



# Draft Artificial Intelligence Strategic Plan Fiscal Years 2023-2027

Operating Reactors KM Session  
July 30, 2022

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# Nuclear Regulatory Commission

## Artificial Intelligence Strategic Plan



Background, Purpose and Preparation

Increased Industry Interest

Regulatory Readiness

Common Understanding of the Levels of Autonomy

AI Strategic Plan



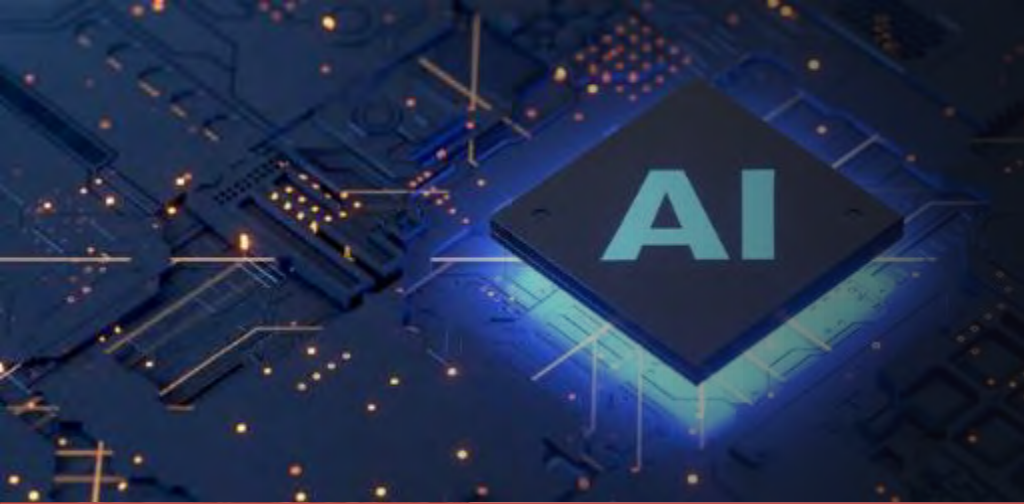


# Developing a Consistent Understanding

- **Artificial Intelligence**
  - A machine-based system that can go beyond defined results and scenarios and has the ability to emulate human-like perception, cognition, planning, learning, communication, or physical action. For a given set of human-defined objectives, AI can make predictions, recommendations, or decisions influencing real or virtual environments. These systems use machine- and human-based inputs to perceive real and virtual environments, abstract such perceptions into models through analysis in an automated manner, and use model inference to formulate options for information or action.<sup>1</sup>
- **Machine Learning**
  - An application of artificial intelligence that is characterized by providing systems the ability to automatically learn and improve on the basis of data or experience, without being explicitly programmed.<sup>1</sup>



<sup>1</sup>National Defense Authorization Act (2021)

A graphic featuring the letters 'AI' in a bold, teal font, centered within a dark blue diamond shape. This diamond is set against a background of a glowing blue circuit board with numerous small, orange-yellow lights and white lines representing circuit traces.

AI

# REGULATORY PURPOSE

- 
- A photograph of the U.S. Capitol building in Washington, D.C., showing its iconic dome and classical columns. The building is illuminated with warm lights, and the sky is a clear blue.
- NRC recognizes a need to use technology innovation for regulatory enhancements as part of its effort to become a modern, risk-informed regulator<sup>1</sup>
  - The nuclear industry is researching and using artificial intelligence (AI) applications; therefore, the NRC must be prepared to review and evaluate the use of AI in NRC-regulated activities
  - The AI Strategic Plan presents the vision and goals for the NRC to cultivate an AI-proficient workforce, keep pace with AI technological innovations, and ensure the safe and secure use of AI in NRC-regulated activities

<sup>1</sup> "The Dynamic Futures for NRC Mission Areas," (ML19022A178)



# PREPARATORY ACTIVITIES



# NRC AI Research Projects

## *Past and Present*

- Watson Content Analytics for Operational Experience Data
- ADAMS NLP Resource Estimation Tool
- Operating Experience Event Classification
- Named Entity Recognition for Regulatory References
- Machine Learning for Non-Destructive Examination
- Regulatory Viability of Digital Twins





# Nuclear Industry AI Survey

- In April 2021, NRC issued an FRN soliciting feedback on the nuclear industry's AI readiness and applications
- FRN responses indicated
  1. Benefits are great, but cost of developing and implementing AI is a challenge
  2. Concerns about data security, including cyber intrusions, proprietary information leakage, and loss of export control
  3. Developers are particularly interested in using NLP, neural networks, and clustering algorithms



## DATA SCIENCE AND ARTIFICIAL INTELLIGENCE REGULATORY APPLICATIONS WORKSHOPS

- Three workshops held in 2021 and archived on the [NRC website](#), [Nuclepedia](#), and [ML21348A637](#)
- Industry expressed interest for the NRC to develop a generic set of AI design criteria in a Regulatory Guide for LWR and non-LWR applications
- As AI applications rely on access to high quality data, agreement needs to be reached on a centralized entity empowered to aggregate and share data
- Industry AI application deployment in 1-2 years, and AI applications for NRC regulatory review in 3-5 years

