Cloud Migrations – Lessons Learned

Cloud Migration Case Studies from Representative Government Agencies

Cloud Migration Working Group

Released: January 24, 2018

Synopsis

This white paper discusses representative case studies from Federal Government agencies and organizations detailing their mission objectives and lessons learned as they moved all or part of their infrastructure and computing needs into hosted and managed cloud service providers.

These case studies cover a broad set of usage models that include Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). They range from data center lift-and-shift endeavors to remote applications and Office 365 migrations.

The case studies in this white paper provide a set of lessons-learned that can be used by Government stakeholders as they plan their cloud migration strategies. These are real-world examples that illustrate in deed and form a topic that is often discussed in abstract terms.

Readers will find information in these case studies that can assist them with cloud migration efforts. This paper provides names and resources that can offer transition guidance and mitigate the risks of cloud adoption.

The choices of vendors and solutions made by represented Government agencies and organizations are based on program-specific selection criteria. The Cloud Migration Working Group respects the independence of these choices and does not itself advocate any one vendor or solution over another.

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Advancing Government Through Education, Leadership, and Collaboration

American Council for Technology-Industry Advisory Council (ACT-IAC)

The American Council for Technology (ACT) is a non-profit educational organization established to create a more effective and innovative government. ACT-IAC provides a unique, objective, and trusted forum where government and industry executives are working together to improve public services and agency operations through the use of technology. ACT-IAC contributes to better communication between government and industry, collaborative and innovative problem solving, and a more professional and qualified workforce.

The information, conclusions, and recommendations contained in this publication were produced by volunteers from government and industry who share the ACT-IAC vision of a more effective and innovative government. ACT-IAC volunteers represent a wide diversity of organizations (public and private) and functions. These volunteers use the ACT-IAC collaborative process, refined over thirty years of experience, to produce outcomes that are consensus-based. The findings and recommendations contained in this report are based on consensus and do not represent the views of any particular individual or organization.

To maintain the objectivity and integrity of its collaborative process, ACT-IAC does not accept government funding.

ACT-IAC welcomes the participation of all public and private organizations committed to improving the delivery of public services through the effective and efficient use of IT. For additional information, visit the ACT-IAC website at www.actiac.org.

Cloud Working Group

The ACT-IAC Cloud Working Group mission is to collaborate with Federal CXOs and other government executives responsible for assessing, acquiring, deploying and maturing cloud technologies to become a major component of their IT and business strategy. The Cloud Working Group leverages the expertise of the IT community to support the Government's cloud computing initiatives.

Disclaimer

This document has been prepared to contribute to a more effective, efficient, and innovative government. The information contained in this report is the result of a collaborative process in which a number of individuals participated. This document does not – nor is it intended to – endorse or recommend any specific technology, product, or vendor. Moreover, the views expressed in this document do not necessarily represent the official views of the individuals and organizations that participated in its development. Every effort has been made to present

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Further Information

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Introduction and Executive Summary

Despite the widespread and almost universal civilian and commercial adoption of the cloud as the essential infrastructure of a global and mobile world, introducing the cloud into federal government agencies remains a challenge. The act of signing up for a Gmail or Office 365 account is a process taking only a few minutes. Signing up for cloud services and creating a virtual server or web site is easy thanks to the portals and services offered by cloud service providers (CSPs). With these transitions, the worries of size, weight, power, cooling, backups, continuity, and elasticity vanish with the quick entry of a credit card and the ease of service and server deployment. To be sure, the revolution is over and in today's connected world, the cloud has moved from novelty to necessity and has become transparent as it pervades both individuals and infrastructure.

In the government world, things are not quite as smooth and easy. The mission needs of government are unique and vertical. Differing user-bases have unique requirements that are bounded by security, internal connectivity, legacy applications, specific authentication needs, auditing mandates, training concerns, and privacy regulations. Significant foresight and planning is required for any government cloud transition. There are often many roadblocks – some are based on policy and process, others on fear and perception. While FedRAMP[1] and FISMA[2] provide a great framework, the overall process from inception to the final Authority to Operate (ATO) can be daunting, even to the most seasoned CIO and CTO. Where do I start? How do I manage the process? What services do I need? How will I staff and manage this new environment? These, and many others, are the questions that keep Government cloud strategists awake at night.

The former ACT-IAC Cloud Community of Interest (COI) recognized these challenges and appreciate the tasks that are required for a successful cloud migration. To address these needs and challenges, the Cloud COI formed the Cloud Migration Working Group with leaders from government and industry that have first-hand experience in managing cloud transitions. The working group captured various case studies of successful cloud migration implementations and presented some of these at the 2017 ACT-IAC Management of Change (MOC) conference.[3] Members of the ACT-IAC IT Management and Modernization COI participated in both the MOC presentation and in the production of this paper.

The Cloud Migration Working Group reached out to government members of ACT-IAC soliciting case studies for the MOC conference. The requests were presented as a single presentation slide format capturing the mission need, the solution, the outcomes, and the lessons learned by each

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respective government agency. The working group then selected six case studies for inclusion in the MOC conference brief based on the maturity of the information.

After MOC, additional case studies were developed resulting in the overall set presented in this paper. These case studies give government and industry leaders a set of templates that match in whole or in part the mission needs of ongoing and future government cloud migration efforts.

