SAARC Energy Centre

KNOWLEDGE SHARING WEBINAR

AI in Transmission Line Asset Management

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Date 30, 2024

Agenda of Discussion

- Transmission Line Asset Management
- Artificial Intelligence in Transmission Line Asset Management

Transmission Line Asset Management

Systematic approach to maintaining and optimizing the performance of transmission lines within an electrical grid.

- **Condition Assessment**: Regular inspections and monitoring of components (conductors, insulators, towers).
- **Maintenance & Refurbishment**: Scheduled and preventive maintenance to ensure reliability and extend lifespan.
- **Risk Management**: Identifying and mitigating operational risks (environmental impacts, equipment failures, safety hazards).
- **Lifecycle Management**: Planning from installation to end-of-life disposal or replacement.

Transmission Line Asset Management

Assets: Scope and Complexity

- Tower
- Conductor
- Insulator
- Hardware
- Easement/RoW

Transmission Line Asset Management

Transmission Tower Component

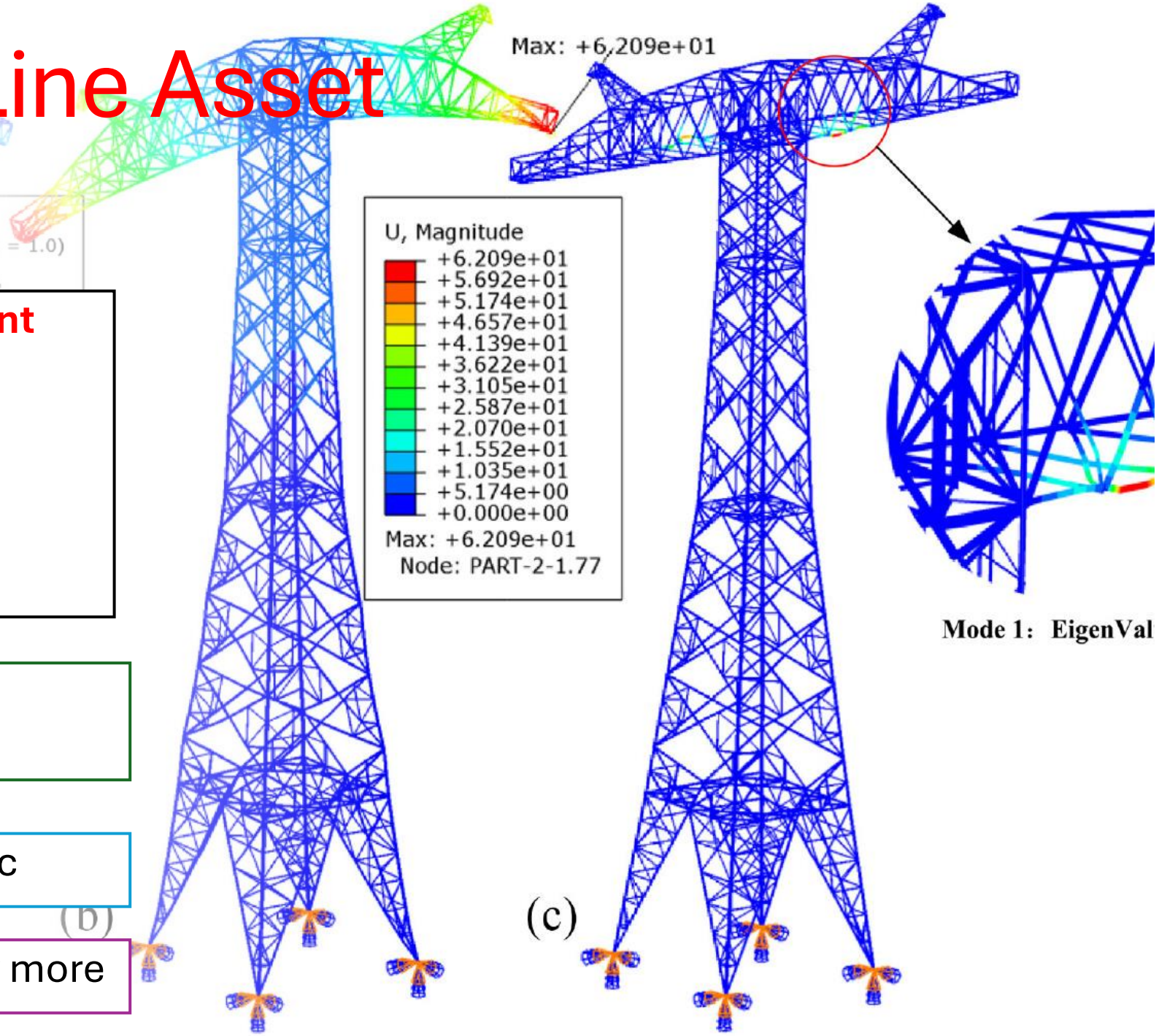
- Foundation
- Leg
- Body
- Cross Arm

Drawing

DPR, Construction Data

Testing Details: Type test, FAT etc

Vendor, Contractor Detail, Many more



Transmission Line Asset Management

Conductor, Insulator, OPGW/Earth wire:

