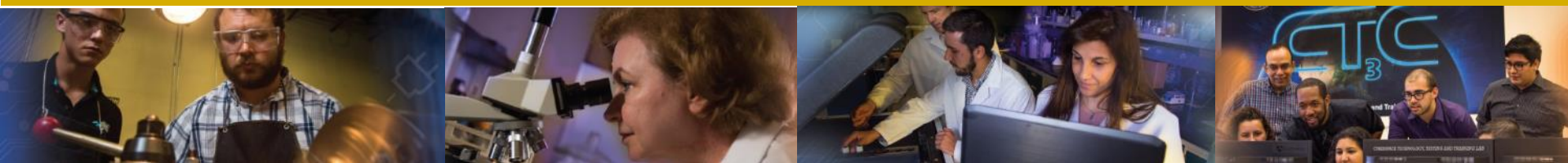
FIU Project 3 – Waste and D&D Engineering and Technology Development

Presented: August 6, 2019

Dr. Himanshu Upadhyay and Mr. Joseph Sinicrope

Florida International University



FIU Personnel and Collaborators

Principal Investigator: Leonel Lagos

Project Manager: Leonel Lagos

Faculty/Staff: Himanshu Upadhyay, Joseph Sinicrope, Walter Quintero, Clint Miller, Jesse Viera

DOE Fellows/Students: Joshua Núñez, Tristan Simoes-Ponce, Ryan Cruz, Alejandro Koszarycz

DOE-EM: Bart Barnhart, Andy Szilagyi, Dinesh Gupta, Rod Rimando, Genia McKinley, Jonathan Kang

SRNL: Mike Serrato, Aaron Washington, Connor Nicholson, Brent Peters

SRS: Jack Musall

Project Tasks and Scope

Task 1 Waste Information Management System (WIMS)

- Manage complex-wide waste forecast information for planned treatment/disposal
- Provide web-based system to receive, organize, and report DOE waste forecast streams via a common application

Task 2 D&D Support for Technology Innovation, Development, Evaluation and Deployment

- Address high priority fire resiliency and safety requirements in support of SRS 235-F D&D project in collaboration with SRNL
- Implement phased approach for standards development, testing/evaluation, and deployment of D&D technologies
- Identify broader applications for intumescent coatings to meet other challenges across DOE complex

Project Tasks and Scope

FIU Applied Research Center

Task 3 Knowledge Management Information Tool (KM-IT)

- Maintain and preserve D&D knowledge by enhancing communication, information sharing, and distribution to assist future D&D projects and workforce

Task 6 Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

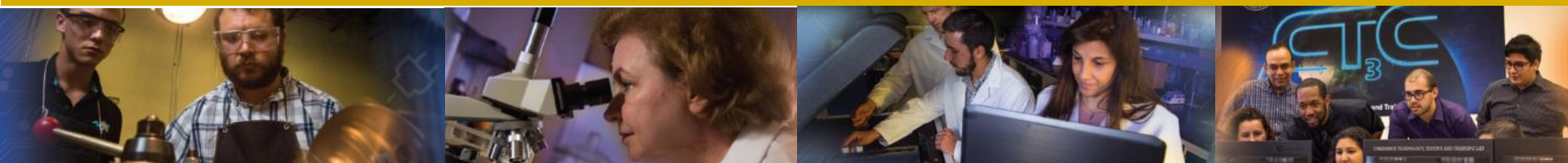
- Develop a pilot-scale infrastructure using machine learning/deep learning and big data technologies for structural health monitoring of facilities using investigate a imaging technologies deployed at FIU mock up facilities

Knowledge Management Information Tool (KM-IT)

www.dndkm.org

Dr. Himanshu Upadhyay

Florida International University



Task 3 – Knowledge Management Information Tool (KM-IT)

FIU Applied Research Center

Site Needs:

To prevent the loss of the collective knowledge from the aging workforce, the need to collect, retain and disseminate knowledge in an organized and structured way through the development and maintenance of a universally available and usable knowledge management system was identified by EM.

Objectives:

Knowledge management (KM) is a modern approach & discipline being used within EM to capture knowledge. Objectives for KM-IT are to attain the long-term active use, operation, and continued growth of the knowledge from across the DOE global community and capture within the KM-IT system, resulting in enhanced worker safety, improved operational efficiencies, improved communication & knowledge among stakeholders, and the cross-generational transfer of knowledge to the future workforce.

Importance of KM to EM

- A significant portion of the EM workforce (including DOE and contractors) is past or nearing retirement age.
- KM aids in the retention of knowledge and experience when employees leave.
- KM provides a centralized location for data and information, improving time management of users.
- KM allows experiences to be captured and shared with Lessons Learned and Best Practices.
- KM reduces redundant work by helping users avoid re-inventing the wheel.
- KM allows the sharing of valuable information throughout the organization.

Knowledge Base for Environmental Management

FIU Applied Research Center

DND KM-IT	WIMS	DOE FELLOWS	DOE RESEARCH	Fixatives Mobile App	Robotics KM-IT
dndkm.org	emwims.org	fellows.fiu.edu	doeresearch.fiu.edu		rkmit.org