The case studies include objectives, solutions, and lessons learned for various government agencies and organizations. When possible, resources were included for consultation and guidance as the move of federal space from internal server implementation to the reliability and accessibility that the cloud provides.

Recommended Guidance

It is recommended that you read these case studies and match them with the requirements matching your organization's mission needs. The following template will help in assessing specific situations:

1. What is my overall mission and how can a cloud implementation better help me meet my mission needs?

2. Who are my users? How will they access a cloud-based system and who will administer it?

3. What is my current capital and operational budget? How much additional budget will I need during a transition (i.e., before the legacy implementation is retired)?

4. What are my security requirements and what type of ATO will I need to become operational?

5. Who are my stakeholders? This includes management, peer agencies, funding sources, and oversight committees.

6. How will I manage change? What communication plan will I need to announce my planned cloud migration? What is the frequency and means of regular progress updates during the transition?

7. What type of training will I need? This is not only user training, but training (and retraining) system administrators who will now need to manage a cloud-based environment versus an on-premises implementation.

8. What is my transition's level of granularity? Am I just shifting servers to the cloud or spending the additional time investigating Platform-as-a-Service options?

9. What is the scope of my transition plan? Do I need to migrate thousands of users from an internal Exchange server to a cloud-based directory? How will this be managed?

10. Do I need to consider hybrid implementation? Is part of my infrastructure mandated to still be on-premises? Do I need to consider hybrid storage and application environments?

11. In application migration scenarios (i.e., moving applications from on-premises to a cloud provider), how can I reduce the time required for data transfer, which is a critical component to any cutover period? Are there network latency considerations between my source and target cloud provider that must be accounted for?

12. What is the impact to my non-production systems? How will these environments be segregated from production in the cloud?

13. What impacts are there to my interface partners? Who will be responsible for defining communication protocols, new addresses, routes, and inbound and outbound ports to be used among applications and systems once we are in the cloud?

14. Are there any host names or IP addresses may be static in existing software or system configuration files? How can I ensure they are part of the migration and test planning?

15. What are the long-term cost implications? Moving to the cloud is not a guaranteed cost-saving endeavor. What are the increased operational costs that involve development, consumption, licensing, training, and staffing that could offset the localized savings?

Case Study Taxonomy

The cloud migration case studies have been categorized using a taxonomy that orients the efforts along service categories, solution categories, and service providers. Service categories define the amount of responsibility relegated to the cloud service provider. Solution categories identify the nature of the work being performed. The service providers specify the vendor or vendors selected for solution hosting.

Service Categories

Cloud service providers offer varying levels of operational support. They vary in the type and number of resources managed by the customer versus those managed by the service provider. Table 1 compares the resources that are managed by the customer, agency, or organization against those managed by the service provider for each service category.

Table 1 - Cloud Service Providers (CSP) service categories and operational support models

On Premises	Infrastructure-as-a-Service (IaaS)	Platform-as-a-Service (PaaS)	Software-as-a-Service (SaaS)
Applications	Applications	Applications	*Applications*
Data	Data	Data	*Data*
Runtime	Runtime	*Runtime*	*Runtime*
Middleware	Middleware	*Middleware*	*Middleware*
Operating System	Operating System	*Operating System*	*Operating System*
Virtualization	*Virtualization*	*Virtualization*	*Virtualization*
Servers	*Servers*	*Servers*	*Servers*
Storage	*Storage*	*Storage*	*Storage*
Networking	*Networking*	*Networking*	*Networking*

Legend (shading key):

Managed by the Customer/Agency/Organization	*Managed by the Cloud Service Provider*

On the left is the non-cloud (on-premises) solution where the customer manages all physical and computing resources. From there the number of resources managed by the cloud service provider increases from the left to the right.

In canvasing these cloud migration case studies, the project team found that most are either in the Infrastructure as a Service (IaaS) or Software as a Service (SaaS) category. The IaaS service category represents the typical "lift and shift" scenario when virtualizing a data center. The SaaS service category is typified by the move to an Office 365 environment. The PaaS category is the middle ground where, for example, instead of purchasing licenses for and installing SQL Server and IIS, the customer takes advantage of these being offered as services. PaaS usually results in lower cost for commodity software over the IaaS model, both in terms of up-front acquisition and installation costs as well as operational administrative and licensing costs.

As a note of completeness, there exists a fourth category called "Anything-as-a-Service," often abbreviated XaaS. This term recognizes that network, storage, and other system components can be offered as services including containers and serverless deployment models.

Solution Categories

While the service categories are a widely-accepted industry reference framework, this paper further disambiguates the case studies by identifying common solution categories that qualify each case study in terms of the primary problem being addressed or design aspect being implemented.

Table 2 lists these solution categories along with their abbreviation and description. The abbreviation is used in the profile for each cloud migration case study.

