May 2014

Refining Visitor Tracking for Museum Victoria

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Refining Visitor Tracking for Museum Victoria

Historic and Artistic Preservation Technology Division
Project #AGK-1407

An Interactive Qualifying Project Report
submitted to the faculty of
Worcester Polytechnic Institute
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
Submitted on May 8th, 2014

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Abstract

Melbourne Museum, Scienceworks, and Immigration Museum are part of the larger premiere organization of Victoria known as Museum Victoria. Museum Victoria utilizes a visitor tracking system to improve exhibition design and improve visitor satisfaction. The goal of this project was to evaluate Museum Victoria's current pen and paper system for visitor tracking, to propose updates to the pen and paper tracking system, and to evaluate alternative digital systems for future implementation. Our team's final recommendations included a new methodology for Museum Victoria's pen and paper visitor tracking system and information on a potential digital technology that Museum Victoria could implement in the future.

Acknowledgments

We would like to recognize several individuals who have supported our team during the past four months. Their assistance was vital to the success of this project.

We would like to thank Museum Victoria for making this project available to Worcester Polytechnic Institute. In particular, we would like to thank our sponsor, Carolyn Meehan, Manager, Audience Insights for Museum Victoria, and Erica Chin, Research Analyst at Melbourne Museum, for their guidance, input, and support.

Additionally, we would like to thank the staff at Melbourne Museum for their support during our stay, and their participation in interviews conducted for this project. Their assistance was crucial to understanding the unique visitor tracking needs of Museum Victoria, and in particular, Melbourne Museum.

Lastly, we would like to recognize the faculty from Worcester Polytechnic Institute who played a major role in the completion of this project. Professors Andy Klein and Seth Tuler contributed valuable guidance during the course of completing this project, including advice on our final paper and presentation. Additionally we would like to recognize Dr. Andrea Bunting, Melbourne Coordinator, and Professor Holly Ault, Melbourne Project Center Director for providing us with the opportunity to complete this project.

Executive Summary

Museum Victoria has made it their purpose to contribute to their community's understanding of the world using innovative exhibitions and programs that engage and fascinate visitors. To assess whether or not they are achieving this objective, Museum Victoria currently uses a pen and paper visitor tracking system to improve exhibition design and improve visitor satisfaction. The **goal** of this project was to evaluate Museum Victoria's current pen and paper system for visitor tracking, to propose updates to the pen and paper tracking system, and to evaluate alternative digital systems for future implementation.

To accomplish this goal we completed the following **objectives:**

1. **Gathered background information on visitor tracking in museums**
   Through web searches and surveys sent to museums in the United States, we learned about visitor tracking systems that were used in the museum setting. We also identified information on real time locating systems that we believed to be applicable to Museum Victoria's needs.

2. **Conducted a trial of Museum Victoria's pen and paper visitor tracking system**
   Crucial to the subsequent development of the evaluation criteria, this study allowed us to understand strengths and weaknesses of Museum Victoria's visitor tracking system.

3. **Developed criteria to evaluate visitor tracking systems based on the needs of Museum Victoria**
   From data gathered through our literature review, staff interviews, and the trial of the pen and paper system, the main evaluation criteria developed were the following: affordability, accuracy, types of data collected, labor requirements, convenience to visitors, and reliability. The supplementary criteria developed were the following: real time access to visitor behavior, ability to push information, and adaptability.

4. **Evaluated Museum Victoria's current visitor tracking system based on ability to meet the developed criteria**
   By performing 40 whole site observations, we determined the relative strengths and weaknesses of Museum Victoria's pen and paper visitor tracking system.

5. **Evaluated technologies used by alternative real time locating systems based on ability to meet the developed criteria**
   The evaluation of the real time locating systems revealed the relative strengths and weaknesses of each technology.

6. **Provided recommendations to Museum Victoria on ways to improve their current visitor tracking system and alternative systems they might implement in the future**
   From the evaluation of the pen and paper visitor tracking system, we created a new methodology for Museum Victoria. After evaluation of alternative real time locating systems, we developed a recommendation for a real time locating technology to implement in the future.

In order to complete our six objectives we used a variety of methods. Tools used to aid this process included background research, staff interviews, and visitor tracking studies performed at Melbourne Museum, one of the three museums managed by Museum Victoria. The following sections present the findings from the completion of this methodology.

The main evaluation criteria were determined to be the following: affordability, accuracy, types of data collected, labor requirements, convenience to visitors, and reliability.

- Affordability: Since the pen and paper tracking system has low cost demands Museum Victoria is looking to improve their visitor tracking system in the least expensive way possible.
- Accuracy: Museum Victoria is interested in a system that can provide exhibit level data. A system that delivers this information needs to have accuracy to within 1 meter.
- Types of data collected: For the information collected to be as valuable as possible for Museum Victoria, the system needs to collect four types of data: timing data, tracking data, demographics, and situational variables.
- Labor requirements: The museum desires a system that takes less time to collect and analyze data than the pen and paper system.
- Convenience to visitors: As to not affect the visitors' experience, the system should be one where the visitors do not notice they are being observed or where they are not asked to carry a device.
- Reliability: A system that will be consistent with the collection of data is crucial; therefore, it should not have any human or system malfunctions.

The supplementary evaluation criteria were determined to be the following: real time access to visitor behavior, ability to push information to visitors, and adaptability. We identified additional criteria that were desired by staff members, but that were not essential to the museum at the time of this study. The supplementary criteria were developed to complement the main criteria and provide additional basis for evaluation; in the event that two technologies were similar based on the main criteria, these supplementary criteria could determine the superior option.

- Real time access to visitor behavior: The museum wanted the capability of using a smartphone or a computer to view where the visitors were in the museum at a specific moment.
- Ability to push information to visitors: Many museums are using electronic devices to provide visitors with more educational information during their stay. In the future, Museum Victoria would like to implement this as an option while simultaneously tracking visitors.
- Adaptability: Circumstances may require the floor plan of a gallery to change, and a suitable visitor tracking system could be easily modified to function in the new layout.

Museum Victoria's current visitor tracking system meets the following criteria: affordability, accuracy, types of data collected, and adaptability. It failed to meet the

following: labor requirements, convenience to visitors, reliability, real time access to visitor behavior, and the ability to push information to visitors (Table 1).

- Affordability: This system only requires a pen, paper, stopwatch, and printing materials, therefore it costs almost nothing.
- Accuracy: The observer can note where the visitor stops with accuracy to within 1 meter.
- Types of data collected: The pen and paper system is able to collect timing data, tracking data, demographic data, and situational data.

The system did not meet the labor requirements, convenience to visitors, and reliability criteria.

- Labor requirements: Our group of four took approximately one hundred hours to complete a forty-four whole of site visitor tracks.
- Convenience to visitors: In the forty-four visitor tracks performed, eight visitors noticed they were being followed, which may have affected their behavior at the museum.
- Reliability: In the forty-four visitor tracks, human error caused four visitors to be lost during the tracking study. Each group member recorded data differently, which resulted in minor consistency issues in the study.

When evaluating the pen and paper system with regard to the supplementary criteria, only one criterion was met.

- Adaptability: If there were to be a change in the gallery layout, the pen and paper system would be simple to modify since the only necessary change would be to create a new tracking map.

Main Criteria		Supplementary Criteria	
Met	**Not Met**	**Met**	**Not Met**
Affordability	Labor Requirements	Adaptability	Real Time Access to Visitor Behavior
Accuracy	Convenience to Visitors		Ability to Push Information to Visitors
Types of Data Collected	Reliability		

Table 1: Pen and Paper Evaluation

Implementing a real time locating system would allow Museum Victoria to enhance their current visitor tracking system. We evaluated real time tracking systems based on our main and supplementary criteria. These systems would allow Museum Victoria to collect more detailed visitor behavior data during studies. Tables 2 and 3 show a summary of the results obtained from the evaluations of Radio Frequency Identification (RFID), Ultra-wideband (UWB), Wi-Fi, and Bluetooth systems based on our main criteria. Table 4 shows a summary of the results obtained from the evaluations of these same real time located systems based on our supplementary criteria.

