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Arctic Domain Awareness Center (ADAC) Climate Change Analytics Requirements Workshop

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1. About this Document

The purpose of the report is to provide a public record of the Climate Change Analytics Requirements Workshop, including: (i) A catalogue and analysis of data sources and analytical capabilities and frameworks; (ii) Technological and analytic data gaps that impact DHS mission; and, (iii) Research questions addressing any analytic gaps. This document has been delayed in finalizing at the University of Alaska due to ADAC organizational changes

2. About the Arctic Domain Awareness Center

The Arctic Domain Awareness Center (ADAC) is a DHS Science and Technology (S&T) Center of Excellence (COE) hosted by University of Alaska. Its mission is to develop and transition technology solutions, innovative products, and educational programs to improve situational awareness and crisis response capabilities related to emerging maritime challenges in the dynamic Arctic environment.

ADAC is seeking to develop capability for the US Coast Guard to fuse information relevant to the Arctic Domain to support their mission needs, while also seeking to connect capabilities to from an array of collaborators to benefit DHS emergency responders, principally focused on the US Coast Guard, and in particular USCG District 17. ADAC is striving to collaborate and solicit data from authentic/authoritative sources, connecting with user defined knowledge needs to provide timely and actionable information to the decision makers at the operational and on-scene response levels. Through collaboration with an array of Federal, State, Local, Tribal, Academic, International and Industry entities, ADAC is seeking to gain synergy. avoid duplication of effort, inspire partnerships and support an open architecture approach to iteratively advance domain awareness. In order to incease understanding, improve resiliency and reduce risk in the Arctic.

3. Workshop Summary

3.1 Purpose

The purpose of the workshop was to gather knowledge about the predictive analytic capability to use historical, current, and future big data analytic modeling with regard to climate change and its effects on infrastructure and equipment in Arctic extremes. The workshop was organized by the DHS S&T Arctic Domain Awareness Center of Excellence led by the University of Alaska in partnership with DHS Science and Technology (S&T) Homeland Security Advanced Research Projects Agency (HSARPA).

The workshop supported data analytics efforts of DHS S&T/HSARPA and ADAC. The ADAC and HSARPA teams' goals include engaging complex actors and stakeholders in order to better understand data analytics opportunities in the area of climate change and Arctic extremes, initializing a framework for gathering analytical requirements and achieving better understanding of potential use cases for the HSARPA Data Analytics Engine (DA-E) and ADAC.

The specific objectives of the workshop were:

1. Provide a predictive analytic capability for maritime and coastal emergency management requirements through the U.S. Coast Guard and FEMA.
2. Develop DHS measured and predictive analytics with infrastructure protection, security, and planning requirements that can be examined and applied in the Arctic.
3. Discuss and evaluate existing climate change and Arctic specific data collection and analytic efforts.

3.2 Workshop Format

The workshop follows a format approved by DHS/S&T Office of University Programs (OUP).

Day 1 - Presentations

Briefings presented on the first day of the workshop provided visibility into Arctic maritime activities, current climate change research, research methods, data analysis and data availability. In addition, geo-spatial and analytics tools were demonstrated.

Day 2 – Panel Presentations and Discussion

On the second day, three participants contributed to a panel discussion focused on various aspects of climate change with regard to communities, the environment, research, analysis and solutions:

- Climate Informatics – Dr. Claire Monteleoni, Computer Science Professor, George Washington University Machine Learning and Informatics
- Impacts to Alaskan communities and their high-value subsistence living lifestyles from both *climate change* and the *conducting of research* –Nome Eskimo Community, Kawerak, Inc.
- ADAC's developing intelligent integrated system of systems (IISOS) - Robotic Technology Inc.

Day 2 – Breakout Groups – Requirements Discussion

Following the panel, the workshop broke into three groups to discuss climate change data analytical requirements, with discussion centering on the following questions:

- What environmental information is currently most useful to your group or organization?
- What related questions are most important to answer? (What analysis is needed?)
- Who should have awareness of the analysis results?
- What problems or missing elements prevent full awareness? (Issues and gaps?)
- What are anticipated or desired outcomes and improvements?

