



*About the Cover. The cover photo is the beacon from a light house on display at the Museum. To protect privacy, this paper refers to the partner organization as the Museum. Just as this beacon once guided ships safely through hazardous waters, I hope that effective decision-making systems and evidence may help guide museums and other organizations through complex and difficult times.*

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## Dedication

First, I want to thank Cyndi, my wife, for her love and support during the long hours spent in class, researching and writing. She also managed the home front during multiple deployments overseas and together we raised four fine sons. As a mother, she watched her sons deploy to combat multiple times. My parents have provided unconditional love and support all my life. Finally, I want to dedicate this paper to the philosophers of the Enlightenment and the statesmen and soldiers that helped to birth its principals in our great Republic. I would especially dedicate it to sons who have fought to keep it free. With the efforts of people of goodwill and critical thinking we can transfer this great Republic to future generations.

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Effective Decision-Making at the Museum  
Marshall 2021

Capstone Project: Effective Decision-Making at The Museum  
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*Author Note:*

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## Executive Summary

The Museum is a nationally known museum on the east coast. To protect privacy, the partner organization, and others near it as anonymized. The paper refers to the partner organization as the Museum. Along with two nearby nationally known museums, it is a key part of both the educational and tourism segments of the area. It has the largest collection of mariner-related documents and artifacts in the Western Hemisphere and houses the remains of an important historic Civil War ship. Its \$8M in annual revenues ranks it as a large museum. However, even before COVID, it was under pressure both financially and operationally from a combination of high fixed costs and declining visitation.

The Museum operates in an environment with three principal dimensions.

- It is a historical museum and has traditionally engaged this market segment.
- It is in an area with a developed tourism industry and a focus on both entertainment and education. As Beatty (2020) notes, tourism is down significantly in the area.
- It is in a heavily African American area. The Museum already has a relationship with many of the schools that serve this population but wants to do more to reach out and engage them.

The environment in which museums operate was changing even before the dual effects of COVID-19 and an increased focus on social justice took effect in 2020. Tourism in the area has declined for the last several years. Beatty (2020) cites a 50% decline from the 1980s to 2016, and interviews I conducted with local museum leaders show the trend is continuing. The American Alliance of Museum's (2020) latest study shows a third of museums in the US are in financial trouble and may close permanently.

Research shows that while younger audiences go to museums, their tastes and preferences have changed (Wilkening, 2018). They tend to go to art museums rather than history museums. Like the other museums in the area, the Museum is essentially a history museum, with the same dynamics as the two other historic museums in the area. The three museums face the same challenges and changing audience preferences and declining visitations.

ACME Ticketing, a leading provider of ticketing systems, notes that demographics and technology are driving change in museums and that effective museums use technology and social media to gather data and make data-driven decisions (ACME, 2019). Museums need to understand their environment and customers to make effective program and operational decisions. However, this requires more than data. It requires actionable information. The organization must transform data into information and then assess to make it actionable. This Capstone provides a systematic way to help The Museum thrive in an increasingly complex environment.

Now, more than ever, museums need to understand their environment and make effective decisions that will help them adapt and secure their future. The Museum has a high ratio of fixed costs with highly variable revenues, which creates high financial leverage. On the positive side, leverage means that incremental revenues produce a higher percentage of net income. On the negative side, it creates high risk. If revenues fall, the Museum may not cover their fixed costs. As the CFO and others stated during interviews, there are often unbudgeted maintenance requirements or new projects that can derail an execution plan. With lower attendance and the museum closed for a year now from COVID, this situation creates increased strategic and

operational risk, which can raise the financial risk. When they re-open, the Museum needs to engage the new market dynamics and grow revenue, or its financial risk could imperil its future.

As the research found, the Museum has data. The problem is the Museum segregates the data into siloes; they do not understand it very well; they do not turn it into actionable information; and the leadership does not have a system to integrate it into an enterprise capability for situational awareness and decision-making. They may also need to bring in external information to help them better understand the impact of changing demographics and preferences. For example, Brida, Dalle, Nogare, and Scuderi (2015) note there are two motivations to attend a museum: knowledge gain and recreation. With tourism down, the recreation motivation is at historic lows. While tourists can engage in both recreational and knowledge gain, as shown by Millennial preferences, the museums need to adapt to new tastes and create more interactive displays. As the CEO of one museum told me, “we can longer teach history the way we did in the 1950s”. Museum leaders need to understand the new market dimensions and incorporate them into their strategy and potentially change many of the ways they present exhibits to make them more engaging, interactional, and present multiple dimensions to an issue.

The Museum recognizes this need and began work to engage the local community and expand attendance in 2018 by significantly reducing the admission price to \$1 to drive up visitation, particularly from the local large African American community. This was a bold move given the lack of data and research they had. It illustrates the gaps in their decision-making process. They had little or no information on which to base the decision, and they made it with few or no processes to structure the decision. Some research may have helped. For example, the Museum relies on a revenue stream from memberships. Individuals and families pay a fixed yearly fee for unlimited visits to the Museum and access to special members only programs. The \$1 admission could erode the value of the membership program and potentially reduce revenues, which in their highly leveraged situation could create financial distress. In an interview with the Museum President, he stated the leadership did not perform any analysis to determine the impact on the membership program or other museum programs and revenue streams. They essentially decided blind and based on their gut feelings.

This situation illustrates the core problem the museum faces. When faced with an existential threat, the Museum had fragmented and poorly understood data and virtually no decision-making processes. The Museum leadership made a critical decision without understanding the impact it may have on other revenues streams, programs, and systems.

The threat to the museum’s viability and continued operations is real. As the CFO stated during her interview, seven-eighths of their costs are fixed, and the revenues can vary depending on programs and even weather. The revenues come primarily from grants, donations, memberships, and attendance. Attendance does two things for the museum. First, it is a source of revenue from either individual, family, and group visits or from the museum’s contracts with local school districts from educational programs. Second, while the CFO stated attendance is not the biggest money-maker, high attendance and effective programs provide an incentive for donor contributions. The CFO also noted they have little data on the contributed revenue from donations. Since this is a key revenue stream, especially if admissions revenue goes down, it is imperative the museum understands what donors need and what they will fund.

The President confirmed the nature and the severity of the problem in both a presentation to the West Point Alumni Association and in my interviews with him. The Museum’s Board of Trustees (BOT) originally brought him in as a consultant to help right the ship and prevent it

from sinking. They liked his ideas and selected him as President and CEO to implement them. He is not a museum insider and brings a new perspective through his leadership and business consulting background. He saw the problems threatened the museum's viability and needed quick and effective solutions. The first issue he told me needed immediate attention was the data problem. He said the data was stovepiped, fragmented and not well understood. As we discussed the situation, he also said there were no decision processes, and the Museum made most ad hoc with little or no data to support them.

The stovepiped and fractured data, with no dashboards or reporting capabilities, prevents everyone, to include the President, from having an enterprise view of the museum. This impairs strategic execution and financial stability. Problems tend to be addressed in insolation with little or no empirical evidence or research. Therefore, as multiple department directors stated, one-off decisions can dominate the museum and take resources from planned strategic activities. The museum is therefore reactionary and subject to problems leaders cannot anticipate.

To address these issues and develop an effective solution, this study uses research questions as shown in Table 1.

Question #	Question
RQ1	What are the Museum's current gaps and limitations in data and decision-making?
RQ2	What are the data and decision needs of the organization?
RQ3	How can the Museum gain an enterprise view of their data for effective employment?
RQ4	What are the key system configuration and management elements to enable the data and decision-making framework?

From the literature review, Truex (1984) provides a strong Decision Support System (DSS) framework for museums. A DSS has at least three components: Data, an Analytical Model, and a User Interface (UI) that work together to transform data into actionable information for decisions. There is a robust literature on each of these components, and how museums can employ a DSS to integrate data and analytics to make effective decisions.

When we look at DSS, however, we need to view it through the organizational lens. Many museums are under significant cost constraints given the declining attendance, aggravated by COVID. Some are staying open because of generous donors. The Museum is no exception. There is no budget for an expensive, off-the-shelf DSS. Adding a DSS and new processes will have organizational cultural implications. Organizations also must assess their technical capabilities and determine what they can successfully implement and sustain. A feasible solution must use existing resources and concepts that are congruent with their culture and technical capabilities. As the Director of Interpretation notes, there is a problem understanding and integrating systems. The Museum has one technical position, the Director of IT. His skills are dated and there are no significant IT programs currently working. An effective DSS must address this problem and bring systems and data together effectively. Given the constraints they face, this research will identify solutions that are within the capacity of the museum to execute.

This paper will research the components of the DSS and then develop a solution based upon it, that the Museum can implement and sustain within organizational constraints, to promote effective situational awareness and decision. The first three research questions focus on the Museum gaps/constraints and the DSS components. The fourth research question focuses on the tools the Museum need to engage the DSS and use its outputs.

Based on the research and findings, the paper proposes three recommendations.

Table 2 Summary Findings and Recommendations	
Finding	Recommendation
Finding 1: The Museum has most of the data required for effective decision-making or can acquire it through external sources. However, it is not integrated or well-understood.	Implement a simple DSS that fits within the constraint's envelope.
Finding 2: While most of the Museum's leaders understand the fundamentals of decision-making, there is no enterprise-wide approach to decision-making or processes to support it.	Build management and governance processes that balance flexibility and control.
Finding 3: There are significant technical, financial, and cultural gaps and that will constrain solution feasibility and design.	Implement a Research-Practice Partnership (RPP) to help expand the constraints envelope.

These recommendations allow the Museum to build within the constraints' envelope while expanding it through an RPP and implements a low-cost approach to a DSS. Each recommendation has implementation recommendations to make them actionable within the organization's constraints. The RPP can design and implement a simple DSS on the Google Cloud. If an RPP grant funding request is successful, scale the first DSS design to a pilot based on the Education Pilot we conducted as part of the study and deploy on Google Cloud using open-source software and interns from local universities.

### Organizational Context

The Museum is a learning institution dedicated to fostering an understanding of how the world's waters unite people. The museum's mission statement is: "The Museum [sic] connects people to the world's waters, because through the waters—through our shared maritime heritage—we are connected to one another."

The museum website provides a good overall introduction to the museum and its history. It is a museum steeped in the region's history and an understanding of the importance of the world's waterways in history and today. The bullet points below summarize data from the website.

- The museum is over ninety years old.
- It has the largest collection of maritime objects in the Western Hemisphere.
- It sits on a 550-acre park, which includes a large lake.

The Museum's organization is typical for a large historical museum. A President and CEO, who the board brought in to help fix structural and performance issues, leads it. The Chief Financial Officer (CFO), IT Director, and several departments report to him. The high-level structure is shown in Figure 1.

The organization is like many large historical museums. It has a small central staff, with 3 people

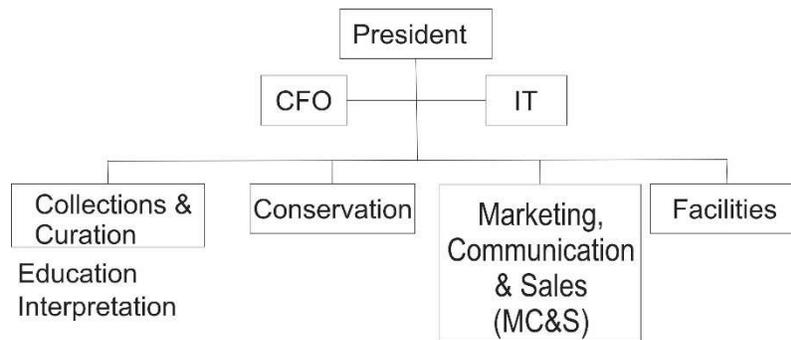


Figure 1 Organization

in Finance and 1 in IT. The CFO rose through the ranks from an entry-level position, and the Director of IT has a similar path. Neither have the traditional professional certifications often seen in senior positions. Nor do they have significant work experience with other organizations that could broaden their perspectives.

These limitations can affect their ability to lead change in their areas.

The Collections and Curation department is the key customer facing department and is critical to make the changes the leadership knows they need to make. However, in the words of the Director of Conservation, the department director got the position by attrition and is resistant to change. The bright spot is a new project to re-vitalize their online presence using Project Management Institute based methods.

The Conservation Department has the largest operational budget because of grant funding for the Civil War ship project. The National Oceanic and Atmospheric Administration provides nearly \$4M per year for conservation efforts. The program significantly changed the museum by bringing in professional conservation experts, higher funding, and an elevated national exposure.

The Marketing, Communications, and Sales (MC&S) Department understands the changes in the demographics and the market. They are working to expand their social media presence and more effectively engage their audience via Twitter, Instagram, and Facebook. However, their budget and access to information hinders their efforts. The director said, "The overall biggest challenge is information to make decisions. Different people have different parts, but it is not shared well". Marketing contributes to the problem. Presently social media data, when gathered, is not effectively managed, stored, or shared.

Facilities manages the infrastructure. They rely upon a consultant's report that is now several years old and has frequent unplanned maintenance requirements. Unplanned requirements can exceed their budget, which then affects the budgets from the other departments. The CFO confirmed the problem and its impact on strategic execution and management. Several department leads also confirmed the impacts.

The Museum came to national attention with the salvage, preservation, and display of Civil War ship. This project brought new capabilities and funding to the Museum, particularly in the Conservation Department. This department expanded and received grant funding from the

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"I wouldn't say "in-spite of" [COVID-19] - I would say "because of". We've been adaptive and pivoted hard to accelerate our digital transformation and engaging folks in the Park and we likely wouldn't have done it without the pandemic."

-- President

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National Oceanic and Atmospheric Administration (NOAA) for the Civil War ship. This was a significant transformational event for the Museum. Now, the Museum truly has a global impact with its many outreach programs to include educational outreach to schools throughout North America, research, and project help such as they did for the recovery of a Confederate submarine, and research support from their vast library.

As the President of the Museum notes in the quote above, COVID-19 has had a mixed impact. While the Museum had an online presence before COVID-19, the museum's closure required a far more robust online presence to continue to engage with its audience. Therefore, they have re-vitalized their website and online programs. The two other museums noted a similar effect. Within a crisis, there are opportunities for leaders bold enough to seize them.

But simply being bold can lead organizations to disaster if they do not chart their course carefully. The Museum leadership understands this and is actively changing the way they use data and make decisions.

## Area of Inquiry

### Situation

The Museum is currently closed because of COVID-19. Before it closed, the staff was working on ways to reach out to the community, especially the minority community that surrounds it. They were also working to develop a strategic management process and other strategic initiatives the President identified as a consultant.

The dynamics of tourism that have helped the Museum in the past are also changing. Tourism was declining before COVID and is down even more now. Therefore, the Museum needs to look at alternative ways to meet its mission and generate the funds required to create new, enriched programs that meet the needs of changing stakeholders and customers. To facilitate these changes, the President and CEO is wants to establish an “aspirational, adaptive culture” and build the resiliency into the museum to mitigate the impact of future crises. To do this, they need to understand both themselves and their operating environment far better.

