

Cutting-Edge Technologies Transforming Environmental Practice: AI, IoT, Geospatial Technology, and Digital Twins

Panelists



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**The National Association of
Environmental Professionals
(NAEP) Conference**

Anchorage, Alaska

11:30 AM – 1:00 PM, Tuesday, May 12

Breakout 2: Technology



Agenda

- Overview of Cutting-Edge Technologies Transforming Environmental Practice: AI, IoT, Geospatial Technology, and Digital Twins
- AI in Environmental Documentation
- Geospatial AI (GeoAI)
- AI and Automation in Data Collection and Analysis
- Environmental Concerns
- Risks, Defensibility, and Professional Judgment
- Panel Discussion

Overview of Cutting-Edge Technologies

Definitions

What are these technologies in simple terms?

AI or Artificial Intelligence

- The capability of a machine to imitate intelligent human behaviors like learning, reasoning, problem-solving, and making decisions

IoT or Internet of Things

- The networking capability that allows information to be sent to and received from objects and devices using the Internet

GeoAI or Geospatial Artificial Intelligence

- The integration of AI with location-based data to automatically detect patterns, map features, and make predictions about the physical world

Digital Twin

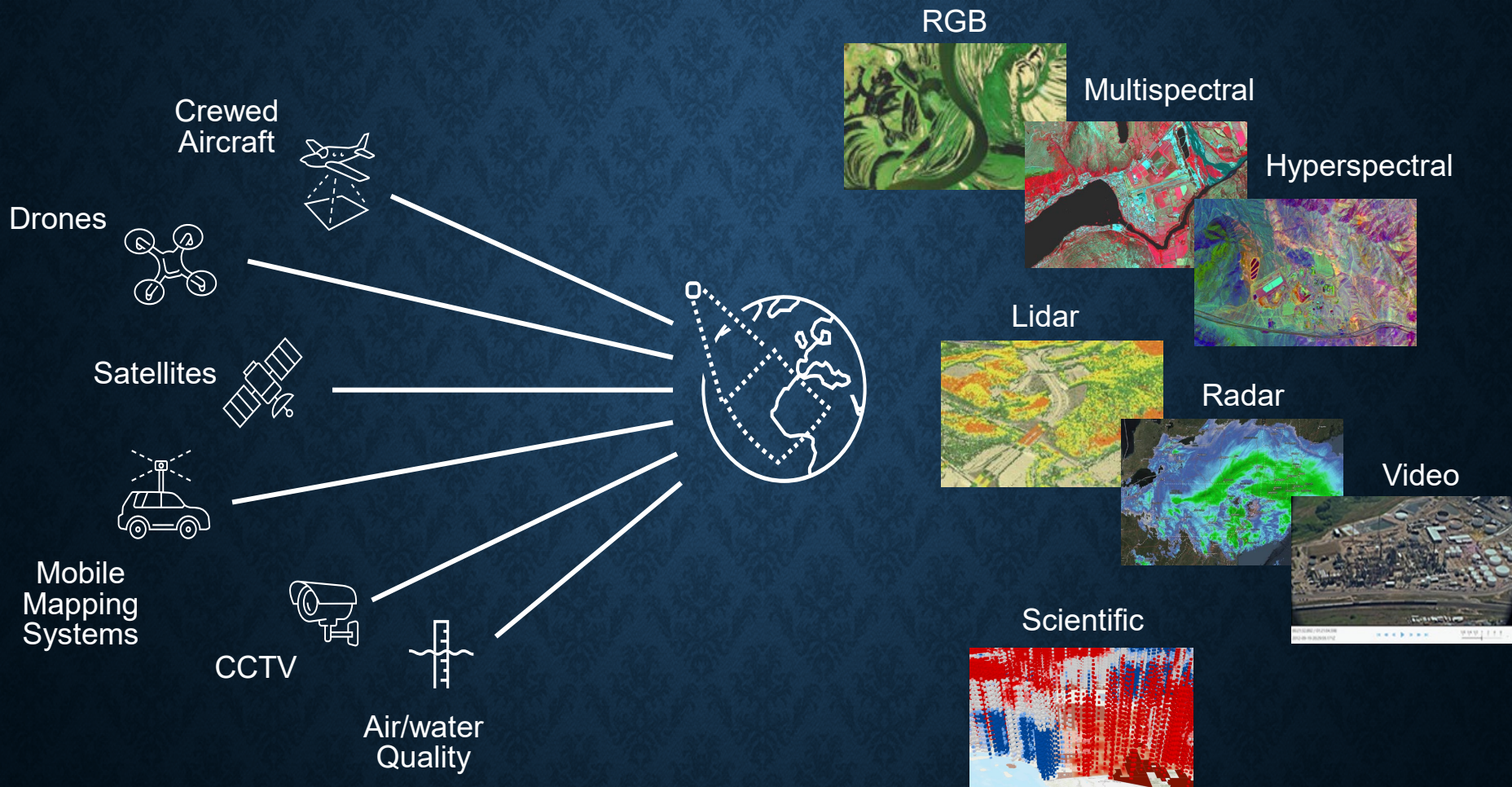
- The dynamic, virtual representation of a physical asset, system, or process, synchronized in real time using IoT sensor data, machine learning, and software analytics

What Is a GIS?

A System for Managing, Sharing, and Applying Geographic Information



Remote Sensing and Imagery



Field, Reality, Real-time

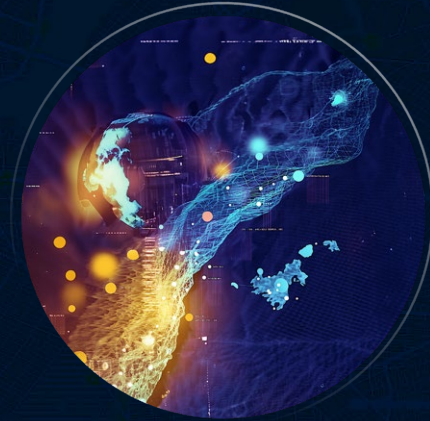
Three legs of the table



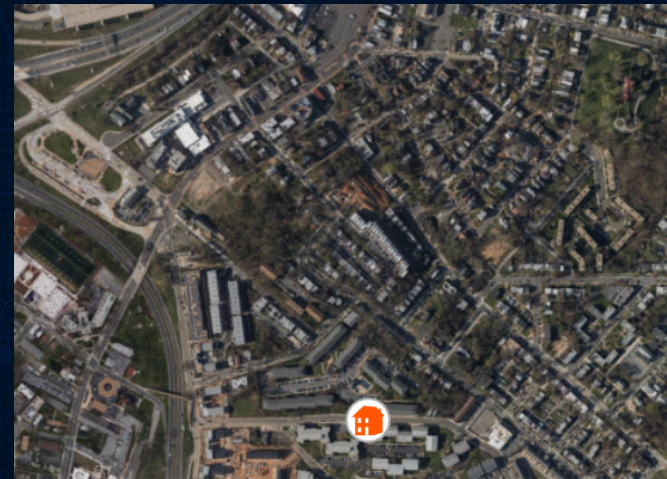
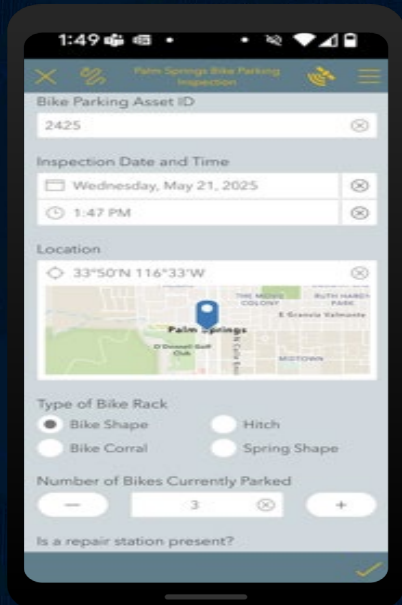
Field Mapping



