

Enterprise Architecture for a National Climate Response for

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Executive Summary

The earth's climate is changing. Average global temperatures are warming, and seas are rising. Extreme weather events are occurring on a regular basis.

Many US government agencies are researching and documenting climate change. Those efforts are hampered by programs, research, and data collection fragmented across many federal agencies. Presidential leadership on climate change is minimal. This Administration's priorities lie elsewhere.

The President should emphasize to the American people that climate change poses a serious danger to the United States. The President and Congress should work together to create a strategic plan to steer United States climate adaptation efforts. That strategic plan would include the creation of a national enterprise architecture (EA) for climate change response. The climate change EA would include a central repository for climate change data, a climate change knowledge management system to communicate with decision-makers and other stakeholders, and a climate data quality assurance program.

A climate change EA would save governments money by guiding expenditures on a range of projects including agriculture and infrastructure and by eliminating the redundancies of the current uncoordinated response. A national climate enterprise architecture would move climate information from information silos in which it is currently stored into the hands of decision-makers at all levels in the public and private sector.

Creating a national urgency to respond to climate change and develop an enterprise architecture to align the US response will be a challenge in the current political climate. Due to the urgency of the climate change crisis, the time to go to work on the problem is now.

Background

A Look at Climate Change

Extreme weather was in the news again recently when hurricane Dorian devastated the Bahamas. Hurricanes Harvey, Irma, and Maria caused over \$200 billion in damage to the US mainland and Puerto Rico in 2017 (Drye 2017). Scientists are still researching the correlation between hurricanes and climate change, but research shows that warmer ocean temperatures and higher sea levels intensify the impact of hurricanes. (C2ES n.d.)

According to the National Science Foundation (NSF), "Climate is what you expect, weather is what you get." Climate is the weather of a region over time. Global climate is the average of all regional trends. The Earth's climate is warming (NSF 2008). The average global temperature on Earth has increased by at least 0.8° Celsius (1.4° Fahrenheit) since 1880, two-thirds of that since 1975. (NASA n.d.) The oceans have absorbed as much as 90% of that heat. The rate of sea level rise is accelerating and could reach one to two feet by 2100. So-called "once in a century" sea level events will occur annually in many places by 2050 (IPCC 2019).

The impact of climate change is not limited to the coasts. Wildfires caused \$400 billion in damage to California in 2018 alone. The U.S. Forest Service spends over half of its annual budget on firefighting, significantly more than it spends on forest management (Amadeo 2019). Extreme weather, from heat waves to floods to droughts, is increasingly common. Agriculture has suffered. Part of the cost of climate change will be borne by governments, including the US federal government.

US Governmental Response to Climate Change

How is the US government responding to climate change? The President's Office of Science and Technology Policy (OSTP), which advises the White House on issues of science, the environment, and technology, currently does not have a page on its website dedicated to climate change (Office of Science and Technology Policy n.d.).

Multiple federal agencies are responsible for the government's response to climate change. Congress created the United States Global Change Research Program (USGCRP) to coordinate the climate efforts of thirteen federal entities, including the Department of Commerce, the Department of Agriculture (USDA), the Department of Defense, the State Department, the National Science Foundation, and NASA (USGCRP n.d.). The USGCRP publishes a National Global Change Research Plan every three years summarizing the progress, priorities, and challenges of its climate change efforts (USGCRP n.d.).

Two agencies are leading the government's response to climate change. The National Oceanic and Atmospheric Administration (NOAA), part of the Department of Commerce, is trying to improve climate change research, assess current and future states of the climate, lead efforts to mitigate and adapt to the effects of climate change, and educate the public (USGCRP n.d.). That education effort includes the Climate.gov website.

The USDA Climate Change Program Office (CCPO) coordinates its responses to climate change, focusing on implications of climate change on agriculture, forests, grazing lands, and rural communities (USDA OCE n.d.). The USDA Economic Research Service (ERS) researches climate change issues related to agriculture, including impacts on crops and livestock, land use, and risk management (USDA n.d.).

Other government efforts include the US Climate Resilience Toolkit and the climate area of the Data.gov web portal. The latter is a data aggregation system created by the GSA Technology Transformation Service. Over 23,000 federal climate-related datasets are accessible through the Data.gov climate web portal (Data.gov n.d.).

The current US enterprise architecture is operating with a diversification model. Like other diversified organizations described in *Enterprise Architecture as Strategy*, multiple climate information programs exist that serve few common users, there is limited centralized management control, and there is little shared data and few data standards (Ross, Weill, and Robertson 2006).

Please see appendix A for a diagram of the existing US climate change enterprise architecture.

Criticism of the US Response to Climate Change

Despite federal efforts, there are critics of the US government's response to climate change. The non-partisan Climate and Security Advisory Group (CSAG) recently issued a report calling for the US government to make climate change a national security priority. They wrote, "The President should announce a government-wide Climate Security Plan for America, and implement it through a new National Strategy Directive and White House Office on Climate Security, led by a senior official reporting directly to the President" (Center for Climate and Security 2019).

The US Government Accountability Office (GAO) said the government does a good job of collecting climate observations and archiving data, but much of the climate information process is fragmented. Information silos among and within federal agencies are a barrier to climate

resilience planning. The current system is uncoordinated and inefficient. Agencies have created multiple climate programs that operate independently, fail to share information, and do not learn from each other. Turf battles exist between various government agencies (GAO 2015).

European Climate EA

The GAO report noted that several European countries, including Germany and the UK, "have organized systems to meet the climate information needs of decision makers. (T)he government provides direction and funding, and entities within and outside the government help translate climate information to meet decision makers' needs" (GAO 2015).

