Augmenting Space Technology Program Management with Secure Cloud & Mobile Services

Robert F. Hodson[1]
NASA Langley Research Center, Hampton, Virginia 23666

Christopher Munk[2], Adelle Helble[3], and Martin T. Press[4]
Booz Allen Hamilton, NASA Langley Research Center, Hampton, Virginia 23666

Cory George[5] and David Johnson[6]
Mori Associates Inc, NASA Johnson Space Center, Houston, Texas, 77058

Nomenclature

3D	=	Three Dimensional
ASP	=	Active Server Pages
AWS	=	Amazon Web Services
CSV	=	Comma Separated Values
GCD	=	Game Changing Development Program
EC2	=	Elastic Compute Cloud
ELT	=	Extract Load Transfer
FTE	=	Full Time Equivalent
HTTPS	=	Hyper Text Transfer Protocol Secure
IIS	=	Internet Information Services
JSC	=	Johnson Space Center
JSON	=	JavaScript Object Notation
JPL	=	Jet Propulsion Laboratory
MVC	=	Model View Controller
NASA	=	National Aeronautics and Space Administration
OS	=	Operating System
REST	=	Representational State Transfer
S3	=	Simple Scalable Storage
SSL	=	Secure Socket Layer
TRL	=	Technology Readiness Level
URL	=	Uniform Resource Locator
VPN	=	Virtual Private Network
XML	=	eXtensible Markup Language

I. Abstract

The National Aeronautics and Space Administration (NASA) Game Changing Development (GCD) program manages technology projects across all NASA centers and reports to NASA headquarters regularly on progress. Program stakeholders expect an up-to-date, accurate status and often have questions about the program's portfolio that requires a timely response. Historically, reporting, data collection, and analysis were done with manual processes

[1] Deputy Program Manager, Game Changing Development Program, NASA Langley Research Center, MS250.
[2] Senior Systems Engineer, Game Changing Development Program, NASA Langley Research Center, MS250.
[3] Senior Aerospace Engineer, Game Changing Development Program, NASA Langley Research Center, MS250.
[4] Senior Software Engineer, Strategic Innovation Group, 8283 Greensboro Drive, Herndon, MS: Hamilton 2A2031.
[5] Custom Applications Supervisor, COMIT Applications & Data Center, 2450 NASA Parkway, MS 226.
[6] System Engineer IV, COMIT Applications & Data Center, 2450 NASA Parkway, MS 226.

that were inefficient and prone to error. To address these issues, GCD set out to develop a new business automation solution. In doing this, the program wanted to leverage the latest information technology platforms and decided to utilize traditional systems along with new cloud-based web services and gaming technology for a novel and interactive user environment. The team also set out to develop a mobile solution for anytime information access. This paper discusses a solution to these challenging goals and how the GCD team succeeded in developing and deploying such a system. The architecture and approach taken has proven to be effective and robust and can serve as a model for others looking to develop secure interactive mobile business solutions for government or enterprise business automation.

II. Purpose and Need

The GCD program manages approximately 80 different technology development activities ranging in size and complexity. The program office coordinates work activities across all NASA centers, JPL, industry, and academia. Historically, the program office has used web-based file management systems to manage documents and a variety of manual processes to mine data and respond to questions about the portfolio. Questions range from detailed requests about specific technologies such as:

- When will the technologies be ready for mission infusion?
- What is the current life cycle cost for a particular technology?
- What are the advancements over the current state-of-the-art for a given technology?

Other questions are more general and/or strategic in nature:

- Where is the program focusing technology investments?
- Are there any gaps or redundancies in the investment portfolio?
- How does the portfolio of technologies change throughout program years, and what are the trends?
- How much does GCD invest in academia and industry for technology development?

Answering these types of questions typically required mining documents and formulating a response – a slow, labor intensive, and time consuming process that could also be error prone. Our stakeholders require an accurate and, in many cases, quick response to information queries and our current information systems could not readily support these needs. Requests were often similar in nature which could produce different outputs via a manual process – inconsistencies which were sometimes the result of numerous, disparate spreadsheets and files of program and project data and no common, authoritative program data source. Analysis that required weeks to perform was requested within days. The need for rapid accurate information access and efficient systems led GCD to explore new information technology paradigms and develop a robust, anywhere-anytime, mobile platform for both information dissemination and interactive query capability. In addition to these high level requirements, the solution also needed to be lightweight developmentally – leveraging commercial technologies and solutions – and secure, especially when crossing the boundary to mobile devices that may operate outside of government networks. Lastly, there was a desire for a robust solution that could easily evolve developmentally but also (hopefully) provide responses to unanticipated queries – effectively being a robust information solution.

III. Leveraging Technology

There are various technologies and platforms for building information systems. Each has its own strengths and weakness. Some focus on document management, others transactional data access, others visualization, and others workflow/process management. In selecting a solution for GCD, several factors came into consideration. First, our day-to-day activities heavily leverage Microsoft products and there was organizational experience with Sharepoint as an information system. Sharepoint provides a web-based document management solution with strong Microsoft office product alignment for Word, Excel, Power Point, Project, Visio and other Microsoft applications. It also supports customizable interface development and workflow development allowing solutions tailored specifically for GCD.

Secondly, there was a desire to leverage the billions of dollars invested in the commercial gaming industry and mobile markets, and apply resulting innovations to business solutions for GCD. We were searching for ways to better visualize our portfolio of projects, approaches that more efficiently accessed information, and a more modern user experience. We also wanted remote, anytime mobile access. The Unity gaming engine, an industry leader for multiplatform visual solutions for both desktop and mobile systems, provides 3D functionality and scripting to render and control graphically rich scenes and objects. It has support for texture compression, resolution setting, shadow maps, light sources and other features found in today's gaming systems. It also supports over 25 platforms including iOS and Windows which are essential for use at NASA. These capabilities and features made Unity a key building block in our approach.

