

What is Artificial Intelligence & Machine Learning... and Why Should Bridge Engineers Care?



Innovative Bridge Technologies/Accelerated Bridge
Construction University Transportation Center
(IBT/ABC-UTC)

What is AI?

Artificial Intelligence is the art, science, and engineering of getting machines to do intelligent things.

Begs the Question:
What is intelligence?



1997
(Deep Blue)



1961
(SAINT)

Answer: It's a moving target, and we don't know.

Rule of Thumb: If a task requires a person now,
it definitely requires intelligence

A Short History of AI: Three Waves

1950s – 1980s

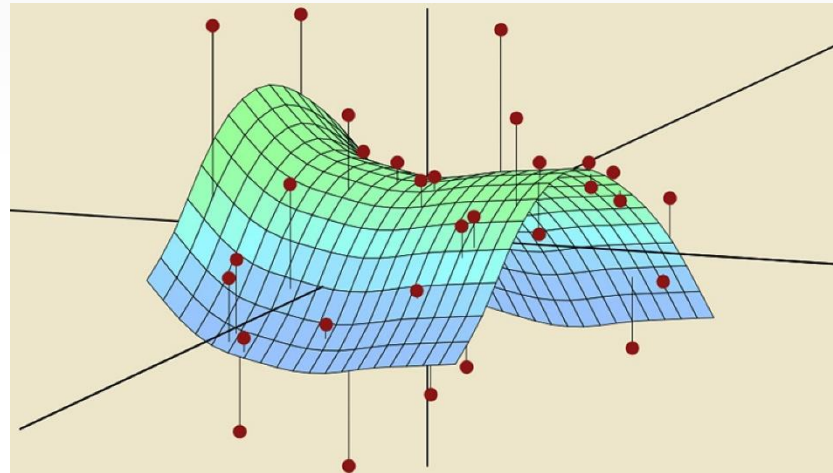
- Turing Test (1950)
- Toy Worlds ('60s)



- Expert Systems (70s–80s)

1990s – 2000s

- Era of “Big Data”
- Scientific Rigor
- Statistical Machine Learning



2010s – now

- GPUs
- Deep Neural Networks



- Neural Large Language Models (LLMs)

Notable Recent AI Successes



- **Speech Recognition**
Engineering Integration
Training Data



- **Machine Translation**
Transformer models
Training Data!



- **Chat Bots**
Reinforcement Learning
TRAINING DATA!!!

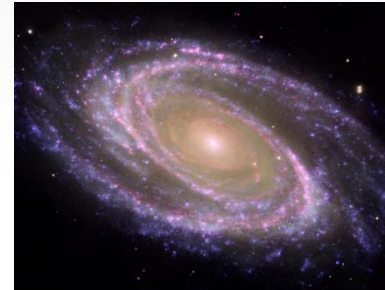
AI vs. Big Data / Data Science

Big Data is extremely large sets of data targeted for pattern analysis
(so large that it cannot simultaneously put it all in one place, i.e., in memory, on disk, etc.)

Youtube: 183 hours of video per minute = 30 years / day

In contrast: **AI Combinatorial Explosion**

1 chess game >



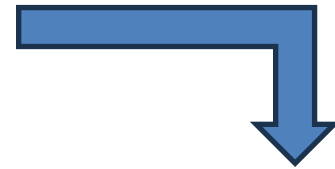
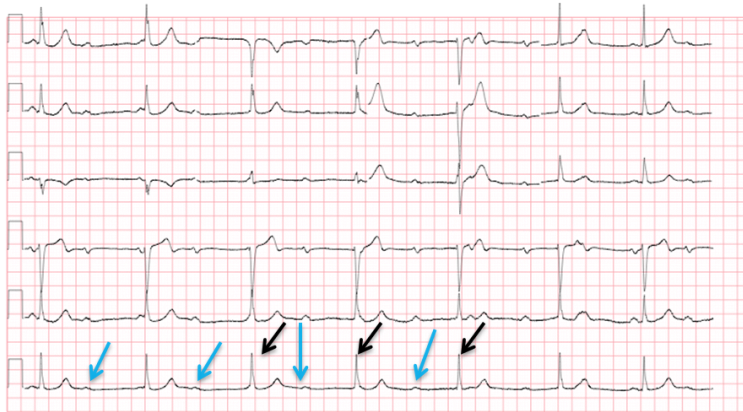
Big Data \neq the right data
 \neq your ability to solve the problem

AI vs. Machine Learning (ML)

What's the Difference?

