

# Artificial Intelligence in Emergency Planning (for Chemical and Other Hazards)

## What is it, and how can we use it?

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1

### Vision

TTI leads in the creation of knowledge that transforms transportation for the benefit of society.



### Mission

TTI delivers practical, innovative and sustainable solutions to improve the movement of people, data, and goods through research, education, and technology transfer.

2



3

## What is artificial intelligence (AI)?

AI refers to software systems that:

- Identify patterns in data
- Generate or summarize content
- Classify and organize information
- Support forecasting and scenario modeling
- Automate repetitive analytical tasks

Its primary value is **efficiency gains in analysis and documentation.**

Currently have “Narrow” AI, “General” and “Super” AI are still concepts

4

4

## Why does this matter now?

AI is increasingly embedded in government operations, reinforced by federal policy direction such as EO 14110 and OMB Memorandum M-24-10.

Emergency planners, managers, and responders will encounter:

- Vendor-driven AI solutions
- Staff (and the public) experimenting with AI tools
- Public expectations for faster, data-driven decisions

The operational issue is not adoption, but **controlled & secure use**

5

5

## What are some AI technology types?

- **Rule-based Systems:** Uses predefined rules for decision-making and automation (e.g., expert systems)
- **Machine Learning (ML):** Learns patterns from data to make predictions or classifications, with rules inferred during training rather than programmed
- **Deep Learning:** Employs multi-layered artificial neural networks to solve complex tasks like image and speech recognition
- **Natural Language Processing (NLP):** Enables computers to generate human language by learning linguistic patterns – e.g., chatbots and translation
- **Generative:** Creates novel content (text, images, audio, code) using advanced models (like LLMs)

6

6

## What are some planning applications?

- Computer vision: Image or object recognition, tracking
- Natural language processing: Understand, generate language
- Generative: Draft plans, summaries, exercise injects
- Predictive: Estimate risk, demand, or consequence likelihood based on past experience
- Geospatial: Analyze exposure, infrastructure, and access
- Optimization tools: Allocate routes, resources, staffing

7

7

## What can't AI do?

AI is not a decision authority or a substitute for local knowledge or regulatory expertise.

It has some important limitations:

- Cannot reliably handle novel or rare catastrophic scenarios
- Cannot guarantee accuracy
- Is dependent on input data quality (garbage in, garbage out)

8

8

# Some planning examples

- Audio transcription and summary of meeting notes
- Image analysis of hazmat placards in transport
- Hazard analysis using image analysis output
- Scenario development using hazard analysis output

# Audio transcription and meeting summaries

The place where it is, it's salient to what you're talking about is we've again working with the Forest Service for fighting forest fires.

You know the the infrastructure is gone.

The cell towers are burnt. Yeah, yeah. There is no communications.

The drones can be brought in to do what you're talking about, a little bit with the situational awareness helping collect data. That's real time, but then also they can carry routers and in the case of the first responders, you know, it's like we know what channels they're using.

And nobody's going to be messing with it.

It's is fairly captive audience now when you start.

Now, if we're talking about scaling that so that.

You know you're not gonna carry a cell tower on a drone.

Well, first net has has in essence a a small cell on a in a box and they'll light up an area with LTE, OK.

Yeah, I was gonna say so.

You, you you know, you could put Wi-Fi in the air, so to speak, a little bit and and do some things.

Is there any research though on use cases and applications of drones in a DOT environment?

I mean that the research project.

There is is. Yeah. Is there.

Yeah, North Carolina is using them.

I mean Western North Carolina.

I think what you're talking about.

Oh, it might be a good research statement for this group to put forward is all I'm saying. Good. I was just gonna say I know North Carolina DOT is using it for flood management, for their courts or coast.

I guess they probably would have wanted to have it out there, but in terms of they have.

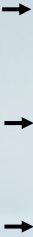
They they use their information.

On where, Where floods are gonna go and you know they get the elevation and they know.

They are.

It is flooding, yeah, but.

And then bridge inspection is another.