Lastly, cloud services – or more specifically government-approved cloud services – allow for server development with a rich set of features for performance scaling, load balancing, secure storage, and data access with an attractive use-based pricing model. Government Cloud (GovCloud) services that are a subset of Amazon Web Services (AWS) have been approved by NASA and are considered a trusted, virtual private cloud resource that is accessible from other NASA internal systems. This trusted level of support makes the GovCloud services an ideal bridge that could be leveraged to tie legacy NASA systems to new cloud-based services in a scalable approach that can be used to connect a new mobile community for information access.

The combination of heritage technologies (SharePoint 2013), and emerging technologies (Unity and AWS) allowed us to architect and implement a system to meet our requirements for a secure, interactive, robust, mobile information access.

IV. Architecture Overview

At the highest level, the GCD data management architecture consists of a SharePoint collaboration system serving as a common data source (data and document repository) and mobile clients that are interconnected via cloud services. The key components and high-level information flow are depicted in Figure 1. Project managers and other project personnel input project information via SharePoint's web-based interfaces. Project inputs include both documents as well as other project data such as technology descriptions, partnering information, customer data, technology readiness level, project images, and more. The program office also uses SharePoint to manage GCD's technology portfolio. Program inputs to SharePoint include schedule data, financial data, and other program management information such as actions. SharePoint workflows are used to approve project changes and send automated notifications. A subset of all GCD project and program data stored in SharePoint is made available to the GCD mobile app. Although not the focus of the paper, SharePoint has serves as an evolvable platform for core project and program management functions.

The GCD mobile client that runs on iPhones, iPads or Window/Mac computers allows for an interactive information interface for anytime access. The applications are built on Unity providing a compelling 3D interface to access and visualize data. The cloud services perform a translation and synchronization function between SharePoint and the numerous instances of the mobile applications. An administrator interface controls synchronization and data revision management along with providing a manual upload capability that is useful for data quality checks, testing, and debugging.

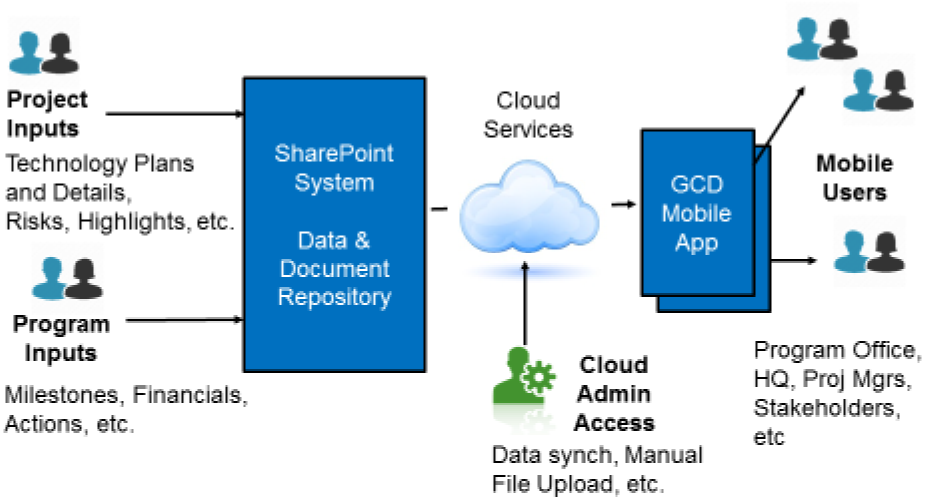

Project Inputs
Technology Plans and Details, Risks, Highlights, etc.
Program Inputs
Milestones, Financials, Actions, etc.
SharePoint System
Data & Document Repository
Cloud Services
GCD Mobile App
Mobile Users
Cloud Admin Access
Data synch, Manual File Upload, etc.
Program Office, HQ, Proj Mgrs, Stakeholders, etc

Figure 1: High level information flow.

The information processing maps onto multiple servers and the mobile app client as depicted in Figure 2. The NASA Johnson Space Center (JSC) Server hosts the SharePoint 2013 environment for web-based program/project management and collaboration. Data is stored in list and libraries, and is updated and/or uploaded via SharePoint forms. Some information such as schedule milestones are updated directly in Microsoft Project and synchronized to SharePoint via mapping to SharePoint lists. SharePoint serves as the single data source for information about the GCD projects and technologies.

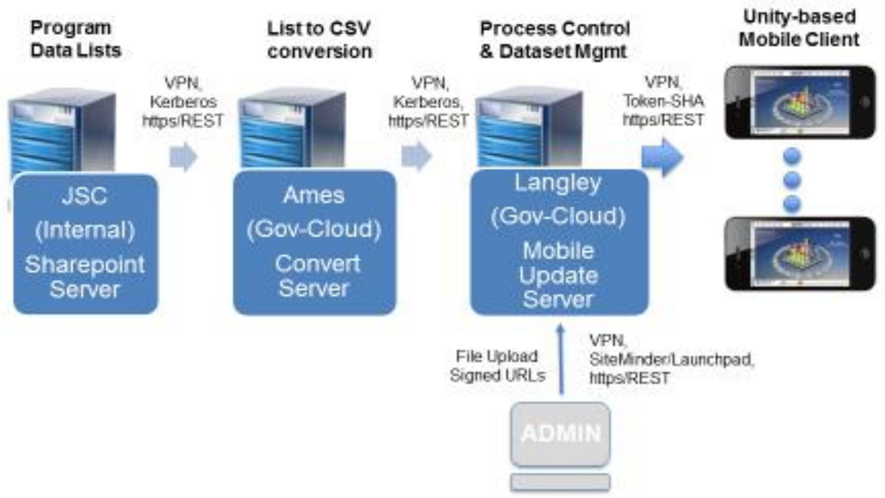

Program Data Lists
List to CSV conversion
Process Control & Dataset Mgmt
Unity-based Mobile Client
VPN, Kerberos https/REST
VPN, Kerberos, https/REST
VPN, Token-SHA https/REST
JSC (Internal) Sharepoint Server
Ames (Gov-Cloud) Convert Server
Langley (Gov-Cloud) Mobile Update Server
File Upload Signed URLs
VPN, SiteMinder/Launchpad, https/REST
ADMIN

Figure 2. GCD Application, Web Service, and Server Architecture

GCD program and project information is extracted from SharePoint and synchronized with the GCD mobile applications through two web services. These services reside in the NASA Ames Research Center and NASA Langley Research Center GovCloud which are considered Amazon Web Services approved for government use. The processing flow from initiation of the data synchronization through final file transfer are depicted in Figure 3 and described in greater detail in subsequent sections of this paper.