Reality Mapping

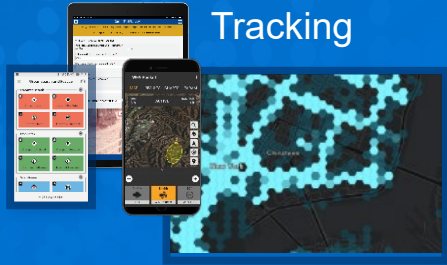


Real-time

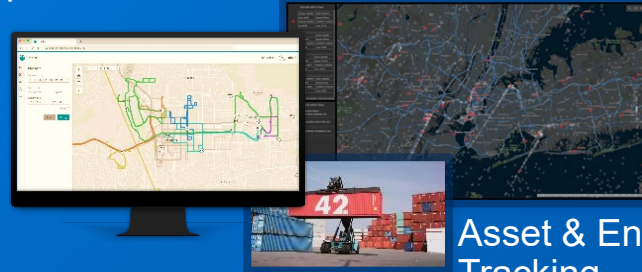


Real-Time in the Real World - IoT

Personnel Tracking

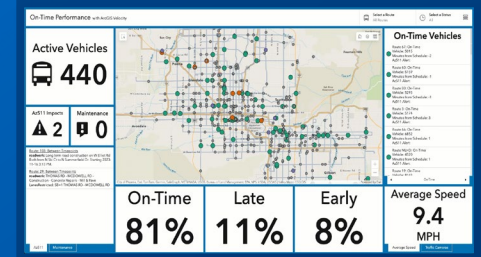


Resource Optimization

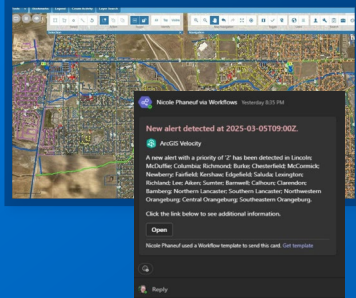


Asset & Entity Tracking

Traffic & Connected Cars



Work Order Automation



Infrastructure Protection



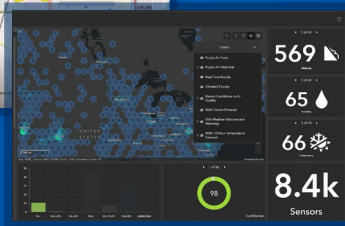
Security Operations Monitoring



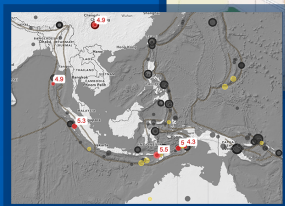
Soil & Crop Monitoring



Air Quality Monitoring



Anomaly Detection



Digital Twins



Artificial Intelligence

Machine Learning

Deep Learning

Generative AI

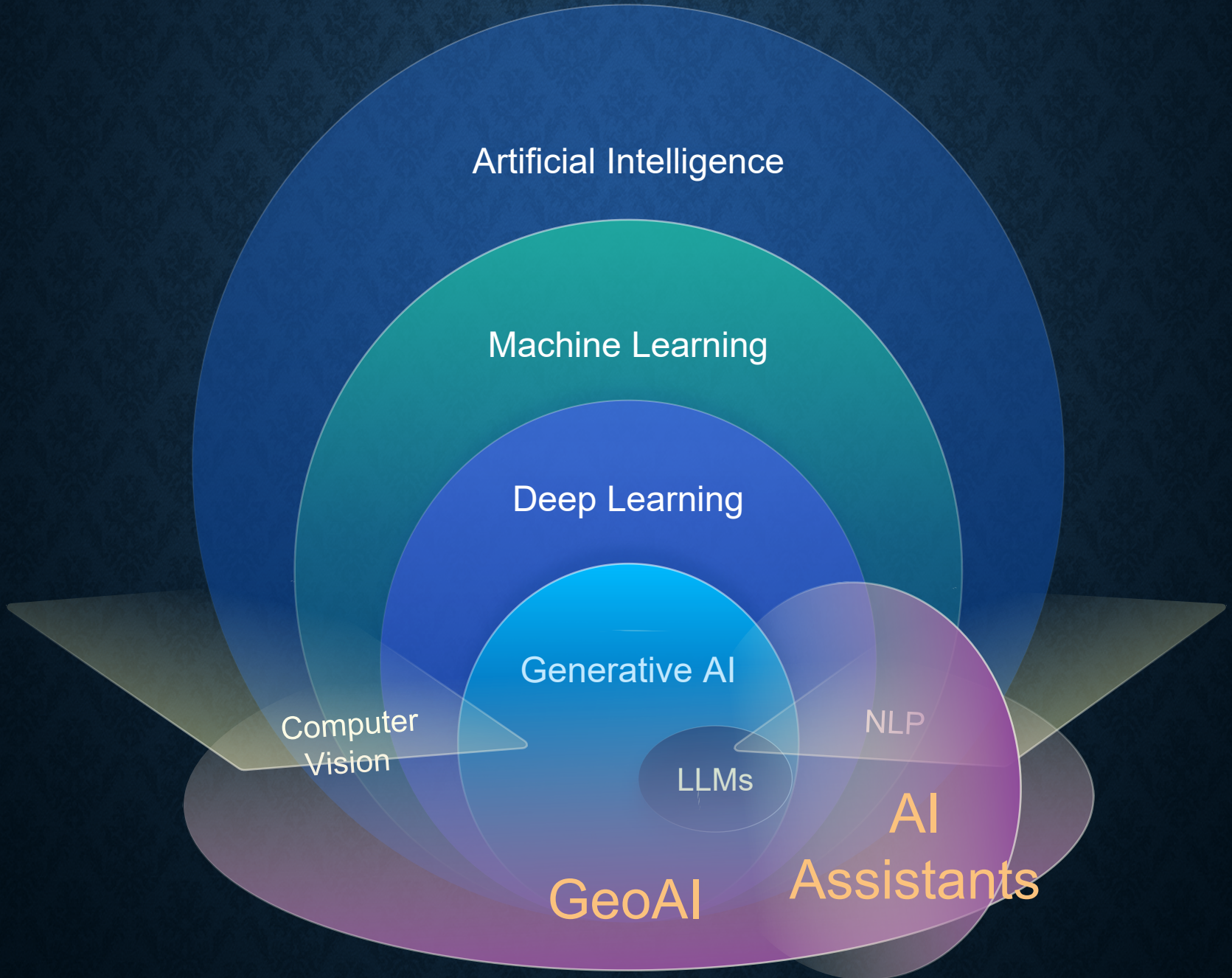
Computer
Vision

LLMs

NLP

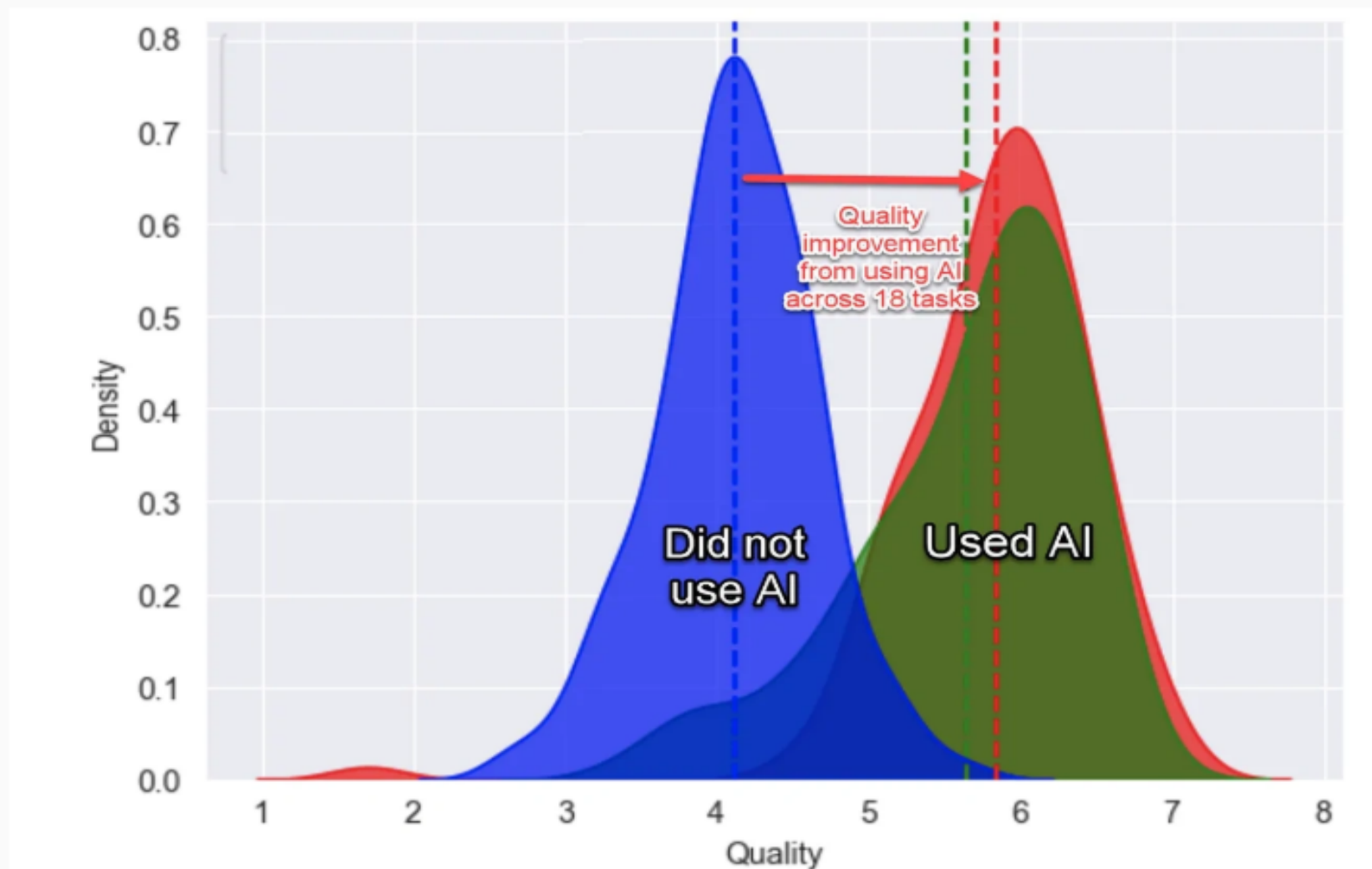
GeoAI

AI
Assistants



Knowledge workers have measurable performance gains when deploying Generative AI

Based on the research of Fabrizio Dell'Acqua, Edward McFowland III, Karim R. Lakhani



What is a Digital Twin?



A data-driven virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity.