Vision of Architecture Project Success

A successful enterprise architecture for US climate change response will adopt elements of European models while incorporating as much of the current US climate response as possible. The new EA will start with strong leadership creating an urgency for a unified response to climate change. That urgency will be reflected in additional funding for restructuring, research, a centralized data structure, and improved climate knowledge management.

Major Architecture Issues

Listed below are the primary issues hampering a formal enterprise architecture for the US federal response to climate change.

- 1. Leadership** -- There is no clear, unified federal agenda or mandate for climate change response.
- 2. Structure** -- Climate change response is spread across multiple agencies with no centralized direction.
- 3. Siloed data** -- Data is locked in silos within and among federal agencies.

4. **Knowledge management** -- Climate data and knowledge are not getting to the decision-makers who need it.
5. **Data quality** -- There is no quality assurance system for climate data.

Analysis of Major Architecture Issues

Issue 1: Leadership

There is no clear, unified federal agenda or mandate for climate change response.

Business Case. According to the Intergovernmental Panel on Climate Change (IPCC), ""Warming of the climate system is unequivocal... Changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause" (IPCC 2014). The Climate and Security Advisory Group states, "Combating these risks will require extraordinary leadership and a response involving a broad range of Federal agencies" (Center for Climate and Security 2019). Governments that have made efforts at climate change adaptation have been led by a strong chief executive who has made climate change adaptation a government-wide priority (Smith, Vogel, and Cromwell 2009). Key steps for organizational change include creating urgency, creating a vision for change, and communicating that vision (Kotter 2012).

Base Architecture. The current US Administration has not created a sense of urgency to change the US response to climate change. The Office of Science and Technology Policy currently does not have a page on its website dedicated to climate change (Office of Science and Technology Policy n.d.). More broadly, this Administration has stopped maintaining pages on federal websites related to climate change, has removed some federal climate change web

pages or restricted access to them, and has changed words and phrases such as "climate change" and "adaptation" to less-specific terms (EDGI 2019).

Target Architecture. Leaders in several European countries have shown leadership regarding climate change response enterprise architecture by empowering key national agencies to take the lead in climate change response and providing funding to create or expand programs for climate change research and information dissemination (GAO 2015).

At other times in US history, the President has shown strong leadership that has reshaped much of the government in response to an external threat. For example, President Eisenhower launched Project Solarium to unify his divided Cabinet and federal agencies in response to the threat of the Soviet Union in the 1950s (Center for Climate and Security 2019).

Gap Analysis. There is a large gap between the response to climate change by European countries such as Germany and that of the US. While some European countries are creating and expanding climate change enterprise architecture programs, the US is cutting funding for many federal agencies, and those agencies are in some cases actively reducing access to existing climate change information. Although that leadership gap seems vast, the leadership issue may not be insurmountable.

Issue 2: Structure

Climate change response is spread across multiple agencies with no centralized direction.

Business Case. Enterprise architecture can create policies that align an organization's capabilities, resources, and decision-making (Scott 2012). Early in the EA development process, an organization should develop an operating model to create a foundation for execution.

Organizations with a foundation for execution have higher strategic effectiveness, greater efficiency, and more agility. Organizations with a high degree of business integration but low standardization use the coordination operating model. In addition to the benefits listed above of a strong foundation for execution, the coordination operating model leads to higher transparency and better decision-making. A major challenge of the coordination model is integrating data (Ross, Weill, and Robertson 2006). This paper will return to the issue of data integration later.

Base Architecture. According to the GAO, "As of December 2014, almost 40 federal departments and agencies produced climate change adaptation plans and metrics to evaluate adaptation performance" (GAO 2015).

The GAO's 2015 report on climate information observed that the federal government has launched many intra-agency and even some government-wide efforts to address climate change information needs. Federal officials say that the actions of federal agencies on climate change are consistent with their mandates and missions. Officials say that there is collaboration and some coordinated efforts. Many more efforts, however, are fragmented and do not meet the needs of decision-makers at all levels of government and in the private sector. Many federal agencies have created their own climate programs that stand as separate systems, fail to share information, and fail to learn from each other. Climate information "exists in an uncoordinated confederation of networks and institutions" (GAO 2015).

Some of the fragmentation is caused by distrust and competition between agencies that causes turf battles. Structural issues only add to the cultural issues. Most agencies and their climate change programs were not created to coordinate with other agencies and programs.

There are few mandates for using climate change information in federal decision-making (GAO 2015).

Current US federal climate change response would be described as using the diversification operating model. The many various federal agencies with climate change programs have few shared customers, little shared data or data standards between different agencies and programs, and few shared processes. Control of climate change programs is primarily at the local level.

Target Architecture. Organizations with a coordination operating model share customers and products, but individual business units still have unique operations and capabilities. Those organizations focus on customer service. Central management coordinates cooperation between business units and facilitates "big picture" thinking (Ross, Weill, and Robertson 2006). In the case of an enterprise architecture for climate change response, the primary customers are decision-makers at all levels but could be anyone on earth, since climate affects everyone. Climate change EA products include climate research, data and information, and knowledge management.

Germany, the Netherlands, and the UK all empower a single agency within their respective governments to lead climate change adaption processes and coordinate the efforts of other government and non-government agencies. According to Bernard Scott, enterprise architecture can create policies that align an organization's capabilities, resources, and decision-making (Scott 2012). In those three European countries, the climate change enterprise architecture helps to coordinate the work of multiple agencies responding to climate change,

allocate resources appropriately, provide climate information to decision-makers at all levels, and collect climate data (GAO 2015).

Please see appendix B for a core diagram of the target US climate change enterprise architecture.

