Nationally Integrated Geospatial Information Management: How to Scale SDG Monitoring

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Corporate Director, Esri
Vision

GIS
Is Enabling a Sustainable World
Our World Needs a Nervous System

An Intelligent and Responsive Platform

Creating More Understanding

... Collaboration and

... Action

... Geography Is Essential
Your Work
Is Already Creating
Geospatial Infrastructure

Intelligent and Responsive . . .

Integrating All Sources of Data . . .

Creating Digital Nervous Systems
for Your Organizations
and Countries

Connecting Everything . . . And Everyone

Applying The Science of Where . . .
Creating a Global Nervous System

Sharing Data, Apps
... and Geographic Knowledge

... At Scale

A System for Understanding... And Collaborative Action

Your Work
Is Also Contributing to
Global Geospatial Infrastructure
Geospatial Infrastructure
Supports Individuals . . .
. . . And Organizations of All Sizes

Engaging Everyone

Communities
Organizations
Departments
Teams
Individuals

Sharing and Collaboration

GIS at Scale

Distributed
. . . And
Interconnected
Integrating Open Science, AI and Machine Learning

Revolutionizing Spatial Analysis and Data Science

Python Notebooks

Analytic Services

Python API

Integration

AI & Machine Learning

Open Science Tools

Big Data GeoAnalytics

Spatial Analysis & Geoprocessing

Geospatial Infrastructure
Extending GIS to the Edge
Including and Integrating . . . Challenged Network Environments

Connected and Disconnected

Edge Computing Nodes

Replication (Sync)

Analytics and Data Management

Geospatial Infrastructure

Internet of Things

Real-Time Measurement (Field / IoT / Remote Sensing)

Supporting GIS Workflows in All Environments
Supporting and Integrating Advanced Technologies

- Distributed Services
- Real-Time Measurement
- Extensive Content
- StoryMaps
- Data Science
- GeoEnrichment
- AI & ML
- Geocoding
- Analytic Services
- Big Data
- Accessing and Leveraging Distributed Resources
- Shared Apps
- Publishing Services
- Content Management
- Remote Sensing
- Search & Discover
- Extensive Content
- Field Operations
- Real-Time Measurement
- Tracking
- Geospatial Infrastructure
- Open Data
- Publishing Services
3D Visualization

New and Improved
- 3D Smart Mapping
- Mobile
- Point Clouds
- BIM Support
- Symbology

Smart Mapping
Data Visualization
Edge Rendering
3D Symbols
Effects
Power Lines
BIM Integration
Lidar
City Modeling
Underground
Extrusion
Augmented Reality / VR

Mobile Scene Packages
Mobile
BIM as Scene Layers
3D Analysis

Apps
- CityEngine
- Mobile
- Pro

3D GIS
- Visualization
- Procedural Modeling

Scene Viewer
- Volumetrics
- Interactive Slice
- Volumetric Slicing
- 3D Interpolation (EBK)

Visual analytics
- Flood Impact
- Shadow Analysis
- Lidar to Buildings
- 3D Measurement
- Elevation Profile
- Line of Sight & Viewshed

3D Visualization and Analytics
- Earth
Field Operations  Location-Enabling All Aspects of Field Work

New Capabilities
- Tracking
- Offline Workflows
- Preplanned Routes

Planning and Management

Location Tracking

Navigation

Data Capture

Maps & Mark Up

Workforce

Dashboard
Spatial Analysis and Data Science

Many Improvements
- Functionality
- Scalability
- Accessibility

Charting
- Balanced Zones
- 3D Interpolation (EBK)
- Calendar Heat Map
- Scatter Plot Matrix
- Data Clock

Spatial Statistics
- Logistical Regression
- Forest-based Classification and Regression
- Floodplain Delineation
- Cost Distance
- DEM Error
- River Classification
- DEM Error

Raster Functions

Improved Processing
- Tool History to Models
- Models to Python
- Hosted Python Notebooks
- Enterprise
- Pro
- Scalable GeoAnalytics
- Deep Learning
Hosted Python Notebooks  
For Integration, Modeling and Automation

- Integrating Distributed Services and Data . . .
  - . . . The World of Open Science & Big Data

- Ready-to-use Code
  - Notebook Gallery and Code Snippets

- Organizes
  - Code
  - Data
  - Visualization
  - Documentation

- Integrating Distributed Services and Data . . .
  - . . . The World of Open Science & Big Data

- ArcGIS
  - Notebook Server
  - Data Stores / Lakes
  - ArcGIS Analytic Servers (Image, GeoAnalytics, Spatial)

- Open Science Libraries
  - CONDA
  - Keras
  - pandas
  - XGBoost
  - matplotlib
  - jupyter
  - OpenCV
  -SciPy
  - SymPy
  - TensorFlow
  - PyTorch

- Enterprise (Now) and Online (soon)