4. Presentation Highlights

Keynote – Tom Case, Chancellor of UAA

- Importance of:
    - Regional Resiliency Assessment Program (RRAP)
    - Protected Critical Infrastructure Information (PCII)
    - Port Security Assessments (PSAs) – continuity plans
    - Cyber resiliency assessments
    - Indigenous knowledge and observations
    - Collaboration "… knowing people personally in all sorts of organizations with an aligned focus on the Arctic…"

Arctic Domain Awareness Center Overview – Dr. Helena S. Wisniewski, ADAC Executive Director and Principal Investigator

- The Arctic Domain Awareness Center (ADAC) is a DHS S&T Center of Excellence established at the University of Alaska Anchorage
- Mission: Develop and transition technology solutions, innovative products, and educational programs to improve situational awareness and crisis response capabilities related to emerging maritime challenges in the dynamic Arctic environment.
- Addressing objectives from:
    - President's National Strategy of the Arctic, May 2013
    - USCG Arctic Strategy 2013 Objectives
    - Arctic Council Priorities
- ADAC is seeking to develop an Arctic Domain Awareness Capability, leveraging integrated intelligent system of systems (IISOS) (**Figure 1**) to enhance situational awareness for maritime responders by:
    - Fusing data from multiple heterogeneous sources collected and integrated to include: CBONS, ADAC developed sensors for remote Arctic monitoring and long range UUVs developed by ADAC for oil detection in and under ice, and new models incorporating Arctic sea ice and currents, various databases for real-time data/models from multiple agencies including NOAA data, models and tools; real-time AIS data; forecasting models from the US Navy; as well as all data sources federated and hosted by ADAC's partner Axiom Data Sciences, such as digital elevation models and bathymetry, weather sensor data and models forecasts, socio-economic and subsistence data sets and GIS layers, environmental sensitivity data sets, and infrastructure data.
    - Using Big Data methods to analyze, determine gaps, detect patterns and trends of Arctic activities.
    - Incorporating an agent based modular approach for intelligent processing that includes value judgements and prediction

- Providing actionable information to respond to intentional and unintentional catastrophic events
- Providing predictive models for preparing and planning for these events. For example: Enhance the Coast Guard's ability to prepare for and respond to oil spills in the Arctic Ocean, search and rescue missions, and support efforts to prepare for disasters caused by large coastal storms.

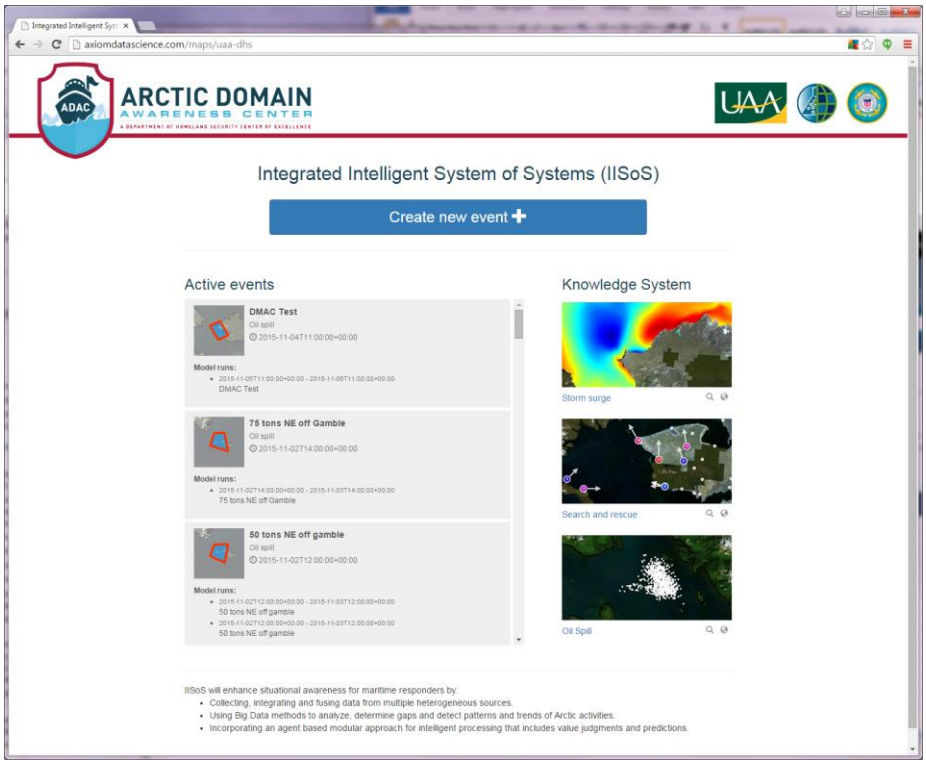

Figure 1: ADAC's IISOS

Data Analytics Engine – Christopher Featherston, DHS S&T HSARPA Senior Advisor; and Chuck Lewis, MITRE Senior Principal Systems Engineer / Data Scientist

