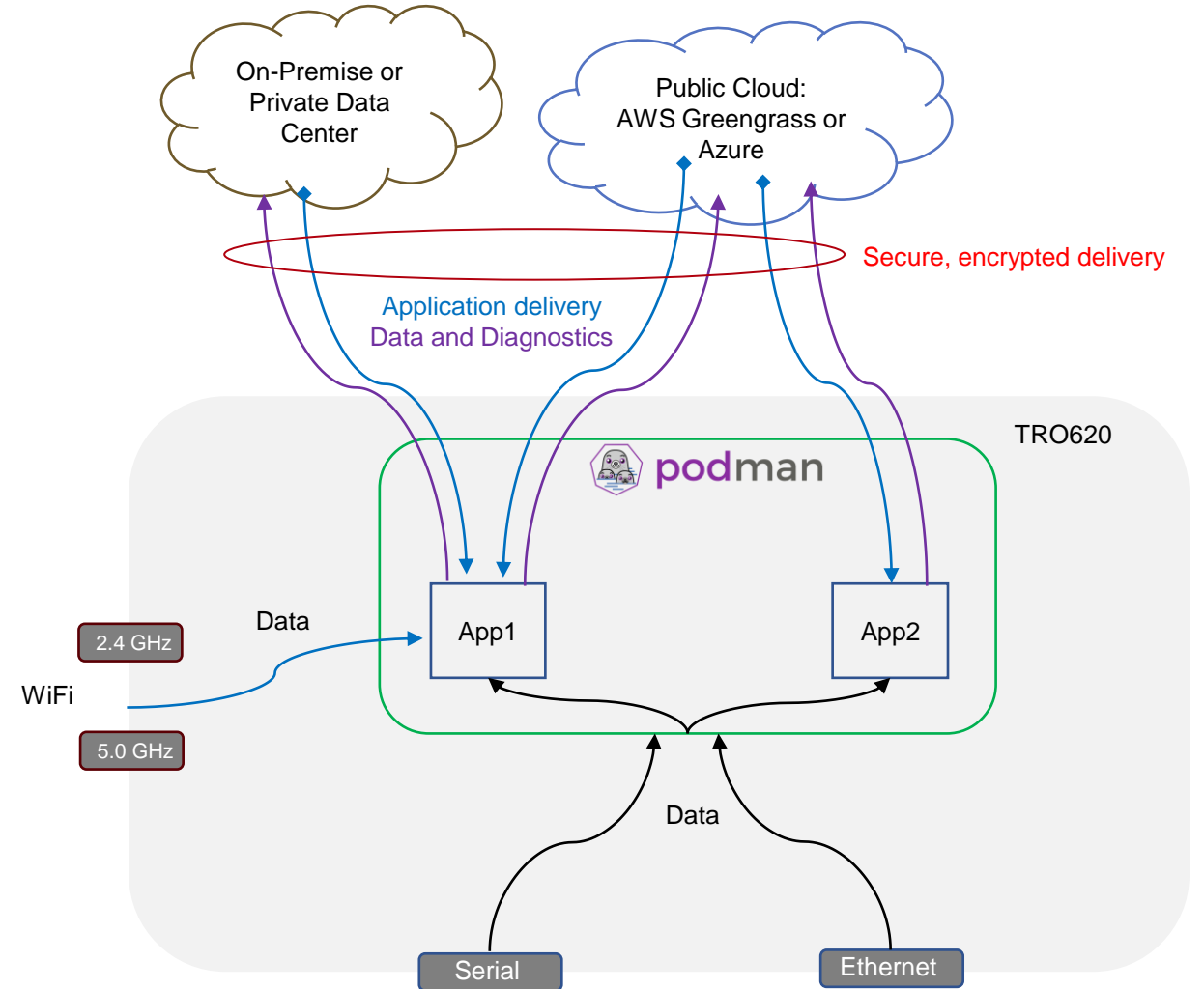**FCAPS:-** Fault, Configuration, Administration, Performance, Security

TRO600 as an Edge Compute Gateway

- Compute environment, memory and storage
  - o The number and type of applications will be determined as PoCs and Demos are completed
- Connection to Public Cloud or Private Cloud (On-Premise)
- Podman lightweight container environment
  - o Supports Docker containers
- Applications should not interfere with the core functionalities of the router
- Customers will develop applications
- Integration with Amazon Greengrass or Azure Cloud environments are to be explored further based on customer demand
- Customers can install applications to compute and translate messages to MQTT to send data back to the Cloud

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SvK Case

TRANSMISSION GRID FOR ELECTRICITY 2020

The Swedish transmission grid for electricity consists of about 17,000 km power lines, just over 200 transformer and switching substations as well as AC and HVDC interconnectors.