- Providing Notebooks as Items . . .
  - . . . and ArcPy Geoprocessing as a Service
AI, ML and Deep Learning

Integrating Open Science

New and Improved
- Clustering
- Prediction
  - Classification
  - Regression
  - Interpolation
- Object Identification

Coming
- Feature Extraction
- Site Selection
- Event Prediction

Desktop GIS

Spatial Machine Learning
- Density-Based Clustering
- Empirical Bayesian Kriging Regression Prediction
- Training Data Preparation

Python Notebooks

AI, ML and Deep Learning
- Accident Prediction
- Object Detection
- Feature Extraction

Multiple Frameworks & Platforms
- OpenCV
- Keras
- TensorFlow
- PyTorch

Pro

PACI, Kuwait
Real-Time Analytics Integrating Sensor Networks and IoT

Supporting High-Velocity Data Streams
Tracking, Monitoring and Alerting

Improved
• Performance
• Scalability
• Resiliency
• Cloud Connectors
• Actuation

Sensors
Vehicles
Assets
Environment

Real-Time Data
GeoEvent Server
GeoAnalytics Server

Situation Awareness
Analytics
Alerting

Collapsing the Time from Measurement to Decision Making

Enterprise Now . . .
. . . SaaS Coming
Imagery: A Comprehensive System for Imagery and Remote Sensing

New
- Image Cube Support
- Deep Learning Tools

Image Management

Image Analyst

Image Server

Image Mosaics
- Dynamic
- Pre-Processed

Image Cube

Time

(Multi-Dimensional Raster)

Map Production
- Pixel Editing
- Drone2Map
- DTM Generation

Segmentation
- Raster Processing Functions

Deep Learning Tools
- Deep Learning Tools
- Segmentation
- Object Detection
- Pixel Classification

Visualization & Exploitation
- Full Motion Video
- Stereo Feature Capture
- Oriented Imagery

Structured Observations

Imagery
- Rich Content
- All Types & Formats
Engaging and Interconnecting Communities
Bringing Together People, Organizations and Stakeholders

Creating New Opportunities to Participate

HUB

Citizens
Academics
Businesses
NGOs
Government

Geospatial Infrastructure

Maps
Stories
Apps
Open Data
Surveys
Reports
A Network for Monitoring SDGs Is Emerging
Connecting Statistics Agencies and Communities

http://data-irelandsdg.opendata.arcgis.com

http://sdg-pcbs.opendata.arcgis.com

http://www.sdg.org

http://odsprueba-ambiente-esri-co.hub.arcgis.com

http://sdgsuae-fcsa.opendata.arcgis.com

https://senegals-ansdsdg.opendata.arcgis.com

https://mapstat-psa.opendata.arcgis.com

https://senegals-ansdsdg.opendata.arcgis.com
<table>
<thead>
<tr>
<th>Target</th>
<th>Goal</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contribute to progress on the Target, not necessarily the Indicator</td>
<td></td>
<td>Direct measure or indirect support to the Indicator</td>
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<tr>
<td>1.4 1.5</td>
<td>1  No poverty</td>
<td>1.4.2</td>
</tr>
<tr>
<td>2.3 2.4 2.c</td>
<td>2  Zero hunger</td>
<td>2.4.1</td>
</tr>
<tr>
<td>3.3 3.4 3.9 3.d</td>
<td>3  Good health and well-being</td>
<td>3.9.1</td>
</tr>
<tr>
<td>4.4 4.5 4.b</td>
<td>4  Quality education</td>
<td></td>
</tr>
<tr>
<td>5.a</td>
<td>5  Gender equality</td>
<td>5.a.1</td>
</tr>
<tr>
<td>6.1 6.3 6.4 6.5 6.6 6.a 6.b</td>
<td>6  Clean water and sanitation</td>
<td>6.3.1 6.3.2 6.4.2 6.5.1 6.6.1</td>
</tr>
<tr>
<td>7.2 7.3 7.a 7.b</td>
<td>7  Affordable and clean energy</td>
<td>7.1.1</td>
</tr>
<tr>
<td>8.4</td>
<td>8  Decent work and economic growth</td>
<td></td>
</tr>
<tr>
<td>9.1 9.4 9.5 9.a</td>
<td>9  Industry, innovation and infrastructure</td>
<td>9.1.1 9.4.1</td>
</tr>
<tr>
<td>10.6 10.7 10.a</td>
<td>10 Reduced inequalities</td>
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<tr>
<td>11.1 11.3 11.4 11.5 11.6 11.7 11.b 11.c</td>
<td>11 Sustainable cities and communities</td>
<td>11.1.1 11.2.1 11.3.1 11.6.2 11.7.1</td>
</tr>
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<td>12.2 12.4 12.8 12.a 12.b</td>
<td>12 Responsible consumption and production</td>
<td>12.a.1</td>
</tr>
<tr>
<td>13.1 13.2 13.3 13.b</td>
<td>13 Climate action</td>
<td>13.1.1</td>
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<tr>
<td>14.1 14.2 14.3 14.4 14.6 14.7 14.a</td>
<td>14 Life below water</td>
<td>14.3.1 14.4.1 14.5.1</td>
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<tr>
<td>15.1 15.2 15.3 15.4 15.5 15.7 15.8 15.9</td>
<td>15 Life on land</td>
<td>15.1.1 15.2.1 15.3.1 15.4.1 15.4.2</td>
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<tr>
<td>16.8</td>
<td>16 Peace, justice and strong institutions</td>
<td></td>
</tr>
<tr>
<td>17.2 17.3 17.6 17.7 17.8 17.9 17.16 17.17 17.18</td>
<td>17 Partnerships for the goals</td>
<td>17.6.1 17.18.1</td>
</tr>
</tbody>
</table>
Machine Learning using Drone Data

