IT Assessment of Department of Geology and Mineral Industries (DOGAMI)

Enterprise Technology Solutions on Behalf of The Office of the State CIO

Date: December 30, 2015

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1. Introduction

From September to December, 2015, a multi-disciplinary team comprised of staff from Enterprise Technology Services and the Geospatial Enterprise Office conducted an IT assessment of DOGAMI at the behest of the Office of the State Chief Information Officer.

DOGAMI is a State of Oregon agency with 42 full-time employees responsible for providing earth science information and regulation. DOGAMI's Geological Survey & Services Program develops maps, reports and data to help Oregon manage natural resources and prepare for natural hazards such as earthquakes, tsunamis, landslides, floods, volcanoes, coastal erosion and climate change[1]. Growing awareness of Oregon's geologic risks has increased demand for geoscientific information. The department produces geologic information in partnership with state, federal and local government natural resource and planning agencies.[2] DOGAMI's Mineral Land Regulation & Reclamation Program (MLRR) oversees the state's mineral production and works to minimize impacts of natural resource extraction and to maximize the opportunities for land reclamation.[3]

DOGAMI is a very information-technology-reliant organization and requires volumes of data much larger than might be expected of an agency its size.

DOGAMI is a very information technology-reliant organization. The production, management and publication of its services rely on a combination of highly scientific, technical and specialized personnel and equipment. The data sets produced by and for its geographic information systems (GIS) are very large and require a large volume of data storage and transfer; much larger than might be expected of an agency its size.

DOGAMI's legislatively approved budget for the 2013-15 biennium was $14,967,003, and $15,601,789 for 2015-17, which was a 4.2% increase. During the 2015 legislative session, the legislature noted that there were considerable issues with the agency's accounting and budget structures, business and organizational structures and IT operations. The Joint Committee on Ways and Means attached two budget notes obliging the agency to review its business structures and processes including one budget note specifically directing the OSCIO to conduct an IT assessment.

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[1] *DOGAMI Strategic Framework; 2015-2021*, DOGAMI, 2015 p.2

[2] *SB 5512 A, Budget Report and Measure Summary*, Joint Comm. On Ways and Means, 78th Leg. Assembly

[3] Op. Cit. *DOGAMI Strategic Framework,* p.2

2. Executive Summary

This assessment was requested by the Legislature to support decision making and next step development for DOGAMI's budget and operations. This IT Assessment is intended to document and communicate the current IT operations and business organization of DOGAMI to the State CIO and the Legislature and to provide recommendations for DOGAMI to move forward in optimizing their IT operations. The IT Assessment Team collaborated with DOGAMI staff to conduct the assessment through individual and group interviews, DOGAMI-provided documentation, and the team's own research and analysis. Budget information was provided by the LFO to assist in the team's research and was used in the financial information displayed in this report. However, the need for detailed and accurate budget and expenditure information is critical to analyzing the financial expenditures of the agency. With the detailed financial information absent, the team was not able to provide a financial analysis and include expenditure recommendations.

DOGAMI provides two main services to the state and the public. First is the acquisition, management, analysis and formatting of very large quantities of geographic information systems (GIS) data. This data describes and maps 72 percent of Oregon's populated areas at a very high resolution. This data is used to produce a number of GIS-derived products that are electronically distributed to the public, private industry and governments at the local, state and federal levels.

This GIS data is expected to grow to nearly 300 terabytes (TB) by 2021. The individual file sizes that must be manipulated and electronically transferred both internally and externally are often in excess of 50 gigabytes (GB)[4]. Compared to most agencies' IT operations, these are very large data sets and files. The organization, management and distribution of GIS data should be considered the primary work and challenge of DOGAMI's IT operation.

DOGAMI is also the state agency tasked with licensing and regulating extractive industries in Oregon. The Mineral Land Regulation & Reclamation Program (MLRR) uses many of the products derived from the Geological Survey & Services Program to do its work. MLRR also must maintain extensive licensing, inspection and restoration records for the many hundreds of sites in Oregon. MLRR is still very much dependent on paper records and transitioning to digital record keeping will be one of the program's biggest challenges.

DOGAMI has 42 FTE positions. Eleven of these are in the Information System Specialist (ISS) job classification even though the actual job duties are those of GIS specialist positions and do not directly support IT systems. Holly Mercer, Deputy Director of DOGAMI, is actively working with DAS HR to reclassify these positions to support the GIS specialist role for clarity and accuracy. The agency gets most of its primary IT support from an independent contractor, Ken Aaro.

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[4] For context, a terabyte is 1,000 gigabytes. A full-length, high definition feature film in digital form is about 6 gigabytes. Therefore, the agency works and is required to move around every day files equivalent to more than 8 HD movies. The agency's total storage needs of 300 terabytes is the equivalent the high definition version of every Hollywood movie made since 1920.

While this report will identify a number of specific IT gaps and risks for DOGAMI and will make detailed recommendations for the agency in Section 5 Conclusions, DOGAMI's crucial gaps lie in three main areas:

- Lack of IT management and operational positions to support the agency's complex IT operational and planning needs.
- Understanding and compliance with State purchasing and procurement policy.
- The agency is overburdened with operating a complex and inefficient IT operation and is trying to be self-sustaining in all areas of IT; from desktop support, network security, to storage and GIS management.

These three gaps are the root causes of the many specific deficiencies in DOGAMI's IT operations as they struggle to maintain large and complex "soup-to-nuts" IT operation: network, servers, productivity applications, multiple storage devices and a wide variety of desktops at DOGAMI's makeshift data center in the Portland State Office Building and two field offices. The agency's IT infrastructure has grown organically over the years and is now outdated. The agency has not had the personnel, skills or resources to stop, review and plan for its IT needs or prepare for the future of IT as technology and the business changes.

Closing the gaps in IT strategy and operations and in procurement need to be addressed soonest. DOGAMI will then have the resources it needs to move forward and make thoughtful, value-oriented decisions about its IT objectives, strategy and business needs. From there, the agency should immediately focus its IT strategy on two efforts:

1. DOGAMI does not have the human or financial resources to maintain a "soup-to-nuts" IT infrastructure. Therefore the agency should focus on its core business needs and competencies: managing its GIS and regulatory data. All other aspects of the IT operation; ordinary productivity applications, desktop support, network support, web servers, can and should be handed off to third parties. These are areas where commodity solutions exist. Such solutions could be procured through state services, e.g. ETS or from state contracts and partners, e.g. NIC Inc. or Atmosera.

   Doing this will remove the need for periodic big-ticket capital expenditures and replace them with ongoing operational expenditures. It will also allow the internal IT resources to focus on the core business needs and operations.

2. The fact that agency needs its huge, "every day" data sets available over very fast local network connections cannot be avoided. In addition, DOGAMI is mandated to electronically deliver its products to its customers. This also will require very fast connections to the Internet.

   The agency needs to develop a strategy to maintain all this data both for internal and external consumption. Although we do not go into specifics, Appendix C does recommend a number of best practices for GIS management that would require the agency to maintain both local hardware and contracted services for the internal and external storage and transfer of data.

Following these recommendations will still require the maintenance of extensive storage hardware (capital expenditure, operational maintenance) and/or contracted services to deliver the same functionality. In either case the budget ramifications of putting the agency on the footing to move forward sustainably is going to require the agency to substantially recalibrate its IT budget.

The IT assessment team made repeated requests to DOGAMI for detailed agency expenditure and budget information. No such information was forthcoming during the data gathering and analysis phases of the assessment. On December 30, 2015, the team was provided a copy of the 2015 budget worksheet for the agency which provides some top-line budget and expenditure data for the IT operations of DOGAMI. However, it has not been possible for the team to make any detailed analysis or recommendations with regard to the appropriateness of the size of the agency's IT budget nor to how well it uses the resources in its current budget. Based on the data at hand the team can only make a broad observation to the OSCIO, LFO and the Legislature on how to adjust the agency's IT budget to align with our technical and operational findings and recommendations.

Caveats about the granularity of budget data provided to the assessment team aside, DOGAMI's 2015-17 IT budget and expenditures through November, 2015 by broad category are below.[5]

Budget Category / Line Item	2015-17 Budget by Funding Source				2015-17 Revenue & Expenditures through November 2015			
	General Funds	Other Funds	Federal Funds	All Funds	General Funds	Other Funds	Federal Funds	All Funds
GS&S Program								
Telecom	5,728.00	218.00	9,395.00	15,341.00	6,422.71			6,422.71
Data Processing	10,746.00		6,841.00	17,587.00	387.15			387.15
IT Professional Services					660.00			660.00
IT Expendable Property			28,622.00	28,622.00	31,134.43			31,134.43
MLRR Program								
Telecom		44,161.00		44,161.00		3,823.82		3,823.82
Data Processing								
IT Professional Services						460.00		460.00
IT Expendable Property		26,115.00		26,115.00		2,812.91		2,812.91
Totals	**16,474.00**	**70,494.00**	**44,858.00**	**131,826.00**	**38,604.29**	**7,096.73**	**0.00**	**45,701.02**

The budget document notes that the agency is delinquent in its payments for IT professional services for all of FY 2015 and owes its contractor, Aaro Computing Services, "approximately $5,000."

It is the conclusion of the assessment team that DOGAMI will have to have additional budget resources to support its IT operations. Our broad strategic recommendations are that DOGAMI

[5] DOGAMI spreadsheet provided to the DOGAMI Board, November, 2015.

outsources most of the "commodity" IT services and focuses internally on supporting its users and core data needs. If these are followed, it necessitates that there will need to be steady funding sources which can:

1. Support the recurring annual operational costs of outsourced services, e.g. email, web hosting, file transfers and shared software services.
2. Maintenance and periodic (semi-annual) capital expenditures to support the infrastructure that it does own and manage.

DOGAMI should work with the OSCIO and LFO to produce the budget estimates it will need to support the detailed implementation of the strategic recommendations so that it can go before the Legislature with a 2017-19 budget that reflects supporting this strategic direction

3. Background and Agency Overview

3.1 Budget Note

Pursuant to the budget note from the Legislative Fiscal Office, the State CIO directed ETS and GEO to perform this IT Assessment. The budget note dictated the scope of the IT assessment.

The Department of Geology and Mineral Industries (DOGAMI) is directed to work with the Office of the State Chief Information Officer (OSCIO) to conduct a comprehensive assessment of DOGAMI's information technology related operations. The assessment is to include, but not be limited to, an evaluation of the following:

1) IT organizational structure, policies and practices, management and staffing, funding and expenditures, and governance;

2) Inventory of current systems, hardware, software, data resources, and applications;

3) Business drivers and organizational mandates for information technology and data management;

4) Current and potential alternative methods for data exchange and providing online access to data resources;

5) Current operational and technical deficiencies and gaps;

6) Operational and technical requirements for systems, data, and applications;

7) Requirements necessary for any recommended changes or enhancements to IT management, staffing, funding, policies, and practices.

A report on this comprehensive assessment is to be submitted to the Legislative Fiscal Office and jointly presented by DOGAMI and the OSCIO to the Joint Legislative Committee on Information Management and Technology and to the Joint Committee on Ways and Means during the 2016 Legislative session.

3.2 DOGAMI Core Business Description

DOGAMI uses information technology extensively to support its core business processes. The team reviewed those business processes and business drivers with DOGAMI staff to better understand the deficiencies and gaps in the IT environment. In reviewing the core business processes, we focused on the use of data and data management technologies.

The mapping data that comprises DOGAMI's core products and services are very storage and computationally intensive. In the last two decades, the fields of geology and geographic information systems have begun to manage larger and larger data sets. Maps can be printed for convenience, but they are not simply paper products. The power and utility of the maps lies in the underlying data itself. DOGAMI deals with data (in very large quantities) as a key element of its core mission and in support of the core business of many other agencies.

DOGAMI helps government agencies and the public manage natural resources and prepare for natural hazards such as earthquakes, tsunamis, landslides, floods, volcanoes, coastal erosion, and climate change.

The Geological Survey & Services program develops maps, reports, and data to help Oregon government agencies and the public manage natural resources and prepare for natural hazards such as earthquakes, tsunamis, landslides, floods, volcanoes, coastal erosion, and climate change. The Mineral Land Regulation & Reclamation program oversees the state's mineral production, and works to minimize impacts of natural resource extraction and maximize the opportunities for land reclamation.

The core business processes of DOGAMI fall into four main categories: Earth Science, Natural Hazards, Resource Management, and Education & Outreach. The latest DOGAMI strategic plan document does a good job of summarizing the main focus of each category, as follows:

<u>Earth Science</u>

- Develop data, maps and models describing Oregon's geology, tectonics, physical landscape and processes that shape it.
- Collect information on geothermal, metallic and aggregate mineral resources of Oregon.
- Acquire, organize and distribute high resolution Lidar and other remotely sensed imagery for the state.
- Develop and maintain earth science databases to broadly support the mission of the Agency and other professionals working to keep Oregon's coast, rivers, forests, and other ecosystems healthy.
- Design earth science information products that effectively reach a wide audience.

<u>Natural Hazards</u>

- Map, model, and monitor hazards related to earthquakes, landslides, volcanoes, floods, the coast, tsunamis, toxic minerals, and climate change.
- Collect information, including Lidar data, physical landscape change data, and inventories of the built environment, to assess the vulnerability of communities to natural hazards.
- Promote probabilistic assessments of natural hazards to allow comparison of risks from all hazards, and to inform mitigation decisions.
- Support agencies and local governments in developing regulatory frameworks and tools to mitigate hazards.

- Collect and distribute data to inform response and recovery following natural disasters, and preserve disaster data for future scientific study.

Resource Management

- Provide the regulatory framework to ensure beneficial reclamation and restoration of disturbed lands.
- Increase understanding of cultural, environmental, and economic effects of natural resource extraction.
- Ensure mitigation of mining's impacts, including those to water and air quality, habitat, waterways, and slope stability.
- Improve the efficiency of the regulatory programs by using appropriate and emerging technologies.
- Develop practices and procedures to assist mine operators in meeting new resource management challenges.
- Continually improve communication and coordination with stakeholders to support resource stewardship.

Education and Outreach

- Raise awareness of, support for, and engagement in the Agency's efforts to achieve a safe and prosperous Oregon.
- Reach wider audiences with Agency information by improving existing or adding new communication channels.
- Promote hazard awareness and preparedness.
- Inspire geologic exploration and discovery.
- Expand the use of Agency information through partnerships, collaboration and coordination, active engagement, and other communication strategies.

In the subsections below, we will focus on a few specific business processes that rely heavily on large data sets and labor-intensive data management.

3.2.1 Lidar Acquisition and Distribution

One of the key business processes is acquisition and delivery of highly accurate Lidar data. Lidar is a highly accurate form of elevation data, made by firing a laser thousands of times per minute from an airplane flying in parallel tracks at a set altitude. The airborne sensor measures how long it takes the laser signal to bounce back from whatever it hits on the surface. In Oregon, the data is captured at 8 laser pulses per square meter, providing an extremely accurate depiction of the surface. The data captures the elevation of vegetation, structures, and the bare earth. It is very useful for accurately modeling the potential effect of natural hazards, including floods, landslides, tsunamis, volcanic eruptions, windstorms, even falling trees.