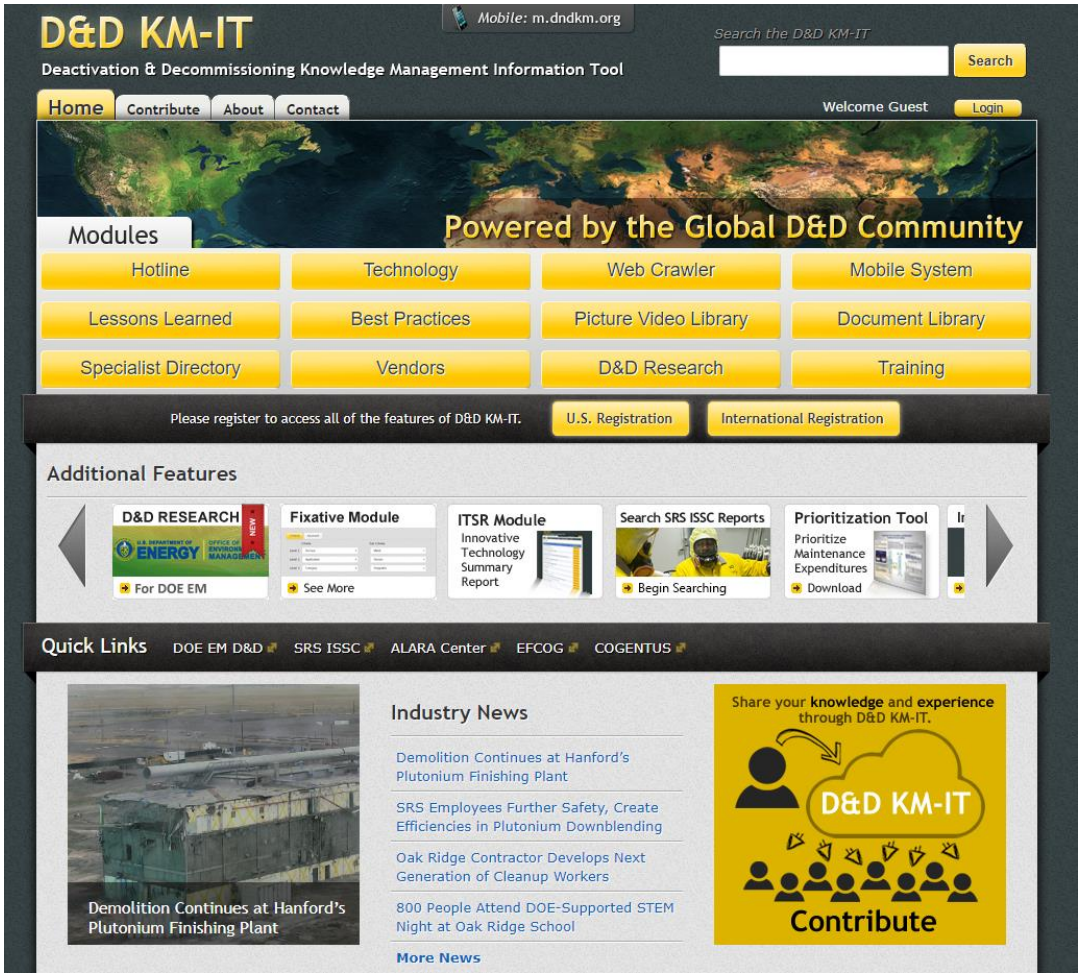


KM-IT Modules

https://kbem.org/

KM-IT Modules

- D&D Hotline
- Technology Module
- Vendor Module
- D&D Research
- Mobile applications
- Lessons Learned
- Documents
- Pictures/videos
- Search tools
- Training
- Specialists
- Best Practices



www.dndkm.org

Task 3 – Knowledge Management Information Tool (KM-IT)

FIU Applied Research Center

Accomplishments Year 9:

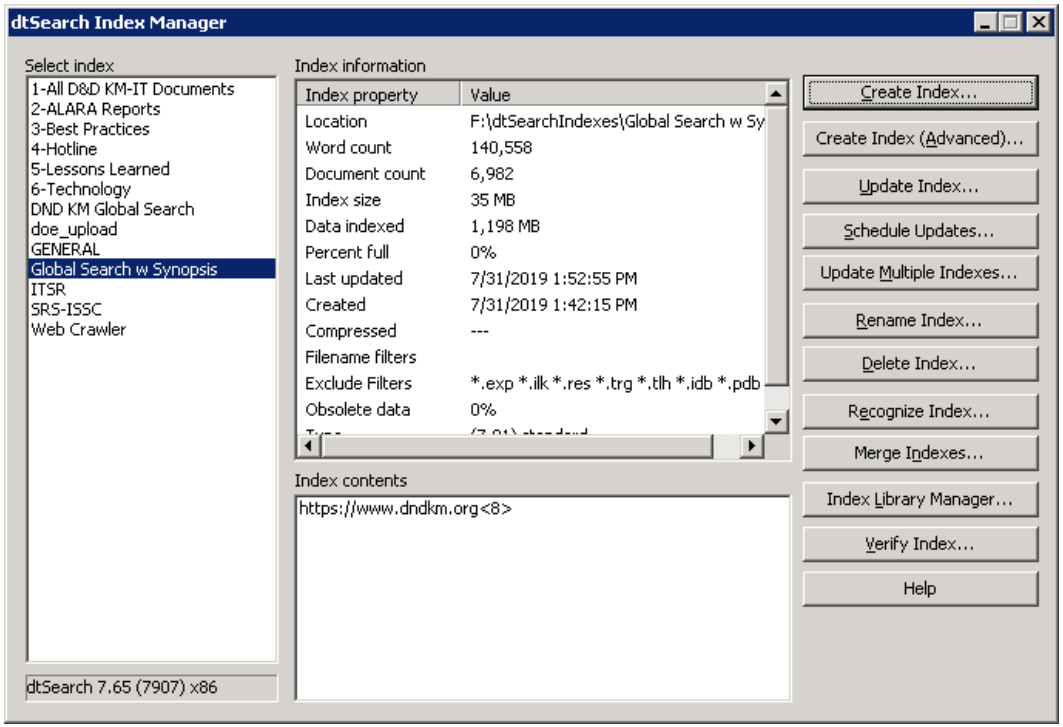
- KM-IT development and enhancement.
- FIU completed enhancing and optimizing the web crawler to search and retrieve information related to D&D from within KM-IT as well as from OSTI and identified internet sources/websites.
  - Search KM-IT
  - OSTI Search
  - Search Web

Task 3 – Knowledge Management Information Tool (KM-IT)

FIU Applied Research Center

Accomplishments Year 9:

- Search KM-IT – This feature involves search index optimization
  - Search process crawls through D&D KM-IT system and stores key information about each document so that when users perform a search, the information can be retrieved in real time.
  - The index is built using documents, pdfs, html and other readable documents stored in the system.
  - The latest index captured a total of 6,982 documents.

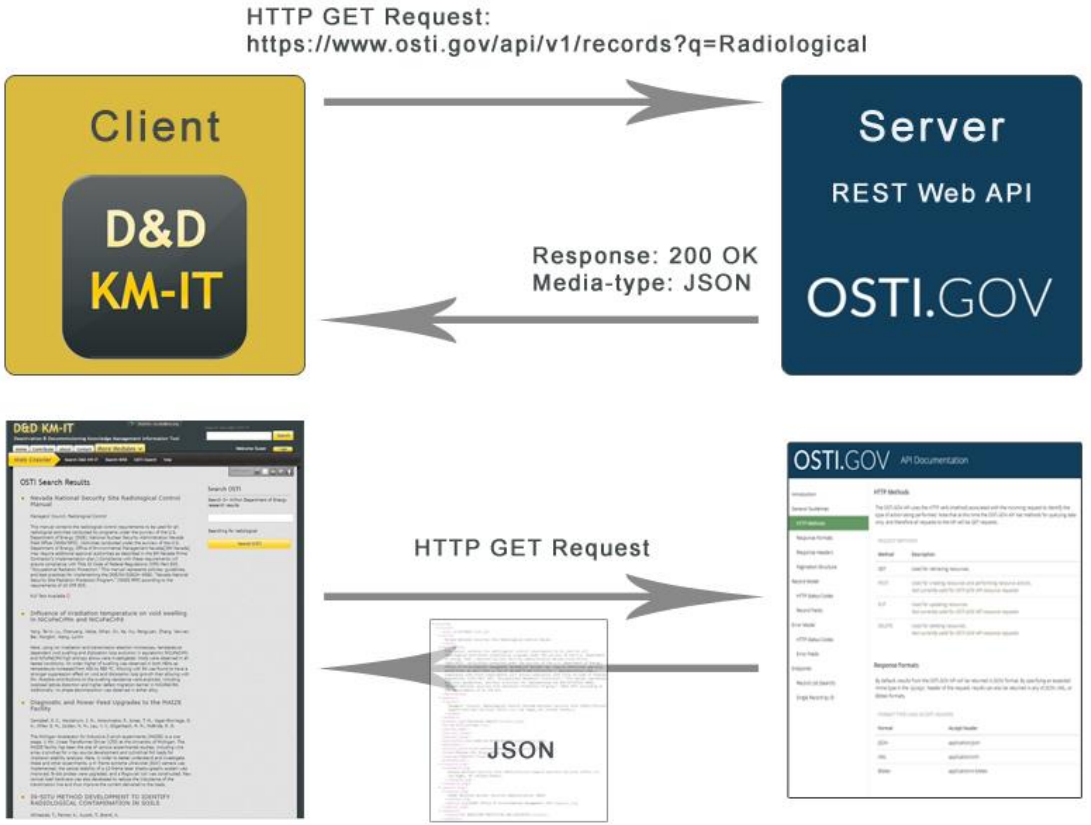


Task 3 – Knowledge Management Information Tool (KM-IT)

FIU Applied Research Center

Accomplishments Year 9:

- OSTI Search – A significant portion of the effort was focused on the OSTI search integration.
- FIU replaced the old OSTI search widget with a REST best API to retrieve real time search results from OSTI.GOV .
- The diagram on the right represents the data flow between KM-IT and OSTI.