Understanding, Decision Making & Action

Transform businesses by accelerating and automating holistic understanding, optimal decision-making, and effective action.

Outcomes, Use cases, Integrations

Are motivated by outcomes, tailored to use cases, powered by integration, built on data, guided by domain knowledge, and implemented in IT/OT/ET systems.

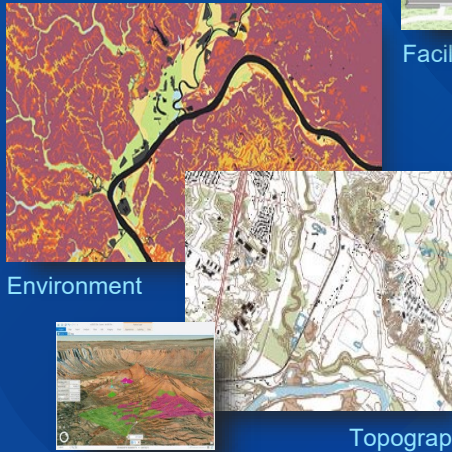
Past, Current & Future

Use real-time and historical data to represent the past, present and simulate predicted futures.

Building from Existing Approaches

Digital Twins are Abstracting and Modeling Everything

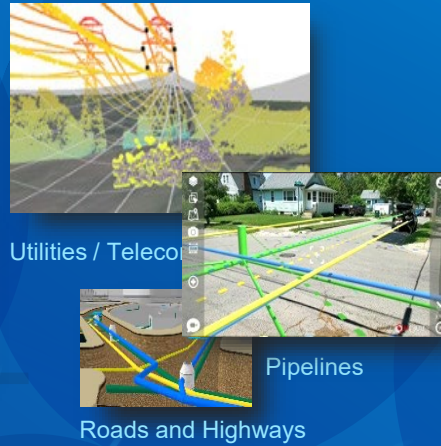
Landscapes (LIM)



Facilities or Buildings (BIM)



Networks (NIM)



Cities (CIM)



Digital Twin Maturity



01. DESCRIPTIVE
Virtual representations of the physical assets or networks

Reality Mapping

Virtual Model (Static)

2D/3D Data

02. INFORMATIVE
Real-time connection to sensors from multiple sources

IoT Sensors

Analytics

Connected Data Environments

Virtual Model (Dynamic)