DOGAMI is the lead state agency in coordinating acquisition of Lidar among the many partners that require the data for their own business processes. The agency worked with the DAS State Procurement Office to set up a sole source mechanism with Quantum Spatial to acquire Lidar data. They expend considerable effort to find and make agreements with a wide variety of government and private sector partners to pay for the expensive Lidar data. At the time of this report, they have agreements with over 70 partner organizations. They process invoices to those partners at three different stages of each acquisition, another time-intensive effort. When a federal partner is involved, which is generally the case, there is federal reporting to do for each project, as well.

The data is delivered on portable hard drives by Quantum Spatial as it is completed, project by project. Staff maintains a database of Lidar data locations on the servers. They perform quality control checks on the data using their desktop computers. The QC is done on the desktop machines because the network is not fast enough to accommodate the size of the data. The use of desktop machines at this point, however, also helps prevent confusion between preliminary and final data. Some of the data may be sent back to Quantum Spatial for re-processing based on the QC process.

When all the delivered data has been accepted, it is copied to the DOGAMI servers, although that process has been temporarily halted due to lack of sufficient storage space on the servers. Delivery of data to project partners and customers, including state and federal agencies is by means of shipping portable hard drives. This is due to the lack of server space, secure file transfer software and insufficient Internet bandwidth.

> Lack of storage, file transfer software and Internet bandwidth means that customers' Lidar data is delivered via shipping portable hard drives.

Quantum Spatial also delivers several other products derived from the raw Lidar data. These products are very useful for many government and private sector stakeholders, as well as the public. These derived products are made available for download to agencies and the public via the web. The website has not been optimized for public consumption of data, which makes it difficult to find and access specific data. The data is presented as ZIP files for consumption via the web, rather than being made available for streaming at the resolution at which it is acquired. DOGAMI has been exploring solutions for these issues with Esri, the GIS software vendor they use for managing and using their geospatial data. In addition, the U.S. Corps of Engineers has been developing a website that may be of use for this purpose. Oregon State University's Institute for Natural Resources has all the derived product data and may be a possible distribution point. DOGAMI is evaluating these options, with the help of the Oregon Geographic Information Council (OGIC) Elevation Framework Implementation Team.

The Lidar data is used internally for many projects. For internal data management purposes, the Lidar data is used to make county mosaics, blocks of data that are somewhat easier to use than the form in which the data is delivered. Recently, staff have decided to move away from county mosaics, which have proven to be cumbersome. They had considered grouping the data into mosaic blocks at a scale of 1:250,000. They are now working with Esri on a solution that will produce mosaics for each delivery from the contractor, then create a single statewide Derived Mosaic Dataset that references all deliveries.

3.2.2 Geologic and Natural Hazards Mapping

DOGAMI only receives 18 percent of its operational budget from the General Fund. It performs and pays for much of its geologic and geographic mapping work in the form of projects which are paid for by an ad-hoc consortia of stakeholders.

The agency performs geologic mapping projects on an ongoing basis. The Geologic Map Advisory Committee selects the sites to be mapped. An initial search is conducted for existing data for each site, such as available aerial imagery, Lidar data, water well surveys, etc. A field crew uses iPads with iGIS, an open source geospatial software tool, to collect, preview and cache data. When the crew returns to the office, the data is processed to build complex models. There are significant topology problems with the data that have to be resolved. The models are the basis for the geologic map products. The data is stored as an Esri geodatabase, from which maps can be generated as needed. Adobe is used for final map preparation to make the best available, highest resolution map products. Ultimately, the agency aspires to a single statewide geologic map at 1:100,000 scale. The existing geologic mapping, while covering the entire state, is at a variety of scales.

> *DOGAMI "receives approximately 40% of its funding from federal agencies. As a result, the federal sequester and the ending of specific programs (NOAA tsunami mapping) has made predicting federal funds for projects difficult. Some of their program areas, such as coastal erosion and landslide mapping, do not have an ongoing source of funds, which limits the Agency's ability to provide services in these areas. The Agency's General Fund revenue has not kept up with inflation or communities' needs, resulting in the Agency seeking and becoming more dependent on outside sources of funds."*[6]

DOGAMI only received 18 percent of its operational budget from the General Fund[7] for previous biennia and only 12 percent for the 15-17 biennia. It performs and pays for much of its geologic and geographic mapping work in the form of projects which are paid for by an ad-hoc consortia of stakeholders. These consortia often consist of both public (BLM and FEMA are two of the largest customers) and private (e.g. wood and paper industries, property developers) entities. Putting together these consortia – often through cold-calling known stakeholders – can take up to a year.[8] Managing the billing and the delivery of the end products takes a large amount of the staff's time and requires its own set of IT-related data and accounting products.

The agency does a wide variety of natural hazards mapping, including landslide risk mapping and studies. For this type of hazard, DOGAMI produces three separate views that indicate the risk. One of the views requires adding in the built infrastructure; roads, buildings, etc. For buildings, there is often no existing digital data available. The staff digitizes the building information based on aerial imagery and other sources. From this information, they conduct a risk assessment and

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[6] *DOGAMI Annual Performance Progress Report* for FY2013-14, p.2

[7] Op. Cit. *DOGAMI Strategic Framework*, p. 2

[8] Jacob Edwards, DOGAMI interview 12/07/15

analysis that estimates potential loss if a landslide were to occur. They use a FEMA HAZUS formula for this analysis and assessment that runs on Esri software. The result provides an estimated recovery cost and time for city, county, state and federal use.

DOGAMI produces flood hazard maps that have been approved by FEMA to update the FEMA flood maps. In addition they are occasionally paid by property owners to produce individual flood hazard maps. Lidar data is used to help determine the elevation of the potential flood surface. The DOGAMI group that does this kind of hazard mapping is also working on a statewide levee mapping project funded by the Oregon Geographic Information Council (OGIC). The group is also working on wind hazard and falling tree projects.

DOGAMI has also digitized all the buildings and streams on the coast and in the Portland metro area. The data from these projects is aggregated on a community level. The uncertainties in the risk models make the data unsuitable for making decisions at the level of an individual house or property. But the data is available for viewing via the FEMA HAZVIEW web tool.

DOGAMI's Coastal Program performs considerable hazard studies specific to coastal hazards such as tsunamis and erosion. They map changes to the coast at several stations, on a seasonal and an ad hoc basis, as funding is available. The data and models developed by the staff at the Coastal Program office are used to create highly accurate tsunami simulations that show 10-second flows over an entire inundation period. This data is in a proprietary format not easily shared with others. They have accumulated approximately 15 TB of model data over a four year period, all stored currently on portable hard drives. The storage method makes the data difficult to discover and access.

DOGAMI's Tsunami Evacuation Map program produces the maps and brochures used by municipalities and the general public in preparing and planning for tsunamis. These show very detailed information on how far to evacuate and the safest most effective routes to use. There is a lot of post-processing work required to render the tsunami data into useable evacuation maps and information. This work is peer-reviewed to ensure its accuracy. The Coastal Program also performs wave climate analysis in collaboration with Oregon State University, published through FEMA.

3.2.3 Mineral Land Regulation and Reclamation

DOGAMI's Mineral Land Regulation and Reclamation (MLRR) section is responsible for the permitting and inspection of all mining and extractive industries in Oregon. MLRR staff accepts and reviews mining permit applications that are submitted in hard copy to their office. They are accompanied by a hard copy surveyor's map of the site. The staff scans and digitizes those survey maps. Application information is entered into an Access database, and the digitized maps are stored in an Esri geodatabase via cloud services. A paper completeness checklist is circulated with paper copies of the application through DOGAMI and 10-15 other government agencies for each application. Scanning the applications and sending them digitally through this process by email is used in some cases, but the files are 10-15 GB. Using FTP to move the digital files between agencies doesn't work because many of the receiving agencies can't use FTP technology.

The MLRR program generates and uses a great deal of map data and licensing paperwork. MLRR also ensures that in post-production, such sites are reclaimed by their users to a safe and

useful state. MLRR staff conduct site inspections for all 891 active permitted mining sites. MLRR's goal is to inspect "every site every two years."[9]

The Agency acquires aerial photos of each site every four years as an addendum to the inspection process. The original, approved hard copy application is taken to the site to aid in the inspection process. They are starting to use digital tablets to help with this, but not in a systematic way. They don't have internet connections for these portable devices. The Access database and Esri geodatabase are updated with inspection information after the inspection team returns to the office.

A large number of DOGAMI's staff spend a large portion of their time in the field, often in remote areas. Working in the field requires technology that allows them to be as productive as possible and to allow them to work in a secure way when working remotely.

Many of the MLRR inspection sites are located in remote areas of Oregon. There is a need for the inspectors to access data over the wireless cellular network.

The permit review and site inspection process are still undergoing evaluation and revision. The Legislature approved a fee structure for this process in the 2015 session. MLRR staff are in the process of reviewing administrative rules and statutes before making decisions about modifying their process. MLRR recognizes that there is significant room for improvement in the tool and processes used for inspections. Among other things, staff say they would like online submission of permit applications, online renewal applications, fee payment, public download of all files related to a permit, improved document management, and a faster, more reliable web connection.

3.2.4 Education and Outreach

Much of DOGAMI's core business is focused on helping government agencies at all levels understand and manage the built and natural environment and prepare for responses to natural hazards. As stated above DOGAMI continues to provide a wide variety of material for the general public, the private sector and for local, county, state and federal agencies. These materials form key elements of public safety education, emergency management planning and growth planning. It is also part of their mission to share scientific information with the public in an understandable and useable manner.

Until 2015, DOGAMI operated a retail store that sold to the public a wide variety of the agency's maps and documents. In 2015-17, the agency was instructed to close the store but was still mandated to make the published material available electronically and free of charge. The agency is in the process of scanning the contents of their paper library that currently exists mostly in boxes. That content will be made available online at some point in the future, as time and budget permits. This requires a greater than normal amount of storage and network bandwidth to make electronic distribution practical.

[9] DOGAMI Portland interviews, 12/7/15

For their web presence, DOGAMI uses multiple generations of Esri web map viewers. The agency understands that this is both a practical and a public image problem. However, the agency does not have both the internal capacity and knowledge to develop a single web map interface or to contract this work out. The result is that data discovery and access proves very difficult and frustrating for the public. Although they have not come to fruition, DOGAMI continues to investigate various cooperative approaches to solving the problem.

DOGAMI did work with Portland State University GIS staff to develop an open-source web map viewer, but that partnership ended before the work was completed and the agency did not retain any access to the code at this time.

Recently the agency has been investigating the US Geological Survey National Cooperative Geological Map Program (NCGMP). DOGAMI thinks NCGMP may have a solution as model for other Oregon agencies that need to distribute geospatial information to the public. NCGMP looks like a typical web-browser map program such as Google Maps. When zoomed out it provides national level data, but as the user zooms in, the software switches to show data drawn from state providers and servers, like DOGAMI. In this way, the public doesn't have to know where to go in order to find the data they seek, but they know the source of the data once they discover it through a single site. The Oregon Spatial Data Library, to which DOGAMI is a contributor, could use this as a functional model.

3.2.4 Organizational Mandates:

As part of this IT assessment, the team reviewed the 2013-14 APPR for DOGAMI. This Performance Progress Report outlines 11 key performance measures (KPM) which speak to the mandates and business drivers of DOGAMI. They are:

1. Earthquake and Landslide Map Completion: Percentage of inhabited areas with maps and data.
2. Tsunami Evacuation Map Completion: Percentage of at-risk communities with new evacuation brochures.
3. Coastal Erosion Map Completion: Percent target communities with standardized, 4-risk zone erosion hazard maps.
4. Reclamation: Total number of mining acres that have been reclaimed and returned to secondary beneficial use.
5. Detailed Geological Map Completion: Percent of inhabited areas with detailed geologic data to be used for local problem solving and resource management.
6. Regional Geological Map Completion: Percent of Oregon with statewide geologic data for regional resource and hazard assessment.
7. Mine sites Inspected Annually: Percent of unique mine operators with active permitted sites inspected annually.
8. Tsunami Inundation Map Completion: Percent of coast provided with detailed tsunami inundation maps for local planning.

9. Customer Service: Percent of customers rating their satisfaction with the agency's customer service as "good" or "excellent": overall customer service, timeliness, accuracy, helpfulness, expertise and availability of information.
10. Governance: Percent of yes responses by Governing Board members to the set of best practices questions.
11. Geologic Hazard Preparedness: Percent of Oregon communities with geologic hazard data and prevention activities in place.

"KPM 2 and 9 have reached the targeted 100% coverage, and need to be replaced or updated. The Agency is currently developing a new 6-year strategic plan, which will be used to develop new targets or measures."[10]

DOGAMI's *Strategic Framework*: 2015-2021 lays out the agency's goals for the next three biennia. It will continue to focus on earth science, natural hazards, resource management, governance, and education and outreach. It is inevitable that DOGAMI will continue to require a sophisticated and extensive IT infrastructure to support its core mission due to the nature of GIS, Lidar and MLRR requirements.

As mentioned above, DOGAMI was mandated to cease its retail distribution of physical copies of its products in 2015-2017. Therefore, it now must rely on the electronic distribution of its products not just to the general public but to its business partners and regulated businesses. This mandate puts additional pressure on the agency's already thinly stretched storage capacity.

Finally, DOGAMI has an internal mandate to digitize all of its paper records and move the MLRR Program's permit and licensing records into a digital format and database. This will put additional pressure on the storage resources described in Section 4.3, Data Storage and Access. The result is heavy receipts of paper applications and an obstacle of making the digital version available to all applicants.

[10] Op. Cit. *DOGAMI APPR*, p.2

4. Current State

The IT Assessment team is multi-disciplinary with subject matter experts in various fields. The team assigned categories to the specific members and developed the following checklist.

	DOGAMI Provided?
IT Infrastructure	
IT Contractors and vendors list	yes
Software Licensing Information	partial
Security Scan Results	no
Server Health Check Results	no
Active Directory and Security Group policies	no
Diagrams of IT infrastructure	no
Security Policy	no
Firewall Specifications and Configuration	no
Asset Inventory	no
Policy and Process Documentation	
IT Service Continuity Plan	no
Asset Management Plan	no
Change Management Policy	no
Incident Management Policy	no
Access Management Policy	no
Vendor Service Level Agreements	no
Capacity Management Policy	no
OS and Software Patching Policy	no
IT Systems and Network Hardware Standards	no
Business Operations	
Organizational Chart	yes
Budget Documentation	partial, high-level only
Record Management and Retention Policy	no
Public Records Request records	no
Disaster Recovery Plan	no
Vendor Management Plan and Policy	no
IT Equipment Lease Details	n/a (no leases)
Performance Measurement Processes (KPI)	yes

The checklist acted as a guide to begin the discovery into DOGAMI's business and systems. Though not all of the items in the checklist were received by the assessment team, they were discussed and considered as part of the assessment report.