While they have internal and some external data, they think it is fragmented and not well understood by the leadership team. There may also be some issues in data quality and integrity since there are multiple sources of some data elements. During the Education pilot we conducted, we found several issues with data quality, to include schools with multiple names, misspellings, and data conflicts between sources. These problems will affect the ability to use the data until they fix the quality problems or clean it as part a data transfer process. Since the data is not fused together via data relationships, it is of limited use for situational awareness and to make effective decisions to pursue their mission statement in a complex environment. Data fusing is complicated since the data is in separate silos and no one has an enterprise view of what data is available.

Their decision-making process is also fragmentary and ad hoc. While this has not been a significant problem in the past, in the complex environment in which they now operate, it constricts their ability to make timely and relevant decisions and to respond to changes. They want to power down decisions and authority as part of their adaptive culture initiative, but do not have the systems and processes to understand their data and use it to make effective decisions.

Key background points and questions include:

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- The museum is now closed because of COVID-19.
- The museum currently relies on grants and donations to keep the staff on pay. Museum staff stays in contact through Google Meetings.
- Currently, TTMP has various data sources that are not connected and do not effectively support analysis and decision-making.
- Curation and other creative projects use a design thinking approach with multiple iterations.
- Other projects, especially management projects, employ a more traditional approach based on operational decision-making. There is a tension between the two approaches that can negatively affect the decision-making.
- The museum BOT brought the current President onboard specifically to fix the structural and cultural issues that have created significant problems, such as financial stress, declining attendance, and a perceived lack of relevance.
- The museum has relationships with various schools in the area and supports their learning efforts.
- The Museum must decide whether the museum in the education market, the entertainment market, or both. If both, it needs to determine how to fuse the two lines of effort together to create synergies and more effective programs. This is essentially the two types of audiences that Brida et al. (2015) and Tsai and Lin (2016) discuss: knowledge gain and entertainment.
  - Entertainment: The museum cannot compete with Bush Gardens and the Water parks and beaches.
  - Education: The museum has outreach programs with local schools. This is an opportunity to leverage its strengths, reach out to the local community during COVID through innovative online programs, and then link them to onsite programs when the museum re-opens.

### Strategic Initiatives over the past four years:

- A new mission statement.
- A collections-based audience-focused strategy with three operational tenets: conservation, access, and value.
- Restructure of its team and budget around four core functions (conservation, research, programs, and exhibits), and adopted a new business model to improve strategic alignment with the mission, financial execution, and program development. This is a matrix-based approach, which will have cultural impacts and require the directorates to work much more closely together.

Clearly the museum leadership recognizes the issues and is taking action to meet them. Their leadership is working on building resiliency and an adaptive culture. They also understand they need to be more strategically focused and expand their engagement with the local community and other stakeholders and truly enable its mission statement. To do this, the Museum needs to integrate data. But data integration is not enough. By itself, data does nothing. The organization must transform data into actionable information and used to maintain situational awareness and make effective decisions.

As Skinner, Ekelund, and Jackson (2009) note, a museum's decision cycle is longer than a year. That means the museum leadership needs to plan with greater uncertainty, leading to potentially

more complex problems. With the current environmental disruptions from social justice movements and COVID-19, the problem is even more significant. The social justice movement has affected the Museum so far by triggering a decision to remove a statue of a Confederate admiral and rename a lake on their large park named for him. Once the museum re-opens—a large strategic issue—there may be more to follow. As Shaw and Krug (2013) note, social media is taking a larger role in shaping museum's impact and plans. When the Museum re-opens and is again in the public eye, there could be an impact on the strategy and execution. With the plans to provide greater emphasis on the local African American community, The Museum may need to change displays and programs. If they do that, they may risk what Hede and Thyne (2010) note about the dangers of inauthenticity, such as alienating visitors and creating a sense of dissonance with programs and exhibits they do not engage them and meet their needs. A good initiative could cause problems if not properly planned. The Museum's leaders need actionable information about the internal museum operations and what its community and stakeholders want if they expect to re-open successfully.

That is where this Capstone engagement comes into the museum's strategy. It will lift the focus from data to actionable information and knowledge they can use to make decisions to meet the changes and challenges in the environment. The approach will also help the Museum leaders to balance strategic execution with operational problems to make effective decisions that protect the museum today and in the future.

### **Problem of Practice**

The Museum's data is poorly understood and fragmented across commercial capabilities, such as their finance and ticketing systems or in individual spreadsheets. All the departments shown in Figure 1 have one or more spreadsheets that are available only within the department. In some cases, such as Facilities, they are based on dated information. Facilities uses a spreadsheet based on a consultant's report from over five years ago. Most departments have little or no understanding of the data in AlTru, the ticketing system, and are uncertain whether they can even use it. They are not getting what they need from the current financial system and want to replace it. Departments now get their financial data via a spreadsheet extract rather than directly from the financial system in a near real-time manner. They have little or no organizational processes to use this data in an effective approach to decision-making. They have no way to see entire enterprise and how actions in one department can affect other departments and the strategic execution. This problem hinders effective decision-making, especially with complex problems.

The \$1 admission decision illustrates the problem. The Museum leadership had no way to assess the probability of success of the decision and made it primarily on their instincts. It worked because of donor offsets. If donor funding lessens, the Museum may not be able to maintain the \$1 policy. Department heads also noted significant issues, including the inability to plan and execute because their department had to pay for problems in other departments. The huge, fixed costs, which raise financial risk, and the potential problems of alienating members with the \$1 admission and donors if the museum does not re-open soon and with effective onsite programs that inter-relate with online programs could affect their long-term viability. Leaders also did little or no research to assess the decision. For example, Dilenschneider (2015) notes that free admission has little or no lasting affect and the dominant driver in attendance is desires and preferences. In this light Brida et al. (2016), Nowicki (2015), and Hede and Thyne (2010) may have provided additional insights to the decision by looking at why people attend museums,

issues with authenticity, and visitor constraints. These references support Dilenschneider's research and findings. With more research and analysis, the Museum may have made a different decision and focused on how better to engage the African American community and provide an incentive for them to want to visit.

### **Literature Review**

I organized the literature review around two core concepts from the literature on museum decision-making. The first is Truex (1984), who discusses using Decision Support Systems (DSS) to aid museum decision-making. He first lays out the structure of a DSS to include dialog (User Interface [UI]), data, and a model. This approach is based on museums and provides an overall framework for organization and analysis. He also provides a list of key operational data required for an effective DSS. The second is Basso and Funari (2020), who discuss balanced scorecards (BSC) in a museum and provide relevant museum metrics and an analytical approach. In a unified framework, The BSC provides the metrics and unifying structure for the DSS. The DSS and the BSC are proven concepts in both the museum industry and many other industries and institutions.

There are two supporting concepts from the literature to make the DSS/BSC concept actionable. The museum must be able to configure and control the DSS components and then provide an effective UI that users can use to gain insights from the DSS. Configuration and management provide the methods to manage data, develop the measures and metrics for the BSC, and processes to govern the system and to use it. Business Intelligence and Analytics (BIA) provide analytical tools and effective UI for the DSS. The UI is often a dashboard.

Any effective solution must address these four components and gaps and constraints. The literature review uses RQ1 (Gaps and Constraints) to find the key aspects for gaps and constraints to ensure it covers the key areas pertinent to the area of inquiry.

A Literature Review Matrix is in Table 8 in Appendix A. This shows the sources used and their role in the analysis.

# DSS COMPONENTS

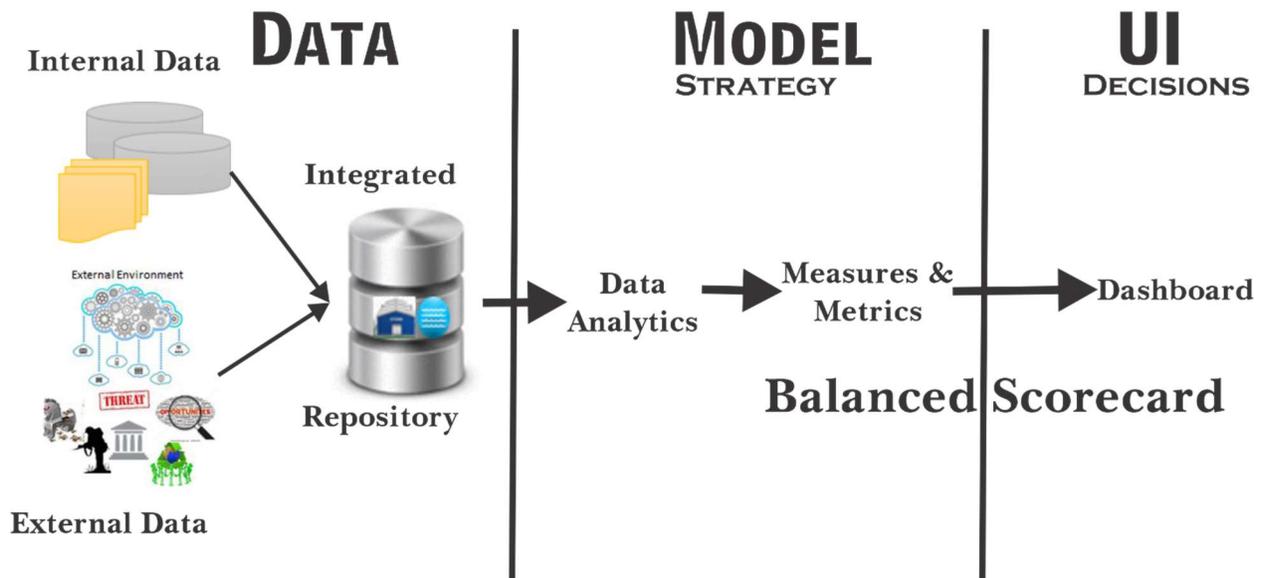


Figure 2 DSS Components

## DSS Components

The structure in Figure 2 incorporates the DSS components based on TRUEX (1984). Based on Basso and Funari (2020) work on museums and BSC, it embeds a BSC that helps to enable the Model and the UI. They work together to turn data into actionable information that supports decisions to enable the outcomes the President specified. The literature review follows this framework from data to the analytical to UI.

## DSS Approach

Arnott and Pervan (2008) provide an overall theory to strengthen the DSS approach and component requirements and provide a critical analysis of the academic literature on DSS. This provides an excellent bibliography for DSS study, but it does not include articles after 2004. They note there is a tension between academic research and professional relevance. During the literature review, I found and reviewed many professional articles on DSS design and implementation, but there was little or no theory behind them and they were not peer reviewed. In the peer reviewed academic literature, there was a wealth of theory, but few had practical approaches to design and implementation. Arnott and Pervan have a very valid point.

The most valuable information from the peer reviewed sources in DSS literature is on DSS performance management and use and acceptance. Chan, Song, Sarker, and Plumlee (2017) developed an experimental DSS to track its usage and the user motivations. They found when the DSS corresponds well with the users' tasks, motivation to use it is high. While Shibl, Lawley, and Debus (2013) studied general practitioner use of DSS, their model for DSS acceptance is readily extensible to museums and other organizations. Key aspects are trust in the data, an effective UI, training, and workflow that helps users to enhance task performance. van Os, Herber, and Scholtens (2016) looked at the social acceptance of a DSS and concluded that

“subsurface” activities are critical to acceptance. Again, this points to helping users perform their tasks and functions rather than only operating from a strategic or operational perspective. McCoy and Rosenbaum (2019) found “shadow” use of the DSS that were unintentional practices users had to create because the DSS design and development did not include their needs. Liu, Duffy, Whitfield, and Boyle (2010) found that standalone DSS systems that are not integrated with other systems and functions are less effective and less well accepted.

These issues imply the DSS should have cascading analytical models and dashboards that tie the strategic, operational, and tactical levels together with drill down capability to trace issues and problems. User involvement in the design and development is key to acceptance to ensure that addresses their tasks and needs.

The literature suggests three general forms of a DSS.

First, as suggested by Truex, Basso and Funari, and La Russa and Santagati (2021) an organization can build the components of the DSS internally and then integrate them together. More recent research, such as El-Aghoury, Ebid, and Mahdi (2020), Ali, Aziz, and Siti (2020), Ji, Yu, Xi, Xu, Qin (2020), and Abdellatif, Bouaud, Lafuente-Lafuente, Belmin, Séroussi (2021) also shows custom DSS frameworks that leverage specific new technologies in each component and configured to support specific task and functional requirements are effective. This approach builds each component of the DSS framework within the organization and ties them together into an integrated DSS. Ideally, the organization leverages existing resources. It may contract out developmental support or do it all with organizational developers.

Second, the organization can use a packaged DSS solution. Li and Wen (2011) and Demirkan and Delen (2013) discuss cloud based DSS approaches. A cloud-based approach contracts out all or parts of the DSS implementation and support to a third-party cloud provider. Li and Wen (2011) provide a holistic approach and assess it. Demirkan and Delen (2013) provide a list of services required in a cloud approach and how to create specific DSS services. This approach can save upfront capital expenses and can compensate for limited technical resources but will have ongoing operational costs for the services.

Third, the organization can purchase a packaged DSS solution. Most of the literature on packaged DSS solutions tends to be older, such as Wang and Keh (1987) and La Blank and Tawfik (1989). While the technology is dated, the general approach to selection still is valid.

A blended solution may use a cloud’s infrastructure, Infrastructure as a Service (IaaS) but custom DSS components. This lets the organization have the flexibility of a custom DSS with the benefits of a cloud to manage the infrastructure and administration.

## Data

Data must be relevant and reliable. It must be efficiently organized in a structure and repository that can effectively feed the Analytical Model. As Figure 2 shows, data can originate from internal sources such as financial systems and ticketing systems or external sources such as social media, investment, audience and stakeholder data, and environmental data.

### Relevant and Reliable

Data comes in two forms. The first is the traditional operational, research (audience, market, stakeholder, market, etc.), and environmental data generated by internal systems or collected from external sources. The second is metadata used to define measures and metrics and configuration items.

Truex (1984) lays out most of the operational data required to include revenues by type, cost elements by type, and visitor data. The environment and markets in which museums operate have, however, changed a great deal since 1984. Social media and other relevant environmental data such as weather, general demographics, survey data for tastes and preferences is now far more available either for free or purchase. Taheri, O’Gorman, and Baxter (2016), Boric (2016), Sökmen, Yolal, and Özel (2020), Shaw and Krug (2013), Evans, Bridson, and Rentschler (2012), Richani, Papaioannou, and Banou (2016) all note the importance of marketing for museums and understanding what the consumer wants and needs. While Pei-Hsuan, Chin-Tsai (2016, 2018) write of museum strategy evaluation and competitive advantage. The factors they discuss such as economics, the impact of Information Technology, the performance of collections and exhibits, and risk factors all have data the museum will need to collect to support strategy development and assessment.