AI is a lot more than ML

(Supervised) ML =
Train a classification model on
labeled data



Did the patient have a
heart attack? Yes or No

Areas of AI:

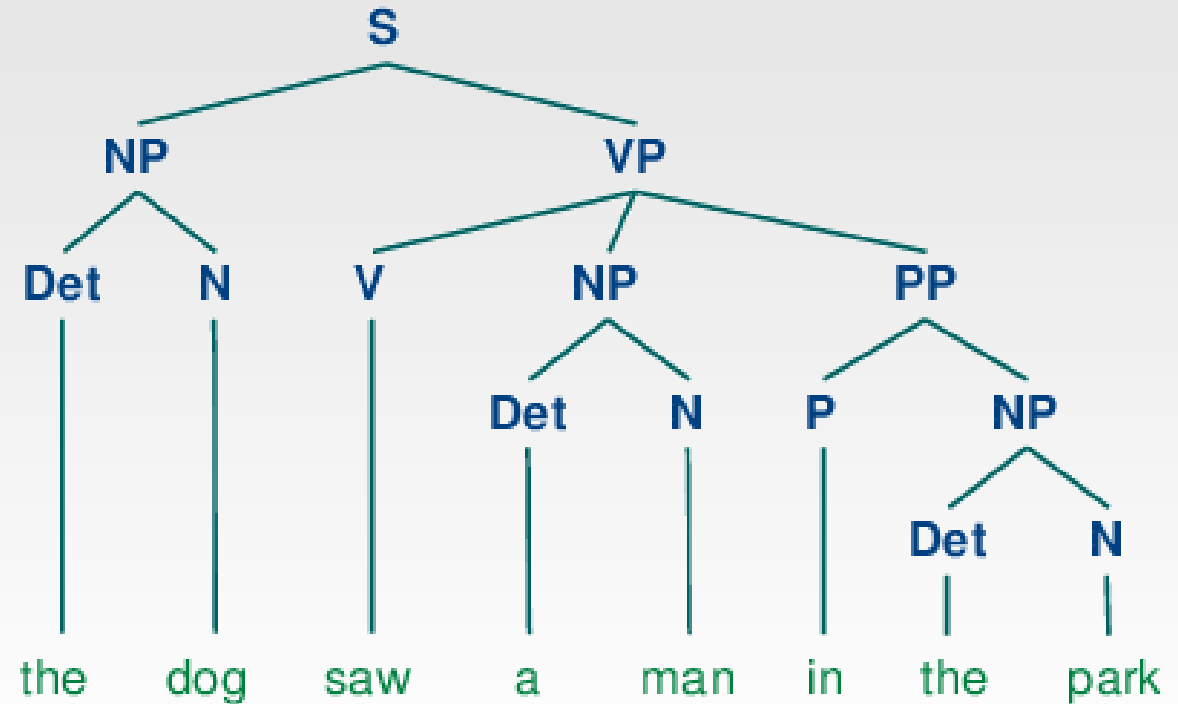
Natural Language Processing
Cognitive Systems, Cognitive Modeling
Game Playing & Interactive Entertainment
Game Theory and Economic Paradigms
Heuristic Search
Human Computation
Human-AI Collaboration
Humans and AI
Knowledge Representation & Reasoning
Multiagent Systems
Planning, Routing, & Scheduling
Robotics
Constraint Satisfaction
Vision
AI & Ethical/Social Questions

AI vs. Natural Language Processing (NLP)

What's the Difference?