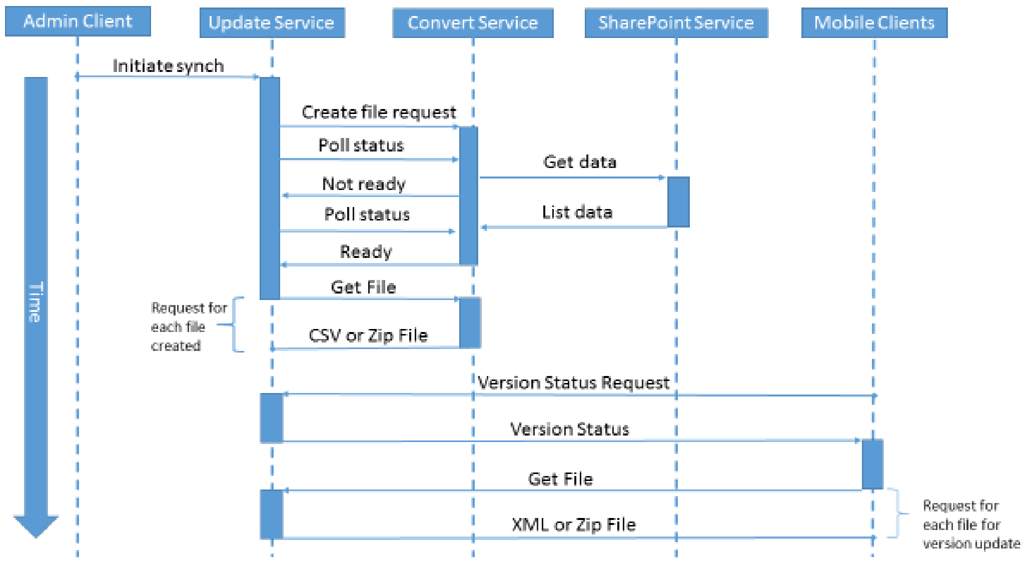


Figure 3. Data flow for mobile client data update

V. Key Functions

Each part of the architecture serves a number of key functions for the overall system. The four primary components performing key functions are SharePoint service, mobile applications, mobile update service, and convert service. The mobile applications act as the ultimate view of GCD portfolio data within the architecture. GCD stakeholders are able to use the client applications to perform daily work activities. The GCD Data Manager also uses the mobile application for data quality review. The web service and server components act as the repository, distribution, and organizational center for the mobile application data. Data is appropriately stored, tagged, and managed for proper distribution to the various mobile applications. Once stored in the web service repository, data is extracted, formatted, and transferred to mobile applications in a controlled and secure approach. The following sections provide additional detail on the key functions and components that integrate to provide an end-to-end implementation of a holistic mobile portfolio visualization and analysis solution for end users.

A. SharePoint Service

The SharePoint system implements the core document repository for GCD, along with meta-data storage, and configuration management functions. The organization of information within SharePoint is hierarchical. Information is grouped by themes; themes contain projects; and projects contain technologies and tasks. GCD elected to manage data access at the project level, although finer granularity is possible. The system also varies the view of the information, based on user permission levels. For example, a program office manager will see different data and functionality than a project manager or task lead. Thus, the data presented to each system user is filtered by role, providing the most relevant data through the simplest data representation and user interface – enhancing usability and user experience.

The SharePoint system goes beyond simple document management in several ways. The current system is designed to provide project managers with capability to share schedules, risks, and highlights with the program office. The system leverages the capability to synchronize with Microsoft Project for schedules and implements NASA’s traditional 5x5 risk matrix approach that defines likelihood and consequence for each risk. Highlights are a mechanism to report progress (or issues) to the program office. Both the Risk and Highlight management capabilities can generate consolidated reports across the tasks and technologies within the program. The system also implements workflows for office processes, such as change requests or new project initiations. Workflows allow for automated notifications and control gates to be programmed into an automated process to ensure the right steps are performed in the right order, by the right people.

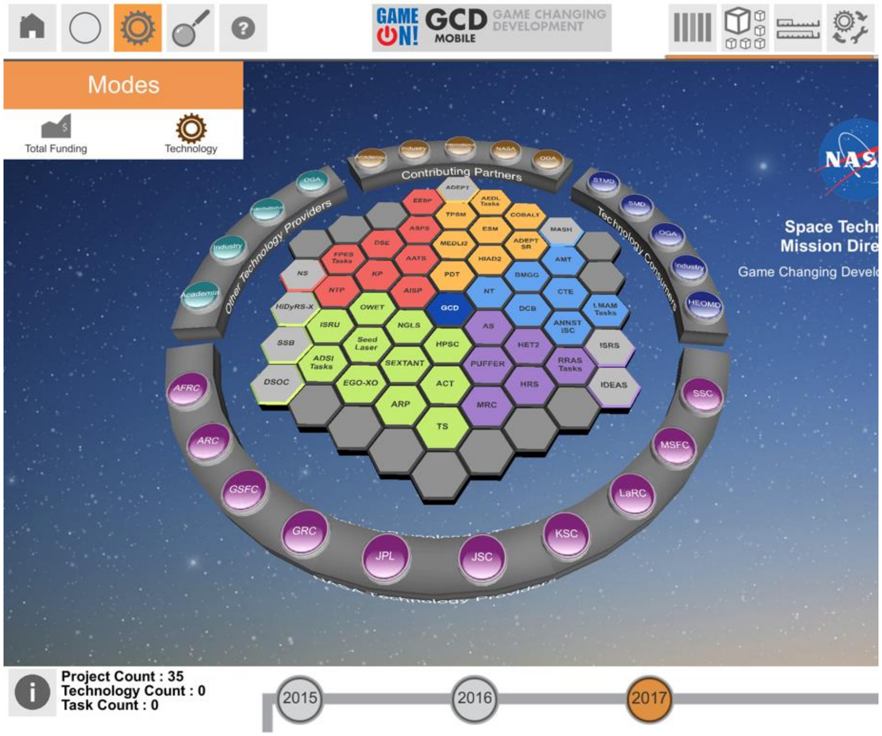
Another important feature of the SharePoint system is the capability to store meta-data with documents which allows for easy custom reporting and filtering. In addition to document meta-data, the GCD system is designed to support meta-data for projects, technologies and tasks. For example, project descriptions, Technology Readiness Level (TRL), partners, infusion paths, workforce, resources, and more are represented as attributes (meta-data) of technologies and tasks. This information allows for a variety of business questions to be answered with appropriate queries. The cloud services and mobile applications utilize the Sharepoint data as their common data source for project and program data.