Technology	Affordability	Accuracy (meters)	Labor Requirements	Convenience to Visitors	Reliability
RFID	$$$	1.0-3.0	Low	Low	High
UWB	$$$	0.2-1.3	Low	Low	High
Wi-Fi	$$	1.0-3.0	Low	High	Medium
Bluetooth	$	0.5-3.0	Low	High	Medium

Table 2: Alternative Real Time Locating System Evaluation – Main Criteria (1/2)

Technology	Types of Data Collected			
	Timing Data	Tracking Data	Demographic Data	Situational Data
RFID	Yes	Yes	Yes	No
UWB	Yes	Yes	Yes	No
Wi-Fi	Yes	Yes	Yes	No
Bluetooth	Yes	Yes	Yes	No

Table 3: Alternative Real Time Locating System Evaluation – Main Criteria (2/2)

Technology	Real Time Access to Visitor Behavior	Ability to Push Information	Adaptability
RFID	Yes	Yes	Limited
UWB	Yes	Yes	Limited
Wi-Fi	Yes	Yes	Yes
Bluetooth	Yes	Yes	Yes

Table 4: Alternative Real Time Locating Systems Evaluation - Supplementary Criteria

By evaluating the alternative real time locating systems and the pen and paper system, we were able to identify the relative strengths and weaknesses of each technology. We were able to draw conclusions about future steps that would positively influence Museum Victoria's tracking system. Based on our findings and experience with the project, we produced the following recommendations.

Recommendation for Pen and Paper Tracking for Museum Victoria: Implement an improved methodology for future visitor tracking studies at Melbourne Museum.

By testing Museum Victoria's current visitor tracking system, we were able to identify the strengths and weakness of the system. We developed a methodology to improve the current visitor tracking system for Museum Victoria for future tracking studies. This methodology includes a systematic breakdown of the steps used to set up and conduct a visitor tracking study. Our team also created a set of standardized maps, a data collection document, and a demographic survey for Melbourne Museum to supplement this methodology. By following the guidelines presented in the methodology, the process for collecting visitor behavior data at Melbourne Museum will be more time efficient, more reliable, and have a lower chance of causing inconvenience to visitors.

Recommendation for Follow-up Study for Museum Victoria: Modify and implement the visitor tracking methodology developed for Melbourne Museum at Scienceworks and Immigration Museum.

During our time in Melbourne, our team was able to visit Scienceworks and Immigration Museum, two additional components of Museum Victoria's organization. We observed small differences within each of the museums. For example, Immigration Museum had much more open space within their exhibitions compared to Melbourne Museum. In Scienceworks, exhibits were spaced farther apart than in Melbourne Museum. However, with the standardized methodology our team developed for Melbourne Museum, Museum Victoria can easily modify the visitor tracking system for use throughout these institutions. Through development and implementation of the visitor tracking methodology in these other museums, Museum Victoria may uncover additional procedures they wish to make a part of their enhanced visitor tracking methodology. Additionally, this will provide an opportunity for Museum Victoria to verify the decrease in labor requirements, the increase in reliability, and the decrease in visitor inconvenience from the use of our developed methodology.

Recommendation for Digitalized Visitor Tracking for Museum Victoria: Implement a Bluetooth system for visitor tracking within Melbourne Museum.

Our team selected Bluetooth systems over other technologies due to lower cost and high accuracy. Additionally, Bluetooth systems were able to meet our three supplementary criteria developed from interviews conducted at Melbourne Museum. These three criteria were real time access to visitor behavior data, the ability to push information to visitors, and adaptability. While each technology that we evaluated had the ability to push information to visitors and provide real time access to visitor behavior data, only Bluetooth and Wi-Fi systems were easily adaptable to gallery layout changes. Many RFID and Ultra-wideband systems are installed for a specific design. The cost and labor requirements to change this infrastructure is much larger than simply moving a Bluetooth beacon from one exhibit to another. While our team was limited by time and budget constraints and not able to evaluate individual real time locating systems, we did identify numerous systems that could be used in Museum Victoria's institutions.

Recommendation for Follow-up Study for Museum Victoria: Pilot test real time locating systems incorporating Bluetooth technology recommended in this report before attempting a full-scale implementation.

Due to time and budget limitations with our project and Museum Victoria, our team was unable to implement demonstrations of systems presented in this report. However, our team identified several Bluetooth systems that the museum could purchase. A follow-up study that incorporates trials of Bluetooth systems will allow Museum Victoria to identify which system is best suited to their needs. Using the criteria developed in this project, along with additional new criteria, will allow Museum Victoria to evaluate each system. A thorough review of proposed Bluetooth systems would provide Museum Victoria with a clear choice as to which Bluetooth system would best enhance their current visitor tracking system.

Through our background research and first-hand experience with visitor tracking at Melbourne Museum, our team was able to identify areas of improvement for Museum Victoria's visitor tracking system. We provided recommendations to Museum Victoria with updates to the current visitor tracking system, an alternative digital update for future implementation, and

follow-up study recommendations. These recommendations were based on the data collected through fourteen weeks of work. Museum Victoria will be able to use the information presented in this report to improve their evaluation of their goals, specifically, dispersing knowledge throughout their community.

Authorship

Pedro Escuer, Ana Mateo, Christopher McConnell, and John Schutes all contributed to the research and writing of this report. The following is a breakdown of how the report was written for this project.

Pedro Escuer contributed to this report by writing Chapter 2 and the Acknowledgments. Mr. Escuer also contributed by organizing the slide shows for all presentations for this project. He also completed the summaries of visitor tracking studies completed for this project that are located in Appendix B and C.

Ana Mateo was responsible for the writing of Chapter 4 and the Executive Summary. Ms. Mateo also recorded and formatted the interview minutes located in Appendix F. She also compiled the consolidated list of companies presented in Appendix G.

Christopher McConnell completed the writing of Chapters 1 and 5. Mr. McConnell also completed the maps for tracking located in Appendix E. He was also the main editor for content for the writing of this report. Lastly, he formatted the entire paper into a single cohesive document.

John Schutes wrote Chapter 3 as well as completing the enhanced tracking methodology located in Appendix H. Mr. Schutes also created the museum survey located in Appendix A. Additionally, he lead the team in editing this report for grammar.

In addition to their individual contributions, Pedro Escuer, Ana Mateo, Christopher McConnell, and John Schutes all edited the paper for continuity as a group. Furthermore, the Abstract and maps located in Appendix D were created through a single group effort. A simplified breakdown of the main sections concludes this section.

Abstract ..... Group (ed. John & Christopher)
Acknowledgments ..... Pedro (ed. John & Christopher)
Executive Summary ..... Ana (ed. John & Christopher)
Chapter 1 Introduction ..... Christopher (ed. John & Christopher)
Chapter 2 Background ..... Pedro (ed. John & Christopher)
Chapter 3 Methodology ..... John (ed. John & Christopher)
Chapter 4 Results and Analysis ..... Ana (ed. John & Christopher)
Chapter 5 Conclusions and Recommendations ..... Christopher (ed. John & Christopher)
Appendix A ..... John
Appendix B ..... Pedro
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Appendix H ..... John

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1. Introduction

Knowledge gained through education is one of the most important factors in determining quality of life (Flanagan, 1982). Education plays a major role in attaining a job, earning a living, and becoming an independent individual. Museums are a cornerstone of education in society, serving as sources of knowledge and stewards of natural and cultural commonwealth (Lord, 2006; Screven, 1986). Museums have the potential to engage visitors, "to teach them, to stimulate their understanding, and most important, to help them assume responsibility for their own future learning" (Gardner, 1991, p. 202). For example, the Smithsonian contributes to the education of their visitors by making their mission "the increase and diffusion of knowledge" (Smithsonian, 2014). Additionally, the British Museum aims to "inspire and excite visitors" (British Museum, 2003, p. 3). All museums, including the Smithsonian and the British Museum, seek to serve as sources of knowledge in their communities.

Likewise, Museum Victoria has made it their goal to contribute to their community's understanding of the world using innovative exhibitions and programs that engage and fascinate visitors (Museum Victoria, 2011b). Museum Victoria recently completed a five million dollar renovation of the First Peoples exhibition in Melbourne Museum that included the installation of interactive audio and visual exhibits (Meehan, 2014). Additionally, Melbourne Museum and Scienceworks host touring exhibitions throughout the year, which provide additional opportunities for visitors to Museum Victoria's institutions to gain a better understanding of the world. Furthermore, Museum Victoria's online science collections team is developing a program to allow visitors to access additional digital information about the collections that is not able to be presented within the limited space of the museum galleries (Smith, 2014).