The current state of DOGAMI was discovered using interviews, on-site visits, phone calls and web meetings to gather information and have discussions. Each DOGAMI office, except for Baker City, was visited by some or all of the assessment team members. The current state was then documented in various ways as communicated.

4.1 Organizational Assessment

4.1.1 Staff Organization

DOGAMI does not have any positions in its current organizational structure that include any dedicated IT-specific personnel or roles. Although the current organizational chart (See Appendix A) includes 11 FTE positions in the Information Services Specialist classification, this is a longstanding error. The ISS positions are filled by people working as GIS, geology or mineral licensing specialists performing specific work. GIS and Lidar systems require specific technical knowledge and training but they have a very narrow scope and do not include general IT computing, desktop maintenance, storage, server and network skill sets.

> DOGAMI has no dedicated IT positions in its current organizational structure even though IT operations are core to its mission.

According to Deputy Director, Holly Mercer, DOGAMI is currently working with DAS HR to attempt to rectify the ISS staffing situation. The state has no GIS Specialist classification. DOGAMI and DAS HR are working to try to map the skill sets of the current ISS staff to NRS specialist positions in an attempt to correctly classify DOGAMI's earth sciences and geology specialists and give those individuals a plausible career path within state service. According to Ms. Mercer, this new HR reclassification structure is planned to be delivered to the Legislature for the 2016 session.[11]

The closest position DOGAMI has to an IT manager in the organization is Rudie Watzig, hired as a Spatial Data Specialist. He is an educated geologist and currently employed as an ISS5. Mr. Watzig reports that he spends about 25 - 100% of his time engaged in IT support activities supporting end-users and the agency's servers and network.[12] Ed Buchner, a GIS Analyst in the MLRR program in Albany, is employed as an ISS4 and has developed the line-of-business database for the licensing program. Mr. Buchner is also an educated geologist and states he spends 5-10% of his time, perhaps 1 hour a week, supporting IT services and assisting their IT contractor.

DOGAMI purchases high-level IT services from a contractor, Ken Aaro, of Aaro Computing Services, who has been supporting DOGAMI for many years. DOGAMI's contract with Mr. Aaro is limited to $10,000 per year, about 80 hours of his time, or merely 6 hours per month. This time is spent mostly doing the high-level server and network support tasks that DOGAMI staff cannot do, thus pushing the general maintenance tasks onto the DOGAMI staff. A few DOGAMI staff have developed some skills with database systems, though the need for a well-designed database system has surpassed the skill level of the staff.

According to our interviews with DOGAMI leadership, the agency is under the impression that there is a statewide contractual a limit of $10,000 per year for Mr. Aaro's services. The $10,000 per year limit on Mr. Aaro's contract severely limits the amount of services he can provide. There is a risk that important work related to disaster recovery, patching and security is not being

[11] Holly Mercer, DOGAMI interview, 12/7/15

[12] Rudie Watzig, DOGAMI interview 10/16/15

completed due to the limits on Mr. Aaro's time and the gap in the skill sets between the Mr. Aaro and the agency's available "IT" staff. The operational constraints of this $10,000 limit can be illustrated as follows:

> Mr. Aaro charges $80/per hour[13]. This equals 125 hours annually, 10.42 hours per month. For example, based on the assessment team's subject matter experts, 10.42 hours per month would allow Mr. Aaro to perform any ONE of the following tasks:
>
> - Run and support a server backup and add storage to a server, OR
> - Run a cycle of software updates on servers and PC's, OR
> - Resolve one incident of a failed drive in a server.

The limited availability of the key contractor plus the lack of true IT specialists organic to DOGAMI presents some specific problems and risks for the agency.

1. By State policy, Mr. Aaro cannot provide security services to the agency as a contractor. Since the DOGAMI staff do not have the training, knowledge and skill sets necessary to support security technologies and DOGAMI is not able to fully secure the IT systems. This presents an elevated risk of destructive loss of business and/or data due to malicious action.
2. The lack of actual IT specialists in the organization on a full-time, dedicated basis presents a risk of decreased productivity and data loss due to the complexity of their IT environment because:
    a. Service disruptions are dependent on contractor availability and response time for resolution
    b. Current geology staff are interrupted from geologist work to assist coworkers with IT tasks such as login failures, restoring lost files, mobile device assistance.
    c. Current backup procedures require assistance of geologist to regularly replace and mail external storage drives.
3. There is not a designated person to manage the strategic IT direction of the agency. The contractor is essentially fulfilling this role. The absence of knowledge of, or adherence to, state procurement policy means that the agency is likely not doing the best job of spending state resources for its IT needs either in the short- or long-term. Specific examples are:
    a. Continued dependence on a large physical server farm instead of a virtual server architecture.
    b. Continued dependence on server-attached storage systems with multiple servers instead of an expandable single, unified storage system.
    c. Purchase and installment of the recent SonicWall network and security device without a business case or consultation with other agencies or the Enterprise Security Office.
    d. Decision to purchase custom built PC's without warranty, maintenance or lease option

[13] Ken Aaro interview, November, 2015

4.1.2 Current Policies and Processes

DOGAMI's current level of maturation for IT policy and processes is ad-hoc, or person dependent, meaning that the activities of the process are solely conducted by an individual on a case by case basis and not documented or communicated across the agency. DOGAMI does recognize the importance of having standardized policies and processes and is working on mediating such issues.

The staff are well skilled in GIS and Lidar data processing and can repeat the ad-hoc steps easily. The MLRR office appears to be efficient at their ad-hoc processes. Newport and Baker City also have daily business processes and procedures clearly understood and conducted efficiently. The fact that the staff is relatively small and close-knit may be a contributor to their success. All offices could use assistance to document their processes. This documentation can then be analyzed to determine areas of strength and concerns. Repeated steps and common needs can also be identified by documenting the processes.

DOGAMI wasn't able to provide any policy documentation as requested (see checklist above). There may be many reasons for the lack of documentation. The recent changes in staffing can be a contributor as well as the reactive state DOGAMI has been in for the IT systems. DOGAMI has expressed interest in abiding by required policies as well as developing their own. Education regarding policy development and application should be a focus.

4.2 IT Systems Inventory and Operations Assessment

The current IT systems were assessed using on-site interviews with IT staff and DOGAMI employees and with reviews of the documentation which DOGAMI was able to supply. The assessment team assembled physical asset inventory collection and built the system diagrams with the assistance and cooperation of DOGAMI staff. The collaborative effort between the assessment team and DOGAMI was critical to conduct the assessment. This section will summarize the IT systems findings and identify many of the gaps in the systems and operations. The detailed inventory, diagrams of hardware, software and network architecture is included in Appendix B.

4.2.1 Desktop and Laptop Hardware

GIS data processing workstations often require advanced storage, processors and graphics. DOGAMI has elected to custom build their workstations to accommodate this need. However, this type of workstation is available through manufacturers with warranties and does not require a custom build. They can be acquired through purchase or lease options using existing state contract avenues and/or via DAS Technology Service Center.

"We [TSC] support a number of hardware hungry apps & environments – video rendering, software developers, GIS people – they all run our standard systems with certain specific graphics,

RAM, and chipset upgrades. Fast RAM, an additional hard drive, i7 processors and chipsets are what we do for the GIS team."[14]

> The agency should work with DAS to develop a standard "scientific workstation" desktop option from the State's vendors and utilize those instead of custom-built workstations.

As noted in the Executive Summary, the assessment team was unable to acquire detailed IT expenditure data, so no specific dollar figures can be estimated for the custom computers. However, custom built workstations do not include warranties and may not include standardized parts. This presents a risk to the business from lost productivity due to additional time required to resolve a hardware failure and to perform maintenance work, patching, updating, etc. In the last year, one employee was forced to work from home for three weeks due to a failed cooling fan in the employee's workstation. Procurement issues also prevented a spare from being acquired in a timely manner.[15]

DOGAMI could not provide full documentation for their hardware, including information about the age, operating system and patch level for each device. This deficiency is a serious concern from a security standpoint and also presents an additional risk of loss of productivity or data due to software or hardware malfunctions.

The Portland office has 42 desktop PC's which are all custom-built and running Windows 7. There are 11 laptops, makes and models that the team was not able to determine. All PC's are running Windows 7 but the patch levels are unknown.

The Albany office has 9 desktop PC's; 5 Hewlett-Packard and 4 custom-built. There are 11 laptops; 6 Hewlett-Packard and 5 Lenovo. All PC's are running Windows 7 at unknown patch levels except two of the Lenovo laptops which are running Windows XP, an end-of-life operating system that no longer has security patches available. These two laptops are used extremely rarely and are to support an old application that is not compatible with a newer operating system. These two laptops and the old application depending on Windows XP should be removed and replaced immediately.

The Newport office has 6 desktop PC's, all of which are custom-built running Windows 7 at unknown patch levels. There are 7 laptops, three Dell and 4 of unknown make running Windows 7 at unknown patch levels.

The Baker City office has 1 laptop of which the operating system and model is not known.

4.2.2 Server Infrastructure and Architecture

DOGAMI still relies almost exclusively on a farm of physical servers with server attached storage. For institutions with DOGAMI's needs the transition to virtualized servers with storage area networking (SAN) has become the technical common practice. DOGAMI recognizes this as a

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[14] Adrian Turpin, DAS Technology Service Center, Team Lead, via email, 12/15/15

[15] Rudie Watzig, DOGAMI interview 10/16/15

problem, but planning a move to a virtualized environment has stalled due to lack of staffing resources with the proper skill sets to design, build and support a virtual infrastructure and the inability to navigate the procurement process for such a large IT project.

DOGAMI supports 17 physical servers and 1 virtual server in its three primary offices; 13 in Portland, 3 in Albany and 1 in Newport.

In the Portland office, there are three servers that run the normal line of business applications: file server, business applications, Active Directory and Mail. The remaining 10 are all in GIS storage and data processing-related roles.

Lack of documentation on hardware and software patch levels is a serious concern from a security standpoint and also presents an additional risk of loss of productivity or data due to software or hardware malfunctions.

The servers are in the former library filing room within the main office in the Portland State Office Building (PSOB). The corner of the room is partitioned off with soft, removable walls and no door is available. The shelving units used to support the servers, network equipment, UPS (Uninterruptable Power Supply) and other components are not sturdy and are starting to bow. The most notable risk factors for this location:

- Insufficient HVAC to support the server density. There are portable fans and air conditioners to provide cooling. The air conditioner condensation drains to a plastic trash can that must be emptied daily, including weekends and holidays.
- No physical security of the devices other than the security of the DOGAMI offices as a whole. DOGAMI has a receptionist to help require quests to sign in near the main entrance. The doors into the old library room are not kept locked or secured.
- No redundant power. There are several UPS' adequate for power conditioning and brief low-power events but no backup for power outages lasting longer than a few minutes.
- A single-server runs both the Active Directory (v. 2010) Doman Controller and the Exchange (v. 2010) mail services. This is a configuration that is strongly discouraged by the manufacturer, Microsoft, and presents a significant risk of data loss due to software conflicts or corruption.

Building a data center for DOGAMI in the PSOB is not a viable solution for the agency's server and data management issues.

The remaining servers in Portland all serve and store data for GIS and Lidar mapping work. The data storage need for this type of data is quite large. *The details of DOGAMI's storage are addressed in Section 4.3, Storage and Data Access.*

In Albany, there are three servers; an Active Directory Domain Controller/Exchange server, and two file servers. The only test server, named Experimental, is running Windows Server version 2003, which is no longer supported and presents a security risk. However, this server is no longer used and is ready for retirement. It should be removed from service as soon as possible. The servers are in a rack with a lock but the cabinet was not locked at the time of our visit. The rack is in a closet within the main office and is

shared with the neighboring businesses. This closet houses all the network equipment for those businesses. The voice system is also shared between the multiple businesses.

In Newport there is a single server supporting the file, email and storage roles in the main office. The office is quite small, so this is not surprising. However, the Newport staff cannot access their local files and use VPN to access the data in Portland at the same time. The Newport staff must log on and off VPN depending on the location of the data they need to access. This is disruptive to their productivity.

Only one server in the office has a highly redundant disk array (RAID 6), all of the others are in a RAID 5 configuration. Three of the servers are backed up to a second external storage array, acting as a RAID 10. The agency is at risk of permanent data loss if more than one drive failure occurs and a valid backup is not available.

DOGAMI backs up its data quarterly to external hard drives and ships those to Iron Mountain. DOGAMI also performs monthly and bi-weekly backups locally to external storage arrays. The specific backup schedule for the servers and storage could not be provided. Any data loss or server outage during the period after the backup risks permanent data loss.

> The best practice back up schedule is to have daily incremental backups to store any changes that occurred every 24 hours and a full backup of all systems monthly.

The agency is aware that its server infrastructure and present engineering solution in Portland is inadequate and in violation of many best practices for IT management. They have expressed a strong interest in designing and building a server room on the 9th floor of the PSOB as a solution. This is not a sustainable solution for the following reasons:

1. DOGAMI does not have the personnel to support such a large and complex hardware environment in perpetuity with all of the ongoing maintenance and capital expenditures for lifecycle replacement that this would entail.
2. The 9th floor of the PSOB is not a suitable location for a data center because:
    a. The building lacks adequate HVAC facilities for the current and anticipated future density of hardware.
    b. The building lacks redundant power circuits and backup power in general – if needed it would have to be retrofitted for DOGAMI at great expense.
    c. Access to the building and/or server room would need to be modified to provide adequate physical security to meet State of Oregon security requirements.
    d. The 9th floor of a high-rise building is at significant seismic risk.

4.2.3 Network Architecture and Devices

DOGAMI supports its own network infrastructure both in external, wide area network (WAN) connections and in the local area networks (LANs) at the offices. The sole exception is the network connection to the Portland State Office Building (PSOB) provided by ETS. This is a shared, 1Gbps circuit used by all tenants of the PSOB. The utilization of this shared circuit averages approximately 10-15% with peak usage of nearly 50%. This circuit is sufficient for the current need of all PSOB tenants, DOGAMI included.

DOGAMI maintains all of its own LAN switches for the office network. These are a mix of Cisco's higher-end enterprise devices and smaller, consumer-grade devices. In November, 2015 DOGAMI installed a new SonicWall network security appliance to replace all of the network equipment for the Portland office. This device fills the roles of LAN switching, firewall, VPN concentrator, anti-spam and anti-malware for the Portland office.

The agency's lack of a qualified or permissible person to manage its network security is a cause for great concern.

Since Ken Aaro, a contractor, configured the device and is prevented from doing security work by State policy and there are no known subject matter experts employed by DOGAMI, it must be presumed that the device has been installed and configured in contravention of State policy. Its actual effectiveness cannot be determined as the agency has not provided the assessment team with the configuration. The SonicWall device has not yet been fully implemented per statements of DOGAMI and Mr. Aaro. Security and routing features have not been reviewed to determine if this device can be used to meet minimum State security requirements and policies.

The assessment team is concerned regarding the install of the SonicWall as this was not discussed with the assessment team during interviews or on-site visits prior to the installation. The assessment team recommends that a separate security scan and/or assessment be performed.