- Overview of Data Analytics Context at DHS
- Data Analytics Engine (DA-E) Capabilities:
  - Rapid experimentation, prototypes, pilots
  - Assessment of emerging technologies
  - Strategic R&D
- Components supported by DA-E
  - Customs and Border Protection (CBP), Federal Emergency Management Agency (FEMA), Immigration and Customs Enforcement (ICE), National Protection and Programs Directorate (NPPD), Transportation Security Administration (TSA), United States Citizenship and Immigration Services (USCIS), and United States Coast Guard (USCG)

Climate Change Analytic Project (C-CAP) – Christopher Featherston, DHS S&T HSARPA Senior Advisor

- Proposed project for DHS, to improve effectiveness of DHS and Homeland Security Enterprise operations in the Arctic and how analytics focused on climate change will be able to support DHS Components on decision making processes.
- Develop predictive analytic capability
    - Where are affected areas?
    - How much damage already exists?
    - How fast is the progression?
    - What is the timeline for infrastructure protection or relocation?

Maritime Activity in the Arctic – USCG

- Shipping activity increase – ice melt is opening navigable area and lengthening shipping season
    - Volume: 1.36 million tons in 2013, predicted 4 M tons 2015 and 65 M tons 2020
    - Most traffic funnels through Bering Strait
    - First luxury passenger ship to cruise the Northwest Passage scheduled Aug. 2016
- Concerns
    - The Healy is currently the only USCG ice-cutter
    - Heavy traffic (Bering Strait)
    - Offshore oil spill
    - Ship casualties
    - Need to automate “Arctic Area of Concern Transits” data

Global Warming and Impacts on Alaska Maritime Operations – Marine Exchange of Alaska

- Marine Exchange provides info, communications and services to aid safe, secure, efficient and environmentally sound maritime operations
    - 1.5 million square miles of US waters
- Automatic Identification System (AIS)
    - Used by USCG, State of Alaska and marine industry to locate and track vessels
    - Destination shipping, delivery of goods
    - Support of oil exploration
    - Shipping routes
    - Location of ice – first-year ice and multi-year ice
    - Notifications to ships
    - AIS and Environmental Stations – 130+
        - Includes remote self-supporting transmission sites
    - real time 24/7

- Moving from maritime domain *awareness* to maritime domain *management*
- "We have data – now what are we going to do with it?"

The Marine Exchange of Alaska URL is http://www.mxak.org.

Arctic Collaborative Environment (ACE) Joint Capability Technology Demo (JCTD) – USEUCOM and NASA

- NASA (Lead)
- COCOM Sponsors:
  - US EUCOM
  - US NORTHCOM
- Partners
  - US Army
  - US National Ice Center
  - National Oceanic and Atmospheric Administration (NOAA)
  - Defense Research and Development Canada
  - University of Alaska Fairbanks
  - Alaskan Command
- ACE is a web-based tool allowing sharing of Arctic geo-referenced maritime and terrestrial data
  - Most required software is free (translation software for chat is $200)
  - Provides collaborative platform for study capability
  - Based around self-forming data sharing communities
  - Extensive data catalog

Website URL: https://ace.arsc.edu (hosted at UAF)

Model / Data Analytics and Infrastructure for Climate and Environmental Dynamics –

- Vision: Fusing numerical models, data streams, pattern analysis, visualization and distance collaboration
  - Change detection
  - Extreme event prediction – hurricanes, tsunamis, floods
  - Allow highly informed policymaking and real-time response management
- Importance of:
  - Physics-based models, not just statistics
    - Need "reality check" of confidence levels
- NSF Earth-Observing: sensor networks, advanced computing and instruments that enable advanced environmental science:
  - National Ecological Observatory Network – a single, scalable, integrated research platform for conducting continental-scale ecological research