Again, AI is a lot more
than NLP

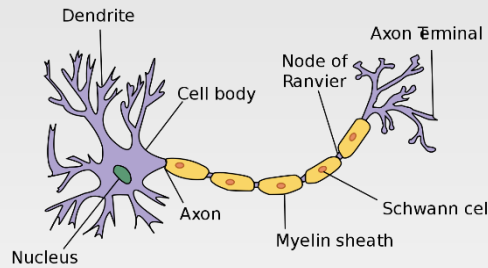
NLP =
computers doing tasks
with human language
requiring intelligence



Syntactic Parsing
Word Segmentation
Morphological Processing
Part of Speech Tagging
Information Extraction
Text Mining
Sentiment Analysis

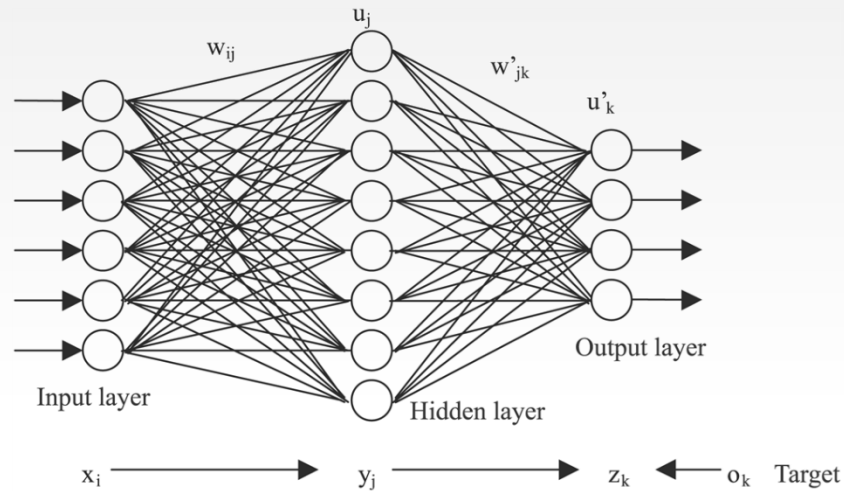
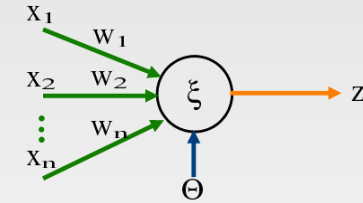
Machine Translation
Opinion Mining
Argument Mining
Question Answering
Document Classification
Discourse Structure
Chatbots

A Recent Advance: Deep Learning

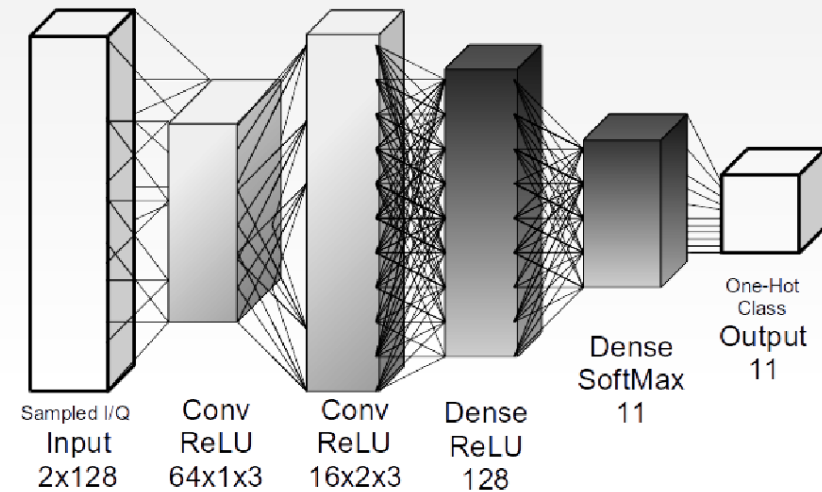


Neurons
(1950s)