SvK – Svenska Kraftnät the Swedish TSO

Svenska Kraftnät Back Grounder

Svenska Kraftnät is the Swedish Authority (TSO) that is operated in the form of a state-owned enterprise.

The Swedish national grid for electricity consists of approximately 17,000 km of power lines, about 200 substations and switching stations and 16 connections to other countries.

All the Swedish DSO and private Wind and Solar enterprises have to connect to the TSO SvK. In Sweden there are **approximately 170** DSOs, which are connected to SvK transmission network.

The Business Case for SvK Smart Grid

The trend for power generation becomes more decentralized. SvK want to take full control with the quality and load balancing of the production of decentralized power generation

The load balancing use case is an EU trend

TRO600 - 5G Use Cases

5G at a glance

5G is not just another technology

5G is the mother of all wireless technologies!

- High bitrate (CCTV, video process optimization)
- Ultra low latency (teleprotection & control for distribution)
- Massive IIoT (sensors, smart meters, asset monitoring)
- Mobility (drones, inspection robots, mobile worker)

5G has 2 legs

- Broadband / ultra-low latency
  - Industrial device scale: 1000s or 10,000s
- Massive IoT
  - Industrial device scale: 100,000s or 1,000,000s

Why now?

- With the push toward digitalization and carbon neutrality, industrial customers are looking for operational efficiency
- Data is power, real-time data is cost saving
- They need to make a technology leap, period!
- 5G is the most robust technology on the market, with the longest horizon into 6G/7G – investment protection

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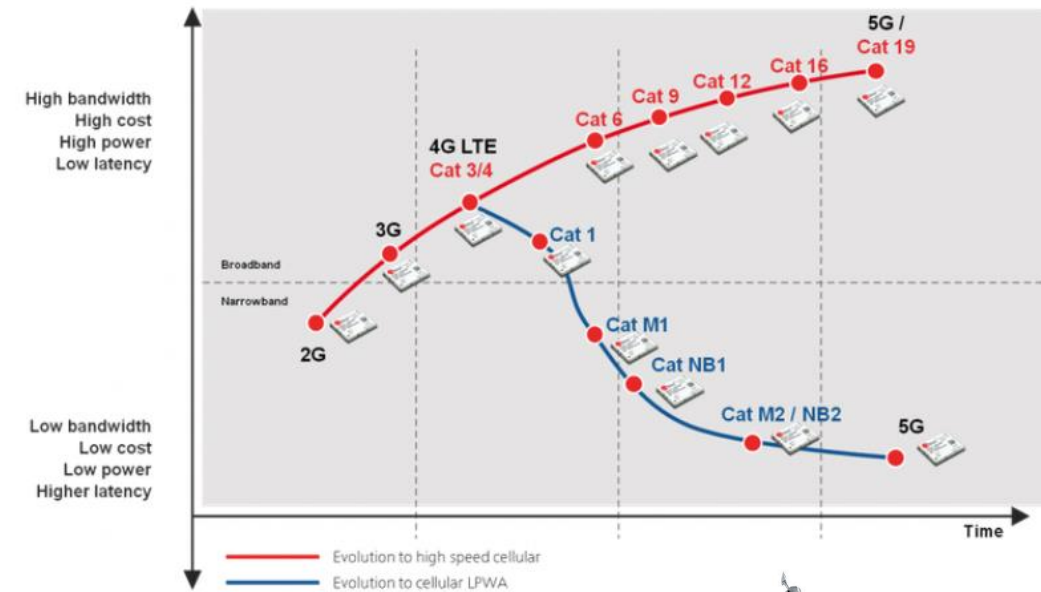
5G use cases are we working on today and what are the requirements?

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Use Case	Bandwidth				Latency			Mobility			Volume				Density				Reliability			Solution Considerations					Technology Fit			
	Very Low	Low	Medium	High	Medium	Low	Very Low	None/ Fixed	Nomadic	Mobile	Low	Medium	High	Very High	Low	Medium	High	Very High	Medium	High	Very High	RF Coverage	RF Capacity	QoS	Features	Ports	NB-IoT/CatM1	4G/ 5G	Broadband Mesh/ Wi-Fi	Wired Backhaul
Remote Edge Node Connectivity		UL			X			X				X					X			X			O			O		O	O	
Real Time Asset Data		UL			X				X		X				X					X				O			O			
Industrial IoT	UL					X		X	X				X				X				X		O			O	O	O		
Unmanned Autonomous Vehicles				UL	X				X	X		X					X				X	O	O					O*	O	O
Inspection Robots & Drones				UL			X		X	X							X				X	O	O	O				O		
Video HSE violations				UL	X			X	X		X						X		X				O					O	O	
Video Process Safety Monitoring				UL		X		X	X		X						X				X		O					O	O	O
Video Process Optimisation				UL		X		X	X		X						X				X		O					O	O	O
Smart Mobile Worker			UL		X					X		X				X			X			O						O	O	
Emergency Personnel Mustering	UL				X					X			X			X				X		O			O		O			
Fixed Wireless Access				DL	X			X	X		X				X				X				O					O	O	O
Mobile Broadband (incld VoIP)			DL		X				X	X	X				X				X			O	O	O				O	O	
Emergency Call		X			X					X		X			X					X		O		O			O	O	O	
Group Call		X			X					X		X			X					X		O			O		O	O	O	
Teleprotection for Distribution		X					X	X			X					X					X	O		O				O		O