Other than the PSOB office, DOGAMI procures WAN connections for Albany, Baker City and Newport from local telecommunication providers whose services were not ordered using the State contract. These are: Charter Communications in Newport, Comcast/Xfinity in Albany and Qwest/CenturyLink for Baker City.

The Albany office has a consumer-grade Cisco router with a Barracuda firewall for security. Using the consumer grade services results in smaller data packet sizes. These smaller packets are not compatible with the State of Oregon network without a VPN connection. In addition, the network configuration for the Portland office, though using the State of Oregon network, has a max packet size of 1500. The minimum needed is 1546. In the past, DOGAMI has been informed of this issue and the effects of this issue on network connectivity. DOGAMI has not had the ability to resolve the packet size issue and still deals with lost connectivity and data packets as a result.

DOGAMI has struggled with connectivity outside of the state network via the state's single perimeter firewall, managed by ETS. ETS has collaborated with DOGAMI to better understand the root cause for the issues. No results have been found. This issue does not arise with other ETS supported customers. ETS does believe the issue can be identified and resolved if DOGAMI had staff capable of troubleshooting with ETS technicians as a focused effort.

The Barracuda and SonicWall devices could provide a secure point-to-point, encrypted virtual private network (VPN) connection from the Albany, Baker City and Newport offices to the PSOB, though this has not been implemented. Instead, each individual user must establish a VPN connection from the Microsoft client on their PC to the PSOB network. This is time-consuming, prone to failures and is not an efficient use of the shared network resources. The default Microsoft client DOGAMI uses for VPN has severe limitations that has negatively impacted productivity. While a staff member is using VPN to access data at another DOGAMI office, they cannot also access their own directories. As such, two impacting situations exist:

1. The staff have to complete all their work using VPN without access to local files and the data will remain at the other office.
    a. Prohibits use of using local software and applications to complete work
    b. Local data needed to perform tasks are not available to complete work using the VPN
2. The staff are required to move the data to their own workstation, disconnect the VPN, then move the data onto local storage.
    a. Consumes much of the network connections
    b. Results in duplicated data stored in multiple locations
    c. When data is changed/altered in once location, not synchronized in remaining locations

If the Barracuda and SonicWall devices were fully implemented and configured properly, these situations would not exist. Standard vendor recommended deployments of the security devices used for VPN will address these situations as well.

DOGAMI has opened three network-related service disruption tickets in 2015 with ETS. The following is a short summary of the requests and the resolution.

1. *SSL Site Access Issues* – This request is believed to be associated with ETS switches and referred to the replacement of the switches the year prior. This information is inaccurate. ETS has one switch on site used by DOGAMI and another owned and managed by CenturyLink for voice services. Neither switch was replaced the year prior. The switches in discussion are:
    a. pdx-psob9e-s1 that was deployed 11/2012 and DOGAMI uses to access the State of Oregon network and enter the WAN
    b. pdx-geo-s1, a VoIP switch owned and managed by CenturyLink and deployed many years prior.

    The SSL was an issue inside the DOGAMI LAN. The issue simply disappeared and the disruption was closed.
2. *Issues with Connecting to HTTPS* – The root issue was not identified. ETS moved DOGAMI to a different port on the same WAN switch and DOGAMI deployed a SonicWall appliance for network routing and firewall services. The ticket was closed with no identified root cause or resolution. The issues seemed to have disappeared.
3. *Internet Really Slow* – DOGAMI stated their internet connection was performing very poorly. ETS observed the Internet connection from DOGAMI and didn't find any issues. After several weeks of troubleshooting, the issue disappeared. DOGAMI still requested a new switch with the impression the switch they had was 100Mb. ETS only deploys switches with 1Gbps port speeds. ETS moved DOGAMI to a new port on the same switch with new Gigabit uplinks. No other changes occurred. The disruption was closed after the issue disappeared.

The above disruptions are examples that demonstrate the agency's need for dedicated IT staff to understand their infrastructure and assist with all technical needs. These disruptions certainly have a root cause and may occur again.

4.2.4 Software Inventory and Management

DOGAMI employs the usual suite of Microsoft Office applications, but versioning and licensing information is inconsistent. Much of the software used by DOGAMI are standard products for GIS and scientific work such as:

- ArcGIS for Desktop and Server
- HEC GIS visualization software
- Adobe Creative Suite products for producing maps and reports
- Mathlab for statistical analysis and number-crunching

The various non-GIS software programs used by DOGAMI are listed below. DOGAMI and the IT Assessment team are unsure if the following programs are up to date or currently supported. The software programs include:

- PC Operating Systems: Microsoft Windows 7 and some Linux for desktops/laptops
- Server Operating Systems: Microsoft Server 2008 and 2012. One instance of Server 2003 (unsupported)
- PC/Endpoint Security: MalwareBytes anti-malware and Kaspersky anti-virus. *The exact versions of which and the policies and procedures for managing and maintaining their updates are unknown*.
- Email Software: Microsoft Exchange 2010 hosted on a single Server 2008 instance in the PSOB. *This server is also the Active Directory Domain Controller, which is a configuration strongly discouraged by Microsoft due to the risk of data corruption or loss.*
- Backup and Recovery Software: Symantec System Recovery on some servers, various versions, 2011-2013R3, Symantec BackupExec also various versions. *There is no documentation of licensing or support contracts for any of these. The ability of the agency to recover fully from a hardware failure should be in doubt.*
- Microsoft Hyper-V for one virtual server.

The table on the next page displays the various application programs used by each office. For all cells that have a question mark (?), the number of licenses are not known but the application is used. This table is also intended to show duplications of licensing in multiple offices and the potential ability to move to an enterprise version for one office but used by all. Consideration should be taken to purchase group licenses or bundles to reduce cost and support consistency between offices.

Table 1: DOGAMI Application Inventory

NUMBER OF LICENSES	LOCATION				NUMBER OF LICENSES	LOCATION			
Software Name	Albany	Newport	Portland	Grand Total	Software Name	Albany	Newport	Portland	Grand Total
3D Analyst	1	?	13	14	Flood and Coastal	Not Used	Not Used	?	0
Acrobat 9	Not Used	Not Used	3	3	Flood Map Desktop	Not Used	Not Used	?	0
Adobe Acrobat Pro	2	Not Used	Not Used	1	Google Earth Pro	1	Not Used	?	1
Adobe Illustrator	Not Used	?	Not Used	0	Hazus	Not Used	Not Used	?	0
ArcGIS Desktop Advanced	1	1	11	13	HEC - DDSVue	Not Used	Not Used	?	0
ArcGIS Desktop Basic	Not Used	2	15	17	HEC - GeoRAS	Not Used	Not Used	?	0
ArcGIS Desktop Standard	Not Used	Not Used	6	6	HEC - HMS	Not Used	Not Used	?	0
ArcGIS for Server Enterprise	Not Used	Not Used	1	1	HEC - SSP	Not Used	Not Used	?	0
ArcPad	Not Used	Not Used	1	1	Image Analyst for Server	Not Used	Not Used	1	1
ArcSDE	Not Used	Not Used	1	1	Lidar Analyst	Not Used	Not Used	1	1
Bentley Microstation	Not Used	Not Used	1	1	LP360	Not Used	Not Used	?	0
Canvas X	?	Not Used	Not Used	0	MapInfo 8	?	Not Used	Not Used	0
Corel Draw	Not Used	?	Not Used	0	Matlab	Not Used	Not Used	2	2
Creative Suite	Not Used	Not Used	32	32	QT Modeler	Not Used	Not Used	4	4
Data Interoperability	Not Used	Not Used	1	1	River Bathymetric Toolkit	Not Used	Not Used	?	0
Dreamweaver CS5.5	Not Used	Not Used	1	1	Spatial Analyst	1	?	13	14
ET GeoWizards	Not Used	Not Used	?	0	TerraModeler	Not Used	Not Used	?	0
Fladermaus	Not Used	Not Used	1	1	TerraScan	Not Used	Not Used	?	0
Flash Builder	Not Used	Not Used	2	2	**Grand Total**	**5**	**3**	**110**	**118**

Other than the gross counts of software licenses provided in the table, DOGAMI does not maintain an inventory of the versions and patch levels of the software running on the PC's in its offices, nor are they able to verify that it is properly licensed for all of the software it is running. This includes Microsoft server, and Office suites as well as the core security and backup packages.

DOGAMI should research avenues for cost sharing with other agencies for enterprise licensing of commonly used software. For example: DCBS is currently using an off-the-shelf software for managing professional licensing. This software contains a GIS module as well.

Many of the software packages in use appear to be licensed in bundles of one, five or ten users at a time. Most vendors offer so-called, "enterprise" licensing that allows unlimited use of the software and makes tracking and paying for licensing much more convenient. Most state agencies use this model. If DOGAMI is unable to afford these themselves, they could consider working with the state or other agencies to cost share on enterprise licensing.

In the last year, DOGAMI placed three requests with ETS for assistance in managing and troubleshooting their Exchange messaging system. Though DOGAMI is not an Enterprise Email customer, ETS has provided assistance in troubleshooting issues upon request. These requests

server as additional examples of DOGAMI's need for dedicated IT personnel and also the finding that the agency should outsource such "commodity" IT services.

1. *MLRR cannot receive email from other state agencies* – While investigating with Ken Aaro, Ken made changes to the whitelist and the issue resolved, though the root cause was not identified.
2. *Assist DOGAMI with CENDIR* – DOGAMI was stamping all CENDIR objects with their own domain name and rerouting emails. This is not the proper way to handle email routing. ETS contacted Ken Aaro and he cooperatively reconfigured CENDIR for more efficient routing.
3. *Give Login and Access to DOGAMI for State Phone Book Editor* – Request was approved and completed.

The MLRR Program uses a Microsoft Access database built in-house by Ed Buchner in the Albany office. Although this database offers a vast improvement over the paper-based permitting and licensing process used in the past, it is still quite limited. This core, line-of-business application has the following risks:

- Microsoft Access' inherent software limitations prevent MLRR from moving forward. It does not allow fully functioning and reliable multi-user access, nor are there current, supported methods for integrating it with websites.
- The technology itself does not perform well with complex data structures like those required for the MLRR's program.
- There is a single point of failure with the database: only Ed Buchner knows how it is built and how to maintain it.
- Also due to the inherent limitations of the software, data integrity is not well-protected, resulting in high risk of data loss, manipulation and corruption.

There are off-the-shelf permitting and licensing products that are available to do the job that the MLRR Access database is performing. Many of the State's smaller licensing agencies are already using them and cost-sharing opportunities exist. DOGAMI should investigate and pursue this option as a high priority to replace the Access database.

The agency's deficiencies in its software management processes and policies highlights their need for an IT specialist in-house and their need for assistance with procurement. For example, an IT person conducting oversight would flag as requiring immediate attention the lack of licensing, updates and support for the critical security and backup software suites. In addition, procuring group licensing is a standard operation for most agencies, being readily available from the State's contracts with Dell and CDW-G.

4.2.5 Other IT Hardware

DOGAMI maintains a fairly standard collection of office printers and plotters of various brands; HP, Ricoh, Canon and Xerox. DOGAMI requires quite a bit of high-quality color printing because many of its reports contain map graphics. There are three large format plotters for printing maps and large projections, two in Portland and one in Albany.

DOGAMI possesses a large number of UPS devices for power protection for workstations in Portland, Albany and Newport.

There are a number of external USB hard drives and storage arrays that are used for temporary storage of Lidar and GIS data as well as transporting between locations. DOGAMI did not provide the assessment team with full inventory or use/movement logs for these devices. Such documentation was part of the request from the assessment team and all information gathered regarding the external storage devices were a result of visual identification and discussions with the DOGAMI staff.

4.3 Storage and Data Access

DOGAMI's core products and services largely revolve around very large sets of data that comprise very high resolution geologic and geographic descriptions of millions of square miles of Oregon's complex landforms. Recognizing and solving DOGAMI's gaps in their storage and data access architecture are key to putting the agency on a sustainable future path.

The recommend storage system should have the following attributes:

- A storage system that is flexible and can grow to accommodate DOGAMI's storage needs.
- A single, unified storage system that implements data deduplication.[16] Data is currently spread across 13 server-attached storage sets.
- The ability for each office to readily access and use the central storage.
- The ability to reliably transfer the large data files between offices and to be able to electronically distribute products to the public and customers.
- A reliable, documented backup and recovery process for all data.
- Documented user access and controls.
- Documented roles and responsibilities for data management.
- Database backend and appropriate user interface for data management and integrity.

4.3.1 Storage Capacity

Because of the gaps in staffing, finance and budget that are described in this assessment, DOGAMI has perpetually been in a reactive state with regards to how to organize, manage and deliver its data dense products to its customers and the public. The problem begins with the agency's storage resources.

The agency uses a combination of server-attached storage, network accessed storage (NAS) devices and loose, USB hard drives.

The storage attached to all servers total 147 TB. But each server only has access to the capacity of its own drive array. Sharing large data sets between servers is technically clunky, slow and often cannot allow the functions some software need, e.g. all the data on one logical drive.

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[16] Data deduplication is a mechanism whereby a file can be used or referred to many times but is only stored once. The simplest example is an enterprise email system in which a large attachment is sent to 20 recipients. Instead of making 20 copies of the attachment, a single copy of the attachment is stored as a reference point for each recipient to read or copy only as necessary.

Thus the GIS server cannot easily be configured to pull data from the three separate servers that all house Lidar data.

Several external storage drives are used for multiple purposes. Albany and Portland use external storage devices as part of their backup solution. Newport uses an external storage device to store data received from various contractors and institutes. Albany and Newport both use external storage devices to ship/receive data to and from the Portland office regularly. Portland currently has 15TB of Lidar data on an external storage device that cannot be used until more Lidar server storage becomes available. (The three separate Lidar currently are at their 45TB capacity).

See Figures 2 and 3 in Section 4.3.2, Data Transfer for more detail on servers and the storage architecture.

As mentioned in Section 4.2.2, IT Systems and Hardware, DOGAMI maintains 13 physical servers in Portland, 3 in Albany and 1 in Newport that all store and process data. Two servers are end-of-life and are ready for decommissioning. The storage is attached to each server as well as on external storage devices and a Network Area Storage (NAS) device in Albany.

The capacity of DOGAMI's storage devices are full and do not meet the needs of the business. The current processes used by DOGAMI requires all data to be transferred to a drive on a server. The staff will then make copies of the data and move to another server, a workstation or onto an external storage device. This method requires more overhead for each device (server and other) to store data. (*See need for deduplication, above*.)

The current storage capacity of 123 TB through physical server drives and noted external storage devices. An additional 60 TB is needed in the next year for incoming Lidar data. An estimated additional 10 TB is needed for application and staff use of data processing in the next year.