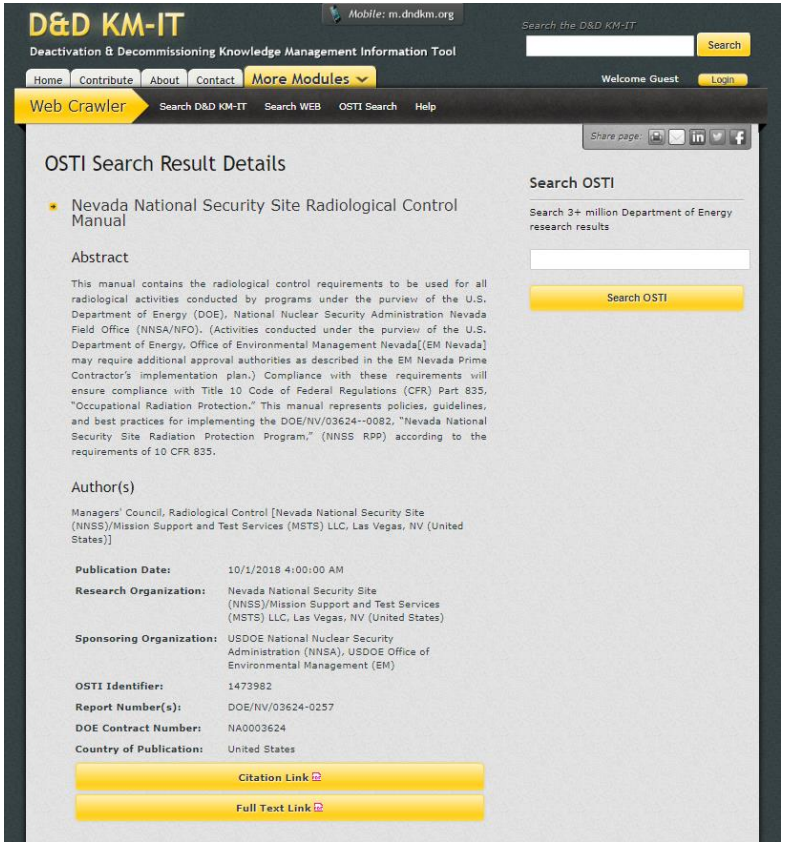
Task 3 – Knowledge Management Information Tool (KM-IT)

Accomplishments Year 9:

From the results summary screen, user can click on the result summary link to get additional details about the document.

The details screen shows the document title, abstract, author(s), publication data, research and sponsoring organization(s), OSTI identifier, report number(s), DOE contract number and country of publication.

There are additional links on the details page to view full text of the document and citations.



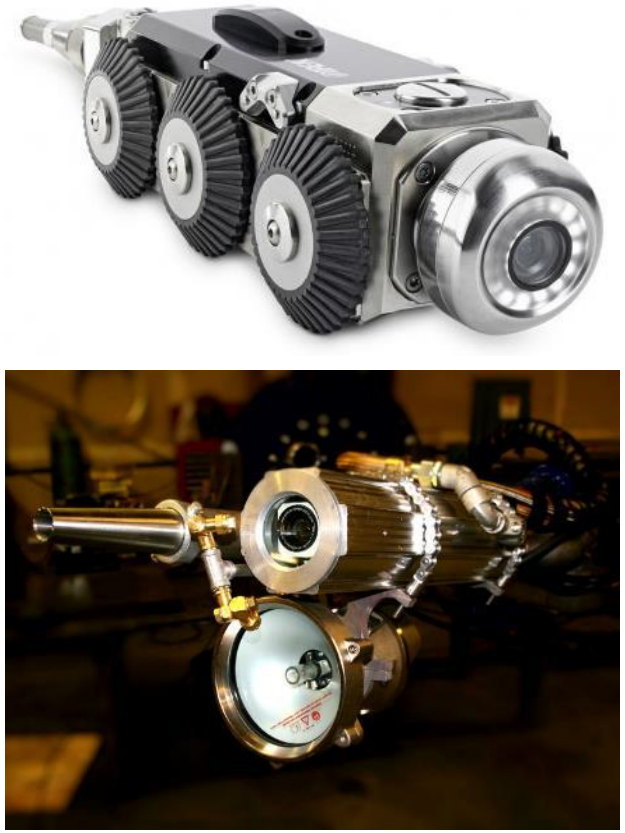
OSTI results detail view showing details for the document and associated links.

Task 3 – Knowledge Management Information Tool (KM-IT)

FIU Applied Research Center

Accomplishments Year 9:

- FIU continues to publish current and relevant information into the KM-IT system such as news, vendors, technologies, lessons learned & best practices related to D&D.
- Development of articles, newsletters and infographics for the D&D community.
- 196 technologies were published on this platform in this fiscal year.



Sample Technologies recently added to KM-IT: Portable Industrial Rovver (Advanced Inspection Technologies, Inc.) on top and Manway Cannon robotic tank nozzle (AGI Engineering) on bottom.

Task 3 – Knowledge Management Information Tool (KM-IT)

FIU Applied Research Center

Accomplishments Year 9:

- Researchers and DOE Fellows continued to research the latest penetration testing, malware analysis and forensics tools to secure KM-IT system and infrastructure
  - Regularly performed penetration testing on network, KM-IT database and application servers.
  - Trained DOE Fellows in DOE-EM Cybersecurity lab on advanced security tools commonly used in the industry.

Linux

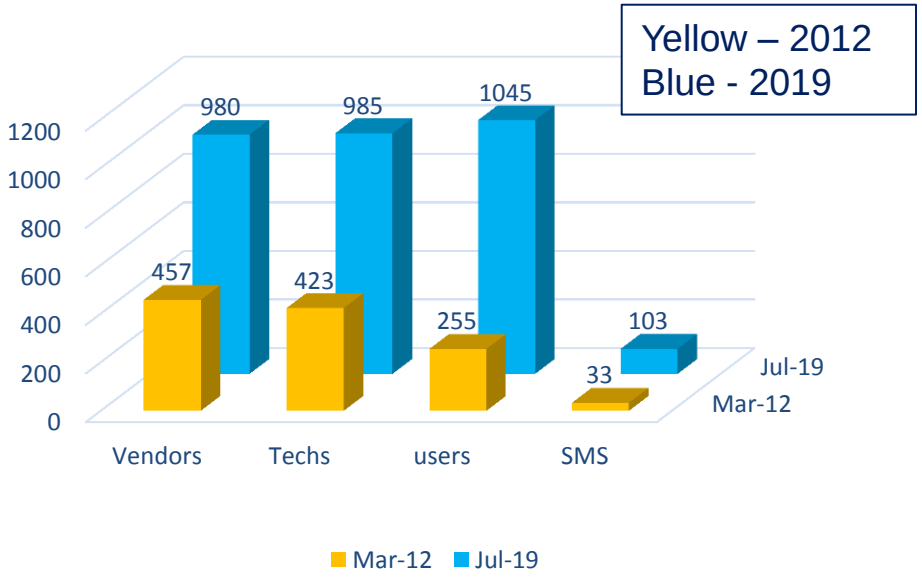
NMAP

Windows

KALI

D&D KM-IT Statistics as of July 2019

- D&D KM-IT web analytics to track usage metrics.
- 985 D&D technologies
- 1045 registered users
- 980 D&D vendors
- 195 Hotline questions/solutions
- 103 subject matter specialists