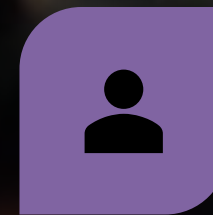
### Workshops Objectives and Findings



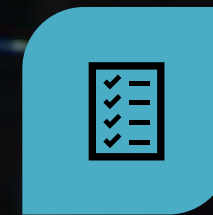
FOUNDATIONAL  
KNOWLEDGE



COLLABORATION  
OPPORTUNITIES



DATA SHARING



CURRENT  
PROJECTS



FUTURE  
ACTIVITIES



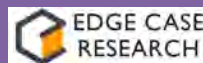
# External Awareness

- Commenced interactions with other federal partners to explore AI evaluation approaches, lessons learned, and collaboration opportunities
- Similarly engaged with international counterparts interested in AI for nuclear
- Maintaining continual engagement on state-of-the-art research
- Enhancing and leveraging existing MOUs

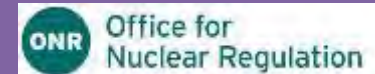
## Other Federal Agencies



## Research Organizations and Academia



## International Counterparts



## Leveraging MOUs



New Data Science and AI Addendum



Operating Experience and Data Analytics



TALEN  
ENERGY



## Nuclear Industry AI Applications

- Department of Energy and Industry Project Categories
  - Increasing existing NPP economic efficiency
  - Plant condition monitoring
  - Process improvement and cost reduction
  - Plant automation
  - Sensor-enabled degradation assessment and wireless security
- Operating Reactor Projects
  - CAP Analyzer for informed inspections
  - Palo Verde Process Automation
  - Core design optimization
- Advanced Reactor Projects
  - Digital twins using deep neural networks
  - Autonomous operation in remote locations



# NRC AI Challenges

## Current

Workforce Training

Traceable and Auditable Evaluation Methodologies

Internal Challenges: Automating Internal Agency Business Processes

External Challenges: Understanding Licensee and Applicant AI Usage



## Future

Regulatory Guidance and Decisionmaking Development

Differentiating AI Usage for Reactor Design Versus Autonomous Control

Explainable AI and Trustworthy AI – Reliability and Assurance

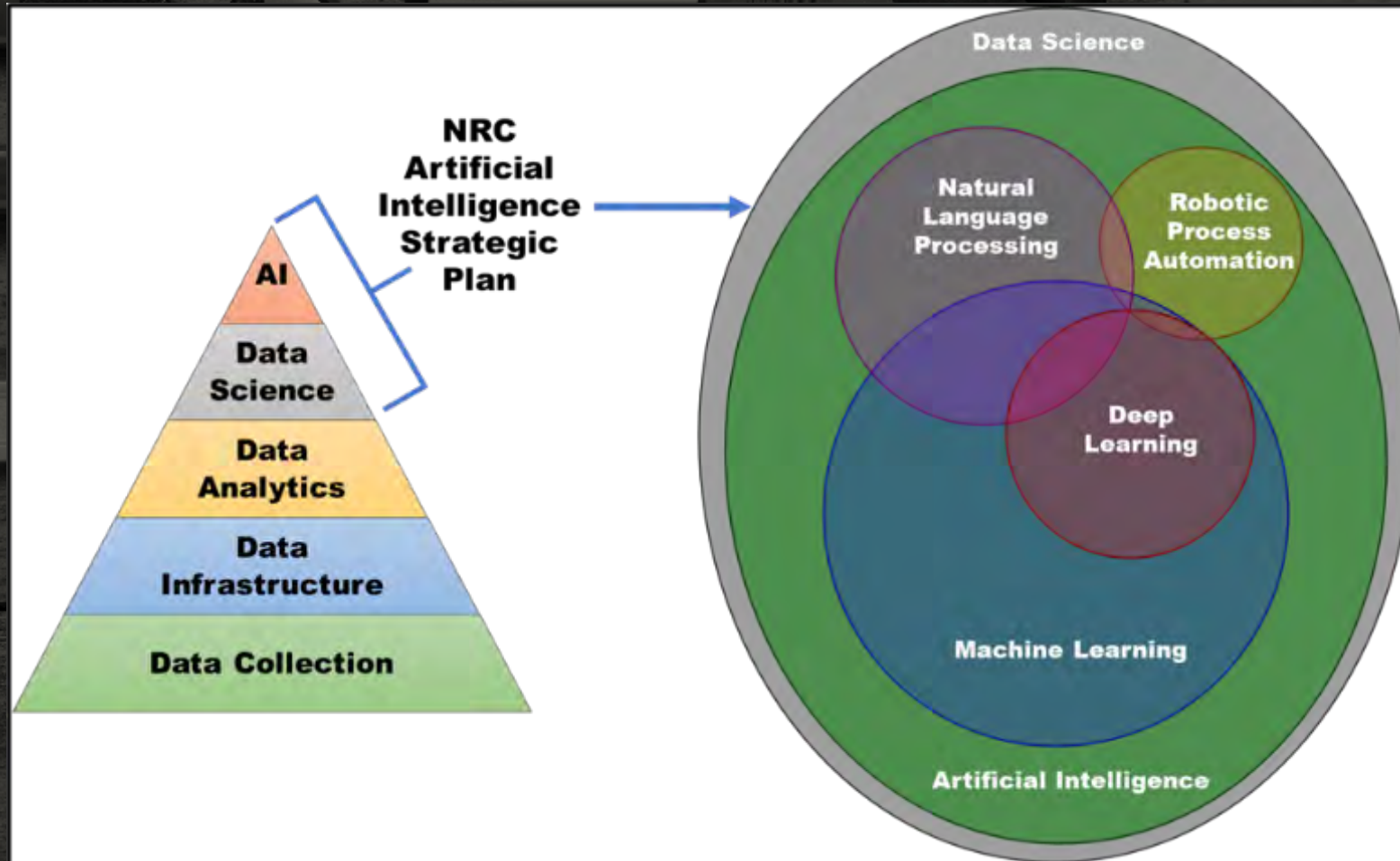
Internal AI Budget Predicated on Emergent Industry Applications