Without metadata, a DSS will not work since the analytical model will have nothing to assess performance. Leach-Murray (2020) and Habermann (2020) discuss how metadata provides the framework for interoperability between projects and concepts. This is critical to nest department level BSCs and dashboards together and relate them to elements of the strategic plan. Modes, Valasselaer, and Lemahieu (2016) and Pinoli, Ceri, and Martienghi (2019) discuss the use of metadata for model building and decision-making. These are critical for the Analytical Model component of the DSS to ensure it nests with strategy and the decisions required during execution. Kalita and Deka (2020) discuss how metadata shapes and drives ontologies, which is a key element in designing the organization and structure of the data repository. Venter (2019) provides additional insights and complements Modes et al. (2016) discuss the role of quality data to support decision-making.

Data quality is critical to reliability and to ensure the outputs from the DSS are valid and verifiable. Quality is a complex topic and includes reliability and relevancy. Chiang, Goes, and Stohr (2012) add volume, velocity, and variety to the measures noted by Venter. This helps to build a framework to assess data sources to validate relevancy and reliability. The goals are to both understand the nature of the data and how its use will affect decision-making and situational awareness in the BIA component of the framework.

#### Organization and Structure

Data structure can enhance or impede analysis. Structure can range from a set of spreadsheets, such as the Museum currently uses, to simple relational databases and data warehouses, to newer forms such as graph data, big data, memory resident data, and NoSQL data. Each of these structures has its own strengths and weakness. These will work if they can effectively feed data into the Analytical Model. The key is that the selected structure must provide the access, in the right form or aggregation, and with the right security to meet the task and functional requirements as well the strategic and operational requirements. Chen, Goes, Gupta, and Marsen (2006) provide a set of rules for creating a data structure. To implement the Chen et al. (2006) concept, data designers must understand the decisions, tasks and functions as discussed by Chen et al. (2006), van Os, Herber, and Scholtens (2016) and McCoy and Rosenbaum (2019).

Sugumaran and Storey (2006) discuss using ontologies to capture domain knowledge. In a DSS this may flow from the expected decisions and the data needed to support them and to evaluate them. Osterwalder (2004) provides concepts to link the ontology to a business model and Haug, Holmen, Wu, Mynam, and Ferraro, (2014) links the ontology to predictive models that help enable strategy. The information captured in the ontologies must then be used to build schema

that drive data design. Bellahsense, Bonifati, and Rahm (2011) discuss building data schemas. Without this data architecture framework, the DSS may not have access to the data it needs to enable task and functional management and enable decision-making.

If the data moves into more unstructured requirements, which can include spreadsheets and reports, then Bjeladinovic (2018), Link and Prade (2019), and Chaudhry, Moyne, Rundensteiner (1999) provide design guidance. This design the flows through to the overall data design to ensure both structured and unstructured data are included and structural requirements for both are identified.

#### Repository

Early DSS architectures relied heavily on a data warehouse structure, but it is still in use today as Faisal, Sarwar, Shahzad, Sarwar, Jaffry, Yousaf (2017) show. The data warehouse literature is robust. Faisal, Sarwar, Shahzad, Sarwar, Jaffry, Yousaf (2017), Ouaret, Boukraa, Boussaid, Chalal (2019), Quaddus and Intrapairot (2001), El-Sappagh, Hendawi, and El Bastawissy (2011) provide insights into how to design, build, and govern a data warehouse. Park (2006) and Molinaro, Romano, and Battisutta (2019) discuss the data warehouse impacts on decision-making. Park and Kim (2013), March and Hevner (2007), and Ahmad, Azhar, and Lukausis (2004) discuss data warehousing operating with a DSS framework. Park and Kim provide an example using sewer systems and provide several structures for a data warehouse. March and Hevner (2007) discuss how data warehouses effective support analysis and BIA. Ahmad et al. (2004) discuss how they integrated a DSS into a prototype DSS. Data warehouses are still an excellent fit for a DSS.

However, technology has advanced since the introduction of data warehouses. New structures and technology can improve response times and integrate unstructured data as and structured data are now available. Merendino, Dibb, Meadows, Quinn, Wilson, Simkin, and Canhoto (2018) discuss big data and its support to decision-making. They point out that big data can great speed decision-making, but it can come at the cost of decision quality if the organization does not understand the data and the process. This is a caution that the analytical model needs to factor into the analysis and reporting if using big data. Data lakes are an important structure within the big data environment and can provide effect tools to manage and analyze big data. Lo Guidice, Musarella, Sofo, and Ursino (2019) and Llave (2018) show how organizations can use data lakes to support BIA. Llave notes that organizations can use data lakes as staging areas for data warehouses or a direct source for BIA. The proper role may depend on the Analytical Model.

Since the data often originates in separate sources and organizations must migrate it to a consolidated repository, the organization needs processes and tools for this task. El-Sappagh et al. (2011) discusses Extract, Transform, and Load (ETL) tools and processes to load data into a data warehouse. These do three functions:

- Extract data from the original source according to a set of rules and schedules.
- The transformation step performs quality audits, fix issues found in the data and transforms the data into a format used in the consolidated repository. This could be data cubes in many data. warehouse structures or single or aggregate rows in a more traditional database.
- Load the transformed data into the consolidated repository.

Nath, Hose, Pedersen, and Romero (2017) discusses techniques to program the ETL function. Petrović, Vučković, Turajlić, Babarogić, Aničić, and Marjanović (2017) discuss ways to automate it. Karagiannis, Vassiliadis, and Simitsis (2013) discuss ways to schedule ETL processes. These more automated approaches can range from simple scripts that execute in database scheduling routines to expensive comprehensive ETL solutions with robust transformation capabilities.

### **Analytical Model**

Chiang et al. (2012) note that processes, data, and analytics are critical to develop actionable information from data. Data by itself is not enough. Organizations need analytics to create actionable insights and intelligence. They discuss three key domains in the analytical approach: Descriptive, Predictive, and Prescriptive. These three domains are important to develop a strategic approach to shape the environment and link the strategy to the analytical model. Analytical models can range from simple spreadsheets, such as the Museum current uses, to complex spreadsheets that bring in external data and rules and coding, to models built within a BIA software package to complex Artificial Intelligence (AI) and Machine Language (ML) driven models.

Given the significant constraints found in RQ1 (gaps and constraints), a BSC combined with basic BIA, based on existing museum research, may be the most effect model type.

Organizations must consider stakeholders and accountability in the Analytical model to ensure it captures these key requirements. Key museum stakeholders will include Board members, donors, members, and key civic and education leaders. Dainell, Manetti, and Sibilio (2013) provide practices to include these stakeholders for large museums such as the Museum. Villaespesa and Tasich (2012) and Zbucheá and Birt (2020) expand on these concepts by creating an analytics culture that embraces the stakeholders. Skinner et al. (2009) provide a model to assess attendance and counter-cyclical funding.

Organizations can use the analytical model to help guide operations and scheduling. Lee and Lin (2010) and Martínez-De-Albéniz and Valdivia (2019) provide examples of using decision models to schedule exhibitions and enhance attendance. These methods may also be ways to meet key stakeholder objectives.

Elina Sairanen of the Metropolitan Museum Art (Sairanen, 2017) recognizes the key aspects of data in museum decision-making and conducted a literature review and interviewed other museum professionals to see how leading museums use data and analytics to make decisions. In particular, she addresses the need for analytics to turn data into information and use it to make decisions. Villaespesa and Tasich (2012) echo this with a discussion of creating an analytics culture. Agyeman (2019) discusses the need for museums to use data and analytics. However, Castor (2020) provides a note of caution about overuse of data and notes some caution about data-driven decisions unless the organization understands the business questions and decision criteria and has solid metrics. Ghasemaghæi (2019) notes the value is not data per se, but rather the creation and sharing of knowledge. Proper use of an analytical model may help to do that, but the model needs to be tied into the organization's strategy to be effective, as discussed by Pei-Hsuan, Chin-Tsai (2016).

Basso and Funari (2020) discuss analytical models for museums and highlight the role of a BSC. Based on their research, they developed the high level BSC show in Figure 3. This is essentially Kaplan and Norton's (1996) BSC reordered with a few nuances added, such addition innovation to learning and growth and using the concept of "perspective" in each area.

BSCs are a well-established way to track organizational performance. Organizations can tie them into strategy maps that help to enable strategic planning and execution and track progress. Kaplan and others provide the groundwork for this linkage (Gibbons & Kaplan, 2015; Kaplan & Norton, 1996; Kaplan, 2012).

Huang and Hu (2007) discuss this linkage with a BSC. When Kaplan and Norton (1996) developed the concept of the BSC, they clearly tied to organizational strategy via strategy maps.

Since their introduction, BSC's have received accolades and criticisms.

Kaplan (2012) addressed some academic concerns and many others have studied the efficacy and use of BSCs (Agostino & Arnaboldi, 2012; Nørreklit, 2000, 2003). The keys to overcoming the criticism are ensuring the BSC is effectively used, linked to strategy and operational plans, and provides actionable information to the user. These go straight back to the same requirements for task and function linkage and an effective UI discussed in the DSS section. To help build this linkage to task and function, Basso and Funari (2020) discussed specific data analytical approaches and use them to calculate the scores shown in each area in Figure 3. They provide a set of museum metrics for each BSC area that organizations can tailor to their specific requirements.

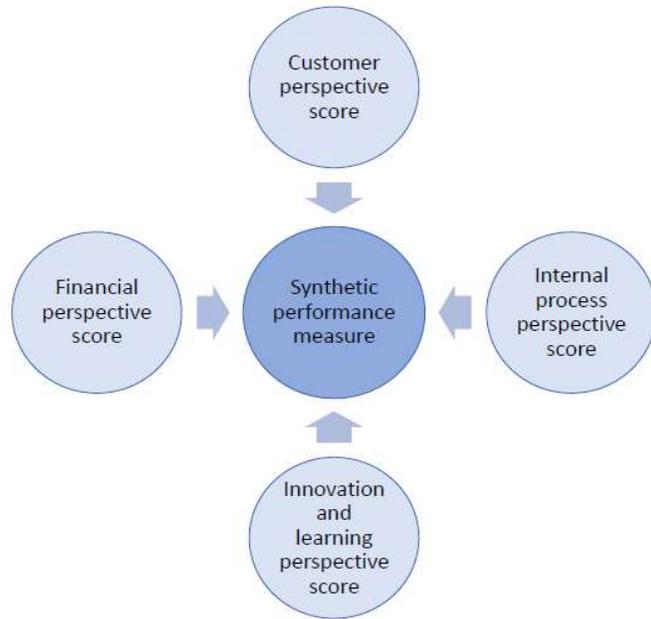


Figure 3 Basso and Funari's Museum Balanced Scorecard

### User Interface (UI)

Banerjee, Nguyen, Garousi, and Memon (2013) and Pastushenko, Hynek, and Hruška (2019) discuss UI testing and metrics on general UI design. This is critical because as Shibl et al. (2013) notes a poor UI can impair DSS acceptance.

#### BIA

BIA spans the Analytical Model and the UI components in a DSS, depending on the BIA capability.

Isik and Sidorova (2013) note the BIA system needs to understand the decisions that the organization makes, and it is dependent on data quality, user access, and integration to other systems. This ties with the discussion above on DSS user acceptance. Lim, Chen, and Chen (2013) discuss how to improve BIA effectiveness and the need for further practitioner-research collaboration and innovation to ensure BIA usage. Teixeira, Oliveira, and Varajão (2019) complete the cycle of design, development, and implementation of BIA with a discussion evaluation of the success of a BIA project. They provide seven core project success metrics to assess. While nuances may change from organization to organization, they are extensible to many industries and organizations, especially if we keep Isik and Sidorova's (2013) insights in mind and incorporate them as specific assessment criteria.

Chiang, Goes, and Stohr (2012) and Chen, Goes, Gupta, and Marsden (2006) discuss the role of data in a BIA. Chiang et al. (2012) focuses on the impact of big data, while Chen et al. (2006) is a more general approach to data requirements and focuses on getting the information at the right time/right place to decision-maker and the need to structure the data to do so. They present a data design approach tailored to BIA systems.

#### Dashboards

As Bir, Chew, Smith, and Day (2019) note, dashboards are an effective way to create actionable information. Nadi, Maedche, and Schieder (2020) note they also provide effective ways to gain and to maintain situational awareness. Person (2013) provides actionable ways to achieve these goals with a BSC. Bir et al. (2019) developed and tested an interactive dashboard using structured and unstructured data. Their core concept was to allow the user to configure the dashboard to show the information they need when they need it. As discussed in the DSS section, the important concepts are an easy UI and relate the user's tasks and functions to the dashboard's capabilities. Nadi et al. (2020) adds a "what if" capability to the dashboard, allowing users to explore their questions. This may require ontologies and models such as those discussed by Huag et al. (2014) and Matsumoto (2019) to ensure the data required for these analyses are in the data repository and properly structured for these kinds of analyses. Person (2013), although not a peer-reviewed journal source, provides a comprehensive, step-by-step approach to using a BSC to create effective dashboards. Given the Museum's constraints, this may be a useful approach to consider.

#### Constraints

The earliest discussions with the President confirmed the museum was operating under significant technical and cost constraints. One way to address these constraints may be a Research Practice Partnership (RPP). The Museum submitted an RPP a year earlier with a local university (the University) to develop a system of measure and metrics. The proposal did not win funding because it did not meet some foundation objectives.

Henrick, McGee, Greenberg, Dettori, Rasmussen, Yanek, and Reed (2019) build an RPP framework for evaluation. The format will improve the RPP proposal and increase the likelihood of funding as grants and foundations adopt the framework to evaluate RPPs they fund.

Bevan, Henrick, McGee, and Dettori (2019) provide a good discussion of how to develop an RPP. Farrell, Harrison, and Coburn (2019) provide an effective discussion of the roles within an RPP and Coburn, Penuel (2016) discuss ways RPPs have been used in education, which is a significant competency of the Museum. Henrick, Munoz, and Cobb (2016) discuss weaknesses in RPPs and how to strengthen them. These papers, coupled with Henrick et al. (2019), may allow the Museum and CNP to collaborate more effectively based on well-defined roles and prepare a proposal that meets foundation expectations.