B. Mobile Applications

GCD has two different portfolio-viewing mobile applications using the same data schema, with one application a subset of the other. One application, GCD Analytics, has enhanced functionality and is populated with a comprehensive dataset. The second application, GCD Mobile, contains a subset of GCD data approved for broader user distribution. These applications are currently built for three targeted platforms: MacOS X, Microsoft Windows, and Apple iOS using the Unity 3D engine for cross compilation. The mobile applications allow for quick what if analysis to be performed using a number of modes including: Technology, Funding (total and breakout), Workforce, and Milestones.

Data is displayed using a 3D game board analogy within the application, as shown in Figure 4. GCD projects are placed on a hexagonal grid and colored by common themes. By touching (or clicking) a hex tile on the board, information about the project is displayed and links to additional technology details are provided. The rings and associated buttons around the board are high level filters based upon categories of producers and consumers of GCD technologies. GCD Project data can be filtered by Technology Providers (NASA Centers, Industry, Academia, Other Government Agencies, etc.), Contributing Partners, and Technology Consumers (including NASA Mission Directorates) using these filters. Additional second tier filters are provided in two-dimensional space along the top of the app interface and are accessed by touching (or clicking) the icons. The complex filtering system allows for over a billion filtering combinations to exist within the data displayed within the client applications. This rich set of filters includes:

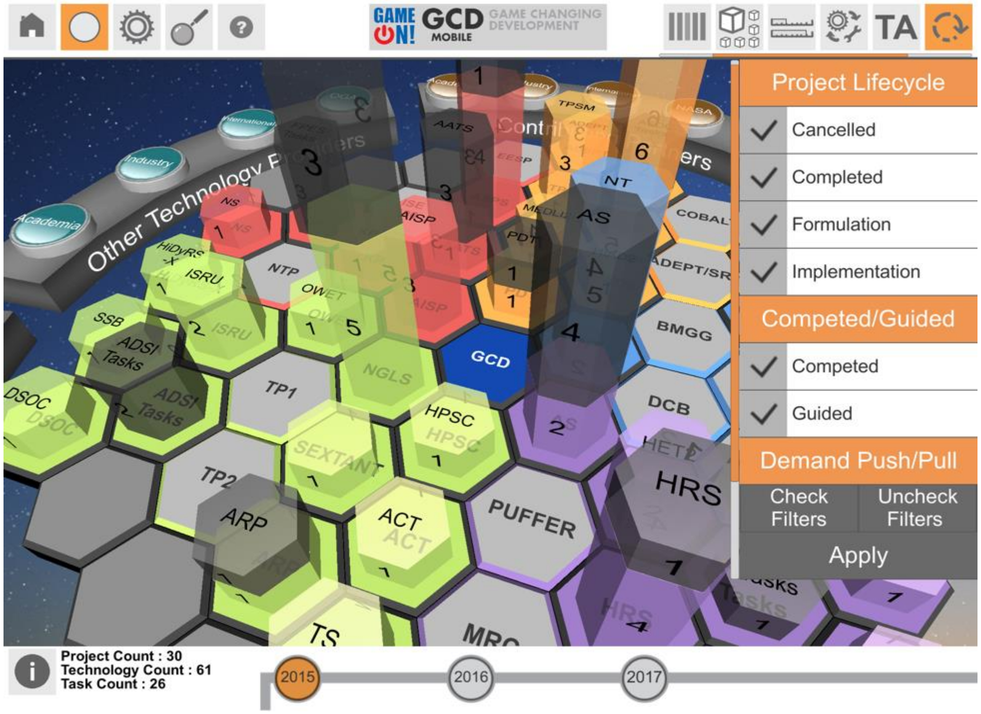
- Lead and Supporting Centers
- Technology Readiness Level
- Technology or Task Classification
- NASA Technology Roadmap
- Project Life Cycle
- Industry or Academic Partnerships
- NASA/Industry or Other Government Agency Programs
- States with Work
- Technology Thematic Area
- Competed or Guided
- Demand – Push versus Pull Technologies



Project Count : 35
Technology Count : 0
Task Count : 0

Figure 4 GCD Mobile Application "Game board"

When filters are applied or when the game board is set to one of its functional modes, GCD technologies and tasks are displayed as 3D hexagons placed on top of corresponding project tiles to create a 3D stack, as shown in Figure 5. Project technologies visually represented as 3D stacks on a hex tile. This allows users to easily see aggregate project data and trends of the overall portfolio at once. Users can modify the filters to be applied in order to change the visualization, which will then be updated in real-time according to the scenario selected by the user. In addition to just applying filters, users can look at the results across different fiscal years by using the fiscal year filters on the timeline at the bottom of the application's display. Users are able to quickly compare the currently selected filters across any of the years the application has stored. This lets the users examine year to year trends in a compelling 3D visualization. GCD refers to this capability as *scenario-based visualization* – enabling each app user to find answers to their questions about the GCD technology portfolio based upon their area of interest by selecting a scenario of filters to be applied and instantaneously visualizing the results. This is a great enhancement over previous portfolio analysis techniques which were based primarily on pre-defined charts and diagrams to be populated and inspected at regular intervals. Finally, navigation around the GCD Mobile app game board and up/down/through the stacks, such as zooming in/out, rotating, panning, etc., as well as selecting filters and buttons are accomplished through natural touch gestures to which users are now accustomed for mobile apps and touch screen devices.