Growth from March 2012 to July 2019

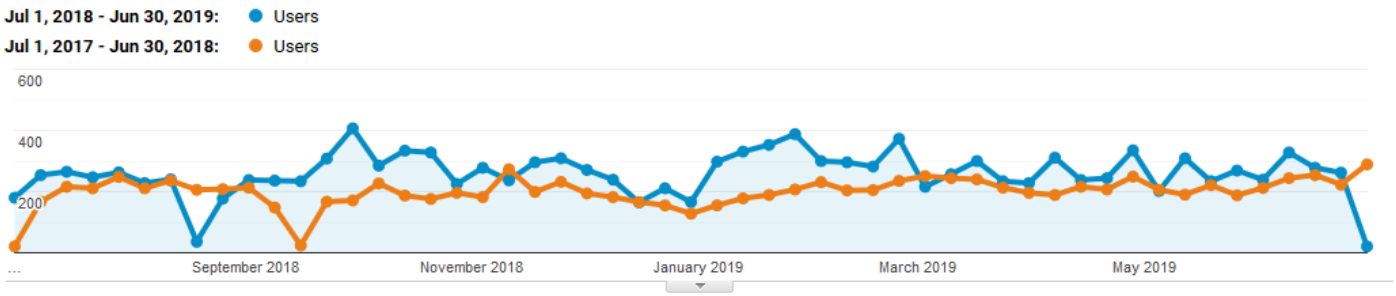
<u>Fully searchable resources – Original sources no longer available</u>

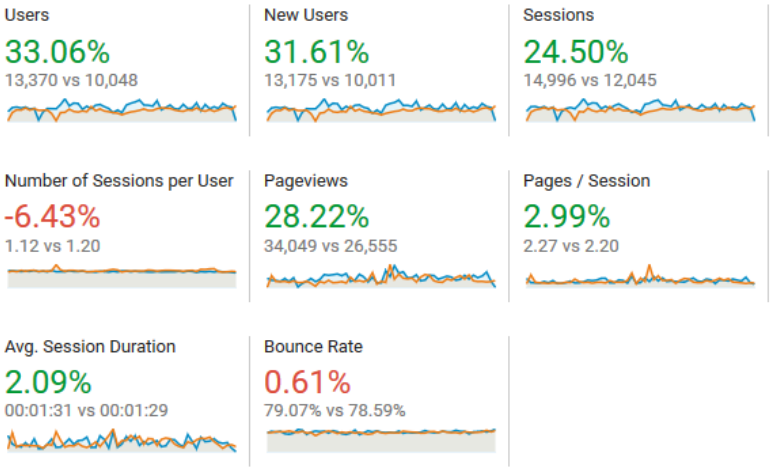
- 169 ALARA Center reports archived (Hanford and SRS)
- 231 Innovative Technology Summary Reports archived

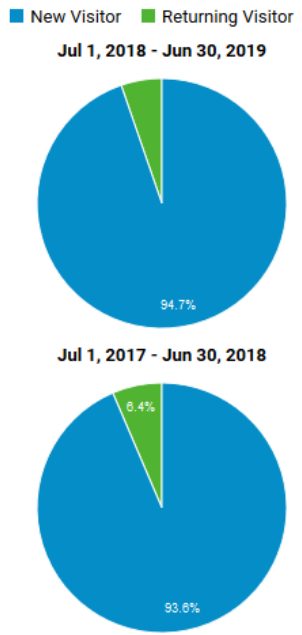
D&D KM-IT Statistics as of July 2019

FIU Applied Research Center

- Year comparison activity on D&D KM-IT (2019 vs 2018)
- Double digit percentage increase on: Users, New users, Sessions and Pageviews
- Minor increase on: Pages per session and Avg. session duration
- Unchanged bounce rate



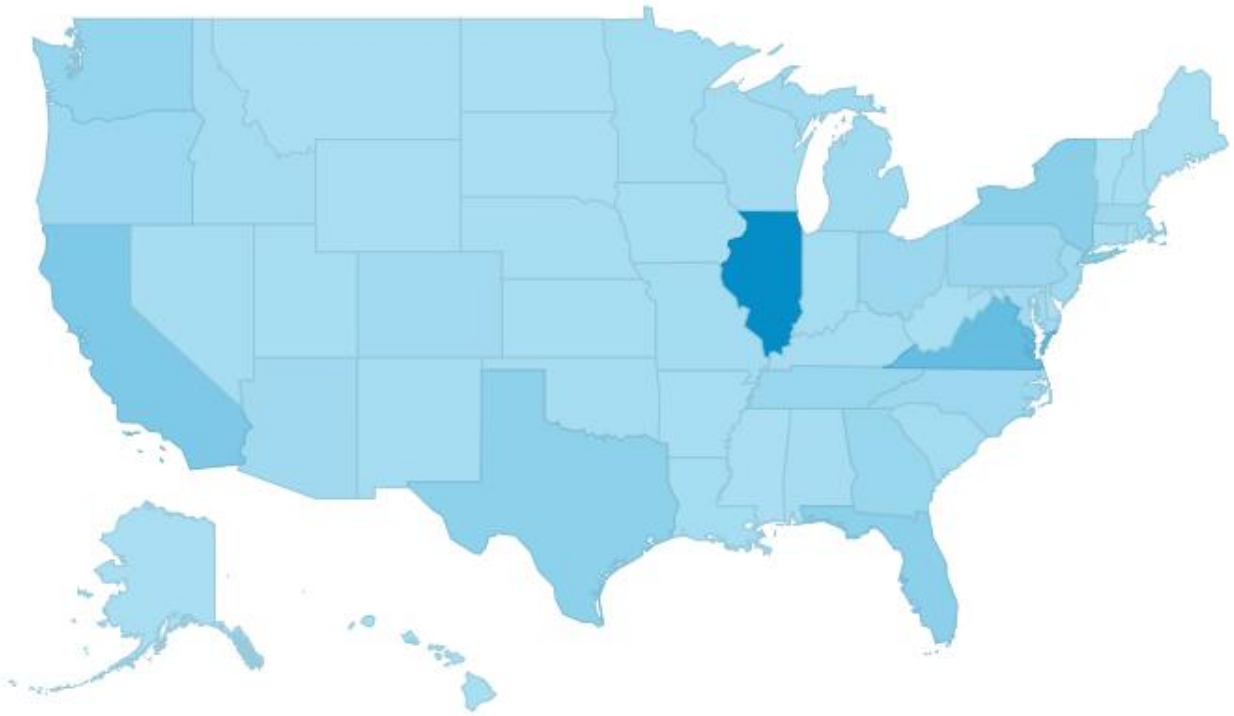




D&D KM-IT Statistics as of July 2019

KM-IT visited by every state of the union in the last 12 months with the top being:

- Illinois
- Virginia
- California
- New York
- Florida
- Texas
- Washington
- Georgia
- Tennessee



Task 3 – Knowledge Management Information Tool (KM-IT)

Accomplishments Year 9:

- FIU presented D&D KM-IT research at WM2019, demonstrated at FIU booth and student alumni pavilion

  Abstract: 19107

  Title: Robotics on KM-IT Platform
  Authors: Himanshu Upadhyay, Walter Quintero, Leonel Lagos, Peggy Shoffner

  Session: D&D General - Posters

Task 3 – Knowledge Management Information Tool (D&D KM-IT)

FIU Applied Research Center

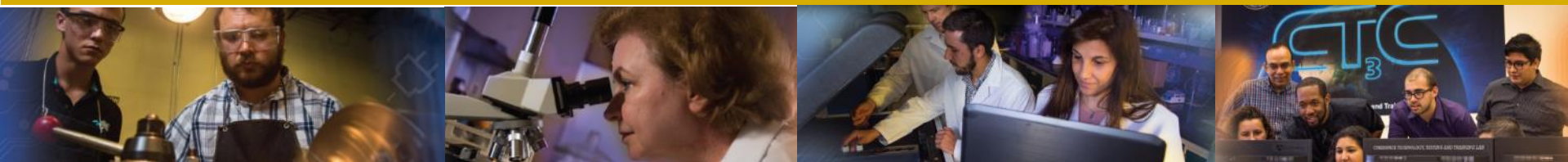
Proposed Scope for Year 10

- KM-IT Development and Enhancement
  - Enhance D&D Research module for multiple DOE EM sites, universities and national labs
- KM-IT Outreach – Community Support
  - Participation in industry conferences and workshops
  - Newsletters and mass communications
  - User support, including requested ad hoc specialized reporting
- KM-IT Maintenance & Administration
  - Cybersecurity & Administration of KM-IT Infrastructure
  - Content Management (Published technologies/vendors, news, lessons learned/best practices on the KM-IT platform)
  - Web Analytics (Quarterly update of Google analytics, server log analysis, and metrics reporting)
  - KM-IT Application and Database hardware upgrade

Waste Information Management System (WIMS)

https://www.emwims.org

FLORIDA INTERNATIONAL UNIVERSITY



Task 1 – Waste Information Management System (WIMS)

Site Needs:

Accurate estimates of the quantity and type of present and future radioactive waste streams is critical to the development of tools to integrate the complex-wide management of LLW/MLLW treatment and disposal. A complex-wide LLW and MLLW database and reporting system is needed to communicate this information to local and national stakeholders and governmental groups.

Objectives:

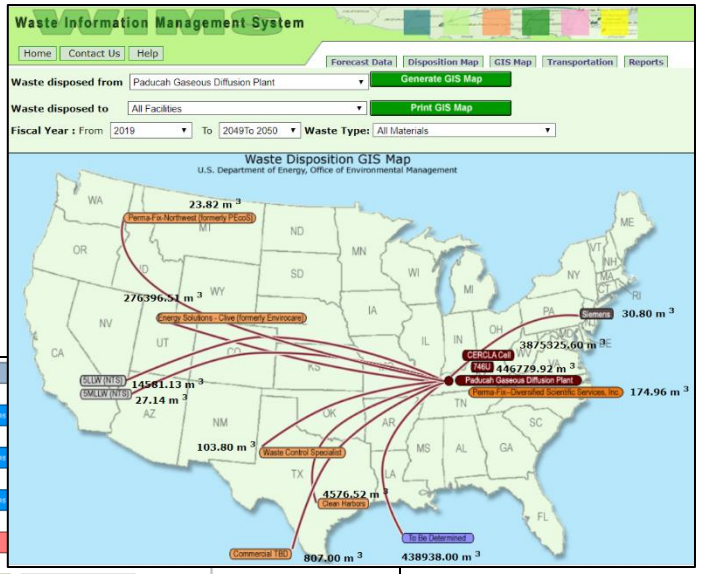
- Provide a central web-based system to access waste forecast streams for sites across the DOE complex.
- Provide easy-to-use tools to view the data in various formats.
- Update data on an annual basis.

Task 1 – Waste Information Management System

FIU Applied Research Center

Accomplishments Year 9:

- Easy-to-use tool to visualize and understand the forecasted DOE-EM waste streams & transportation information.
- WIMS is deployed and available at https://www.emwims.org
- Various modules of WIMS are Forecast Data, Disposition Map, Successor Stream Map, GIS Map, Transportation, Reports and Help.



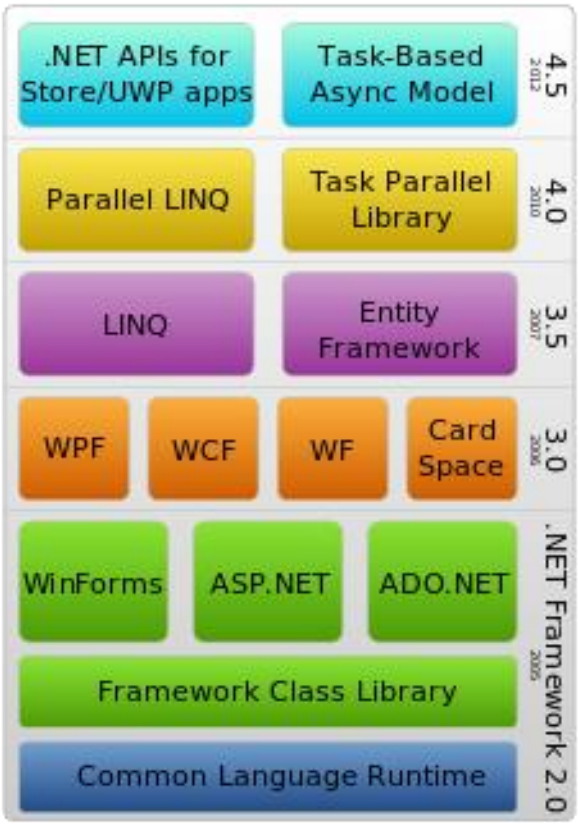
Task 1 – Waste Information Management System

FIU Applied Research Center

Accomplishments Year 9:

- Upgraded WIMS application framework & published updated system on March 30, 2019.
- FIU successfully upgraded the WIMS application to the latest Microsoft.Net framework 4.6.1 from framework 1.1 (Win 2003)
  - Deployed Database and Application servers with updated framework.
  - Configured WIMS application to execute on upgraded framework.
  - Upgraded WIMS components, controls and modules to the new framework.