To assess whether Museum Victoria, and other museums around the world, are achieving their goal of providing knowledge to their visitors, they often evaluate programs such as those listed above. To conduct this evaluation, Museum Victoria needs to record how much knowledge a visitor gained from attending a program or exhibition. Through this evaluation, the museum would gain information on how to improve their current programs and exhibitions, as well as gaining valuable insight for development of new programs and exhibitions (Bronnenkant & Yalowitz, 2009; Meehan, 2014). The ideal method for this evaluation would be to administer some variation of a verbal or written test to each visitor. Through such a test, the museum would be able to determine how much knowledge a visitor gained exclusively during their visit. However, the museum would have to administer two tests, an entry and exit test, on every subject presented in the museum to gain an accurate measure of how much knowledge a visitor gained. As this approach is impractical for many museums to implement, they must have an alternative method to evaluate how much a visitor learned while in a museum.

The main alternative Museum Victoria uses to evaluate their programs and exhibitions is using data gathered on the timing and tracking of visitors. This idea of collecting data on visitor behavior in order to evaluate the quality of exhibitions has become an important focus of many museums (Chiozzi & Andreotti, 2001; Falk, 1993; Korn & Jones, 2000; Serrell, 1997). While this is an indirect approach to measuring a visitor's knowledge, researchers have suggested that the amount of time visitors spend at an exhibit can predict their level of engagement, and thus learning potential (Falk, 1983b; Serrell, 1995). More recently, researchers have accepted this method of collecting data on visitor behavior to be a conventional method to measure learning of visitors (Kaynar, 2005).

However, the challenge with this approach is the ability to complete three tasks simultaneously. These tasks are 1) to observe where visitors are within the museum, 2) to

observe how long visitors spend within certain parts of the museum, and 3) to record this set of data for future evaluation. Being able to complete these tasks allows researchers to gain critical information on visitor behavior (Bitgood & Patterson, 1987). Many museums use this information when evaluating the ability of their exhibitions to provide educational opportunities to the community (Klein, 1993).

Museum Victoria currently uses a pen and paper system to observe and record visitor behavior data. However, many museums have started to incorporate innovative techniques into their observations, including the use of visitor tracking through Closed Circuit Television (CCTV), Radio Frequency Identification (RFID), Bluetooth, and Wi-Fi. In order to gain more insight into the visitor experience, organizations such as Museum Victoria are investigating these alternative methods of collecting visitor behavior statistics. Museum Victoria sought to identify the weaknesses of their current pen and paper visitor tracking system and explore possible digital options that could enhance the abilities of their current visitor tracking system. For Museum Victoria to revise their current visitor tracking system, they required convincing evidence that a digital alternative would be able to provide more detailed data for exhibition designers than their pen and paper visitor tracking system.

The goal of this project was to evaluate Museum Victoria's current pen and paper system for visitor tracking, to propose updates to the pen and paper tracking system, and to evaluate alternative digital systems for future implementation. To provide these recommendations, our team conducted background research, interviews, and trials of Museum Victoria's pen and paper visitor tracking system. Through this, our team was able to develop criteria upon which we could evaluate the pen and paper system as well as possible digital alternatives. From this, our team developed an updated methodology to refine Museum Victoria's pen and paper visitor tracking system. Simultaneously, our team gathered information on products that Museum Victoria could implement in the future in order to enhance their visitor tracking system. As a result, we provided Museum Victoria with confidence in their ability to measure their goal of contributing to the education of their community.

2. Background

The purpose of this chapter is to provide information on the concept of visitor tracking in a museum setting. This chapter begins with a discussion on the goal of museums. Following this, the chapter presents a discussion on visitor tracking as an essential evaluation tool for museums. The chapter concludes with information on the abilities and complications of visitor tracking systems. For this chapter, each subsection will answer one of the following questions:

1. What is the goal of museums? (2.1)
2. Why do museums track visitors? (2.2)
3. What information can be gained from visitor tracking studies? (2.2)
4. When did museums start tracking visitors? (2.3.1)
5. What needs to be recorded during a visitor tracking study? (2.3.2)
6. What complications may arise when tracking visitors? (2.3.3)
7. What are some examples of visitor tracking systems? (2.3.4)

2.1 Education: The Goal of Museums

Three different forms of education are prevalent in today's society: formal education, non-formal education, and informal education (Livingstone, 2006). Formal education refers to learning environments in which instructors provide a curriculum for their students, while non-formal education describes settings where students solicit additional information from their instructors. Informal education is different in that it removes instructors from the learning process; students are free to learn as they choose, without relying on a teacher to convey information. This form of learning does not impose any obligations such as exams or classroom attendance, so informal education normally refers to learning outside of school. Informal education can occur through after school programs, community organizations, museums, libraries, or home learning (Dib, 1998).

Museums are institutions where learning has been prioritized using informal education. They are stewards of natural and cultural commonwealth, sources of knowledge, and educators about the past (Lord, 2006). In order to fulfill their educational goal, museums strive to determine the most educational and captivating way to present information (Falk & Dierking, 2000). As a result, museums have implemented several informal education methods that can allow them to enrich their visitors' educational experience. These methods include the use of museums' collections and archives, interactive exhibits, and publications, among others.

Museums strive to improve society's understanding of the information within their collections and archives and enhance their visitors' cultural and historical knowledge. Museum learning has been classified as a transformative, effective experience during which visitors can develop new attitudes, interest, appreciation, and beliefs (Lord, 2006). Through the implementation of innovative informal education tactics, museums have been able to increase the learning value of their exhibitions. This improved learning experience allows museums to better achieve their primary purpose of educating visitors.

Museum Victoria's goal is to "reach out to an increasingly diverse audience through its collections and knowledge using innovative exhibitions and programs that engage and fascinate" (Museum Victoria, 2011b). Museum Victoria wishes to contribute to their community's understanding of the world, and ensure that their organization's inheritance is augmented and passed on to future generations. Museum Victoria uses three organizations to accomplish this goal: Melbourne Museum, Scienceworks, and Immigration Museum. While the results of our

project may be applicable to all of Museum Victoria, we focused our research primarily upon Melbourne Museum.

The three organizations that form Museum Victoria have different goals and target audiences. Melbourne Museum uses innovative exhibitions that engage and fascinate visitors to become a central, accessible, and sought after component of Melbourne's cultural life that will contribute to the Melbourne community's understanding of the world (Museum Victoria, 2011b). Their target audience is adults and families. Scienceworks strives to be recognized throughout Australia, and the world, for innovative programs (Museum Victoria, 2011c). They aim to contribute to their community's understanding of science and technology, and stimulate the quest for knowledge and lifelong learning through the vitality of their exhibitions and programs. Scienceworks primarily attracts an audience of school students and families with children under the age of twelve. The Immigration Museum aims to produce an experience recognized throughout Australia and the world as a vibrant and inclusive living cultural center that represents the immigration experience to Victoria and Australia, which resulted in cultural diversity (Museum Victoria, 2011a). They wish to contribute to a greater understanding of the many dimensions of Australia's diverse cultural heritage. Their target audience is primarily adults and older school students.

While Museum Victoria's main goal is to be a source of knowledge for the community, there is no way of knowing how well they are achieving this goal without first understanding how much knowledge visitors are gaining from their visits to the museums. This project focuses on the idea of being able to measure and evaluate Museum Victoria's ability to disperse knowledge to their community. Without the information derived from such measurements, Museum Victoria would be unable to determine if they were successful in their aims to provide education to the community.

2.2 Understanding Visitor Behavior: Timing and Tracking

Like all organizations, museums require a method for determining how successful they are in accomplishing their primary goal (i.e. education). Numerous methods can acquire the type of information required to make this determination, but few are a good fit for the typical museum environment. For example, a museum could administer tests to visitors as they leave, but such a technique would be poorly suited to the atmosphere of informal education that museums strive to uphold. For the purposes of our project, we focused upon a technique used by Museum Victoria and many other museums worldwide.

Museum Victoria measures the success of their exhibitions and galleries by tracking visitors. For the purpose of this report, we will define two terms relating to visitor behavior: timing and tracking (Bronnenkant & Yalowitz, 2009). Timing refers to observing how long visitors spend in certain areas of the museum. This can include total time spent in an exhibition, total time spent in the museum, and total time spent at specific exhibits. Tracking refers to observing where in the museum a visitor is located. This can include the number of stops a visitor makes and where the visitor walked in the museum. A visitor tracking system incorporates observing and recording this timing and tracking data.