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3 ways to connect to a 5G network

5G Equipped sensor:
- Today, this is still rare
- Requires sensor replacement

5G Equipped gateway:
- Single device connectivity
- Generally low spec
- Avoids sensor replacement

5G Equipped CPE:
- Multi device connectivity
- More connectivity, more capability (more intelligent device)
  - Edge compute
  - Security protocols
  - More technologies
- Avoids sensor replacement
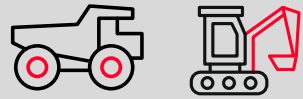- Cumulatively cheaper than adding individual gateways for each device

New use cases enabled by 5G Broadband

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- Ultra Low Latency
- High bitrate
- Cyber Security
- Reliability

- Ultra Low Latency
- Cyber Security
- Reliability

- Ultra Low Latency
- High bitrate
- Cyber Security
- Reliability

- High bitrate
- Cyber Security

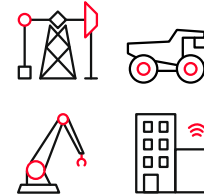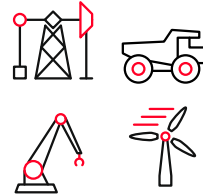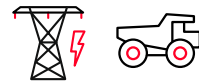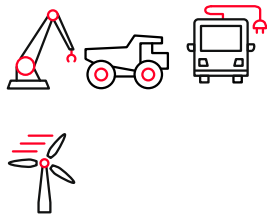Autonomous vehicle control

Teleprotection in Distribution

Augmented/ Virtual Reality

8K video & facial recognition

…

DSOs

Oil & Gas

Mining

Transportation

Manufacturing

Renewables

Smart City

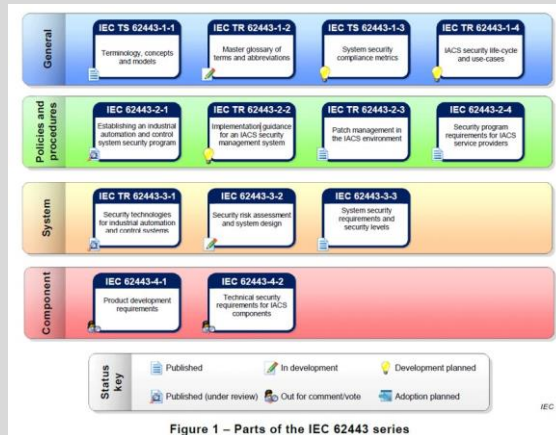Hitachi Energy

Mission Critical Cybersecurity

Pillars of End to End Security in Wireless Portfolio

Process & Organization Security Standards

Procedures/processes
IEC 62443

Figure 1 – Parts of the IEC 62443 series

Cyber Security Product Features

IPSec & VPN

Data Encryption

User Authentication

Client Authentication

Role-based Network Management

Hashed Firmware

Restricted Dataflow

Certificate Management

TPM v2

QRNF (future)

Industrial Cybersecurity Standards Compliance

IEC 61850, IEC 62351, IEEE 1711.2, IEEE 1686, NISTIR 7628/IEEE C37.240
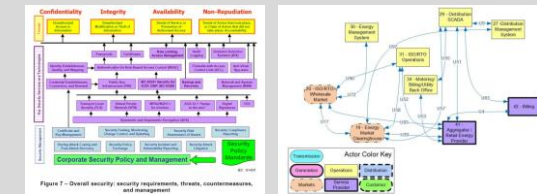
Regional Guidelines and Regulations

IT SIG 2.0, EU NIS2, NERC CIP

Secure integration with **SuprOS**

Hitachi Energy

TRO600 Cyber Security Features

IPsec & VPN

32 IPSec tunnels
IKEv1 & IKEv2 over IPv4 and IPv6
AES 256, SHA 256, DH Group 14

Data Encryption

Compliant with 3GPP AES level
AES 256 for mesh
WPA2 (128, 256 bit, AES) for Wi-Fi client traffic