Project Lifecycle
- ☑ Cancelled
- ☑ Completed
- ☑ Formulation
- ☑ Implementation

Competed/Guided
- ☑ Competed
- ☑ Guided

Demand Push/Pull

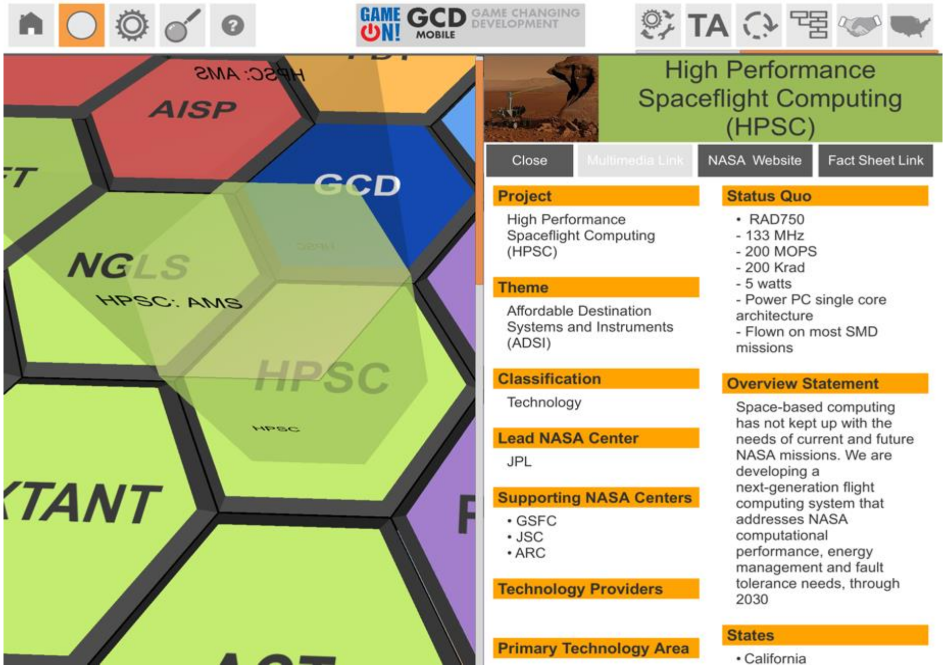
Check Filters | Uncheck Filters | Apply

Project Count : 30
Technology Count : 61
Task Count : 26

Figure 5. Project technologies visually represented as 3D stacks on a hex tile.

Details of every GCD technology development effort are stored and accessible through the mobile application, even when the device running the app is not connected to a network. Touching (or clicking) tiles or stacks brings ups key information about the activity. The information is displayed on what is called a “baseball card” as it contains the “vital statistics” for the project. Figure 6 (on the right side) shows a technology baseball card. The card is scrollable and contains the following information:

- Project Name
- Technology or Task Name
- Technology Overview
- Lead/Supporting Centers
- Technology Readiness Level
- Points of Contact
- Contributing Partners
- Funding Levels
- Milestones
- Status Quo (description of currents state of the art)
- Technology Providers
- Start and End Dates of development
- Primary NASA Technology Roadmap
- Industry or Academic Partnerships
- States where work is being performed
- Technology Consumers
- End Item Deliverables
- Pertinent Web Links



High Performance Spaceflight Computing (HPSC)

Project
High Performance Spaceflight Computing (HPSC)

Theme
Affordable Destination Systems and Instruments (ADSI)

Classification
Technology

Lead NASA Center
JPL

Supporting NASA Centers
- GSFC
- JSC
- ARC

Technology Providers

Primary Technology Area

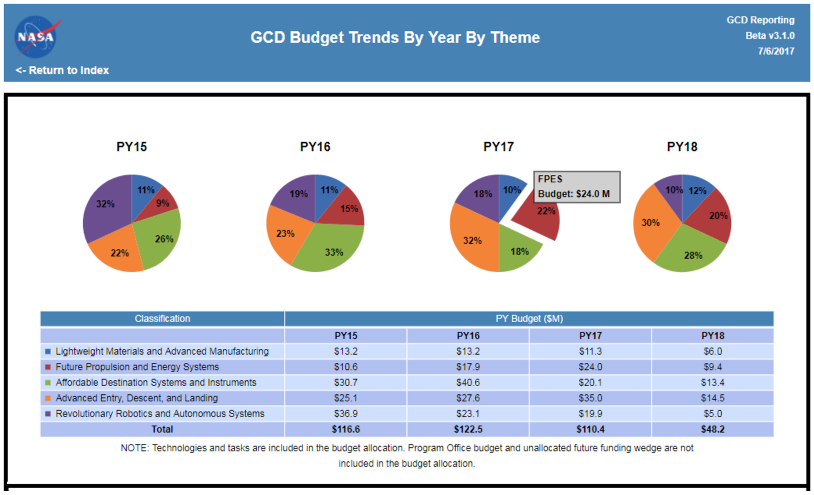
Status Quo
- RAD750
- 133 MHz
- 200 MOPS
- 200 Krad
- 5 watts
- Power PC single core architecture
- Flown on most SMD missions

Overview Statement
Space-based computing has not kept up with the needs of current and future NASA missions. We are developing a next-generation flight computing system that addresses NASA computational performance, energy management and fault tolerance needs, through 2030

States
- California

Figure 6. Technology details – "Baseball Card"