Study Design

Conceptual Framework

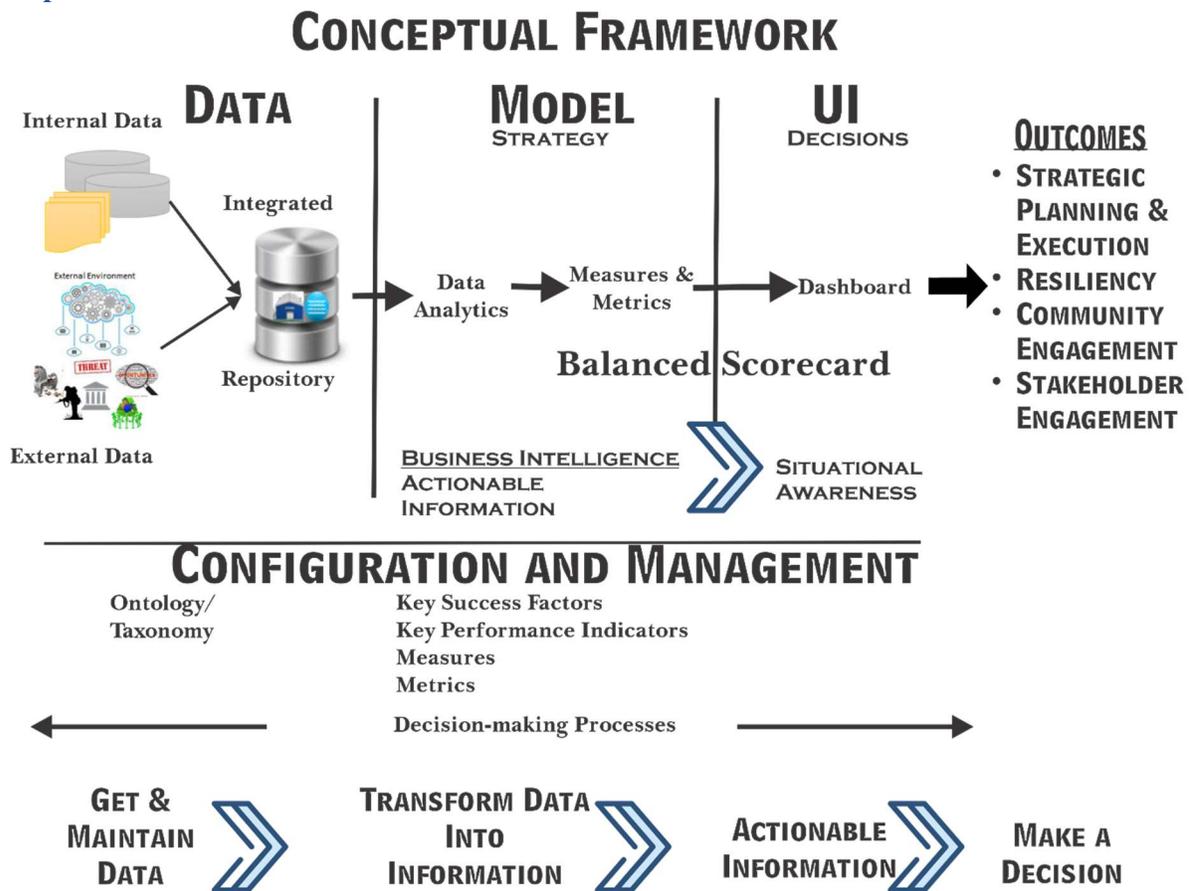


Figure 4 Conceptual Framework

The Conceptual Framework shown in Figure 4 extends the DSS component framework based on the literature review. It adds several sub-components and a new primary component: Configuration and Management. The literature review found a common theme that if the DSS and component elements do not reflect strategy, functions, and tasks and do not have a user-friendly UI, it will not be used. The Configuration and Management component addresses this requirement.

The Configuration and Management component provides the managerial layer to ensure the data has the needed metadata and reflects the decisions required and functional and task assessment data through ontologies that capture them at the user level and then translate it into effective data schema. Processes help the organization ensure the system captures user requirements during design and integrates effectively with other organizational systems to improve user support and acceptance.

The Model component adds Data Analytics and Measures and Metrics to ensure the model effectively assesses decision and performance data and can feed the UI.

The UI component adds dashboards to provide user-configurable reporting and tools to help users gain and maintain situational awareness, make effective decisions, and perform their tasks and functions.

The bottom row shows how data is transformed to actionable information and used for decisions. The DSS outputs are shown at the right. These match the leadership’s key concerns.

### Research Questions

The research questions are derived from the initial interview with the President and the literature review. The President provided some initial insights into RQ1, which were used during the literature review, especially for the constraints section of the literature review.

Question #	Question	Conceptual Framework Element(s)	Collection Methods
RQ1	What are the current gaps and limitations in data and decision-making?	Data, Analytical Model, UI, Configuration and Management	Qualitative Interview Quantitative Survey Focus Group
RQ2	What are the data and decision needs of the organization?	Data	Qualitative Interview Data Source Review
RQ3	How can the Museum gain an enterprise view of their data for effective employment?	Analytical Model, UI	Qualitative Interview Focus Group
RQ4	What are the key system configuration and management elements to enable the data and decision-making framework?	Configuration and Management	Qualitative Interview Focus Group

### Research Methods and Instruments

The study used a mixed methods approach with interviews, a focus group, a survey, a data review, and a small pilot used to assess key day and develop measures and metrics for the Education Department. Research instruments are listed in Table 4 and associated questions and execution discussion follow below the table. The research plan originally included interviews and focus groups with the BOT, donors, and key stakeholders. The President elected to defer them until he had a better understanding of the internal museum issues. He replaced them with a small pilot with the Education Department.

The Education Department had unsuccessfully filed for an RPP grant with their partner university to develop measures and metrics and build a dashboard to facilitate engagement with local schools. The President wanted to use this opportunity to explore the data and decision-making issues with the Education Department to be able to go back to the University and work with them to re-do the RPP for a new grant application. This pilot helped to identify changes to the grant request to improve the likelihood of funding.

Method	Focus	Objective
CEO-Level Interviews	President 2 nearby museum CEOs	<ul style="list-style-type: none"> <li>Identify executive level concerns.</li> <li>Identify potential approaches.</li> <li>Determine key environmental issues across the area.</li> </ul>

		The two other museum executives included given the similarities in size, mission, and location. They face many of the same issues and problem as well as the same external environment, markets, and consumers.
Leader Interviews	CFO Director of IT Collections & Curations Education Interpretation Conservation Marketing, Communication and Sales (MC&S) Facilities	<ul style="list-style-type: none"> <li>• Understand department mission and tasks.</li> <li>• Identify key concerns.</li> <li>• Identify gaps and constraints.</li> <li>• Identify data sources and issues.</li> <li>• Identify processes, dashboards, other decision tools.</li> <li>• Identify measures and metrics.</li> </ul>
Focus Group	President CFO Director of IT Collections & Curations Education Interpretation Conservation MC&S Facilities	Bring the team together to discuss the results of the individual interviews and confirm or reject interview data. Use this discussion to stimulate cross-conversation between leaders to identify additional data.
Leader Survey	CFO Director of IT Collections & Curations Education Interpretation Conservation MC&S Facilities	Survey on Qualtrics to complete the triangulation of individual interviews and focus groups in a more structured approach.
Data Sources Review	Data sources identified during the interviews	Assess the data sources using a framework developed from the literature review.
Education Department pilot	President Education	Develop a full pilot for the Education Department and execute the first phase that evaluates key data, identifies key decisions and metrics, and builds a prototype approach to data integration and analysis. This will form the basis for a revised RPP submission and test concepts from the literature review.

These interviews were designed to identify the key gaps and constraints. The interviewees are the key leaders the President selected for interviews. Collectively, they are the museum’s brain

trust and provide insights into how the museum operates, their culture, gaps they see and constraints. Adding the executive leaders of the two other museums provides additional perspectives that may help formulate the way ahead and recommendations to address the problem of practice since they face similar issues.

Table 5 CEO Interview Questions	
Question	Objective
What are the decisions your museum needs to make?	Identify key strategy drivers and concerns.
How are these decisions tied to strategy or operational execution?	Identify how the museums link strategy and decisions.
What kinds of data do you use to inform your decision-making?	Identify key data sources and how they use them.
Do you have a data governance process?	Determine whether they have systems in place to manage data.
Do you have data analytical tools to help analyze your data?	Identify any systems and tools they use and how they use them.
Does the museum have a formal decision-making process?	Identify any existing processes and how they use them.
What are the key challenges your museum faces?	Identify common environmental issues and marketing challenges.
How does your approach to decision-making help to address these challenges?	Identify system linkages and how they impact the museum operations.

Table 6 Leader Interview Questions	
Question	Objective
What are your key issues and challenges?	Identify department level concerns and how they relate to other departments and to overall museum operations. Are there common issues?
How is your department staffed?	Determine potential staffing constraints for solution development and implementation.
What data sources do you use?	Determine key data sources and the concerns the leadership may have about them. What do they think they are missing? Are there data constraints?
Does your department and the museum have a decision-making process?	Identify existing processes, missing processes, and potential constraints.
What types of decisions you make?	Identify the key decisions they need to make to use for system design.
Do you have any measures and metrics that you use to help understand the situation and make decisions?	Identify what they are using now and what may be missing.

Does your department or the museum use any dashboards?	Identify any current practices that may be leveraged in a solution.
What kind of reporting do you do and how do you do it?	Identify how they report, what they report, to whom they report. This will help in any solution design.
How do you understand Evidence Based Management?	Determine how well the departments understand and assimilate the President’s strategic drivers. Are there organizational and cultural constraints?
How well do you understand the concept of Adaptive Culture?	
How do you understand the concept of Anti-fragility?	

The data sources study reviewed and assessed the key data sources identified during the interviews. The objective was to assess the sources to see if they cover the data discussed by Truex (1984) to build the initial database.

The Education Pilot is a phased comprehensive approach for decision-making in the Education Department. During the study, we executed Phase I, which built a small analytical system using AlTru (Ticketing System) data and a spreadsheet the Education Department developed to track school visits. We imported AlTru data into an Access Database and built a proof-of-concept Analytical Model and rudimentary dashboard. Follow on phases are designed for later implementation as part of an RPP project.

## Data and Analysis

### Data

#### Qualitative

The qualitative data comes from two sets of interviews and a focus group and a review of current data sources. The interviews were with the President and key leaders and the executive leaders of two nearby museums. The executive leaders of are collectively referred to as the CEOs. Raw and intermediate data for these interviews are shown in Appendix B–Data.

Since the data sources are central to the problem, I assessed the principal internal data sources. We (the Museum and I) also designed an Education Department Pilot to investigate data source and approaches. During this research project, we executed the first part of the Pilot to review the AlTru (ticketing) data and approaches to data integration and use in the BIA approach. The data sources assessment is included in Appendix B–Data.

The coding of interviews with the key leaders and the CEOs generated three principal themes that occurred in every interview: strategy, systems, and change. Systems have three important sub-codes: data, processes, and decisions. The statements and import of the themes, however, varied with position. Change has two sub-codes: internal and external.

Theme	Assessment
Strategy	The three CEOs were primarily concerned with strategy formulation and communication. Department leads were more concerned with the effect of the

	strategy on their departments and the lack of a way to assess the impact of changes on strategy execution.
Systems - Data	All interviewees were concerned about data. All mentioned at least a degree of concern over data availability. CEOs and customer facing departments were concerned about lack of data to understand their markets and the external environments. Several mentioned concerns with AlTru, the ticketing system. Concerns included the data it collects and even whether they could use AlTru. The CFO stated, “Were not great about getting data from it.” The Director of IT and the CFO both stated they were not happy with the financial system and wanted to replace it. MC&S is now looking more at social networking data but does not have a consistent approach to mining and storing the data. The director of MC&S, stated, “The overall biggest challenge is information to make decisions. Different people have different parts, but it is not shared well. We are not capturing information on people.”
Systems – Processes	Processes were a mixed bag. The CEOs and customer facing departments were concerned that strong processes could inhibit creativity and reduce flexibility. The President and leaders from Collections and Curation talked about using Design Thinking and the need to implement it within the Museum. The Director of MC&S noted the need for an integrated decision-making process.
Systems – Decisions	All personnel were uniform in stating there was no defined approach to making decisions and that most were unstructured and ad hoc. Department leads uniformly noted that decisions were often made with little regard for strategy and there was no consistent approach to assessing the impact of the decision on strategy. The Director of Interpretation said, “everything we do is haphazard”. While the CFO provided a potential high-level decision-making framework, she stated that there are no objective criteria for decision-making or procedures. All personnel uniformly stated there were no consistent metrics upon which to evaluate decisions and assess their impact and effectiveness.
Change – Internal	Museum personnel agreed they are engaging in organizational change introduced and led by the President. While all interviewees felt the change was positive and moving into the right direction, there was some difference of opinion over the rate of change. Newer personnel tended to think the changes needed to be faster and more expansive. For example, the Director of Conservation said, “The angle of politics is a factor”, and “massive reluctance to change can be an impediment”, and “modern methods are hard to put in place”. The bright spot is an initiative in the Interpretation Department for better online content and an improved website. They are implementing a Project Management Professional (PMP) approach to the project.
Change - External	The CEOs were concerned over external changes in the environment and their markets. The two nearby CEOs especially noted these changes and the need to get data to track them effectively. The directors of MC&S and Education were the most concerned with changes in the external environment and markets. The Museum’s online content and re-vitalized website may help to better understand and adapt to these changes.

The focus group confirmed the themes in Table 7. It did not identify any additional themes.

The data sources review confirmed the museum has the internal data that Truex (1984) specifies, but there are concerns about reliability and confidence in several data sources and enterprise-wide accessibility for virtually every data source. The data source review is included in the Appendix B–Data.

The initial phase of the Education pilot gathered data to help assess the ticketing system’s data and to develop measures and metrics for the Education Department. This data is included in Appendix C.

#### Quantitative

The data from the survey confirmed the data gathered in the interviews. However, there were some differences between the survey data and the interview data on strategic initiatives. The differences may reflect a desire to demonstrate they understand the President’s initiatives when they had more time to think about the concepts. The survey data is included in Appendix B–Data.

### Analysis

#### Overview

There are clearly some issues with data and decision-making. There is no central data repository for analysis and reporting, and the data is in multiple stovepipes that are not connected. When analysis occurs, it is at the department level, using department data and extracts from financial or ticketing data. The only enterprise analysis is the financial reports the CFO prepares and these use only financial data. Likewise, there are no set processes to govern analysis and decision-making. There are also no dashboards. The closest thing to a dashboard is spreadsheets used by a few departments. Therefore, none of the DSS components are in place and there is no DSS.

#### Constraints

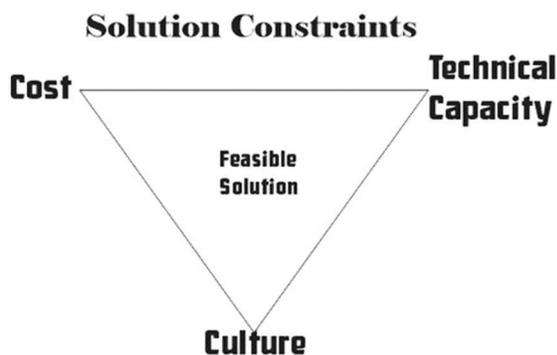


Figure 5 Constraints’ Envelope

The Museum has three constraining factors: IT capability, Cost, and Culture as shown in Figure 5. The technical constraints are a factor of IT resources and professional staffing. The cost constraints are a factor of the significant financial leverage the CFO discussed, heavy donor and grant funding, and the lack of operational revenues since the Museum has been closed for a year. Culture is more nuanced, but comments from several leaders and the low penetration of the President’s strategic concepts, combined with an “old school approach” that is resistant to change creates a limiting factor.