Gap Analysis. The diversification operating model describes many aspects of the US government. For example, the USDA has responsibilities that are significantly different than the departments of Commerce, Defense, or State. A farmer in Nebraska, a sailor in Hawaii, or a banker in New York are all affected by climate change. Each of their businesses would benefit from climate change information and research. To close the gap and move from a diversification model to a coordination model, the US would need strong leadership on climate change issues (see Issue #1, above) and an agreement between federal agencies and their respective climate change programs to work together to provide better customer service to their customers, decision-makers and the American public at-large.

Barbara Krolikowska notes that federal structures add challenges to creating an EA because of distributed decision-making, political influence, data protection rules, privacy concerns, and access to public information (Krolikowska 2011).

Issue 3: Siloed Data

Data is locked in silos within and among federal agencies.

Business Case. The Task Force on Climate Preparedness and Resilience issued a report in November of 2014 identifying “silos” among and within federal agencies as a barrier to climate resilience planning (GAO 2015). A data silo is a situation wherein only one group in an organization can access a set or source of data. Silos can also apply to services and processes.

Early in the process of developing an enterprise architecture, enterprise architects develop a maturity model for an organization. At the Business Silos maturity level, EA is driven by the business needs of individual business units (Bente, Bombosch, and Langade 2012). Organizations at the silos maturity level deliver solutions for individual business units. They may share some services but do not have a set of shared standards (Ross, Weill, and Robertson 2006). Redundant systems are more expensive to maintain, provide less value to an organization, and inhibit productivity and structural change.

Base Architecture. The most important assets of climate change EA are climate information: data describing the climate in the past and present and predictions for the future.

Almost 40 federal departments and agencies are involved in the US climate change response. (GAO 2015). Over 23,000 federal climate-related datasets are accessible through the Data.gov climate web portal (Data.gov n.d.). The United States Global Change Research Program (USGCRP) is mandated by Congress to coordinate the climate efforts of thirteen federal entities. The USGCRP publishes a National Global Change Research Plan every three years summarizing the progress, priorities, and challenges of its climate change efforts (USGCRP n.d.). Often when an EA is at the Business Silos maturity level, an organization will share some services, such as the USGCRP in this case, but those services meet the needs of local units, not necessarily the entire enterprise (Ross, Weill, and Robertson 2006). Information is stored separately within each agency, with certain exceptions such as the USGCRP, and not shared across the government.

Target Architecture. Enterprises with a more mature business model have business units that see themselves as allies rather than adversaries. Those mature enterprises have

technology to promote data and knowledge sharing, which might include common databases, data lakes, data warehouses, etc. The European countries cited earlier for their climate change EA all have mechanisms that effectively break down data silos. The German Climate Service Center 2.0 conducts research and provides climate change data products and services. The Netherlands Meteorological Institute conducts climate research and provides a climate change help line using Dutch climate science data. In the UK, the Met Office Hadley Centre does research and is a clearinghouse for UK climate change data (GAO 2015).

An open climate change enterprise architecture can provide "demand-driven information sensitive to the needs of decision makers, not just the proliferation of more undirected information" (Smith, Vogel, and Cromwell 2009).

The ultimate goal of breaking down business silos is Boundaryless Information Flow, which means, "getting information to the right people at the right time in a secure, reliable manner, in order to support the operations that are core to the extended enterprise" (The Open Group 2017). "Boundaryless" does not mean free of boundaries but does mean that enterprises are able to cross boundaries easily.

Gap Analysis. Moving beyond the business silos maturity level requires organizations to change both culture and technology. A part of the process of breaking down silos is the principle of rationalization. That principle produces a standardized architecture of interfaces, systems, and data. Elements that do not comply to the EA standards are migrated or eliminated.

Organizations following the TOGAF ADM may try to achieve the Boundaryless Information Flow by using the Information Infrastructure Reference Model (III-RM). Following

III-RM helps a business create infrastructure to support data flow across the enterprise and break down data silos (The Open Group 2017).

Issue 4: Knowledge Management

Climate data and knowledge are not getting to the decision-makers who need it.

Business Case.

According to the GAO, "State, local, and private sector decision makers can drive federal climate-related fiscal exposures, as they are responsible for planning, constructing, and maintaining certain types of vulnerable infrastructure, such as roads and bridges, paid for partly with federal funds, insured by federal programs, or eligible for federal disaster assistance" (GAO 2015). Those decision-makers need the "best available climate information... such as observed and projected temperatures for a geographic area" (GAO 2015). The information decision-makers need to understand climate change and make appropriate choices includes observed climate conditions, impacts and vulnerabilities as well as health and economic impacts of climate change (GAO 2015).

Base Architecture. Almost 40 federal departments and agencies are involved in the US climate change response (GAO 2015). Over 23,000 federal climate-related datasets are accessible through the Data.gov climate web portal (Data.gov n.d.). The federal government "does an excellent job collecting climate observations and archiving quality climate data, but it does not communicate or translate this information in ways useful for decision makers" (GAO 2015). Decision-makers may not be aware climate change information exists or may be unable to use it (GAO 2015).

Climate data and knowledge in the US has primarily been conveyed to decision-makers via scientific publications, forecasts, information sheets from individual federal agencies and programs, and through the media. Those methods, however, have had limited success in conveying climate information to decision-makers, planners, and others who need it (Keele 2019).

Target Architecture. The GAO states, "Decision makers need consistent, geographically specific, and accessible information and tools to identify climate risks and support resilience planning in their communities" (GAO 2015). Since there is already so much climate change data and information, decision-makers most need tools to use the information that already exists. There is also a need for "common scenarios" that are shared scenarios among the research community analyzing climate change impacts, adaptation, and mitigation (van Vuuren, Kriegler, O'Neill et al 2014). Finally, decision-makers need help with mainstreaming, the integration of climate change into everyday institutional decisions (Smith, Vogel and Cromwell 2009). The ideal EA would be a framework where all the federal agencies involved in climate change could work together but not get in each other's way (GAO 2015).

