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

Presented: August 25, 2020

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FIU Personnel and Collaborators

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SRNL: Aaron Washington, Connor Nicholson

PNNL: Vicky Freedman, Rob Mackley

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

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

Project Tasks and Scope

Artificial Intelligence Support to DOE-EM – D&D and Soil & Groundwater

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 imaging technologies with D&D mock up facilities at FIU

Task 7 – AI based Evaluation of Cr (VI) Concentrations in Groundwater in a Dynamic Pump and Treat Remediation Scenario (New)

- Development of machine learning and deep learning models to identify patterns, address knowledge gap and ultimately predict transport of Cr(VI) in the subsurface of the 100-H Area

Knowledge Management Information Tool (KM-IT)

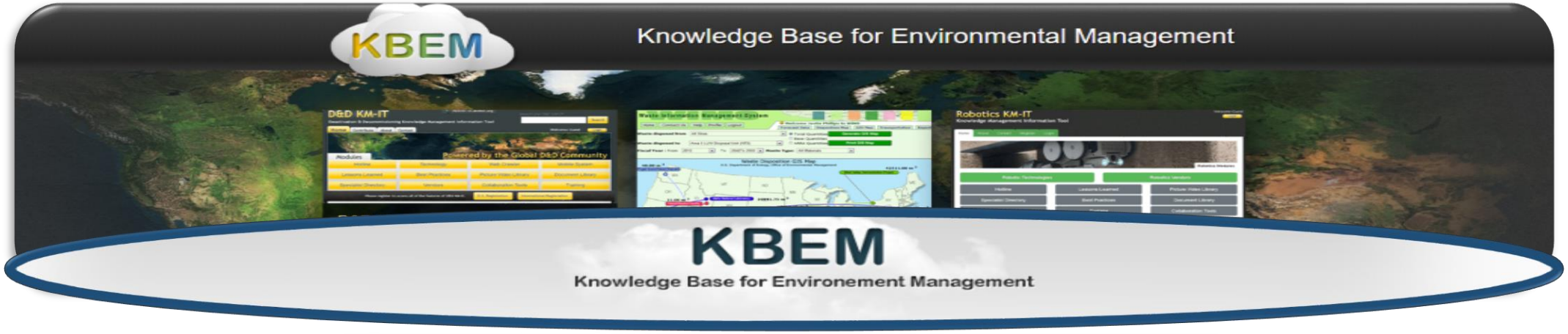
www.dndkm.org

Dr. Himanshu Upadhyay

Florida International University

Knowledge Base for Environmental Management

FIU Applied Research Center



DND KM-IT
dndkm.org

WIMS
emwims.org

DOE FELLOWS
fellows.fiu.edu

DOE RESEARCH
doeresearch.fiu.edu

Fixatives Mobile App

Robotics KM-IT
rkmit.org

Knowledge Base for Environmental Management

https://kbem.org/

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

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 for DOE-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.

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 10:

- FIU continued to conduct outreach and community support for KM-IT
- Participating in conferences and workshops
- 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.

D&D KM-IT
Knowledge Management Information Tool

In this issue...

As we mark over 100 days since the enforcement of coronavirus academic and lockdown policies began in the US, FIU has remained busy at work. Here are just a few of the tasks that have kept us occupied during this time.

- 2019-2020 Waste Stream Forecast Data on WIMS
- New Technologies Added to KM-IT
- What is YOLO?
- DOE Fellow Experience at Waste Management Symposia 2020

2019-2020 Waste Stream Forecast Data on WIMS

In May, FIU collaborated closely with DOE HQ personnel to publish new forecast data on the Waste Information Management System (WIMS). WIMS tracks forecast data from 36 sites, 33 facilities, and 5 different waste types. The goal of WIMS is to provide a user-friendly online system to gather, organize, and present waste forecast data from DOE sites. The new data recently added contains data from 2020-2050. The new data can be accessed at https://emwims.org/

New Technologies Added to KM-IT

In May, 24 new technologies were added to the Deactivation & Decommissioning Knowledge Management Information Tool (D&D KM-IT) with an additional 40 published in April. Among these technologies were face masks, detection devices, sensors, and heavy machinery for demolition. These technologies were added by the DOE Fellows working on this project as well as various vendors supporting the D&D mission. Contact us if you are a D&D vendor and would like your technology listed/showcased in KM-IT. You can also browse our technology page to see if your technology is already featured.

D&D KM-IT

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

FIU Applied Research Center

Accomplishments Year 10:

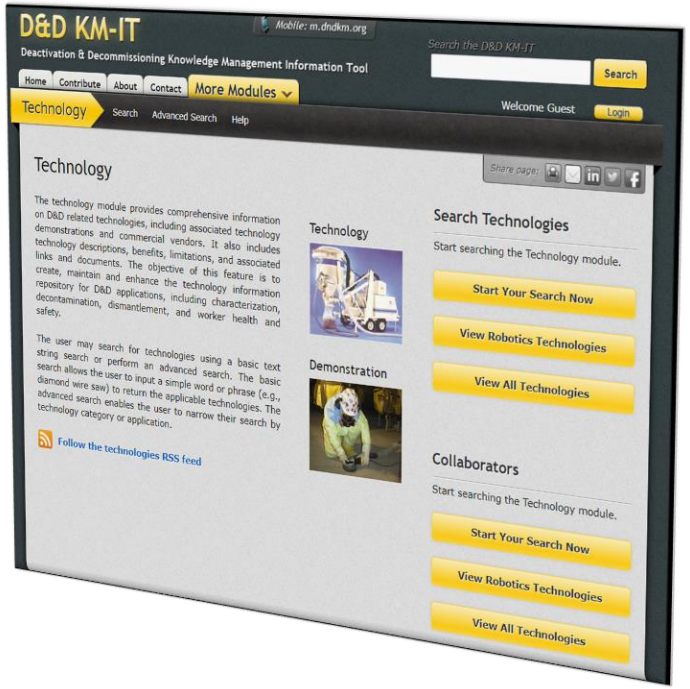
- 281 technologies were published on this platform in this fiscal year, bringing the total technologies published to 1259
- This is an increase of over 40% over the previous year when 196 technologies were added

Porter-Cable Circular Saw with Vacuum System

110 First Look Robot

Brokk 400

Anti-Contamination "BLU" Suit

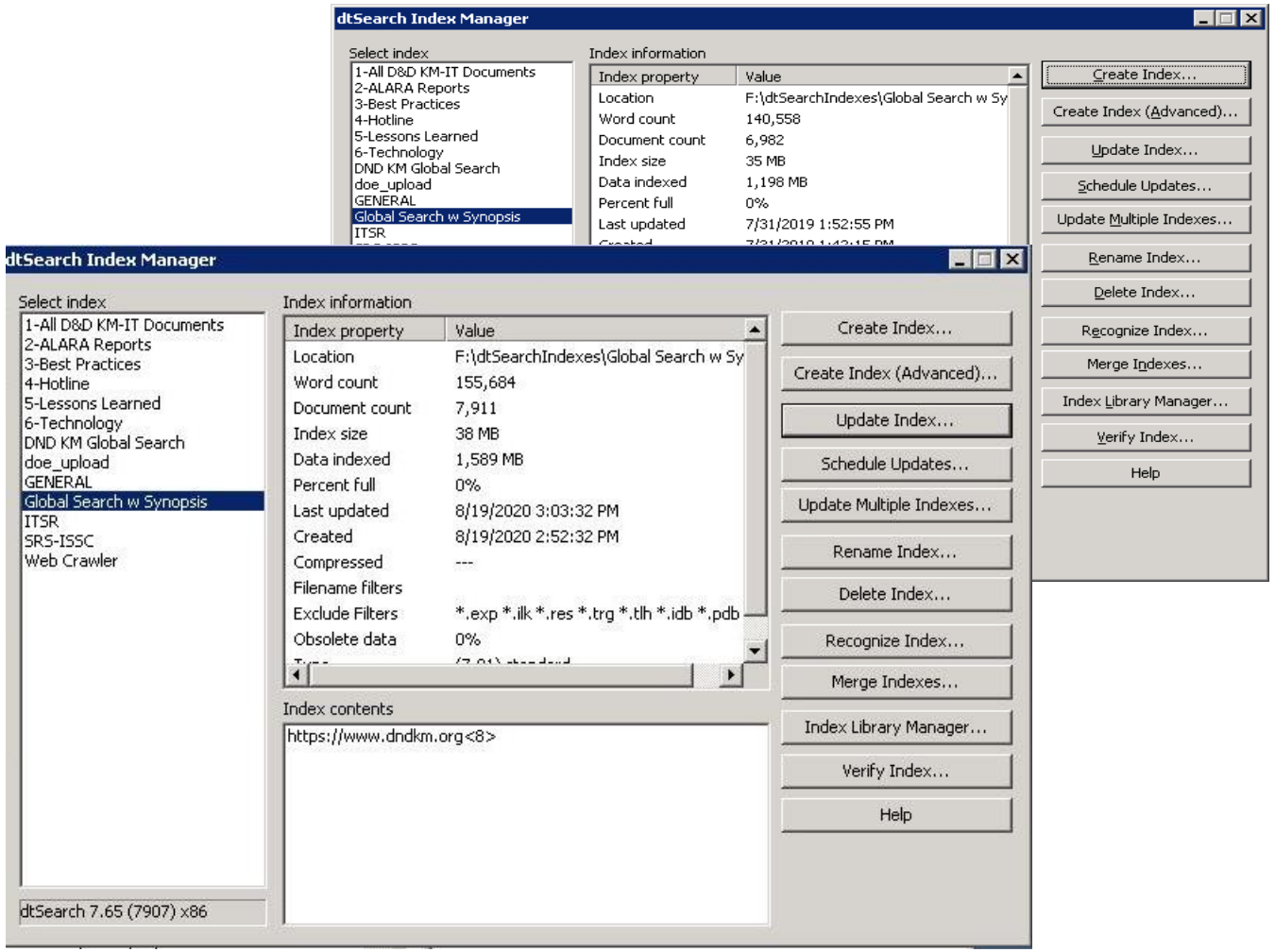


Task 3 – Knowledge Management Information Tool (KM-IT)

FIU Applied Research Center

Accomplishments Year 10:

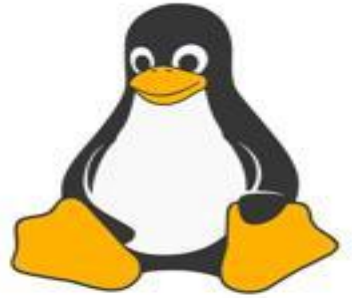
- Search KM-IT – This feature involves search index optimization
  - Search process crawls through D&D KM-IT system and stores key information about each document so that when users perform a search, the information can be retrieved in real time.
  - The index is built using word, pdf, html and other readable documents stored in the system.
  - The search index is updated manually after any significant changes to the D&D KM-IT (6-8 times per year)
  - Since last year, the D&D KM-IT has added 929 files (html, pdf and doc)
    (6,982 documents - 7/31/2019 to 8/19/2020)



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

Accomplishments Year 10:

- Researchers and DOE Fellows continued research on 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.