The staffing data revealed three critical constraints.

First, there is only one person in the IT department, the director. He has been with the Museum for quite a few years and his skills are dated and limited. He has never heard of several key programs such as the Capability Maturity Model Integration (CMMI) or the Information Technology Information Library (ITIL). These are two industry standards that have been in use for over twenty years and help organizations develop effective IT policies and procedures. He has no specific database background or background in software development. Like others in the Museum, he seems to hold his position more from longevity than professional expertise. This

constraint is a critical limiting factor in any technology-based solution unless they host it in a cloud environment and the Museum relies on the cloud provider to provide technical services. While this approach may solve the technology constraints, it may add significantly to the operational costs.

Second, the Education Department, which the President thinks is critical the strategy, has only two people. The director is smart, savvy, and understands what needs to execute outreach to the African American community. Unfortunately, she cannot develop specific programs or exhibits to extend this outreach and make it effective. Rather, her job is more to coordinate school visits and online programs using existing programs and exhibits. She may be able to influence program development if she had actionable information about what the schools want and need.

Unfortunately, the surveys she uses to help gain this information are not uniform or always generated or completed. Those that are completed are stored in individual spreadsheets and not brought together for analysis. Her assistant primarily schedules school visits and uses a spreadsheet to track them. This is separate from AlTru and has numerous data quality problems and cannot readily be linked to AlTru in its current state.

Third, the CFO, while she has twenty-one years of experience with the Museum, is not a professional accountant or finance manager. She grew into the position through the ranks. Her only professional certification is the Certified Payroll Professional. While this career path does not mean she does not have skills for the job, it may indicate a lack of familiarity with newer financial systems and approaches. It could be a reason the Museum has some difficulty with financial analysis and control. She has two people in the department, an accounting manager, and a data entry/AP/cash manager.

From an infrastructure perspective, there is no enterprise database or services. The infrastructure is primarily individual point systems such as Finance and Ticketing and a reliance on Google for file sharing, internet services, and internet reporting. This is a significant limiting factor for hosting a DSS. Since there is only one person in IT, there are no system administrators, database administrators, network engineers, or full stack developers. Therefore, in the current environment, the Museum cannot host or sustain a DSS. A potential solution is cloud hosting to use a cloud provider's infrastructure and services. While this will mitigate the technical constraint, it adds to the operational costs.

The Museum has significant financial constraints. The Museum has been closed for over a year now from COVID and relies solely on donor and grant funding. While this has kept the staff employed, it significantly constrains what they can do. While the President has been creative, and, as noted above, has used the shutdown to shift to a more online presence, their limited technical resources constrain what they can do. Even when the Museum re-opens, as the CFO stated, with their financial leverage and the need to fund museum operations and exhibits, their funds will be constrained to day-to-day operations and critical issues that may arise. Leaders understand these constraints, which is one reason they applied for an RPP grant. Unfortunately, their applicant was unsuccessful, and the metrics and decision-making project was suspended because of the funding constraints.

Cultural constraints are far more nuanced and come through comments made by leaders during their interviews and from the survey results. The President has two key strategic initiatives: Adaptive Culture and Anti-Fragility (resilience). Survey results and interview comments indicate that leaders have at best a surface awareness of these two concepts. Most indicated they were aware because of discussions with the President but did not have a deep understanding and were

not deliberately implementing the concepts in their departments. These two concepts are key to executing the strategy in an uncertain and changing environment. The Adaptive culture will help to rapidly adapt and change in response to new directions such as those discussed by Biondo et al. (2020), Brida, et al. (2016), Forstiere, Lattarulo, Mariani, Mealli, Rassolini (2002), Lattarulo, Marian, and Rassolini (2017), Gilmore and Retschler (2002), Kisida, Greene, and Bowen (2014), and Hsieh, Chen, Hsieh, and Tsai (2018). These changes, as Gilmore and Retschler (2002) discuss, will require different approaches to marketing and managing customers and stakeholders. The teen dynamics that Forstiere et al. (2002) and Lattarulo et al. (2017) discuss may well affect the Education Department's efforts. The only leader that acknowledged these dynamics was the Director of MC&S.

In terms of internal resistance to change, the Director of Conservation comments, "The angle of politics is a factor", "massive reluctance to change can be an impediment", and "modern methods are hard to put in place", are revealing. He is also the newest member of the leadership team and came because of the Civil War ship's conservation requirements and funding. He also noted that a senior member of the leadership got his position solely through attrition and does not "rock the boat". One other comment is particularly telling in terms of culture and the ability to adapt and be resilient, "How do you engage in professional development with no budget?" He might be dismissed as a lone voice, but he is responsible for much of the budget and federal grant funding.

The current constraints' envelope is extremely tight, and any solution will require mitigation to expand the envelop. Cost and technical capacity will be straightforward to mitigate: the Museum can gain new resources and bring on new people if they can expand funding. The cultural aspects will be far more difficult and will require constant attention from the President.

#### Data

There are two enterprise data sources, the financial system, and the ticketing system.

The current financial system is Microsoft Dynamics, a top Enterprise Resource Planning (ERP) software package. As an ERP, it has a great deal of capability beyond financials and is therefore complex. Both the CFO and the Director of IT discussed their concerns with Microsoft Dynamics and their desire to move to QuickBooks, a far simpler and straightforward software package. While Dynamics is an ERP platform, it is not well understood outside of the Finance Department, and then primarily the basic financial functions. The departments rely on budget extracts in the form of spreadsheets for financial information. Given Dynamics complexity, there is also concern that the financial system may not be properly configured for effective reporting and analysis, as evidenced by the CFO's concerns over lack of visibility over contributed revenue.

The current ticketing system is AlTru, which is designed for museums, zoos, and similar organizations membership driven organizations. It is a cloud-based solution, so it requires minimal onsite infrastructure or technical support. Most of the leaders interviewed were uncertain about what is in AlTru or whether they can even use the data. For example, the CFO said AlTru is a CRM and they "are not good getting data from it". The Director of Education stated "AlTru does not work well for Education because you can't track grade level and transportation, etc.". The Director of CS&M stated AlTru will track member data, but not nonmember visits. The Director of Interpretation stated he does not know what he can get from AlTru and it does not do anything for his department. He also said the Museum deleted the

AlTru support position so not much comes out it and he was told he cannot do anything with the data because of privacy issues.

During the Education pilot, we included extracts from AlTru and imported them into Microsoft Access. We found and tracked school visits, although there was none of the supporting data as the Director of Education stated. The pilot showed AlTru has relevant and usable data for reporting, but it needs to be fused with other data sources for complete reporting. The pilot also showed there are some quality issues with the data, primarily from data input errors. Overall, however, the pilot showed the Museum can use AlTru for reporting and it has relevant data. Therefore, the Museum sent two people to AlTru training to integrate it more effectively into museum operations and reporting.

There are other supporting data sources that enable specific functions. These range from spreadsheets to Google Analytics, and some social marketing data from Facebook, Instagram, and Twitter. These all have their niche uses, but they are all stovepiped and not connected or shared. The Museum does not capture the data into a database but uses it more in one-off analysis.

There is no consolidated enterprise data repository that has visibility over all aspects of the organization. There is no set of metrics, knowledge-based ontologies, and associated metadata. There are no ETL processes, data standards and data governance. Under the current environment, there is no data component for a DSS. There are pieces of a data component that can bring together and added to processes, ontologies, governance.

#### Analytical Model

There are very few measures and metrics, which are at the heart of Analytical Model. Virtually every director and the President stated there no effective metrics that govern decisions. There are a handful of smaller metrics, but generally does not use them since there are no models and processes or standards against which to evaluate them. There are some isolated spreadsheets, but they are not Analytical Models since they do not have rules, metrics, criteria, and actions.

Leaders do, however, understand they need them and want them. During the Education pilot, we developed a series of draft metrics for the department.

The Museum does not have the capability to systematically analyze their operations or the changes in their environment. Therefore, their decisions tend to be ad hoc and without a great deal of supporting information.

#### UI

The Museum does not have a BIA capability. Virtually all leaders agreed there were no effective dashboards in the departments and no enterprise dashboard across the organization. The Museum does not have the capability to maintain a comprehensive situational awareness inside the organization or over their environment.

#### Configuration and Management

The Museum does not have significant decision-making, data management, or governance processes and tools. While there is an understanding of the need for decision-making processes, several of the leaders have concerns that process could inhibit creativity and innovation. The customer facing departments are working a design thinking approach they feel can conflict with more standard decision-making approaches and processes. The President embraces the design thinking approach and is careful to ensure any actions they take facilitate it. The two other CEOs also echoed concern over processes and concern over being overly controlled.

There is, however, a good starting point for configuration and management. The Interpretation Department website project is implementing a Project Management Institute-based approach. This is the first significant process and management capability using established professional practices. A successful project will provide a strong foundation for other projects and approaches using professional processes and governance structures.

#### RPP

Leadership recognized the need to bring in funding and expertise to help build a more effective decision-making capability. They partnered with the University for an RPP to tackle the problem and jointly submitted a grant application for funding. Unfortunately, the grant request was turned down. They still recognize the need to use an RPP to expand their constraints' envelope and want to re-do and re-submit their grant request. As part of the Education Pilot, we brought in Vanderbilt's Dr. Erin Henrik to help the better understand the nuances of the RPP process. She also discussed an RPP evaluation framework and agreed that including this framework in the grant request and using it as a framework for the RPP design could be effective.

#### Summary

While the Museum has significant constraints and issues, there is a foundation upon which to build. AITru provides more capabilities than many thought, and can, along with the financial system, form the backbone of an enterprise data repository. The few spreadsheets they developed and used can inform the development of an enterprise analytical model as well as a dashboard system. The Project Management Institute-based approach for the website could form the basis for more effective management and processes. A successful RPP grant will significantly expand the constraints' envelope and provide an opportunity to build a DSS.

## Findings

The Museum currently has none of the DSS components in place. They do have core data, but it is siloed and not consolidated into an enterprise capability. Their web project using Project Management Institute processes and tools may provide the foundation for the Configuration and Management component of the Conceptual Framework. The Analytical Model and UI components will require considerable design and implementation work to put into place.

### Summary Findings

Finding 1: The Museum has most of the data required for effective decision-making or can acquire it through external sources. However, it is not integrated or well-understood.

Finding 2: While most of the leaders understand the fundamentals of decision-making, there is no enterprise-wide approach to decision-making or processes to support it.

Finding 3: There are significant technical, financial, and cultural gaps and that will constrain solution feasibility and design.

### RQ1: What are the Museum's current gaps and limitations in data and decision-making?

- There are significant gaps in all elements of the Conceptual Framework.
  - There is no enterprise data repository for analysis and reporting, and key data for engaging new customers is missing.

- There are no analytical tools or models other than some disconnected spreadsheets used by individual departments. Nothing exists at the enterprise level. There are no enterprise level metrics and very few department level metrics.
- There is no enterprise level dashboard or similar capability. Decision-makers have no place to gain situational awareness and access actionable information.
- There are no managerial processes and governance for data and decision-making.
- The Museum has significant, quantifiable limitations in technical capacity and financial capacity.
  - There is only one technical position in the organization, and the incumbent has limited technical skills. There is a limited technical infrastructure onsite.
  - There are only two people in the Education Department, which has a clear role in the strategy to better engage the local African American community.
  - There are only three people in the Finance Department, and the CFO's skill set is potentially limited.
  - Neither the CFO nor Director of IT have the traditional professional certifications often seen in senior positions. Nor do they have significant work experience with other organizations that could broaden their perspectives. These limitations can impact their ability to lead change in their areas.
- The culture may inhibit change.
  - The Director of Conservation spoke of a "massive reluctance to change". Others also mentioned concerns about changes, especially implementing processes.
  - The President's strategic concepts have limited adoption within the organization.
- The Museum is under significant financial stress.
  - High fixed costs.
  - The museum shutdown constricts revenue.

### **RQ2: What are the data and decision needs of the organization?**

- The financial and ticketing systems can provide much of the data specified by Truex (1994). The CM&S has started to mine social media to help the Museum engage Millennials and other emerging customer segments discussed by Kisida et al. (2014), Lattarulo et al. (2017), and Taheri et al. (2016), but now these efforts are limited and not connected to the operational data.
- The Education Pilot identified key decisions the department required. However, at the enterprise level and within the other departments there is no stated decision framework. Most leaders can verbally list the key decisions they need to make but not documented them. While being able to verbally list them is good for ad hoc decision-making, the lack of documentation and review impedes data design and therefore the data may not have the data elements and structure required to meet decision-making requirements.

### **RQ3: How can the Museum gain an enterprise view of their data for effective employment?**

- The Museum currently does not have an enterprise view of its data, nor do any departments have a comprehensive view.
- There are no true dashboards or other situational awareness and decision support capabilities.
- There is no BIA capability within the Museum.

**RQ4: What are the key system configuration and management elements to enable the data and decision-making framework?**

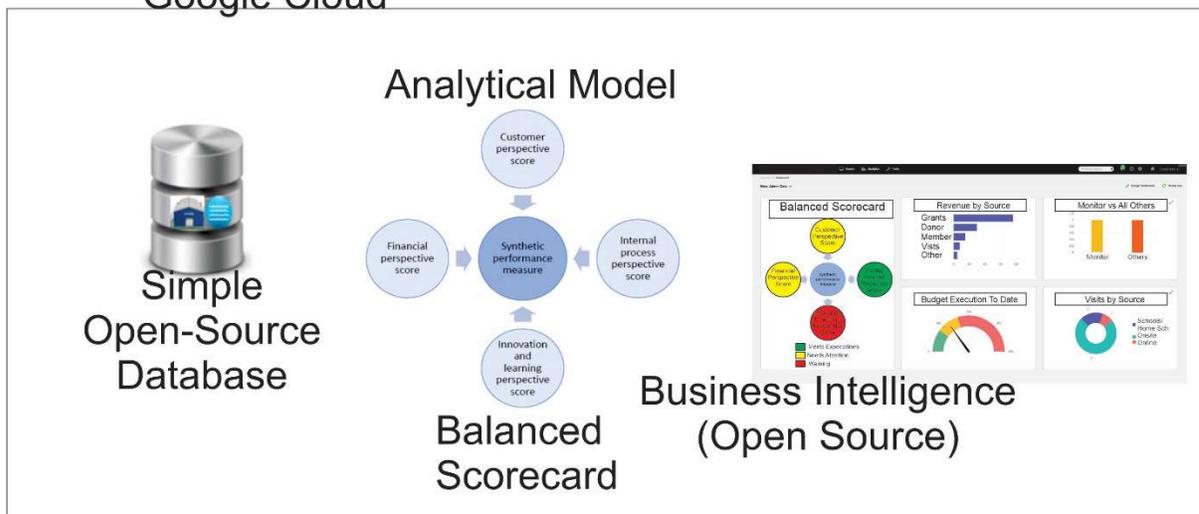
- There are currently no decision-making processes, and several department leaders are concerned that a specified process could impact their flexibility and stifle their creativity.
- There are no metrics and no tools and processes to ensure metrics when developed are enabled in the enterprise data repository design and structure and the required data is captured by the Museum systems.
- There is no ETL capability to extract data from individual systems and load it into an enterprise repository. There are some existing capabilities to extract data from the finance and ticketing systems to spreadsheets. This capability could be the foundation for a system wide ETL approach.