In order to derive useful results from visitor tracking data, Museum Victoria makes the reasonable assumption that visitor behavior is an indication of how much visitors have learned during their visit to the museum. Before these studies on visitor behavior became widely used in museums around the globe, researchers discovered a link between visitor behavior and learning. In a preliminary study performed by Cone and Kendall, it was shown that there was a

relationship between time spent at an exhibit and information that could be recalled about the respective exhibit (Cone & Kendall, 1978). This study showed that the more information a visitor was able to recall about a certain exhibit, the longer they had stayed at that respective exhibit. Although this ability to recall information did not directly link visitor behavior to gaining knowledge, it gave researchers a basis for future studies. In later studies, researchers were able to show a direct link to time spent at an exhibition through the difference between pretest and posttest scores in a group of school students (Falk, 1983a). Recent studies have confirmed this assumption and concluded that learning is directly related to time spent at an exhibit (Borun, Chambers, & Cleghorn, 1996).

Recording visitor timing and tracking data has become widely accepted as a predictor of learning. Therefore, Museum Victoria and other museums around the world are confident in their use of these studies to support decisions regarding many elements of their facilities. For example, exhibition designers can use this information to determine the relative success of exhibitions, to support changes to exhibition designs, to determine future research needs, and overall, to gain a better understanding of visitor behavior within their facilities (Kelly & Bartlett, 2002). In a more recent study, Bronnenkant and Yalowitz established the following list of uses for visitor tracking data (Bronnenkant & Yalowitz, 2009):

- Determine successfulness of exhibitions and exhibits
- Determine design considerations for future exhibition development
- Understand level of engagement among visitors
- Understand visitor paths and circulation patterns
- Identify the most and least attractive exhibits
- Compare visitor behavior trends across multiple exhibitions
- Restructure layouts for exhibit items
- Redesign interactive exhibits

While this is not an exclusive list, it does show the wide range of uses for visitor tracking data. Overall, visitor behavior data enables exhibition designers to gain an understanding of visitor preferences and patterns, and allows them to redesign aspects of the museum to provide an improved learning environment. Understanding how visitors interact with exhibits is key to developing a meaningful learning environment for visitors (Falk, 1993). In order to gain this information, researchers must be able to record the timing and tracking data presented above. The next section provides a background to our project focused on this ability of Museum Victoria to record timing and tracking data of visitors.

2.3 Visitor Tracking Systems: Recording Visitor Behavior Data

This section discusses the concept of visitor tracking and develops guidelines upon which we will base our future evaluations. It begins with a discussion on the origins of visitor tracking. Next, it defines what information museums must collect in order to properly analyze visitor behavior. Finally, it discusses complications that arise from visitor tracking and recent innovations to overcome these complications. The conclusion of this chapter discusses the notion of an ideal visitor tracking system.

2.3.1 Visitor Tracking Systems: Origins

Visitor tracking began in the 20th century, when researchers realized the need to evaluate the educational experience provided by their exhibits. To begin understanding visitor behavior, these researchers conducted systematic observations of museum visitors (Melton, 1935; Robinson, 1928). These initial studies involved observations on general movement patterns of visitors throughout a museum space. By 1980, these observations had become an important part of visitor studies. (Falk, Koran, Dierking, & Dreblow, 1985; Peart, 1984; Rosenfeld & Terkel, 1982). By 1990, numerous cultural institutions (including museums, zoos, and aquariums) were conducting visitor observation studies, which allowed researchers to compile a comparative report of visitor behavior across different institutions (Serrell, 1998). Visitor tracking has since become a fundamental tool for evaluating exhibition quality.

Early tracking studies were completed using manual methods of data recording. One method involved studying the wear patterns on the carpet of an exhibit (Bronnenkant & Yalowitz, 2009). Driven by the need to acquire more detailed data, researchers developed an observation system where they used a pen and paper to record visitor behavior. This system consists of an observer physically following a visitor around a museum. During this process, an observer would record information on visitor timing and tracking on a document, usually a map of the museum. The observer's tools were a pen, paper, and a stopwatch. Data collected in these studies was limited by the observer's ability to write down and remember as much data about each visitor as possible. Despite the limitations of the pen and paper system, the data acquired from this method quickly became the predominant method for evaluating exhibition quality. Over years of recording visitor paths, museums have collected vast amounts of data on visitor preferences and patterns.

2.3.2 Visitor Tracking Systems: Collecting Data

Over years of experimentation with visitor tracking studies, researchers have determined that timing and tracking data comprises the most useful information on visitor behavior. Initially, "visitor tracking" referred only to recording a visitor's physical location in a museum. However, researchers quickly realized that recording the time a visitor spends in an exhibition space provided more revealing information (Bronnenkant & Yalowitz, 2009).

Previous timing and tracking studies, such as Serrell's *Paying attention: Visitors and museum exhibits,* determined the basic variables that comprise a successful tracking study (Serrell, 1998). There are the following four categories:

- Stopping behaviors: Describes the number of stops, location of each stop, and time spent at each stop
- Other behaviors: Describes what visitors did during their time at the museum. This includes the path they followed, who they talked to, and what videos they watched in the exhibitions
- Demographics: Describes the visitors, where they are from, gender, age, and other factors that museums might consider necessary, such as postcode
- Situational variables: Describes events that can affect visitor behavior, such as day of the week and current programs at the museum

The primary accomplishment of Serrell's study was the establishment a standardized set of variables to record when conducting a visitor tracking study. By collecting this set of data

about each visitor, exhibition designers could develop conclusions about visitor behavior. In order to present those conclusions, the data gathered must be analyzed. One common analysis method consists of using Microsoft Excel and simple analytic methods to produce graphs with time as their focus. Time is the easiest data point to measure for assessing visitor behavior and exhibit quality (Falk, 1983b). Figure 1 shows a simple representation of where visitors spent their time within Melbourne Museum's First Peoples exhibition. However, this figure lacks the visual aspect that shows the relative size of each exhibition and how this relates to the time spent there. Other graphs can be produced using different combinations of times and stops at each exhibit.

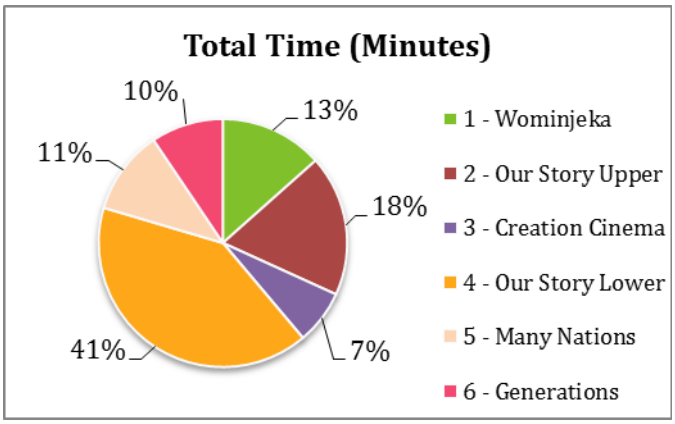

Figure 1: Sample Graphical Data Representation

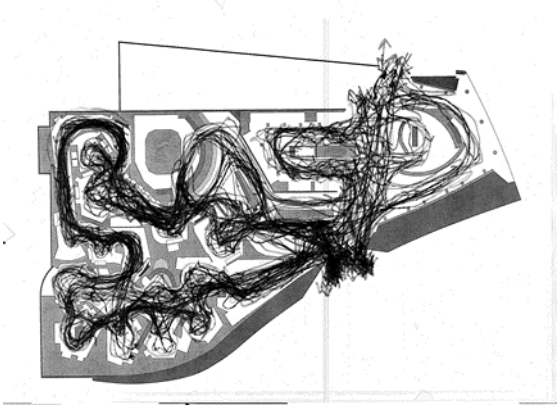

Figure 2: Sample Visual Data Representation

While bar and pie charts are able to present data in a structured display, being able to present visitor behavior data in different forms can provide for easier analysis. For example, instead of plotting the data on a graph, the visitor paths are plotted on a map of the exhibition. A sample from an analysis of the First Peoples Exhibition at Melbourne Museum is shown in Figure 2. While Figures 1 and 2 both convey the same visitor behavior data, researchers may find one form more useful than the other for a specific project. Using the visual method from Figure 2, researchers can gain insight on certain paths traveled by visitors as they pass through the exhibition. In contrast, the chart method can provide insight on how long people are actually staying in the exhibition as a whole. Regardless of the way the information is presented, museums use the data in order to help determine visitor preferences and patterns.

2.3.3 Visitor Tracking Systems: Complications

This section discusses the complications that arise when museums attempt to track visitors. These issues with visitor tracking systems include the following: privacy concerns, visitors realizing that they are being observed, the scale of the tracking study, labor requirements, associated costs, and reliability.