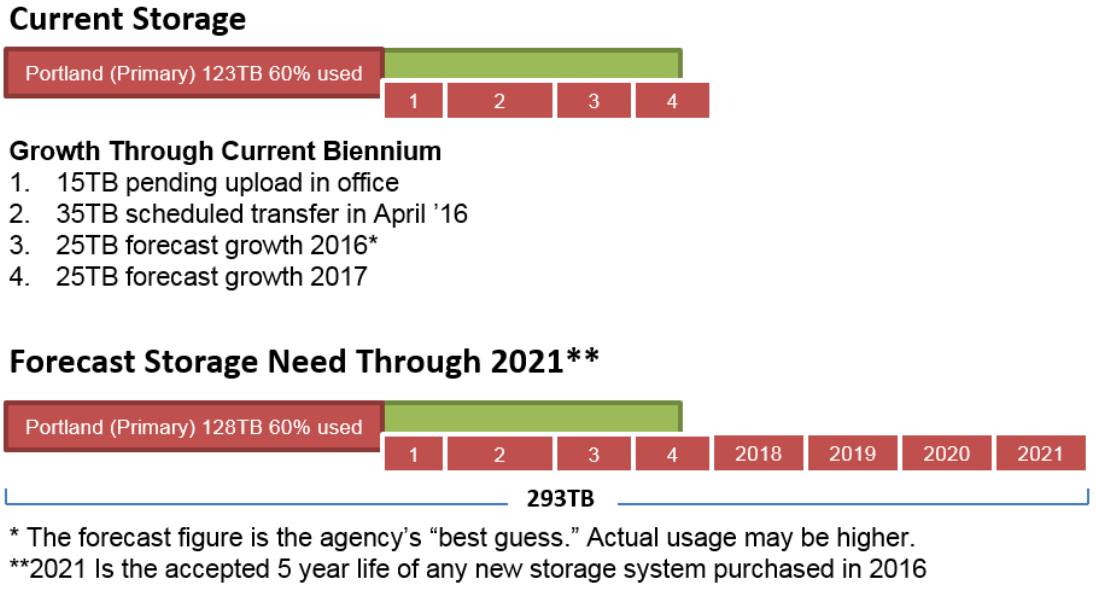


Figure 1: DOGAMI Current and Projected Storage Needs

According to their records and our investigation, a "best guess" is that DOGAMI is in need of up to 100TB additional storage to support operations and estimated growth through the end of 2016. DOGAMI does not have historical data regarding storage use to develop an actual trending number specific to their business needs.

The need for large amounts of data is a common requirement of many businesses handling GIS and Lidar data simply due to the nature of the large data and technical advances allowing more data to be collected with better tools and processes. The applications used to process the data and storage for the staff to save files also requires additional storage.

The current server-storage architecture is a technological and maintenance dead-end. It cannot be efficiently or economically scaled up any further. A future model will require the agency to redesign both its compute (server) and storage architectures in order to implement more efficient storage systems (unified storage) and deduplication processes (no multiple copies, software defined deduplication).

4.3.2 Data Transfer

The problems of delivering digital products to both its paying business partners and the public include the proper storage and a secure public interface via a server. These two audiences require different products. The business partners require raw Lidar data and the public wants useful, human-readable map products. The public audience require a web interface with searchable results and downloadable libraries in human readable form.

Figure 2 illustrates the complex architecture of DOGAMI's Lidar systems, showing the transfer of Lidar data from the contractor to DOGAMI offices and the limited Lidar data available to the public.

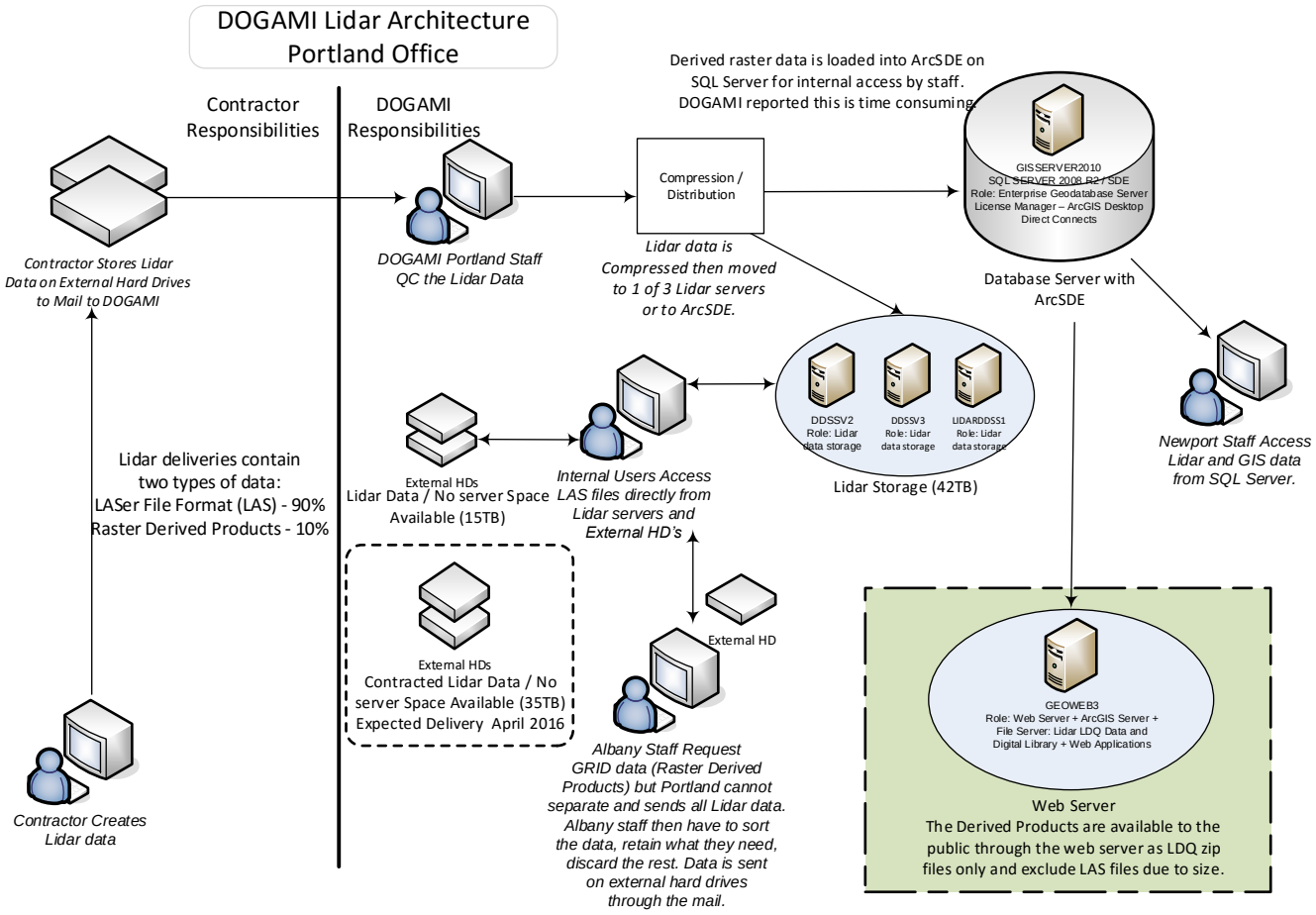


Figure 2: DOGAMI Lidar Architecture – Depicts the Transfer of Lidar Data from the Contractor

Figure 2 above depicts the flow of Lidar data from a contractor, how it is then stored, processed and disbursed to the various users. Please note the first step is compression, not be confused with deduplication. The data must be separated according to Lidar and GIS formats then moved to the next resting point. Internal users will access the data they need directly through Portland office storage.

Because the data sets are so large and the bandwidth between the offices is not and is not expected to be sufficient for electronic transfer, the Albany staff have to rely on the Portland staff to copy the Lidar data onto an external hard drive and mail the Lidar data to Albany. The Newport staff access the smaller GIS data sets through their highly inefficient VPN connections. [17] The public accesses the GIS data through the GEOWEB3 server located at the PSOB after the Portland staff have made it available.

[17] See Section 4.2.3, page 24.

Lidar data comes in two parts: 1) the raw data in LAS files comprises 90% of the volume of the data and 2) Raster Derived Products (so called because they are human-readable image files derived from the raw data) comprise the other 10%. DOGAMI staff performs quality control (QC) on the data before uploading it to one or more of the agency's servers. Raster Derived data is uploaded to the ArcSDE server which resides in an industry standard SQL database that is linked to the web server, while the LAS files go to one of the three physical servers that house the Lidar data for staff use.

Much of the raw data DOGAMI uses is produced by contractors who fly a specialized Lidar collecting aircraft. That data is delivered by a physical hard drive to DOGAMI.

Those Lidar servers, as previously explained, are at or near (>80%) their storage capacity. DOGAMI's contractual agreements with their business partners require specific projects to be completed by agreed-upon dates[18]. *DOGAMI is in jeopardy of breaching of contracts without additional storage.* The DOGAMI staff are already behind with the contractual work because 15 TB of Lidar data is not accessible due to lack of internal storage.

The difficulties in making Lidar data available are not unique to DOGAMI, but are faced by any agency or company responsible for Lidar data distribution.

Because working copies are just as large as the original files, the non-Lidar servers and workstations also require copious of storage. The working copies are disbursed throughout the remaining servers and workstations as the staff need.

DOGAMI is currently hosting its web site, www.oregongeology.org on premises in the Portland office. There is a security issue with having the web server (GEOWEB3) hosting the files on the same logical network. The risk of a data breach is much greater when the public can access a system within the same logical network as all of the other agency data. A bandwidth problem also exists for DOGAMI as it moves towards digital distribution of more and more data. It is possible that as DOGAMI does that, it could impinge on the 1GB data connection that is shared among all of the PSOB tenant agencies.

[18] See Section 3.2.1, page 10.

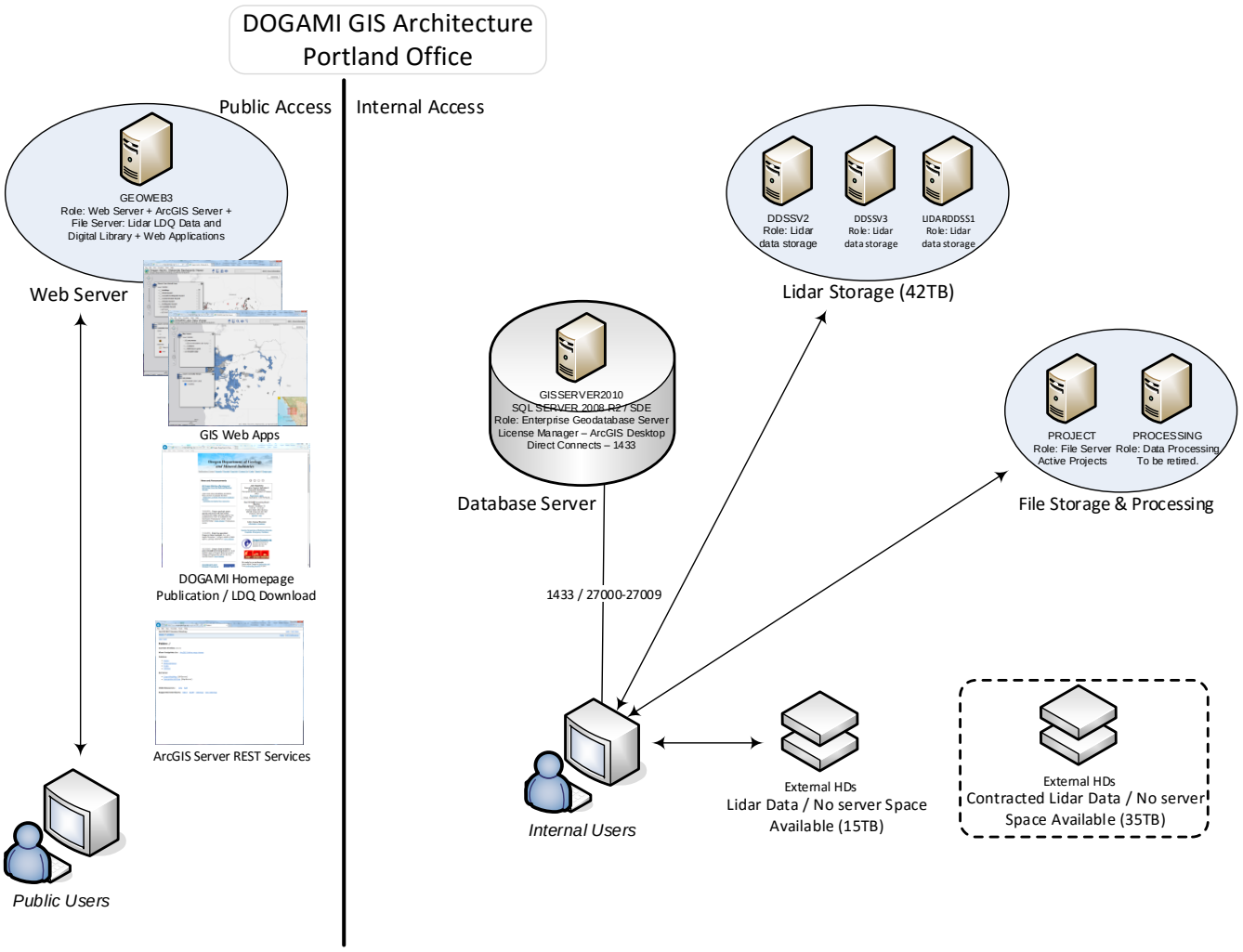


Figure 3: DOGAMI GIS Architecture – Comparison of Public Access and Internal Access to GIS Data

Currently, DOGAMI distributes most of its Lidar and GIS data via physical hard drives shipped to both business partners and sometimes, if the requested files are large enough, to the general public. This is a process that is very inefficient for both staff and customers. But if DOGAMI were to go to an all-digital distribution model, it would present the following problems:

- Link even more of its data to the website (a security problem in the current setup)
- Multiple download sessions on the website could congest the shared circuit in PSOB, affecting other State of Oregon agencies in the building. If DOGAMI were allocated a specific portion of the 1Gigabit circuit, then they potentially would not have enough bandwidth to serve the files in a way that meets customer expectations.
- Albany, Newport and Baker City offices do not have enough bandwidth to receive the data through their existing circuits.

4.4 Summary of Operational and Technical Deficiencies and Gaps

4.4.1 Gaps in IT Business Operations

As part of the assessment the following gaps between DOGAMI's IT business operations and industry best practices were observed. These gaps include the areas of IT business structure, policies, practices, management and staffing, funding and expenditures and IT Governance.

1. DOGAMI does not have formalized IT policies and procedures. They are particularly deficient in the areas of:

    a. IT Service Continuity: No business continuity or disaster recovery plan or policy either for a large incident or for a hardware failure of a critical server. (the backup and recovery software is not tested regularly)
    b. Information Security Management: No network and end user security policies. No acceptable use policies or controls over the many loose storage devices.
    c. IT Asset Management: Lack of hardware inventory and of software licensing and support records.

2. DOGAMI has no formal IT governance structure, policy or documentation. Based on our interviews of staff, IT decisions at both the strategic and the day-to-day levels are made on an as-needed basis by combinations of the DOGAMI stakeholder involved, agency management, Rudie Watzig and Ken Aaro, the agencies contracted IT expert. The Strategic Plan on DOGAMI's web site was not mentioned as an actively used resource and the Strategic Plan does not reference IT.