Perceptrons
(1960s)



Neural Networks
(1980s–1990s)



Deep Neural Nets
(2010s–Now)

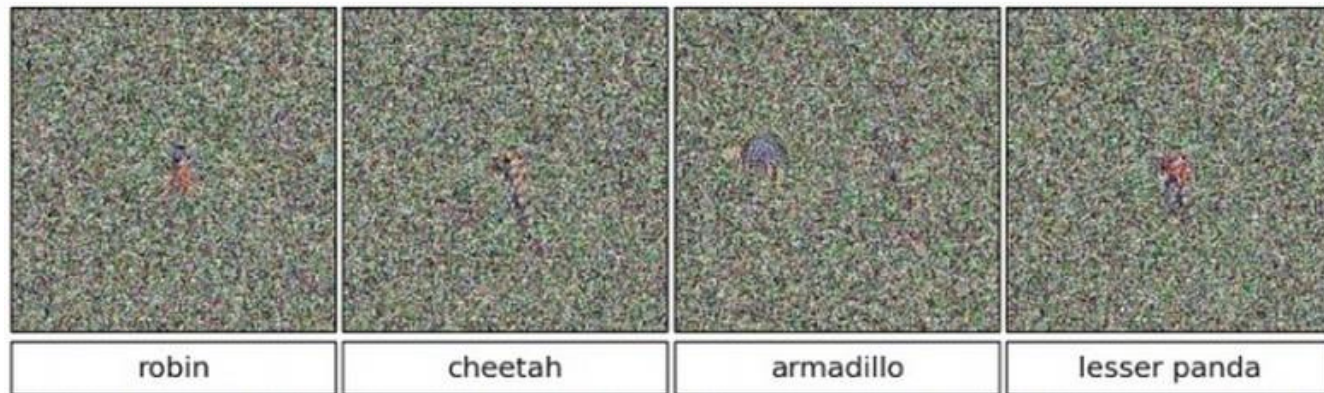
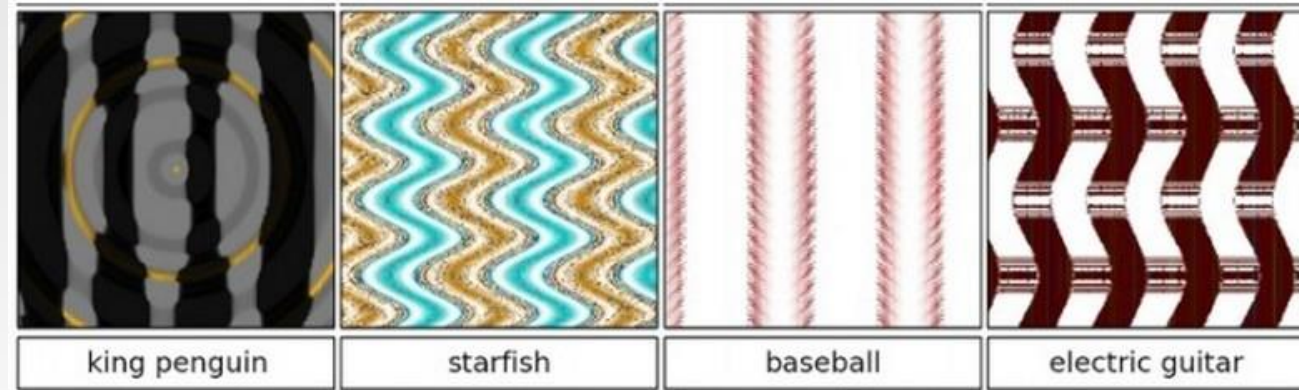
Will Deep Learning “Solve” AI?

Cutting through the Hype (I)

Deep Learning



King Penguin



Generative Models

What is a **Large Language Model** (LLM)...really?



Guess the next word:

The water was so transparent that...