Microsoft® .NET

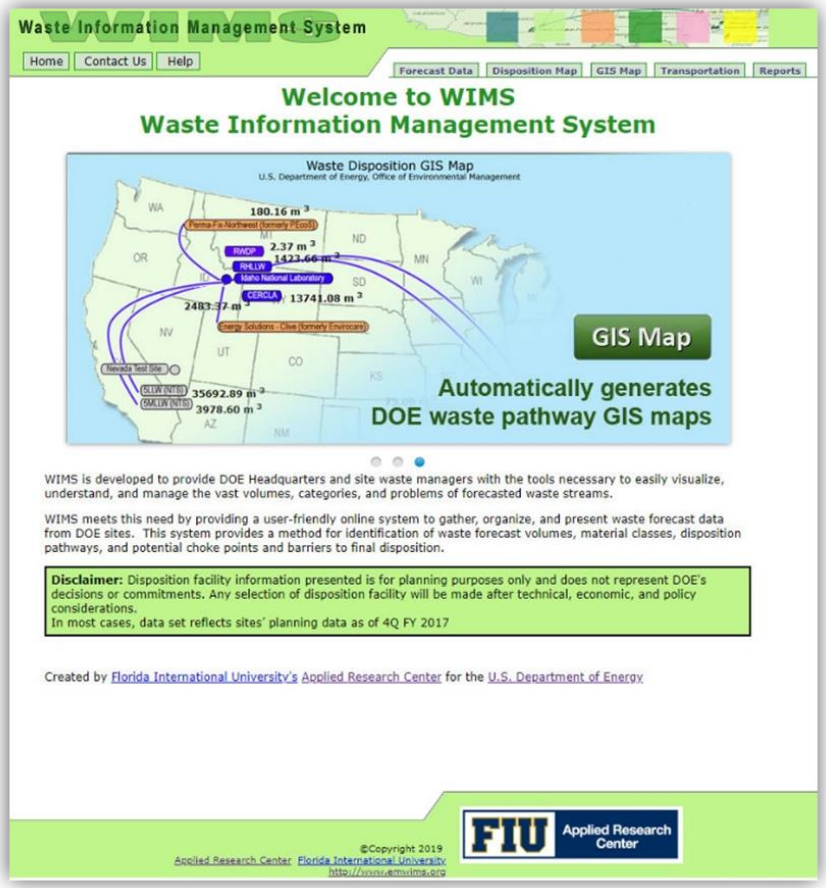


Task 1 – Waste Information Management System

FIU Applied Research Center

Accomplishments Year 9:

- Upgrade of .Net Framework resulted in:
  - Increased reliability and security of the system.
  - Increased efficiency in publishing new waste streams.
  - Improved user experience.
- Completed integration of 2019 waste forecast and transportation data into WIMS system.
- Published 2019 Forecast Waste stream data in May 2019.



Task 1 – Waste Information Management System

FIU Applied Research Center

Accomplishments Year 9:

- FIU presented WIMS research in 2019 Waste Management Symposia.

Title: Waste Information Management System with 2018-19 Waste Streams
Authors: Himanshu Upadhyay, Walter Quintero, Leonel Lagos, Peggy Shoffner
Abstract and Session: 19106, Poster Session 2 – Characterization

Walter Quintero presenting WIMS poster at WM2019

WM SYMPOSIA

Task 1 – Waste Information Management System

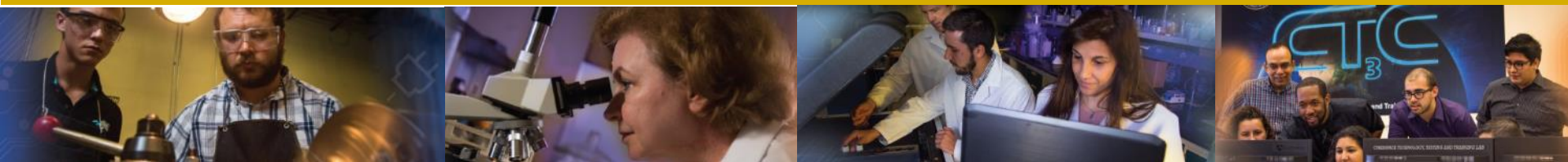
FIU Applied Research Center

Proposed Scope for Year 10

- Integrate 2020 waste stream and transportation data into WIMS.
  - Update WIMS modules – Forecast Data , Waste Stream and GIS map
  - Update and Publish reports
  - Update and Publish Transportation Module
  - Publish updated application on secured socket layer
- WIMS Identity Management
  - Design and develop Registration Database
  - Develop Authentication Module
  - Authorization Module Development
- Upgrade WIMS Report Server & Report Function
  - Deploy and integrate report server
  - Design, develop and publish reports
  - Integrate report in WIMS application

Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FLORIDA INTERNATIONAL UNIVERSITY



Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Site Needs:

Assess the structural integrity of aging facilities in support of ongoing surveillance and maintenance (S&M) across the DOE complex.

Objectives:

Under this subtask for FIU Performance Year 9, FIU will develop a pilot-scale infrastructure to implement structural health monitoring using scanning technologies, machine learning / deep learning and big data technologies. This pilot system is intended to serve as a starting point to engage the DOE field sites on related data sets and their decision making needs.

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

Data Collection:

- Set up mock-wall in outdoor test facility that simulates structural conditions of D&D facility.
- Collected over 28,000 images from different wall sections.
- Data variation contains different light exposure, wall angles and scale ratios.
- Image data sets are stored in the Big Data Platform.
- Data subsets are replicated in local storage networks for increased I/O transfers.

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

Algorithm Development:

- Implemented Deep Convolutional Neural Networks using Keras and TensorFlow.
- Designed and developed Convolutional Neural Network architecture for D&D mock up image dataset.
- Developed “driver” function that runs model combinations and permutations automatically.
- Model runs on CPU and GPU servers with parallel processing providing better performance.
- Convolutional Neural Network models are stored and published for prediction.

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

Results:

- Classification of walls into “baseline” or “degraded” categories with high confidence.
- Some Convolutional Neural Network model achieved an accuracy of 99.87%.
- Very low False Positives and False Negative predictions.
- Performance Benchmark: CNN models on GPU server performed 15x better than the CPU machines.

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

Image classification, a topic of pattern recognition in computer vision, is an approach of classification based on contextual information in images.

Data Analysis is a four step process:

1. D&D structure image data collection and pre processing.
2. Algorithm Selection - Modeling starts with the selection of an algorithm.
   - Image Classification
3. Build model – Develop model with the D&D image data and CNN algorithm.
   - Load the data
   - Create neural network layers
   - Train / Test model
   - Iterative process – Multiple epochs
4. Evaluate/Test – Validate and test the model with new D&D image dataset.

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

Baseline Model Development and Categorization

The baseline was created from images collected from the outdoor D&D mockup facility.

- A total of 28,000 images were collected.
  - 14,000 images were classified as “baseline” (all sections containing “CL” tag).
  - 14,000 images were classified as “deteriorated”.