Table 2 - Solution categories for different use-cases

Solution Category	Abbreviation	Description
Applications-to-Cloud	ATC	Migrating or modernizing existing applications into a cloud environment. This may involve application modifications for hosting or a complete rewrite of an existing application. In contrast to SaaS, this category usually refers to custom applications.
Data Center Consolidation	DCC	Transforming a typical on-premises hardware configuration into a virtualized server environment. Often synonymous with IaaS, it involves the migration of both hardware and software. The customer is using the cloud instead of their own data center(s).
Hybrid System Design	HSD	Creating a system topology that exists both in the cloud and on-premises. Often associated with multi-location storage, it involves the sharing of assets and services between a cloud model and the system elements remaining on-premises.
Micro-Service Architecture	MSA	The primary output of the cloud migration is making data and services accessible as cloud endpoints. These are frequently agency-specific data sets or services unique to an organization. For example, elastic search over public drug adverse interaction data.
Virtual Consumer Applications	VCA	Taking applications typically installed on the desktop and migrating users to a cloud-based model of those same applications. The canonical example is moving an organization from installed Microsoft Office products to an Office 365 implementation.
User Experience Assessment	UXA	Studies and analysis that discover how users perceive, or will perceive, the migration of systems and services to the cloud. This can include not only end-users, but the administrative and support staff required to manage a cloud-based implementation.

Deployment Models

The National Institutes of Standards and Technology (NIST) publication *The NIST Definition of Cloud Computing[4]*, defines four different deployment models for cloud implementations. They are repeated in Table 3, verbatim, from the NIST publication:

Table 3 - Deployment Models for Cloud Implementation

Model	Description
Private Cloud	The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.
Community Cloud	The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.
Public Cloud	The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.
Hybrid Cloud	The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

An example of an off premises private cloud is the FBI data center in Pocatello, Idaho. Both the Amazon Web Services (AWS) GovCloud and Microsoft's Azure Government are examples of community clouds. The AWS C2S cloud, although "private", is also a community cloud serving the intelligence community.

Case Studies

Each case study is presented in a one- or two-page format. If printing this document double-sided, each case study can be a "tear off" sheet for ease of use. Each case study is detailed using the following template:

Case Study Title	
Logo Image	Description and mission of the agency or organization.
Case Study Profile:	Service and solution category and the cloud service provider.
Agency or Organization:	The name of the agency or organization.
Mission Need Statement:	What mission need is satisfied by migrating to the cloud?
Purpose or Desired Result:	The overall goals and success criteria of the migration.
Objectives:	What are the overall resulting benefits to the agency, organization, users, and stakeholders?
Solution:	What was done to achieve the desired results and accomplish the objectives?
Outcomes:	What measurable results were obtained by the cloud migration? These include cost factors, reliability improvements, increased accessibility, performance upgrades, and meeting mandated mission objectives.
Lessons Learned:	What are the overall takeaways from this effort? What was learned by the agency or organization? These include unanticipated cost and schedule issues as well as items that others should plan for when undertaking a similarly-scoped migration.
Resources / POCs:	Names and email addresses of government and industry points of contact. Also, URLs of web pages or other resources that can be referenced.

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U.S. Nuclear Regulatory Commission Financial Management System Modernization

U.S. NRC — United States Nuclear Regulatory Commission — *Protecting People and the Environment*	The U.S. Nuclear Regulatory Commission (NRC) was created as an independent agency by Congress in 1974 to ensure the safe use of radioactive materials for beneficial civilian purposes while protecting people and the environment. The NRC regulates commercial nuclear power plants and other uses of nuclear materials, such as in nuclear medicine, through licensing, inspection and enforcement of its requirements.[5]
Case Study Profile:	Service: IaaS | Solution: ATC | Provider: Azure
Agency or Organization:	U.S. Nuclear Regulatory Commission
Mission Need Statement:	Migrate to a FedRAMP cloud environment to support the agency and OMB initiatives of "Cloud First".
Purpose or Desired Result:	Reduce OPEX associated with the core financial system, help align with their AIM2020 initiative, and leverage FedRAMP to meet NIST 800-53 rev 4 requirements.
Objectives:	Migrate Momentum Core Financial System (FAIMIS) from the CGI Momentum Community Cloud to Microsoft Azure's Government Cloud. Also, provide a reliable and secure hosting environment with significantly lower operational cost and enhanced security/technical requirements.
Solution:	NRC developed and deployed a cloud solution using Microsoft Azure and CGI's Unify360 Framework for NRC FAIMIS. They then integrated with the Azure Government Cloud, Oracle Enterprise Edition, and the Barracuda VPN. Finally, NRC migrated the entire application, including all users, and performed a thorough security assessment through NRC 3CPAO, leveraging Azure FedRAMP JAB ATO.
Outcomes:	• This was the first major NRC application to be hosted in a CSP FedRAMP Cloud. It became a showcase app for CGI and Microsoft demonstrating the Federal capabilities of the Microsoft Azure cloud and Momentum.

	• The operational costs were reduced by 30% per month for hosting services. • It resulted in an improved disaster recovery solution with improved recovery times. It also improved the FAIMIS application architecture, infrastructure, and performance while significantly reducing costs. • The solution met the agency's strategic objective of migrating and modernizing systems to operate in a cloud environment.
Lessons Learned:	• Government and Industry should consider application and third-party integration licenses, whether they are cloud enabled and supported, prior to designing a solution. • Translate the agency's desired technical and security requirements to meet the Cloud/CSPs capabilities. Not always a simple "lift and shift", but consider limitations/constraints of the overall CSPs service catalog. • FedRAMP P-ATO helps but spend adequate time to perform a gap analysis between security requirements inherited from FedRAMP to what is required by the agency. • Effectively manage infrastructure up-time to reduce CSP costs.
Resources / POCs:	Candice Ling candice.ling@cgifederal.com Linnea Walker linnea.walker@cgifederal.com Vishal Ranjan vishal.ranjan@cgifederal.com