User Authentication

RADIUS or local authentication for users

Client Authentication

RADIUS based machine client authentication

Role based network management

Access restricted based on role – root, read/write, read only

Hashed Firmware

All firmware is protected against tampering - hashed at Hitachi factory and only decodable at upgrade by TRO devices

Restricted Dataflow

Stateful & zone-based firewall
MAC ACLs, Allow and Deny list

Certificate Management

Hitachi and customer certificate renewal and management using X.509 PKI certificates

Trusted Platform Module v2 (future)

For storing asymmetric private keys

Encrypted Configuration

NMS control over HTTPS
Configuration exports are encrypted and only decryptable when restored on a TRO device

Industry Standards

IEC62443-4-1 & IEC62443-4-2
NERC CIP
IEEE 1686

QRNG (future)

Quantum safe random number generator

IEC 62443

Figure 1 – Parts of the IEC 62443 series
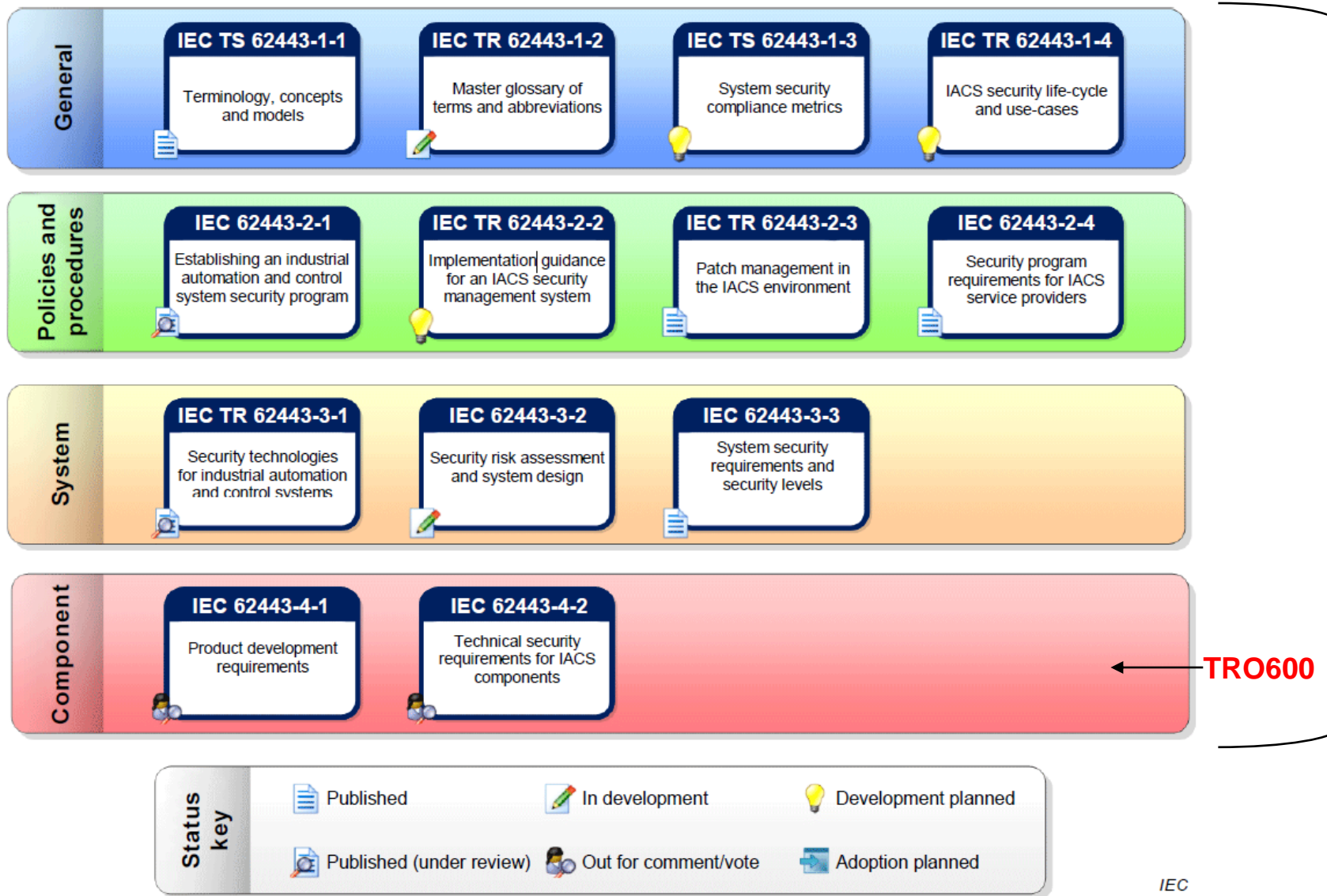
Hitachi Energy current & planned compliance

- Cyber security is **not about a product or features**

- Cyber security is in the heart of everything we do, from products to documents, from the way we write our code to the way we run our organization.