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

Deep Convolutional Neural Network Architecture:

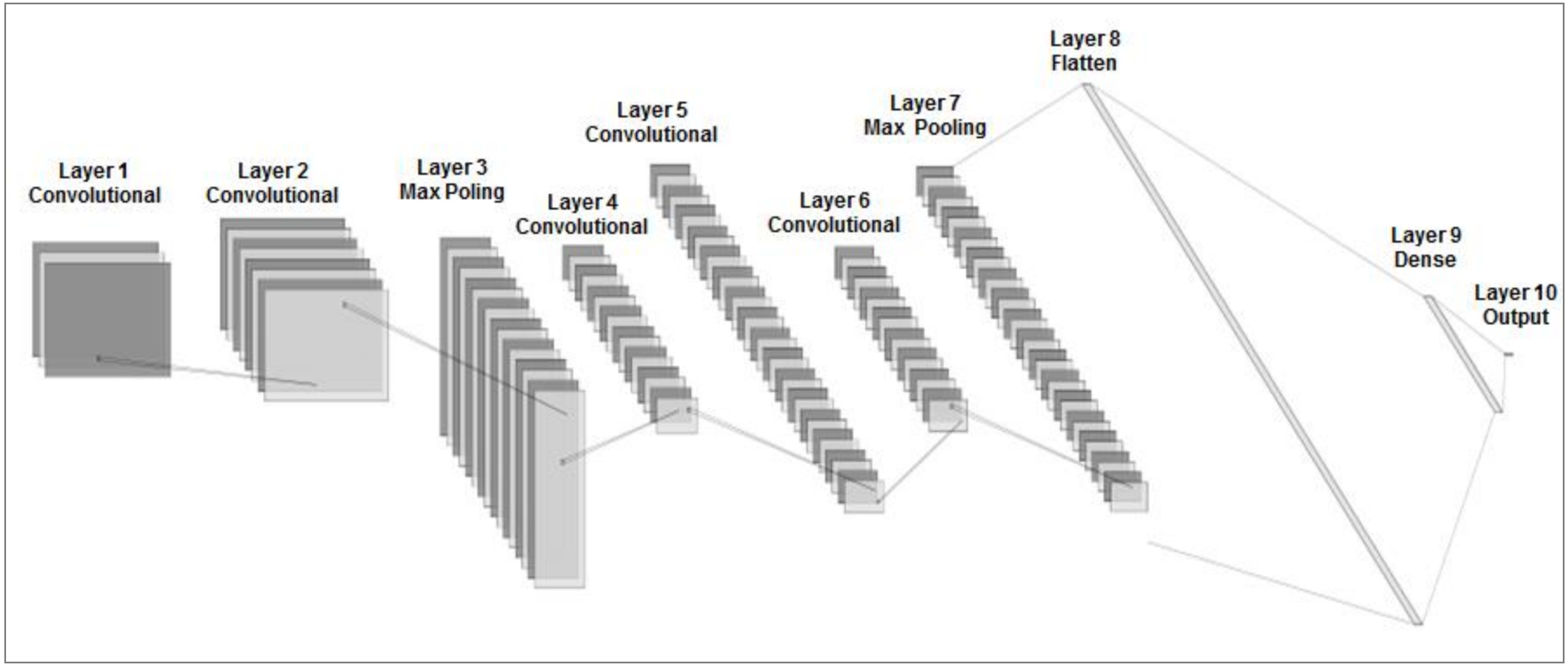
- Deep Convolutional Neural Network (CNN) is a feed-forward artificial neural network commonly applied to do image classification and object recognition.
- CNNs use a variation of network layers designed to solve specific problems.
- A total of 10 layers each with multiple hidden neurons was created to achieve a model accuracy of 99.87%

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

Deep Convolutional Neural Network Architecture:



Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

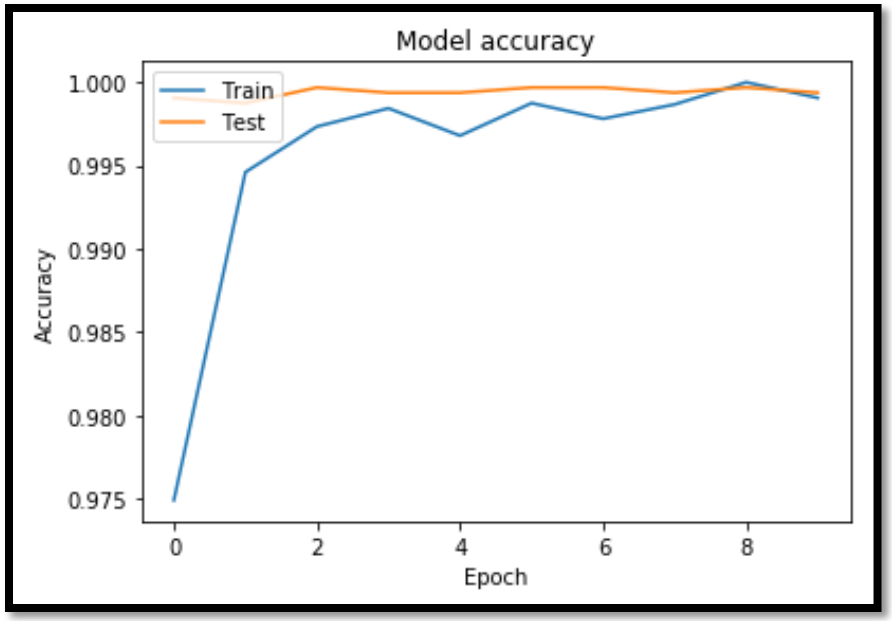
Neural Network Layer Terminology

1. Convolution Layer
   - Convolution layers are the core building blocks of the Neural Network.
   - They do most of the heavy computation.
2. Max Pooling Layer
   - Progressively reduce the spatial size of the problem to reduce the amount of parameters and computation in the network.
3. Dense Layer
   - A linear operation in which every input is connected to every output by a weight.
   - This layer sees the entire spatial dimension of the previous layer.
4. Output Layer
   - This is the final layer in the model and it is the one responsible for deciding the category/classification of images.

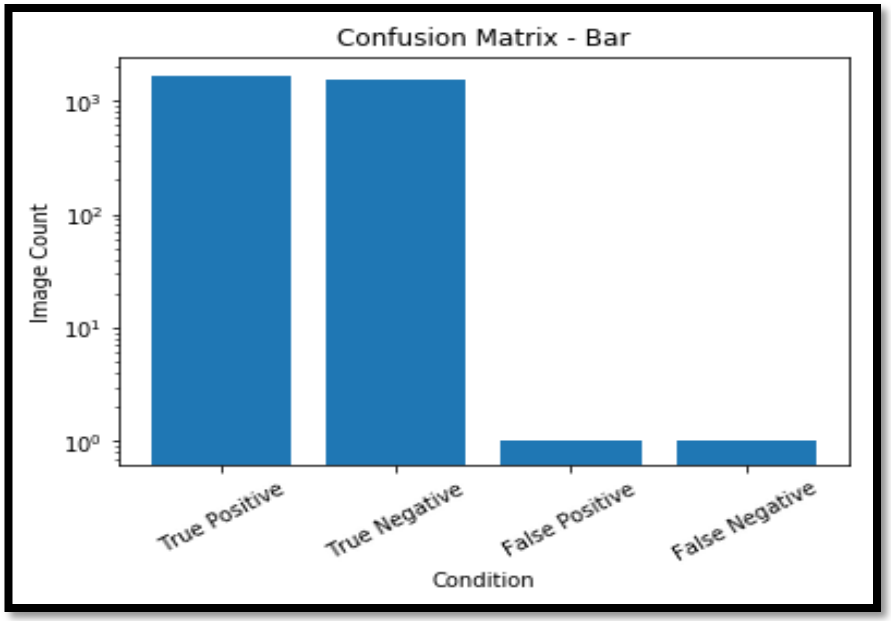
Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9: Results



Model Accuracy



Confusion Matrix

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9: Classification of Wall Images