- EarthCube – enabling geoscientists to address challenges of understanding and predicting complex, evolving earth system, through community-governed effort to develop common cyberinfrastructure
  - Collect, access, analyze, share, visualize data and resources
  - Support interoperability standards and advanced technologies
  - Educate scientists in emerging data and software stewardship, and open science
- Website URL: http://earthcube.org

Arctic Environmental Response Management Application (ERMA) Demonstration – NOAA

- Arctic ERMA is "an online mapping tool that integrates both static and real-time data in a centralized, easy-to-use format for environmental responders and decision makers" (**Figure 2**). Data includes:
  - Environmental Sensitivity Index (ESI) maps
  - Ship locations
  - Weather
  - Ocean currents
  - Daily Ice Edge and Marginal Ice Zones
  - Arctic Ocean Observing Station data
  - Sea Ice and Iceberg Limits
  - Arctic Shield 2015 – direct applicability to Arctic ERMA data sets
  - Data from USCG Ice cutter Healy
  - Data from NOAA Puma™ AE (All Environment) Small Unmanned Aircraft System (UAS)
  - Data sets from Deepwater Horizon

- Website URL: https://erma.noaa.gov/arctic/

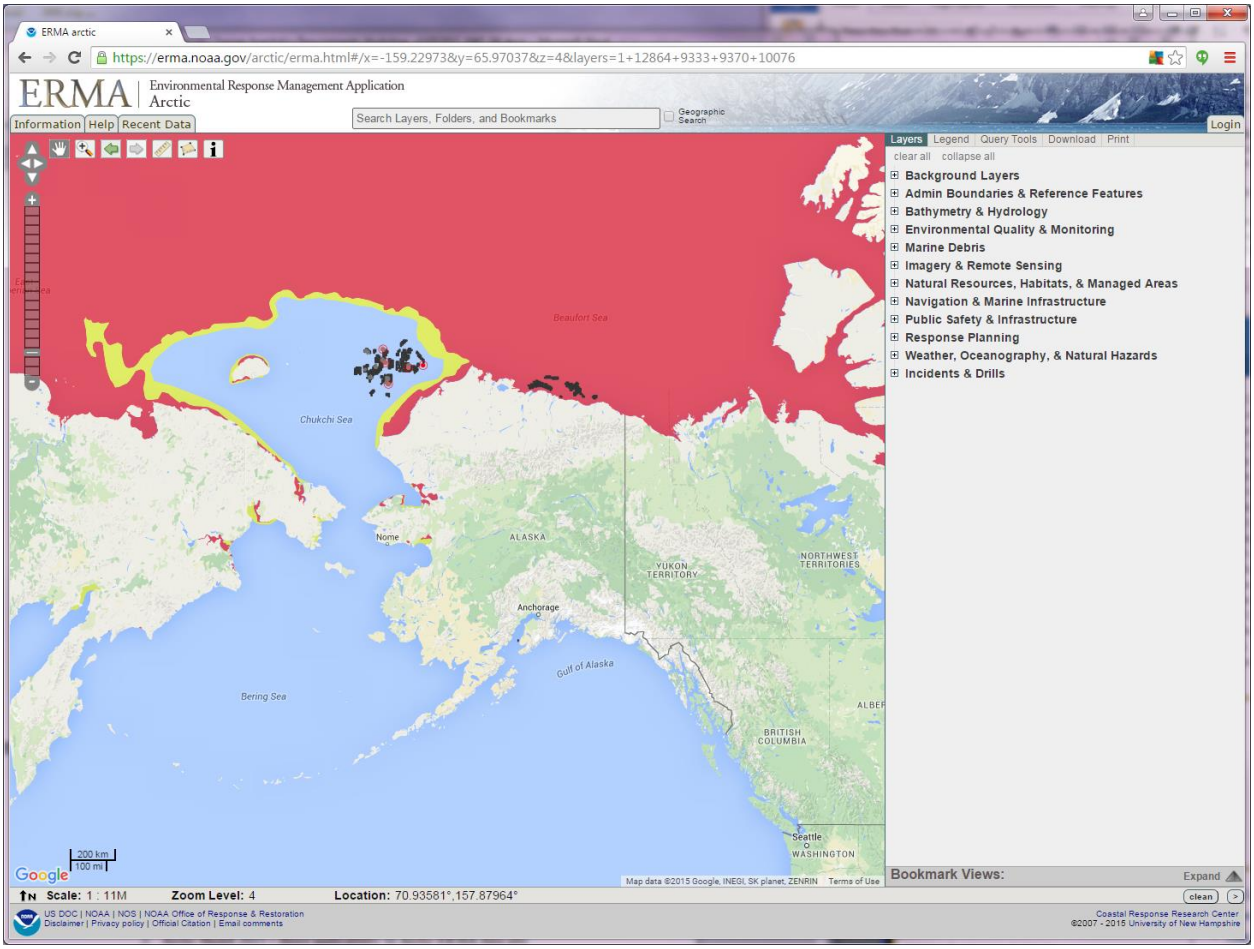

Figure 2: Arctic ERMA

Cloud Computing and Grants for Research – Microsoft Inc.

- Collaborating with NOAA to host federal weather, climate, ocean and water data on Microsoft Azure cloud platform
- Microsoft awarding research grants to universities and non-profits in areas:
    - Climate Data
    - Innovation Challenge for Food Resilience

Anticipating Arctic Social Ecological System Change – Dr. Lilian Alessa, Director, Alaska Experimental Program to Stimulate Competitive Research (EPSCoR); and Lead of ADAC's Community Based Observing Networks (CBONS)

- Need to work with communities in place and make data more operable
    - CBONS – trains intelligent observers to use 42 variables to assess change
- Need to integrate data streams and predict Arctic critical events
- Community based intelligent observers are often the first to notice a change in:
    - Weather, tides
    - Marine animal health

    - Infrastructure deterioration
- Three most important tasks:
    - Build models
    - Perform predictive analytics with the IISoS
    - Create scenarios based on being informed by the past and present "… walk into the future facing backwards…"

5. Workshop Takeaways

5.1 Gaps

1. Lack of visibility into the array of research projects funded throughout government and the availability of data resulting from that research
2. Lack of principled approach to evaluate data quality and establish data standards
3. Lack of formal data sharing system
4. High quality/high resolution predictive models from both physics and statistical methods