- Captured images for two study areas
  - Animal Farms
  - Crop Farms
- Use Esri Artificial Intelligence tools
  - Multi-spectral image analysis
  - Auto-detect features
- Focus on-site inspections to farms that have regulatory issues
Sewer Inspection

Switzerland

Work Order Management

New Jersey

Sanitation Cleanout Locations

California

Drainage Network Modeling

Washington

Water Monitoring

Los Angeles

Water and Sanitation Projects

Mozambique

Sewer Inspection

Switzerland

Water Quality Monitoring

China

Pipeline Alignment

Montana
Electricity Consumption per Capita:
- Uganda (2016): 71 kWh/Capita
- Germany (2014): 7,035 kWh/Capita
- EU (2014): 5,909 kWh/Capita
- World (2014): 3,128 kWh/Capita

Goal:
Developing a GIS based decision support Model to decide whether it is more economical to electrify a village using Solar Home Systems, Mini-Grid or On-Grid Solutions

Data:
- Energy Sector GIS Working Group
- Uganda Open Data Site
- Facebook Population Data
- https://ciesin.columbia.edu/data/hrsl/

Building Extraction from Satellite Images
Cluster Buildings to Settlements
Load Transformer and Distribution Line Data as well as Electrification Status Estimates
Creating buffer around distribution lines and transformers according to economic data
Create a Ranking of Villages/Trading Centres to be electrified first
Sharing this information with investors

Solar Containers for rural communities
Walking and Transit Model

Wisconsin

Traffic Management

Germany

Public Transit

Washington

Recycling Communications

Charlotte

Rail Status Monitoring

USA

Smart Routing (UPS)

Pennsylvania

Postal Delivery

Los Angeles

Smart Routing (UPS)
Biodiversity

Philippines

Sediment Change

Mexico

Ecologically Significant Areas

NOAA—Monterey Bay

Reef Health

Cook Islands

Marine Sanctuary

California

Marine and Terrestrial Habitat

Abu Dhabi, UAE

Coral Communities

Martinique

Ocean Modeling

NOAA

Biodiversity

Philippines

Marine Protection Planning

Australia
Predicting Environmental Phenomena
Where Seagrasses Grows, Empirical Bayesian Kriging (EBK), Random Forest classifier

```python
from sklearn.ensemble import RandomForestClassifier
import numpy as NUM
import arcpy as ARCPY
import arcpy.da as DA
import pandas as PD
import seaborn as SEA
import matplotlib.pyplot as PLOT
import arcgisscripting as ARC
import SSUtilities as UTILS
import os as OS
```
Using Deep Learning to Assess Palm Tree Health

- Harnessing drone real-time capabilities of monitoring of crops and plants (e.g. Palm Trees)

- Inferring presence of fungal & bacterial diseases using image classification enabling an immediate response to identify containment zones & to contain contaminations

- Benefits:
  - Supervised Classification for autonomous systems
  - Real-Time Detection & Accelerated Response
City in Motion
Geography-Wide Monitoring

- CRM
  Demographics, Visitor Lines

- Signaling Network
  Movement, Roaming

- Analytics
  Home/Work Locations

- Data Packet Inspection DPI
  Web Activity

- 1 Billion Records Daily
- 200 GB Daily
The Global Data Commons aims to deploy AI to help achieve the SDGs

The position papers discuss several challenges that prevent the implementation of a GDC

- Access to quality data: 30
- Technical challenges: 26
- Legal challenges: 23
- Political/regulatory challenges: 22
- Social challenges: 21
- Business/commercial challenges: 11

Example quotes from position papers:

1. "Capitalizing on the immense volume of data available and use AI to tackle the world's greatest challenges.
2. "Detect, present, and help scale-up use cases for AI enabling the 17 SDGs.
3. "The use of AI for Sustainable Development Goals will allow us to:
   - Monitor progress towards the achievement of SDG
   - Simulate implications
   - Predict outcomes of measures taken
   - Provide recommendations for policy makers"