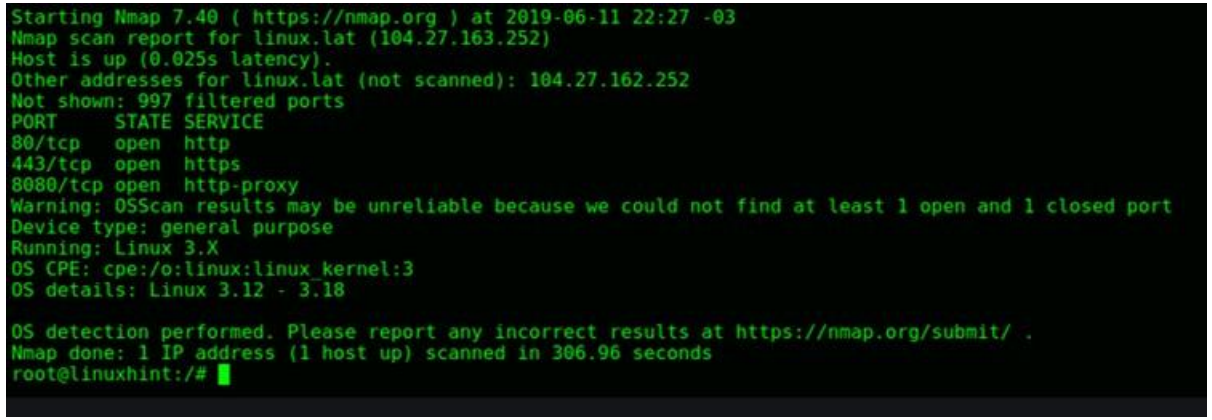


Task 3 – Knowledge Management Information Tool (KM-IT)

FIU Applied Research Center

Accomplishments Year 10:

- DOE Fellow Alejandro Koszarycz is supporting the cybersecurity research efforts
  - Learning about the ISO OSI seven-layer network model
  - Learning to use hacking tools to simulate cybersecurity attack
  - Working with Kali Linux which contains a suite of cybersecurity tools
  - Sample cybersecurity tool nMap shown here used for network reconnaissance



KALI

NMAP

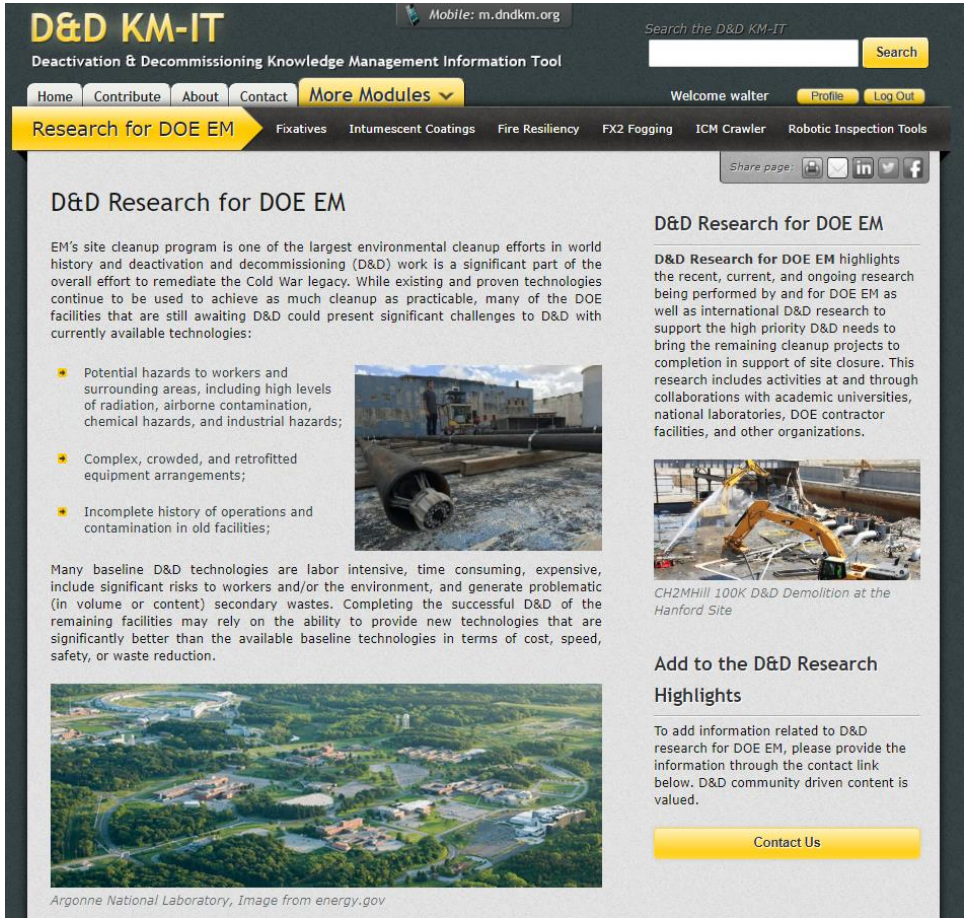
Task 3 – Knowledge Management Information Tool (KM-IT)

FIU Applied Research Center

Accomplishments Year 10:

- FIU is working to enhance the D&D Research module by collaborating with universities, national labs and DOE sites.
- 10 potential entities are being followed. They include:
  - Idaho National Laboratory
  - NAC International
  - Gilbane, Inc.
  - Perdue University
  - Florida A&M University
  - University of Leeds
  - University of Bristol
  - Polestar Technical Services, Inc.
  - John Wood Group PLC
  - Los Alamos National Laboratory

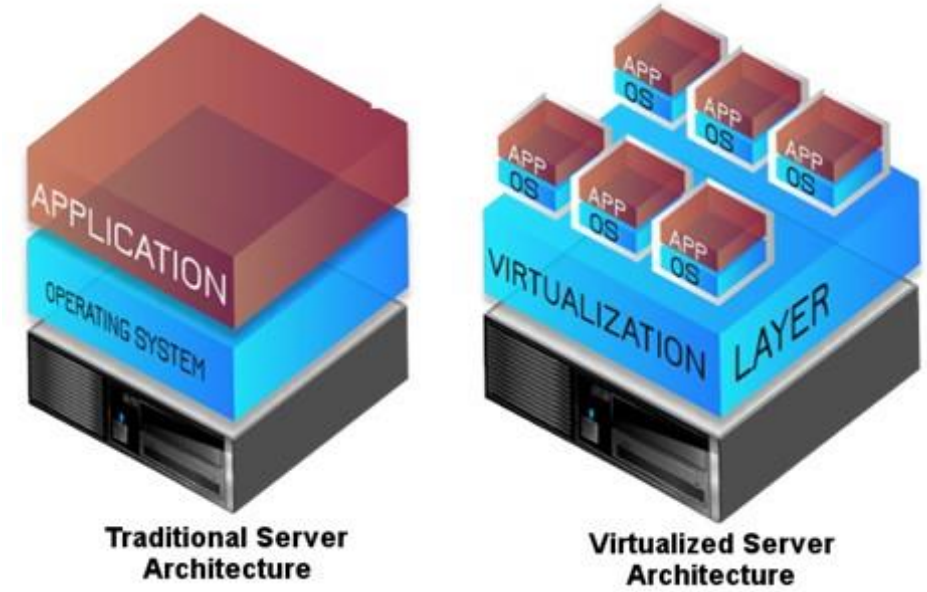
D&D RESEARCH



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

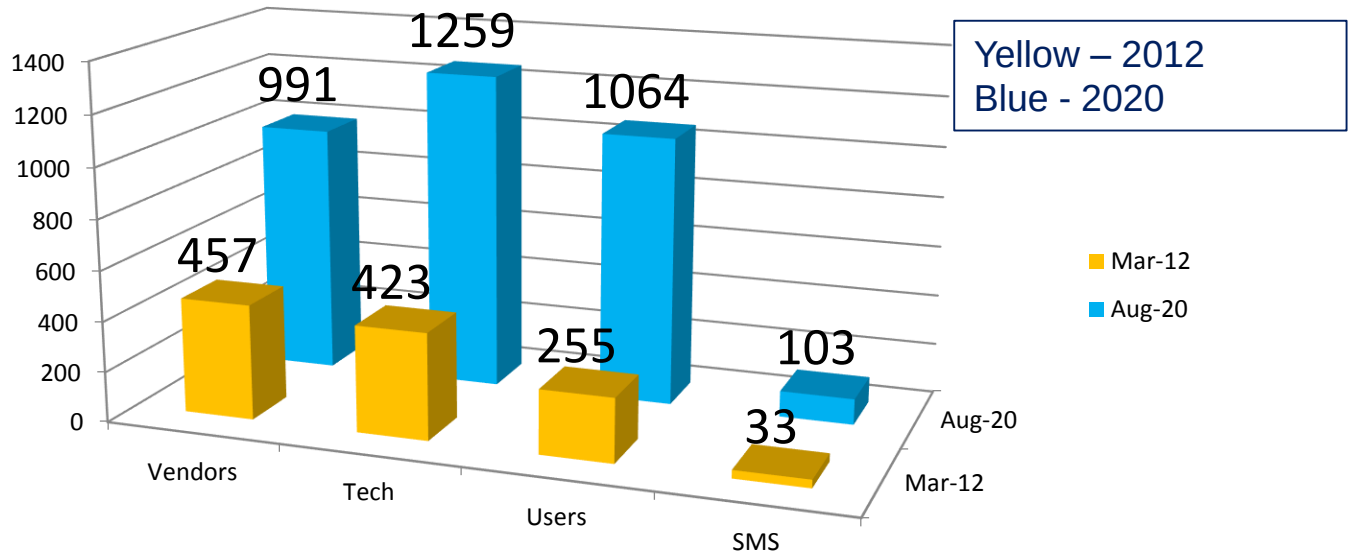
Accomplishments Year 10:

- FIU has migrated the KM-IT physical environment to the virtual servers.
- Deployed the KM-IT application and database to the virtualized environment.
- This effort resulted in virtual KM-IT infrastructure that is
  - More reliable
  - More secured
  - Easier to maintain
  - More efficient to backup and conduct disaster recovery
  - Easier to migrate and upgrade



D&D KM-IT Statistics as of August 2020

- D&D KM-IT web analytics to track usage metrics.
- 1259 D&D technologies
- 1064 registered users
- 991 D&D vendors
- 195 Hotline questions/solutions
- 103 subject matter specialists



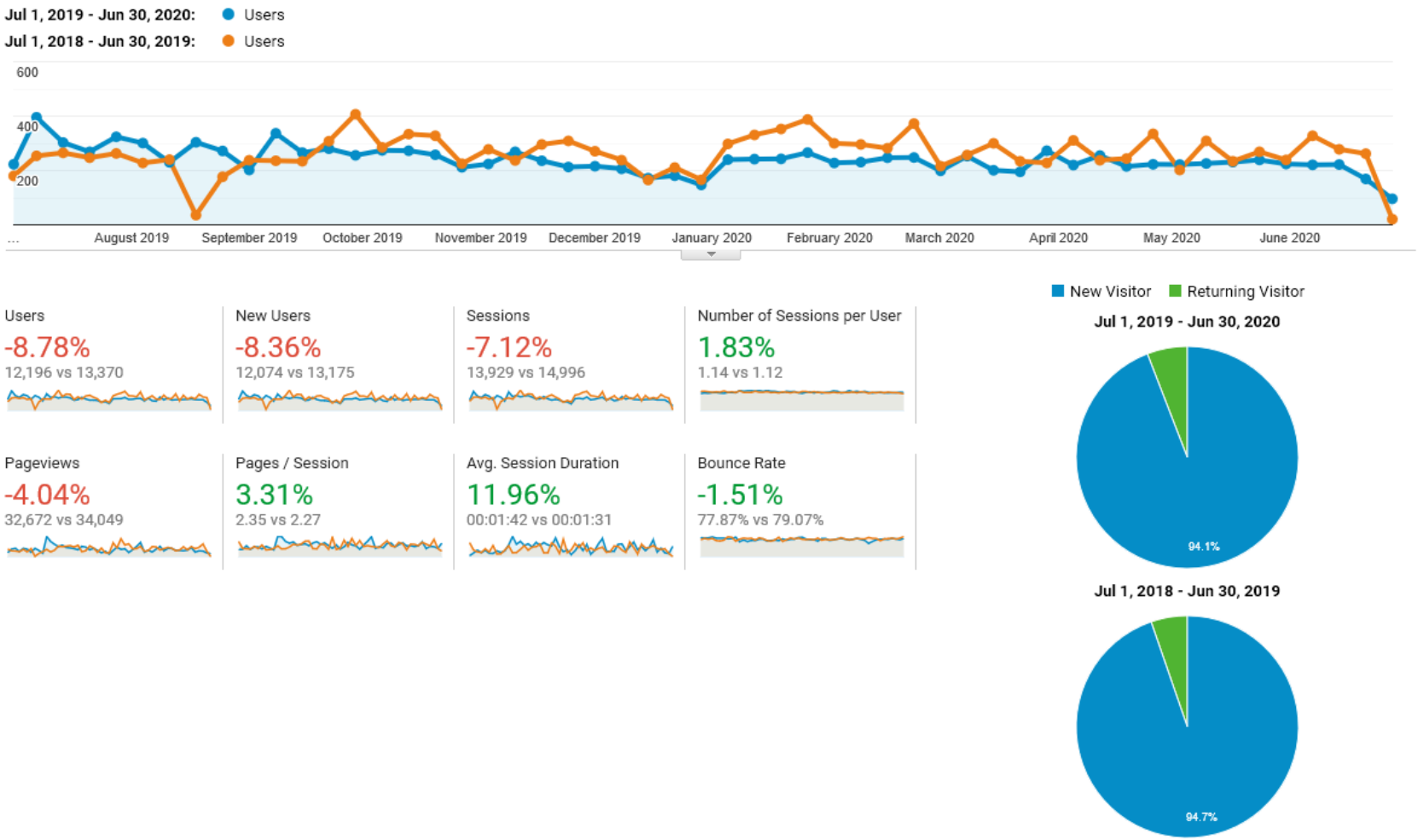
Growth from March 2012 to Aug 2019

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

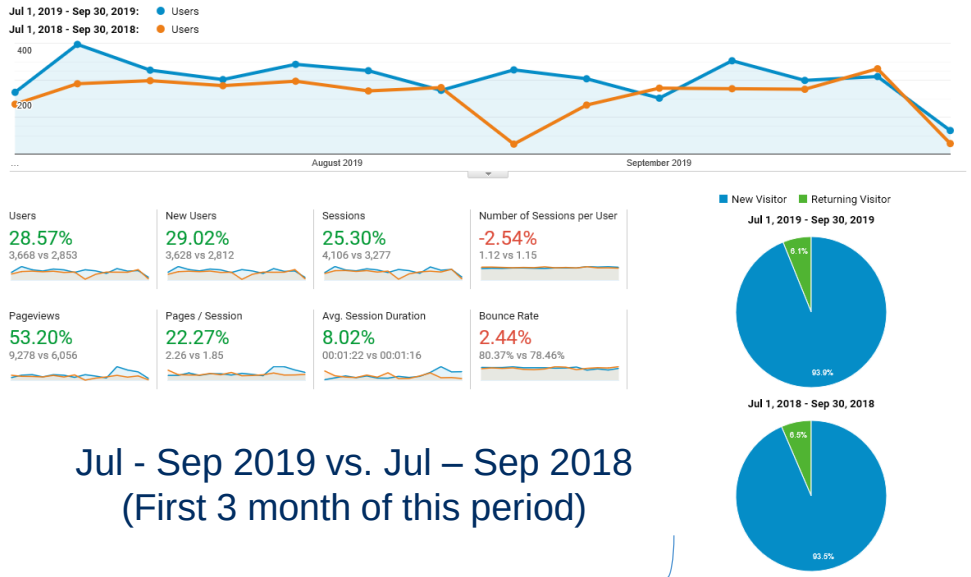
- 169 ALARA Center reports archived (Hanford and SRS)
- 231 Innovative Technology Summary Reports archived