- Summary by Topic Areas**
- 1. Identifying Research Gaps in Emergency Management.** Participants emphasized the importance of identifying unmet needs and under-researched areas in emergency management. Key points included:
    - There's a need to assess whether certain technologies or strategies are already being implemented or if they represent true innovation opportunities.
    - Examples of research gaps included unmapped or poorly mapped roads in rural areas such as the Upper Peninsula of Michigan which complicate emergency response and infrastructure maintenance.
    - The idea of a multi-state collaborative study was proposed to inventory and assess such infrastructure gaps.
  - 2. Use of Drones in Emergency Response.** Drones were a central topic, with numerous applications discussed.
    - **Situational Awareness:** Tethered drones used in Colorado provided real-time traffic monitoring during large events.
    - **Infrastructure Inspection:** Ontario and other regions use drones for bridge inspections, capturing high-resolution imagery and thermal data to detect cracks and structural issues.
    - **Emergency Communication:** In wildfire zones where cell towers are destroyed, drones can carry routers or small LTE cells to restore communication.
    - **Public Messaging:** Drones equipped with speakers were used during ice storms to communicate with stranded motorists.
    - **Medical and Supply Delivery:** There was discussion about using drones to deliver critical supplies to remote or mountainous areas, especially during pandemics or disasters.

Transcription using Microsoft Azure AI Speech Service via Teams; Summary using GPT-4 Turbo and GPT4o via Copilot; Enterprise data isolation agreement protection.

# Image analysis of rail hazmat placards



Project: "Hazmat Identification in Transportation Corridors Using Advanced AI Techniques." By S. Samant (PI), L. Ruback, B. Trefz, and D. Bierling. Supported by a grant through the Texas A&M University Advancing Discoveries to Market Grant Program. 11

11

# Image analysis of roadway hazmat placards



Analysis on a locally-hosted model using YOLO architecture.

12

12

# Hazard analysis (1)

UN ID
1999
1075
1203
3257
1267
1993
1992
1863
1663
1992
1999
3257
1203
1824
1073
3257
1786
1203
1993
1267
3257
3257
1307
1202
3286
1760
1073
1203
1789
2672
1992
1993

## 2. Community Hazard Summary

### A. Fire and Explosion Risk (Highest Concern)

Many placards (1203, 1202, 1863, 1075, 1993, 1267) represent highly flammable fuels.

Community implications:

- High potential for vehicle collision fires
- Risk of BLEVE explosions (especially LPG)
- Large radiant heat zones impacting nearby homes, schools, and businesses
- Potential need for wide evacuation zones

AI Hallucinations

### B. Toxic Vapor and Health Hazards

Several materials release toxic or corrosive vapors:

- Nitric acid (1663, 1786)
- Hydrochloric acid (1789)
- Ammonium hydroxide (2672)
- Toxic flammable liquids (1992, 3286)

Uh-oh

Community implications:

- Respiratory injury from vapor clouds
- Shelter-in-place orders due to airborne release
- Long-term health impacts if exposure occurs
- Special risk to elderly, children, and those with asthma

### C. Corrosive Damage to Infrastructure

Corrosive liquids (1760, 1824, 1789):

- Damage roads, bridges, drainage systems
- Create long-term cleanup and soil contamination issues
- Pose major risks to first responders without proper PPE

### D. Thermal and Specialized Industrial Hazards

Prompt:

“These hazmat placard numbers were observed on trucks at a location in a small town. Identify the materials and summarize the hazards for the community from these trucks.”

13

13

# Hazard analysis (2)

Prompt:

“Rank these hazards by worst case accident scenario, then estimate evacuation distances for each.”

## 1. Worst-Case Hazard Ranking (Highest Consequence First)

### Rank 1 — LPG / Propane (UN 1075)

Why highest: Potential for BLEVE (Boiling Liquid Expanding Vapor Explosion)

A single catastrophic rupture can produce:

- Massive fireball
- Structural damage
- High fatalities within seconds

Worst-case scenario: Tank failure after fire exposure

AI Hallucinations

Evacuation distances

- Immediate isolation (all directions): 0.5 mile (800 m)
- Fire/explosion evacuation: 1-2 miles downwind
- Heat-radiation threat zone: Up to 0.75 mile

Uh-oh

### Rank 2 — Gasoline / Jet Fuel / Diesel (UN 1203, 1863, 1202)

Why: Large pool fires, vapor cloud ignition, urban fire spread

Worst-case scenario: Cargo tank rupture with vapor ignition

Evacuation distances

- Immediate isolation: 300-500 m (1,000-1,600 ft)
- Downwind evacuation: 0.5 mile
- If vapor cloud explosion risk exists: Up to 1 mile