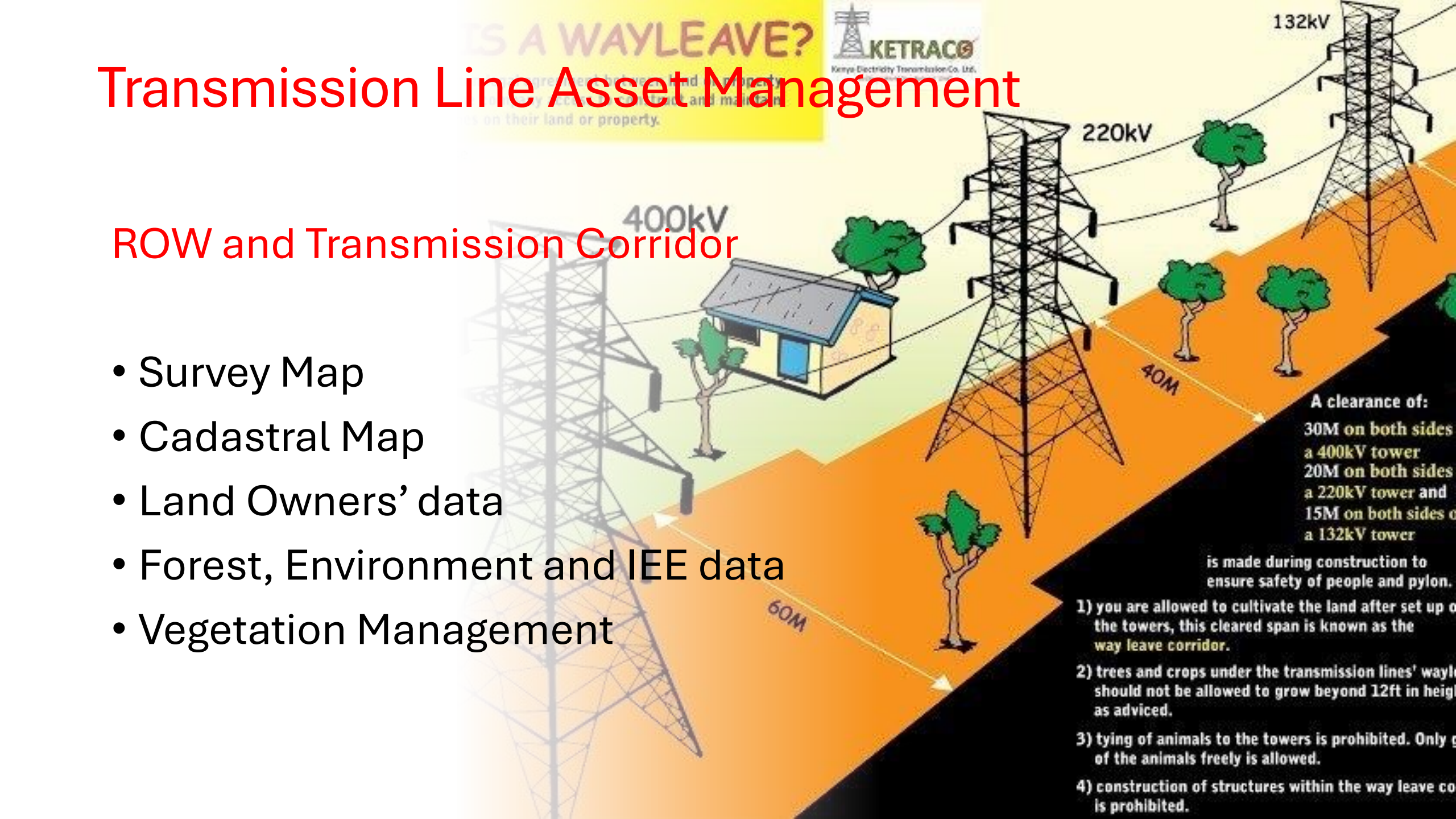
- Name, Vendor, Test Reports;
- Thermal, Mechanical and electrical data sheet

Tower Fitting Hardware

Transmission Line Asset Management

ROW and Transmission Corridor

- Survey Map
- Cadastral Map
- Land Owners' data
- Forest, Environment and IEE data
- Vegetation Management



Transmission Line Asset

Static Data

- Detailed Project Report, Shop drawing
- Contract and Bid data
- Data during Construction

Dynamic Data

- Real Time Data
- Condition Monitoring data

Challenges in Traditional Asset Management

- Traditional transmission asset management methods rely on manual inspections and periodic maintenance schedules.
- Inability to predict asset failures with reasonable accuracy, necessitating additional maintenance that might be redundant.

A complex task involves the acquisition and management of large amounts of data.

AI Tools

Artificial Intelligence

AI can be broadly categorized as either "Narrow", “Generative”, and “General.”