Personal privacy is an important factor in every society. Violations to an individual's privacy can occur anywhere: online in the form of social media, in the workplace, or in public places, such as churches, libraries, or even museums. Therefore, when tracking visitors, museums need to account for a wide variety of legal and social factors that might result in infringements on their visitors' privacy. The most important factor for museums to consider is privacy laws. While these laws vary between countries, there are universal standards of privacy that are respected by the governments of most free societies. In Australia, privacy laws were established under the Privacy Act of 1988, which dictates who is covered by privacy rights, how

these rights are applied, and the sanctions that can be applied due to a violation of these rights (Australian Government, 2014).

Museums do not have a universally accepted method to inform visitors that they might unknowingly participate in a tracking study. Some researchers believe that visitors should be informed in order to avoid complications with privacy violations (Bronnenkant & Yalowitz, 2009). Some believe that a general warning to all visitors entering the museum, such as a sign in front of the admission counter, is enough to satisfy the privacy laws (Gutwill, 2002, 2003). Many researchers believe that informing visitors that they are under observation might affect their behavior, thereby compromising the study. However, it is widely accepted that if the observer concludes the tracking study with an interview of the subject, the observer should inform the subject that he or she was tracked (Bronnenkant & Yalowitz, 2009).

During the course of a tracking study, visitors sometimes realize that they are being tracked, which can impede the study. An observer is usually forced to cease tracking if the visitor being tracked questions the observer about his or her actions. Observers typically wear the official ID of their institution and sometimes carry an information sheet explaining the study; presenting these items often helps appease uncomfortable subjects (Bronnenkant & Yalowitz, 2009). For these reasons, a visitor tracking system should be able to provide accurate data to exhibition designers while at the same time being convenient for visitors.

Another complication lies in the ability of a visitor tracking system to accomplish visitor tracking studies on multiple scales. Some studies only investigate broad movement patterns and the length of time visitors spend in certain galleries within the museum. On the other hand, some studies analyze visitor behavior down to an exhibit level, which helps designers understand how long visitors interact with specific exhibits. To accomplish such a study requires that a visitor tracking system have accuracy to within 1 meter. Without this detailed information, researchers lose the ability to analyze some aspects of the visitor experience. For this reason, a visitor tracking system must be able accurately determine, to within 1 meter, where a visitor is within the museum.

Another concern that arises in conducting visitor tracking studies is the labor requirements. Our team identified two areas of the visitor tracking study that would require human labor: data collection and data processing. With the pen and paper method, labor requirements are one of the largest concerns, as most of the time spent conducting these studies is during the actual tracking of visitors. Even after the tracking is completed, the observer must compile all of the collected data in a recording device such as a computer or notebook. If they did not have to spend time following visitors around the museum, museum staff would be able to undertake more tasks for the museum to improve the visitor experience. For this reason, a visitor tracking system should try to minimize the amount of labor required to collect and process visitor behavior data.

Another complication in conducting studies on visitor tracking is affordability. This includes the cost of equipment and infrastructure, installation costs, usage fees, and maintenance costs. Museums should be able to use most of their budget for creating innovative exhibits and programs. If museums were to spend an excessive amount of money on trying to evaluate their programs and exhibitions, it would take away from the potential of the programs or exhibitions to provide knowledge to the community. For this reason, a visitor tracking system should have the lowest possible installation and operating costs.

A final complication is the reliability of a visitor tracking system. In order to gain reliable data from visitor tracking studies, the equipment and process of visitor tracking must be precise.

Without this precision, researchers would not be able to analyze data collected by different studies. Additionally, the museum would lack confidence in their decisions based on the results produced by the studies. For these reasons, a visitor tracking system should have both low system malfunction rates and a high level of precision.

As technology advances, researchers have developed techniques to overcome these complications. Many modern techniques utilize cutting-edge technology; while they may not be able to overcome every complication, they can enhance a museum's ability to collect data on visitor behavior. The following section will present information regarding the conventional pen and paper visitor tracking method and recent technological developments.

2.3.4 Visitor Tracking Systems: Techniques[1]

While the pen and paper visitor tracking system has been around since the conception of visitor tracking in museums, recent technological developments have allowed museums to enhance the conventional visitor tracking system. This section will discuss the various techniques employed by museums to collect data on visitor behavior and their respective strengths and weaknesses. In order to discuss these strengths and weaknesses thoroughly, we identified a basic set of guidelines that a visitor tracking system should meet based on the challenges we discussed in the previous section. The six areas we will consider are the following: convenience to visitors, accuracy, labor requirements, cost, ability to collect multiple types of data, and reliability.

The common system used by many museums, including Melbourne Museum, is the pen and paper system. Our understanding of this system will provide the baseline for our comparisons with other products. This method involves observing visitors during their stay at the museum and manually recording data on their movement. This system is easy to use, easy to implement, and has a low cost in terms of required supplies. The system is very accurate, as the observer can record exactly where a visitor moves and how long they stay in that location. The system also allows the observer to take notes on specific visitor behaviors (such as reading, watching, touching, etc.). However, this system is very time consuming to use. Observers must follow visitors for the duration of their stay in the museum, and compiling the data after completing the track takes additional time. The system is also very inconvenient to visitors, as they often realize that they are being observed. The reliability of this system is limited due to discrepancies in data collection that can occur due to of a lack of a standardized collection method. Melbourne Museum and the University of Cambridge museums use a pen and paper visitor tracking system.

Radio Frequency Identification (RFID) is a technology used in real time locating systems that can be applied to visitor tracking. RFID can locate tagged assets with accuracy to within 1 meter, but the most common systems have accuracy to within 1 to 3 meters. RFID systems can collect, compile, analyze, and display data automatically. However, the system is very expensive, due to the large cost of installing the required infrastructure. Visitors also need to carry an RFID tag, which means that they know that they are being tracked. RFID systems are usually very reliable if the system is set up in a way that prevents disruption of radio signals by structures within the museum. The National Museum of Math in New York City and the Museum of Old and New Art in Hobart use this technology.

[1] We acquired this information on systems primarily through web searches. See Appendix G for company information.

Wi-Fi is another technology used in visitor tracking applications. Wi-Fi based systems can locate tags or endpoint devices with accuracy to within 1 to 2 meters. Like RFID based systems, real time locating systems that utilize Wi-Fi can collect and display visitor tracking data automatically. Such systems can also track visitors within minimal obtrusion, as any device connected to a Wi-Fi network is traceable. However, this system also requires a great deal of expensive infrastructure, as most Wi-Fi networks need improvement before they can effectively track visitors. However, Wi-Fi systems are limited in reliability, as the signals can be easily distorted by many factors, including structures and other signals present in a museum. The Fernbank National History Museum in Atlanta and the Powerhouse Museum in Sydney have implemented this technology.

Bluetooth also has applications for visitor tracking. Bluetooth based real time locating systems can locate a tag or endpoint device with accuracy to within 0.5 meters. These systems are unobtrusive to visitors, as this technology can locate any Bluetooth enabled device (smartphones, tablets, etc.). Bluetooth requires a network of beacons to provide location data, but these beacons are relatively inexpensive (typically $20 AUD per beacon). Like Wi-Fi and RFID, Bluetooth systems collect and compile tracking data automatically. However, Bluetooth systems have potential issues with reliability, as most beacons are battery powered. The reliability of such as system would be based on an individual within the museum's organization tasked with replacing dead beacons. The Louvre in Paris and the State Library of New South Wales use this technology.

Ultra-wideband (UWB) is another technology used in real time locating systems. Systems using this technology can provide accuracy to within 0.2 to 1.3 meters. Like RFID, it requires an expensive network of receivers to provide accurate location data and visitors must carry a tag so the system can track them. These systems provide the same data collection and presentation features of RFID, Wi-Fi, and Bluetooth system. Like RFID, the reliability of this system is high. This technology is not currently used by any museums but the Excel London Convention Center is investigating it as a possibility for visitor tracking.

Closed Circuit Television (CCTV) is also applicable to visitor tracking. This visitor tracking system is an enhancement of the pen and paper tracking system, and shares the same benefits and limitations. It allows researchers to review footage of visitors moving through the museum and record any data that they need for their study. However, observing people using security cameras carries many legal issues. This system is used in the New Art Gallery Walsall in Britain.