Germany, the Netherlands, and the United Kingdom have organized climate change EA to provide information to decision-makers. Those governments get the information to decision-makers by providing leadership, funding, and technical assistance from both government and non-government entities (GAO 2015).

Gap Analysis Going from 40 departments and 23,000 federal datasets to providing climate change information for Denver or Miami or Springfield is a huge challenge on many levels. There are social, structural, political, and technical obstacles, among others. Even getting

out the information that there is information may be a challenge. Climate change is a political issue on multiple levels. Some parts of the US populace inherently distrust the US federal government or specific agencies within it, such as the USDA or the Department of the Interior. Other Americans may have more or less trust in private entities such as higher education institutions or scientific organizations.

Issue 5: Data Quality

There is no quality assurance system for climate data.

Business Case. There is a tremendous amount of federal climate information being produced by many agencies and programs. There is not, however, a single source of definitive climate change information in the United States. That is a symptom of many of the other architectural issues discussed previously, especially the broad structure of federal climate change response, siloed data, and the inefficiency of climate knowledge getting to key decision-makers.

Due to the uncertainty of climate predictions at the local level, many decision-makers have a "wait and see" attitude toward climate adaptation (Smith, Vogel, and Cromwell 2009). Decisions that leaders make today regarding climate change adaptation will continue to play out for many years. For example, allowing people to build or rebuild in flood-prone areas is dangerous to life and property. Doubt about the quality of climate change data leads to inertia at best and bad decisions at worst.

Base Architecture. The US does not have a lead agency tasked with disseminating climate change information the way several European nations do. There is no authoritative federal data source, and there are no federal quality assurance guidelines. As a result, it is up to

scientific publications and individual federal agencies and programs to convey climate change information to decision-makers and the public. That process has had limited success (Keele 2019). Stakeholders seeking climate change information may not know how to find that information nor whether to trust it (GAO 2015).

Target Architecture. The National Research Council states that the federal government "should be responsible for maintaining the nation's official climate records" as part of a national climate change enterprise architecture. The GAO recommends that the government "develop and periodically update a set of authoritative climate change observations and projections" to give access to the best-available climate information to decision-makers (GAO 2015). That information would be sensitive to the needs of decision-makers, not just a proliferation of undirected information (Smith, Vogel, and Cromwell 2009).

Climate data quality assurance would start with a set of shared policy assumptions common to different studies, which would allow apples-to-apples comparisons (van Vuuren, Kriegler, O'Neill et al 2014). Climate data quality assurance also would involve the development of shared scenarios throughout the climate research community. That would allow for integration between researchers in different areas, make it easier to access climate change literature and studies, and create a baseline for other researchers who cannot or prefer not to create climate scenarios from scratch (van Vuuren, Kriegler, O'Neill et al 2014).

Also important in the development of climate change data quality standards is research into the climate adaptation process. That research would question what kinds of climate data society needs for climate adaptation as well as what kind of information encourages or impedes

adaptation. In other words, data necessity would determine data quality (Smith, Vogel, and Cromwell 2009).

Gap Analysis. Although decision-makers need consistent, geographically specific, and accessible information and tools to identify climate risks and support planning for climate change adaptation, the GAO notes that "a single source of information may not be necessary, as a minimum level of certification, a "seal of approval," could be applied to multiple data sources that meet certain criteria" (GAO 2015).

Whether or not it has a seal of approval, a single, definitive source of climate change data is often not necessary to justify climate change adaptations. Many adaptations can be justified regardless of what the future holds, for example improved agriculture production methods, water resource management, and insurance reforms to discourage questionable building practices (Smith, Vogel, and Cromwell 2009).

Recommended Solutions

Issue 1 Solution: Leadership

Recommended Solution. The President should communicate to the nation that climate change poses a serious danger. The President should also empower federal agencies to respond to climate change. That response should include climate change research as well as planning and funding climate change adaptation and hardening. Climate change represents a great risk to the United States, for reasons including national security, financial security, and the safety of US citizens at home and abroad. Science and predictive capabilities offer US leadership foresight into climate change and its effects (Center for Climate and Security 2019). The US

President has a responsibility to warn American citizens of the risks of climate change and to prepare the country for its effects.

Alternatives. Congress could act to empower some federal agencies to take stronger actions to address climate change and adaptation in spite of the President's resistance. A growing number of Republicans in Congress have taken the position that climate change is real, and that Congress should address it (McMahon 2018). It is possible, however, that the President would veto any legislation with the words "climate change" in it.

States and cities could act on climate change independently of the federal government. To some extent, that has already happened. 24 US states and Puerto Rico are members of the US Climate Alliance, which has taken steps to reduce carbon dioxide emissions and promote clean energy. One problem is that the President recently declared a California law regulating car fuel economy invalid. The President could do the same with actions by the US Climate Alliance that he does not like. A second problem is that although the states could take small steps to affect climate change, the federal government has far greater resources at its disposal to fund climate change science and adaptation.

Issue 2 Solution: Structure

Recommended Solution. The President and Congress should work together to create a strategic plan to steer United States climate adaptation efforts. The plan would create an enterprise architecture for federal climate change response. The EA would include a climate change management office within the Executive Office of the President (EOP) and a restructuring of federal agencies with a mandate for the agencies to work together to respond

to climate change. The plan would create clear responsibilities for all agencies and programs involved in climate change efforts.

The GAO first recommended development of such a strategy in 2009 and reiterated that recommendation in reports in 2014 and 2015 (GAO 2015). The government needs a framework for its response to climate change that allows coordination and reduces redundancies. Federal agencies need a clear mandate to work together due to different missions and cultures at the various agencies. Some agencies and programs are also currently prevented from working on climate change issues due to their charters or funding requirements.