# Notional AI and Autonomy Levels in Commercial Nuclear Activities

<div>Human Involvement</div> <div></div>	Level	Notional AI and Autonomy Levels	Potential Uses of AI and Autonomy in Commercial Nuclear Activities	<div></div> <div>Machine Independence</div>
	Level 1	<u>Insight</u> Human decisionmaking assisted by a machine	AI integration in systems is used for optimization, operational guidance, or business process automation that would not affect plant safety/security and control	
	Level 2	<u>Collaboration</u> Human decisionmaking augmented by a machine	AI integration in systems where algorithms make recommendations that could affect plant safety/security and control are vetted and carried out by a human decisionmaker	
	Level 3	<u>Operation</u> Machine decisionmaking supervised by a human	AI and autonomy integration in systems where algorithms make decisions and conduct operations with human oversight that could affect plant safety/security and control	
	Level 4	<u>Fully Autonomous</u> Machine decisionmaking with no human intervention	Fully autonomous AI in systems where the algorithm is responsible for operation, control, and intelligent adaptation without reliance on human intervention or oversight that could affect plant safety/security and control	
Common Understanding of the Level Key for Regulatory Readiness				



# AI STRATEGIC PLAN SCOPE



# ARTIFICIAL INTELLIGENCE STRATEGIC PLAN OVERVIEW



NUREG-2281

## Artificial Intelligence Strategic Plan

Fiscal Years 2023-2027

Draft Report for Comment

Office of Nuclear Regulatory Research

### AI Strategic Plan Development

- NRC AI Team: Engaged interdisciplinary team of AI subject matter experts across the agency
- Leveraged insights from 2021 Data Science and AI Regulatory Applications Workshops ([ML21348A637](#))

### The AI Strategic Plan ([ML22175A206](#)) consists of five strategic goals:

- Goal 1: Ensure NRC Readiness for Regulatory Decisionmaking
- Goal 2: Establish an Organizational Framework to Review AI Applications
- Goal 3: Strengthen and Expand AI Partnerships
- Goal 4: Cultivate an AI-Proficient Workforce
- Goal 5: Pursue Use Cases to Build an AI Foundation Across the NRC





# AI Strategic Plan

## Near-Term FY23 Outcomes

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- Establish Data Science Training and Qualification Plan
- Establish AI Steering Committee (AISC) and Working Groups
- Establish AI Community of Practice
- Develop NRC-specific language model for Natural Language Processing (NLP)
- Optimize NRC software intake and approval process for AI tools
- Coordinate with NRC Data Strategy to target cloud development and deployment environment
- Continue Data Science and AI Regulatory Applications Workshops
- Host internal RES AI Seminars (next planned August 2022)



# RECENT NRC AI RESEARCH PROJECTS

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# USING AI TO ENHANCE NRC ACTIVITIES

- Administrative Conference of the United States Statement on Agency Use of Artificial Intelligence
- Evidence-Based Policymaking Act of 2018
- National Artificial Intelligence Initiative Act of 2020
- Office of Management and Budget Guidance for Regulation of AI Applications (M-21-06)



AI Strategic Plan outputs may also support the agency use of AI tools to enhance internal NRC activities



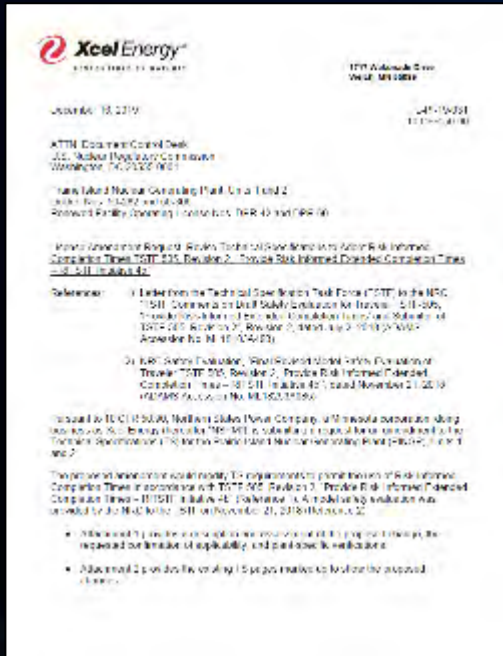
# Resource Estimation

- **Challenge:** Deviations between resource estimates to complete a licensing review and the actual hours charged
- **Goal:** Create tool to assist project managers in formulating resource estimates
  - Leverage historical data
  - Find historically similar reviews
- **Method:** Use term frequency-inverse document frequency vectors to represent documents and perform similarity calculations
  - Rank documents based on similarity