There are several other technologies that could be applied to visitor tracking, but that are not widely used by industry. For instance, eMotion technology can track visitors' psychological response to the items they view in a museum. This system is accurate for location tracking, but it is very obtrusive to visitors and most museums do not have a method for analyzing the psychological response data. The Saint Gallen Art Museum uses this technology. Similarly, Global Position Systems (GPS) would be applicable for outdoor tracking purposes, but their accuracy is severely diminished or eliminated indoors. There are also many new technologies currently under development that might be applicable to visitor tracking in museums.

The ideal visitor tracking system would be able to accurately and reliability collect visitor behavior data while being low cost, convenient to the visitor, and requiring minimal labor. With a system such as this, a museum would be able to gather detailed data on visitor behavior. Many systems, such as those listed above, have been developed in order to fulfill this role. Our project will focus on evaluating each of these technologies (based on criteria developed later in our

report) in order to identify the visitor tracking technology that meets the needs of Museum Victoria.

2.4 Chapter Summary

This chapter presented information regarding visitor tracking systems and their influence on exhibition design and moreover, on their impact to dispersing knowledge in a museum's community. We have shown that the goal of museums is to improve society's understanding of the information within their collections and archives and enhance their visitors' cultural and historical knowledge. Beginning in the early 1920s, visitor tracking proved to be a fundamental part of a museum's ability to understand visitor behavior and evaluate their ability to accomplish their goal. Over the years, it has been shown that visitor tracking studies need to collect data regarding timing and tracking which can be analyzed by researchers. Museums use this information for changing current designs and creating better exhibitions in the future. Lastly, after researching visitor tracking systems currently in use by museums and compiling the information gained from past studies, we have concluded that the ideal visitor tracking system would fulfill the following set of guidelines:

1) The system can record all types of visitor behavior data
    a. Tracking Data
    b. Timing Data
    c. Demographic Data
    d. Situational Data
2) The system is convenient to visitors in the museum
    a. Visitors do not notice they are being observed
    b. Visitors do not have to carry an extra device or tag
3) The system is accurate
    a. Accuracy to within 1 meter to conduct exhibition level studies
4) The system is affordable
    a. Low installation cost
    b. Low maintenance cost
5) The system has low labor requirements
    a. Low labor to collect data
    b. Low labor to process data
6) The system is reliable
    a. Low system malfunction rates
    b. Consistency

This chapter has briefly discussed some of the technological options used by museums today and developed a baseline set of guidelines to evaluate possible options. However, information was required about the needs of Museum Victoria in order to develop the criteria needed to provide a recommendation on the digital visitor tracking system that best suited their needs. In order to develop these criteria, our group conducted studies and interviews at Melbourne Museum that allowed us to gain the extra information required to evaluate alternative visitor tracking systems for Museum Victoria.

3. Methodology

Museum Victoria required information on alternatives to their current visitor tracking system. This would help Museum Victoria decide whether their current visitor tracking system could provide the most detailed visitor behavior data to exhibition designers, or if they should plan to implement a digital technology to aid in the data collection process. Therefore, the goal of this project was to evaluate Museum Victoria's current pen and paper system for visitor tracking, to propose updates to the pen and paper tracking system, and to evaluate alternative digital systems for future implementation. Our team achieved this goal by completing the following six objectives:

1. Gather background information on visitor tracking systems in a museum setting
2. Conduct a trial of the Museum Victoria visitor tracking system
3. Develop criteria to evaluate visitor tracking systems
4. Evaluate Museum Victoria's current visitor tracking system based on our developed criteria and ability to meet Museum Victoria's additional needs
5. Evaluate alternative real time locating systems based on our developed criteria and ability to meet Museum Victoria's additional needs
6. Provide recommendations to Museum Victoria on refining their pen and paper tracking system and enhancing their visitor tracking system with the aid of a digital technology

This chapter discusses each of the objectives in a separate subsection, and concludes with a list of deliverables that our team completed during this project.

3.1 Gathering Background Information

Before we began investigating Museum Victoria's visitor tracking system, we collected general information on visitor tracking in museums. We accomplished this research through web searches and surveys that we sent to museums in the United States. In the course of this investigation, we collected information about different types of visitor tracking systems used by museums. We also found some information on real time locating systems that we thought might be applicable to Museum Victoria's needs. The surveys we sent to museums were a major portion of this research, as they informed us about what type of systems are currently used by museums. This initial research provided us with the background we needed to move ahead with our investigation of visitor tracking for Museum Victoria.

Our team used Google, Google Scholar, and other databases to collect basic information on visitor tracking and real time locating systems. The following keywords and phrases generated useful results: Real Time Locating System, RTLS, Real Time Tracking System, Tracking System, Visitor Tracking System, Museum Visitor Tracking System, People Tracking Software, People Tracking Hardware, Indoor Positioning System, and IPS. This method of research provided our team with the most promising and relevant data for our evaluation.

A large amount of the data we found on specific real time locating systems came from the websites of companies selling these products. This data was biased towards the products that these companies were trying to sell, but since many of the products were very new, this was the best source available. At such an early point in our research, this bias was not a significant problem, as we were using this information to identify potential systems and not making any detailed or substantial evaluations. We also examined scholarly articles on the subject of visitor

tracking, which tended to deal with broad technological categories such as tracking via RFID or Bluetooth, rather than specific systems.

To supplement our preliminary internet research, our team gained a broader understanding of visitor tracking systems used in the museum industry. In order to accomplish this, we asked other museums for information about their visitor tracking systems. We sent a Google Forms survey to a list of selected museums in order to gather this set of data[2]. When making this list, we attempted to create a diverse range of museum types and sizes. We selected many museums located in the New England area of the United States so that we could visit their facilities if necessary. Our survey requested basic information about each respondent's tracking system, and a contact within each institution who could provide more detailed information about the system. We asked them to describe what system, if any, they use to collect information on visitor behavior. We also asked for some basic information about the museum, such as size and visitor traffic per day. In addition to sending our survey to museums, we also conducted internet research on tracking systems used by museums and contacted representatives for more information.

These data are important for our evaluation because the surveys showed us which tracking systems are used by the museum industry. This sort of insight is valuable for making practical recommendations, as it draws on the years of work that these museums have already invested in producing visitor tracking systems. Some of these systems incorporated technology that might be applicable to Museum Victoria, and examining these systems helped give direction to our research. Even though museums use these systems currently, they may not represent the best options available for use in Museum Victoria's institutions.

While we employed the best possible research methods, we did face several problems and validity challenges. Some museums did not fill out our survey, and because a limited number of museums publish information about their tracking systems, our information on tracking systems used by industry was limited. We also only focused on museums located in the New England area and did not send surveys to any museums outside the United States. We did not want to eliminate the option of visiting the museums to test their systems, but this limitation on our sample reduces the validity of our data. However, we found that many of these museums use very similar types of systems for visitor tracking. Therefore, we established an accurate representation of each technological category based on the data we collected from the museums and internet research.

3.2 Trialing Museum Victoria's Visitor Tracking System

The next step towards providing a recommendation for Museum Victoria's visitor tracking system was gaining a first-hand understanding of their current visitor tracking system. We accomplished this by conducting visitor observations in the First Peoples gallery at Melbourne Museum using the tracking methodology currently used by Museum Victoria. In the process, we gained a basic understanding of Museum Victoria's visitor tracking system while simultaneously completing a study for our sponsor.

The information we gathered while conducting the observational study was important to our sponsor, but our primary goal in performing the study was determining whether the guidelines we identified during our background research would be applicable to Museum Victoria's visitor tracking system. While we did not perform any specific evaluations of the

[2] See Appendix A.

system during these trials, our criteria for evaluating visitor tracking systems, discussed in the next section, were based in part on this experience. We evaluated the visitor tracking system during our whole visit study which is discussed in section 3.4.

The study we completed for our sponsor was one that another student had started but never completed. We tracked ten visitors throughout the First Peoples exhibition using the pen and paper system, which formed a full observational study when combined with thirty tracks the student had completed before we arrived.

This pen and paper tracking system involved numerous steps. Once visitors entered the exhibition we started to record their time. As they moved around the exhibition, their path and stops were recorded, along with how long they stayed in each section of the exhibition. When the visitors were about to leave, we approached them and asked a few questions regarding their demographics. Each visitor path was traced, scanned, and imported to a computer individually. After we compiled all the data, we assembled a map to show all the paths at once to determine any patterns in visitor flow. This system is similar to those used by other museums and cultural institutions, such as the British Museum, who use it to successfully analyze visitor behavior in their Coin and Money gallery (Corini, Liu, Moore, & Osborn, 2013).