D&D KM-IT Statistics as of July 2020

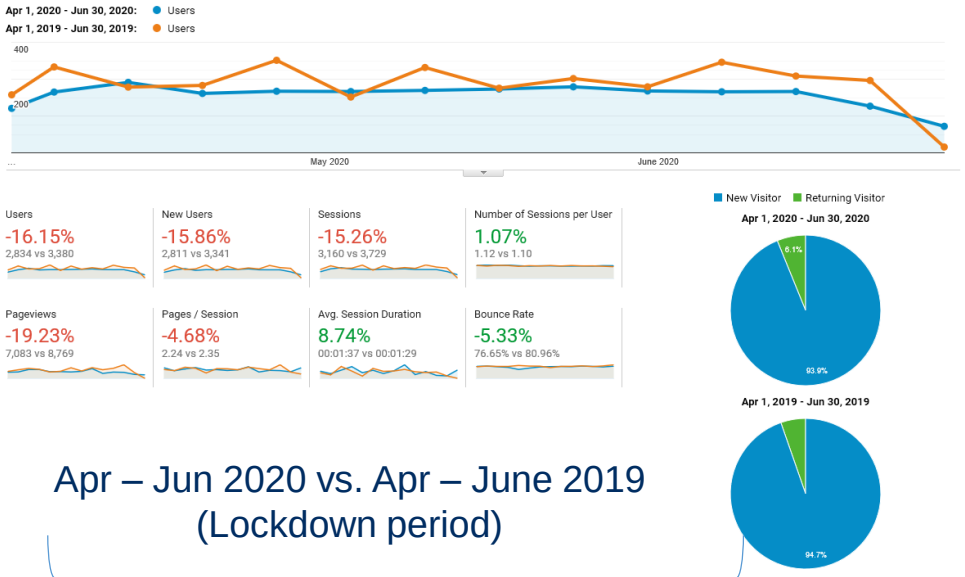
- Year comparison activity on D&D KM-IT (2020 vs 2019)
- Double digit percentage increase on: Average Session Duration
- Minor increase on: Number of Session per User, Pages per Session and Bounce Rate
- Decrease on: User, New Users, Sessions and Pageviews



D&D KM-IT Statistics, a closer look



Jul - Sep 2019 vs. Jul – Sep 2018
(First 3 month of this period)



Apr – Jun 2020 vs. Apr – June 2019
(Lockdown period)

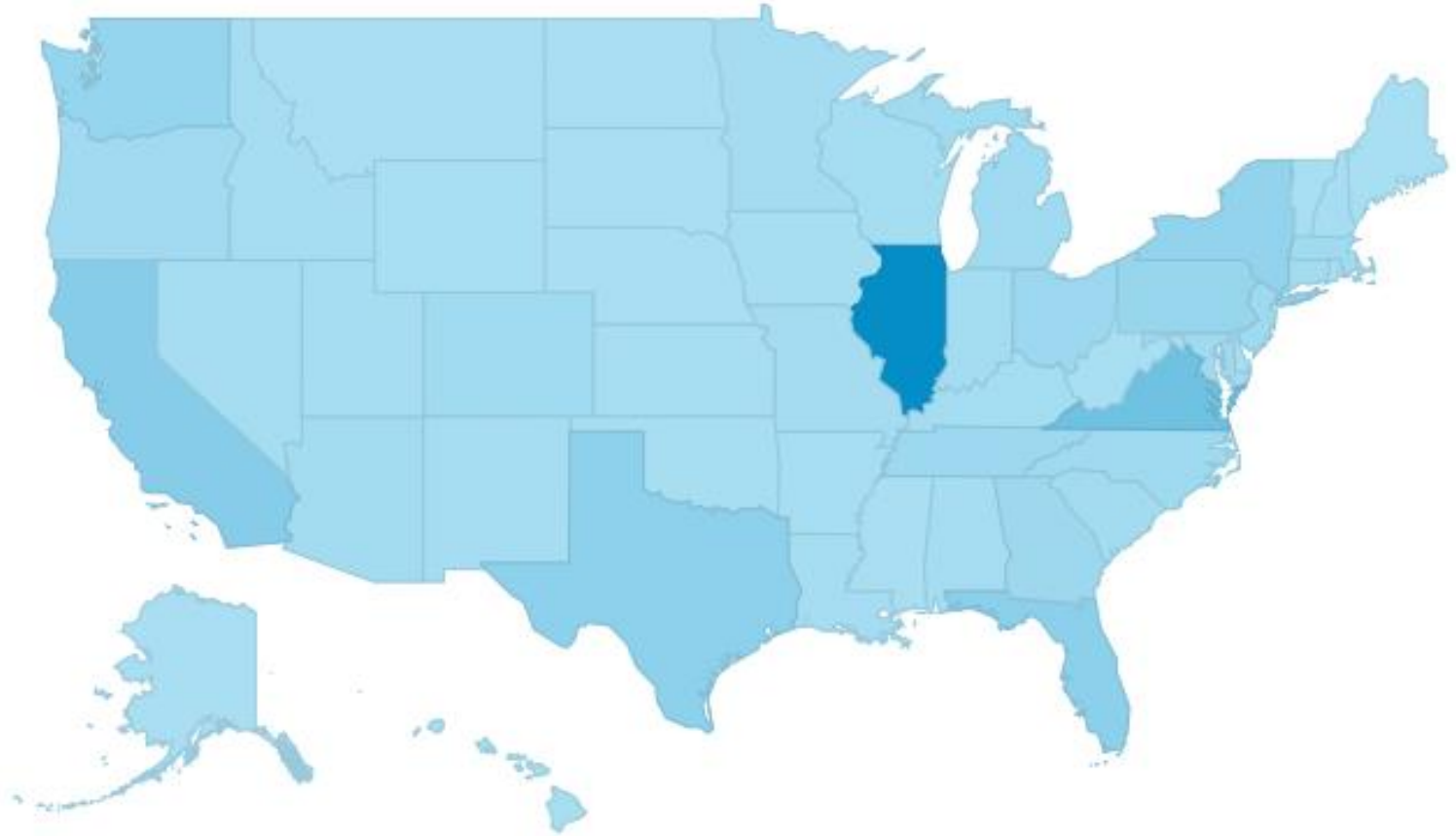
Jul Sep …….…….....…….. Jul Sep

- The analytics seem to suggest that the lockdown has affected traffic across the D&D KM-IT
  - Typically Monday through Friday are the most active periods
  - During the first 3 months of this period, the site experience double digit increase in many of it's metrics
  - However, during the lockdown months (April – June), the site has experience double digit decrease

D&D KM-IT Statistics as of July 2020

KM-IT visited by every state of the union in the last 12 months with the top 10 being:

- Illinois
- Virginia
- California
- Florida
- Texas
- New York
- Washington
- Pennsylvania
- Ohio
- Tennessee



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

Accomplishments Year 10:

- FIU presented D&D KM-IT research at WM2020, demonstrated at FIU booth and D&D KM-IT Poster

Title: D&D Research on KM-IT platform
Authors: Walter Quintero, Himanshu Upadhyay, Leonel Lagos
Session: D&D Technology Application - Posters

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

Proposed Scope for FY20/FY21

- Subtask 3.1: D&D KM-IT Enhancement
  - Enhancement will include user interface responsive design and development.
- Subtask 3.2: Software Upgrades (Database and .NET Framework)
  - Migration of the existing database to SQL Server 2017 and KM-IT modules to .NET Framework 4.2
- Subtask 3.3: Content Management
  - Publishing D&D Technologies, vendors, lessons learned, best practices, D&D News and conferences with the assistance of DOE Fellows
- Subtask 3.4: Marketing and Outreach
  - Participation in industry conferences and workshops
  - Newsletters and mass communications
  - Reaching out to sites/national labs/universities to increase KM-IT user involvement

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

Proposed Scope for FY20/FY21

- Subtask 3.5: D&D KM-IT System Administration
  - System administration is an ongoing task which involves day-to-day administration of KM-IT infrastructure.
  - Updating patches, OS fixes, updating antivirus engine and definitions, updating drivers and.
- Subtask 3.6: Cyber Security of D&D KM-IT Infrastructure
  - Cybersecurity & Administration of KM-IT Infrastructure
  - Conduct daily/weekly/monthly cyber security tasks, review audit reports to secure the KM-IT infrastructure.

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.

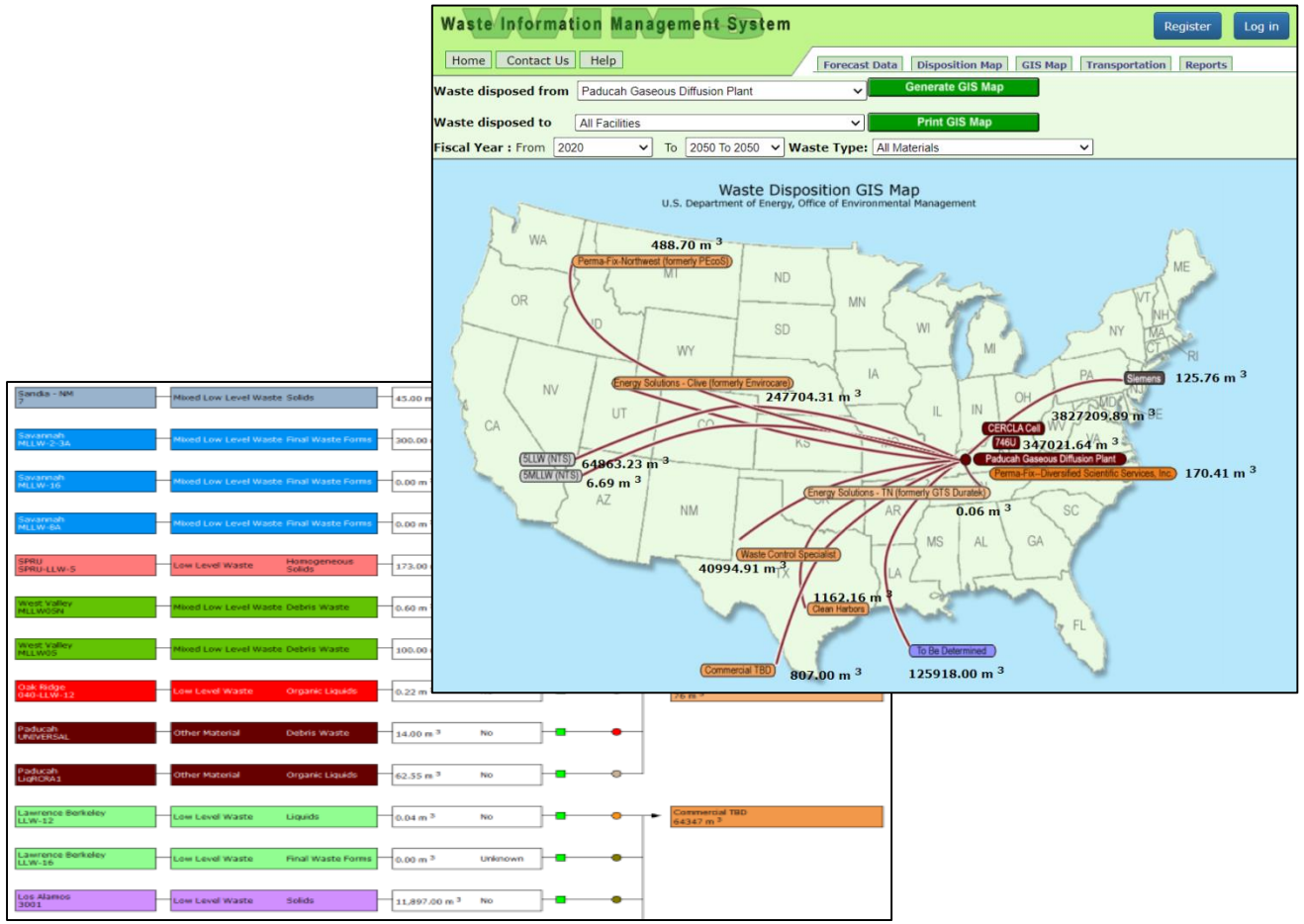
Objectives:

- Provide a central web-based system to access waste forecast streams for sites across the DOE complex.
- Provide easy-to-use systems to view & download waste stream forecast information in various formats.
- Update waste stream forecast information annually.