3. DOGAMI's staff is made up of many ISS classified employees who do not possess formal IT skills and training for the ISS classification. Instead, the ISS positions are used for GIS specialists. This does not appear to be willful on the part of DOGAMI but rather is a historical HR issue that the agency is working with DAS HR to resolve.

4. DOGAMI doesn't have any FTE individuals in the IT management/systems expert or general IT support roles. The current method of using staff part-time and a contractor been demonstrated to be insufficient and unsustainable.

5. DOGAMI was unable to provide the assessment team with detailed reports on their IT expenditures.

6. DOGAMI management and finance staff have insufficient knowledge of the State's procurement policies and procedures. They require education in these matters if the agency is to move towards being able to manage not only their IT but the agency's business in general.

4.4.2 Gaps in Current Operating Systems/Software

The assessment team identified the following gaps in IT best practices as it gathered data for an inventory and analysis of DOGAMI's computers, servers, network architecture and software licensing:

1. Desktop computers and laptops are heterogeneous and most desktops in use are custom-built. This contributes to the following:
    a. Adds complexity to maintenance and procurement process.
    b. Poses a risk of lost productivity due to additional time required to repair.
    c. Increased security risk without automated patching and updating.
2. DOGAMI does not keep accurate records of the patch levels of desktop operating systems, server operating systems or of key applications. This is a risk for security.
3. The "server room" in Portland lacks the following items which present an elevated security and data loss risk:
    a. Lack of physical security.
    b. Insufficient building or room HVAC. *Cooling is performed by a portable air conditioning unit that drains condensation into a garbage can. This can must be emptied frequently, including on weekends or holidays.*
    c. No redundant power circuits in the building. No auxiliary power for either the building or the room if utility power is lost.
4. A single server runs the Microsoft Active Directory Domain Controller and Microsoft Exchange messaging. This configuration is extremely discouraged and contrary to Microsoft best practices. There is an elevated risk of lost productivity and/or data loss in this configuration.
5. The storage configuration is less than optimal with RAID 5 being standard. Backups are done nightly, bi-weekly, and monthly on site, depending on the system, and quarterly off-site for a select data set. This presents a data loss risk.
6. The core network devices (routers, switches and firewalls) do not meet State best practices. The configurations and patching levels of these devices have not been audited for this assessment.

    Note: The Portland network edge equipment was replaced with a SonicWall appliance in the midst of this assessment.
7. The IT contractor is presumed to be providing the configuration and maintenance of the security devices in contravention of State policy.
    a. The contractor understands the limitations of addressing security configurations for DOGAMI as expressed in interviews.
    b. The contractor deployed the SonicWall device in cooperation with DOGAMI staff. It is currently being used for routing/switching and as a firewall.

8. Remote offices (Albany, Baker City and Newport) utilize end-user VPN connections to provide a secure connection to Portland.
    a. The built-in Microsoft VPN service limits the staff from access to local systems while the VPN tunnel is in use, decreasing productivity.
9. The agency makes common use of external hard drives for data transport and temporary storage, but inventory and use logs were not provided.
10. DOGAMI appears to license software in small bundles. This adds to administrative overhead and is probably more expensive than enterprise licenses.
    a. Not all DOGAMI offices use the same software versions.
11. The MLRR Program uses a Microsoft Access database as its database application for permit data. MS Access:
    a. Does not allow for concurrent multi-user access;
    b. Cannot be interfaced with web services for an online permit renewal solution;
    c. Does not have inherent data protection;
12. The MLRR Access database was developed in-house by a single individual. If that person were to leave, the agency would have a very difficult time maintaining and supporting the application. This is a productivity and data loss risk.
13. DOGAMI has already outgrown its storage capacity and is having increasing productivity issues due to this.
14. The web server used for public-facing services is a single system with many roles. A server used in this manner presents risk for failure during configuration changes, testing and maintenance tasks.
    a. The likelihood to restore or rebuild a like server is very low due to complexity.
    b. The likelihood of server failure is great due to the extreme workload on the system.
    c. No test environment increases risk of an outage during server modifications.
15. The architecture of the agency's Lidar storage system is inefficient as follows:
    a. The data structure is an inefficient use of the available storage and makes it difficult to find and use the data.
    b. Searching, accessing and transferring the data to customers and the public is more difficult

4.4.3 Gaps Relating to Business Goals/Objectives

The following is a list of key areas of concern where IT gaps can prevent DOGAMI from meeting both short- and long-term agency goals and performance metrics.

1. The current MLRR database cannot support the program's goals and mandates to:
    a. Migrate to a paperless registration and licensing system;
    b. Develop an online license and inspection process;
    c. Support the goal to allow inspectors to work remotely in the field without original paper documents.
2. The current storage capacity will not allow the agency to complete its digitization of all of its older paper records, including the MLRR Programs extensive paper documentation library.
3. The full storage on the Lidar servers threatens to delay project completions putting the agency at risk of breach of contract.
4. There are no IT Service Continuity plans in place to ensure that IT Services can recover and continue should a serious or minor incident occur.

5. Recommendations

5.1 Summary

The agency has been making honest, good-will attempts to do the best with what they had and are willing to learn new processes.

Understanding and support from the OSCIO and the Legislature will be of the most value to assisting DOGAMI with improving the business. As disorganized as DOGAMI's IT systems, process and spending have been, much of that has been due to a lack of budgetary support and misunderstanding the procurement processes. Putting the agency on the path to an efficient and sustainable future is going to require that the agency's IT budget rise to a level appropriate for the central role that IT plays in the agency's delivery of its core services. The agency will also require teaching/training opportunities in order to learn State of Oregon procurement procedures.

Our recommendations are broadly that DOGAMI:

1. Request that inclusion of two FTE actual IT personnel

2. Request the support of the OSCIO, LFO and ETS in working with DAS Procurement to educate itself on state purchasing and procurement regarding not just IT but generally. And to also work to develop more mature IT and business processes and policies in order to mitigate risk and develop operational efficiencies.

3. Divest itself of the daily maintenance and running of hardware and software that are not directly required for the agency's mapping and geospatial data processing needs. This

could come from a combination of outsourcing or partnering with other State entities or completely outsourcing to authorized vendors such things including (but not limited to):

a. Email and messaging services.
b. Local and Wide Area (LAN/WAN) network management.
c. Development or off-the-shelf purchase of MLRR licensing database.
d. Web services development and management, including file transfer services and website hosting.
e. Backup and disaster recovery services.

4. Develop a storage management and distribution architecture modeled around the best practices for Lidar data management outlined in Appendix C. Focus DOGAMI's IT operations on the agency's core business, the organization and processing of geospatial data. That plan should include (but not be limited to):
    a. Building a virtualized server environment for those server functions not outsourced above.
    b. Building the server environment around a flexible, expandable storage technology that can utilize deduplication technologies.
    c. Housing this infrastructure not in the PSOB but in a location where providing 1GB or better throughput to the local network is cost effective and where proper security, HVAC and power protection can be provided.
    d. Provide connectivity to outsourced web services for distribution of the agency's products.
5. To develop a plan and budget for implementing 1-4 above and to present same to the Legislature for the 2017-19 biennium for a reassessment of DOGAMI's IT budget so that it can implement these steps.

5.2 Specific Recommendations

5.2.1 Create Positions for IT Professionals in DOGAMI

The agency needs appropriate IT staffing so that it can produce the budget, plans, procedures and processes for running its IT operations in a safe, stable and efficient manner for DOGAMI employees and for the customers they serve.

The assessment team supports the realignment of the job classifications for the 11 current ISS individuals into natural resource specialist or other appropriate job classifications. Two actual technology FTE positions should be provided for the agency. These should be:

a. A high-level IT subject matter expert capable of helping with planning, budgeting, policy and process development as well as advanced operational support.
b. A mid-level technician to assist with the day-to-day operations of desktop support, patching, backups and storage and GIS system maintenance.

The migration path to the recommended "slimmed down" IT operation will be complex. These individuals will provide DOGAMI the resources it needs to proceed to a more sustainable infrastructure and to keep the in-house IT business running safely and efficiently.

5.2.2 Business and IT Policy and Process

DOGAMI does recognize the importance of having standardized policies and processes and is working on remediating these issues. It is recommended that DOGAMI continue that processes using three priorities as a starting point:

1. DOGAMI needs support and training from DAS Procurement for DOGAMI's management and financial analysts. Such support and training will help the agency and its leaders understand and work within the State of Oregon procurement policies and procedures to help the agency move forward, not just in the IT realm but across the agency's operations.
2. DOGAMI needs a formalized Business and IT Service Continuity Plan that is used to identify risks, threats, and vulnerabilities that could impact business and IT operations that might be caused by serious incidents or disasters. DOGAMI should appoint a team within the organization which can create, implement, and maintain the Business and IT Service Continuity Plan for all DOGAMI offices statewide.
3. The agency needs a formalized IT Asset Management policy and process. IT Asset Management is the set of processes and systems that involve the gathering of detailed information for IT software and hardware systems purchased by an organization. IT Asset Management is used to make decisions about the purchasing and redistributing of hardware and software. It can also provide cost savings by avoiding unnecessary purchases related to IT hardware and software.

Organizations that develop and maintain an effective IT Asset Management process avoid risks such as:

- Financial overspend due to the lack of information on current IT asset inventory
- System failures due to the end of lifecycle of IT hardware and software systems
- Delaying any projects due to the procurement of IT hardware and software

Deploying an IT Asset Management system will provide information for knowledgeable decision making regarding the IT systems and result in financial savings.

5.2.3 Divest DOGAMI of Non-Core IT Operations

As has been demonstrated, an agency of DOGAMI's size struggles to maintain all of the moving parts that a very data-intensive agency requires to perform its mission. Fortunately, this is not a completely unusual circumstance and there are ways for agencies to pare down to the IT essentials. This can involve leveraging inter-agency partnerships, State IT services or approved vendors to unload the overhead and maintenance of "commodity" systems from the agency.

1. Email Services: The most obvious choice would be the State's own Enterprise Email Services run by ETS. However, the State also has approved vendors such as BAE Systems that perform Exchange email hosting.

2. LAN/WAN Management: ETS provides both local and wide area network management for many state agencies. This service includes all configuration and support of the network as well as ongoing security management. It also relieves the agency of the periodic capital expenditure of replacing worn equipment.

3. MLRR Licensing Development: The State provides application development and web-application hosting services if DOGAMI wanted to develop and application from scratch. There are also state approved contractors that could be procured to work in-house on development. But the agency should first investigate whether there are existing off-the-shelf options that could be purchased and hosted either in the State Data Center at ETS or with one of the state's hosting partners, such as Atmosera.

   Additionally DOGAMI should look into working with other agencies that do licensing to see if cost-sharing arrangements could be made to the benefit of multiple agencies. For example DCBS is using a commercial professional licensing software system that does include GIS modules.

4. Web Hosting and File Transfer Services: For security reasons, the public-facing part of DOGAMI's operation should not exist on the same logical network as the rest of the business. For operational efficiency it probably does not need to be physically in DOGAMI's offices at all. Both the State and its vendors offer web and secure file hosting services. These could easily be integrated into the National Cooperative Geological MapProgram. Offsite hosting also would relieve any stress on the shared PSOB WAN circuit that DOGAMI shares with the building's other agencies.

5. Backup and Disaster Recovery: Both ETS and various State approved vendors offer a variety of server and storage backup options for state agencies. Moving the storage system out of the physical PSOB (as recommended below) building would allow this to happen over the wire without impinging on the building's other tenants. These outsourced systems offer much more granular and flexible backup, retention and restoration options than the agency currently has and would greatly reduce the risk of data loss that DOGAMI currently operates under.

6. Others: The agency should remain mindful that operating server and software infrastructure outside of geospatial data management is not its core competency or mission and continually assess opportunities to divest itself of the capital and operational expenses of maintain such systems.

5.2.4 Update Storage Capacity and Architecture

Much of the specifics of solving the agency's storage and architecture problem will be impacted by how well the agency does in implementing the best practices described in Appendix C

DOGAMI knows it needs to move to a unified storage system in order to better manage its data and also because only unified storage in the form of storage area networks (SAN) or network access storage (NAS) arrays can grow with the volume and flexibility that DOGAMI requires.

The agency has contemplated building their new system in their offices in PSOB, but as we have pointed out, that is a non-starter for a number of practical and policy reasons.

GIS and Lidar data is best stored in a network with a 1Gbps speeds for fastest data transfer due to the nature of the large files and the file types. Therefore, the storage system should be in a location with no network constraints between the storage and the end user.

One option that the assessment team has contemplated would be to place the storage system at the Pittock building in a leased rack. The network connection between the Pittock Building and the PSOB 9th floor can be provisioned at 1Gbps. Many backup providers are connected to the Pittock Building with large network connections and can support the backup and replication requirement. The Pittock meets the security requirements of the ESO regarding physical access.

Data breaches are a security risk for all storage devices. Physical security of the storage devices is a requirement. The security policies set forth by the ESO are good principles and strongly recommended. The location of the storage system should satisfy physical security compliance with State of Oregon security policies as follows:

1. Information Asset Classification – ESO Policy #107-004-050
2. Controlling Portable and Removable Storage Devices – ESO Policy #107-004-051
3. Information Security – ESO Policy #107-004-052
4. Employee Security – ESO Policy #107-004-053
5. Transporting Information Assets – ESO Policy #107-004-100

The Pittock Building concept outlined above would meet all of these requirements.

Regardless of where the new storage is situated, before DOGAMI moves to purchase a new storage system it should follow procurement best practices, to wit:

1. Consult with other agencies who have similar storage needs.
2. Develop a formal business case and have that vetted by the OSCIO.
3. Develop and RFQ and do a best value analysis on the responses.

While doing that, DOGAMI should track the data consumption quarterly at a minimum. The tracking should be used to produce trending of storage consumption and forecasting future storage needs. Without this information, estimating the storage needed to support DOGAMI's core businesses is at best, "a good guess."