U.S. Department of Agriculture, Economic Research Services (Pilot Program)

	The mission of USDA's Economic Research Service is to anticipate trends and emerging issues in agriculture, food, the environment, and rural America and to conduct high-quality, objective economic research to inform and enhance public and private decision making.[6]
Case Study Profile:	Service: IaaS/PaaS | Solution: ATC, HSD | Provider: Azure, AWS
Agency or Organization:	U.S. Department of Agriculture, Economic Research Services (ERS)
Mission Need Statement:	Enhance the flexibility and scalability of research operations by migrating them into the cloud and reduce the reliance on aging in-house infrastructure that is expensive to maintain and has little room left for growth.
Purpose or Desired Result:	Reduce costs, improve ERS work efficiency, and provide more innovative tool sets to support research analysis and operations.
Objectives:	Understand business needs and priorities to help design solutions to aid in infrastructure modernization and enhancing flexibility for research operations. Deploy Microsoft Remote Apps in the cloud that provided an easy desktop based access to computation software in the cloud. Deploy file shares in the cloud that allows data to be directly accessed for computation.
Solution:	ERS developed and deployed a cloud pilot solution using Microsoft Azure & Amazon AWS Cloud Platform. They then used the remote applications infrastructure, file shares, and SQL databases to provide a scalable platform for supporting research analytic operations. Finally, they conducted pilots to validate use cases and concept of operations in the cloud.
Outcomes:	• Validated ERS research operations can be supported on a public cloud platform. • Cloud Pilot results concluded that cloud based infrastructure does significantly reduce the time needed to perform big data

	analytics (for example 1 hour in the cloud vs. 12 hours using in-house infrastructure.) • Sized the infrastructure and cloud costs for supporting all of ERS infrastructure in the cloud. • Remote application based access to the cloud significantly reduces need for purchasing high end (CPU/RAM) desktops.
Lessons Learned:	• Although pilots show cloud's promise, managing the cloud environment needs new skills and capabilities. • Cloud based governance, cost controls, operations support, and reporting is an area of focus prior to migration of production workloads. • Cloud platforms are still nascent and both MS Azure and AWS are constantly enhancing / changing their offerings which poses potential challenges for supporting production environments.
Resources / POCs:	Candice Ling candice.ling@cgifederal.com Linnea Walker linnea.walker@cgifederal.com Madaleine Hillsberg madaleine.hillsberg@cgifederal.com

U.S. Department of Agriculture, Economic Research Services (Migration Evaluation)	
	The mission of USDA's Economic Research Service is to anticipate trends and emerging issues in agriculture, food, the environment, and rural America and to conduct high-quality, objective economic research to inform and enhance public and private decision making.[7]
Case Study Profile	Service: IaaS/PaaS | Solution: ATC, HSD | Provider: Azure, AWS
Agency or Organization:	U.S. Department of Agriculture, Economic Research Services (ERS)
Mission Need Statement:	Enhance the flexibility and scalability of research operations by migrating them into the cloud and reduce the reliance on aging in-house infrastructure that is expensive to maintain and has little room left for growth.
Purpose or Desired Result:	Reduce costs, improve ERS work efficiency, and provide more innovative tool sets to support research analysis and operations.
Objectives:	Understand business needs and priorities to help design solutions to aid in infrastructure modernization and enhancing flexibility for research operations. Leverage cloud services that provide researchers with a desktop-based analytics model with full access to cloud applications and data. Create a seamless environment that integrates local desktop and storage with cloud services.
Solution:	ERS performed a rigorous gap analysis between on-site tools and cloud services. This included interviewing ERS stakeholders for data accessibility and tool needs. ERS then mapped the current business processes to cloud services and evaluated Microsoft Azure and Amazon Web Services. Based on these mappings, ERS created a pilot program and solicited formal feedback. The pilot program was executed with oversight and enterprise management.
Outcomes:	• ERS evaluated the providers and selected Microsoft Azure for their Remote Apps and the StoreSimple hybrid cloud/on-premises storage solution.

	• Organized an evaluation and analysis committee that reviewed existing requirements, identified stakeholders, and mapped mission needs to CSP capabilities. • Migrated user applications to cloud variants, which then provided researchers with a unified data environment. • ERS solicited formal feedback and cataloged the results. ERS also trained operational administrator in the use of Azure portal tools and developed additional in-house tools for cloud monitoring.
Lessons Learned:	• Not all software licenses are conducive to the cloud model and may incur higher costs. Agencies should evaluate cloud tools and services that could accomplish same function. • Managing an enterprise cloud environment (versus a single server or small agency) is not straight forward. Operations must adapt to the cloud with a new organization model, functions, processes, tools, governance, and skillsets. • CSP portals that provide economic benefit may not be familiar to existing administrative staff and processes. • Although CSP portals provide good functions, be prepared to leverage the CSP's API for a full range of services. • Work with the CSP to apply an existing governance model. Improper mapping could greatly increase cost. • Continuously monitor app performance in the cloud.
Resources / POCs:	Chris O'Donnell chris.odonnell@ocio.usda.gov Man Seth mansinghseth@gmail.com