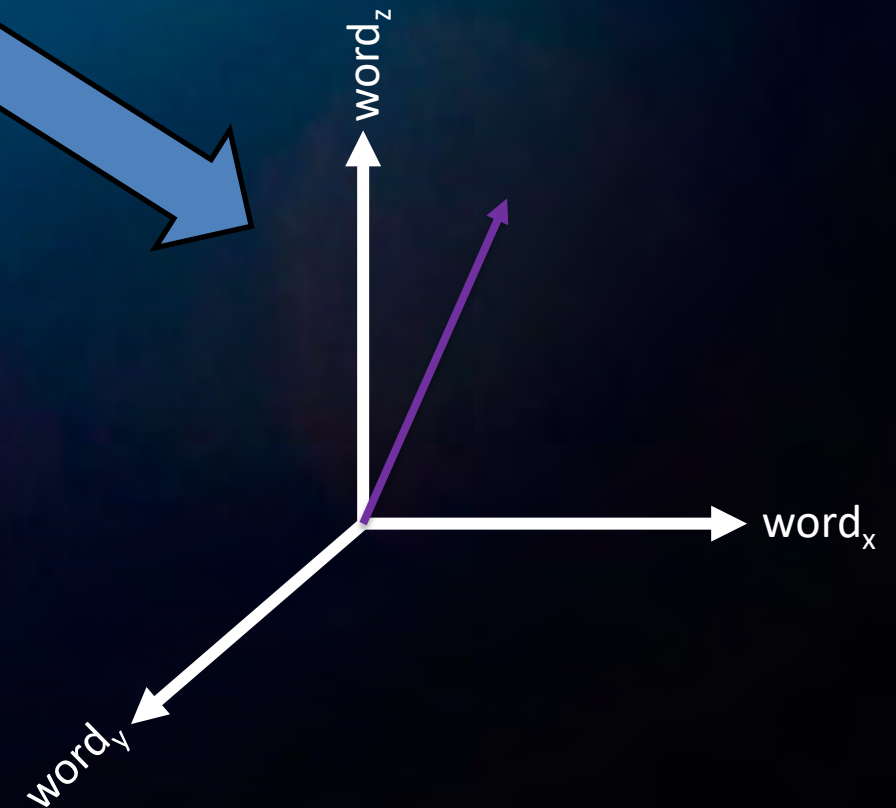
# Term Frequency-Inverse Document Frequency (Vector Representation)

	action	amendment	applicability	assembly	base	...
Document 1	0.0	0.16	0.2	0.00	0.33	

storage	system	technical	time	wording	would
0.0	0.15	0.3	0.22	0.00	0.25



- Represent a document as a vector
  - The vector reflects the word usage in the document
  - The vector will have 1000's of dimensions



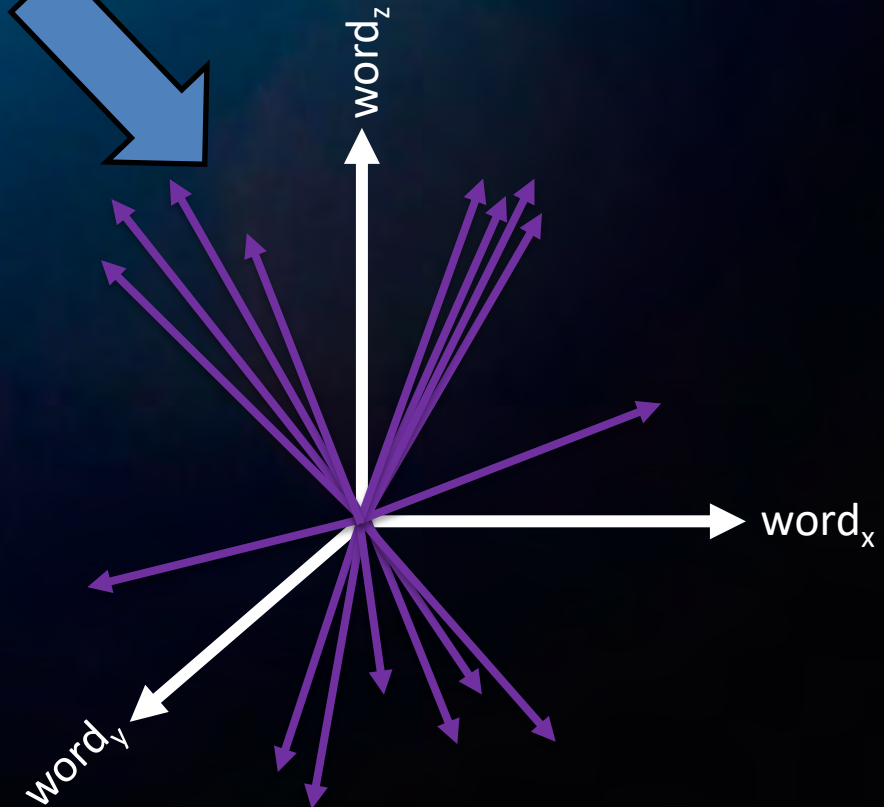


# Term Frequency-Inverse Document Frequency (Vector Space Corpus)

	action	amendment	applicability	assembly	base
Document 1	0.0	0.16	0.2	0.00	0.33
Document 2	0.25	0.0	0.0	0.3	0.0