Alternatives. One alternative to coordinating climate change response through the EOP is strengthening the US Global Change Research Program to direct climate change response. The USGCRP already has experience working with a variety of agencies and stakeholders. The main reason against this option is lack of buy-in from other agencies that are not already part of the USGCRP conglomerate.

A second alternative is creating a new federal climate change agency. That would show a clarity of mission and Presidential support. The downsides of a new agency are the typical growing pains of any new organization as well as possible resentment and turf wars with existing agencies already working on climate change response.

A third alternative would be to fund a nonprofit organization or create a public-private partnership to coordinate climate change response. Such an organization would be more nimble than a government agency, probably enabling a faster response to the growing crisis. On the other hand, that organization might not be respected by other federal agencies, since it would not be part of the federal bureaucracy.

A final alternative would be to create a set of federal regional offices to respond to climate change. Those offices would have a better sense of the needs of decision-makers at the local level. The danger of that plan would be an uneven response between various regions and siloed work and data.

Issue 3 Solution: Siloed Data

Recommended Solution. The new climate change management office should create a central repository for climate change data accessible through a web portal. A repository would allow researchers and decision-makers to take a big picture look at climate change data and perform analytics. A repository would also ease data maintenance, increase data quality and accuracy, reduce redundancy, and maintain historical data. Keeping historical climate data establishes a climate baseline as well as allowing future scorekeeping of climate prediction models. In short, a data repository has the potential to improve federal climate change response and save the government money.

A climate change data repository would also be part of the process of helping to solve architectural issue #4, knowledge management, and issue #5, data quality assurance. Having all the climate change data in one place would make it easier to make sure the data is of high quality and would demonstrate to stakeholders that data in the repository has the imprimatur of the US government. The process of creating the repository would allow data scientists to rationalize the data. The creation of the repository would facilitate Boundaryless Information Flow of climate change data across the entire US federal enterprise.

Alternatives. An alternative to a climate change data repository would be enhancing the existing databases within each agency and climate change program to allow outside access to

the data via service-oriented architecture and APIs. Though that could be cheaper in the short term and might solve some of the current data access issues, it would limit the ability to apply analytics to the data, not solve possible redundancy issues, and perhaps not clarify for decision-makers exactly where to go to look for climate change information.

Please see appendix C for a climate change data migration diagram.

Issue 4 Solution: Knowledge Management

Recommended Solution. The new climate change management office should create a knowledge management system to communicate and interpret climate change information to decision-makers and other stakeholders. The KMS would consist of both a non-federal organization to teach, promote, and transfer climate information as well as incorporating current federal climate change adaptation programs that would continue to provide support while focusing on big picture climate change issues. A non-federal organization would probably be more effective in disseminating and promoting climate change knowledge because it would not be hindered by the federal bureaucratic structure and could work together with existing climate change organizations and local officials. One example of an existing organization is the Climate and Development Knowledge Network (CDKN) which "works to enhance the quality of life for the poorest and most vulnerable to climate change." CDKN combines knowledge and research at the local level to provide technical support who people who need it, primarily in Africa, Latin America, and South Asia (CDKN n.d.). Trying to create a climate change knowledge organization with a ubiquitous local focus from scratch would be too great an undertaking for the federal government. At the same time, the government should continue to leverage

existing climate change response assets, such as NOAA's National Integrated Drought Information System (GAO 2015).

Alternatives. There are several possible alternatives to creating a climate change knowledge management system using a public-private partnership. One alternative would be to rely on the central data repository and its web portal from solution #3 to get climate change information to decision-makers. Many local decision-makers, however, will need guidance and direction to apply climate change knowledge on the local level. Having an outside expert to help put the pieces together is often useful in complex systems.

Other alternatives are either a fully private or fully federal solution. As noted above, a fully federal solution would be daunting to implement and would duplicate some existing efforts. A fully private solution risks distrust from some stakeholders who might not believe in the legitimacy of non-federal organizations.

Please see appendix D for a climate change web portal use case diagram.

Issue 5 Solution: Data Quality

Recommended Solution. The new climate change management office should create a climate change data quality assurance program. There is not a definitive source of climate change information in the United States. Without a federal stamp of approval to indicate which climate change data is "correct," some decision-makers are choosing not to take action on climate change. The data quality assurance program would codify a set of shared policy assumptions about climate change and develop shared climate change scenarios to guide stakeholders in the process of climate change research and adaptation. Only the federal government has the resources to create climate change forecasts and models, keep national

weather data, and determine the accuracy of such data generated by its own agencies as well as outside stakeholders. Climate change enterprise architecture programs in the UK and the Netherlands are both based on authoritative climate data provided by national-level agencies (GAO 2015).

Alternative. An alternative to a data quality assurance program is to accept that there is not one "right" answer to what climate change is and how to respond to it. Rather than trying to get the facts and nothing but the facts, a climate change EA might be better served by educating decision-makers and the public that the big picture matters more than the specifics. One example is that it is probably not a good idea to build in a flood-area in an age of rising sea levels. The danger is the "cannot happen here" mentality, in which people believe bad things will not happen to them, no matter what is happening elsewhere.

Please see appendix E for a climate change enterprise architecture environments and locations diagram. It gives an overview of regional climate change offices that would be part of the EA.

High Level Roadmap

Shown below is a high level roadmap for US climate change enterprise architecture for the solutions listed above.