In Summery

Mission critical communications differentiation

Salt & Dust Resistance

Physical & Logical Security

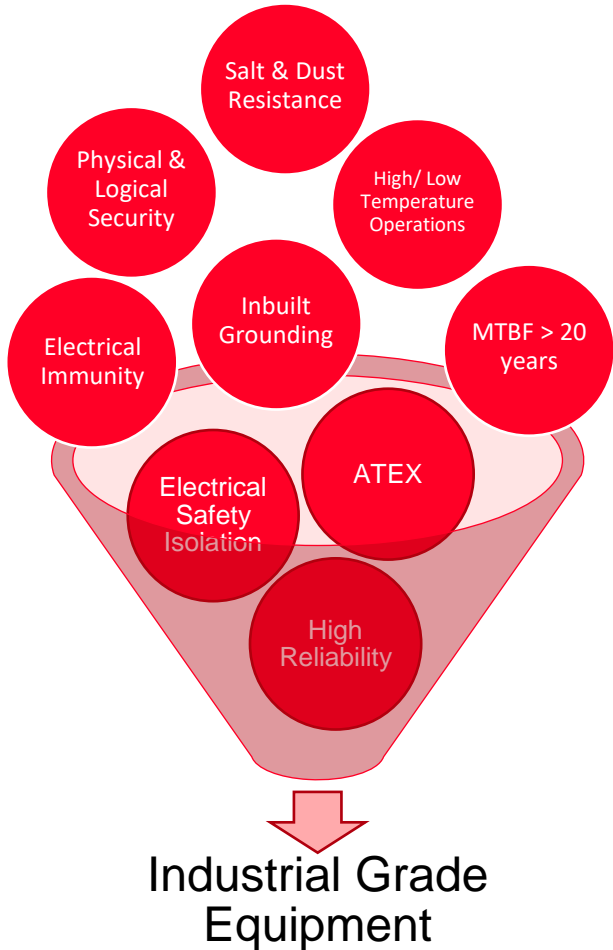High/ Low Temperature Operations

Electrical Immunity

Inbuilt Grounding

MTBF > 20 years

Electrical Safety Isolation

ATEX

High Reliability

Industrial Grade Equipment

	Enterprise Grade	Industrial Grade	Hitachi Energy Value
Ideal Deployment Scenarios	Indoor Office/ Home Stadium Corporate Campus	H/M/V Voltage Substation Harsh environment Chemical/ Explosive Exposure (ATEX)	Hitachi Energy equipment is intrinsically designed for harsh environments without the need for enclosures
Enclosure & Hardware	Plastic/ Aluminum	Metal with Galvanic Isolation	Hitachi Energy industrial hardware is not repurposed commercial equipment, it is designed to serve in harsh environments, protecting the customer investment over **decades**.
Environmental Rating	IP10 – IP20 -20 to+ 50 Deg C	IP30 – IP67 -25 to +75 Deg C Salt Spray Resistant	
Electrical Immunity	Little to None	IEC 61850-3/ IEEE 1613 MV to HV	
Typical Power Consumption	10 - 30W	3 – 10W	Low power consumption results in less wear & tear and superior **longevity** of the hardware
Standard Warranty	1- 2 years	5 years	**Investment protection** for long lifecycles
Typical Lifecycle	5 years	15+ years	

Note: Enterprise Grade routers have historically been positioned in hazardous environments through the use of enclosures and various protection accessories. This introduces an increase in cost, as well as integration risk compared to an industrial device which was designed specifically for these environments and applications.

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TRO600 Back Up Slides

TRO600 and SuprOS Series

TRO600 Connectivity Options

WAN/ Backhaul Connectivity

Client Connectivity

Edge Compute
for application execution at the edge

Private Broadband Mesh

Copper or Fiber

Public & Private 4G/5G

RS232 RS485 — Sensors & Instrumentation

3x3 MIMO Broadband Mesh — Autonomous Vessels & Service Extension

3x3 MIMO Wi-Fi Access — Smart Worker & Remote Inspection Clients

Gbit Eth — Security & Safety, Data Collection (RTUs)

The TRO600 Series

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Variants:
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- Bluetooth (optional local interface)