- *Narrow AI:* Simple and specialized task, eg SIRI, Cortona, Face recognition system
- *Generative AI* use generative models to produce text, images, videos, #D model or other specialized use cases (main stream AI version-chatgpt-04 copilot etc).
- *Artificial General Intelligence (AGI)* demonstrate intelligence across a wide range of cognitive tasks; in the process of developing.

AI Essence

Digital Technology

Sensors

Communication Channel

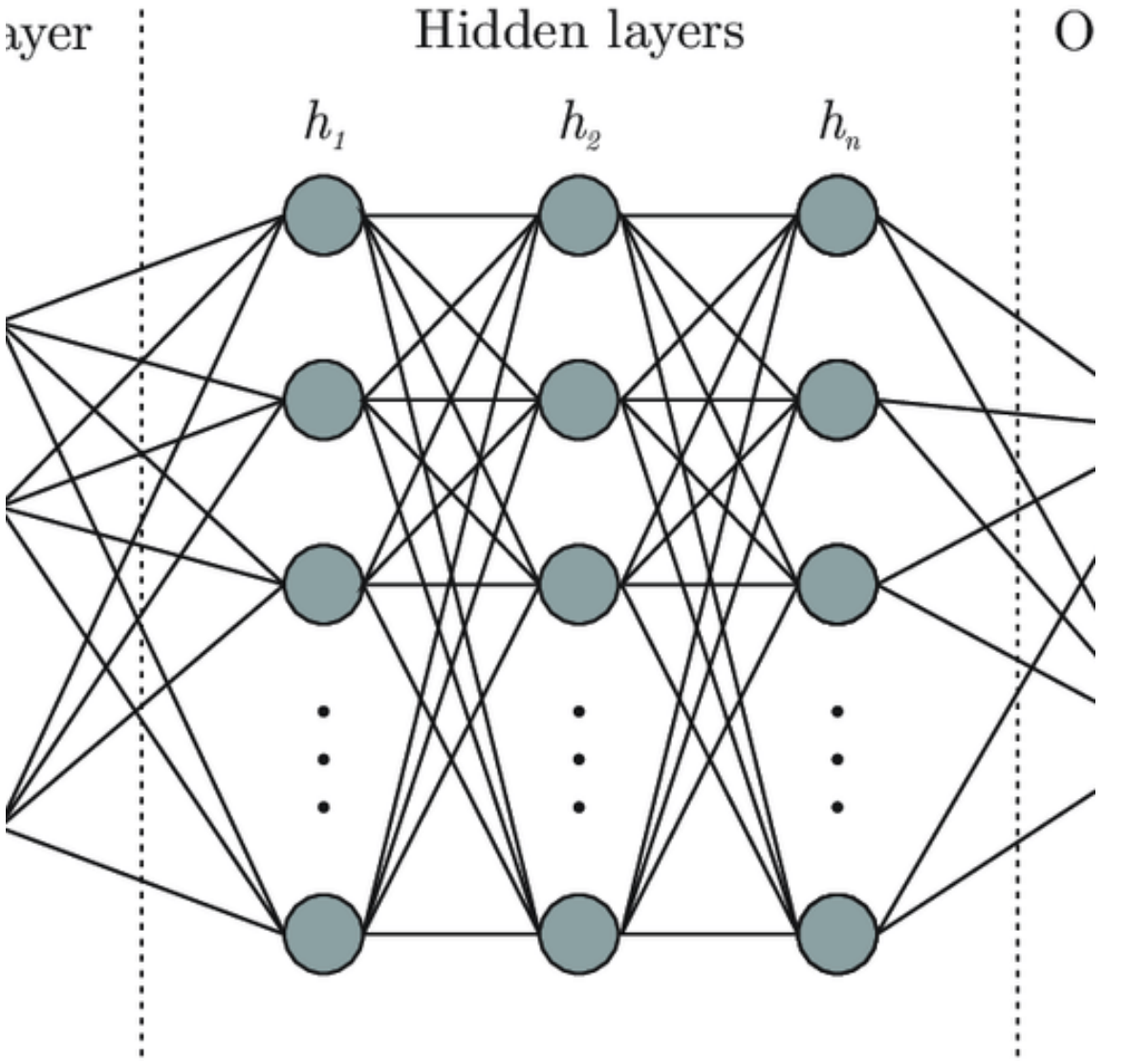
Big Data and IoT

Human Interface

Output Generation

AI Application in Transmission Line Asset

- Artificial Neural Network
  - Transmission Line Routing
- Digital Twins
  - Design and Prototype Testing
  - Line Operation & Maintenance



ANN in Finding Traffic Route

Best 21 min — 1h 11m — —

New Baneshwor, Kathmandu 44600

Thamel, Kathmandu 44600

Add destination

Leave now ▾ Options

Send directions to your phone Copy link

via Madan Bhandari Path/Madan Bhandari Road/NH03 and Kanti Path — 21 min — 6.0 km