ATF O365 Migration and Operations

<table>
<tr>
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<td>ATF is a law enforcement agency in the United States' Department of Justice that protects our communities from violent criminals, criminal organizations, the illegal use and trafficking of firearms, the illegal use and storage of explosives, acts of arson and bombings, acts of terrorism, and the illegal diversion of alcohol and tobacco products. We partner with communities, industries, law enforcement, and public safety agencies to safeguard the public we serve through information sharing, training, research, and use of technology.[8]</td>
</tr>
<tr>
<td>Case Study Profile</td>
<td>Service: SaaS | Solution: ATC | Provider: Azure</td>
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<tr>
<td>Agency or Organization:</td>
<td>Bureau of Alcohol, Tobacco, Firearms, and Explosives</td>
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<tr>
<td>Mission Need Statement:</td>
<td>Establish a Cloud based "evergreen" 5GB exchange boxes, SharePoint, and Lync As-a-Service model.</td>
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<tr>
<td>Purpose or Desired Result:</td>
<td>Create a cloud based solution that provide scalable, secure cost-effective environment for collaboration and data sharing.</td>
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<tr>
<td>Objectives:</td>
<td>Establish the next generation mission support and collaboration environment.</td>
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<tr>
<td>Solution:</td>
<td>

In 2012:

- Moved ATF legacy Exchange environment into Microsoft hosted dedicated ITAR compliant BPOS (O365) Services (Exchange, SharePoint and Lync).

- Leveraged existing DOJ ELA contract and modified it to incorporate BPOS.

- Conducted lengthy executive, legal, and procurement reviews.

- Operated in two Microsoft data centers with full replication and failover.

In 2017:

- Moving to VNext (O365 Defense) "more evergreen/ FedRAMP" with 100GB Exchange, unlimited archive,

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</table>

	SharePoint, Skype for Business, 1TB OneDrive, PIV, telephony and unified messaging, and ExpressRoute. • Operate Hot/Load balanced across 4 Microsoft data centers with two copies in each data center.
Outcomes:	• Provided ATF with an "evergreen" collaboration environment that directly support mission needs which saves the Bureau approximately $1M per year. • eDiscovery is much easier and quicker for all email traffic. • Began the integration of document management policies • Accelerated platform and software innovation • Greater security, eliminated downtime, greatly reduced outages, and provided unified support.
Lessons Learned:	• It is absolutely crucial to clean up the Active Directory (AD) first. • If there are any shared folders, close them out or plan to migrate them to SharePoint. • Obtain senior management support. • Users should be trained often, frequently, and regularly. • Partner early and often with CSP.
Resources / POCs:	Walter Bigelow walter.bigelow@usdoj.gov Herbert Cares herbert.l.cares.jr@usdoj.gov

ATF Mission Application Migration to the Cloud

	ATF is a law enforcement agency in the United States' Department of Justice that protects our communities from violent criminals, criminal organizations, the illegal use and trafficking of firearms, the illegal use and storage of explosives, acts of arson and bombings, acts of terrorism, and the illegal diversion of alcohol and tobacco products. We partner with communities, industries, law enforcement, and public safety agencies to safeguard the public we serve through information sharing, training, research, and use of technology.[9]
Case Study Profile	Service: IaaS | Solution: ATC, DCC, HSD | Provider: AWS
Agency or Organization:	Bureau of Alcohol, Tobacco, Firearms, and Explosives
Mission Need Statement:	Establish a Cloud based infrastructure for DR and Production environments in an as-a-service model.
Purpose or Desired Result:	Create a cloud based solution to provide a scalable, secure, cost effective environment for mission apps and data, and allow ATF to close their physical data center.
Objectives:	Establish the next generation mission application environment for ATF.
Solution:	ATF built a hybrid (public/private) cloud solution to provide public compute (GovCloud) and private storage (NetApp) to deliver disaster recovery based infrastructure for mission applications. They linked public compute to private storage via AWS Direct Connect and created a DR site by migrating ATF mission applications and data to hybrid cloud and refactored or modernized non-cloud ready applications. Once the DR site was operational, ATF started replicating AWS servers and copied systems to AWS GovCloud. They will then establish a presence in AWS East and established an AWS Direct Connect to a second private storage cloud. ATF implemented failover to the GovCloud DR site making it production and designates AWS East as the DR. Finally, they are on track to close the ATF physical data center Q4 FY2018.

Outcomes:	• Provide ATF a hybrid cloud environment for DR and Production infrastructure operations. • Deployed physical architecture for entire environment – commercial datacenter + JUTNET + FISMA high + directed connect to AWS managed in a FedRAMP-managed services operations environment. • Developed target environments in AWS to migrate all 51 mission applications. • Initiated migration, refactoring, and modernization activities with a target completion and data center closing of September 2018.
Lessons Learned:	A very successful mission system cloud migration focuses on the following: • **DR vs. Production**: Start with establishing Application Disaster Recovery (DR) in the Cloud. • **Data vs. Applications**: De-couple data from the applications to create data replication and security in the cloud based data to cloud compute resources. • **Replication vs. Rebuilding**: Leverage DR cloud images to build cloud based Production environment.
Resources / POCs:	Walter Bigelow walter.bigelow@usdoj.gov Herbert Cares herbert.l.cares.jr@usdoj.gov

National Archives and Records Administration (NARA) Electronic Records Archives (ERA) 2.0