### Rank 3 — Nitric Acid (Red Fuming & Standard) (UN 1776, 1663)

Why: Highly corrosive, toxic nitrogen oxide gases, oxidizer

Worst-case scenario: Tank breach forming toxic vapor cloud

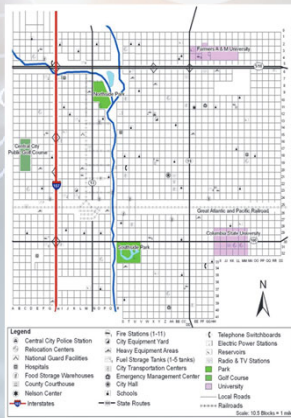
Evacuation distances (toxic inhalation hazard model)

- Initial isolation: 300 m (1,000 ft)
- Downwind protective action distance (night, large spill): 1.0-1.5 miles

14

14

# Scenario Development



## Tabletop Exercise Summary: "Red Plume on Main Street"

### Scenario Overview

This tabletop exercise examines a hazardous materials transportation incident involving UN 1786 (Nitric Acid, Red Fuming) following the rollover of a cargo tank truck on a state highway. The vehicle rolls over, releasing intermittent reddish-brown nitrogen dioxide vapors. The incident occurs adjacent to a mixed-use area, including light industrial properties and nearby residences.

### Incident Conditions

- Weekday, late morning, fair weather with light, steady winds.
- Tank truck upright but damaged, full load onboard.
- Visible vapor release, no fire or liquid pooling observed.
- Potential for toxic inhalation and delayed respiratory injury.

### Key Decision Challenges

Participants must evaluate whether to evacuate, shelter-in-place, or isolate the area based on evolving conditions. The scenario emphasizes application of national hazmat guidance, command authority under political pressure, use of water fog for vapor suppression, and transparent public communication.

### Exercise Focus Areas

- Conditions-based protective action decisions
- Downwind hazard assessment
- Coordination between incident command, elected officials, and public information
- Managing community impact while maintaining safety

### Learning Objectives

The exercise reinforces disciplined risk assessment, appropriate use of shelter-in-place, documentation of command decisions, and clear, calm public messaging during hazmat incidents.

### Core Takeaway

Incidents involving UN 1786 rarely require large-scale evacuation. The most defensible outcomes stem from measured, standards-based decisions guided by observed conditions rather than perceived inconvenience.

## Tabletop Exercise Inject Summary

### Inject 1 – Initial Incident Response

Participants are informed of a cargo tank rollover involving UN 1786 (Nitric Acid, Red Fuming). Shipping papers confirm the material. Responders observe intermittent reddish-brown vapor, no fire, and no liquid pooling. The first decision point focuses on initial isolation, downwind protection, and whether evacuation or shelter-in-place is appropriate based on ERG guidance.

### Inject 2 – Political and Public Pressure

The mayor arrives on scene and expresses concern about evacuating residents and disrupting businesses. Social media activity **increases** and local news coverage begins. Participants must manage elected-official expectations while preserving incident command authority and prioritizing public safety.

### Inject 3 – Operational Complication

The HazMat team identifies a valve packing leak causing a small but persistent vapor release. Discussion centers on whether to use water fog for vapor suppression, the risks of runoff and chemical reaction, and whether this change in conditions alters protective action decisions.

### Inject 4 – Public Health Indicator

EMS reports minor respiratory irritation complaints from individuals downwind of the incident. **Symptoms** are mild but credible. Participants must assess whether these reports trigger expanded protective actions and how to communicate health risk without causing panic.

### Inject 5 – Stabilization and Stand-Down

The leak stabilizes, visible vapor dissipates, and conditions improve. A HazMat contractor is en route. Participants decide when and how to reduce or terminate protective actions, communicate incident resolution, and document command decisions.

## AI hallucination develops a detailed scenario that doesn't match placard IDs

**Prompt:** "Write a tabletop exercise scenario for these hazards; Summarize the scenario in a 1-page MS Word document; Summarize the injects on a 1-page Word document"

Maps adapted from: Integrated Emergency Management Course Exercise Simulation System Document, Version 3.0, December 2015.