Fastest route, despite the usual traffic

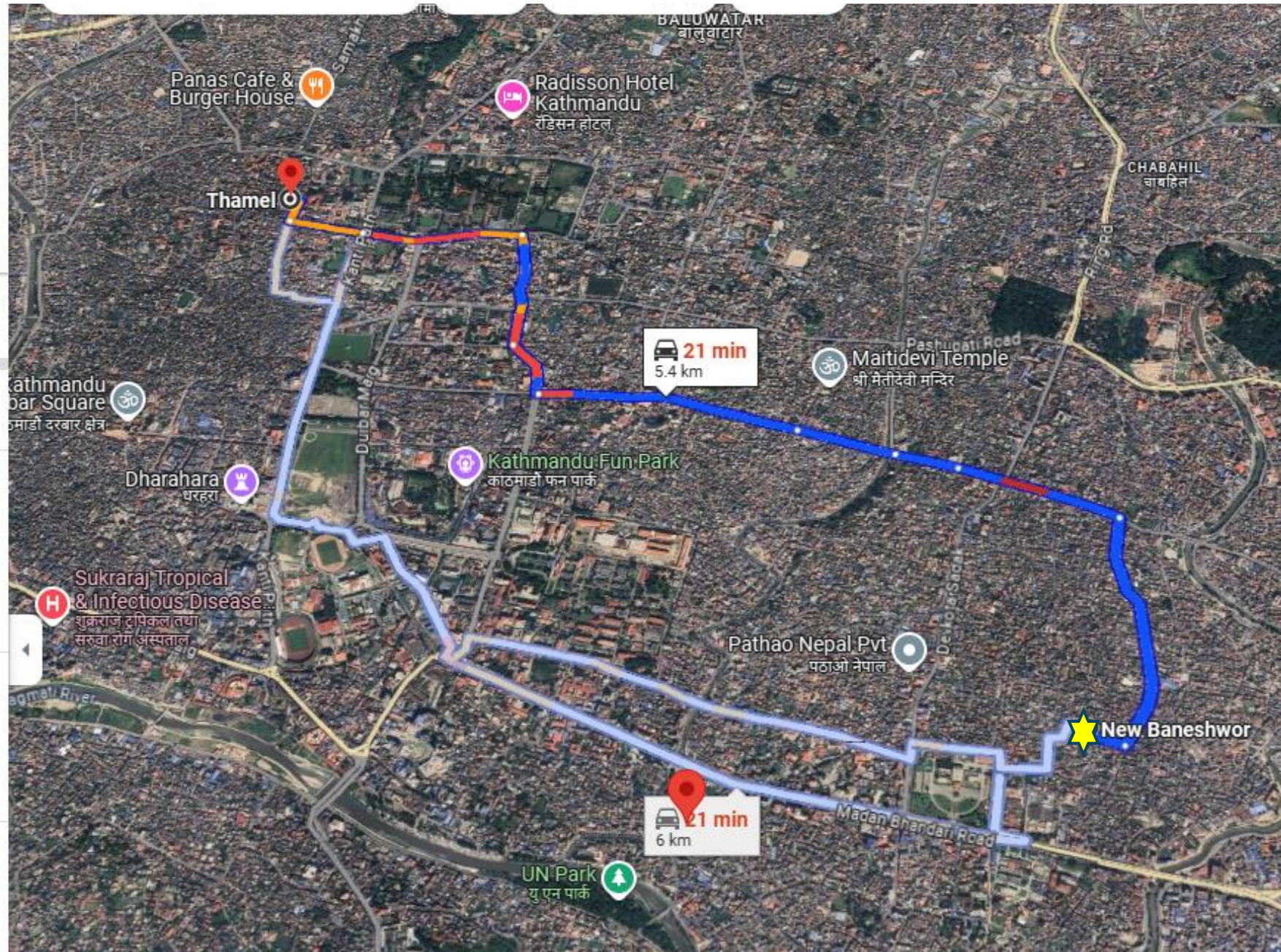
via Bhimsen Gola Marg — 21 min — 5.4 km

Heavy traffic, as usual

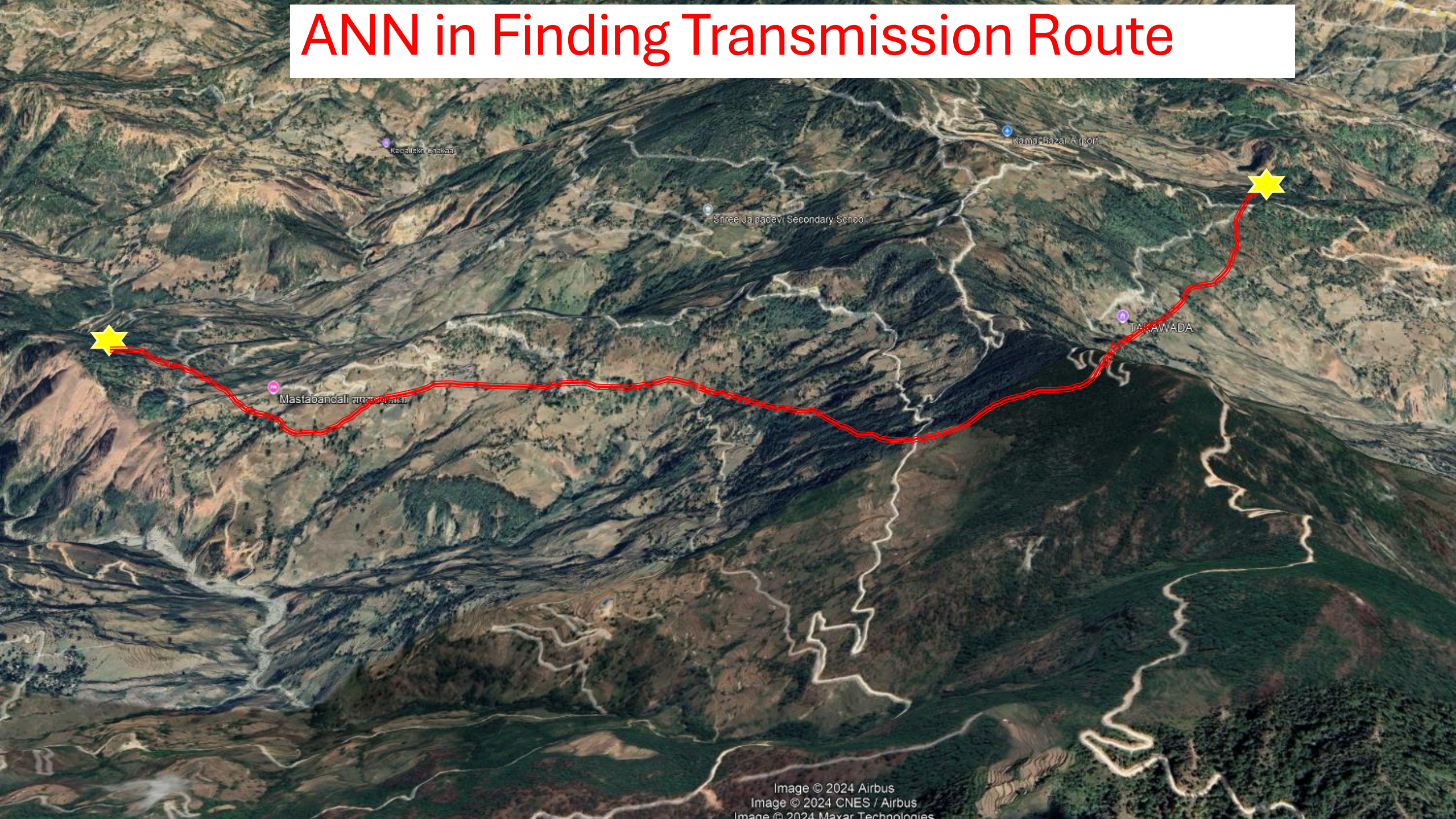
Details

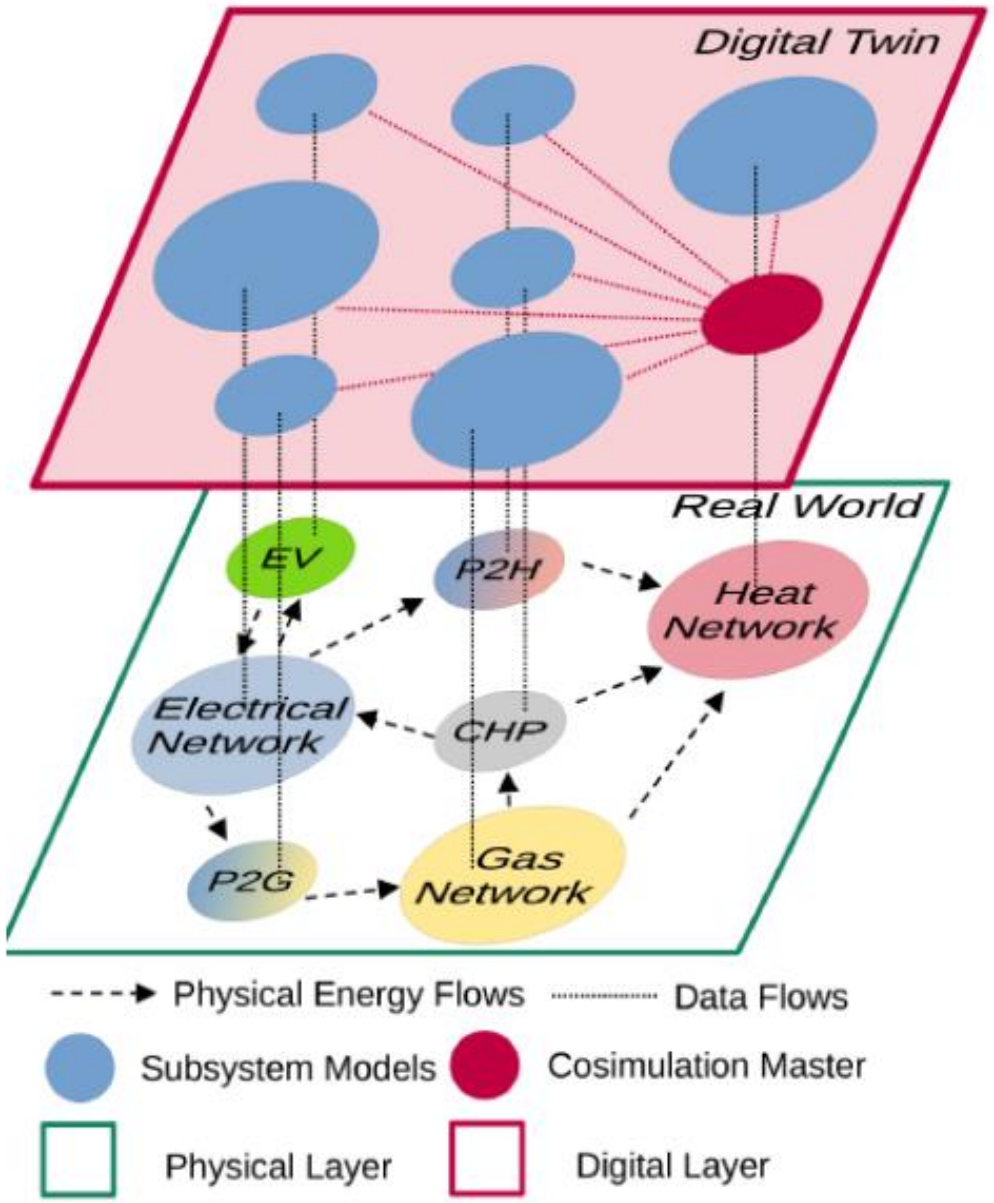