	NARA is building ERA to fulfill its mission in the digital age: to safeguard and preserve the records of our government, ensure that the people can discover, use, and learn from this documentary heritage, and ensure continuing access to the essential documentation of the rights of American citizens and the actions of their government.[10]
Case Study Profile	Service: IaaS | Solution: ATC | Provider: AWS
Agency or Organization:	National Archives and Records Administration (NARA) – Electronic Records Archives
Mission Need Statement:	Improve efficiencies for archivists to perform their work: receive increasingly large transfers of electronic records from agencies, process them, preserve them, and make them available to the public.
Purpose or Desired Result:	Refactor the Electronic Records Archive (ERA) system to enhance its modularity, flexibility and scalability by collaboratively developing the application in the cloud using an Agile process, enabling inclusive participation across the NARA Enterprise.
Objectives:	Design a system architecture for substantial volumes of data and a wide variety of data formats of electronic records. Create an extensible architecture to integrate/subsume disparate legacy systems and meet diverse customer needs for the archival processing and preservation of records.
Solution:	ERA focused on "data-at-rest" by bringing applications to the data in the cloud, instead of the other way around. They also made use of cloud services to accelerate custom software development. They took advantage of the availability of on-demand computing resources and storage for scalability and extensibility. This resulted in an architecture that minimized vendor lock-in.
Outcomes:	• Five Pilot versions have been released to date; production release is expected in 2018.

	• Frequent demonstrations of the application to the broad NARA community on a 4-week Agile iteration schedule; integrating their feedback into future development iterations has led to a high degree of engagement from users across the country. • Iterating on the development strategy, architecture, and governance process has resulted in the development of a roadmap to subsume legacy systems. • ERA 2.0 has been the model for increased adoption of an Agile development methodology and cultural mindset at the agency. • Cloud-based infrastructure allows provisioning to be made in hours versus days or weeks for on-premises deployments.
Lessons Learned:	• Keep users engaged, encourage participation and feedback, and provide visibility into the development process to create user buy-in and trust. • Important to avoid cloud services that cannot be used in other environments – look for vendor agnostic services instead. • It can be challenging to provide visibility of the tasks and milestones in an Agile project to leadership when the direction of work shifts with each iteration.
Resources / POCs:	Mark Busby mark.busby@nara.gov Leslie Johnston leslie.johnston@nara.gov Hung Nguyen hung.nguyen@nara.gov

U.S. Department of State, International Organization Careers (IO Careers)

	The Bureau of International Organization Affairs (IO) is the U.S. Government's primary interlocutor with the United Nations and a host of international agencies and organizations. As such, the Bureau is charged with advancing the President's vision of robust multilateral engagement as a crucial tool in advancing U.S. national interests. U.S. multilateral engagement spans the full range of important global issues, including peace and security, nuclear nonproliferation, human rights, economic development, climate change, global health, and much more.[11]
Case Study Profile	Service: PaaS | Solution: ATC | Provider: Azure
Agency or Organization:	U.S. Department of State, Bureau of International Organization Affairs
Mission Need Statement:	Create a Monster.com-like application for posting United Nations job opportunities.
Purpose or Desired Result:	Become a clearinghouse for these jobs allowing users to search and subscribe to existing and future career opportunities.
Objectives:	Migrate an existing SharePoint application serving over 10,000 users to a modern environment capable of scaling in size, complexity, and customer reach. Develop and deploy a .NET application quickly and with fast response time for modifications and upgrades. Provide a reliable and secure hosting environment with extremely low operational cost.
Solution:	IO developed and deployed a cloud solution using Microsoft Azure Platform-as-a-Service (PaaS) capabilities. They used Azure Websites, Azure SQL, and the Azure SendGrid SMTP Azure Marketplace email service. They migrated all users and performed a thorough security vulnerability (penetration) test by a third party.
Outcomes:	• Provided the U.S. Department of State with their first cloud production application. It now serves over 20,000 users

	seeking domestic and overseas employment with the United Nations.
	• Became a showcase app for Microsoft demonstrating the Federal capabilities of the Microsoft Azure cloud.
	• Operational (non-labor) cost: approximately $130 per month.
	• Development used cloud-based tools as well such as Microsoft's Visual Studio Team Services.
	• Cloud-based infrastructure allows updates to be made in hours versus days or weeks for on-premises deployments.
Lessons Learned:	Overall, a very successful initiation into the cloud for a federal agency. Some takeaways are: • Azure offers a pay-as-you-go service with a variable amount charged each month. This is difficult for government account managers to pay vs. fixed cost. Coordinate ahead of time. • The Platform-as-a-Service model offers a significant savings over the Infrastructure lift & shift model. Consider this first. • External services (i.e., SMTP) are also offered as a PaaS model. Seek these services out rather than standing up servers for services not directly provided by the CSP.
Resources / POCs:	Jon Arbin arbinjs@state.gov Frank Hellwig frank.hellwig@buchanan-edwards.com Public Website: https://iocareers.state.gov

Federal Communications Commission (FCC) Operation "Server Lift"