Completing this project for our sponsor provided an excellent opportunity to understand how the pen and paper tracking system worked. Without having this basic understanding of how the current visitor tracking system worked, we would be unable to accurately evaluate the system during our later whole of site study. However, this project only showed us a small section of the museum; nevertheless, the study provided a good indication of how the system works in other parts of the museum because of the simplistic nature of the visitor tracking system. Our later whole of visit study validated this assumption.

3.3 Developing Criteria

We developed criteria to evaluate visitor tracking systems in a comprehensive and methodical manner. These criteria were based on our research on visitor tracking systems (as described in Chapter 2), interviews with Museum Victoria staff, and our use of Museum Victoria's current system (as described in Section 3.2). During our initial research, we identified some guidelines of excellent visitor tracking systems. We used the additional information from staff interviews to supplement these guidelines. The criteria we developed allowed us to evaluate different visitor tracking systems in a standardized way.

Throughout the course of our background research, we found many variables upon which we could compare visitor tracking systems. However, in order to make these comparisons valid, they needed a common metric. For instance, we could compare systems based on accuracy, but this would provide just a small portion of a larger picture. To provide a comprehensive overview, we considered numerous other factors, such as affordability and ability to collect data.

The first area we examined for criteria establishment was our previous background research. From this information, we knew some of the important characteristics of visitor tracking systems and real time locating systems. For example, we knew that systems varied greatly in accuracy and cost. Using just our background research, we determined six characteristics of visitor tracking systems that would be important to our evaluation. However, we knew that other factors would be involved when recommending a system for Museum Victoria.

To help identify criteria important to Museum Victoria, we conducted a trial of their current tracking system (as described in Section 3.2). This trial showed us the capabilities and

limitations of the current system. The trial also verified that the basic guidelines we identified in the background chapter would be useful for a future evaluation of this system and other visitor tracking systems, and helped us identify other criteria that we could add to our list. Additionally, we spoke to Melbourne Museum staff about what they wanted in a visitor tracking system. We conducted interviews with Carolyn Meehan, Manager, Audience Insight, Johnny Brownbill, Manager, Online Development, Herb Lim, Manager, Information Technology, and Gordon White, Manager, Melbourne Museum. Knowledge gained from these interviews helped us develop supplementary criteria for evaluating visitor tracking systems.

A limitation in the development of our criteria was that we were only able to perform ten tracks using Museum Victoria's current visitor tracking system. Although this is a small number of trials to base our criteria on, we felt that the system was simple enough to understand in these few tests. Conducting more visitor tracking samples would only reinforce what we found in our initial observations. Additionally, we only interviewed five members of the museum staff. While these individuals were highly relevant to our project, we cannot claim that their opinions reflect those of the entire museum.

3.4 Evaluating Current Museum Victoria Tracking System

To further our understanding of Museum Victoria's pen and paper visitor tracking system, we applied our criteria to their system during additional tests. We conducted forty-four whole of site observations, during which we tracked visitors throughout the entire museum. In the process of completing these tests, our team identified strengths and weaknesses of the current visitor tracking system by evaluating it based on our criteria. The solutions we found to address these weaknesses formed part of our final recommendation.

We applied the same methodology to whole of site observations as we did to the exhibition level tracks that we performed in First Peoples gallery. Once we created the materials necessary to complete the tracks, we followed the procedure outlined in Section 3.2. We implemented numerous improvements to the visitor tracking system while conducting these tests, which we discuss in Recommendation 2.

We also assessed how well the system met our six main criteria. To determine the accuracy of the system, we evaluated how closely we could locate a visitor on the tracking map in comparison to their actual location. To determine labor requirements we timed how long it took to conduct each study and compile the data. We collected information on the cost of the materials we used in order to determine the affordability of this system. In order to describe the convenience of the system, we made note of how many visitors realized that they were being tracked. We established a list of the types of data we needed to collect for a visitor tracking study, and determined how many of these data types we could record with the pen and paper system. Finally, we evaluated the reliability of the system by comparing tracking data recorded by different observers and noting the discrepancies in their recording techniques. The data we gained from these tests showed us the strengths and weaknesses of the pen and paper system, while also establishing a baseline for evaluation of other real time locating systems.

3.5 Evaluating Alternative Real Time Locating Systems

With an evaluation of Museum Victoria's current visitor tracking system complete, we began evaluating alternative real time locating systems. Our goal was to learn which of these systems provided the best alternative for Museum Victoria. To make this determination, we

gathered additional data about these systems. We then used our criteria to compare these systems and to the pen and paper tracking system.

Throughout our background research, we collected a large amount of data on real time locating systems and visitor tracking systems (presented in the Chapter 2). However, this set of data was not useful for a recommendation until we applied our evaluation criteria. This process allowed us to systematically examine key characteristics of each system and compare them side-by-side.

Prior to applying the criteria, we conducted internet research on as many potential real time locating systems as possible. We then contacted each company (see Appendix G) with a request for data. We collected the following data in order to apply our evaluation criteria:

- Cost
    - Infrastructure requirements
    - Maintenance requirements
- Type(s) of technology the system uses
- Accuracy
- Type(s) of data the system can collect
- Capabilities and limitations
- Availability of demonstrations and trials

Once we had acquired this data, we organized the systems into groups based on the type of technology each system used. We then applied our criteria to each type of technology in a qualitative manner in order to produce a comparison. We used our evaluation of the current Museum Victoria pen and paper tracking system as a baseline to which we could compare the other technologies. When possible, we also used quantitative comparisons (accuracy and affordability, for example, are simple to compare quantitatively). We tabulated this information in order to make it easy to view and understand (see Finding #5). This information formed the foundation of our recommendation for Museum Victoria.

One limitation to our evaluations is that some companies did not reply to our inquires about their products. This reduced the amount of data we were able to gather about specific systems. We still provided basic information about these products in the report for Museum Victoria so they could seek to supplement the data in the future. However, the results we did receive provided an accurate representation of how well different types of technologies (not specific systems) meet our criteria. When companies failed to respond to us, we acquired the data necessary for our evaluation through their websites.

3.6 Developing Recommendations for Museum Victoria

Museum Victoria requested recommendations on how they could enhance their current visitor tracking system. We provided the following recommendations: a recommendation for improvements to their pen and paper visitor tracking system, a recommendation about a technological option that they might implement in the future, and a recommendation on future studies that Museum Victoria might complete in order to supplement the information gathered within this report.

Time constraints on our project limited our ability to test real time locating systems, so we focused much of our efforts on enhancing the pen and paper tracking system. We provided Museum Victoria with a recommendation on how they could improve weaknesses uncovered

during our evaluation. This recommendation was derived from the findings generated by our test of their current system (described in Section 3.4).

We also formed a recommendation for an alternative to the pen and paper visitor tracking system. As described in Section 3.5, we evaluated types of visitor tracking systems based on how well they met our criteria. Our findings from this evaluation supported our recommendation of the type of technology that Museum Victoria should implement in order to enhance their visitor tracking system.

Finally, we developed a recommendation for future studies to supplement the information gathered in this report. We derived this third recommendation from the limitations of this project, which are described throughout this chapter. With these three recommendations, Museum Victoria has several options for enhancing their current visitor tracking system.

3.7 Completion of Study Deliverables

By completing these objectives, our team was able to produce the following deliverables:

1. A report of visitor behavior in Melbourne Museum's First Peoples exhibition
2. A report of visitor behavior in Melbourne Museum
3. A consolidated list of major tracking technologies available on the market
4. A report containing three recommendations for Melbourne Museum to enhance their visitor tracking system

In this chapter, we discussed our methods for completing our research objectives and creating our project deliverables. Initially our team conducted background research on visitor tracking in museums and conducted a trial of Museum Victoria's visitor tracking system. From this, our team was able to develop criteria upon which we could evaluate Museum Victoria's visitor tracking system and alternative real time locating systems. The next chapter discusses the findings from our research that formed the basis for our recommendations on enhancing visitor tracking for Museum Victoria.

4. Results and Analysis

The goal of this chapter is to present the findings from the analysis of our data. Tools used to aid this processes included our background research, staff interviews, and studies performed in the museum. From this data, we established two sets of criteria upon which to base our evaluations of visitor tracking systems. These criteria were then used to evaluate the pen and paper visitor tracking system and alternative real time locating systems.