Available today

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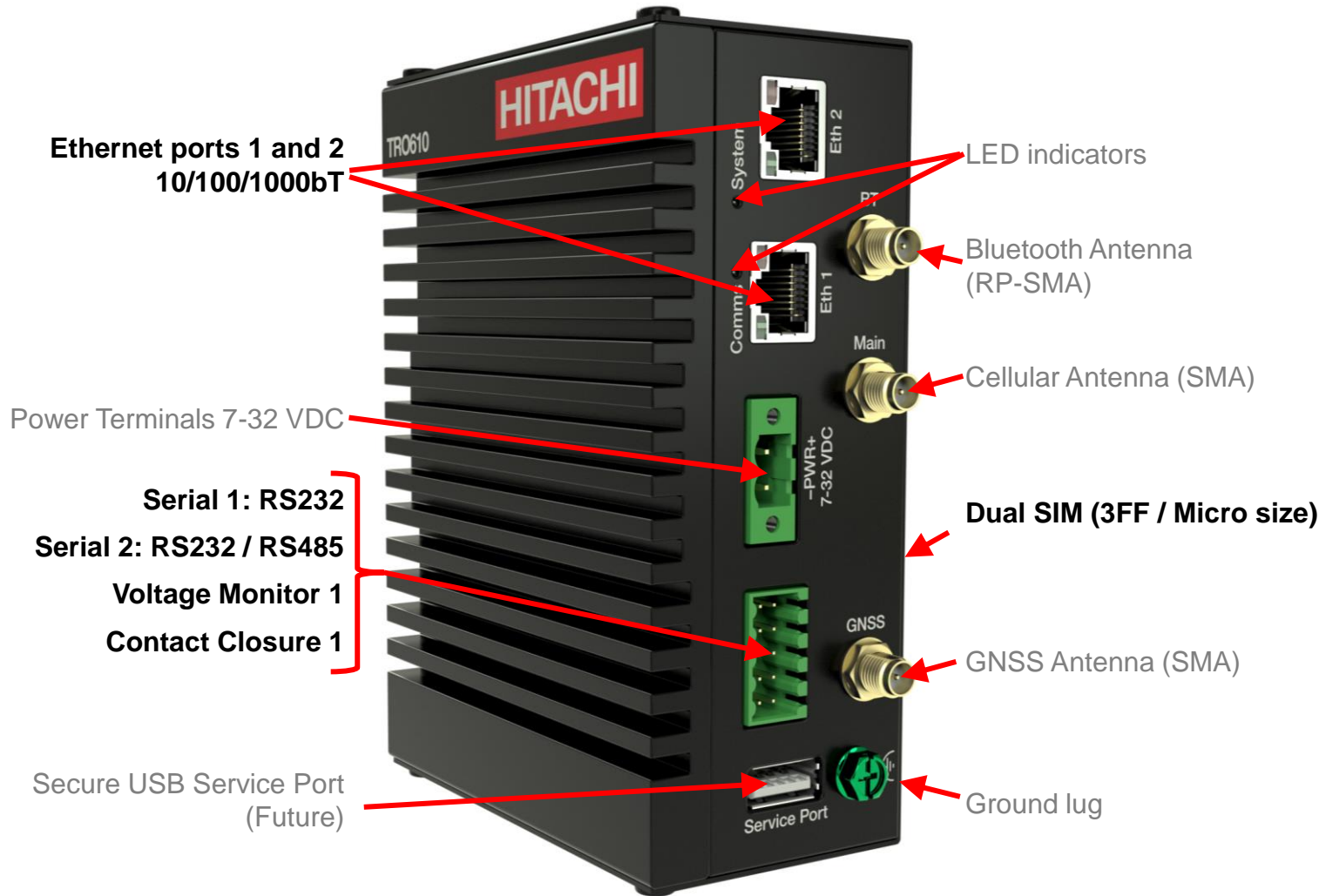- Broadband mesh / Wi-Fi Hybrid

Available Q2 2023

Supros

Single Carrier Grade NMS

Hardware at-a-glance

Ethernet ports 1 and 2
10/100/1000bT

LED indicators

Bluetooth Antenna
(RP-SMA)

Cellular Antenna (SMA)

Power Terminals 7-32 VDC

Serial 1: RS232

Serial 2: RS232 / RS485

Dual SIM (3FF / Micro size)

Voltage Monitor 1

Contact Closure 1

GNSS Antenna (SMA)

Secure USB Service Port
(Future)

Ground lug

Connectivity Options

Cellular

TRO610

Backhaul
Connectivity

Client
Connectivity

Eth   Serial   BT
(Available Q2 2023)

Tropos TRO620

Hybrid wireless router with integrated
4G/5G, SFP + broadband mesh 2.4GHz, 5GHz

Dual SIM

Power Terminals
7-32 VDC

Ethernet 1-4: 10/100/1000bT
(client ingress)

Ethernet 5: GE SFP Cage
(not switched backhaul/ WAN egress)

Secure USB Service Port (HW ready)

Grounding Pin

Three Dual-Band 802.11 Antennas
(2.4/5 GHz)

LED indicators

Three Cellular Antennas
(2G, 3G, 4G, 5G
One GPS Antenna)