PHASE	WHEN	TASK(S)
Phase 1: Climate change leadership plan	Now-1/31/2020	Formulate US climate change plan
	Late January 2020	President announces US climate change plan at State of the Union address
Phase 2: Climate change agency restructuring TOGAF Phases A-B	Q1 2020	Executive Office of the President creates climate change management office
	Q1 2020	Congress passes bill(s) to restructure federal agencies to respond to climate change
	Q1 2020	Congress passes bill(s) to finance US climate change response
	Q2 2020	Establish architecture capability
	Q2 2020	Create architecture vision
	Q2 2020	Create statement of architecture work
Phase 3: Climate change data consolidation TOGAF Phases C-D	Q2 2020	EOP climate change office creates climate data repository
	Q2-3 2020	EOP climate change office manages data migration into data repository
Phase 4: Climate change knowledge management TOGAF Phases C-D	Q4 2020	EOP climate change office formulates climate data KMS structure
	Q1-2 2021	Climate change KMS regional offices opened and staffed
	Q1-2 2021	Sign agreements with local non-federal organizations for climate knowledge work
	Q3 2020	Build climate change web portal
	Q4 2020	Launch climate change web portal

Phase 5: Climate change data quality assurance program TOGAF Phases C-D	Q4 2020	EOP climate change office creates data quality assurance program
	Q1 2021	Climate data quality control work begins
Full Implementation TOGAF Phases E-G	Q3 2021	All climate change programs and technology operational
Target Architecture TOGAF Phase H	End 2021	US climate change enterprise architecture fully functional

Conclusion

Enterprise architecture can align an organization's capabilities, resources, and decision-making. The current US response to climate change has minimal enterprise architecture. Nearly 40 agencies and over 23,000 federal climate-related datasets exist to inform decision-makers and the public about climate change and adaptation to it. There is no clear, unified federal agenda or mandate for climate change response. Climate change data is locked in data silos, is not getting to decision-makers who need it, and may be of varying quality.

The President should make a strong effort to convey to the nation that climate change poses a danger to the homeland, its citizens, and their property. The President should also empower federal agencies to respond to climate change. The President and Congress should work together to create a strategic plan to steer United States climate adaptation efforts. That strategic plan would create a national enterprise architecture for climate change response. The climate change EA would include a central repository for climate change data accessible through a web portal, a knowledge management system to communicate and interpret climate change information to decision-makers and other stakeholders, and a climate data quality assurance program.

A climate change EA would save taxpayer money by guiding expenditures on a range of projects including agriculture and infrastructure. It would also save money by eliminating the redundancies of the current uncoordinated response. Further, a national climate enterprise architecture would move climate information from information silos in which it is currently stored into the hands of decision-makers at all levels in the public and private sector.

Creating a national urgency to respond to climate change and develop an enterprise architecture to align the US response will be a challenge in the current political climate. This Administration has been trying to shrink or consolidate federal agencies and programs. If the US government could achieve bipartisan support for a climate change EA, an equally large challenge could be summed up in the phrase, "think globally, act locally." Decision-makers need current climate data and future predictions for individual localities. Some locales are getting wetter, while other areas are getting drier. Some areas are heating up faster than others. To be successful, a climate change EA will have to get the right data to the right people at the right time. Due to the urgency of the climate change crisis, the right time to go to work on the problem is now.