Task 1 – Waste Information Management System

Accomplishments Year 10:

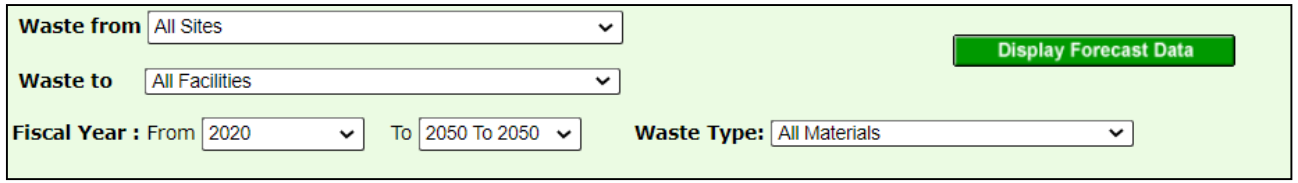
- Easy-to-use system to visualize and understand the forecasted DOE-EM waste streams & transportation information.
- WIMS is deployed and available at https://www.emwims.org
- Various modules of WIMS are Forecast Data, Disposition Map, Successor Stream Map, GIS Map, Transportation, Reports and Help.

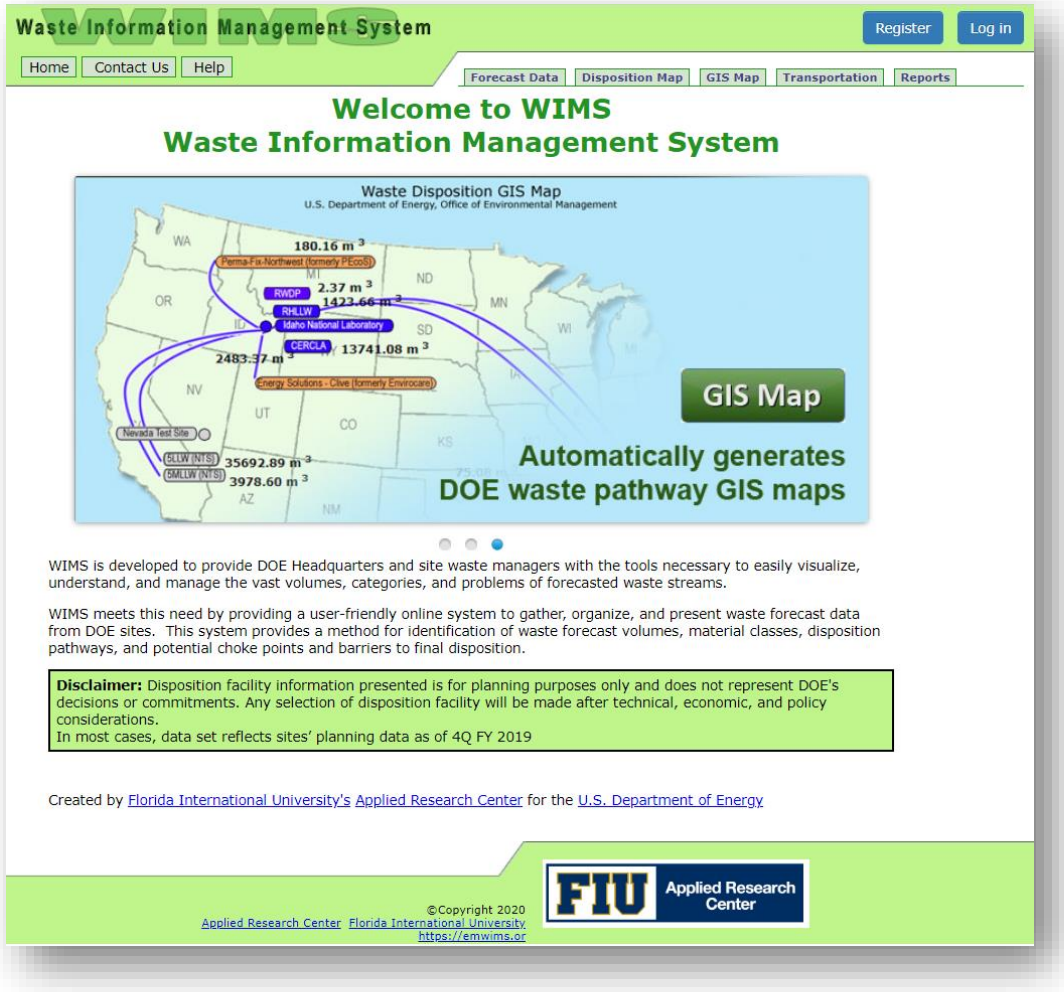


Task 1 – Waste Information Management System

Accomplishments Year 10:

- Completed integration of 2020 waste forecast and transportation data into WIMS system.
- Published 2020 Forecast Waste stream information in May 2020.





36 Supported Sites

- Ames Laboratory
- Argonne National Laboratory
- Bettis Atomic Power Laboratory
- Brookhaven National Laboratory
- Energy Technology Engineering Center
- Fermi National Accelerator Laboratory
- Hanford Site-RL
- Hanford Site-RP
- Idaho National Laboratory
- Kansas City Plant
- Knolls Atomic Power Laboratory - Kesselring
- Knolls Atomic Power Laboratory - Schenectady
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Naval Reactor Facility
- Nevada Test Site
- NG Newport News
- NG Newport News
- Norfolk Naval Shipyard
- Nuclear Fuel Services, Inc. (cleanup site)
- Oak Ridge Reservation
- Paducah Gaseous Diffusion Plant
- Pantex Plant
- Pearl Harbor Naval Shipyard
- Pacific Northwest National Laboratory
- Portsmouth Gaseous Diffusion Plant
- Portsmouth Naval Shipyard
- Princeton Plasma Physics Laboratory
- Puget Sound Naval Shipyard
- Sandia National Laboratories - NM
- Savannah River Site
- Stanford Linear Accelerator Center
- Separations Process Research Unit
- Thomas Jefferson National Accelerator Facility
- Waste Isolation Pilot Plant
- West Valley Demonstration Project

33 Disposition Facilities

- 200 Area Burial Ground (HANF)
- 746-U Landfill(Paducah)
- Alaron
- Area 5 LLW Disposal Unit (NTS)
- Area 5 MLLW Disposal Cell (NTS)
- Clean Harbors
- Commercial TBD
- E-Area Disposal (SRS)
- EMWMF Disposal Cell (ORR)
- Energy Solutions-Clive (formerly Envirocare)
- Energy Solutions-TN (formerly GTS Duratek)
- ERDF (HANF)
- Impact Services-TN
- INL CERCLA Cell (INL)
- Integrated Disposal Facility (HANF)
- New RH LLW Vaults (INL)
- ORNL Liquid LLW System
- OSWDF(Portsmouth)
- Paducah CERCLA
- Perma-Fix Gainesville
- Perma-Fix--Diversified Scientific Services, Inc.
- Perma-Fix--Northwest (formerly PEcoS)
- Perma-Fix/Materials & Energy Corp
- River Metals
- RMW Trenches (MLLW/LLW) (HANF)
- RMW Trenches/IDF (HANF)
- RWMC (LLW disposal) (INL)
- Siemens
- Smokey Mountain Solutions
- Studsvik/RACE , LLC
- TA 54/Area G (LLW disposal) (LANL)
- To Be Determined
- Waste Control Specialists

Forecast Period and Waste Type

Date Range

- 2019 - Inventory
- 2020 to 2024
- 2025 to 2029
- 2030 to 2034
- 2035 to 2039
- 2040 to 2044
- 2045 to 2049
- 2050

Waste Type

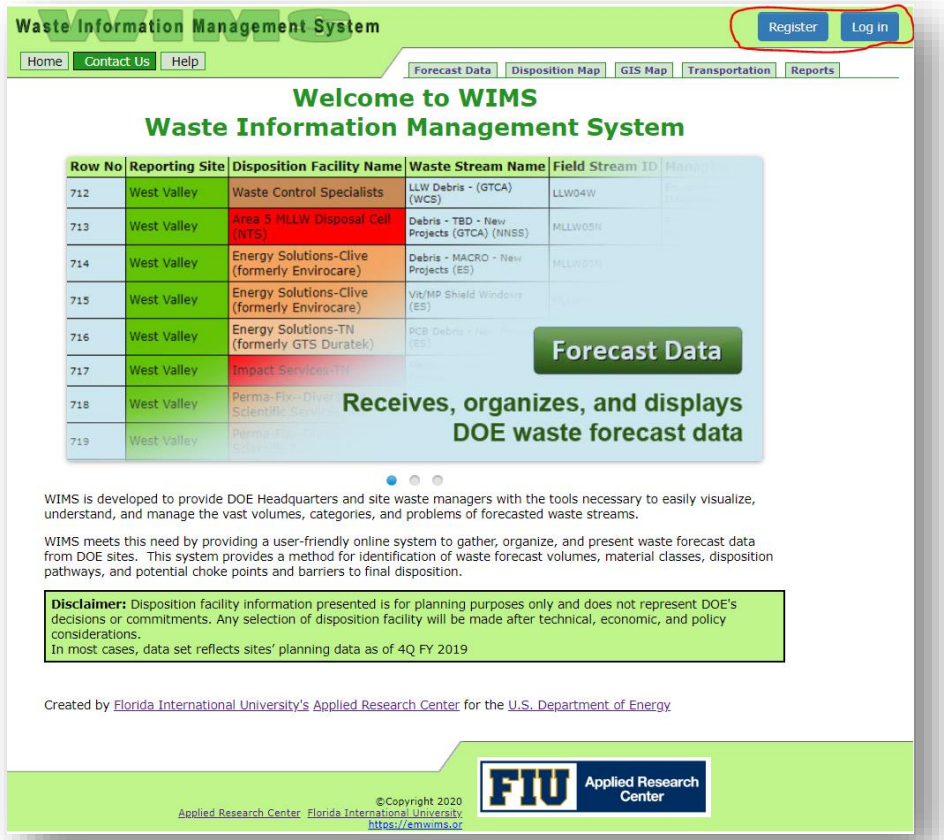
- Low Level Waste
- Mixed Low Level Waste
- 11e(2) Byproduct Material
- Other Material

Task 1 – Waste Information Management System

Accomplishments Year 10:

- FIU successfully upgraded the WIMS application to the latest Microsoft.Net
- Implemented Microsoft Identity Management
- Completion of this task resulted in:
  - More secure & reliable application
  - Custom registration
  - Allow users to have their own profile
  - Administrators can control user roles
  - Improved user experience.