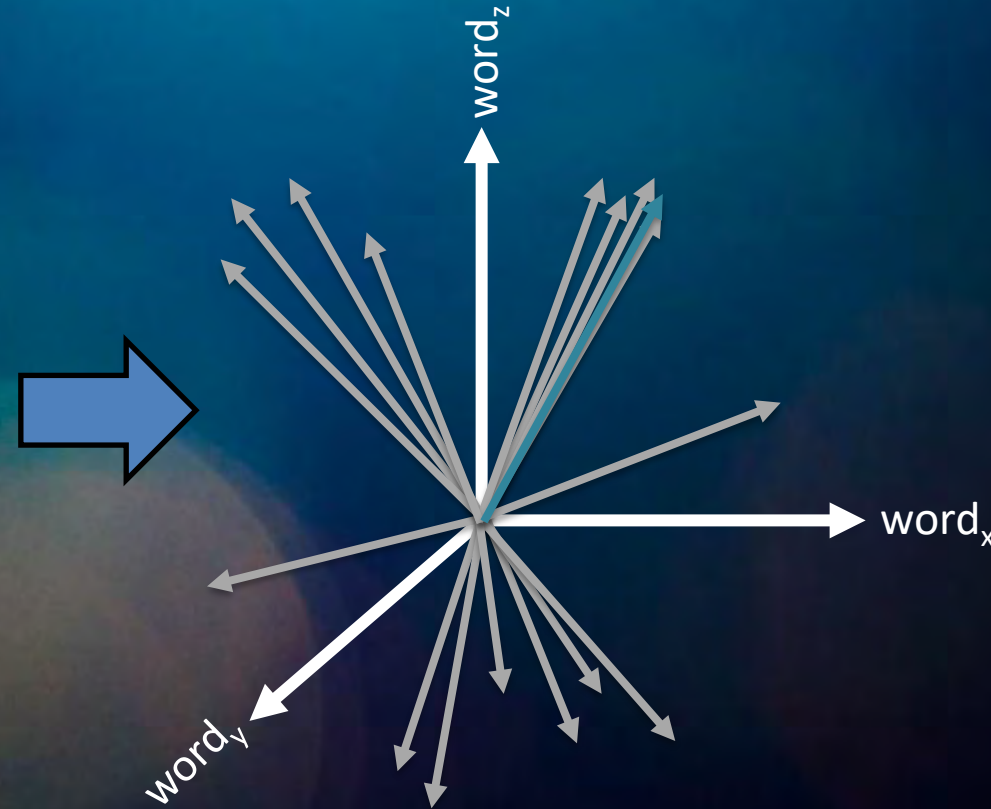
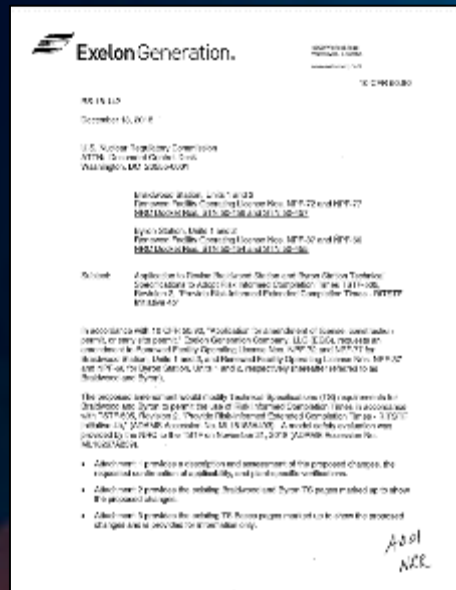
...

storage	system	technical	time	wording	would
0.0	0.15	0.3	0.22	0.00	0.25
0.11	0.0	0.0	0.3	0.14	0.1



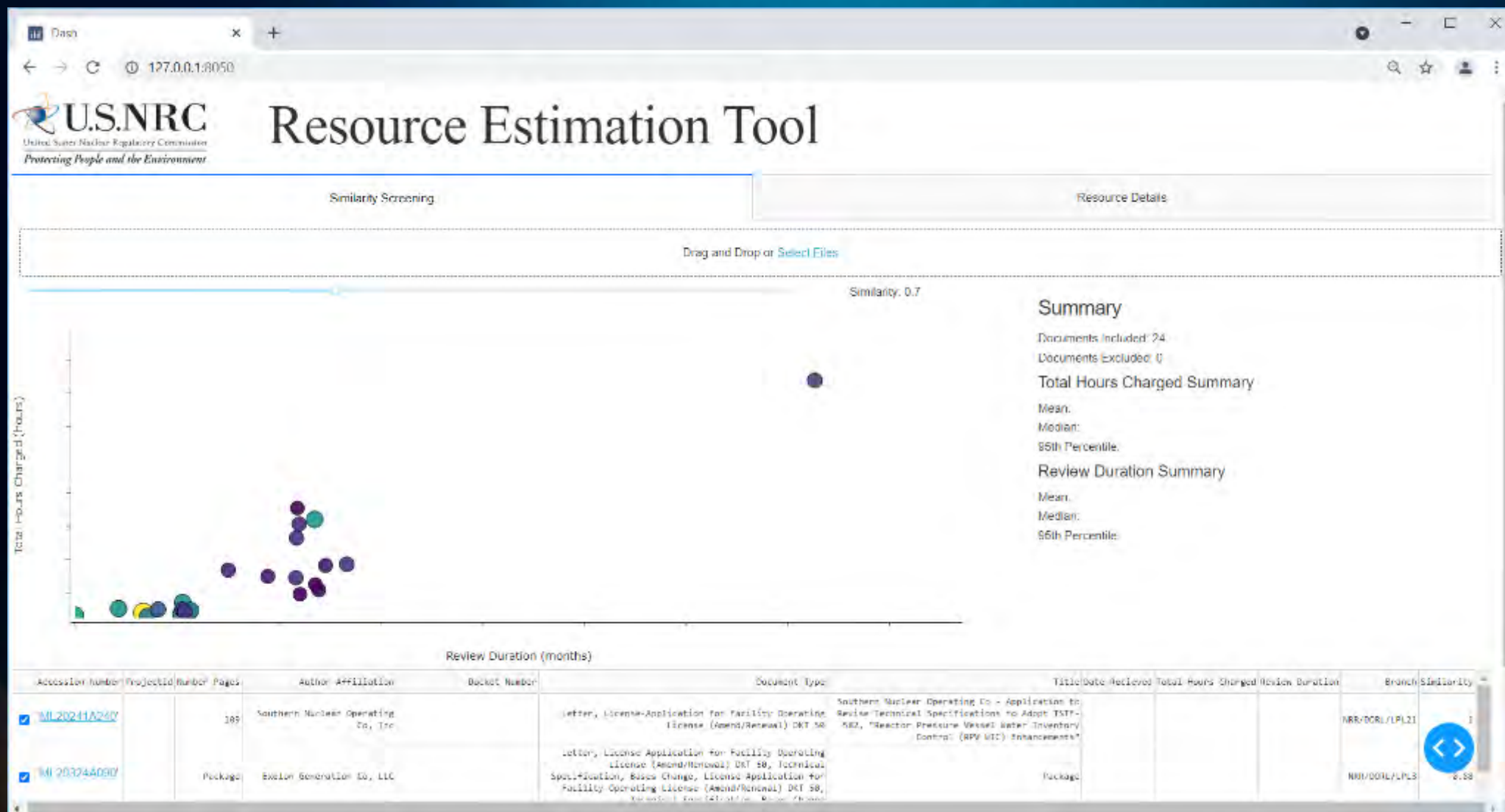
- Represent the collection of documents as vectors
  - Create a vocabulary of all words used in the collection