03. PREDICTIVE
Capable of predicting outcomes

AI / ML

Forecasting & Simulations

Advanced Analytics

04. COMPREHENSIVE
Scenarios of outcomes to make recommendations

Scenario Based Modeling

Remote Controlled Inspections

05. AUTONOMOUS
Self learning and decision making with no human interaction

Autonomous Operations

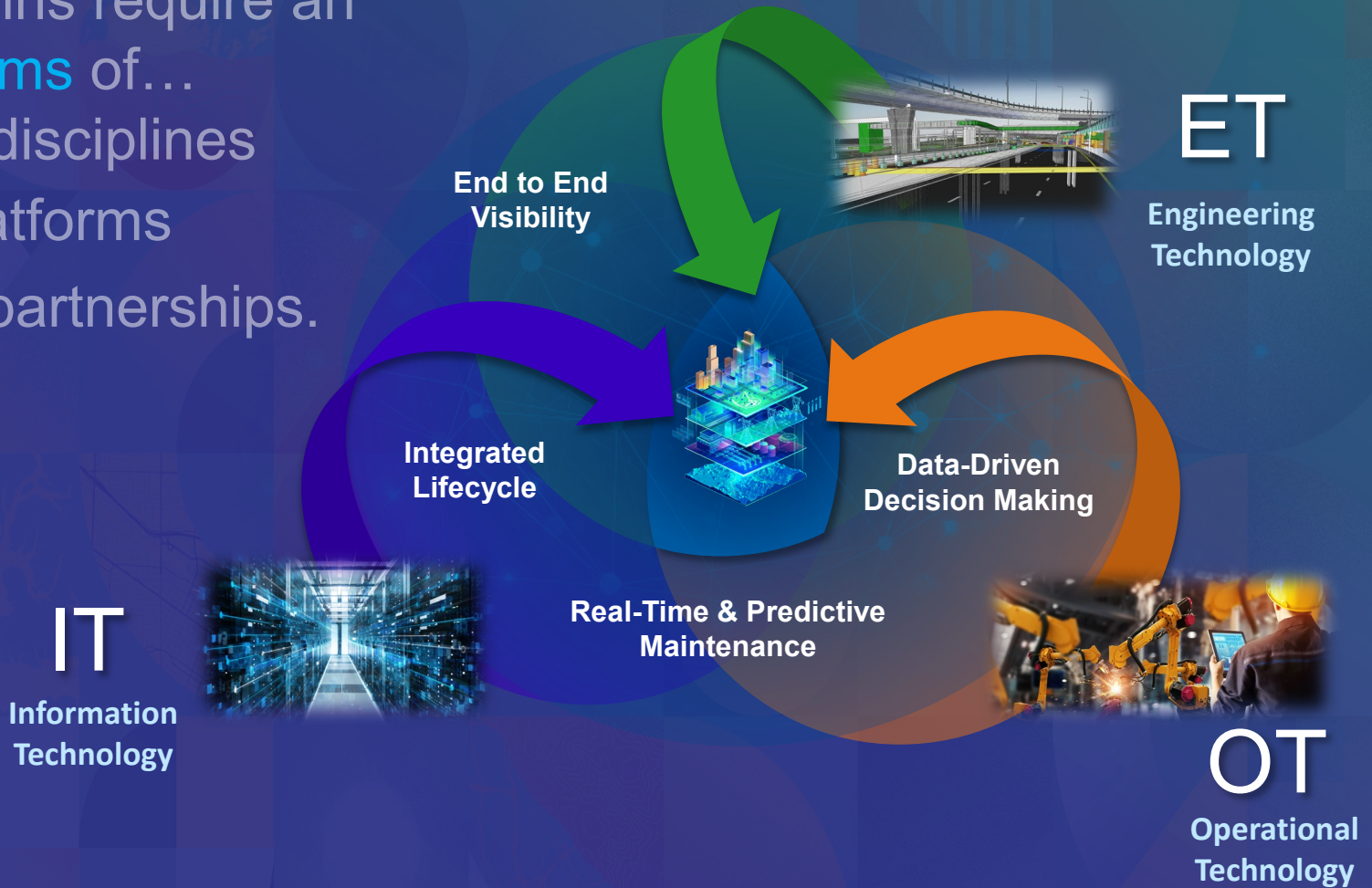
Adaptive

AI Assist & Decision

Living Digital Twin

IT, OT, and ET System Convergence

Digital Twins require an ecosystems of...
...disciplines
...platforms
...and partnerships.



Geospatially Digital Twins

Location is foundational for digital twins

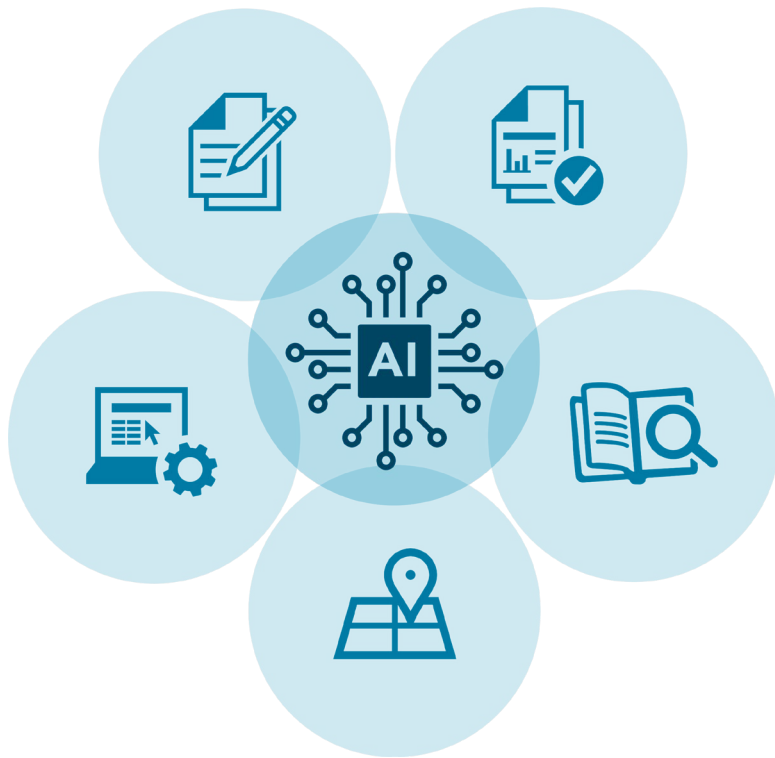


AI in Environmental Documentation: *Use Cases, and Future Potential*

AI in Environmental Documentation

- What we mean by environmental documentation
- The problem AI is solving
- The AI technology landscape
- How AI is applied in practice

How AI is Being Used in Environmental Documentation



- Draft environmental documents (NEPA, permit applications, technical reports)
- Synthesize and summarize environmental data
- Analyze regulatory requirements
- Screen sites for risk
- Support permitting and workflow Processes