    a. Lack of standard requirements for model resolution and quality that are appropriate for real-life tasks and to inform policy makers
5. Need for tools that distill the available data and models into a clear picture
6. Lack of reliable, high-quality internet access is a huge issue for local communities; very limited local access to information
7. Lack of understanding of the local community north of the Arctic Circle by scientists; need for inclusion of community members in research and scientific process
8. Lack of a principled approach to remote and in-situ sensor data collection:
    a. Using the right sensors
    b. Prioritization and planning of data collection (including model-driven planning)
    c. Coastal observations of shore-fast (near shore) ice, beach widths

5.1.1 Other Gaps Discussed

- Policy gaps (Amy Pope, advisor to President Obama asked Dr. Wisniewski, "What type of policy changes would ADAC's work potentially identify?")
- Data governance
- Data analytics
- Interoperability
- Data aggregation / ability to link across data sets
- Need to decide high-priority timeframes for predictive analytics – one generation? Two, three generations?
- Data use agreements
    - Understanding data sensitivity - e.g., of wildlife monitoring, as knowledge of animal location has a high economic value to indigenous communities

- Importance of food security
- Coastal observations of shore-fast (near shore) ice, beach widths
- Coastal zone management plans and system
    - FEMA's National Flood Insurance Program depends upon USGS flood maps
        - Alaska's coastline is only partially mapped by USGS

Over the course of the meeting, initial user requirements and solutions were put forward, but with such a diverse group, consensus around specific needs was not the focus of the workshop; however, a set of potential high-level requirements was developed as a result of the workshop.

6. Potential Requirements

1. A future Arctic knowledge system needs development of the correct approach to federate/host all the available data and model predictions.
2. A future Arctic knowledge system needs appropriate methodology for collection and integration of Arctic infrastructure data.
3. Analytic methods need to support operations with limited information and/or when points of concern are otherwise outliers, e.g., when ships are off course or weather events are extreme.
4. Arctic climate change analytics requires development of high resolution predictive models.
5. Arctic climate change analytics must take into account existing gaps between societal impacts and environmental impacts.
6. Support of timely analysis and prediction in the Arctic requires identification and development of all available resources.