	The Federal Communications Commission regulates interstate and international communications by radio, television, wire, satellite, and cable in all 50 states, the District of Columbia and U.S. territories. An independent U.S. government agency overseen by Congress, the Commission is the federal agency responsible for implementing and enforcing America's communications law and regulations.[12]
Case Study Profile	Service: IaaS | Solution: DCC | Provider: AWS and SoftLayer
Agency or Organization:	Federal Communications Commission (FCC) - All IT Systems
Mission Need Statement:	Overhaul FCC's existing legacy systems and move all physical servers to off-site commercial locations.
Purpose or Desired Result:	To update departments IT systems by utilizing commercial cloud vendor to reduce IT budget expenditures and avoid future disasters (i.e., John Oliver's show shutting down FCC website).
Objectives:	Perform a "Lift and Shift" - Migrate all 207 legacy systems to commercial cloud vendor (FCC owns 400 terabytes of data, 300 servers, 400 applications). Next, retire all old systems, servers, and applications. Then, set up commercial cloud site outside of blast zone to host and service all FCC servers, data, and apps. Determine the best method for transporting equipment and avoid excessive down time during the shift. This means backing up all systems to avoid loss of data during the shift.
Solution:	FCC migrated every physical server from current on-site Data Center in DC to off-site location hosted by commercial cloud vendor using multiple trucks/backups. Next, they retired every old server and system that was no longer supported. Finally, they rolled-out the SaaS Consumer Help Desk to the public to reduce costs.
Outcomes:	• FCC located best commercial cloud vendor for security to host FCC's servers outside of blast zone in case of disaster.

	• They went from 207 legacy systems reduced to around 100 cloud-based systems. • 200 servers, 400 apps, and 400 TB's of data were physically moved to off-site location using traditional trucks in a series of planned trips involving backups for all systems to avoid potential disasters (e.g., the truck getting into an accident). • They retired two Sun E25K's (very old servers weighing one ton each). • They reduced the rack count from 90 to 72. • They reduced on-going maintenance costs from more than 85 percent of their IT budget to now less than 50 percent of their budget.
Lessons Learned:	• Moving to the cloud freed up IT budget to take on other projects. • FCC is now poised to adopt to new cloud technologies and innovative ways of delivering data to customers now. • The thousands of inter-server cables needed to connect the 200 servers did not match the FCC network topology provided to the commercial vendor. This took more man hours to remedy than originally planned. • FCC needed to obtain more funding to mitigate rushed time-lines. • They are now on-track for the FCC to move towards 100% cloud adoption. This is former CIO David Bray's ultimate goal for the FCC.
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Small Business Administration (SBA) – Office 365 Implementation

	The U.S. Small Business Administration (SBA) was created in 1953 as an independent agency of the federal government to aid, counsel, assist and protect the interests of small business concerns, to preserve free competitive enterprise and to maintain and strengthen the overall economy of our nation.[13]
Case Study Profile	Service: IaaS, PaaS, and SaaS | Solution: ATC, DCC, HSD, VCA Provider: Azure
Agency or Organization:	Small Business Administration (SBA)
Mission Need Statement:	Realize the improvements in productivity and security, by migration of core IT services to the Azure Moderate cloud.
Purpose or Desired Result:	To radically reduce the SBA's on-premises resources to reduce costs and improve scalability. Modernize and secure communications services leveraging Office 365.
Objectives:	Migrate the primary data center VMs, recover physical space, reduce power and HVAC consumption, and to apply cost savings to the cloud services operational costs. Eliminate mail and other communications hosts, and migrate all SBA users to a cloud base AD with Microsoft Office 365. Extend the SBA domain to include both on-premises and Azure Moderate cloud. Implement modern cloud security capabilities as well as deploy DHS CDM in Azure to support on-premises as well as cloud infrastructure. Improve performance through upgraded circuits including Express Routes with Private, Public, and Microsoft peering from on-premises data center to cloud resources.
Solution:	Implement Microsoft Office 365 (O365) offers features and services to include Exchange Online, Active-Sync, Active Directory Federation Services (ADFS), Azure AD Connect, OneDrive for Business, Yammer, and Skype for Business Online. Implementation of Azure services to migrate existing on-premises VMs to Azure hosted instances into defined Virtual

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	network for security, management, production, development, and testing.
Outcomes:	• All mailboxes and IM accounts have been migrated to Office 365, resulting in more reliable access to services. • Over 200 VMs that host SharePoint and SQL server applications are currently protected in Azure and will soon be cut-over. • Implementation of mail and IM (Skype for Business) pave the way for using full feature suite of O365 without additional procurement. • Disaster recovery and Backup site is operational in a separate Azure region.
Lessons Learned:	• Worked with stakeholders from all programs/project groups to ensure their business and technology requirements, issues, and concerns were considered in meeting SBA strategic business goals. • Use of legacy clients to access O365 services created some issues. Future efforts should target client side improvements prior to or at the same time. • Service features that are not available or well supported should be either discontinued before a scheduled migration or redirected to another product or product family. • Project dependencies (upgrades to mobile devices and MDM solution) should be carefully monitored to prevent project delays. • Additional monitoring and dashboard tools have wealth of information that we need more training to fully utilize. • Identified gaps and recommendations for improvements with respect to operations, processes, and standards to ensure maintenance of SBA baseline and preparedness moving forward with target architecture.
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National Endowment for the Arts (NEA)