via Kanti Path — 21 min — 5.7 km

Heavy traffic, as usual



ANN in Finding Transmission Route





Digital Twins

- Digital twins are virtual representations of physical entities that mimic their real-world counterparts.
- They are created by combining real-time data from sensors, IoT devices, and other sources with advanced analytics and modeling techniques.

Artificial Intelligence

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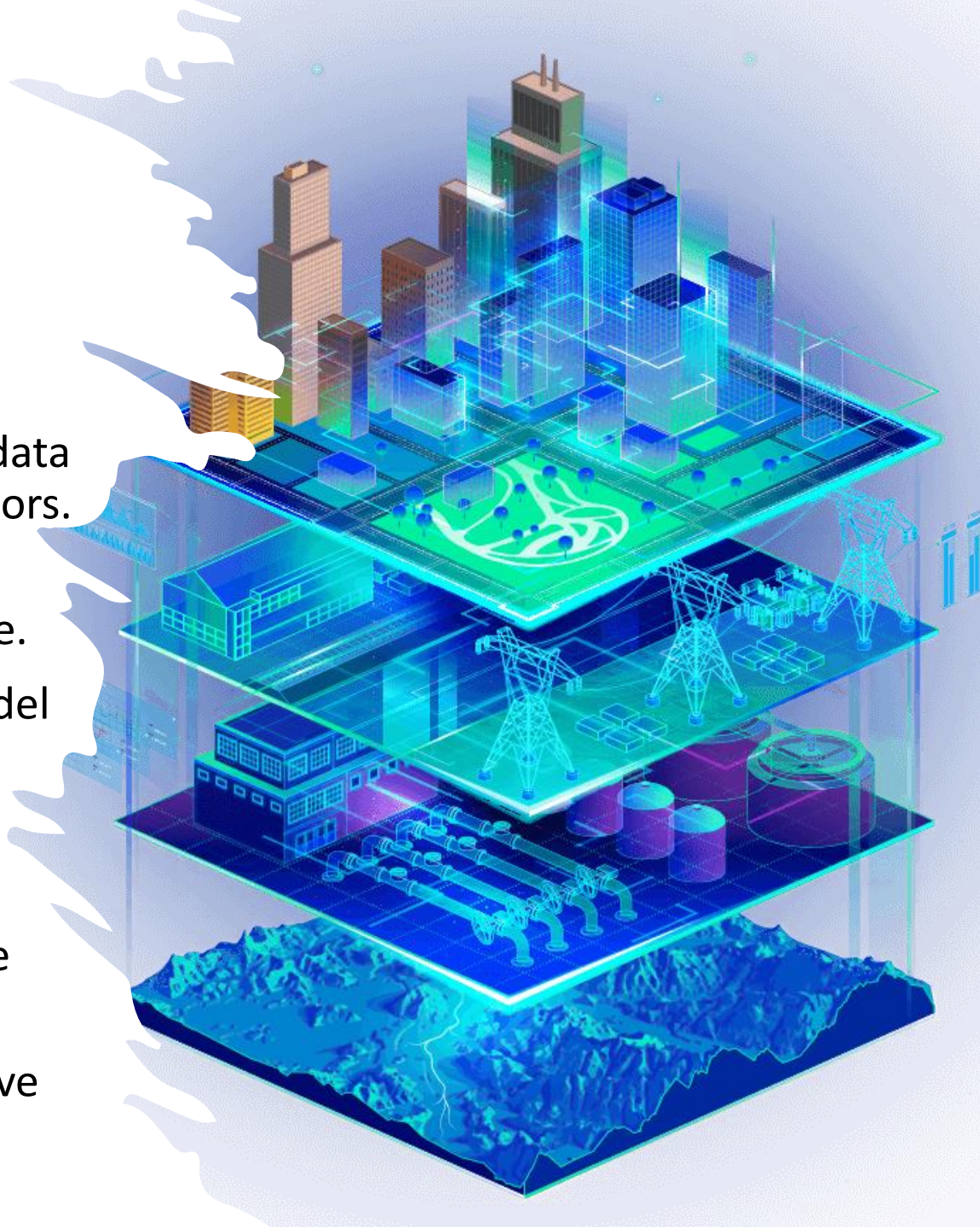
Digital Twins