# Term Frequency-Inverse Document Frequency (Similarity Calculations)



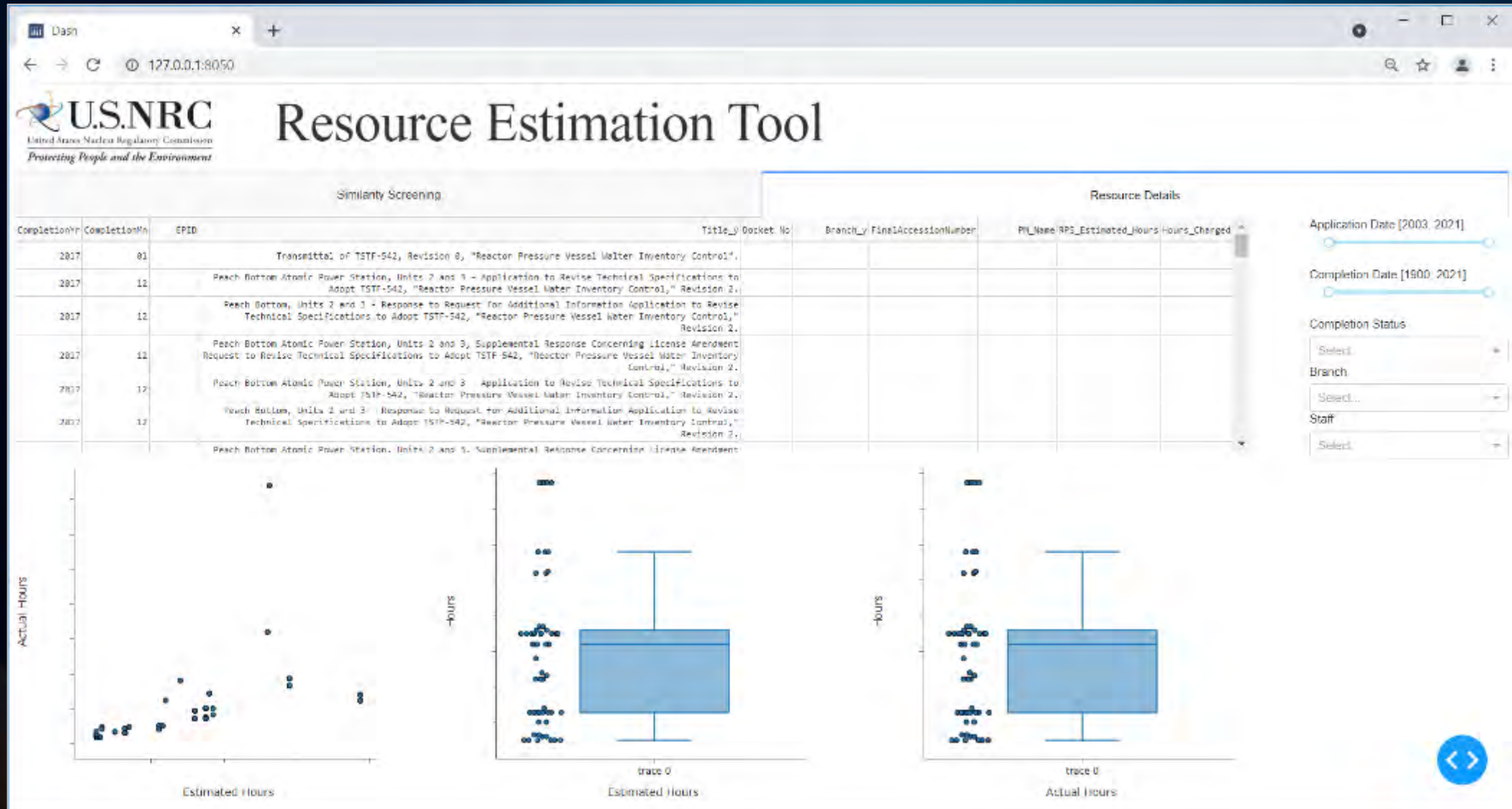
- A new document is converted to a vector based on the vocabulary of the collection of documents
  - The similarity (angle between vectors) is calculated as the dot product between vectors
  - Documents ranked by similarity score