**Recommendations**

**Summary**

Recommend developing an RPP to design and implement a simple DSS on the Google Cloud. With the technical constraints, the solution components must be easy to understand, implement and maintain. The Museum’s shutdown and high fixed costs constrains the funding available for a solution. If an RPP grant funding request is successful, scale the first DSS design to a pilot based on the Education Pilot and deploy on Google Cloud using open-source software and

**Google Cloud**



Measures & Metrics  
 User Tasks & Functions  
 Other Systems  
 Governance  
 Processes  
 Data Management  
 Decision-making

Figure 6 Recommended Solution Architecture

interns from local colleges such as the University. The recommended architecture is shown in Figure 6.

### **Recommendation 1: Implement a simple DSS that fits within the constraint's envelope.**

As discussed in the literature review, there are three options to implement a DSS:

- Do it all internally with custom components.
- Procure a cloud-based solution. There are two variants. Simply procure a cloud platform and the services to manage it and implement a custom DSS or a complete cloud-based solution where the provider provides the platform, the software, and the services to support the solution.
- Procure a DSS package and implement it.

The literature review shows a trend of custom developed DSS solutions where organizations use niche components that best match their needs.

Given the current cost constraints, procuring a DSS package or a full cloud-based solution is potentially beyond the organization's near-term capability. Therefore, the choice is between building a simple DSS internally or on a cloud-based platform. Given the CFO's and the Director of IT's desire to move the financial system to the cloud and the lack of internal IT resources, a cloud-based platform may be the best solution. Recommend implementing a simple component based DSS on the Google Cloud, which it already uses for spreadsheets and analytics. Recommend reviewing Google Cloud and determining costs and then make a final decision. If costs are too high, implement a prototype on their servers.

#### Data

Given the significant cost and technical constraints, the only feasible option is a public domain database such as MySQL or a low-cost solution such as MS Access. Access has the benefit of a full application development environment so an entire DSS can be implemented within Access. However, it is not a robust database and not well suited to multi-user requirements. Also, the Museum did not seem to like Access as a path forward in the Education Pilot. MySQL is a free multi-user database that is often used for interactive websites. However, it does require more setup and support. A third option, like Access, is to build it within MS Excel or Google Sheets. Both can be hosted in a cloud, either MS One Drive or Google cloud. Finally, the Museum can implement one of Google Cloud Databases, such as MySQL. This may have some cost. Depending on cost, recommend either a Google Sheets approach or a Google Cloud Database. While Google Sheets is not a preferred database method, it will work for a prototype and it can use the approach Person (2013) uses to build a BSC in Excel. This database can replicate core functions of a data warehouse and later be converted to a functioning data warehouse if required. Regardless of the individual database selected, it must have a schema that supports the strategy and decision requirements and access to the data required for the Analytical Model and UI components. Ontology and ETL processes are discussed below in the Management processes section. The Museum will also need a data governance policy and process, which is described in the Governance section below.

#### Analytic Model

Recommend basing the Analytic Model on the BSC as discussed by Basso and Funari (2020). The BSC provides a proven framework to build and evaluate metrics. Basso and Funari (2020)

also provide a discussion of the analytical approach to implement a BSC. Recommend using the metrics in Appendix C to develop an initial BSC for the Education Department to test and then work with other departments to develop BSC's for their needs and an enterprise level BSC.

A BSC implementation requires a well-designed repository that has the metrics and operational data it needs and some analytic engine that can perform the calculations and send the results to a UI. Using Person's (2013) approach, the Museum can build the Analytic Model on a spreadsheet. However, this is a good first step for a proof of concept, but not a long-term solution. A better alternative is to use a BIA tool. The BIA tool can be both an analytical engine and the UI.

#### UI

Recommend a dashboard as a principal UI. While the Museum has some experience using spreadsheets as limited dashboards, I do not recommend it, unless the dashboard(s) are part of a system implement such as Person (2013). Otherwise, the solution will be piecemeal, stovepiped, and the Museum will continue to have problems gaining enterprise situational awareness. A better solution is a BIA approach. BIA solutions can perform the analytic engine role and present the results in a dashboard.

There are powerful commercial BIA packages such as PowerBI, Qlik, and Tableau. These can get expensive, so the Museum may want to start with an open-source BIA tool initially. Tableau provides an open-source hosting for small implementations, but it may not be secure enough for the Museum's sensitive information. Likewise, many of the open-source solutions are lesser enabled starter packages to move into a fee-based BIA solution.

Important selection criteria for a BIA tool are:

- How well does it perform the analytics function?
- How easy is it to create custom dashboards?
- Can it schedule analytical runs and send alerts?
- Does it fit within the budget?

The dashboard should be an interactive system and allow drill-down capability to explore the metrics and what is happening with them. Ideally, the system will have an enterprise dashboard and dashboards for each department. The top-level view for enterprise and department dashboards should be a BSC view.

Recommend implementing the Education Department first to leverage the metrics and data work completed during phase I of the pilot project. Basso and Funari's (2020) list of metrics is also a good starting point.

The UI tool and the BIA tool should be the same. Selection should ensure the selected tool can provide both analytics and a dashboard. Most commercial tools provide both functions. Open source may not provide both capabilities well, so the selection process must carefully review any open-source candidates to ensure they can perform both tasks.

**Recommendation 2: Build management and governance processes that balance flexibility and control.**

Identify strategic linkages and questions that tie to decisions:

From the interviews initial strategic and operational decision requirements include:

- How can the Museum effectively engage the local community? What new programs and exhibits are required to meet their needs and expectations?
- How can the Museum effectively engage the Millennials? What new programs and exhibits are required to meet their needs and expectations?
- How much emphasis should the Museum place on its online presence after COVID?
- How can the Museum better engage the donor community and expand donor programs?
- What can the Museum do to improve the membership program and create value for the members given the \$1 admission program?
- How can the Museum become more financially secure and reduce some financial leverage?

Appendix C provides the metrics developed for the Education Department during phase I of the pilot project. These, along with Basso and Funari's (2020) list of metrics can be used to stimulate discussions at the enterprise and department levels.

#### Governance

- Establish a strategic governance body and a data governance body and guiding policies.
  - Strategic governance maintains the strategy and evaluates strategic and operational (department level) decisions. Ensure leaders establish and maintain measures and metrics and the metrics have meaningful standards.
  - Data governance maintains the enterprise data policy and processes. Ensures that ontologies and ETL process are maintained, and the ontology support the current strategy and operational requirements. Specifies data access and security requirements. Approves changes to the enterprise schema and other changes to the repository.

#### Data Design Process

- Develop a simple ontology using spreadsheets to create categorized lists maintained by a person designed by the data governance policy.
- Develop a simple process to maintain the ontology as strategy and the environment changes. This process should then edit and update schemas, identify source data and ensure it is included in any ETL process.

#### Management Processes

- Develop a simple ETL process to move data from originating data sources to the enterprise data repository. This process should include a schedule of when to run the ETL and how to maintain extraction and transformation routines.
- Develop an integrated decision-making process that has defined steps to execute but maintains as much flexibility as possible. Ideally, this process will be form driven and may be hosted on a website, SharePoint, Google Documents, or other access point available to authorized users. Major process steps include:
  - Problem statement and why it is a problem that must be addressed. Clearly state the problem.
  - Identify success criteria/successful outcome requirements.
  - Identify facts and assumptions bearing on the problem.
  - Identify key stakeholders and decision-makers.
  - Develop feasible alternatives and assess them.

- Make a decision.
- Implement the decision and then evaluate its success and impacts.

### **Recommendation 3: Implement a Research-Practice Partnership (RPP) to help expand the constraints' envelope.**

The RPP is a vehicle to gain technical and subject matter expertise from a partner and offset costs through a grant. Therefore, if a grant application is successful, it can significantly expand the constraints' envelope. Recommend a revised RPP with the University to build a museum specific DSS. This approach is sharper in focus than the prior submission and helps meet the criteria for creating shared expertise. The DSS approach the RPP creates, builds and tests can then be replicated by other museums.

Recommend the following be included in the RPP:

- The University personnel include people from their business management, finance, and IT programs. The business programs will work with the Museum personnel to gather the strategic and operational information discussed above and develop measures and metrics from it. They will also help design processes and governance. Finance people will work with the CFO to structure improved metrics and data to ensure she can get the data she needs for an enterprise-wide view of revenues, costs, and key ratios that provide insights into financial and operational performance. IT personnel will help design the data repository, enable processes, implement software, and develop IT and data governance.
- Budget for a BIA tool, and a Google database tool, the University labor any consultants needed.
- Incorporate Henrick et al. (2019) evaluation framework into the grant proposal.
- Discuss the value to the museum industry and how the Museum/the University will share results with other museums.

Recommend working with the University to create an internship program for business and IT majors to help lessen the technical constraints. Recommend highlight this program in the grant request to show commitment from both parties. If the RPP grant is not successful, the internship program, combined with open-source software, may be a way to develop an initial DSS pilot.

### **Recommended Way Ahead**

The key next step is to form a project team that will:

- Refine a strategy should consider the following to address changes in the environment:
  - Understand the Millennial preferences and how they affect the market. This may mean a greater emphasis on social media and marketing.
  - Either work with other attractions to rebuild tourism, find an alternative way to gain attendance, or expand its presence virtually to maintain revenues through both donors and attendance streams.
  - Engage the African American community more effectively. The constraints to leisure activities that Nowacki (2015) notes apply to this community with low income, lack of transportation, and a lack of motivation if they do not see the relevance to the Museum to their experience and culture.

- These three lines of effort require reliable, actionable information to assess the market dimensions and the Museum's capabilities and status and make effective actionable information-based decisions.
- Use the Education pilot as the basis for a DSS prototype.
- Revise the metrics RPP with the guidance from Dr. Henrick and resubmit it.
- Work with local universities to develop an internship program that will work with the RPP team and develop the initial DSS.
- Conduct workshops at the enterprise and department levels to identify decisions and metrics like those conducted during the Education pilot.
- Build and test the prototype DSS and processes.

### Study Limitations

The study did not review all departments to the same level as the Education Department. Therefore, there is some risk that approaches that what worked well for the Education Department may not work a well in other departments. I did not review all data sources, so there could be additional data issues or strengths not covered in the data review. Since the Museum will move from their current financial system to QuickBooks, I did not study it in detail. Finally, the strength of any new ideas and programs relies on the organization's cultural acceptance and willingness to implement it.

### Conclusion

This study identified key gaps in the organization's capabilities and developed an approach for the organization that fit into the current constraints' envelope to close the data, process, and governance gaps identified in the study. This approach will build a strong foundation for continued improvements in the decision-making capabilities that will help the Museum move toward achieving the CEO's vision to strengthen its resilience and adaptive culture.

The pilot project tested and validated the DSS components and approach. The results from the first phase of the pilot execution confirmed the value of the data, and the Museum is currently executing the rest of the pilot build. The President said the study clearly "opened the aperture" and the RPP on metrics is on track and they hope to announce it 2021.

The approach may also be used to strengthen engagement with the Museum's audience. La Russa and Santagati (2021) and Lee and Lin (2010) discuss how DSS capabilities can help with exhibit scheduling and audience engagement. Martínez-De-Albéniz and Valdivia (2019) discuss how effective scheduling can impact attendance. Tsai and Lin (2018) discuss creating a competitive advantage. These approaches may help to improve marketing (Taheri, O'Gorman, and Baxter, 2016) and improve target market attendance as well as identify emerging target markets. Attendance is the life blood of a museum. While it can be virtual through online engagements, given the exhibits, there are tremendous opportunities for hands on engagement and learning, which is what modern audiences seek.

**Annex A - Literature Review Matrix**

Table 8 Literature Review Matrix		
Conceptual Framework Element	Source	Applicability
DSS Framework	Truex (1984)	Truex applies the DSS framework to museums. This provides the unifying element for the research
	Arnott and Pervan (2008)	Provides DSS Theory to strengthen the DSS analysis and component requirements
	Chan, Song, Sarker, and Plumlee (2017)	DSS Motivation and use
	Liu, Duffy, Whitfield, and Boyle (2010)	DSS and decision performance improvement
	McCoy and Rosenbaum (2019)	User shadow practices in DSS
	Shibl, Lawley, and Debuse (2013)	DSS acceptance
	van Os, Herber, and Scholtens (2016)	Social acceptance of DSS
	Li and Wen (2011)	Cloud-based DSS
	Demirkan and Delen (2013)	Cloud-based DSS
	La Russa and Santagati (2021)	AI-Based DSS for a Historical House Museum
	El-Aghoury, Ebid, and Mahdi (2020)	Custom DSS
	Ali, Aziz, and Siti (2020)	Custom DSS
	Ji, Yu, Xi, Xu, Qin (2020)	Custom DSS
	Abdellatif, Bouaud, Lafuente-Lafuente, Belmin, Séroussi (2021)	Custom DSS
Data	Taheri, O’Gorman, and Baxter (2016)	Data to support heritage marketing
	Borić (2016)	Data to support expanding museum attendance
	Sökmen, Yolal, and Özel (2020)	Marketing in the Post-modern era
	Shaw and Krug (2013)	Social Media impact on museums Need to include social media data for analytical purposes
	Evans, Bridson, and Rentschler (2012)	Key drivers and impediments for museum brand identification.
	Richani, Papaioannou, and Banou (2016)	Internet and web marketing for museums