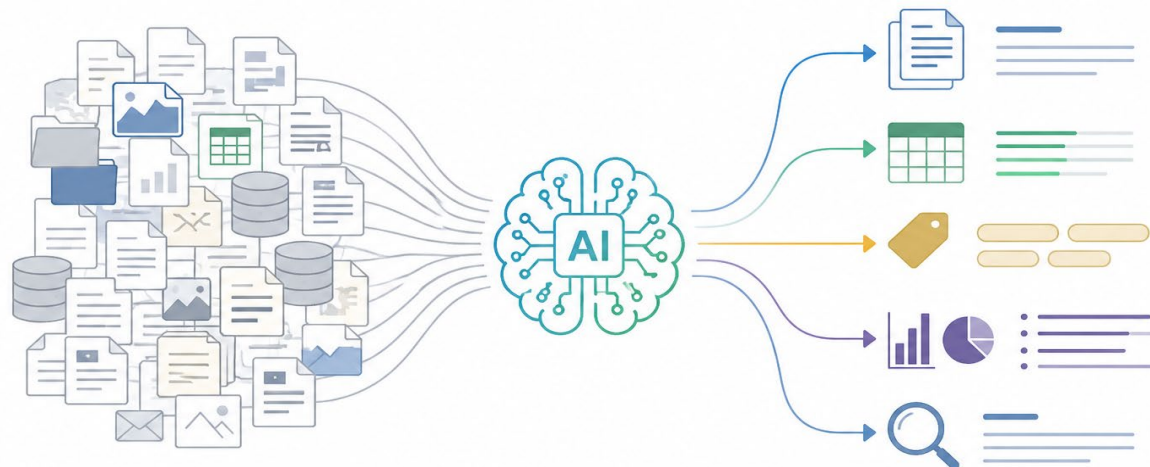
Why Practitioners are Turning to AI

- Work is text-heavy, iterative, and deadline-driven
- Risk often comes from process — not just conclusions
- Increasing data volume and complexity
- AI can improve efficiency — or amplify mistakes



Where AI Adds Value

- Early issue spotting and risk framing
- Organizing large volumes of information
- Improving clarity and consistency across documents
- Supporting, not replacing, professional judgment

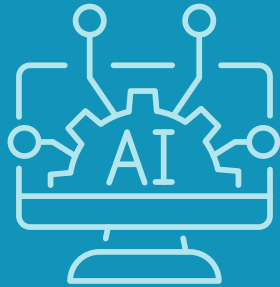


Where AI Should NOT Be Used

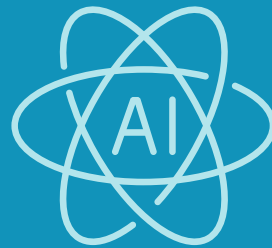
- Make regulatory or legal determinations
- Determine significance of impacts
- Select methodologies or thresholds
- Replace professional judgment



AI Technology Landscape



General AI
Platforms
(LLMs)



Enterprise/
Workflow AI
(e.g., Copilot,
internal tools)



Specialized
Environmental
AI Tools

General AI Platforms (LLMs)

- ChatGPT (OpenAI) – drafting and structuring content
- Perplexity AI – research and sourcing information
- Claude – reviewing and summarizing long documents
- Others



OpenAI



perplexity



Claude

Enterprise & Workflow AI

- Microsoft Copilot (Word, Excel, Teams)
- ChatGPT Enterprise
- Internal knowledge systems (firm-specific tools)
- Integrated with project data and documents

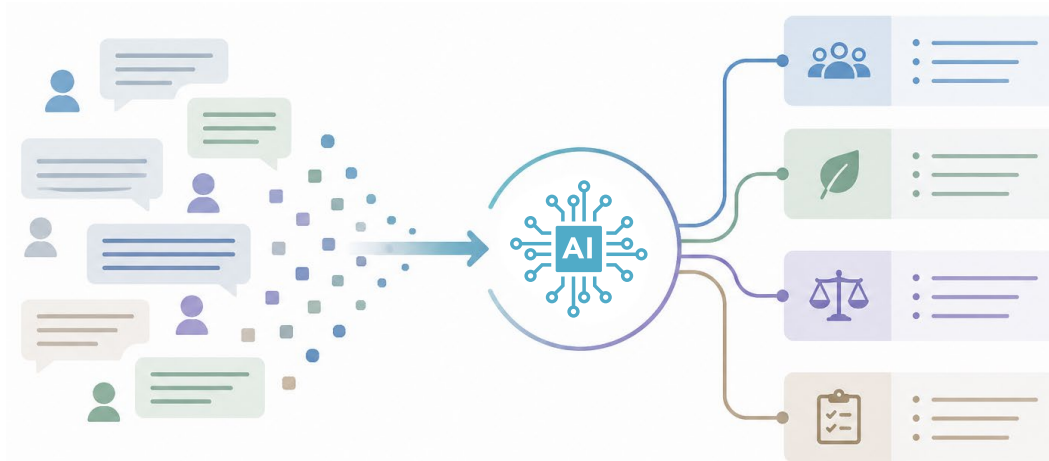


Specialized Environmental AI Tools — Examples

- PermitAI — NEPA document analysis and search
- LandGate — site screening
- Blueman / EnvisorAI — land use and permitting screening
- GeoAI platforms — spatial analysis and modeling (deep dive by Esri)

Example Use Cases

- NEPA drafting support
- Public comment organization and response support
- Environmental screening
- Mitigation Tracking and Reporting



ChatGPT and Similar Chat Tools



Strengths

- ✓ Summarizing text
- ✓ Drafting content
- ✓ Rewriting content
- ✓ Brainstorming
- ✓ Explaining



Weaknesses

- ✗ Reasoning over a problem
- ✗ Formulating solution strategies
- ✗ Taking actions
- ✗ Connecting to your data and systems
- ✗ Iterating and adjusting to new information

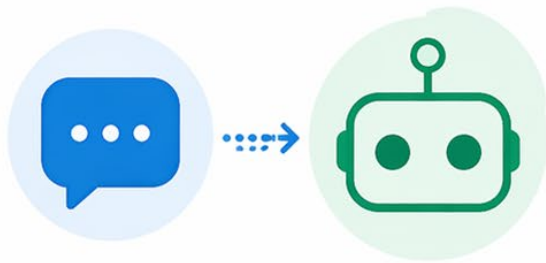









Great at working with content.

Not designed to reason, act, or adapt on your behalf.



How Chatbots Differ from Agents



TOPIC	 CHATBOT	 AI AGENT
 Main job	Generate responses from prompts based on model training	Work toward a goal across multiple steps
 Tool use	Usually limited	Depends on tools to gather information and take actions
 Memory	Often short-lived and session based	Tracks task state, intermediate results, and next actions
 Best use	Writing, summarization, ideation	Workflow support, coordination, document-heavy processes
 Main risk	Wrong or nonsensical answers	Bad decisions, wrong actions

AI Benefits to Environmental Planning



Let's Connect!