One PGS Antenna

Serial 1: RS-232
Serial 2&3: RS-485
Voltage Monitor 1
Voltage Monitor 2
Contact Closure 1
Contact Closure 2

Hitachi Energy

TRO670 Outdoor Mesh and Cellular Router

- Specially built for utility, oil and gas, sea port, mining and industrial applications
- Industrial applications that monitor and control field automation endpoints such as intelligent electrical devices, industrial process controllers, and SCADA devices
- Contemporary applications like video surveillance and other streaming applications
- Ethernet and Serial interfaces support a wide variety of current and legacy protocols

Environmental specifications

- Operating temperature range: -40°C to 75°C / -40°F to 167°F
- Storage temperature range: -40°C to 85°C / -40°F to 185°F
- IP67 rated enclosure: UL579/IEC 60529
- Wind survivability: >200 mph
- Wind loading (200 mph): <330 Newtons
- ASTM B117 salt, fog, rust resistance compliant
- Shock & vibration: ETSI 300-19-2-4 spec T4.1E class 4M3
- Transportation: ISTA 2A
- ATEX zone 2 certified

Front view with cover

Power
- DC Models: 24-48 Volts DC
- AC Models: 100-240 Volts AC
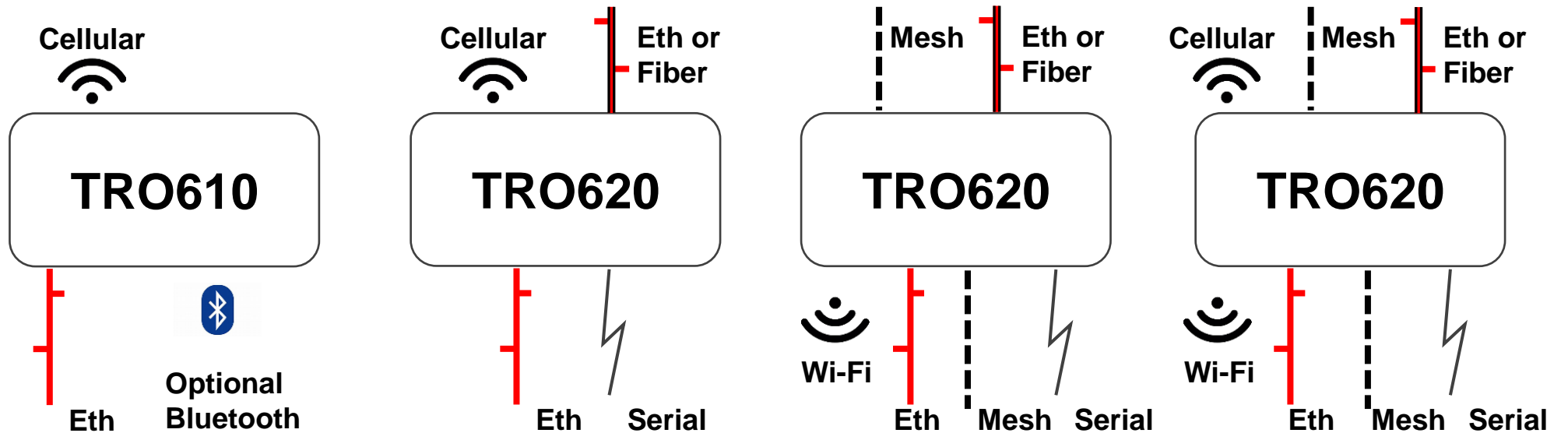- Optional Integrated Battery Backup (60 or 120 Wh)

Front view no cover

Bottom view

Hitachi Energy

TRO610 & TRO620 Connectivity Options

Cellular Only   **Cellular Only**   **Broadband Mesh Only**

WAN/ Backhaul
Connectivity

Cellular

TRO610

Optional
Bluetooth

Eth

Cellular   **Eth or Fiber**

TRO620

Eth   **Serial**

Mesh   **Eth or Fiber**

TRO620

Wi-Fi

Eth   **Mesh**   **Serial**

Cellular   **Mesh**   **Eth or Fiber**

TRO620

Wi-Fi

Eth   **Mesh**   **Serial**

Client
Connectivity

Managed by Supros Network Management and backward compatible with older generations TropOS