7. Workshop Attendees

Attendees included representatives from:

- DHS S&T HSARPA Data Analytics Engine
    - Christopher Featherston, Senior Advisor, Climate Change Analytics Lead
    - Linda Vasta, Senior Advisor - West
- University of Alaska Anchorage
    - Tom Case, Chancellor (Keynote Speaker)
    - Dr. Helena S. Wisniewski, Vice Provost of Research and Graduate Studies, Executive Director of ADAC
    - Dr. George Kamberov, ADAC
    - Andrea Miller, Exec. Assistant ADAC
    - Eric Klein, ADAC
    - Dr. Kenrick Mock, ADAC
    - Dr. Tom Ravens, ADAC
    - Dr. Orson Smith, PE, Port & Coastal Engineer (UAA Professor Emeritus)

  - Dr. Don Spalinger, ADAC
- University of Alaska Fairbanks
  - Dr. Hajo Eicken, ADAC and IARC Interim Director
- United States Coast Guard (USCG) Sector Anchorage
- USCG 17th District
- DHS National Protection and Programs Directorate (NPPD) Infrastructure Protection
- University of Idaho
  - Dr. Lilian Alessa, Community Based Observing Networks and Systems (CBONS) Lead for ADAC; also, Project Lead for Arctic freshwater security assessments during the US Chairmanship of the Arctic Council (2015 – 2017)
- United States European Command (EUCOM)
- National Aeronautics and Space Administration (NASA) – National Space Science and Technology Center, Marshall Space Flight Center
- National Oceanic and Atmospheric Administration (NOAA), Office of Response & Restoration
- National Oceanic and Atmospheric Administration (NOAA), National Ocean Service
- Alaska Native Tribal Health Consortium
  - Center for Climate and Health
  - Emergency Preparedness Program
- George Washington University – Machine Learning and Climate Informatics
- University of Alaska Fairbanks
  - Dr. Hajo Eicken, ADAC
- National Science Foundation (NSF) – Directorate for Computer and Information Science and Engineering
  - Robust Intelligence
- Kawerak, Inc.
  - Nome Eskimo Community
- Aleut International Association
- North Slope Borough – Administration & Finance
  - Disaster Coordination
  - Risk Management
- Applied Research in Environmental Sciences Nonprofit, Inc. and DHS Center for Risk and Economic Analysis of Terrorism Events (CREATE)
- Marine Exchange of Alaska
- Public Safety Canada

- Pennsylvania State University - Applied Research Laboratory
- Robotic Technology Inc.
- Microsoft Corporation
- The MITRE Corporation
  - Charles J. Lewis, Senior Principal Systems Engineer / Data Scientist
  - Lisa A. Kerby, Lead Systems Engineer / Requirements Specialist

8. Works Cited

Featherston, C., Vasta, L., Lewis, C., & Kerby, L. (2015, November 5). Trip Report: Arctic Domain Awareness Center (ADAC) Climate Change Analytics Requirements Workshop. Anchorage, Alaska: Department of Homeland Security.

9. Acronyms

ACE	Arctic Collaborative Environment
ADAC	Arctic Domain Awareness Center
AIS	Automatic Identification System
CBP	Customs and Border Protection
CBONS	Community Based Observing Networks and Systems
COE	Centers of Excellence
CREATE	Center for Risk and Economic Analysis of Terrorism Events
DA-E	Data Analytics Engine
DHS	Department of Homeland Security
ERMA	Environmental Response Management Application
ETL	Extract, transform, load
FEMA	Federal Emergency Management Agency
HSARPA	Homeland Security Advanced Research Projects Agency
ICE	Immigration and Customs Enforcement
IP	Infrastructure Protection
IISOS	Intelligent Integrated System of Systems
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NPPD	National Protection and Programs Directorate
NSF	National Science Foundation
OUP	Office of University Programs
RRAP	Regional Resiliency Assessment Program
S&T	Science and Technology
TSA	Transportation Security Administration
UAA	University of Alaska Anchorage
UAF	University of Alaska Fairbanks
UAS	Unmanned Aircraft System
USCG	United States Coast Guard
USCIS	United States Citizenship and Immigration Services