The storage system should also have the following requirements:

1. A backup schedule with the data fully replicated off-site once per month and incremental changes replicated daily. The incremental data can be stored on site. The data retention should follow the State of Oregon retention policy.
2. RAID 6 or better configuration of the disks. This configurations allows for up to 2 disk failures without incurring any data loss.
3. Be accessible by all field offices
4. Logically separate publicly accessible data from production and staff data
5. Segmentation/stratification of data and storage

5.2.5 Future Planning

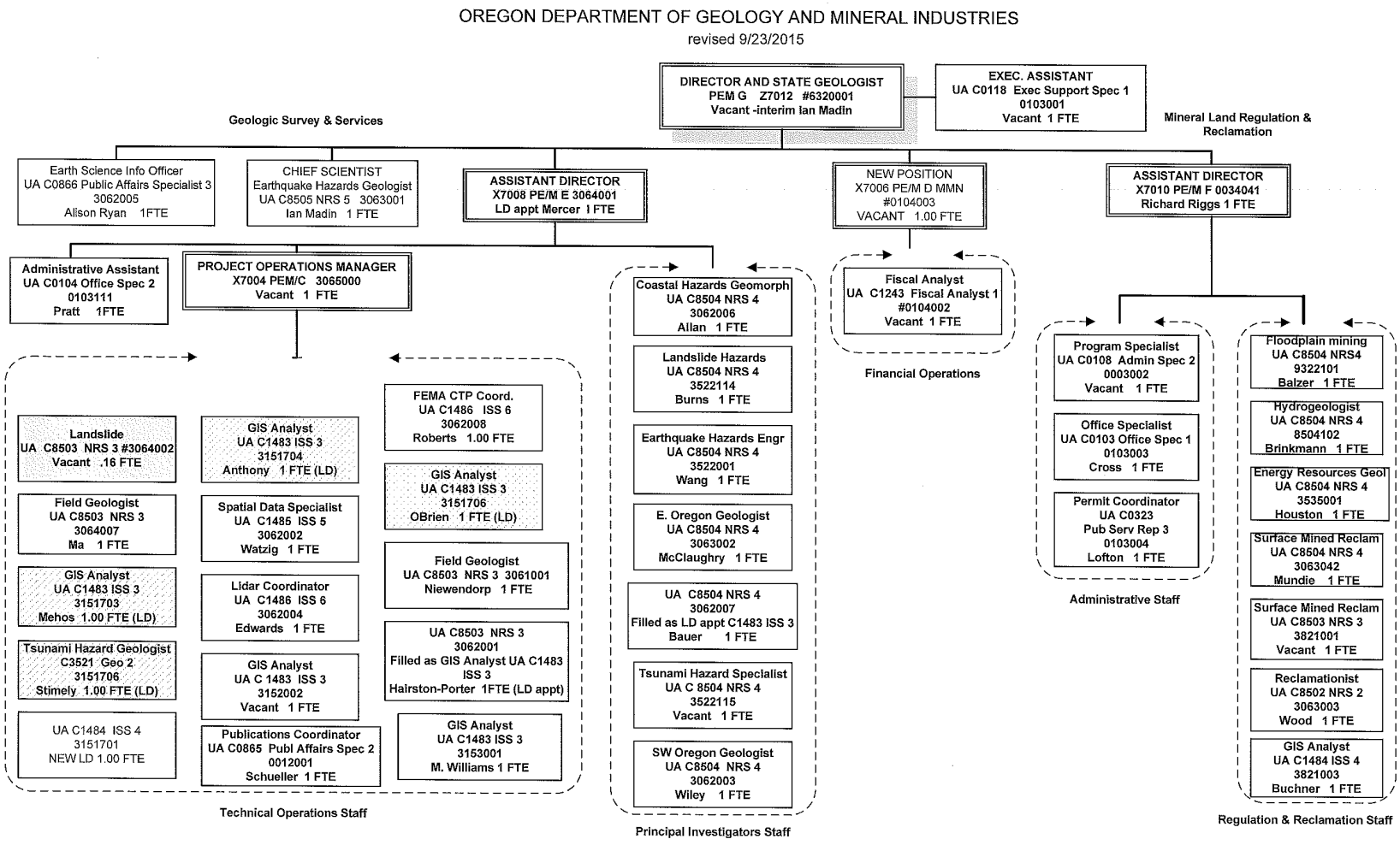
DOGAMI should closely monitor the efforts by OSCIO, DOJ and DAS to formulate a policy for the State of Oregon for the contracting and purchasing of IT services. New services and providers are added to existing DAS contracts and new contracts are created regularly. DOGAMI is encouraged to procure a new contract with a service provider that will meet their needs.

The OSCIO has newly developed and effective processes for acquiring new service providers, products and project implementation. These processes are recommended to be followed for the benefit of not only DOGAMI, but the entire State of Oregon as a whole.

DOGAMI has produced a Strategic Framework document to guide it through 2021. Developing tactics to reach the goals stated in the Framework would assist with correlating future decisions and directions to the Framework. This correlation will support meeting the goals and produce the desired outcomes of serving Oregon.

Developing an internal technical roadmap will assist DOGAMI with future decisions regarding technical changes and purchases. As technology advances, IT systems will change as well as how the systems are used. A technical roadmap will assist DOGAMI by identifying what their IT system looks like today versus what it should look like in 5, 10 or 20 years from now. The roadmap is then used to further identify work efforts needed to travel the road and get to DOGAMI's final destination.

Appendix A – DOGAMI Organizational Chart

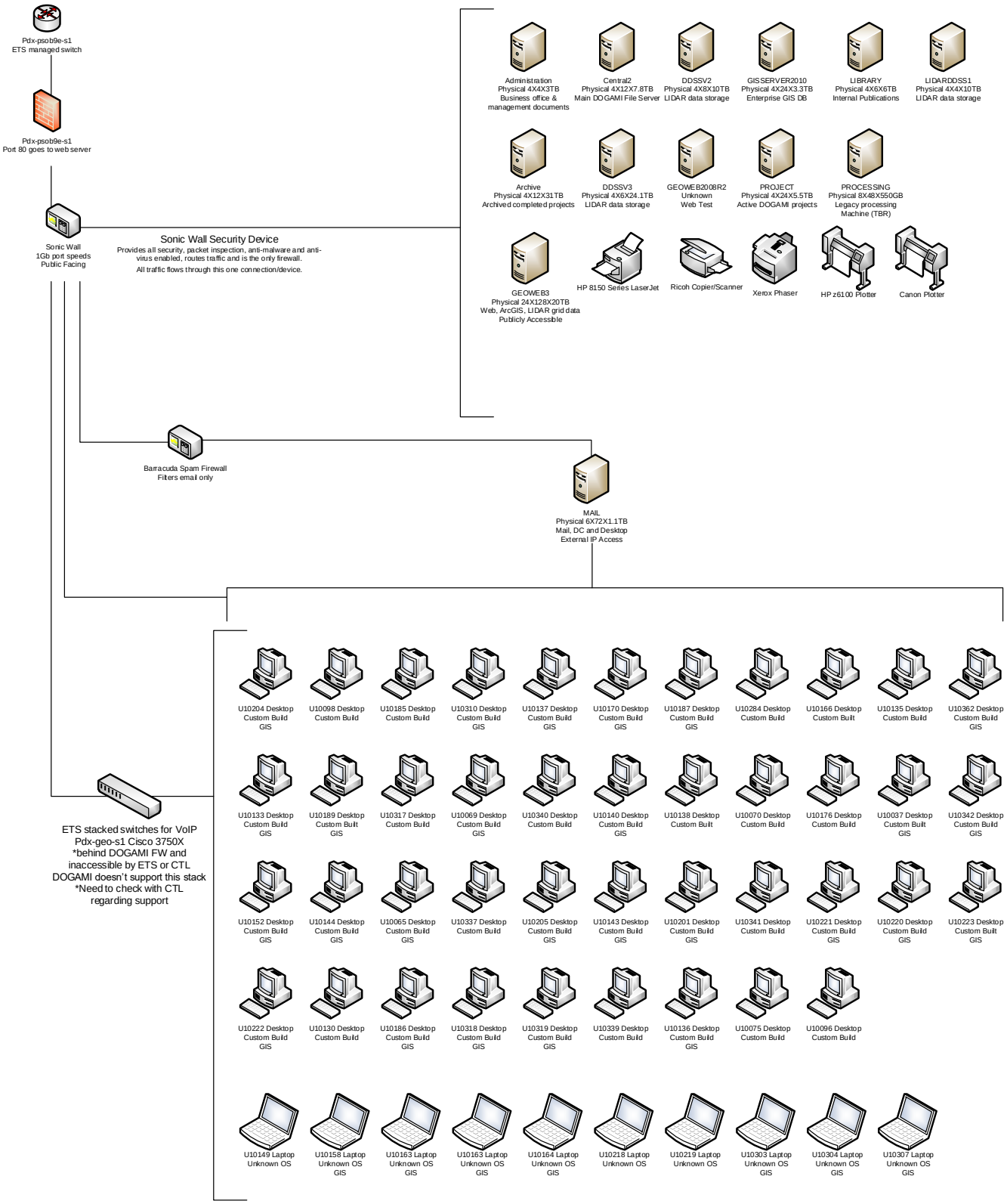


Appendix B – IT Systems Inventory

Portland Office
Currently, Portland makes use of:

- 13 physical servers. One of the physical servers is a host for a single virtual server using Microsoft Hyper-V. 1 server was deployed in 2007, 2 deployed in 2009, 5 deployed in 2010, 1 deployed in 2011, 1 deployed in 2012, 1 deployed in 2014, 1 deployed in 2015 and 1 doesn't have a deployed date listed.
    - Of these servers, 10 need to be replaced due to lifecycle replacement.
    - Replacing servers will be a challenge due to physical nature and undocumented access, support and dependencies.
    - Intend to retire a specific server but cannot until resources are available to migrate the applications and data elsewhere.
    - The single virtual server is GeoWeb server and has licensing constraints. They need the data center license but cannot find money in the budget for the more expensive licensing. No other virtual servers can be deployed on this physical host.
- 42 desktop computers, of which all are customer built and running Windows 7
- 11 laptops, of which no model or operating system information was provided
- 5 network switches: 1 from ETS to provide WAN services, 1 from ETS for voice services, 3 Cisco RV402 with maximum 100Mbps port speeds
- 1 network router: Cisco 8-port router
- 1 Barracuda firewall device on site
- Use of ETS state border firewall services within the SDC
- 5 Printers/Plotters: 3 printers, 2 plotters, no known acquisition date
- Numerous UPS (Uninterruptable Power Supply) throughout the infrastructure
- Several external hard drives
- 123 TB of direct attached storage drives to the physical servers
- Several external hard drives that have not been documented yet

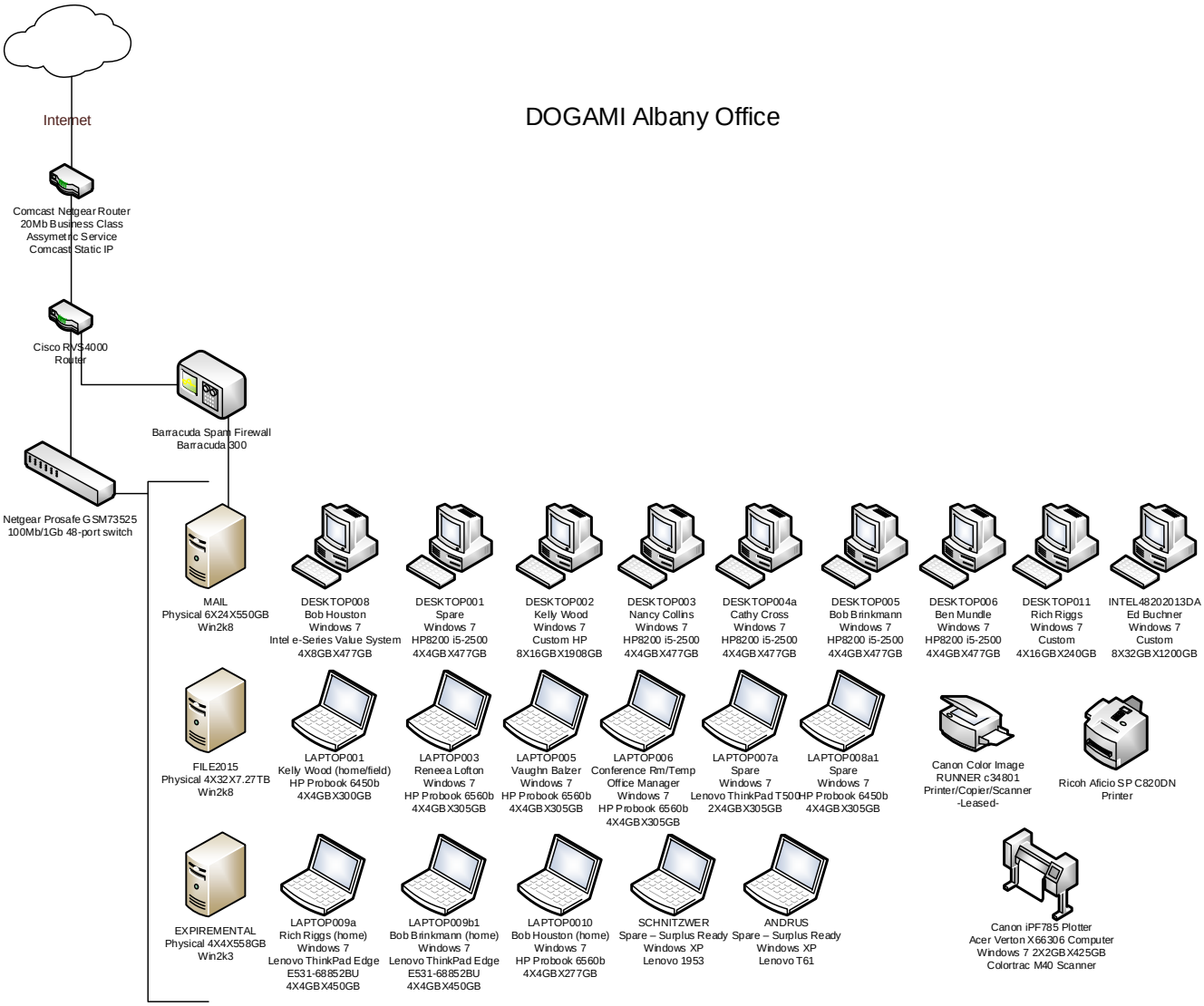
DOGAMI Portland Office



Albany Office

Currently, Albany makes use of:

- 3 physical servers. One of the physical servers is rarely used and could be decommissioned, running Windows 2003 Operating System. The other two are running Windows 2008 R2 and used for Mail/Domain Controller and a File server. Each are a SuperMicro 6027 Series Smart Server and purchase date is unknown.
- 9 desktop computers, of which 5 are HP models, 1 an Intel and 3 are custom built. All desktops are operating with Windows 7
- 11 laptops: 6 HP Probooks and 5 Lenovos. 2 of the Lenovos have Windows XP and are ready for surplus. The Albany office has decided to keep them in case some of the older GIS/Lidar applications they use need accessed but are so old, the newer Operating Systems are compatible with the applications. These older laptops with Windows XP are then used.
- 2 routers, one for the Comcast connection and another for internal routing
- 1 switch for internal connectivity
- 1 Barracuda firewall – proper use and deployment was not confirmed. This firewall was placed separate from the network gear near the server with once Ethernet cable extending to the network router.
- 3 Printers/Plotters: 2 printers of which 1 is leased and the other purchased 2/2015, 1 plotter purchased 12/2011.
- 7 TB of storage attached to the single physical server on site
- 5 TB or more of storage with a single NAS and several external hard drives