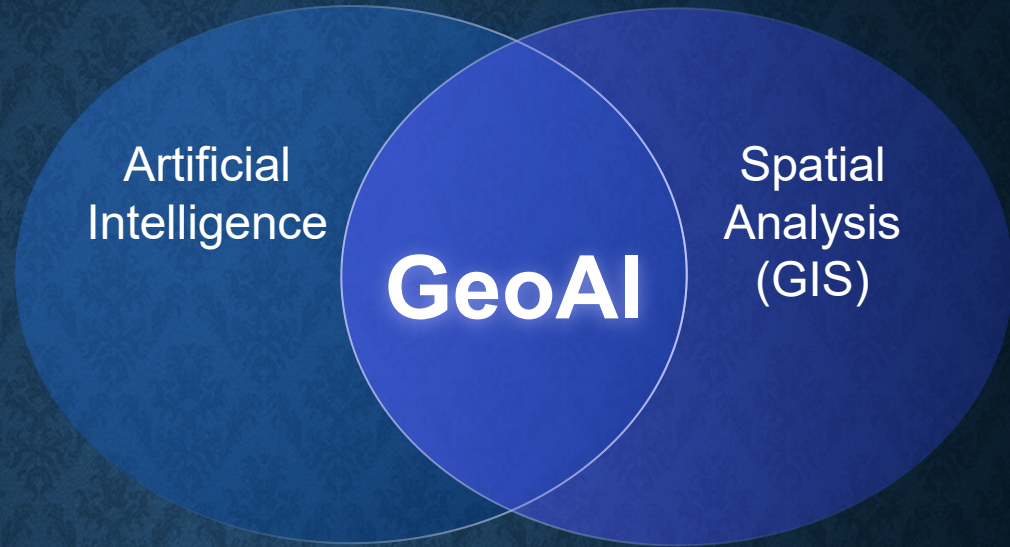


- Faster drafts
- Improved consistency across documents
- More time for QA/QC and technical review
- Stronger focus on defensibility and strategy

Geospatial AI – GeoAI

Generating Rich
Spatial Data

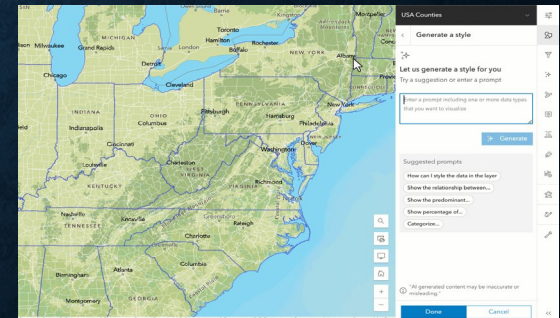
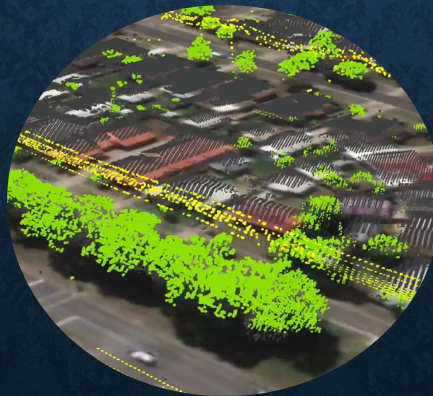
Solving Complex
Spatial Problems



Automation

Analysis

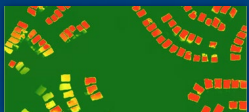
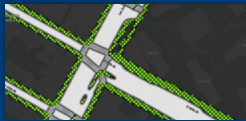
Productivity



GIS Is Being Enhanced with AI

Integrating the Power of GIS and AI

Advancing Science



Foundation,
Vision Language Model
& Embedding

100+ Pretrained Models
... Open & Extendable



GeoAI
(Tools & Models)



Natural Language

AI Assistants
(Improve Access
& Efficiency)

Secure &
Trustworthy

Productivity



Show all the pedestrian injuries that have occurred with 2 miles of Z100 Foxhall Road, NW, Washington, DC 20007

Supporting

- Documentation
- Tech Support
- Mapping & Analysis
- Code Generation
- App & Solution Creation
- Translation

Making GIS easier
... and more intelligent

Pretrained GeoAI Models

Streamlining workflows across industries



State & Local Government



Land Cover Classification



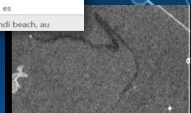
Pool Segmentation (SAM)



Optical Character Recognition

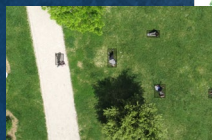
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26, cl palmitos, 4130, es	26, cl palmitos, 4130, es
campbellparade, bondi beach, au	campbell parade, bondi beach, au

Address Correction



Oil Spill Detection (SAR)

Public Safety



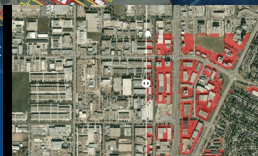
Human Detection (Drone Imagery)



Optical Character Recognition



Parking Spot Detection



Parking Lot Detection

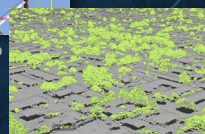
Transportation



Insulator Defect Detection



Transmission Tower Structures



Tree Point Classification

Conservation



Waterbody Extraction (USA)

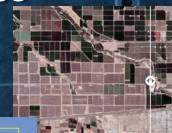


Seabird Detection



Elephant Detection

Utilities

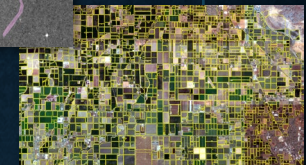


Solar Photovoltaic Park Classification (Global)



Oil Spill Detection (SAR)

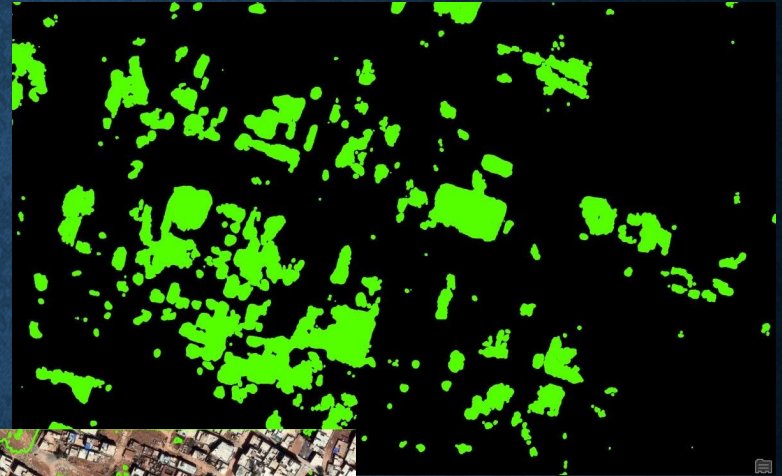
Natural Resources



Agricultural Field Boundary



Flood Impact Analysis – Lost Green Space Extraction with GeoAI

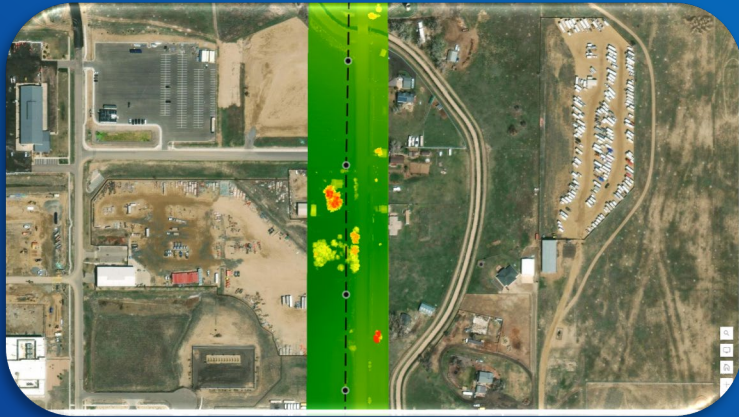


The approximately lost area of 105.6 square kilometers of 927.2 A lost area of ~ 11.3%.