	Venter (2019)	Information quality affects the quality of the decision. Inputs to BIA
	Chen, Goes, Gupta, and Marsen (2006)	Rules for creating data structures
	Habermann (2020)	Role of Metadata in connecting projects together
	Modes, Valasselaer, and Lemahieu (2016)	Metadata to manage quality for decision-making
	Pinoli, Ceri, and Martienghi (2019)	Metadata use in model building
	Leach-Murray (2020)	Metadata to support interoperability
	Kalita and Deka (2020)	Metadata and ontology
	Sugumaran and Storey (2006)	Ontology and database design
	Bjeladinovic (2018)	Hybrid SQL/NoSQL design
	Link and Prade (2019)	Design schema for uncertain data
	Chaudhry, Moyne, Rundensteiner (1999)	Design schema for uncertain data
	Faisal, Sarwar, Shahzad, Sarwar, Jaffry, Yousaf (2017)	Data warehouse design
	Ouaret, Boukraa, Boussaid, Chalal (2019)	Building a data warehouse
	Park (2006)	Data warehouse effect on decision-making
	Park and Kim (2013)	Data warehouse based DSS
	Quaddus and Intrapairot (2001)	Data warehouse policy management
	March and Hevner (2007)	Data warehouse based DSS
	Ahmad, Azhar, and Lukausis (2004)	Data warehouse based DSS
	El-Sappagh, Hendawi, and El Bastawissy (2011)	Data warehouse ETL
	Molinaro, Romano, and Battisutta (2019)	Data warehouse and decision-making
	Khan, Ehsan, Mirza, and Sarwar (2012)	Data warehouse and CRM
	Lo Guidice, Musarella, Sofu, and Ursino (2019)	Data Lakes and BIA
	Llave (2018)	Data Lakes and BIA
	Merendino, Dibb, Meadows, Quinn, Wilson, Simkin, and Canhoto (2018)	Big data and decision-making
Analytical Model	Pei-Hsuan, Chin-Tsai (2016)	Analytical factors to consider for strategy development and evaluation
	Agyeman (2019)	Museums and data analytics
	Agostino and Arnaboldi (2012)	BSC design

	Aureli, Cardoni, Baldo, and Lombardi (2018)	How BSCs can manage and control networks
	Capone (2020)	Data driven decision-making approaches
	Basso and Funari (2020)	Analytical models and museum BSC
	Castor (2020)	Problems with data-driven decisions
	Corrall (2015)	Strategy linkage to a BSC
	Eilat, Golany, Shtub (2008)	Data driven decision-making and the BSC
	Figge, Hahn, Schaltegger, and Wagner (2002)	BSC sustainability
	Ghasemaghaei (2019)	Does data analytics improve decision-making quality?
	Gibbons and Kaplan (2015)	BSCs and organizational culture
	Hansem and Schaltegger (2016)	BSC sustainability
	Harihayati, Lubis, Atin, and Widiyanti (2018)	BSC and company performance
	Huang and Hu (2007)	Strategic alignment and the BSC
	Kabassi, Maravelakis, and Konstantaras (2008)	Criteria for museum tour decision-making
	Kaplan and Norton (1996)	Linking the BSC to strategy
	Kaplan (2012)	Issues with BSC
	Kraus and Lind (2010)	BSC and corporate control
	Meng and Shi (2017)	Data Envelop Analysis
	Nørreklit (2000)	BSC assumptions
	Soderberg, Kalagnanam, Sheehan, and Vaidyanathan (2011)	What makes a BSC?
	Wu, Lin, and Chang (2011)	BSC and performance evaluation
	Peterson (2014)	Book about building a BSC on Excel could be an implementation resource.
UI BIA Dashboards	Banerjee, Nguyen, Garousi, and Memon (2013)	GUI Design
	Pastushenko, Hynek, and Hruška (2019)	UI design and metrics
	Chiang, Goes, and Stohr (2012)	Information requirements for Business Intelligence and Analysis
	Sairanen (2017)	Role of information in museum decision-making
	Avidon (2019)	Use of analytics in museum decision-making
	Chen, Goes, Gupta, and Marsden (2004)	Impact of data structures on dynamic queries for BIA
	Isik and Sidorova (2013)	Role of BI in decision-making
	Lim, Chen, and Chen (2013)	BIA research
	Popovič, Hackney, Coelho, and Jaklič (2012)	BIA and analytical decision-making

	Teixeira, Oliveira, and Varajão (2019)	Evaluating BIA projects
	Bir, Chew, Smith, and Day (2019)	Using dashboards to create actionable information
	Nadi, Maedche, and Schieder (2020)	Dashboards and situational awareness
	Bors, Kemmer, Fulton, Stachecki, and Brennan (2015)	Dashboard design and development
	Person (2013)	Creating a Dashboard with a BSC
Management	Bienvenu, Cate, Ten, and Wolter (2014)	Ontology-based data access
	Bellahsense, Bonifati, and Rahm (2011)	Schema management and its impact
	Haug, Holmen, Wu, Mynam, and Ferraro, (2014)	Ontology tools and predictive model development
	Karagiannis, Vassiliadis, and Simitsis (2013)	ETL scheduling
	Matsumoto (2019)	Ontologies and probabilistic decision-making
	Nath, Hose, Pedersen, and Romero (2017)	Programmable ETL
	Osterwalder (2004)	Ontology and the business model
	Petrović, Vučković, Turajlić, Babarogić, Aničić, and Marjanović (2017)	Automating ETL
	Upward and Jones (2016)	Ontology and Business models
General Museum	ACME Ticketing (2019)	Museum Trends and data
	Beatty (2018)	Trends in the Museum area
	Biondo, Cellini, Cuccia (2020)	Museum attendance drivers
	Brida, Dalle, Nogare, Scuderi (2016)	Motivation and museum attendance
	Dainell, Manetti, and Sibilio (2013)	Accountability practices for non-profits
	Forstiere, Lattarulo, Mariani, Mealli, Rassolini (2002)	Teens and museum attendance
	Gilmore and Retschler (2002)	Museum marketing emphasis
	Hede and Thyne (2010)	Museums and authenticity
	Hsieh, Chen, Hsieh, and Tsai (2018)	Customer loyalty and museums
	Kisida, Greene, and Bowen (2014)	Cultural consumers and museums
	Lattarulo, Marian, and Rassolini (2017)	Teens and museum attendance
	Lee and Lin (2010)	Decision model to schedule exhibitions

	Martínez-De-Albéniz and Valdivia (2019)	Museum scheduling and attendance
	Nowacki (2015)	Museum visitor constraints
	Tsai and Lin (2016)	Museum business strategy evaluation
	Tsai and Lin (2018)	Creating museum competitive advantage
	Skinner, Ekelund, and Jackson (2009)	Public funding and museum attendance
	Taheri, O’Gorman, and Baxter (2016)	Museum and heritage marking issues
	American Alliance of Museums (2020)	Impact of COVID-19 and number of closures
	Dilenschneider (2015)	Impact of free admissions
	Villaespesa and Tasich (2012)	Spreading the analytics culture
	Zbucheá and Birt (2020)	Museums and Stakeholder Management
Constraints – RPP	Bevan, Henrick, McGee, and Dettori (2019)	Developing and understanding RPP
	Coburn and Penuel (2016)	RPPs in education
	Farrell, Harrison, and Coburn (2019)	Roles in an RPP
	Henrick, McGee, Greenberg, Dettori, Rasmussen, Yanek, and Reed (2019)	Measures to Assess an RPP
	Henrick, Munoz, and Cobb. (2016)	Shoring up weak spots in an RPP

**Appendix B – Data**

**Interview Intermediate Data**

Table 9 the Museum Data Collection	
Code	Key responses
Key Issues	<ul style="list-style-type: none"> <li>• Finance: Cannot control 12.5% of budget. \$8M budget, no good way to apply the brakes on expenses. 75% of budget is fixed, but revenue is variable.</li> <li>• Education: Resources are a critical challenge; collective decisions are a challenge. Submitted an RPP grant request to develop metrics but was unsuccessful.</li> <li>• Collections &amp; Curation: Massive amount of complexity in determining priorities-How do we prioritize? Be able to handle emergent issues?</li> <li>• Conservation: Massive reluctance to change that can be an impediment, Personalities get in the middle of things, Federally funded conservation for the Civil War ship.</li> <li>• Marketing Communications &amp; Sales: Information to make decisions, sharing information, Need to better engage member audience and determine what programs they need/want.</li> <li>• Interpretation: Move to market-based program development and Design Thinking, currently zero interaction with visitors about what they really want.</li> <li>• IT: No understanding of CMMI/ITIL, they are building a “Power user” model since there are no IT resources.</li> <li>• Facilities Management: Relies on a board directed facilities assessment.</li> </ul>
Data Sources	<ul style="list-style-type: none"> <li>• Finance: MS Dynamics, JP Morgan Investment data, AITru (Ticketing) has significant limitations.</li> <li>• Education: Altru, spreadsheets (internally generated), teacher surveys; AITru does not work well for education given its limitations in data.</li> <li>• Collection &amp; Curation: Limited explicit data sources.</li> <li>• Conservation: No systems, uses Excel and Google Drive spreadsheets, captures time data, but says there is no museum-wide mandate to capture time.</li> <li>• Interpretation: Google Analytics and Trends (website data), needs more on audience data, no one understands all the systems and can pull them together’ Not getting effective reports from AITru.</li> <li>• Facilities Management: Assessment report, invoices, internal spreadsheet.</li> </ul>
Decision-Making	<ul style="list-style-type: none"> <li>• Need to understand decision-making for audit protection.</li> <li>• Ad hoc decisions.</li> <li>• Determine integration points.</li> <li>• Need to determine rubrics for audience, project, value.</li> <li>• Need to develop budget based on data.</li> <li>• Organizational politics is a fact.</li> <li>• Need cross-compartment metrics and planning.</li> <li>• Need to make decisions on common data.</li> </ul>
Metrics	<ul style="list-style-type: none"> <li>• Finance: Contributed Revenue (but cannot track), Market, Utility Costs, Attendance</li> <li>• Education: # Students served, minimal data collection</li> <li>• Collection &amp; Curation: No good history on post-implementation reviews, mainly anecdotal data</li> <li>• Conservation: No good metrics to make effective decisions, hard to get best practices from other museums.</li> <li>• Interpretation: None</li> <li>• Facilities Management: Cost of Operation, Age of Equipment, Repair Costs</li> </ul>
Dashboard	No formal dashboards. Some departments use Excel as a pseudo dashboard. Some Gantt charts, wants an Artefact Based Programming Gantt System (Conservation)
Analytical Tools	Excel, Google Analytics
Staffing	94 Overall.

	<ul style="list-style-type: none"><li>• Finance:3</li><li>• Education: 2</li><li>• Collection &amp; Curation: 6 (Includes Education and Conservation)</li><li>• Conservation 10</li><li>• Marketing Communications &amp; Sales: 9</li><li>• Interpretation: 5</li><li>• IT: 1</li><li>• Facilities Management: 15</li></ul>
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### **Comparable Museum CEO Interview 1**

**Date:** 12/08/2020

**Interviewee:** Comparable Museum CEO

Zoom Interview

### **What are the decisions your museum needs to make?**

Do not layoff because of COVID.

Manage financial issues.

Things move slowly.

### **How are these decisions tied to strategy or operational execution?**

They have a strategic plan that goes to 2026. Important date (250<sup>th</sup> anniversary for nation and 100<sup>th</sup> for location). It is a living document. Think about areas of history they need to expand. Secure financial future. Grow endowment by a significant amount. Do a better job of using resources and managing the balance sheets. Land is not used effectively and costs money through taxes.

Priority:

- High profile nature.
- Ease of fund raising.
- Ability to educate people.
- Ability to drive visitation.

### **What kinds of data do you use to inform your decision-making?**

Woeful lack of data for decision-making.

Challenge to get data. Do not make a lot of investment in data. Need to address data issues.

Badly outdated CRM. Goal is one integrated CRM system.

Good data on online productions in the digital space.

Visitation. Generally know where people are coming from.

Lack of hard quantitative data. Not sure what to do with data from this year.

Look at social media.

Lot of time on corporate affairs in social media

## **Do you have a data governance process?**

No

## **Do you have data analytical tools to help analyze your data?**

Just a few spreadsheets. Want to get a CRM system to get a better understanding of the customers.

## **Does the museum have a formal decision-making process?**

No

## **What are the key challenges your museum faces?**

Short term and long term

Long term: financial challenges and operational. Negative cash flow. Too much debt. Image and relationship with other institutions, both local and other museums. Lower museum visitation. Where is the location going?

Short term: COVID presented significant challenges. Tourism, retail, hospitality. Impact on financial system. Social Justice awakening Caused a re-weighting of programs, especially with digital programming. Digital programming has exploded. Some stakeholders still want American history as it was told in the 1950s.

## **How does your approach to decision-making help to address these challenges?**

Donor engagement. Good response from donors. Stepped up efforts to communicate with them. Tremendous amount of online discussions. Online programming is essential: show the area is active and vital. Thoughtful about how they engage donors. People invest in organizations they love and feel make a difference. No specific reports to donors. What moves the needle for donors

is how it sustains the museum and keeps the museum vibrant. Working on archeology of the nation's first black church. Advance understanding of history.

## Comparable Museum CEO Interview 2

**Date:** 11/23/2020

**Interviewee:** Comparable Museum CEO

Telephone Interview.

### **What are the decisions your museum needs to make?**

Museums told to behave like for profit. Makes hierarchical and loses something. She works from the middle. Started with frontline personnel. Come up with 3 things. Day-to-day versus strategic decisions. Personnel, programmatic issue, communications.

Front-line, day-to-day in the moment

Mid-level: what will happen over the next month: staffing, training, budget

Leadership team: Not informed by data. Not understanding what they are doing versus peers. Metrics are out of date and not what peers are using to establish success. What they are doing could conflict with the marketing message.

Need to get the board aligned as well.

### **How are these decisions tied to strategy or operational execution?**

Tied back to the mission: Explore, assess history of the location through the conversion of three cultures. Wages not competitive with peers. 60% retention rate. Does the marketing/brand support the mission. Staff says no.

What impact do you want to have?

Keep it simple.

Timeline of 2026, but it may change.

### **What kinds of data do you use to inform your decision-making?**

- Data institute of museum
- Pew research

- American Alliance of Museums
- State and local history association
- Help to understand the visitors.
- Education looking at state education.
- Virginia Tourism commission
- Internal

Visitation, financial, HR, maintenance, projects, capital. Review about every 2 weeks.

Talk to people.

### **Do you have a data governance process?**

Not answered directly, but the indications are they do not.

### **Do you have data analytical tools to help analyze your data?**

Finance Department provides a dashboard. Working on a new dashboard and KPI. Do not have an integration. She gets spreadsheets and graphics. No tools other than spreadsheets.

### **Does the museum have a formal decision-making process?**

Depends on the decision and circumstances. Sounds more ad hoc than not.

### **What are the key challenges your museum faces?**

COVID-19, declining tourism, lack of trained staff and leaders who have just done the same job, day after day with little or no professional growth.

### **How does your approach to decision-making help to address these challenges?**

Since it is primarily ad hoc it is more reactive.

She expressed concern about process in a creative environment. Concern that process could stifle creativity. I explained structure is a balancing act. Not enough structure and process is chaos. Too much is a straitjacket. The mediating factor is culture. Process has to be congruent with culture. But culture may need to adapt as well. Leadership must balance them all.