# Resource Estimation Tool





# Resource Estimation Tool



# Current Status and Follow-on Work

- Preliminary acceptance testing complete
  - Historical data provides reasonable estimates of required resources and review durations
- Coordinating to finalize visualizations with NRC program offices
- Develop and deploy final User Interface
- Potential Follow-on Work:
  - Search capabilities
  - Predict Branch assignments
  - Predict Standard Review Plan
  - Predict which Regulatory Guides were used for the licensing action



# Regulatory Named Entity Recognition

- **Challenge:** Title 10 of the Code of Federal Regulations (CFR), and other regulatory documents, reference sections of 10 CFR
  - Revisions to 10 CFR could impact other sections
- **Goal:** Create a tool to find and extract 10 CFR references from documents
- **Method:** Use Named Entity Recognition (NER) to label text as regulations and extract that text

# NER

- Named Entity Recognition
  - Classify unstructured text (i.e., words or phrases) into predefined categories
- Information extraction
- Typical tools (e.g. spaCy) trained on general language



# Named Entity Recognition

( 2 CARDINAL ) On or before July 26, 1990 DATE , each holder of an operating license for a production or utilization facility in effect on July 27, 1990 DATE , shall submit information in the form of a report as described in 10 CARDINAL CFR 50.75 of this part, indicating how reasonable assurance will be provided that funds will be available to decommission the facility. [ 21 CARDINAL FR 355, Jan. 19, 1956 DATE , as amended at 35 FR 19660 DATE , Dec. 29, 1970 DATE ; 38 CARDINAL FR 3956, Feb. 9, 1973 DATE ; 45 CARDINAL FR 55408, Aug. 19, 1980 DATE ; 49 CARDINAL FR 35752 WORK\_OF\_ART , Sept. 12, 1984 DATE ; 53 CARDINAL FR 24049 DATE , June 27, 1988 DATE ; 69 CARDINAL FR 4448 WORK\_OF\_ART , Jan. 30, 2004 DATE ; 72 CARDINAL FR 49490 CARDINAL , Aug. 28, 2007] DATE 4  
Emergency planning zones (EPZs) are discussed in NUREG-0396 DATE , EPA ORG 520/1-78-016, Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans NORP In Support of Light-Water Nuclear Power Plants, December 1978 DATE .