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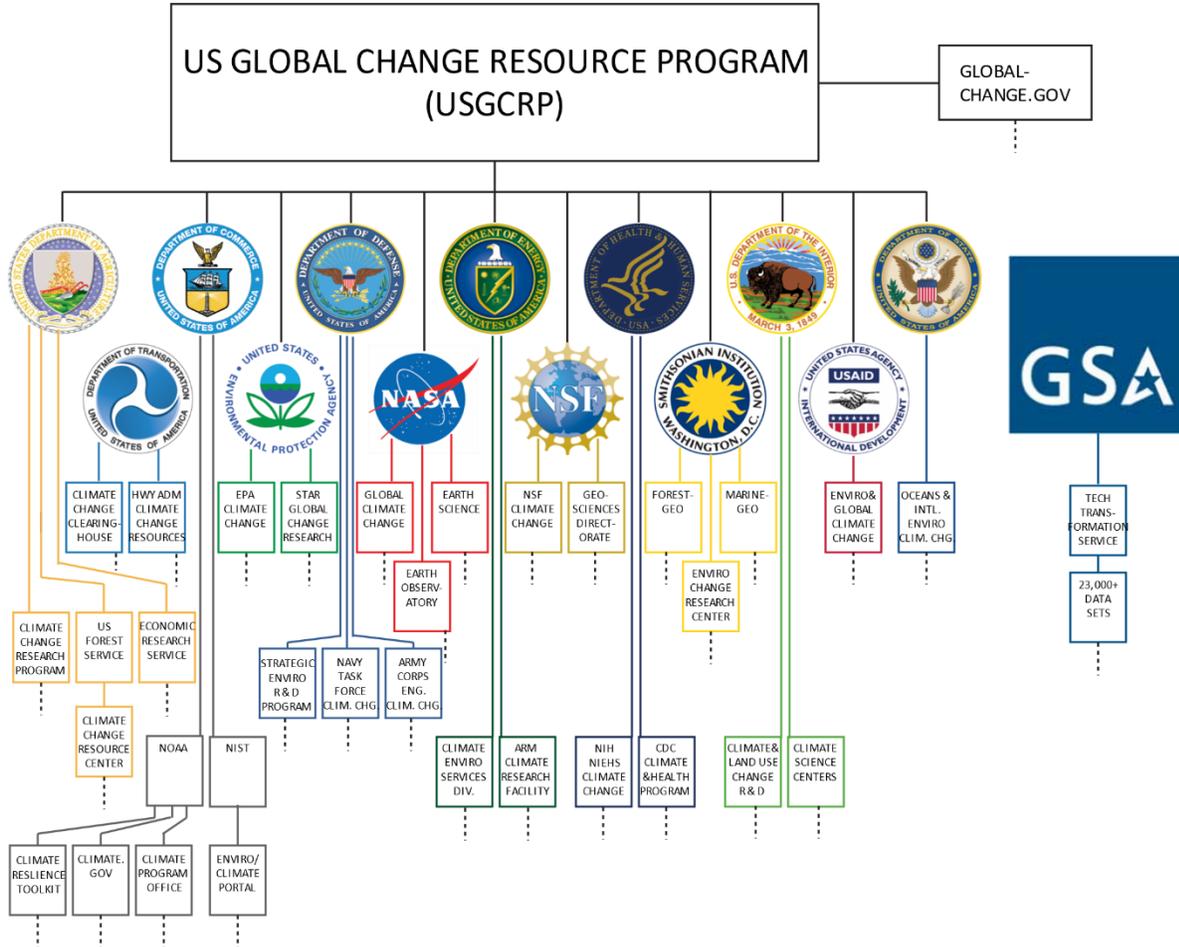
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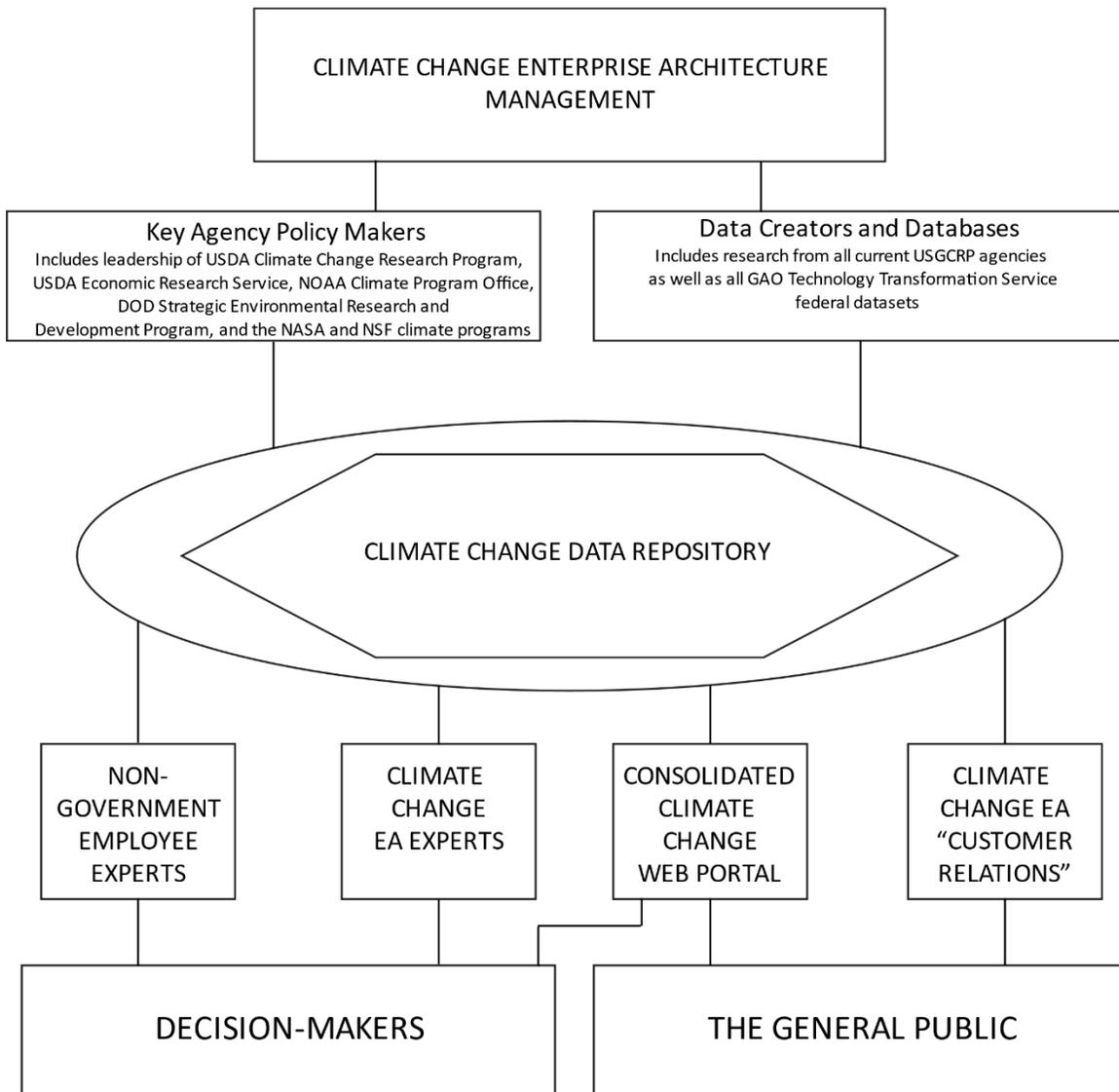
Appendix A: As-Is Enterprise Architecture Diagram