Identity management features

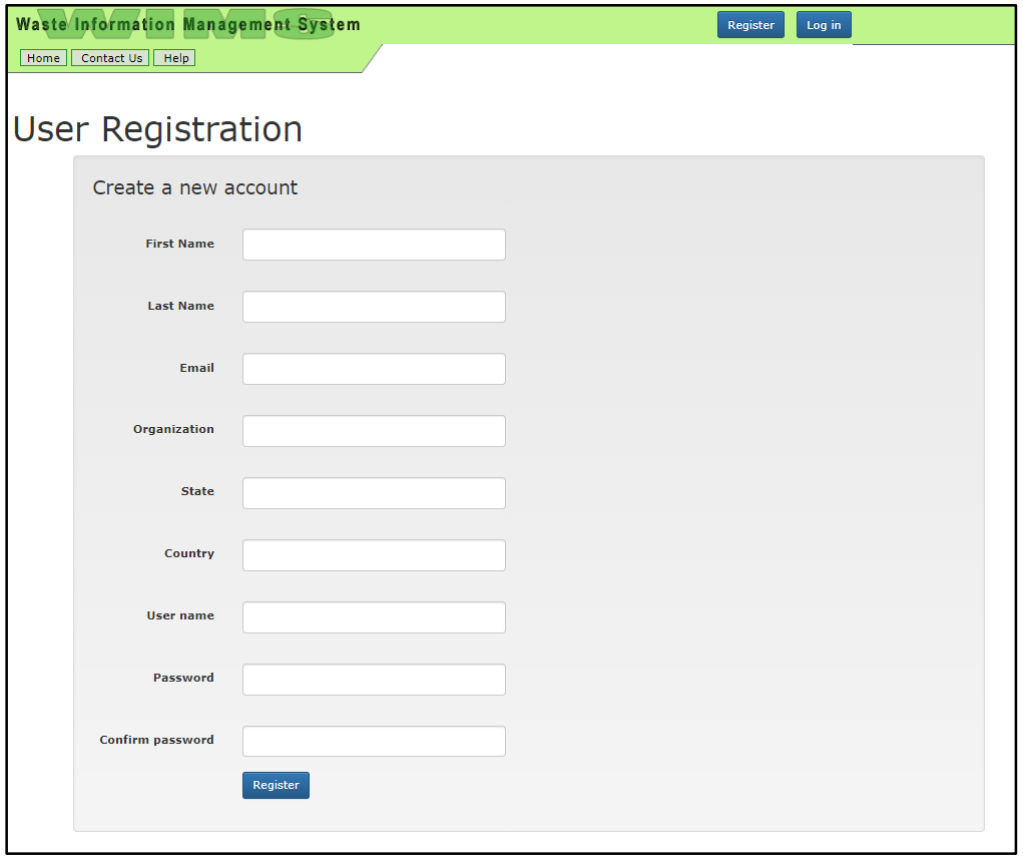


Task 1 – Waste Information Management System

Accomplishments Year 10:

- Identity Management framework was enhnaced to create custom registration

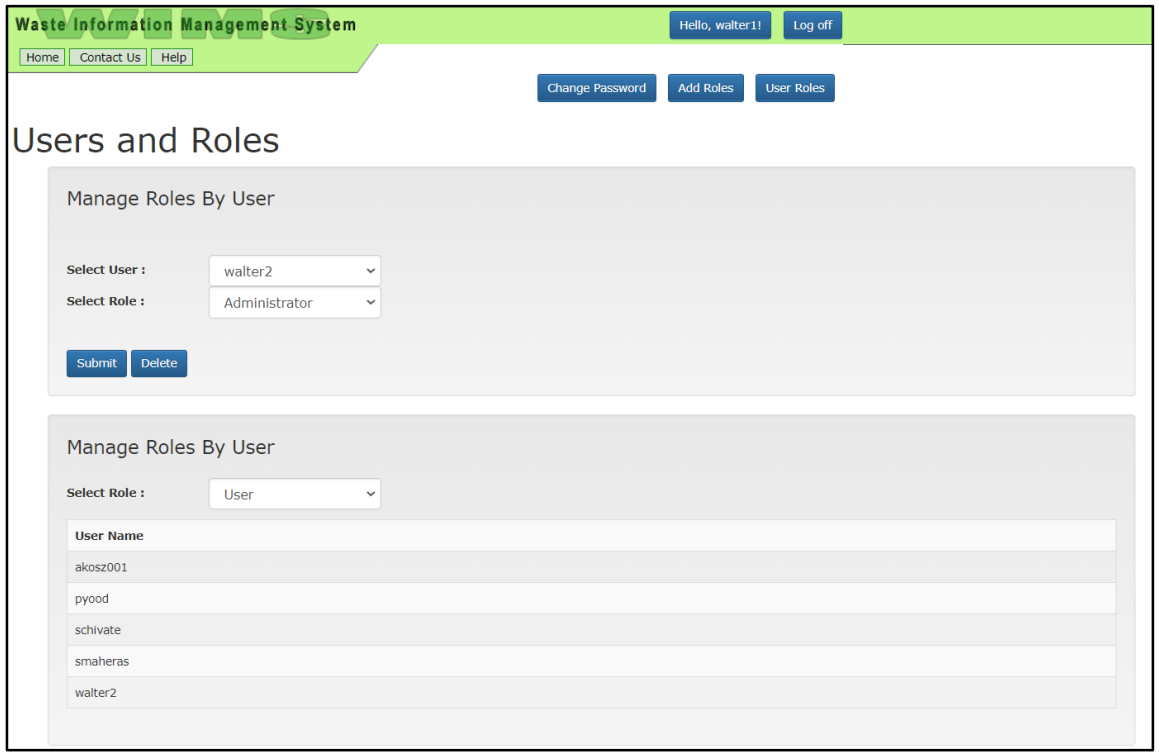
```
18    public class ApplicationUser : IdentityUser
19    {
20        public string FirstName { get; set; }
21        public string LastName { get; set; }
22        public override string Email { get; set; }
23        public string OrganizationName { get; set; }
24        public override string UserName { get; set; }
25        public string State { get; set; }
26        public string Country { get; set; }
27
28    }
```



Task 1 – Waste Information Management System

Accomplishments Year 10:

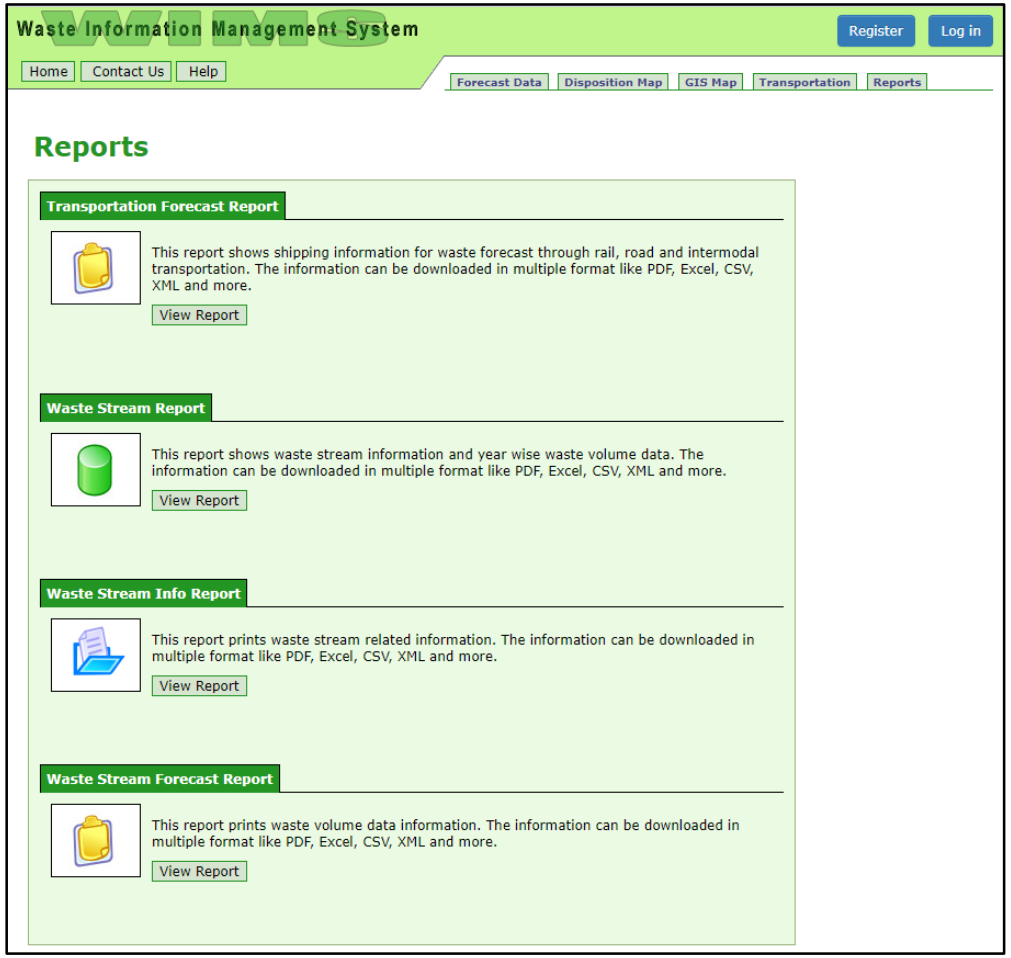
- Administrator can create new roles and assign roles to user



Task 1 – Waste Information Management System

Accomplishments Year 10:

- Upgrade of the WIMS Report Server & Report Function
  - From SQL Server 2005 to SQL Server 2017
- The upgraded module provides access to transportation report, waste stream report, waste stream info and forecast reports
  - Waste stream info report contains all the attributes of stream
  - Waste stream forecast report contains all the waste volume data as well as the reporting site, disposition facility and field stream ID attributes.
- The information can be downloaded in multiple format like PDF, Excel, CSV, XML and more.



Task 1 – Waste Information Management System

Accomplishments Year 10:

- FIU presented WIMS research in 2020 Waste Management Symposia.

Title: Waste Information Management System with 2019-20 Waste Streams
Session: LLW/ILW Characterization
Authors: Himanshu Upadhyay, Walter Quintero, Leonel Lagos

Himanshu Upadhyay presenting WIMS at the 2020 Waste Management Symposia Phoenix, AZ

Task 1 – Waste Information Management System

Proposed Scope for Year 10

- Subtask 1.1: WIMS System Administration - Database Management, Application Maintenance & Performance Tuning
  - This subtask includes the day-to-day maintenance and administration of the application and the database servers.
  - Administrator will monitor the network and server traffic and performs updates necessary to optimize the application performance.
  - FIU will provide application and database security as well as help desk support to DOE site managers, HQ managers and other users who need assistance with WIMS.
- Subtask 1.2: Waste Stream Annual Data Integration
  - 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 for cyber security

Task 1 – Waste Information Management System

Proposed Scope for FY20/FY21

- Subtask 1.3: Upgrade GIS module with Google Map API
  - The current GIS module will be upgraded to reduce the development time when adding new disposition sites and facilities to the module. With Google Map API, the module will be more interactive and will provide richer user experience.
- Subtask 1.4: Deploy Power BI Reporting Server for Waste Stream Reports
  - Power BI is a powerful new reporting server which is reliable and efficient. This task will replace the existing SQL reporting server.
- Subtask 1.5: Cyber Security of WIMS Infrastructure
  - Provide cyber security to WIMS infrastructure, application, database server and reporting server.
  - Cybersecurity training and support of DOE Fellows while working with pen testing & forensics tools used with WIMS system.

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

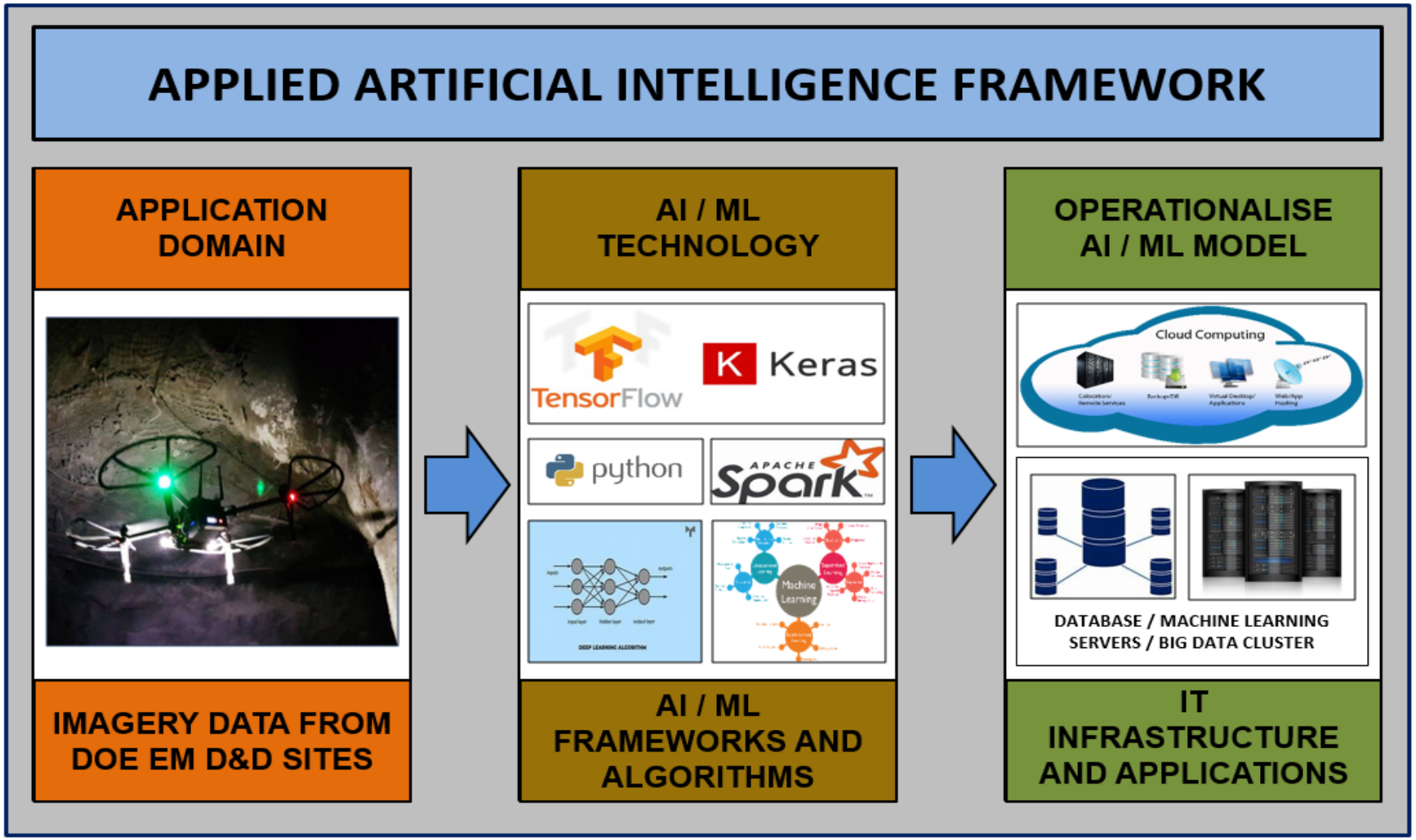
Site Needs:

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

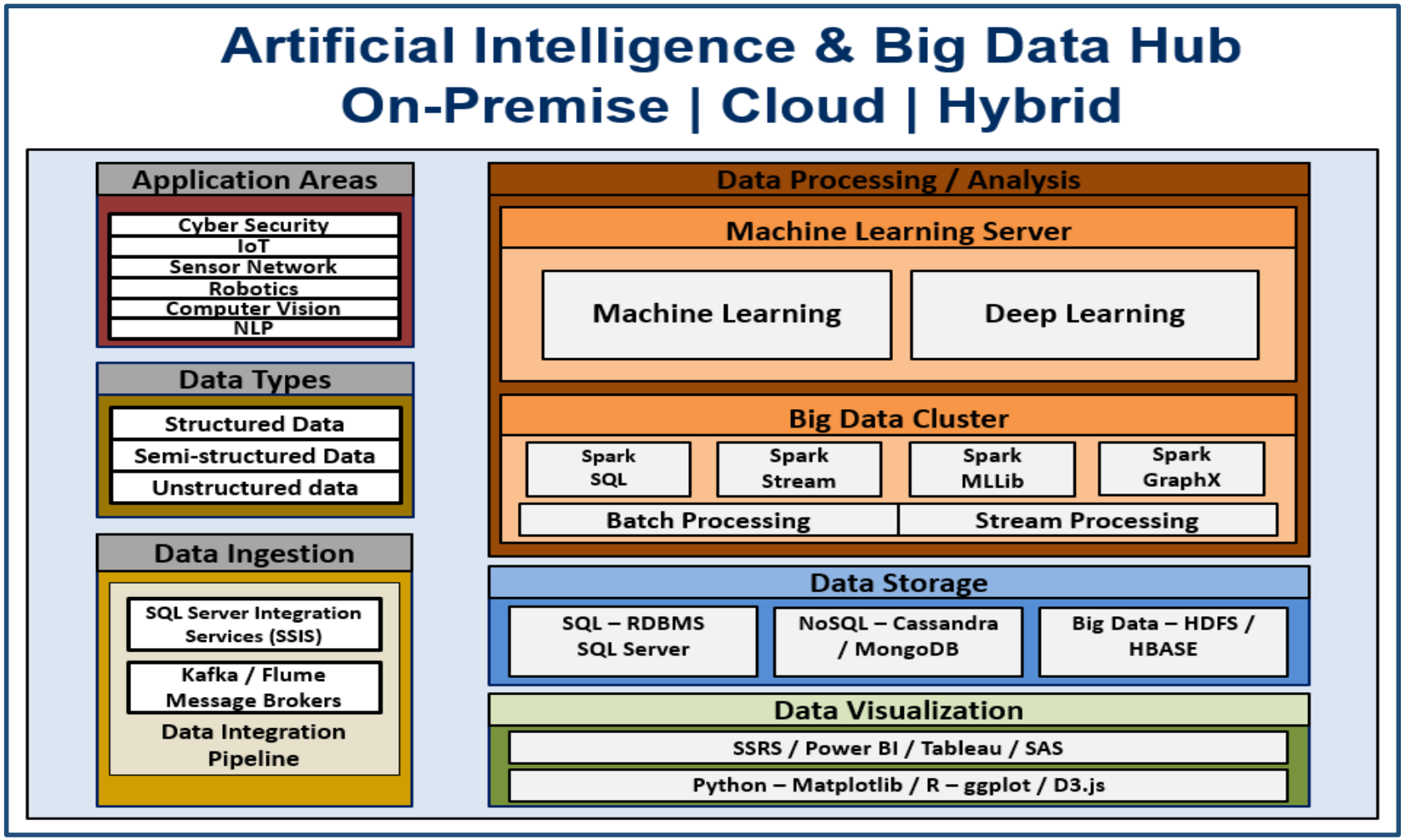
Objectives:

FIU will develop a pilot-scale infrastructure to implement structural health monitoring using scanning/imaging 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 will help in their S&M decision making needs.

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



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



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

Artificial Intelligence Algorithm & Framework

Data Processing / Analysis

Machine Learning	Deep Learning	Machine Learning Framework	Deep Learning Framework
Supervised ▪ Classification ▪ Regression Unsupervised ▪ Clustering ▪ Anomaly Detection ▪ Association / Recommendation ▪ Dimensionality Reduction	▪ Deep Neural Network ▪ Convolutional Neural Network ▪ Recurrent Neural Network ▪ RNN-LSTM ▪ RNN-GRU ▪ Bidirectional-RNN ▪ AutoEncoder ▪ Generative Adversarial Network	▪ Scikit-learn ▪ CRAN-R ▪ RevoScaleR ▪ RevoScalePy ▪ MicrosoftML ▪ NumPy ▪ SciPy	▪ TensorFlow ▪ Keras ▪ CNTK ▪ Theano ▪ Caffe ▪ PyTorch

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

Accomplishments Year 10:

Object Detection using YOLOv3 Algorithm with Data from Camera Device:

Data Collection:

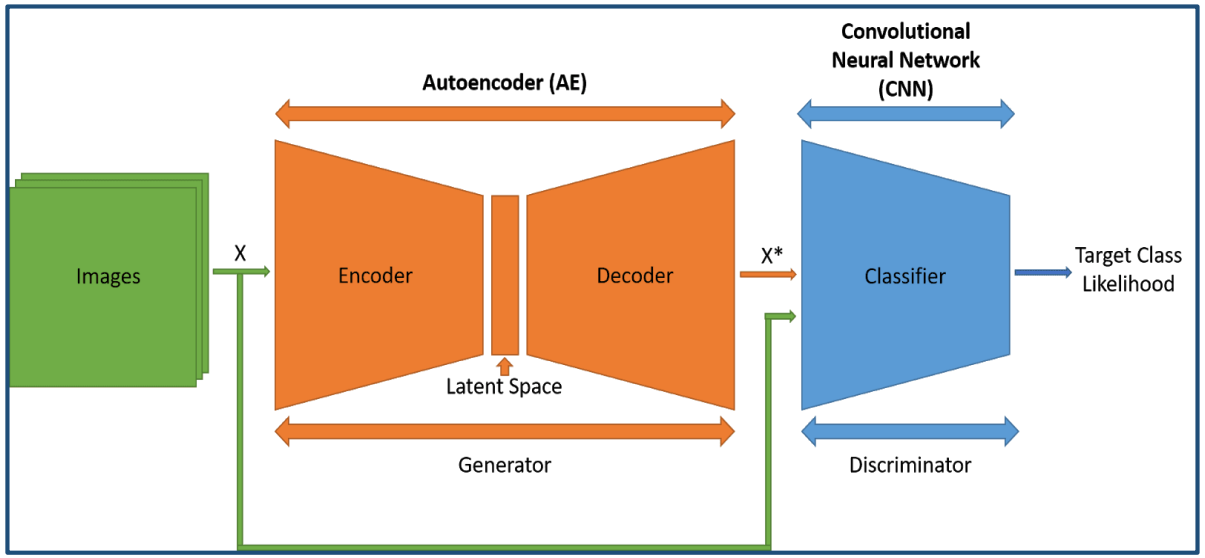
- Three image data sets were collected.
- Data set composition:
  - First data set contains 1,000 images
    - Collected with a digital camera and a green screen.
  - Second data set contains 65 images.
    - Images were taken in an outdoor environment.
  - Third data set contained 50 images.
    - Images were taken in an indoor environment.

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

Object Detection using YOLOv3 Algorithm with Data from Camera :

Data Preprocessing:

- Implemented a One Class Classifier (OCC) for data preprocessing
  - Hybrid model approach between Auto Encoder (AE) and Convolutional Neural Network (CNN).
    - The AE model serves as a data generator.
    - The CNN works as a class discriminator.
  - Model is trained as a Generative Adversarial Network (GAN).
  - Hidden layers include Convolution Layers, Max Pooling, and Batch Normalization.
  - Latent space of 256 filters.



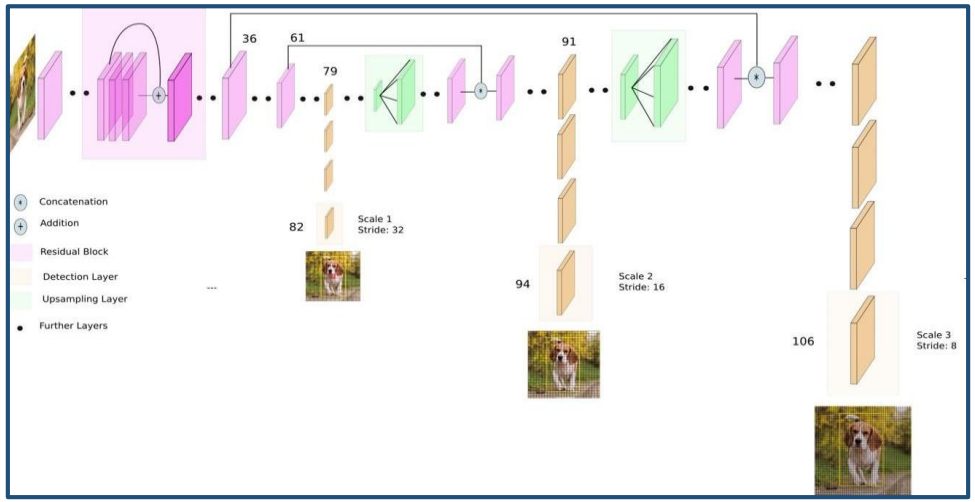
Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

FIU Applied Research Center

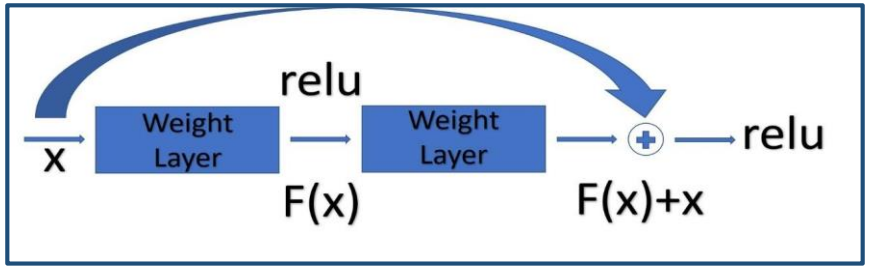
Object Detection Using YOLOv3 Algorithm:

YOLOv3 Algorithm Implementation:

- Implemented YOLOv3 (You Only Look Once V3) architecture.
  - Near-Time and Real-Time object detection.
    - Suitable for streaming videos, static videos, and still images.
  - Uses 53 convolutional neural networks layers (CNN).
    - Deep network for maximum feature extraction.
  - This network uses residual skip connections and up-sampling techniques.
    - Helps the neural network converge and generalize.
  - GPU server is used for the Real-Time object detection.