Creating Digital Twins of Transmission Lines

- **Data Collection**: Gather real-time and historical data (environmental, operational, physical) using sensors.
- **Model Development**: Develop a computational model representing the physical transmission line.
- **Integration**: Link collected data to the digital model for real-time updates.
- **Simulation and Analysis**: Simulate scenarios to predict issues and optimize performance.
- **Validation and Calibration**: Continuously validate and calibrate the model with actual data.
- **Application**: Use for asset management, predictive maintenance, and operational optimization.



Digital Twin vs Simulation Model

Digital Twins:

- **Real-Time Data Integration**: Continuously updated with sensor data.
- **Comprehensive Analysis**: Runs multiple simulations simultaneously.
- **Lifecycle Management**: Monitors and optimizes entire asset lifecycle.
- **Predictive Maintenance**: Uses real-time data for failure prediction.
- **Cost**: More expensive due to advanced analytics and sensors.

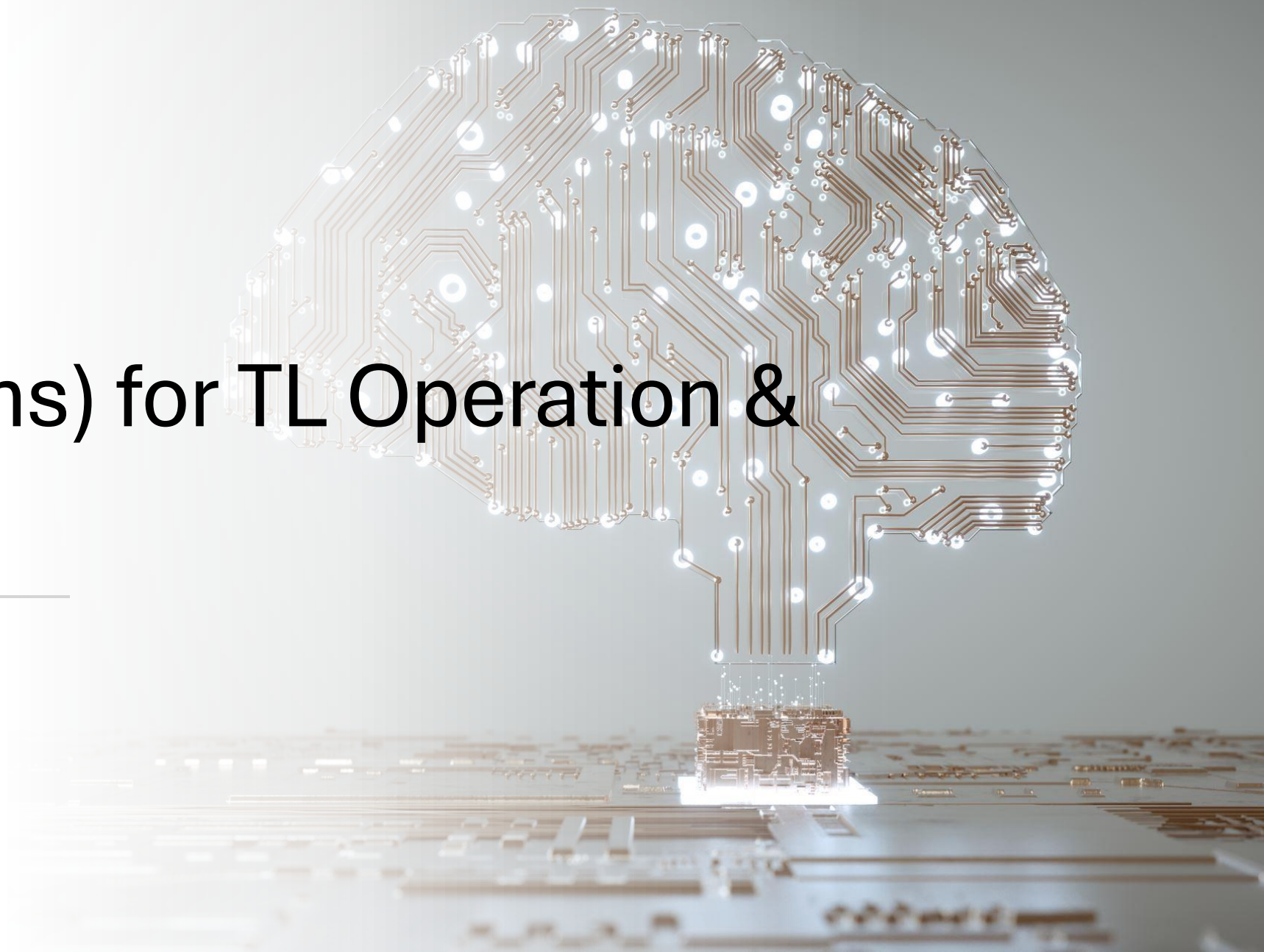
Simulation Models:

- **Static Data**: Uses predefined data and parameters.
- **Focused Analysis**: Studies specific processes or scenarios.
- **Limited Scope**: Primarily for design and development stages.
- **Cost-Effective**: Simpler and less expensive to implement.
- **Predictive Capabilities**: Limited to predefined scenarios.

AI in Design, Prototype and Testing

- DT to be utilized in design of physical assets of transmission line projects, such as tower, conductor, insulator and hardware.
- DT could automatically generate a tower model with required base-width, leg angle, cross-arm width, peak height, etc based upon voltage level, number of circuits, and power evacuation requirements.
- Dt might be able to select optimal member size based upon the tower type, applied forces such as weight and wind spans, deviation angles, type of member under consideration, etc.
- Digital twins could be utilized to predict failure points in tower tests and further optimize design for a reduced weight and greater load bearing capacity.
- DT can avoid the extent of destructive test to be done

AI (Digital Twins) for TL Operation & Maintenance



Digital Twins for TL: Grid O&M

Digital twins allow operators to monitor the data collected from grid components in real-time, providing a comprehensive view of the network's performance. This includes:

- Gaining accurate visibility on the load flow even at low voltage levels where most solar energy, for example, is injected
- Identifying congested areas,
- Monitoring the health of critical portions
- Identifying the DLR of Transmission Line
- Study the impact of Renewable integration

Digital Twins for TL: Asset Management

Digital twins can provide a detailed understanding of each component’s condition within the grid.

Asset managers can optimize maintenance schedules based on actual equipment conditions rather than fixed intervals.

In addition to simulating the impact of new connections, expansions, or upgrades, digital twins help ensure that as the grid evolves, it maximizes efficiency and reliability.

Emergency Plan

Digital twins can also simulate various emergency scenarios, such as natural disasters, critical component failures, or cyber-attacks.

By modeling these scenarios, operators can visualize how the grid might be impacted and develop more effective mitigation strategies and response plans.

Successful AI Implementations

DALIA Project

- The collaboration between Elewit and Aerolaser System has resulted in the *Detecting Anomalies in Lines Inspection Autonomously* (DALIA) project. The project's goal is to **optimise overhead power line inspections**, achieving a higher level of automation in monitoring and diagnosis. This is done with an image processing solution using **computer vision, AI**, and by creating **digital models** of installations using **LiDAR technology**.
- A **digital twin of the entire infrastructure managed by Red Eléctrica, Redeia's subsidiary responsible for the electricity transmission and operation in Spain, is in the process of being created**.

Successful AI Implementations

Digital twin of European electricity grid to be developed

Jonathan Spencer Jones • Dec 28, 2022

Share

From l. Vincenzo Ranieri, President, EU DSO Entity and Hervé Laffaye, President, ENTSO-E Assembly.

Europe's transmission and distribution system operators through their associations ENTSO-E and EU DSO Entity are to develop a digital twin of the region's electricity grid.

In a declaration of intent the two industry organisations have committed to the joint development of the digital twin as part of the ongoing digitalisation of the energy sector.

The proposal for a digital twin of Europe's electricity grid was one of those in the European Commission's action plan for digitalising the energy sector, which was released in October 2022.

The digital twin will be a sophisticated virtual model of the European electricity grid. Its aim is to support the development of innovative solutions and coordination of

Successful AI Implementations

Companhia Energética de Minas Gerais S.A. (CEMIG), a Brazilian power company, has implemented Digital Twin for their grid monitoring, allowing them to optimize assets, reduce operation costs, and minimize carbon emissions.

Fingrid, Finland’s transmission system operator, launched ELVIS - a digital twin model in 2016.

AEP Transmission, a division of American Electric Power transitioned to an Electrical Digital Twin model in 2017.

Thank You