- Satellite Imagery
- Image feature extraction
- Deep Learning, GeoAI
- Green Spaces Damage Assessment



Vegetation Encroachment Analysis



Desktop Transmission Inspection Workflow

Inspection Summary

Jessica Gooch 1
Mike Hirschheimer 1
Brian Berube 4

Inspection Points

Inspector Name	Date and Time	Observation	Priority
Mike Hirschheimer	7/31/2023, 9:00 AM	Broken Bolt	Critical
Brian Berube	7/28/2023, 12:26 PM	Foundation degradation	Moderate
Jessica Gooch	7/31/2023, 11:00 AM	Fill Material Observed-Lan...	Low
Brian Berube	8/1/2023, 8:22 AM	New Gate installed at RO...	Low
Brian Berube	8/1/2023, 9:22 AM	Vegetation for Removal	Moderate





Global Map of Life: Drones, New Sensors, and Geospatial AI Fill in Crucial Species Gaps in Brazil

- **Closing the Data Gap** with autonomous drones and ultra-high-resolution imagery
- **GeoAI Efficiency** with machine learning models to automatically analyze massive datasets to identify tree species and wildlife
- **Digital Twin Creation** tools integrate spatial data to build "digital twins" of ecosystems
- **Proactive Conservation** by providing near-real-time feedback and proactive data-driven monitoring



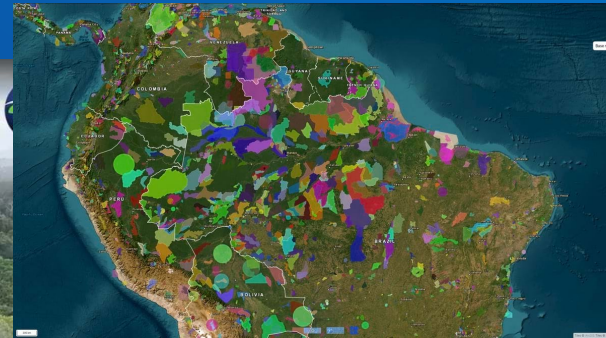
Guianan Saki
Pithecia pithecia



Granular Toad
Rhinella granulosa



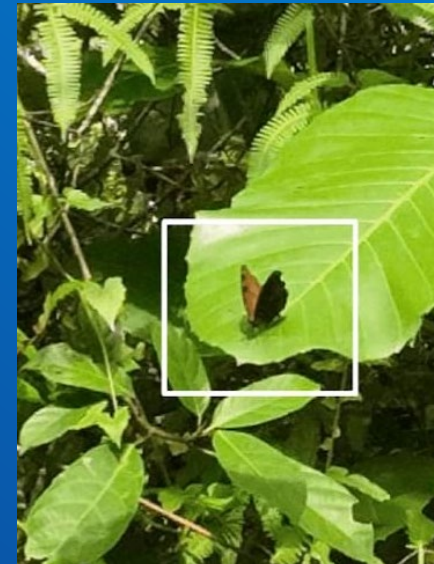
Julia's Butterfly
Dryas iulia



Harpy Eagle
Harpia harpyja

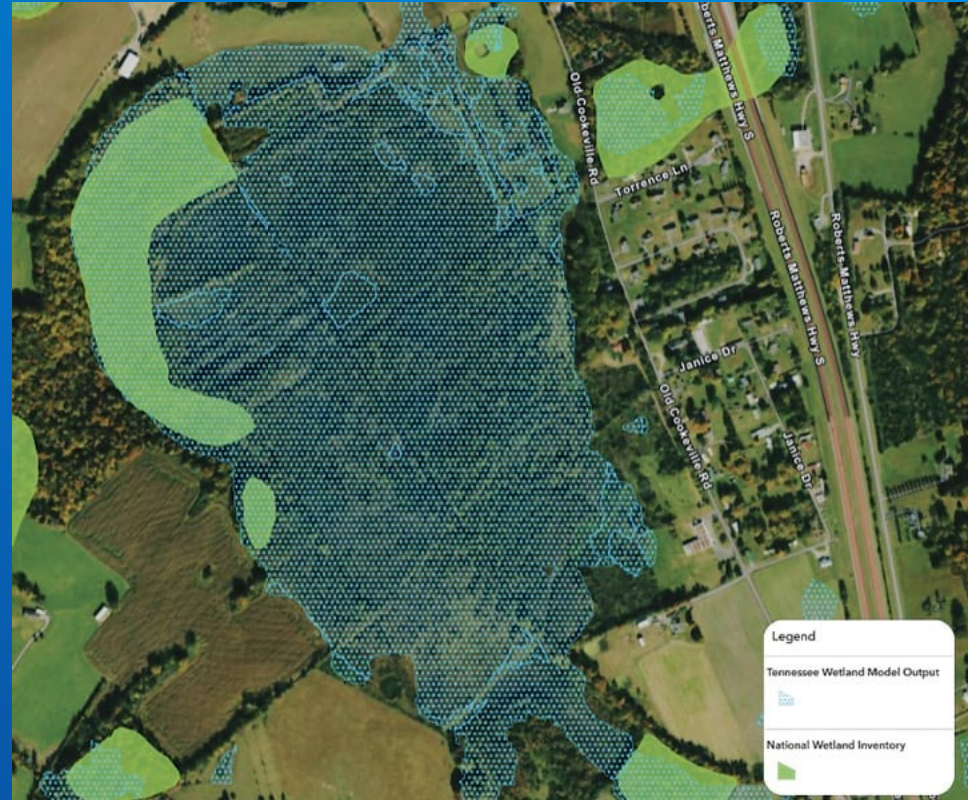
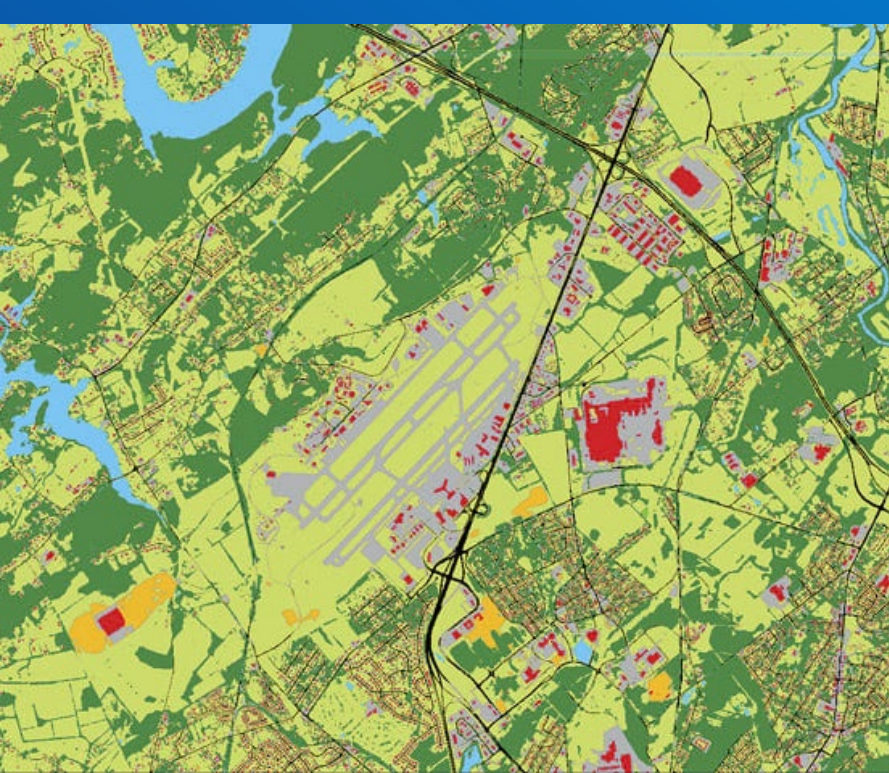