ART WORKS.	The National Endowment for the Arts is an independent federal agency that funds, promotes, and strengthens the creative capacity of our communities by providing all Americans with diverse opportunities for arts participation.[14]
Case Study Profile	Service: SaaS | Solution: VCA | Provider: Microsoft
Agency or Organization:	National Endowment for the Arts (NEA)
Mission Need Statement:	Evaluate future readiness in leveraging the cloud for productivity, supporting a mobile and remote workforce, and COOP/DR. to support the agency and OMB initiatives of "Cloud First."
Purpose or Desired Result:	Reduce OPEX associated by identifying ways to optimize functionality, performance, and administrative oversight. Help align with their Cloud Strategy and leverage FedRAMP to meet NIST 800-53 rev 4 requirements.
Objectives:	Leverage Office 365 capabilities for increased productivity. Identify risks and provide recommendations to implement the cloud-based grants management system and continuity of operations infrastructure using the Microsoft Azure platform.
Solution:	NEA performed a comprehensive six-week assessment using a team of diverse subject matter experts. This involved a five-step assessment process based on TekNirvana's ValueTek™ methodology for performing IT assessments. They interviewed key staff within the agency IT division and analyzed strategy, architecture, policy, and other IT artifacts. This led to an understanding of both the current state, opportunities for improvement, and a more "functional" future state.
Outcomes:	• Provided an objective current state assessment, summary of findings, "cloud-readiness" rating, and actionable recommendations in the following areas – Microsoft Exchange, SharePoint, OneDrive, File shares, Virtual Desktops, Application Migration, and IT Administration. • Documented a reference "To Be" state

	• Identified pilots to validate use cases and concept of operations in the cloud.
Lessons Learned:	• Proactive Active Directory (AD) integration is critical especially for Office 365 and Azure. • Shared Folders should be migrated to SharePoint or OneDrive. • All application and third-party integration licenses should be evaluated for "cloud compatibility" • IT Governance becomes even more important. • Have a clear understanding of your Service Catalog requirements to evaluate against the Cloud/CSPs capabilities. • Prefer a "government" version of the Cloud over "commercial" version for the same CSP. Even with a FedRAMP P-ATO, time has to be spent ensuring security requirements are met. • Current IT staff skills may not match well to managing a cloud environment. New training and/or staff may be needed.
Resources / POCs:	Tarak Modi tarak@teknirvana.com

Summary and Conclusion

The variety of cloud migrations and implementations has demonstrated that cloud enterprise government systems are here to stay and will become the commodity "norm" as more and more agencies move to the cloud. This paper covered a great cross-section of service models – from the fundamental datacenter "lift & shift" to sophisticated platform service usage in addition to migrating typical office functions to cloud-based software.

As varied as these cloud instances are, there are some common threads in the lessons learned. The following are key takeaways that have emerged from documenting the cloud migration case studies in this white paper.

Lesson 1 – Understanding the Cost Model

The license and cost model for software in the cloud can be significantly different than the on-premises version. This is especially true when dealing with dynamic scale up / scale down capabilities that the cloud offers. One approach to mitigating licensing issues for commercial products is to consider using Platform-as-a-Service. Instead of procuring individual software licenses, service usage is the cost driver (bytes of storage, operations per second, usage per day). This model could be better suited for dynamic scaling than buying as many software licenses as one might need, especially if, during times of lower use, these licenses lie dormant.

That said, when using services, it is important not to become too dependent on a unique service offered by a single CSP. A vendor lock-in of CSP services can result in the inability to either migrate to a different service provider or, in the case of hybrid architectures, migrate portions of the system on an on-premises deployment.

Assess your current environment both in terms of hardware/software and in the context of capital expenditures (CAPEX) and operational expenditures (OPEX).

Lesson 2 – Training and Administration

Managing a cloud-based implementation requires different administration skills or, at the very minimum, understanding a new CSP portal through which traditional software administration actions are performed. Having the administrative staff on-board early and ensuring that they are trained for a new environment is critical. This is especially true when migrating from a local infrastructure to Platform-as-a-Service. For example, the database administration of an on-premises SQL Server instance is quite different than administering Azure SQL (even though it is

still SQL Server under the hood). New skills, new reporting methodologies, new interfaces, and sometimes a different mindset is required when performing a cloud migration.

These training and administration challenges also extends to users. Users will find that the cloud counterpart of existing applications may behave very differently than expected. There will be challenges associated with account management and user sign-in. The help desk personnel must also be trained to understand a completely new set of user questions. Having a good training and change management plan in place should be one of the first milestones in a cloud migration effort.

Lesson 3 – Backups and Disaster Recovery

Most CSPs provide redundant operation and geographically distributed instances. The typical physical single-point-of-failure is largely mitigated by the inherent architecture and redundant services offered by CSPs. But errors do occur. In the cloud, this is often the result of human errors. For example, a storage volume being inadvertently deleted or a virtual network accidentally reconfigured.

These problems are far more likely to occur than the typical local data center disasters. This is especially true in the early phase of a cloud migration when the administrative staff is becoming familiar with the new cloud model. Understanding how cloud backups are performed, how to automate them, and how to use them to recover from unintended human errors is another critical step that should be considered early in the cloud migration plan.

Lesson 4 – Select the Correct Cloud

Understand the FedRAMP requirements and Impact Level of the proposed cloud system is one of the decision criteria when selecting a CSP. It is much easier (as noted in one case study) to obtain the Authorization to Operate (ATO) in a dedicated government FedRAMP-approved cloud than trying to secure this ATO in a commercial cloud environment. Many vendors are creating specific enclaves that are dedicated for Government use and, in some cases, for a specific department (i.e., Department of Defense). Learning about these and selecting the appropriate cloud venue can save time down the road when seeking the ATO.

This, of course, must be balanced with what support in terms of infrastructure and service is available for your application profile. Developing decision criteria along with an application and migration assessments is recommended.

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