### **Data Sources Review**

Table 10 Data Sources	
Data Source Name	Microsoft Dynamics
Purpose	Manage Museum financial data
Internal Source?	Yes
Where Stored?	Local servers. Note the CFO wants a cloud-based solution. Dynamics can provide that with Dynamics 365.
How accessed?	Logon
Security and data sharing requirements	Logon. Departments can get an extract exported to Excel
Complexity	Simple: No external links and highly organized structured data. Little or no transformation required during ETL
Volume/Size	Moderate. Measured in Gigabytes.
Velocity/rate of change	Slow. Few changes per day. Stable data
Reliability/Confidence	High confidence. Data has a proven track record of factual basis and has a high degree of integrity with no transformations required during ETL
Relevancy	Relevant. Correlated to operational objectives and tactical tasks. Used in key mission critical processes.
Reliability	Highly reliable. No policy or interface issues. Data is available as required except catastrophic conditions. This would be equivalent to a 99.99% or higher availability.
Comments	Not directly reviewed. Data on Dynamics gathered from Microsoft and other sites. Dynamics is an ERP and therefore complex with a lot of functionality that is not currently used. The CFO wants to move to a cloud-based QuickBooks solution.
Data Source Name	AlTru
Purpose	Manage Museum operational data
Internal Source?	Yes
Where Stored?	Local Servers
How accessed?	Logon
Security and data sharing requirements	Logon. Education Department can get an extract exported to Excel
Complexity	Simple: No external links and highly organized structured data. Little or no transformation required during ETL
Volume/Size	Moderate. Measured in Gigabytes.
Velocity/rate of change	Slow. Few changes per day. Stable data
Reliability/Confidence	High confidence. Data has a proven track record of factual basis and has a high degree of integrity with no transformations required during ETL

Relevancy	Relevant. Correlated to operational objectives and tactical tasks. Used in key mission critical processes.
Reliability	Highly reliable. No policy or interface issues. Data is available as required except catastrophic conditions. This would be equivalent to a 99.99% or higher availability.
Comments	Reviewed and used an AlTru export to Excel. Imported the Excel data into Access for review, analysis and use in a pilot. Data quality was good overall, but there are data entry quality issues. Some cities are not entered. Some data is misspelled. While there appears to be a data input standard, it is not always followed. These issues can make analysis and reporting difficult. AlTru provides data on student number.
<b>Contract Excel Spreadsheets</b>	
Data Source Name	Contract Excel Spreadsheets
Purpose	Help Education Department keep track of contracts
Internal Source?	Yes
Where Stored?	Local storage
How accessed?	Normal Excel spreadsheet open
Security and data sharing requirements	None
Complexity	Simple: No external links and highly organized structured data. Little or no transformation required during ETL.
Volume/Size	Small, Measured in Megabytes
Velocity/rate of change	Slow. Few changes per day. Stable data.
Reliability/Confidence	Moderate confidence. Data is accurate but has some consistency issues that require validation during ETL and follow-on processes.
Relevancy	Marginally relevant. Some correlation to processes used by tactical tasks. Data may be used in some processes.
Reliability	Highly reliable. No policy or interface issues. Data is available as required except catastrophic conditions. This would be equivalent to a 99.99% or higher availability.
Comments	The spreadsheets do not have a common format and data input standards. They seem to be more a set of notes than structured data to support decision-making. Key data element in the spreadsheets in the grade. These may also show the contracts. More information is required on the actual contracts and how they are structured, financial commits, and any service level specification.
<b>Teacher Surveys</b>	
Data Source Name	Teacher Surveys
Purpose	Obtain teacher input on program quality and effectiveness.
Internal Source?	Initially no as the teachers answer the survey. Yes, once it is stored on local servers.
Where Stored?	Internal servers
How accessed?	Normal Excel spreadsheet open

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Security and data sharing requirements	None
Complexity	Simple: No external links and highly organized structured data. Little or no transformation required during ETL.
Volume/Size	Small, Measured in Megabytes
Velocity/rate of change	Slow. Few changes per day. Stable data.
Reliability/Confidence	Moderate confidence. Data is accurate but has some consistency issues that require validation during ETL and follow-on processes.
Relevancy	Marginally relevant. Some correlation to processes used by tactical tasks. Data may be used in some processes.
Reliability	Highly reliable. No policy or interface issues. Data is available as required except catastrophic conditions. This would be equivalent to a 99.99% or higher availability.
Comments	There does not appear to be a systemic way to administer surveys. As the Museum develops decision-making metrics, the Education Department may need to change the survey to collect the data for the metrics. Consider a Google survey and make it easy for teachers to access and complete within 10 minutes.

Data Source Name	Student Surveys
Purpose	<b>There are no current Student Surveys. This is a survey the Education Department wants to start, and they listed it as a data source.</b>
Internal Source?	
Where Stored?	
How accessed?	
Security and data sharing requirements	
Complexity	
Volume/Size	
Velocity/rate of change	
Reliability/Confidence	
Relevancy	
Reliability	
Comments	Consider combining a pre-test concept quiz as part of an initial survey and a post-test concept quiz as part of a survey when the event is complete. This will help to assess the program's impact and effectiveness. Consider Google Survey and perhaps let students use a handheld device during a museum visit so they can easily complete the quiz/survey onsite.

Data Source Name	The Museum Educators
Purpose	<b>There are no current data sources</b>

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Internal Source?	
Where Stored?	
How accessed?	
Security and data sharing requirements	
Complexity	
Volume/Size	
Velocity/rate of change	
Reliability/Confidence	
Relevancy	
Reliability	
Comments	An internal Educator Community of Practice may be an excellent vehicle to collect this data. The CoP could meet weekly, bi-weekly, or monthly to discuss programs and school interactions.
Data Source Name	Staff Time
Purpose	Need to identify the system that tracks time.
Internal Source?	
Where Stored?	
How accessed?	
Security and data sharing requirements	
Complexity	
Volume/Size	
Velocity/rate of change	
Reliability/Confidence	
Relevancy	
Reliability	
Comments	Is there a time keeping system? MS Dynamics has a capability. Leaders indicated, however, there was no way to track hours on projects and other efforts.

Survey Data

Q9 - I understand the organization's mission and strategy (select one or more)

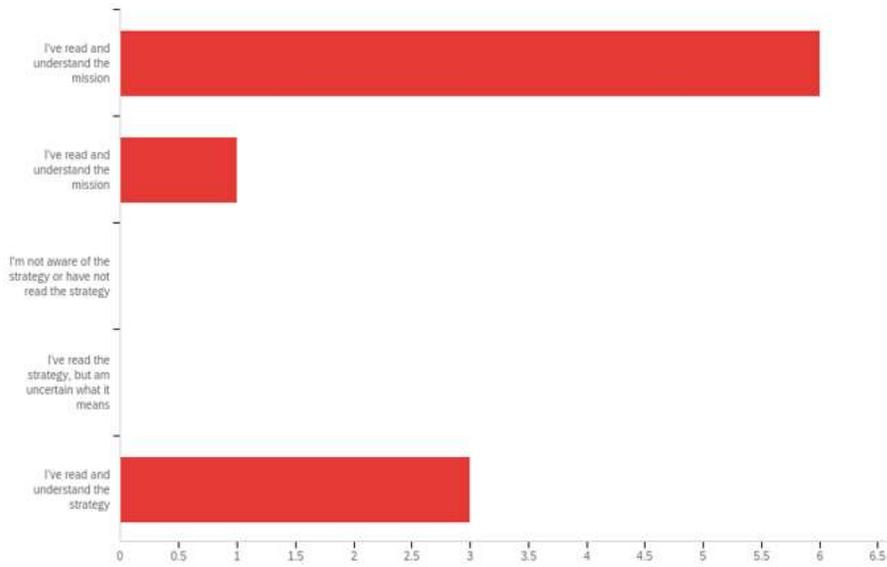


Figure 7 Understanding of Mission and Strategy

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Q10 - My place in the organization

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I understand my role and how it supports the mission	80.00	100.00	93.33	7.99	63.89	6
2	I am able to participate in decisions that affect my immediate organization	60.00	100.00	86.17	13.66	186.47	6
3	I am able to participate in decisions that affect my job	75.00	100.00	88.83	9.37	87.81	6
4	My supervisor solicits and values my opinion	80.00	100.00	94.00	7.30	53.33	6

Figure 8 Understanding Roles and Responsibilities

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
5	I understand the organization's decision-making process	30.00	100.00	73.17	26.65	710.14	6
6	The organization's leadership makes effective decisions that enable mission execution	68.00	100.00	87.67	13.45	180.89	6
7	The organization is a collaborative environment	35.00	100.00	75.33	25.69	659.89	6
8	Leaders and others constructively manage conflict and arrive at effective solutions	50.00	100.00	79.83	17.04	290.47	6

Figure 9 Roles and Decision-Making

Q11 - Data, evidence and how it is used

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I understand the difference between data and evidence	3.00	92.00	67.83	29.69	881.47	6
2	Leaders ask probing questions to test assumptions and fact	2.00	92.00	67.83	31.95	1020.81	6
3	We make decisions based on evidence	3.00	90.00	62.17	30.01	900.81	6
4	I have access to the data I need to do my job	3.00	93.00	63.00	31.98	1023.00	6

Figure 10 Understanding of Evidence vs. Data

Q14 - What data sources do you use the most?

What data sources do you use the most?
Email marketing results event and program registration info, social media data, visitation attendance, survey results
Team feedback and overall fluid communication
I don't use any data sources at the moment.
AlTru
Altru. Lightspeed, Microsoft Dynamics, Excel

Q15 - What data do you need, but do not have. Provide data sources/locations if you have them.

What data do you need, but do not have. Provide data sources/locations if you have them.
Additional information on audiences, specifically feedback - what is their value proposition?
I'm not sure what I need.
More detailed breakdowns of our audience

Figure 11 Data Sources

Q4 - Adaptive Culture

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Adaptive Culture	1.00	5.00	3.17	1.57	2.47	6

#	Answer	%	Count
1	I have never heard of this concept	16.67%	1
2	I've heard of the concept, but am not familiar with it	33.33%	2
3	I understand the concept, but have not worked with it	0.00%	0
4	I am very familiar with this concept, but not used it	16.67%	1
5	I am familiar with the concept and have used it	33.33%	2
	Total	100%	6

Figure 12 Understanding of Adaptive Culture

Q5 - Adaptive Leadership

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Adaptive Leadership	1.00	5.00	3.67	1.60	2.56	6

#	Answer	%	Count
1	I have never heard of this concept	16.67%	1
2	I've heard of the concept, but am not familiar with it	16.67%	1
3	I understand the concept, but have not worked with it	0.00%	0
4	I am very familiar with this concept, but not used it	16.67%	1
5	I am familiar with the concept and have used it	50.00%	3
	Total	100%	6

Figure 13 Understanding of Adaptive Leadership

Q6 - Communities of Practice

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Communities of Practice	1.00	5.00	2.50	1.38	1.92	6

1	I have never heard of this concept	33.33%	2
2	I've heard of the concept, but am not familiar with it	16.67%	1
3	I understand the concept, but have not worked with it	33.33%	2
4	I am very familiar with this concept, but not used it	0.00%	0
5	I am familiar with the concept and have used it	16.67%	1
Total		100%	6

Figure 14 Understanding of Communities of Practice

Q7 - Evidence-based Management

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Evidence-based Management	1.00	5.00	3.50	1.61	2.58	6

1	I have never heard of this concept	16.67%	1
2	I've heard of the concept, but am not familiar with it	16.67%	1
3	I understand the concept, but have not worked with it	16.67%	1
4	I am very familiar with this concept, but not used it	0.00%	0
5	I am familiar with the concept and have used it	50.00%	3
Total		100%	6

Figure 15 Understanding of Evidence-Based Management

Q8 - Antifragility

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Antifragility	3.00	5.00	4.33	0.94	0.89	6

1	I have never heard of this concept	0.00%	0
2	I've heard of the concept, but am not familiar with it	0.00%	0
3	I understand the concept, but have not worked with it	33.33%	2
4	I am very familiar with this concept, but not used it	0.00%	0
5	I am familiar with the concept and have used it	66.67%	4
	Total	100%	6

Figure 16 Understanding of Antifragility.

### Appendix C – Recommended Education Department Metrics

The metrics below were developed as part of phase I of the Education Department Pilot.

#### Current Programs

Measure/Metric	Data Source	Standard
<b>Measures of Performance</b>		
# of events <ul style="list-style-type: none"> <li>• Onsite</li> <li>• IVC</li> <li>• Offsite</li> </ul>	AlTru joined with Education DBMS	
#of students #of cities engaged	AlTru joined with Education DBMS	
#of contracts	AlTru joined with Education DBMS	
%Change Student year-to-year	AlTru joined with Education DBMS	
#of Teacher Survey's completed	Teacher surveys joined with Education DMBS	
Staff time to support the program	Financial management system	
Cost to maintain the program	Financial management system	

Measure/Metric	Data Source	Standard
<b>Measures of Effectiveness</b>		
#change in student quiz scores from pre-test to post-test <ul style="list-style-type: none"> <li>• All schools, all cities</li> <li>• All cities</li> <li>• Individual schools</li> <li>• Individual teachers</li> <li>• Effect of onsite, IVC, offsite</li> </ul>	AlTru joined with Education DBMS	
Teacher comments on the program	Teacher surveys School/Teacher CoP feedback	
Educator review and assessments <ul style="list-style-type: none"> <li>• Continued alignment with mission</li> </ul>	Educator CoP Assessment	

<ul style="list-style-type: none"> <li>Continued alignment with district/school requirements</li> </ul>		
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## New Programs

Measure/Metric	Data Source	Standard
<b>Measure: Alignment with mission</b>		
Education Department Assessment	Educator CoP Assessment; Education Form	
Collections and Curation Assessment (C&C)	Program CoP Assessment; C&C Form	
Conservation Assessment	Program CoP Assessment; Conservation Form	
Interpretation Assessment	Program CoP Assessment; Interpretation Form	
<b>Measure: Alignment with customers</b>		
Is there an expressed need or desire for this program?	School/Teacher CoP feedback Educator CoP feedback	
Does this meet district/school mandated requirements?	School/Teacher CoP feedback Educator CoP feedback	
Education Department Assessment	Educator CoP Assessment; Education Form	
Marketing, Communication and Sales Assessment (MC&S)	Educator CoP Assessment; MC&S Form	
<b>Measure: Donor support</b>		
Are there donors willing to subsidize or fund the program?		
What do Donors want?		
Will a donor value this program?		
Can an RPP fit this need?		
<b>Measure: Cost to develop and sustain</b>		
Cost to develop	C&C Estimate Financial Management System	
Cost to sustain	C&C, Facilities, Conservation Estimates Financial Management System	

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Technology Assessment	Program CoP; Technology Estimate Financial Management System	
Facilities Assessment	Program CoP; Facilities Estimate. Financial Management System Facilities Study Data	
Conservation Assessment	Program CoP; Conservation Estimate Financial Management System	

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