...I, she, he, it, the, John, Mark, ... (10,000 more possibilities)

P = 0.004 0.007 0.001 0.008 0.0009 0.000005 0.00000004



Estimate these from data (e.g., the Internet)

Ingredients:

1. Neural Transformer Models
2. Petabytes of Data
3. Networked Supercomputers



ChatGPT

Cutting through the Hype (II)

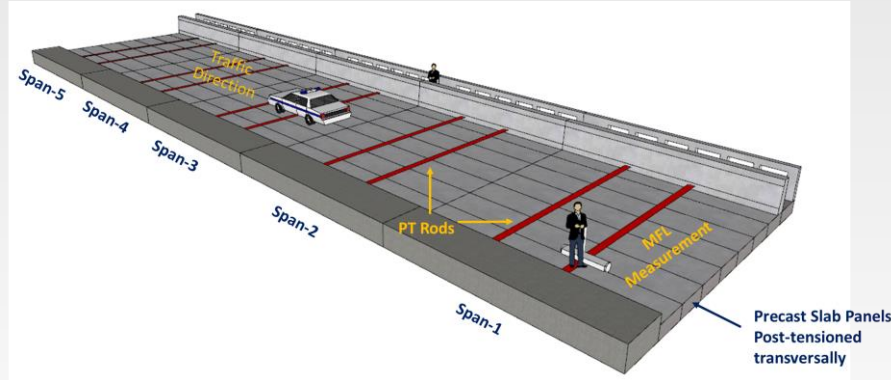
ChatGPT

Stable Diffusion



- No common sense
- Factual errors
- Little specialized knowledge
- Biased, racist, offensive
- Bland, uncreative, over-literal
- Copyright violations

Example 1 – Detect Corrosion Using Magnetic Flux Leakage Method



Supervised Machine Learning can be used to precisely locate anomalies indicated by continuous waveform data

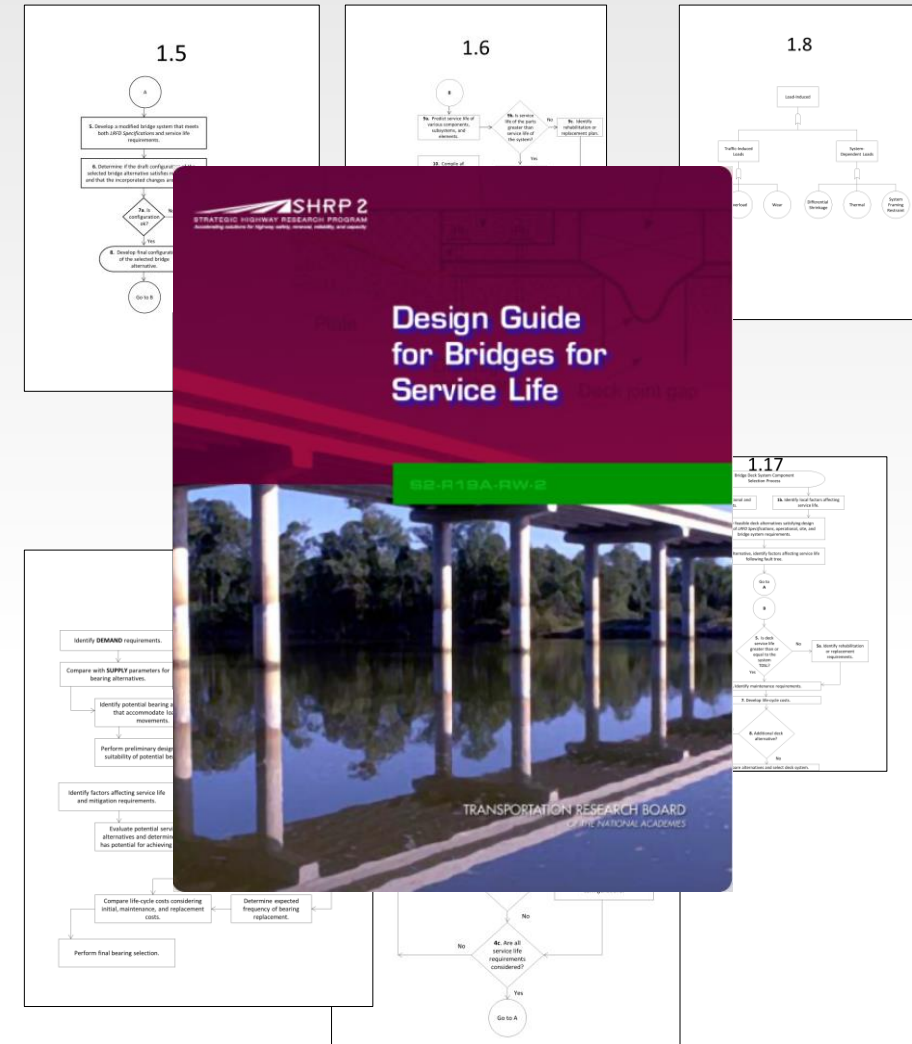
Example 2 – Design for Service Life – SHRP2 R19A (Vision)