Hitachi Energy

SuprOS Carrier-Class Network Management

Comprehensive management with powerful visualization tools

- One application to manage the wireless comms network

- Future support for Eth Switch and Fleet management

- Enhanced Security

- Low Touch Provisioning for ease of deployment

- Edge Application Management

- Network-wide visualization tools

- Scalable to >100,000 devices

- North Bound Interface to integration with other management systems

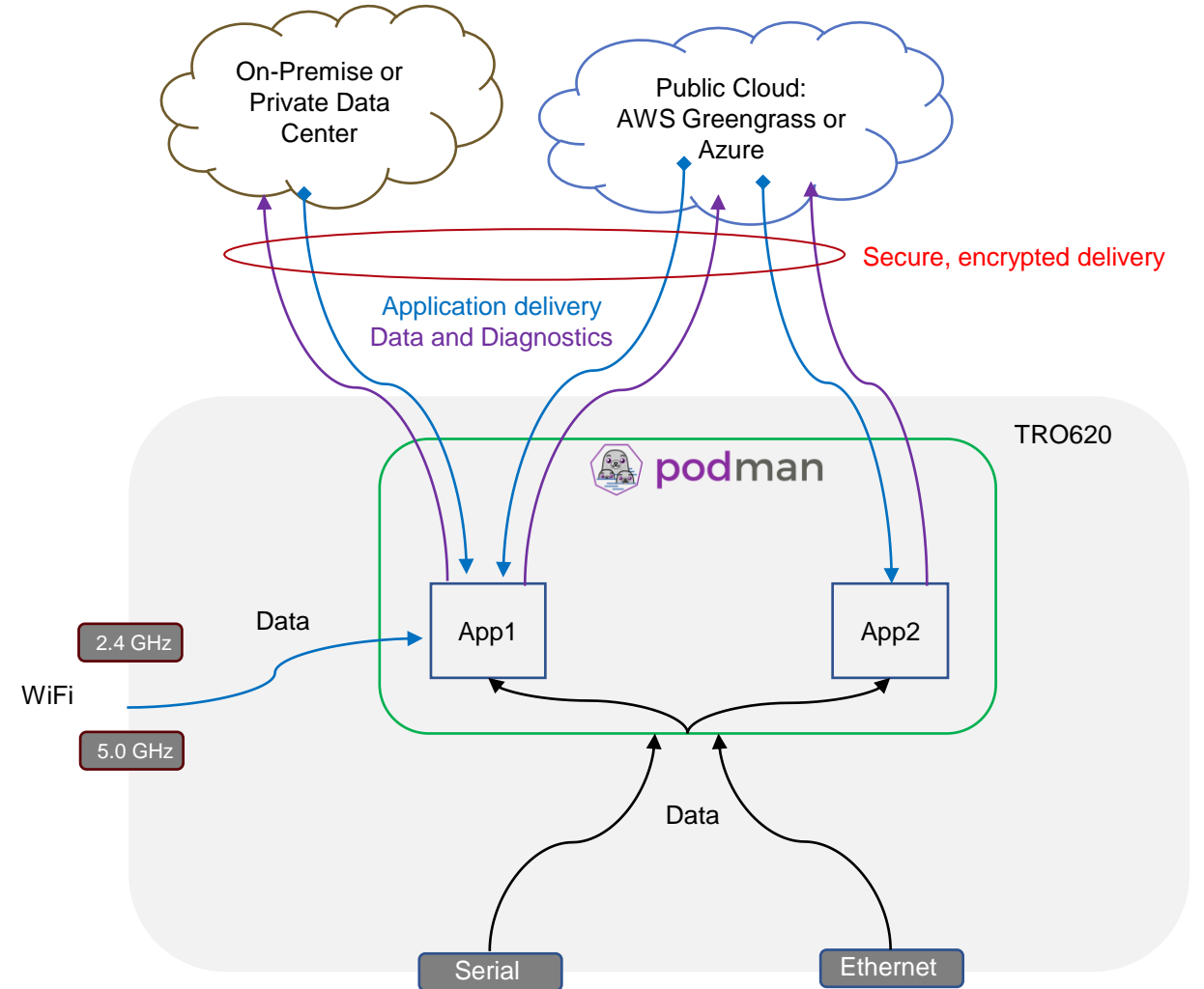**FCAPS:-** Fault, Configuration, Administration, Performance, Security

TRO600 as an Edge Compute Gateway

- Compute environment, memory and storage
  - The number and type of applications will be determined as PoCs and Demos are completed
- Connection to Public Cloud or Private Cloud (On-Premise)
- Podman lightweight container environment
  - Supports Docker containers
- Applications should not interfere with the core functionalities of the router
- Customers will develop applications
- Integration with Amazon Greengrass or Azure Cloud environments are to be explored further based on customer demand
- Customers can install applications to compute and translate messages to MQTT to send data back to the Cloud

On-Premise or Private Data Center

Public Cloud: AWS Greengrass or Azure

Secure, encrypted delivery

Application delivery
Data and Diagnostics

podman

TRO620

Data

2.4 GHz

WiFi

5.0 GHz

App1

App2

Data

Serial

Ethernet

POWERING GOOD FOR SUSTAINABLE ENERGY