You Only Look Once version 3 (YOLOv3) architecture. Source:
Reference: https://towardsdatascience.com/yolo-v3-object-detection-53fb7d3bfe6b



You Only Look Once version 3 (YOLOv3) Skip Connection Implementation

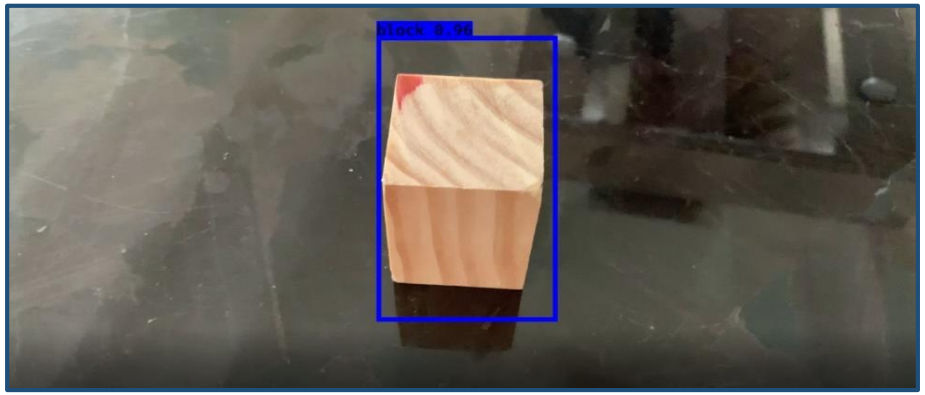
Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

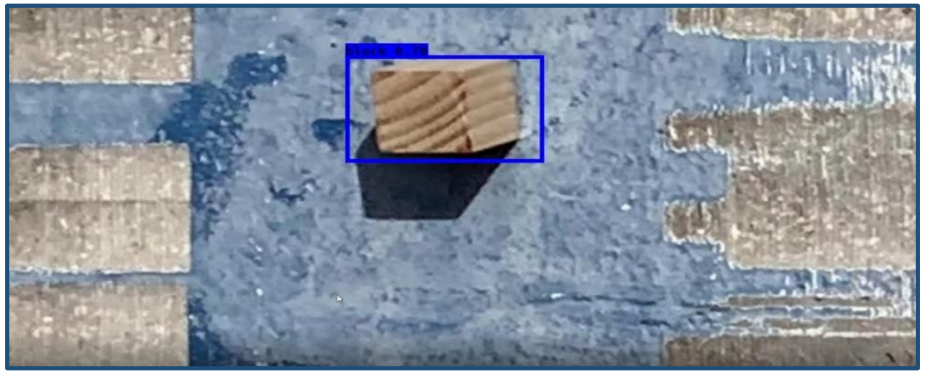
FIU Applied Research Center

Object Detection Using YOLOv3 Algorithm:

Results:

- YOLOv3 model able to detect the wooden block on a countertop surface with 0.96 confidence score.
- YOLOv3 model able to detect the wooden block on outdoor test facility mock-up wall with 0.78 confidence score.



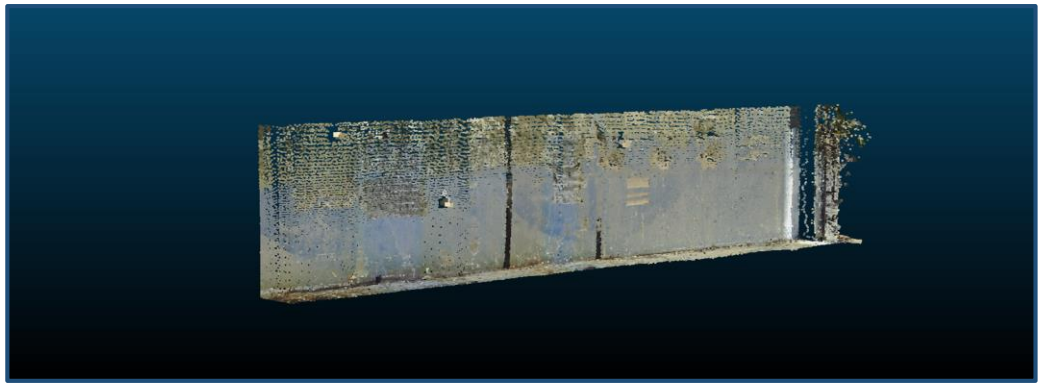


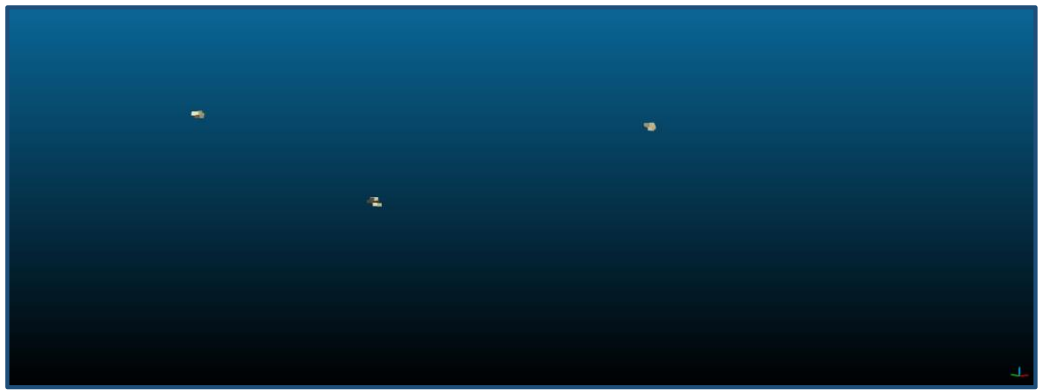
Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

Object Detection using Lidar Scans :

Data Collection:

- The LiDAR point cloud data was collected from the test facility at FIU.
- The set of four blocks are stacked on the wall as an object.
- LiDAR scans are collected to see and identify the four wooden blocks along the side of the wall.
- The data collection using LiDAR device included semi-autonomous platform that collected colored point clouds.
- The map was generated by the LiDAR platform and saved using map_server node.
- Team used a loop closing Simultaneous Localization & Mapping (SLAM) program - Google cartographer to generate maps for the best results.
- The point cloud contains data comprises of X, Y, Z coordinates as well as R, G, B values.



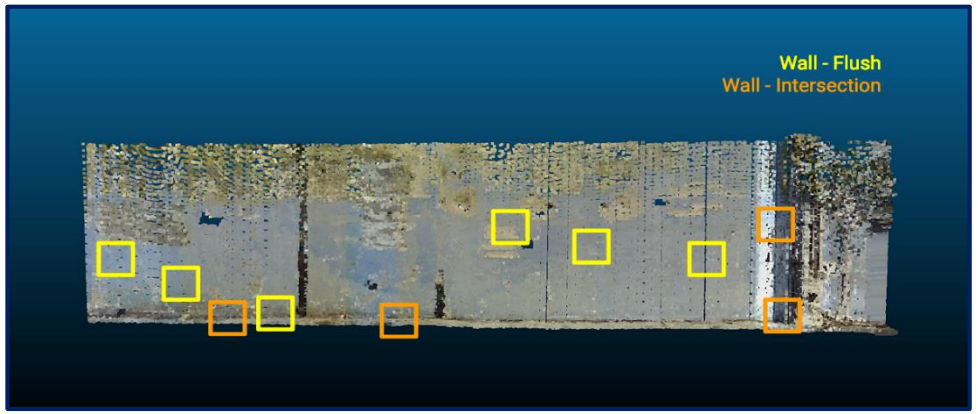


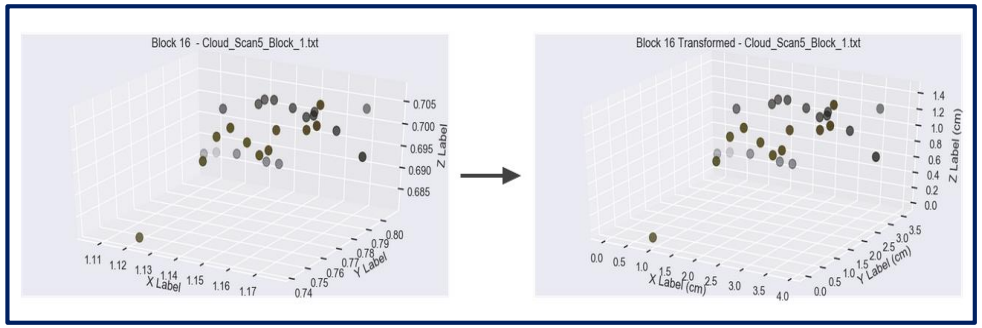
Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

Object Detection using Lidar Scans :

Data Pre-Processing:

- Data preprocessing was performed to remove unnecessary data points such as points belonging to people and the floor using CloudCompare tool.
- Isolated the wooden blocks located on the wall as well as subsets of the wall.
- Two groups of items (block and wall data) have been saved separately for additional preprocess of the data.
- To normalize the data, we reset the origin of each object by subtracting each axis by the respective minimum of that object.
- In order to have a quantifiable data unit, we multiply all the data by a calculated factor to convert in to centimeters.





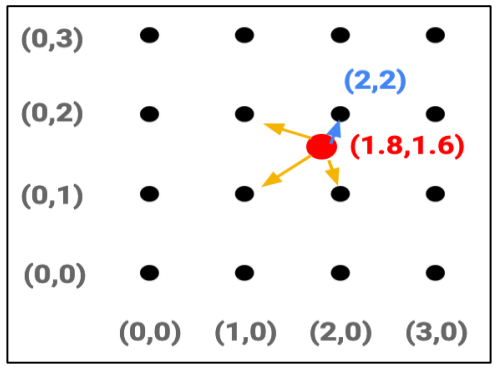
Plots of a block before and after transformation, left and right respectively

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

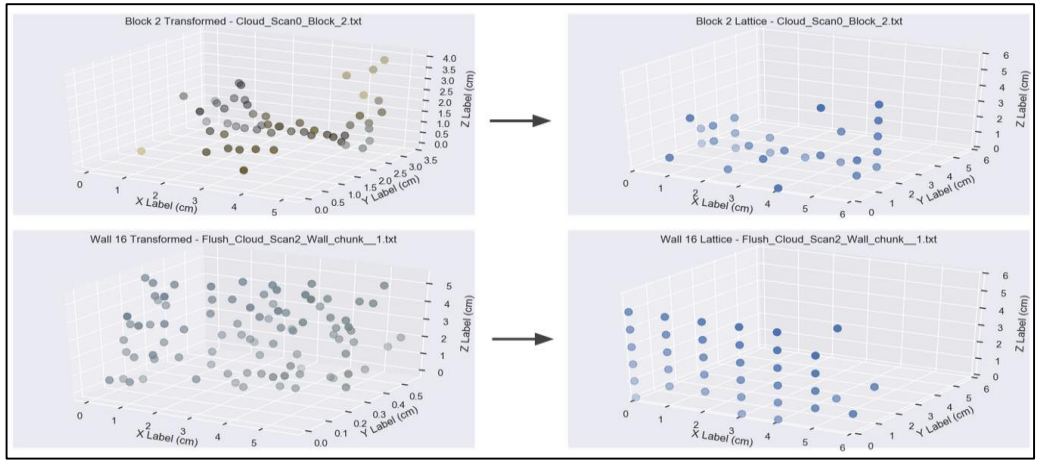
Object Detection using Lidar Scans :

Data Pre-Processing:

- In order to implement the object detection algorithm dataset is converted in to Lattice grid structure.
- A lattice structure is simply a mathematical ordering where numbers fall within integer intervals.
- This structure does not allow any decimal values except for integers. With this type of structure, it could allow floating point values to be approximated to a fixed size lattice.
- Point approximation technique was applied as shown in in the Figure.
- A three-dimensional array of zeros where there is no point and ones where a point exists. This set of 3D arrays can be labeled appropriately and fed to a neural network.



Point approximation onto a 2D lattice



Plots of objects before and after lattice transformation, left and right respectively

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

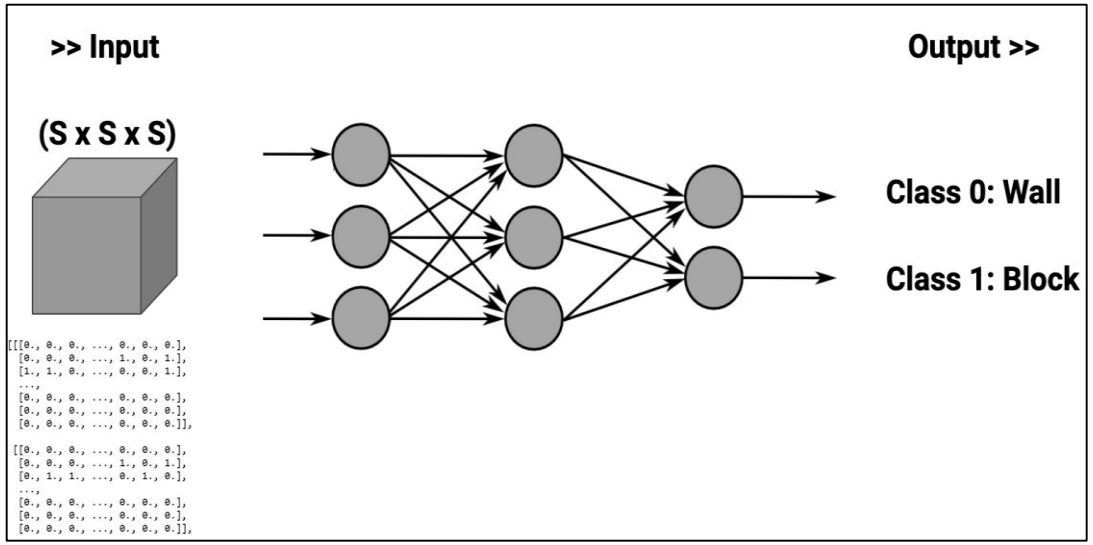
Object Detection using Lidar Scans:

Neural Network Algorithm Implementation:

- The following neural network layers are implemented

Input → Dense (8) → Dense (8) → Dense (16) → Flatten → Dense (2)

- The input to the network is a 3D array of 0s and 1s.
- The last layer of the network is a dense layer of 2 neurons since we want probabilities of the input belonging to either Class 0 (wall) or Class 1 (block).