Flowcharts in various chapters of Design Guide for Bridges for Service Life involves tremendous amount of information, framework and flowcharts that guide users.

However, it is not very user friendly to use.

An AI-enabled design guide could:

- Identify for the user the relevant sections, based on user input
- Guide the user through design flowcharts
- Prompt the user for additional information needed to make decisions
- Suggest appropriate selections based on user input and guide instructions
- Assemble a full draft design, aligned with the relevant guide sections

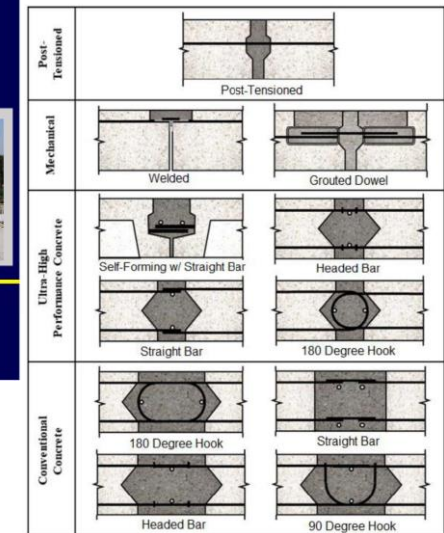
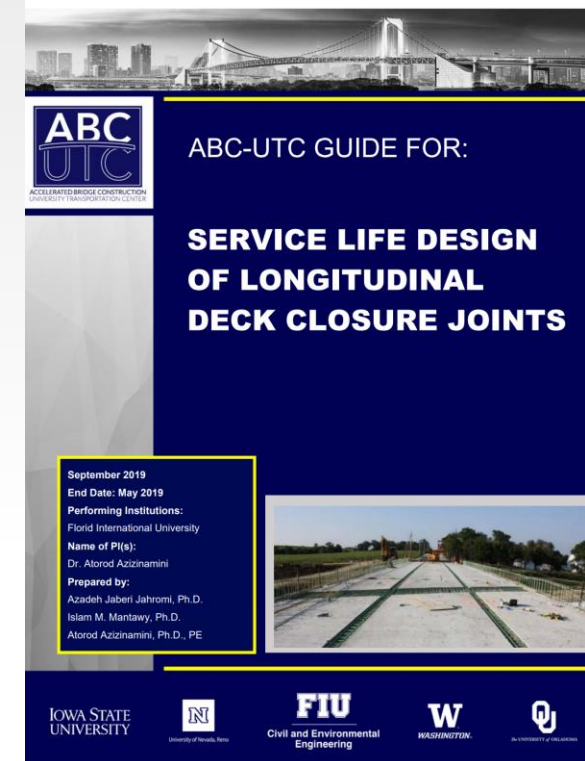


Design for Service Life – Deck Closure Joints – SHRP2 R19A (first step)

We are starting with a subset of the larger document and use AI to walk the user through selecting best detail and materials for longitudinal deck closure Joints