15

15

# Post-presentation note on **AI-hallucinations**

The previous three slides demonstrate a core issue with AI:

- **Plausible but false outputs:** AI generated fabricated facts that appeared credible. This issue occurs under "normal" or standard prompting.
- **Error propagation:** Initial inaccuracies are reused and amplified. An "expert" may catch the error, but non-experts will not.
- **Root cause:** AI optimizes statistically for word associations, not truth.
- **Limits of mitigation:** 1) Better prompts (chat customizations) reduce but don't eliminate errors; 2) Users detect issues only within their domain of expertise; 3) Security risks (e.g., prompt injection) can go unnoticed.

Unchecked hallucinations are **systemic**, requiring validation and controls, not just improved prompting.

16

16

## Some core risks of using AI

- Informational risks: Data leakage (storage, reuse, external access); Exposure of sensitive hazmat intelligence
- Analytical risks: Hallucinated or fabricated outputs; Outdated or biased assumptions; Asymmetric information retrieval/analysis; False precision from weak or unverified inputs
- Operational risks: Overreliance by staff; Poor validation practices; Loss of “hands-on” experience by younger staff
- Security risks: Prompt injection attacks; Vendor data retention or misuse; Unauthorized use of personal AI tools

17

17

## Suggestions for AI security

- In addition to formal AI security & risk management frameworks (e.g., NIST, ISO, etc.) consider using a three-tier informal classification system.
  - Green (Public): safe for approved AI tools
  - Yellow (Internal): restricted to managed, audited systems
  - Red (Sensitive HazMat/Security): controlled environments only

18

18

## Considerations for AI safeguards

- **Access and governance:** Approved enterprise accounts only; Multi-factor authentication (MFA); Role-based access control
- **Data protection:** Prohibit sensitive hazmat data in public tools; Ensure vendor contracts prevent data reuse for training; Maintain audit logs and retention policies
- **Operational controls:** Human verification of outputs → AI also hallucinates sources!; Incident response plan for data exposure; Legal and records compliance (FOIA, retention)

19

19

## Example adoption timeline/roadmap

### 0–30 days

- Establish AI policy
- Classify planning data
- Define prohibited uses

### 30–90 days

- Pilot non-sensitive applications
- Train staff

### 90+ days

- Expand controlled use cases
- Integrate into planning workflows

20

20

## Potential priority use cases

- Plan drafting and gap analysis
- Data cleaning and standardization
- Scenario and exercise development
- Hazard ID & risk screening (non-sensitive datasets)
- Training and after-action analysis
- Public communication templates

21

21

## Safe starter use cases

- Rewrite planning documents
- Summarize regulations
- Generate generic scenarios
- Draft alerts and outreach materials
- Translate preparedness content

22

22

## Potential controlled higher-level use cases

- Identify Tier II data gaps
- Prioritize facility inspections
- Model exposure zones (generalized)
- Analyze evacuation constraints
- Support mutual aid planning

**MUST HAVE EXPERT INPUT AND REVIEW**

23

23

## Rural agency suggestions

- Use pre-approved tools from state/federal partners
- Avoid building custom AI systems
- Keep AI internal; avoid public-facing deployments
- Leverage regional/shared services where possible

24

24

# Evaluate AI hype/claims

- What decision does this improve?
- What data are required?
- What are failure modes?
- How is output validated?
- What happens if data are exposed?
- Can operations continue without it?

# Other planning resources

See: <https://hazmattransport.tti.tamu.edu/>

- Texas LEPC Guide (TDEM): Executive Primer; LEPC Handbook; LEPC Projects Guide
- Hazmat and Train Derailment Emergency Planning Guide for School Districts (TDEM): Summary for Planning Leaders; The Planning Framework and Process (Vol. 1); Project Ideas for All Phases of Emergency Management (Vol. 2); Threat & Hazard Assessments (Vol. 3); Emergency Plan Templates (Vol. 4)



Hazardous Materials and Train Derailment Emergency Planning Guide for School Districts and Community Colleges

Volume 2: Project Ideas for All Phases of Emergency Management

2021 Edition (April 2022 updates)



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27

27

# Questions?

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28

28