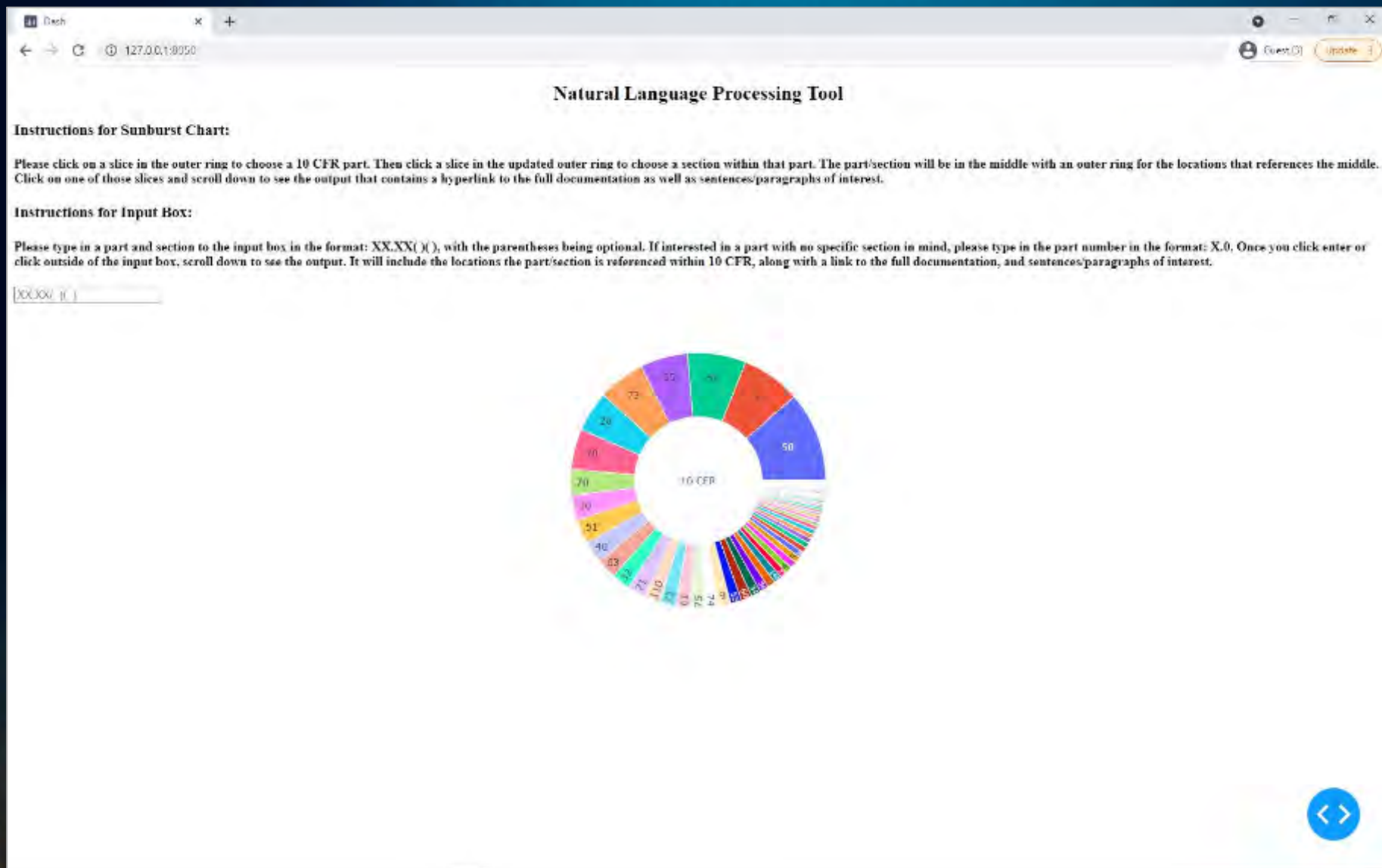
SpaCy Default Entities

## Addition of NRC Specific Language Patterns

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- Used Python package Spacy

# 10 CFR Reference Identification Tool




# 10 CFR Reference Identification Tool

127.0.0.1:8050

Please type in a part and section to the input box in the format: XX.XX( X ), with the parentheses being optional. If interested in a part with no specific section in mind, please type in the part number in the format: X.0. Once you click enter or click outside of the input box, scroll down to see the output. It will include the locations the part/section is referenced within 10 CFR, along with a link to the full documentation, and sentences/paragraphs of interest.

XX.XX( X )



Output from the Sunburst Chart:

Click the link below to see the full documentation:

[10 CFR 50.38](#)

Below is a snippet with the reference of interest (each paragraph is separate):

(a) Each application for a construction permit or an operating license for a facility which is of a type described in § 50.21(b) or § 50.22, or for a testing facility, shall be referred to the Advisory Committee on Reactor Safeguards for a review and report. An application for an amendment to such a construction permit or operating license may be referred to the Advisory Committee on Reactor Safeguards for review and report. Any report shall be made part of the record of the application and available to the public, except to the extent that security classification prevents disclosure.

(b)(1) The Commission will hold a hearing after at least 30-days' notice and publication once in the FEDERAL REGISTER on each application for a construction permit for a production or utilization facility which is of a type described in § 50.21(b) or § 50.22, or for a testing facility.

(5) The Commission will use the standards in § 50.92 to determine whether a significant hazards consideration is presented by an amendment to an operating license for a facility of the type described in § 50.21(b) or § 50.22, or which is a testing facility, and may make the amendment immediately effective notwithstanding the pendency before it of a request for a hearing from any person, in advance of the holding and completion of any required hearing where it has determined that no significant hazards consideration is involved.



# 10 CFR Reference Identification Tool

50.82(a)(1)

Output from the input box:

50.4: <https://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0004.html>

(8) *Certification of permanent cessation of operations.* The licensee's certification of permanent cessation of operations, under § 50.82(a)(1), must state the date on which operations have ceased or will cease, and must be submitted to the NRC's Document Control Desk. This submission must be under oath or affirmation.

(9) *Certification of permanent fuel removal.* The licensee's certification of permanent fuel removal, under § 50.82(a)(1), must state the date on which the fuel was removed from the reactor vessel and the disposition of the fuel, and must be submitted to the NRC's Document Control Desk. This submission must be under oath or affirmation.

50.35: <https://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0035.html>

(6) *Decommissioning.* This paragraph applies only to nuclear power reactor facilities that have submitted the certifications required by § 50.82(a)(1) and to non-power reactor facilities which are not authorized to operate. Technical specifications involving safety limits, limiting safety system settings, and limiting control system settings, limiting conditions for operation, surveillance requirements, design features, and administrative controls will be developed on a case-by-case basis.

50.36b: <https://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0036b.html>

(b) Each license authorizing operation of a production or utilization facility, including a combined license under part 52 of this chapter, and each license for a nuclear power reactor facility for which the certification of permanent cessation of operations required under § 50.82(a)(1) or § 52.110(a) of this chapter has been submitted, which is of a type described in § 50.21(b)(2) or (3) or § 50.22 or is a testing facility, may include conditions to protect the environment during operation and decommissioning. These conditions are to be set out in an attachment to the license which is incorporated in and made a part of the license. These conditions will be derived from information contained in the environmental report or the supplement to the environmental report submitted pursuant to §§ 51.50 and 51.53 of this chapter as analyzed and evaluated in the NRC record of decision, and will identify the obligations of the licensee in the environmental area, including, as appropriate, requirements for reporting and keeping records of environmental data, and any conditions and monitoring requirement for the protection of the nonaquatic environment.

50.44: <https://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0044.html>

(b) *Requirements for currently-licensed reactors.* Each boiling or pressurized water nuclear power reactor with an operating license on October 16, 2003, except for those facilities for which the certifications required under § 50.82(a)(1) have been submitted, must comply with the following requirements, as applicable:

# Contact Us

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- **Andrew Lerch (NRR/EVS) – NRR Liaison**