Like the full system, we envision an interactive system which takes natural, chat-like text and guides the engineer through the design process:

- Gathering appropriate information from the engineer
- Suggesting possible solutions for each step with reference to the guide
- Guiding to the appropriate next step in the decision process based on prior decisions
- Assembling the final draft design with pointers to the design guidance



Example 3 – Enhancements to *ABC Project Database* (1 of 3)

Conventional keywords search function with drop-down menus instead of typing in quotes, to make more user-friendly (Non-AI)

The screenshot displays the 'Project Search' page of the ABC Project Database. The top navigation bar includes links for Home, Project Database, Submit Project, Training Videos, Research Database, and Submit Research Project. The breadcrumb trail shows 'HOME / PROJECT SEARCH'. The main heading is 'Project Search'. A note states: '*Note: For keyword searches, use Keywords for Database Search with quotes (example: "Full-Depth Precast Deck Panel w/o PT")'. Below this is a 'Reset Search' button and a search input field labeled 'SEARCH FOR KEYWORDS_*'. A sidebar on the left contains several filter categories: 'STATE' (highlighted with a blue circle and containing a 'filter by state...' dropdown), 'TRAFFIC IMPACT CATEGORY' (with checkboxes for Tier 1 through Tier 6), and 'CONSTRUCTION EQUIPMENT CATEGORY'. The main content area shows 'Found 126 Results'. The first result is '2023 – CO 61 North of Otis, D-25-EA', which includes a photo of a bridge and a list of details: State: CO, Year: 2023, Owner: State, Location: Rural, Beam material: Concrete, Project Planning: State process, benefit/cost method, CM/GC, formalized partnering, Geotechnical Solutions: (blank), Structural Solutions: adjacent box beam, precast abutment cap, precast wingwall, FDcBc {Full-Width concrete-Decked concrete Beam Unit}, precast approach slab, other miscellaneous prefabricated element: precast sleeper slab, CIP reinforced closure joint, socket connection, asphalt overlay w/membrane, Spans: One-span, Max Span Length (ft.): 112, Total Bridge Length (ft.): 118, Impact Category: Tier 3 (within 2 weeks), and Construction Equipment Category: Lateral Slide. The second result is '2019 – Bridge 7345', with details: State: NM and Spans: Three-span.

HOME / PROJECT SEARCH

Project Search

*Note: For keyword searches, use Keywords for Database Search with quotes (example: "Full-Depth Precast Deck Panel w/o PT").

Reset Search

SEARCH FOR KEYWORDS_*

STATE

filter by state...

TRAFFIC IMPACT CATEGORY

- ☐ Tier 1 (Within 1 Day)
- ☐ Tier 2 (Within 3 Days)
- ☐ Tier 3 (Within 2 Weeks)
- ☐ Tier 4 (Within 1 Month)
- ☐ Tier 5 (Within 3 Months)
- ☐ Tier 6 (Longer But Reduced By Months/Years)

CONSTRUCTION EQUIPMENT CATEGORY

Found 126 Results

2023 – CO 61 North of Otis, D-25-EA

State: CO
Year: 2023
Owner: State
Location: Rural
Beam material: Concrete
Project Planning: State process, benefit/cost method, CM/GC, formalized partnering
Geotechnical Solutions:
Structural Solutions: adjacent box beam, precast abutment cap, precast wingwall, FDcBc {Full-Width concrete-Decked concrete Beam Unit}, precast approach slab, other miscellaneous prefabricated element: precast sleeper slab, CIP reinforced closure joint, socket connection, asphalt overlay w/membrane
Spans: One-span
Max Span Length (ft.): 112
Total Bridge Length (ft.): 118
Impact Category: Tier 3 (within 2 weeks)
Construction Equipment Category: Lateral Slide

2019 – Bridge 7345

State: NM
Spans: Three-span

Enhancements to *ABC Project Database* under consideration (2 of 3)