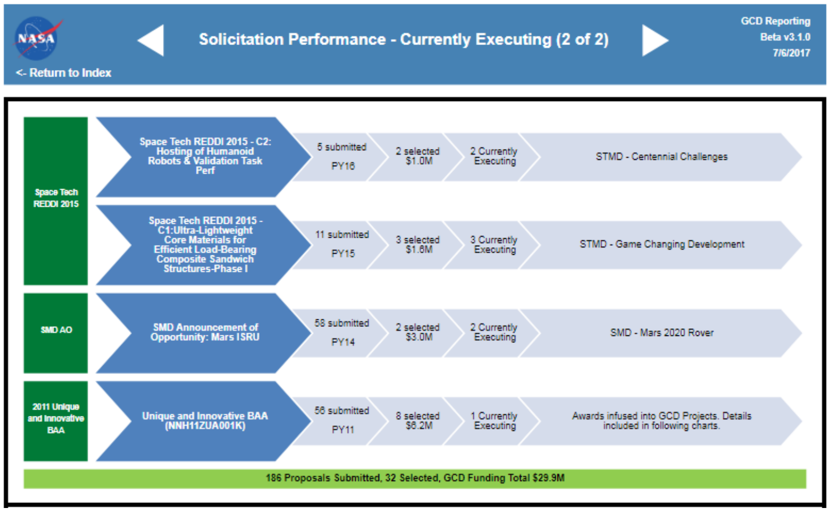
Versions of GCD Mobile for MacOS and Windows (also called the "Desktop" versions) have an additional feature that is not available on the iOS versions due to the additional computational capabilities of desktop/laptop computers. Desktop versions of GCD Mobile include a Reporting mode which creates hundreds of Hyper Text Markup Language version 5 (HTML5) reports in a matter of seconds. These reports are of a pre-defined type and format based upon common and frequently-used portfolio analysis charts, but they are fully data driven from the data within the app. A custom templating system was developed where JavaScript Object Notation (JSON)-formatted data is separated from the HTML5 views. This allows the reduction of the number of files needed to create the reports, which reduces the overall generation time along with the total file size. Example HTML5-based reports are shown in Figure 7.



GCD Budget Trends By Year By Theme

Classification	PY Budget ($M)			
	PY15	PY16	PY17	PY18
🟦 Lightweight Materials and Advanced Manufacturing	$13.2	$13.2	$11.3	$6.0
🟥 Future Propulsion and Energy Systems	$10.6	$17.9	$24.0	$9.4
🟩 Affordable Destination Systems and Instruments	$30.7	$40.6	$20.1	$13.4
🟧 Advanced Entry, Descent, and Landing	$25.1	$27.6	$35.0	$14.5
🟪 Revolutionary Robotics and Autonomous Systems	$36.9	$23.1	$19.9	$5.0
Total	**$116.6**	**$122.5**	**$110.4**	**$48.2**

NOTE: Technologies and tasks are included in the budget allocation. Program Office budget and unallocated future funding wedge are not included in the budget allocation.


<- Return to Index

Solicitation Performance - Currently Executing (2 of 2)

GCD Reporting
Beta v3.1.0
7/6/2017

Space Tech REDDI 2015	Space Tech REDDI 2015 - C2: Hosting of Humanoid Robots & Validation Task Perf	5 submitted PY16	2 selected $1.0M	2 Currently Executing	STMD - Centennial Challenges
	Space Tech REDDI 2015 - C1:Ultra-Lightweight Core Materials for Efficient Load-Bearing Composite Sandwich Structures-Phase I	11 submitted PY15	3 selected $1.6M	3 Currently Executing	STMD - Game Changing Development
SMD AO	SMD Announcement of Opportunity: Mars ISRU	58 submitted PY14	2 selected $3.0M	2 Currently Executing	SMD - Mars 2020 Rover
2011 Unique and Innovative BAA	Unique and Innovative BAA (NNH11ZUA001K)	56 submitted PY11	8 selected $6.2M	1 Currently Executing	Awards infused into GCD Projects. Details included in following charts.

186 Proposals Submitted, 32 Selected, GCD Funding Total $29.9M

Figure 7. Example HTML5-based reports.

The GCD mobile applications also accommodate the situation when there is new or update program or project data. The app was originally designed to be fully data-driven, including the game board configuration, filters, filter values, program/project data and links, and even technology/task images. When the data on a user's local GCD mobile application is out of date and the user is connected to network, a blinking visual indicator in the top left of the main display signals the user that a new data set is available from the Mobile Update Service. If the user is on a secure NASA network, the data can be downloaded to the local app. A key feature of the mobile app is that all the data needed to perform data queries is resident on the local client device after an update. Therefore once an app is updated with the latest data from the Mobile Update Server, it does not need a network connection to make data queries to access information. This data update approach also minimizes the need for users to download and install new versions of the app itself.

C. Mobile Update Service

The dispersed nature of the GCD application ecosystem creates a number challenges for the application's user base and data management process. Application users need to know if the data is up-to-date, as it is an authoritative source of data. Data as part of the application build process makes it unclear how long the build would truly be current and authoritative, which could create confusion among users. Additionally, manually updating the application is a time-consuming process and existing users would still need to be manually notified to download new versions of the app. A number of requirements were derived from these challenges that were experienced during the initial development of the applications ecosystem. Any final solution would have to address the following requirements:

- Centralized, anywhere access
- Scalable
- Data Versioned Controlled

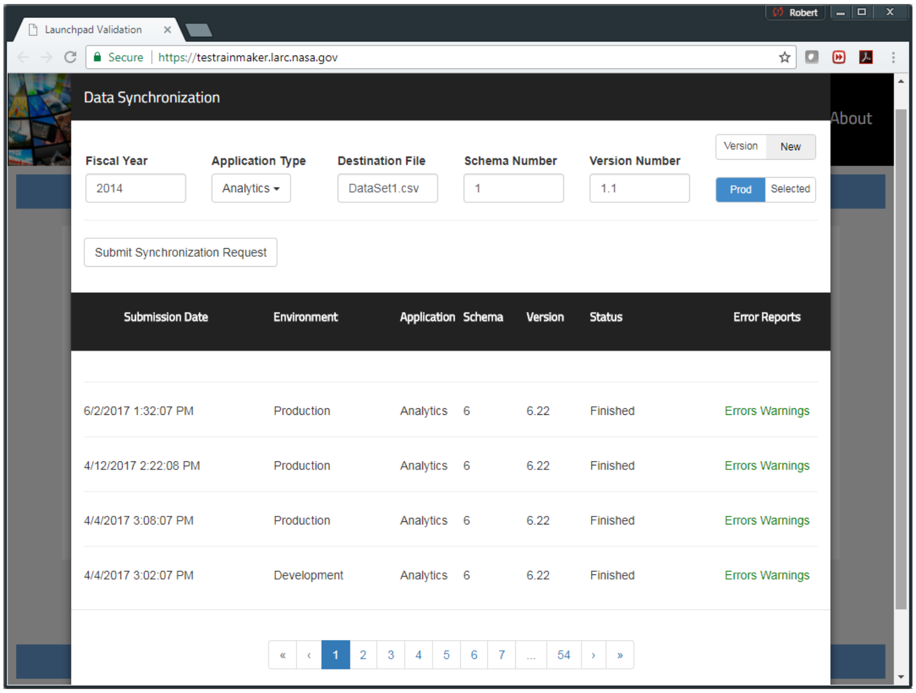
To meet these requirements, a cloud-based approach was utilized when implementing this service. The cloud-based approach provides a number of benefits. First and foremost it provided a centralized point for data distribution to mobile clients. Additionally, the cloud allows for more servers to be enabled when more users try to access the system to ensure scalability. This removed the need to anticipate hardware requirements and allowed GCD agility when managing hardware costs. Centralizing the data also made it possible to implement an authoritative data classification mechanism. A cloud-based approach also isolated the true source of GCD portfolio data (SharePoint), precluding the need for SharePoint servers to respond to and authenticate data update requests from the numerous instances of the GCD Mobile apps.

The Mobile Update Service was developed using a number of standard cloud components found within Amazon Web Services (AWS). AWS provides a number of prebuilt components that are made for enterprise scale allowing us to quickly build out an enterprise architecture. Three major AWS components are used in the server architecture: Load balancer, Elastic Compute Cloud (EC2) and Simple Scalable Storage (S3). The load balancer provides automatic load balancing and encryption functionalities for the Hyper Text Transfer Protocol Secure (HTTPS) traffic. The EC2 component provides a Linux-based virtual machine where a server can execute custom server-side code and host webpages. Lastly, S3 provides a secure storage mechanism for data files within the Update Server.

The data transfers between servers and the mobile apps use the Representational State Transfer (REST) protocol. In the REST interface implementation, requests are made via HTTPS and responses are JavaScript Object Notation (JSON) objects in an array of name-value pairs. Once the proper dataset is selected by an instance of the mobile application, the servers create a secure signed URL that allows direct access to the datasets from S3 storage.

The design includes a tag system in the Update Service to aide in data classification. Each submission is given a schema number and data version number. A data version is a unique numeric label for a dataset that is hosted. Data versions increment in number, thus, a dataset that is tagged as 2.1 is more current than a version tagged 2.0. Each dataset is also tied to a single data schema version. We define a schema version as the data compatibility level a particular client application can process. For example, an application that is on schema level 5 can only download datasets at the same schema level; otherwise the application will not know how to handle the data being consumed. This level of data management is necessary to ensure various, potentially older versions, of the mobile application will only attempt to synchronize with data sets that are supported by that application build.

In addition to the mobile application interface to the Update Service, a full Admin Portal is included to provide an entry point to add data to the system. This administrator interface allows for the data manager to login, add new data sets to be released, and organize datasets in a logical fashion using a tag-based classification system. This capability has been of great value in system test and development. The administrator interface is also the point of entry to initiate an update of new data to the mobile client apps. When an administrator initiates a Synchronization Request command, the Update Service requests up-to-date files from the Convert Service which is described in the next section. The Admin interface of the Mobile Update Service is shown in Figure 8.



Data Synchronization

Fiscal Year	Application Type	Destination File	Schema Number	Version Number
2014	Analytics	DataSet1.csv	1	1.1

Submit Synchronization Request

Submission Date	Environment	Application	Schema	Version	Status	Error Reports
6/2/2017 1:32:07 PM	Production	Analytics	6	6.22	Finished	Errors Warnings
4/12/2017 2:22:08 PM	Production	Analytics	6	6.22	Finished	Errors Warnings
4/4/2017 3:08:07 PM	Production	Analytics	6	6.22	Finished	Errors Warnings
4/4/2017 3:02:07 PM	Development	Analytics	6	6.22	Finished	Errors Warnings

Figure 8. Administrator Interface to Submit Synchronization Requests

The full set of actions supported by the Update server are as follows:

CreateSchema: CreateSchema is called by the Admin Portal to create a new data schema that is used for versioning control.

CreateVersion: CreateVersion is called by the Admin Portal to create a data version that is associated to a given data schema.

FileWrite: FileWrite is initiated by the Admin Portal to transfer a file to the Update Server S3 storage. This command can be used to move test files or production files to the server for synchronization with the Mobile Apps.

Enable/DisableVersion: Once a new set of version files has been put on the Update server, this command can enable those files for mobile application update. The command can also be used to disable currently enabled data versions.

SynchronizationRequest: This request from the Admin Portal initiates a file synchronization via the Convert Service to the Sharepoint.

VersionStatusRequest: This request from a mobile application instance returns a list of the current data versions available for download to the mobile application and associated signed URLs for download.

GetFile: This request from a mobile application instance requests to download a file.