AS-IS US GOVERNMENT CLIMATE CHANGE ENTERPRISE ARCHITECTURE



Appendix B: Target Enterprise Architecture Core Diagram

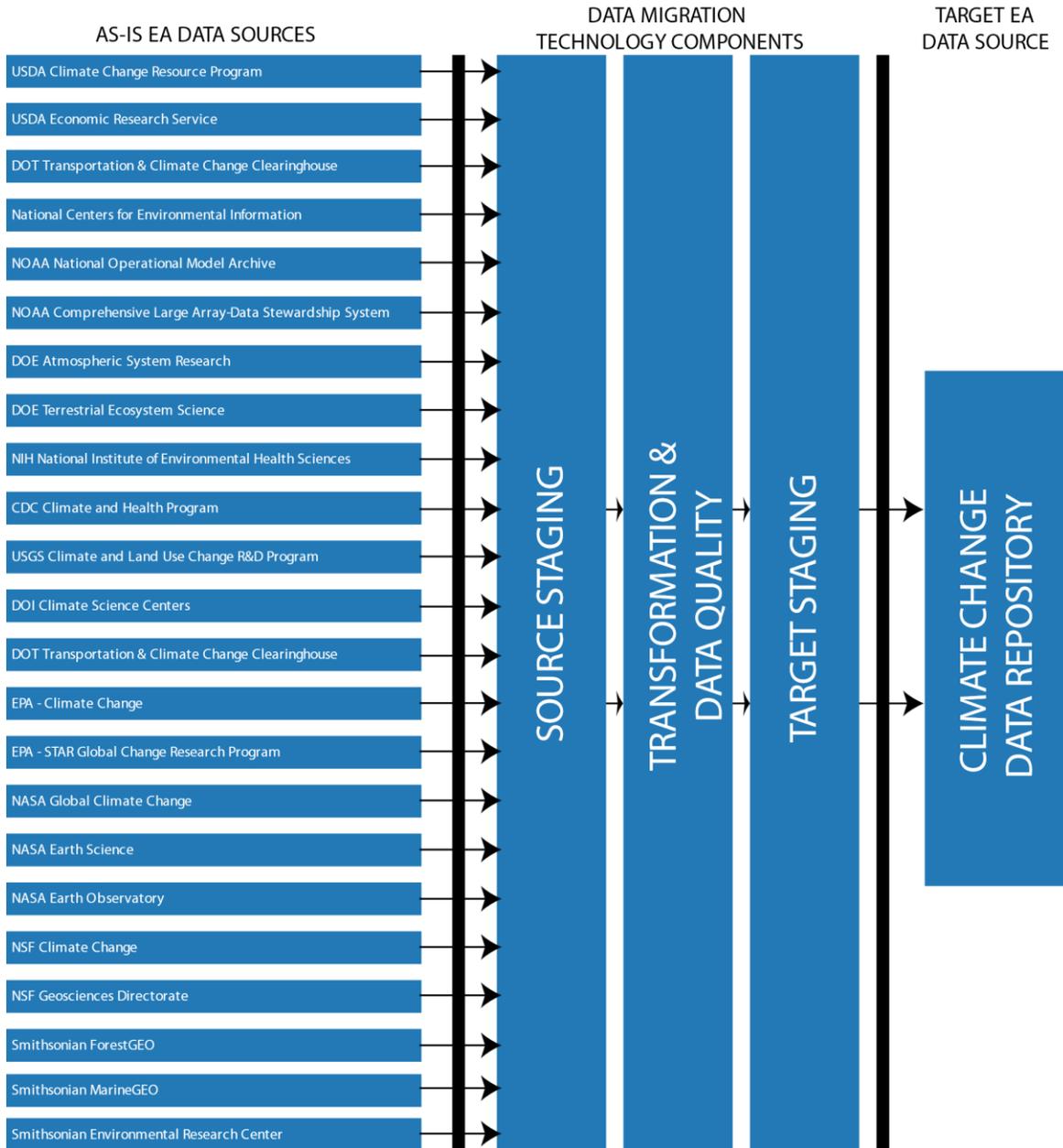
**TARGET US GOVERNMENT CLIMATE CHANGE
ENTERPRISE ARCHITECTURE CORE DIAGRAM**
(SIMPLIFIED FOR READABILITY)



Appendix C: Data Migration Diagram

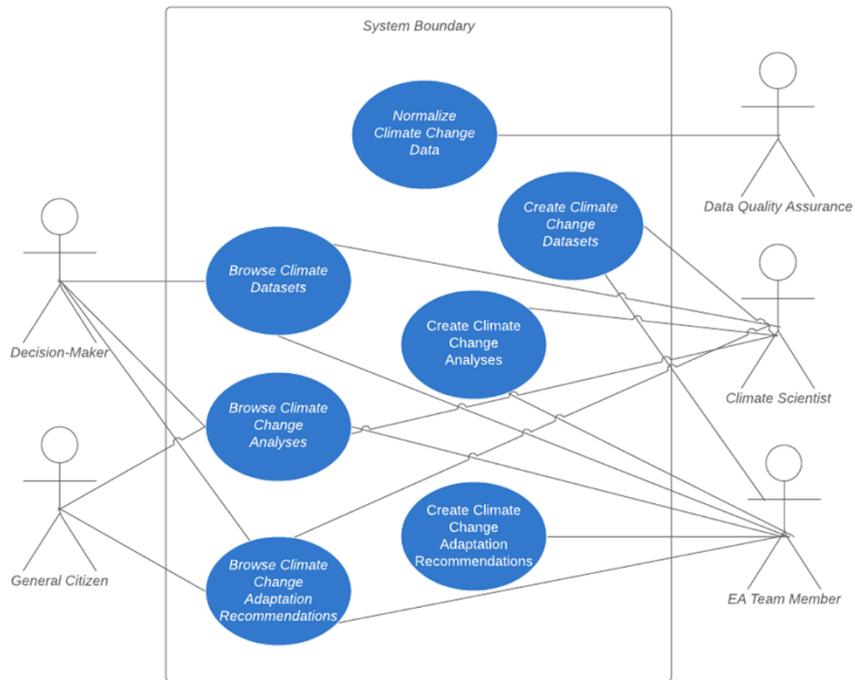
CLIMATE CHANGE ENTERPRISE ARCHITECTURE DATA MIGRATION DIAGRAM

NOTE: The list of data sources may change after the initial architecture assessment.



Appendix D: Enterprise Architecture Web Portal Use Case Diagram

CLIMATE CHANGE ENTERPRISE ARCHITECTURE WEB PORTAL USE CASE DIAGRAM



Appendix E: Environments and Locations Diagram

CLIMATE CHANGE ENTERPRISE ARCHITECTURE ENVIRONMENTS AND LOCATIONS DIAGRAM