AI-enabled ingestion to develop draft submissions for database (initial data from Monthly Webinar presentations of featured projects)

2019 – Blackhall Road at Rum Creek Bridge

Year ABC Built: 2019
State: GA
County: Henry
Owner: County
Location: Urban
Spans: Three-span
Beam material: Concrete
Max Span Length (ft.): 93
Total Bridge Length (ft.): 195
Construction Equipment Category: Conventional
ABC Construction Equipment: none
State ID Number: 151-0070-0; 151-09390M-000.63N
NBI Number: 000000015151270
Coordinates
Latitude: +33.51774 | Longitude: -84.27780



[Back to Search](#)



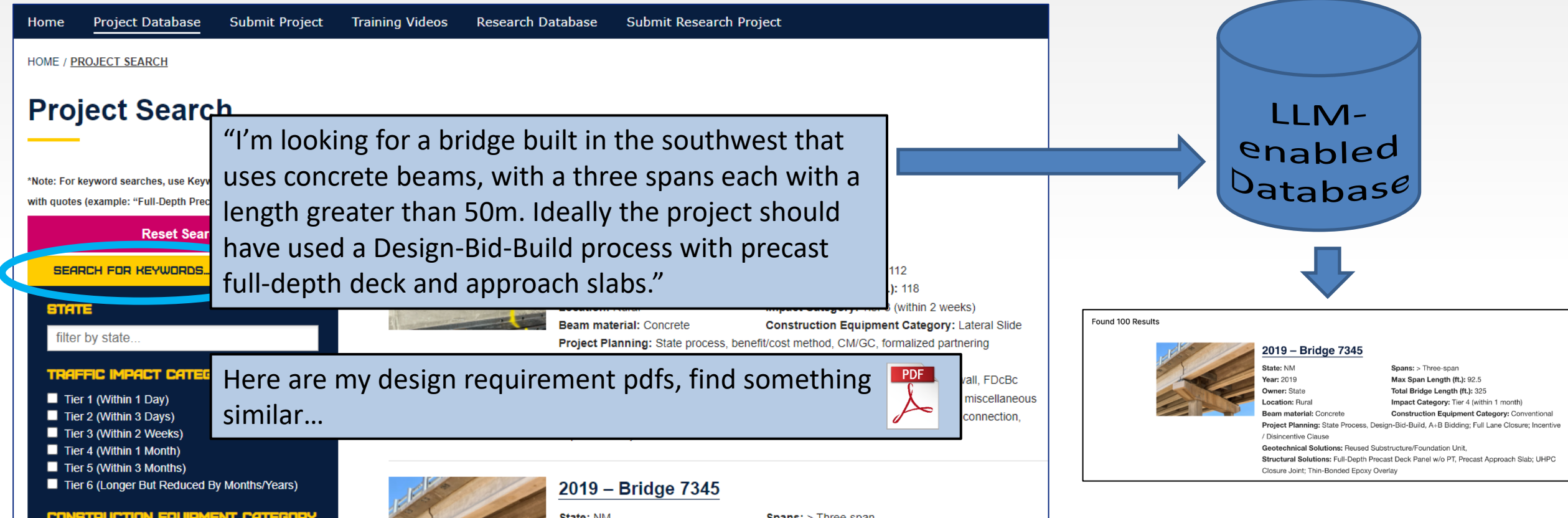
Bridge Description

Project Summary:
Replacement of load-posted bridge with modular decked beams and UHPC deck closure joints

Project Location:
CR 661 (Blackhall Road) at Rum Creek, southeast of the City of Atlanta

Enhancements to *ABC Project Database* under consideration (3 of 3)

AI-enabled general text description for search function



The Takeaway

AI is taking off (again), a long-held dream

There is a lot of hype

AI is still brittle, and we are nowhere near done

Used wisely, AI can enhance your productivity & impact

You won't lose your job to AI...but you may lose it to someone who can use AI better than you!

As always, change is scary

But AI is a huge opportunity ... take advantage!