D. Convert Service

This cloud-based service is used to read in data from the GCD SharePoint site and output it as a CSV and zipped image files. This service responds to requests from the Update Service. As data is retrieved from Sharepoint via the REST protocol all data rows are validated and invalid rows are removed and logged. Software errors are also logged. This program is an ASP.NET Model View Controller (MVC) application that runs on an Internet Information Services (IIS) webserver on a Windows server in the Ames AWS GovCloud. Internally the service uses a mapping file to convert SharePoint data to the CSV file required for the Update Service. The following Update Service requests are supported by the Convert Service:

CreateFiles: This is used to start the background task to generate the files needed to provide a data update to the mobile aplications. Currently four files are generated (program data, two financial files, and a zipped image file). It returns a JSON object to indicate the status or parameter errors. Each time the task is started the data will be refreshed; calling this before the old data is retrieved will result in the loss in the old data cache.

CheckStatus: This is used to check the status of the file generation. It returns JSON object indicating the completion status of the generation, error information, and a URL for each generated file.

GetFile: This used to retrieve the generated files from the CreateFiles call. Each GetFile request retrieves one file. It returns a CSV files and/or a zip file with project/technology image data. The function can also return JSON and XML formats although that feature is not currently in use.

E. Security Approach

When building out the overall architecture a holistic approach was taken to security based on the needs of the GCD Program Office and NASA security requirements. We focused on two key areas during the development: secure authorizations and secure content delivery. Secure content is accomplished using two methodologies. First and foremost, all known data is encrypted in S3 using the built-in AWS encryption, thereby securing GCD data at rest. Secondly, all traffic that delivers data into and out of the cloud environment is also encrypted. The data transfer approach leverages the HTTPS protocol and Secure Socket Layer (SSL) certificates to ensure proper encrypted communication along with verified identity of the web services, which results in securing GCD data in transit.

Secure authorization is accomplished using a number of methodologies within the architecture based on the communications needed between the various segments. Cross-communication between AWS GovCloud environments is authorized using the proven Kerberos protocol and using existing Kerberos authentications servers. Secure authorization between GCD Mobile applications and the Mobile Update Service is accomplished using secure signed URLs that are created by the mobile application and checked using a web service. Access to the Mobile Update Service Admin Portal is controlled using standard authentication credentials and existing authentication servers.

VI. Management Approach

The management approach for the secure cloud and mobile services incorporated agile product development. The development team encouraged the use of the principles in the Agile Manifesto which included but are not limited to early and continuous delivery, working products delivered frequently, daily interaction and face-to-face conversation, and continuous attention to technical excellence. In addition, the team focused on implementing these agile values:

- Individuals and interactions over processes and tools
- Working products over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

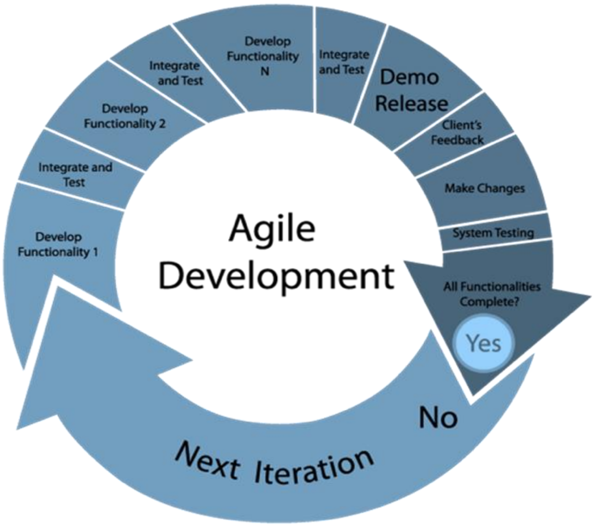


Figure 9: Agile Development Iteration[1]

The benefits of utilizing this approach enabled a quick prototype that provided value to an organization that previously utilized several Microsoft Excel worksheets, PowerPoint files, and Word documents to perform analysis. The short duration sprints allowed for plan adjustments as requirements or priorities changed. Reprioritization could also occur due to user acceptance testing and discovery of new requirements or implementation issues.

All team members and stakeholders can bring inputs into our agile development cycle for consideration. Initial ideas require little detail or vetting to get into our design methodology, to get tracked and later flushed out. Not all ideas reach maturity as frequent prioritization occurs. A few factors used in determining priorities are: frequency of the need for a feature (focus on high-use features), time saved or manual process reduction through feature implementation, and the level of effort required for feature implementation.

VII. Conclusion

Prior to the development of this capability, NASA’s Game Changing Development Program managed numerous and disparate spreadsheets/files containing program and project data. Data was manually consolidated to develop reports and briefings for stakeholders. Figure 10. Four years of technology reporting now accessible via GCD Mobile. These types of reports were often time consuming and required days or weeks to complete. Through agile development and leveraging gaming technology and web services, we have successfully enhanced our data management and business automation with an emphasis on data/analytics and user experience. In addition to benefits of single source up-to-date data and easily accessible information, this new paradigm has enabled real-time scenario-based analysis capability that previously did not exist. The Program has moved from a “data collection mode” to an “increased data analysis mode” with the capability to provide recommendations quickly, efficiently, and based upon data that is the authoritative source. Not only has this technology made our daily activities more efficient, but also we are more effective at meeting our needs and the needs of our stakeholders.

Figure 10. Four years of technology reporting now accessible via GCD Mobile.

VIII. Acknowledgments

The authors would like to thank GCD Program Management including Stephen Gaddis who initiated this project, Mary Elizabeth Wusk who supported the effort, and Daniel Yoo who helped with system development and data management. We would also like to thanks the Sharepoint management and development team: Jeffery Sugar, Sergio Alvarez, Joshua Martinez, and Demetrius Taylor. Additionally, we would like to recognize Andrew Vogel and Wai Kay Kong for their support in the development of the mobile application.

References

[1] Ichanical Technologies. *Agile Software Development: Everything You Need To Know*. URL: http://www.ichanical.com/agile-software-development-everything-you-need-to-know/ [cited 25 July 2017]