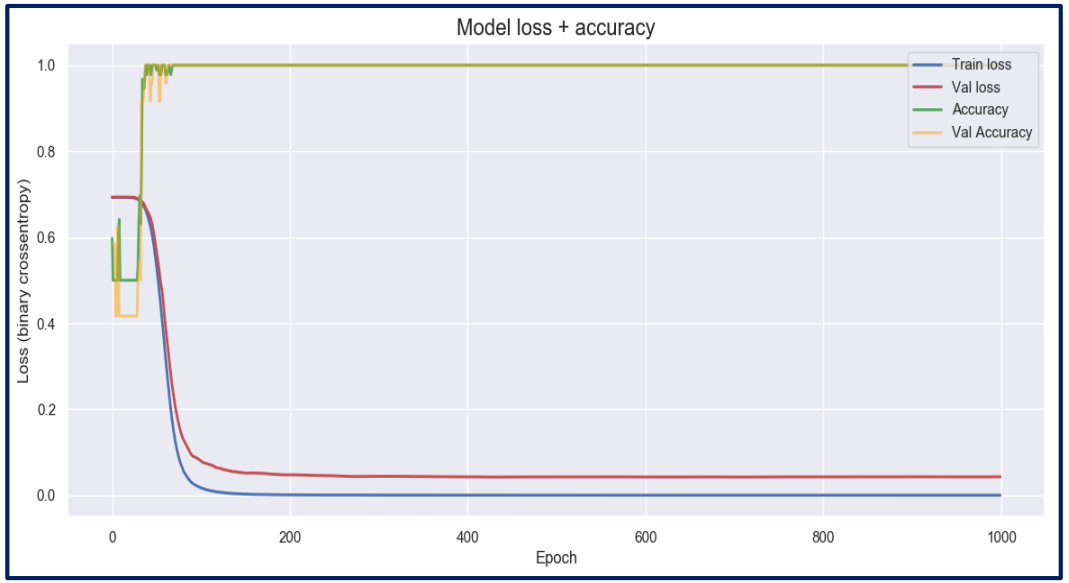


Task 6 – Analysis of Image Data using Machine Learning/Deep Learning and Big Data Technologies

Object Detection using Lidar Scans :

Results:

- The approach of converting the raw data into a three-dimensional lattice structure is performing well.
- The graph shows the accuracy and loss metrics over training iterations.
- Achieved an accuracy of 93.0 % on the test data using the neural network model



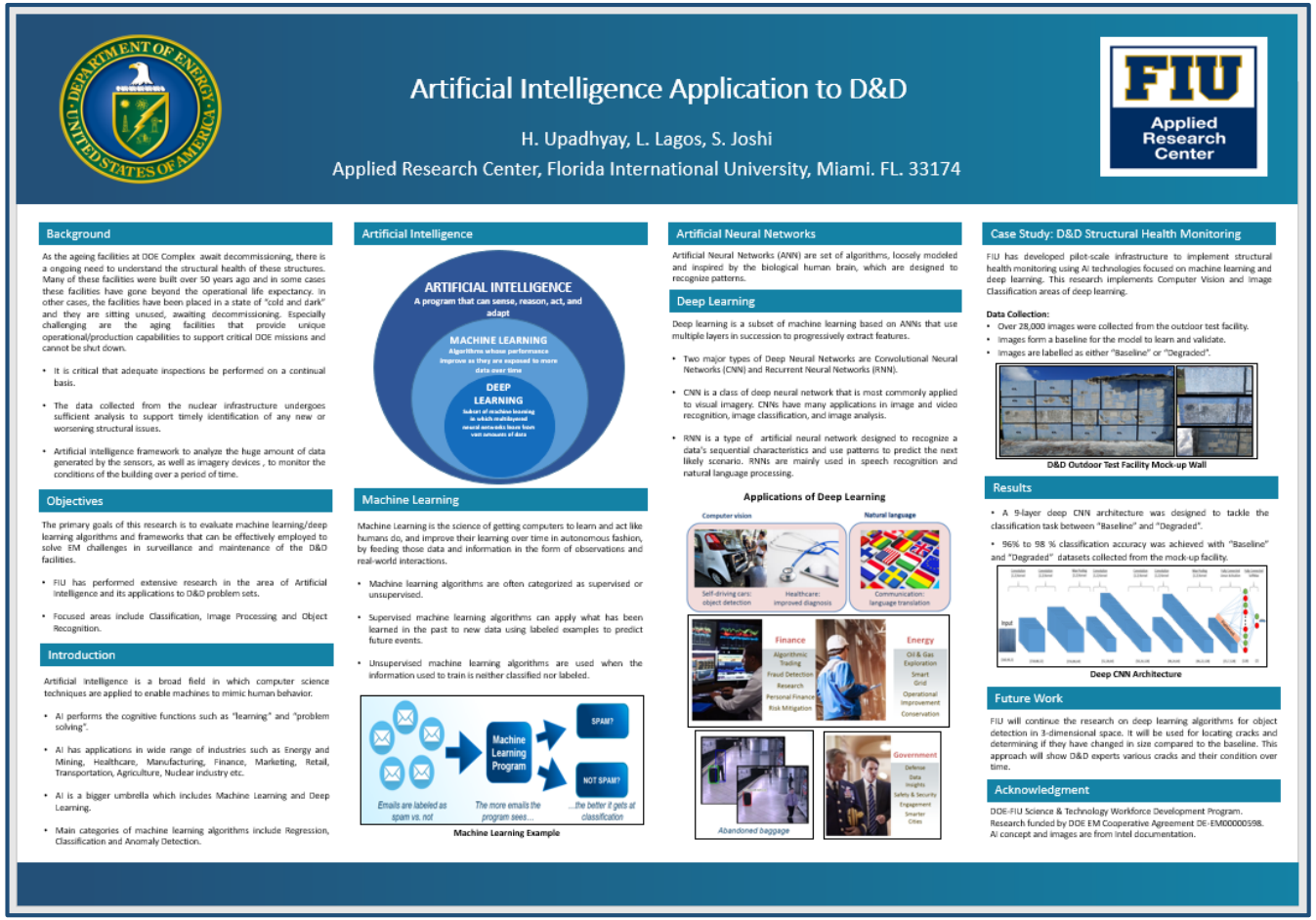
Graph of model accuracy and loss using the network architecture mentioned previously

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

Presented Artificial Intelligence Application to D&D Poster at WM2020 symposium.

Conference attendees had a lot of interest in this research focused on Artificial Intelligence technologies in D&D area.

Title: Artificial Intelligence Application to D&D
Authors: Himanshu Upadhyay, Leonel Lagos, Santosh Joshi



Artificial Intelligence Application to D&D

H. Upadhyay, L. Lagos, S. Joshi

Applied Research Center, Florida International University, Miami. FL. 33174

Background

As the ageing facilities at DOE Complex await decommissioning, there is a ongoing need to understand the structural health of these structures. Many of these facilities were built over 50 years ago and in some cases these facilities have gone beyond the operational life expectancy. In other cases, the facilities have been placed in a state of "cold and dark" and they are sitting unused, awaiting decommissioning. Especially challenging are the aging facilities that provide unique operational/production capabilities to support critical DOE missions and cannot be shut down.

- It is critical that adequate inspections be performed on a continual basis.
- The data collected from the nuclear infrastructure undergoes sufficient analysis to support timely identification of any new or worsening structural issues.
- Artificial Intelligence framework to analyze the huge amount of data generated by the sensors, as well as imagery devices , to monitor the conditions of the building over a period of time.

Objectives

The primary goals of this research is to evaluate machine learning/deep learning algorithms and frameworks that can be effectively employed to solve EM challenges in surveillance and maintenance of the D&D facilities.

- FIU has performed extensive research in the area of Artificial Intelligence and its applications to D&D problem sets.
- Focused areas include Classification, Image Processing and Object Recognition.

Introduction

Artificial Intelligence is a broad field in which computer science techniques are applied to enable machines to mimic human behavior.

- AI performs the cognitive functions such as "learning" and "problem solving".
- AI has applications in wide range of industries such as Energy and Mining, Healthcare, Manufacturing, Finance, Marketing, Retail, Transportation, Agriculture, Nuclear industry etc.
- AI is a bigger umbrella which includes Machine Learning and Deep Learning.
- Main categories of machine learning algorithms include Regression, Classification and Anomaly Detection.

Artificial Intelligence

ARTIFICIAL INTELLIGENCE
A program that can sense, reason, act, and adapt

MACHINE LEARNING
Algorithms whose performance improve as they are exposed to more data over time

DEEP LEARNING
Subset of machine learning in which multilayered neural networks learn from vast amounts of data

Machine Learning

Machine Learning is the science of getting computers to learn and act like humans do, and improve their learning over time in autonomous fashion, by feeding those data and information in the form of observations and real-world interactions.

- Machine learning algorithms are often categorized as supervised or unsupervised.
- Supervised machine learning algorithms can apply what has been learned in the past to new data using labeled examples to predict future events.
- Unsupervised machine learning algorithms are used when the information used to train is neither classified nor labeled.

Machine Learning Example

Artificial Neural Networks

Artificial Neural Networks (ANN) are set of algorithms, loosely modeled and inspired by the biological human brain, which are designed to recognize patterns.

Deep Learning

Deep learning is a subset of machine learning based on ANNs that use multiple layers in succession to progressively extract features.

- Two major types of Deep Neural Networks are Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN).
- CNN is a class of deep neural network that is most commonly applied to visual imagery. CNNs have many applications in image and video recognition, image classification, and image analysis.
- RNN is a type of artificial neural network designed to recognize a data's sequential characteristics and use patterns to predict the next likely scenario. RNNs are mainly used in speech recognition and natural language processing.

Applications of Deep Learning

Case Study: D&D Structural Health Monitoring

FIU has developed pilot-scale infrastructure to implement structural health monitoring using AI technologies focused on machine learning and deep learning. This research implements Computer Vision and Image Classification areas of deep learning.

Data Collection:

- Over 28,000 images were collected from the outdoor test facility.
- Images form a baseline for the model to learn and validate.
- Images are labelled as either "Baseline" or "Degraded".

D&D Outdoor Test Facility Mock-up Wall

Results

- A 9-layer deep CNN architecture was designed to tackle the classification task between "Baseline" and "Degraded".
- 96% to 98 % classification accuracy was achieved with "Baseline" and "Degraded" datasets collected from the mock-up facility.

Deep CNN Architecture

Future Work

FIU will continue the research on deep learning algorithms for object detection in 3-dimensional space. It will be used for locating cracks and determining if they have changed in size compared to the baseline. This approach will show D&D experts various cracks and their condition over time.

Acknowledgment

DOE-FIU Science & Technology Workforce Development Program. Research funded by DOE EM Cooperative Agreement DE-EM0000598. AI concept and images are from Intel documentation.

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

Proposed Scope for FY20/FY21

- Artificial Intelligence support for DOE-EM problem set – D&D
- FIU will continue to work on Surveillance & Maintenance of D&D Infrastructure by applying the AI technologies.
- FIU will work on Predictive Analysis using Machine Learning Models to detect cracks on the infrastructure. This will serve as an early notification to facility maintenance personal to pay particular attention to the identified areas.
- FIU will continue work on One Class SVM, AE, CNN and GAN to improve on object detection leading to identifying cracks on the walls of D&D infrastructure.
- This task will lead to PhD work of DOE Fellow – Roger Boza focused on Computer Vision.

Task 7 – AI Evaluation of Cr (VI) Concentrations in Groundwater in a Dynamic Pump and Treat Remediation Scenario (New)

Proposed Scope for FY20/FY21

- Artificial Intelligence support for DOE-EM problem set – Soil & Ground Water
- Machine learning and deep learning models can be developed to identify patterns, address knowledge gap and ultimately predict transport of Cr(VI) in the subsurface of the 100-H Area.
- Exploratory data analysis of water quality and contaminant data
- Identify key master variables controlling Cr(VI) concentrations in groundwater/monitoring wells and the vadose zone
- Study the changes in precipitation patterns on Cr(IV) distribution
- Data visualization of contaminants and well distribution

Q & A

Thank You