Protium calendulinum





Tennessee Identifies Additional 800,000 Acres of Wetlands with GeoAI-Based Wetland Screening Tool



- Tennessee encompasses 27 million acres
- NWI had estimated 1 million acres of wetlands
- The model has since predicted nearly 800,000 more acres of wetlands
- The tool can help policymakers and developers, as well as farmers and landowners

Technology/Models: Skytec's Wetlands Predictive Model: Esri Wetland Identification Model (WIM), ArcGIS Online, ArcGIS Experience Builder, Deep Learning Models, Imagery

Automation, Data Collection, Analysis, and Reporting

AI and Automation in Field Data Collection Data Capture

How AI is Used

- Computer vision:
 - Auto-extract features from photos or video (e.g., erosion areas, vegetation type, damaged assets)
 - Identify objects (culverts, manholes, wetland boundaries)
- Speech-to-text:
 - Field staff dictate observations hands-free

Example: A field worker takes a photo of a streambank; AI tags erosion severity, bank angle, and vegetation cover automatically.

AI and Automation in Field Data Collection Data Capture

How AI is Used

Real-Time Data Validation - AI checks data before the technician leaves the site.

- Detects missing fields
- Flags outliers (e.g., impossible pH values)
- Validates GPS accuracy and spatial consistency
- Confirms photos match the sampling location

Results: Fewer revisits, higher QA/QC compliance

AI and Automation in Field Data Collection Data Capture

How AI is Used

Automated Classification & Labeling - Instead of manual coding.

- Land cover classification
- Habitat or wetland type identification
- Damage severity scoring
- Asset condition grading

Example: AI classifies field photos into “intact,” “moderately degraded,” and “severely degraded” habitats using trained models.

AI and Automation in Field Data Collection Data Capture

How AI is Used

Edge AI (On-Device Intelligence) - AI models run offline on tablets, phones, or sensors.

- Critical for rural or remote fieldwork
- Enables immediate feedback
- Reduces cloud dependency

Example: Wildlife detection on trail cameras

AI and Automation in Analysis

Remote Sensing & Geospatial Analysis

How AI is used

- Automated land-cover and land-use classification
- Change detection (deforestation, urban growth, wetland loss)
- Feature extraction from satellite and drone imagery
- Large-area mapping at high temporal frequency

Techniques

- Convolutional Neural Networks (CNNs)
- Random Forest, Gradient Boosting
- Transformer-based vision models

Operational examples

- Near-real-time deforestation monitoring
- Wetland and habitat mapping
- Shoreline and coastal erosion tracking

AI and Automation in Analysis Air Quality & Atmospheric Analysis

How AI is used

- Interpolating sparse monitoring stations
- Forecasting pollution events
- Source attribution and anomaly detection
- Street-level air quality mapping

Techniques

- Neural networks
- Spatiotemporal ML models
- Sensor + AI fusion

Operational examples

- Vehicle-mounted sensor networks producing block-by-block pollution maps
- Real-time AQI prediction for public alerts

AI and Automation in Analysis Water Resources & Hydrology

How AI is used

- Streamflow and flood forecasting
- Groundwater level prediction
- Water quality anomaly detection
- Rainfall–runoff modeling

Techniques

- LSTM and RNN time-series models
- Hybrid physics-informed ML models
- AI + IoT sensor integration

Operational examples

- Flood early-warning systems in ungauged basins
- Continuous water quality monitoring with automated alerts

AI and Automation in Analysis Ecology, Biodiversity & Habitat Assessment

How AI is used

- Species identification from images and audio
- Habitat suitability modeling
- Invasive species detection
- Vegetation health and biomass estimation

Techniques

- Computer vision
- Acoustic ML models
- Species distribution models

Operational examples

- Automated wildlife camera analysis
- Drone-based habitat condition surveys

AI and Automation in Analysis Environmental Compliance & Monitoring

How AI is used

- Automated QA/QC of monitoring data
- Outlier and anomaly detection
- Pattern detection across long time series
- Prioritization of inspections and enforcement

Techniques

- Anomaly detection models
- Rule-based AI + ML hybrids
- NLP for field notes and reports

Operational examples

- Early detection of permit exceedances
- Consistent interpretation of field observations

AI and Automation in Data Collection and Analysis

Key Takeaways

01

AI is no longer experimental in environmental data collection and analysis

02

Handle data volume and velocity humans cannot

03

Improve consistency and reproducibility

04

Enable near-real-time insight

05

Support (not replace) scientific and regulatory judgment

Environmental Concerns: AI vs. Traditional Methods



Energy Consumption & Carbon Footprint: AI, especially training large models, requires intense computational power. A single generative AI text query uses dramatically more energy than a traditional search engine query.



Water Usage: Data centers that power AI require massive amounts of water for cooling, often straining resources in drought-prone areas.



Electronic Waste (E-Waste): The rapid advancement of AI hardware leads to short lifespans for GPUs and other components, increasing hazardous electronic waste.



Resource Extraction: Manufacturing AI hardware demands rare earth minerals and metals (e.g., cobalt, lithium), leading to increased mining, soil erosion, and pollution.



Intensity of Use: While traditional computing is static, AI runs 24/7 on high-power servers, making the total footprint exponentially higher over time

Risks and Defensibility & Professional Judgement

- Why AI creates risk
- Core rules for responsible use
- QA/QC framework
- Role of professional judgment



Panel Discussion