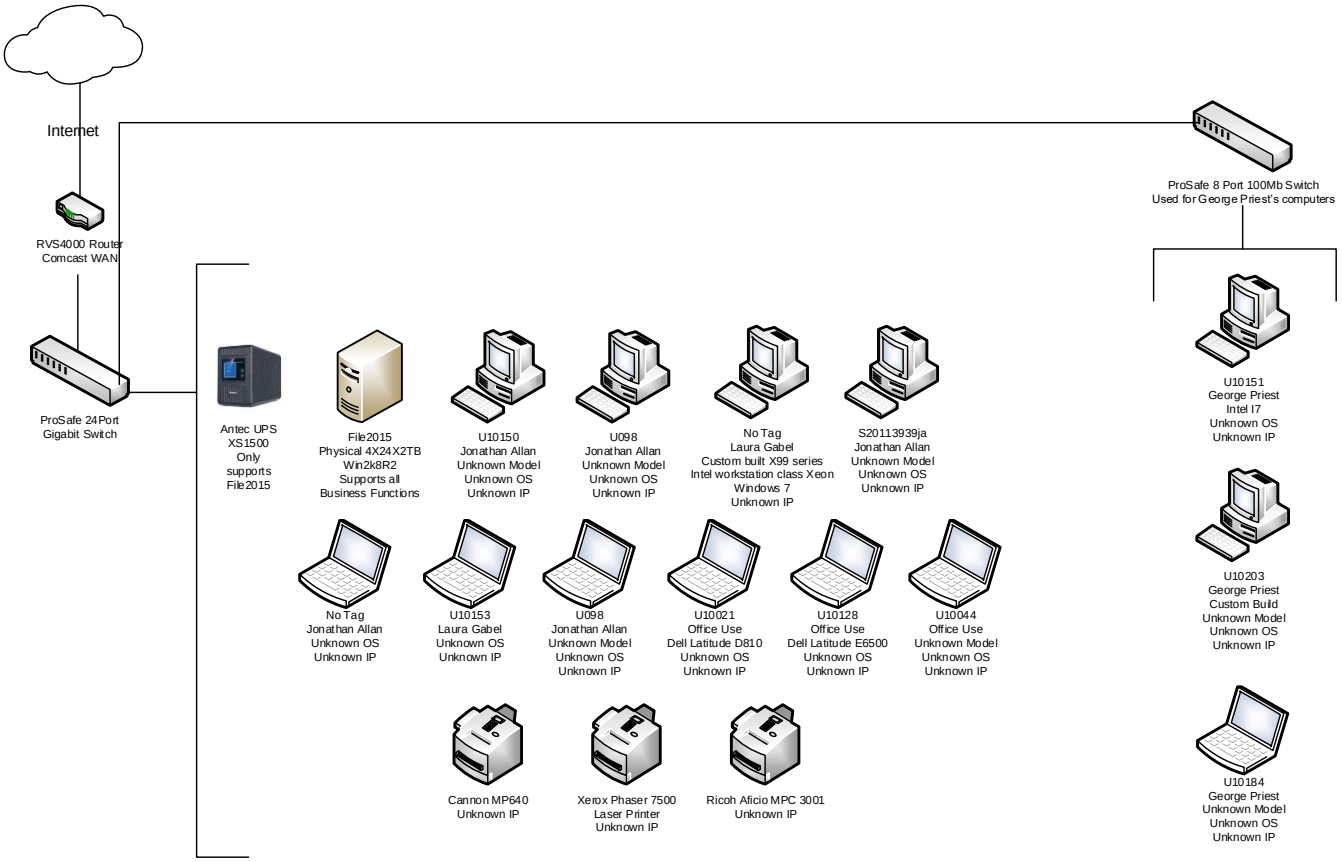


Newport Office
Currently, Newport makes use of:

- 1 physical server to support file, email and storage services
- 6 desktop computers, of which 3 are unknown models, 1 Intel and 2 are custom built. The operating version is unknown. 1 laptop is being replaced with a desktop currently.
- 7 laptops: 4 are unknown models and 3 are Dells.
- 2 network switches. 1 is confirmed use for internal routing of the LAN, the second cannot be confirmed in production or purpose.
- 1 network router to bring in a Charter WAN connection.
- No known security devices on site

- 2 Printers: Unknown purchase dates but 1 was gifted from a neighbor business that moved out and the Newport office has not yet started using it.
- 17 TB of storage directly attached to the single physical server
- 11.7 TB of storage using external storage arrays of which one is connected using outdated USB 2.0.
- A single UPS on site

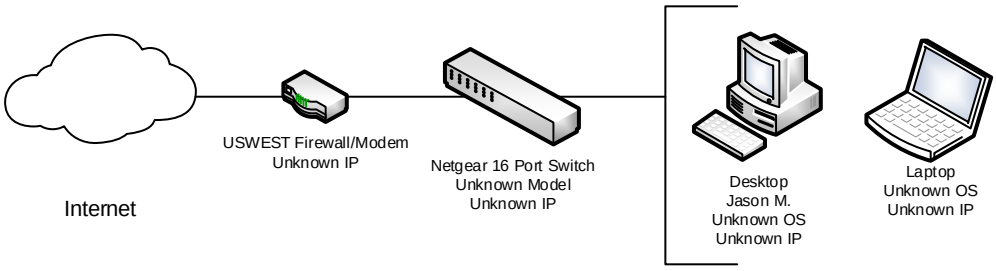
DOGAMI Newport Office



Baker City Office
Currently, Baker City makes use of:

- 1 desktop computer, of which the age, model and operating system is unknown.
- 1 laptop of which the age, model and operating system is unknown.
- 1 network switch with 16 ports
- 1 DSL modem for WAN connectivity

DOGAMI Baker City Office



Appendix C – LIDAR Data Storage; Current State and Best Practices Recommendations

Current Lidar Storage and Practices:

Typical Lidar deliveries received by DOGAMI contain two kinds of GIS data:

LASer File Format (LAS) data, and raster derived products. The LAS data are vector point clouds. The derived products are usually in GRID and TIF format, and include derived products created from the LAS data, such as Digital Elevation Models (DEM) of Bare Earth, Highest Hit GRIDs and Intensity TIFs. LAS files comprise at least 90% of the total storage size of any Lidar delivery. A 10 GB Lidar delivery will be at least 9 GB LAS and 1 GB derived raster products.

The difficulties in making Lidar data available are not unique to DOGAMI, but are faced by any agency or company responsible for Lidar data distribution. The industry is attempting to deal with the prohibitively enormous file sizes Lidar produces using compression. DOGAMI has implemented compression and file sizes would be much larger if the data were not compressed.

DOGAMI has an immediate need for about 100 TB of storage for Lidar data. Current server capacity provides 42 TB of storage. An additional 15 TB of data are stored on external hard drives. 35 TB of data are under contract to be delivered by April 2016. Additionally, DOGAMI anticipates an average of 25TB extra Lidar being delivered each year. Any recommended storage architecture needs to scale appropriately.

Lidar data comes to DOGAMI from contractors on external hard drives. As space is available, the data are uploaded onto designated Lidar storages servers, grouped by contracted delivery. Some QC of the data done directly from the external hard drives. Copies of the data are placed on other servers as needed for project work. Derived raster data is loaded into ArcSDE (Spatial Data Engine) on SQL Server for subsequent access by internal staff. DOGAMI describes the process of managing and importing the data into SDE as time consuming. At this time the filenames in SDE do not indicate project lineage. The data in SDE are then organized spatially by County as Mosaic Datasets. County Mosaic datasets will consist of different deliveries through time, sometimes with different projections and units. Additionally deliveries overlap each other and county boundaries.

A Mosaic Dataset is an industry standard database for organizing and working with imagery and raster data, and is a pointer to the raw source data wherever it resides. Data are accessed by staff internally using Esri Layer files. Layers files are files that link to data and symbolize it in predetermined ways. The LAS data are not put into SDE. LAS must be obtained directly from the Lidar storage servers or external hard drive.

Current GIS Architecture:

Lidar data (compressed LAS and derived products) are stored a series of small servers that have been acquired over time as needed: LIDARDDSS1, DDSSV2 and DDSSV3. These 3 servers provide 42 TB of storage. An additional 15 TB of Lidar data remain on external hard drives. ArcSDE with a SQL Server 2008 R2 backend is used to store the Lidar derived rasters. Internal staff access the raster data typically through connections to SDE. GISSERVER2010 hosts SQL Server and SDE. DOGAMI uses Esri's ArcGIS Server software to make some of its data available as

(REST) web services for public facing applications like the Lidar Data Viewer. Some REST services are based on Lidar derived products such as Hillshade, and are primarily for basemap viewing purposes in web applications. Recently acquired GISWEB3 hosts ArcGIS Server. GISWEB3 is a single point of failure that has many roles. In addition to hosting the ArcGIS Server web services it hosts all the DOGAMI web applications, and is a general web server for the LDQ Lidar data, the DOGAMI website and the DOGAMI digital library. A small project file server named PROJECT server hosts current projects and a small and soon to be retired server PROCESSING is used for minor GIS processing. The majority of data processing is done at staff workstations.

Current Public Download Options

Lidar data is hosted in zipped LDQ format for external download by the public. Individual LDQ files can be up to 5 GB in size. LDQ are tiled by 7.5 minute quad. The LDQ data is are posted and available by either a text search (http://www.oregongeology.org/pubs/search.php), or as a clickable link in an iterative map viewer, the Lidar Data Viewer (http://www.oregongeology.org/dogamiLidarviewer/).

LDQ zip files contain only the derived products, GRID DEM for Bare Earth and Highest Hit, Intensity TIFs and Shapefiles. LDQ downloads exclude the LAS data because of the size of the LAS files. An example LDQ is posted here: http://www.oregongeology.org/pubs/ldq/LDQ-2009-CampCreek-Bundle1.zip Finding a way to post all the LAS Lidar data is and will continue to be challenging because of the extremely large file sizes. There is a backlog of data not in LDQ format. The last LDQ products were put together about 2.5 years ago. Public LDQ postings do not reflect all the Lidar data DOGAMI has in-house. LAS is not currently available for download anywhere on DOGAMI servers.

Some LAS was posted on third party servers when DOGAMI pursued free hosting by NOAA. However the storage sizes became too large and they were not able to continue sending data to NOAA. About 1250 GB of data are hosted at https://coast.noaa.gov/dataviewer/?redirect=301ocm&keyword=Lidar#app=b23b&bda3-selectedIndex=0 This is just a small fraction of the current Lidar holdings of DOGAMI.

LAS is also distributed to the public via copying to external hard drive. Some LAS file can be 20 to 100 GB per file. Hard drive copy is time consuming. DOGAMI says the only way they transfer LAS files right now is via external hard drive. They have processes about 270 LAS requests via external hard drive in 2 years.

Best Practices: Lidar Data Management, Storage, and Access

In terms of best practices, the Esri Imagery Team recommends the following: Store imagery files in a manner that allows optimum read time. Files should be accessible to the server, as close as possible, not on a file share or UNC share over a slow network. SAN or NAS storage with fiber connection is recommended.

File formats for raster data with best performance are TIF with LZW compression. Esri does not recommend using GRID as a file format even though that is what the Lidar DEM data are usually delivered in. Esri recommends converting the GRID to TIFF. Connecting to the data in SDE is not optimal for response time. This creates an additional network hop (to SQL Server) to

access the data. Loading the data into SDE is very time consuming. Esri recommends keeping the data out of SDE as raw source files and creating Mosaic Datasets that read the data directly. DOGAMI is currently using layer files as pointers to the SDE stored DEM data. This is not recommended. Layer files also entail a performance hit.

Use a mosaic dataset to manage the data and define the different products. Create Mosaic Datasets for each contracted data delivery. This keeps the data and all its characteristics including units and projection homogeneous by Mosaic Dataset. Then create a Derived Mosaic Dataset in the desired projection that points to all the Mosaic Datasets for each delivery. This also improves service performance because reprojection only happens once. Serve the Mosaic Dataset with ArcGIS Server as Image Services.

Network traffic can be optimized for Lidar data. Lidar raster data tends to be very large. Rather than access the raw data, Esri says web and desktop clients should be accessing Image Services published on ArcGIS Server. The Image Services themselves reference the Mosaic Datasets that reference the raw source files. An Image Service handles the request in the most resource efficient manner, returning only the pixels needed. In many cases service overviews are returned rather than the raw pixels, eliminating the need for direct reads of the raw imagery. Allowing ArcGIS Server to manage the data requests means that the user gets the data as quickly as possible, and that only a small amount of data is returned. Direct access to the source files would mean much more bandwidth is required for accessing the data, increasing network traffic and latency for the user.

Lidar Management, System and Storage Recommendations:

Compression:

While DOGAMI is already using compression to store their Lidar data, they could look at the new compression tools recently released by Esri called ZLAS. These may perform better than LZIP. LAS files can be compressed using Esri LAS compression to ZLAS file format. The compression does not destroy the LAS file format (1.3, 1.4 etc.). The tool for compressing and uncompressing LAS files is available free from Esri on github.com https://github.com/Esri/esri-zlas-io-library/tree/master/EzLasLib Esri recommends transferring LAS files as ZLAS as well, even when transferring data to external hard drives.

Management:

Use Mosaic Datasets to manage Lidar data. Create Mosaic Datasets for each contracted data delivery. Keep these Mosaic Datasets in the native projection of the delivery. Create Derived Mosaic Datasets to manage all delivery Mosaic datasets. Use ArcGIS Server to serve the Derived Mosaic Dataset as an Image Service. Access the data for staff internal use, and for web clients using connections to the Image Services. Esri has seen users get 20X improvement in performance by moving to this approach vs expecting the client applications to read the full data over networks.

Public Access Scenarios:

Lidar data (both LAS and derived raster products) can be exposed for download via ArcGIS Server Imagery Services. If the administrator allows download capability, source data for the

service can be downloaded. Esri documentation describes the process for download. https://desktop.arcgis.com/en/desktop/latest/map/web-maps-and-services/downloading-from-an-image-services.htm. To enable download of LAS data, LAS datasets need to be created. LAS datasets help manage raw LAS files. The Image Service consumes a Mosaic Dataset which references a LAS dataset, which in turn references the raw LAS files.

Another possible scenario is direct download using a web map. DOGAMI has a shapefile index for all LAS files. Esri suggests it would be easy to provide download if the data could be posted, and an interactive web map created using with associated URLs for each file. This could be HTTP or FTP.

Architecture:

The requirement to provide this extensive Lidar data repository free to the public needs to be accompanied by appropriate funding for a server and storage hardware infrastructure that can accomplish this task. The architecture implemented should meet both the internal data management and access needs of the agency and public external data access needs. Alternatively DOGAMI could seek free or low cost storage from a cloud provider. An internal storage solution would most likely be a SAN or NAS that is scalable for the future data acquisitions that DOGAMI will have. Based on immediate need for 100 TB and future acquisitions of 25 TB per year, DOGAMI could need 150 TB of storage in 2 years' time. A High Availability / Disaster Recovery (HA DR) server architecture should be considered at DOGAMI. This would reduce the single point of failure that is currently the entire public facing web presence of DOGAMI, including the agency website, all web applications, all GIS web services and all digital library and Lidar file downloads. Significant downtime can result from the patching and upgrade process in ArcGIS Server. The ArcGIS Server role should be separated onto its own server or servers if HA is implemented. This would leave the purely web server role of GEOWEB3 intact and allow for separate management of the ArcGIS Server infrastructure on its own. A virtual IP address should be considered if more than one ArcGIS Server is used. Esri best practices for multiple machine ArcGIS Server architecture should be considered.