Sample Baseline Images

Input image feed to CNN model for Classification

Model Prediction = “Baseline”
94.35% probability

Model Prediction = “Degraded”
97.13% probability

Model Prediction = “Baseline”
87.63% probability

Model Prediction = “Degraded”
97.16% probability

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

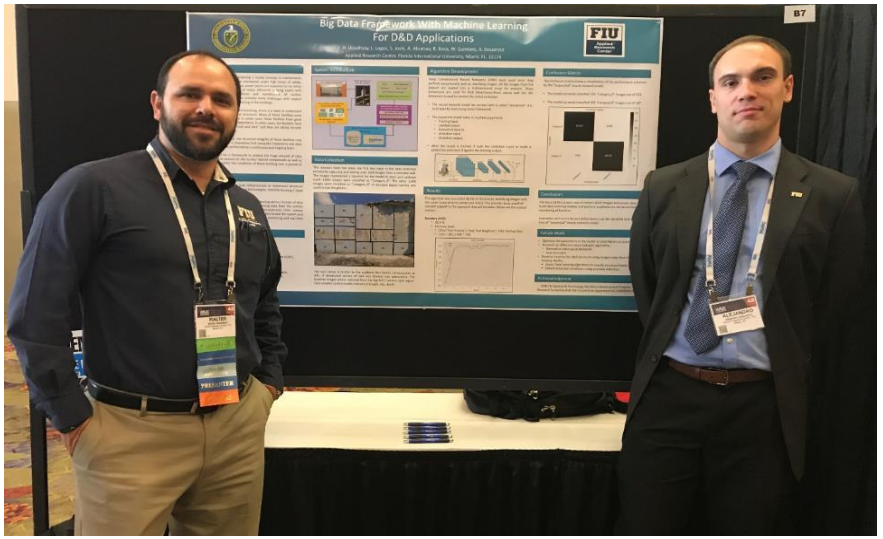
Presented this research at WM2019.

The poster focused on the methodology and approach of this research. Conference attendees had a lot of interest in this research focused on Artificial Intelligence and Big Data technologies.

Abstract: 19108

Title: Big Data Framework with Machine Learning for D&D Applications

Authors: Himanshu Upadhyay, Leonel Lagos, Anthony Abrahao, Walter Quintero, Santosh Joshi



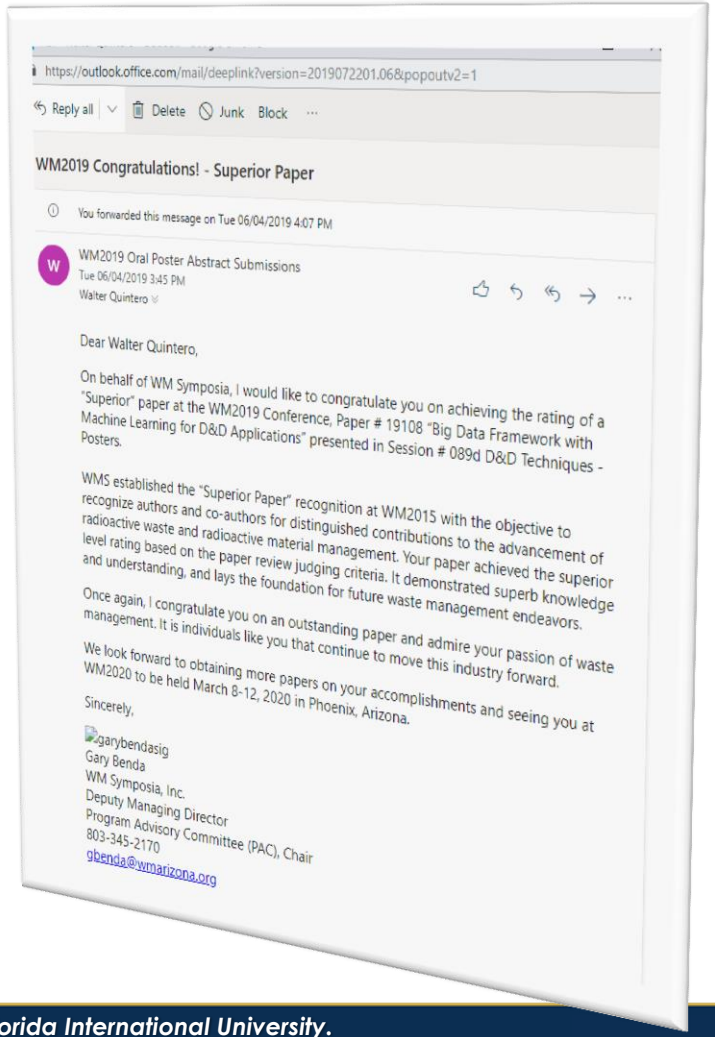
Walter Quintero and Alejandro Koszarycz at WM2019 presenting poster.

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

Accomplishments Year 9:

WM Symposia awarded the rating of a “Superior Paper” for the “Big Data Framework with Machine Learning for D&D Applications” paper.



https://outlook.office.com/mail/deeplink?version=2019072201.06&popoutv2=1

Reply all | Delete | Junk | Block | ...

WM2019 Congratulations! - Superior Paper

You forwarded this message on Tue 06/04/2019 4:07 PM

WM2019 Oral Poster Abstract Submissions
Tue 06/04/2019 3:45 PM
Walter Quintero

Dear Walter Quintero,

On behalf of WM Symposia, I would like to congratulate you on achieving the rating of a "Superior" paper at the WM2019 Conference, Paper # 19108 "Big Data Framework with Machine Learning for D&D Applications" presented in Session # 089d D&D Techniques - Posters.

WMS established the "Superior Paper" recognition at WM2015 with the objective to recognize authors and co-authors for distinguished contributions to the advancement of radioactive waste and radioactive material management. Your paper achieved the superior level rating based on the paper review judging criteria. It demonstrated superb knowledge and understanding, and lays the foundation for future waste management endeavors.

Once again, I congratulate you on an outstanding paper and admire your passion of waste management. It is individuals like you that continue to move this industry forward.

We look forward to obtaining more papers on your accomplishments and seeing you at WM2020 to be held March 8-12, 2020 in Phoenix, Arizona.

Sincerely,

garybendasig
Gary Benda
WM Symposia, Inc.
Deputy Managing Director
Program Advisory Committee (PAC), Chair
803-345-2170
gbenda@wmarizona.org

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

Proposed Scope for Year 10

- FIU will use the LiDAR technology to collect point cloud data by scanning the D&D mock up facility at FIU.
- The point cloud data collected from LiDAR will be stored on a Hadoop distributed file system for storage and processed with distributed nodes using parallel processing.
- FIU will continue to work on the development and optimization of the convolutional neural network algorithm to classify structural wall images using the point cloud data and images.
- FIU will research, design and develop the object recognition algorithm using computer vision to identify cracks and structural defects in the mock up wall.

Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

Proposed Scope for Year 10

- FIU plans to deploy an integrated big data and machine learning server infrastructure using Docker containers and a Kubernetes orchestration framework for image data storage and processing.
- Algorithms and big data technologies developed under this research will help in surveillance and maintenance of D&D buildings to identify cracks, defects and other irregularities using LiDAR or other scanning/imaging technologies.
- Identifying anomalous sensor data collected from various monitoring applications across DOE-EM sites.
- This research task will also support the Ph.D. studies of the DOE Fellow – Roger Boza working on image recognition, neural network design and optimization for image processing and object recognition.