4.1 Findings from Interviews and Trial of Museum Victoria's visitor tracking system

Our background research provided some criteria that were important for museums to have in a visitor tracking system. To develop criteria that would meet Museum Victoria's needs, we interviewed staff members from different departments, which allowed us to obtain multiple perspectives (meeting minutes can be found in Appendix F). The study performed using the pen and paper system showed us that our original criteria (identified during background research) were applicable to this visitor tracking system. These original criteria were then adapted to meet Museum Victoria's needs based on the results of our study and staff interviews. We used these criteria to evaluate the pen and paper tracking system as well as the technologies used by alternative real time locating systems.

FINDING #1: THE MAIN EVALUATION CRITERIA WERE DETERMINED TO BE THE FOLLOWING: AFFORDABILITY, ACCURACY, TYPES OF DATA COLLECTED, LABOR REQUIREMENTS, CONVENIENCE TO VISITORS, AND RELIABILITY.

Based on the information we collected, our team defined six main evaluation criteria. These were established as the main evaluation criteria because they were the necessary components of a visitor tracking system.

The first criterion established was affordability. Although a budget was not defined, we learned through interviews that Ms. Meehan, Manager, Audience Insight, and Mr. Lim, Manager, Information Technology, were interested in an affordable system. Mr. Lim said he would prefer a system with minimal infrastructure requirements. Ms. Meehan said that since the pen and paper system had low cost demands, Museum Victoria would prefer a system that can enhance their visitor tracking system while being as inexpensive as possible. As affordability could mean multiple things, our team defined affordability as minimal expenses for setup and maintenance. Specifically, we defined setup cost as the cost associated with installing new infrastructure or acquiring any required equipment. We considered maintenance cost to be expenses required to keep the system in working order.

The second criterion created was accuracy. This criterion was a concern to Ms. Meehan and Johnny Brownbill, Manager, Online Development. They wanted a system that could provide the museum with exhibit level data collection. To deliver this information, the system needed to provide accuracy to within 1 meter.

The third criterion developed was the types of data collected. This criterion was particularly important to Ms. Meehan, who performs visitor tracking studies to understand visitor behavior. To gain full understanding from the studies, she needs a variety of data. Through interviewing Ms. Meehan and conducting a trial of the pen and paper system, the following data was determined to be most important for these studies:

- Timing data: Refers to the time the visitors spend in an exhibit, exhibition, gallery, and at the museum
- Tracking data: Refers to the path taken by the visitor during their stay, where they stopped, and how many times they stopped
- Demographic data: Refers to where the visitors are from, their age, if it is their first time attending the museum, and whether or not they are Museum Victoria members
- Situational data: Refers to any events that can affect the visitor's behaviors such as the day of the week, holiday, or a special program occurring at the museum

The fourth criterion established was labor requirements. Ms. Meehan said that finding personnel to perform tracking studies was not a problem; however, the time required to collect and analyze visitor data with the pen and paper system was rather extensive. She said that if possible she would prefer a system with lower labor requirements than the pen and paper system. Our team divided labor requirements in two categories: time required to collect data, and time required to analyze data.

The fifth criterion created was convenience to visitors. Visitor obtrusion was a concern mentioned by multiple staff members, including Ms. Meehan, Johnny Brownbill, and Ursula Smith, Sciences Collection Online Coordinator. We divided convenience to visitors into the following two elements: whether or not visitors were required to carry an extra device and whether or not the visitors would notice if they were being followed. Having the visitor carry an extra device or notice they are being followed are not desired by the museum since they can negatively impact a visitor's stay at the museum.

The sixth and final main evaluation criterion was reliability. Mr. Lim mentioned reliability as one of his concerns with a visitor tracking system. Our team also recognized the importance of consistency between different tracking studies. Two categories were created to define reliability: system malfunction and consistency. System malfunction refers to the possibility that the system may inaccurately record the path of a visitor through a museum space, or that the system may not be working when needed. Consistency refers to the precision of the collected data, which might be affected by human or system error.

FINDING #2: THE SUPPLEMENTARY EVALUATION CRITERIA WERE DETERMINED TO BE THE FOLLOWING: REAL TIME ACCESS TO VISITOR BEHAVIOR, ABILITY TO PUSH INFORMATION TO VISITORS, AND ADAPTABILITY.

We identified some criteria that were desired by staff members, but that were not essential to the museum at the time of this study. Since these criteria were not as crucial as other aspects, they were placed in a supplementary evaluation criteria list. However, if a system that met all the main criteria also met some supplementary criteria it would have a higher ranking for the purpose of our recommendation.

The first supplementary criterion was real time access to visitor behavior. Mr. White, Manager, Melbourne Museum, said he was interested in a system that would provide him with real time access to visitor tracking data. He wanted a system that allows him to access data on his phone or computer of where the visitors are located in museum at that moment. Since he is interested in what aspects of the museum attract the most visitors, this is something he feels would be beneficial. A system with this type of data collection could also provide the museum with some security benefits. If an emergency were to occur, the museum would be able to ensure everyone's safety by showing security personnel the exact location of the visitors.

The second supplementary criterion was the ability to push information to visitors. Mr. Brownbill was very interested in a technology that would provide visitors with additional information on exhibits. This approach is used by the MONA museum in Tasmania, Australia. They provide their visitors with an iPod that serves as an interactive guide while simultaneously tracking the user. Museum Victoria could take a similar approach to give visitors access to additional information about museum collections.

The third supplementary criterion was adaptability. This aspect of visitor tracking systems interested Ms. Meehan. She informed us that some galleries change their content and floor plans periodically. This meant that if they wanted to track visitors around those galleries they would need a visitor tracking system that could easily be modified for changes in exhibition floor plans.

4.2 Findings from the Evaluation of the Current Tracking System in Melbourne Museum

To evaluate Museum Victoria's current visitor tracking system, our team performed a whole of site study at Melbourne Museum. Our team used this study to assess the current pen and paper visitor tracking system based on our criteria and to test improvements developed for the pen and paper system. We determined that the pen and paper system met three of the main criteria (affordability, accuracy, and types of data collected) and one of the supplementary criteria (adaptability). The pen and paper system did not meet three of the main criteria (labor requirements, convenience to visitors, and reliability) and two of the supplementary criteria (real time access to visitor behavior, and ability to push information to visitors).

Main Criteria		Supplementary Criteria	
Met	**Not Met**	**Met**	**Not Met**
Affordability	Labor Requirements	Adaptability	Real Time Access to Visitor Behavior
Accuracy	Convenience to Visitors		Ability to Push Information to Visitors
Types of Data Collected	Reliability		

Table 1: Pen and Paper Visitor Tracking System Evaluation

FINDING #3: MUSEUM VICTORIA'S CURRENT VISITOR TRACKING SYSTEM MEETS THE FOLLOWING CRITERIA: AFFORDABILITY, ACCURACY, TYPES OF DATA COLLECTED, AND ADAPTABILITY.

Through the whole of site study, our team evaluated the current pen and paper system used by Museum Victoria. We determined that this visitor tracking system met three of our main criteria (affordability, accuracy, and data collection) and one of our supplementary criteria (adaptability).

Through our evaluation process we concluded that the pen and paper visitor tracking system is inexpensive. We came to this conclusion because this visitor tracking system has no setup requirements; visitor tracking with the pen and paper system can be completed with office supplies that are already accounted for in the museum's budget. To track a visitor, the observer only needs a pen, paper, and stopwatch (most mobile phones have a stopwatch function). The pen and paper system also does not require maintenance since there is no infrastructure.

When performing a track with the pen and paper system, the observer maintains visual contact with the visitor they are tracking. Therefore, the observer is able to record the location of the visitor with to within 1 meter of accuracy. Since the observer is tracking the visitor closely, this system provides a high level of accuracy.

During our study, we discovered that the pen and paper system provides a great deal of flexibility. The visitor tracking system allows observers to record as much detail as they feel is necessary. This flexibility allows for multiple types of data to be collected. The observer can record observations such as the number of stops and the length of each stop as well as any situational variables. This method also allows the observer to approach the visitor at the end of his or her stay to ask a few demographics questions.

The only supplementary criteria met by the pen and paper system is adaptability. Since this visitor tracking system does not require the implementation of any infrastructure or the placement of any beacons, the system could be modified to any floor plan.

FINDING #4: MUSEUM VICTORIA'S CURRENT VISITOR TRACKING SYSTEM FAILS TO MEET THE FOLLOWING CRITERIA: LABOR REQUIREMENTS, CONVENIENCE TO VISITORS, RELIABILITY, REAL TIME ACCESS TO VISITOR BEHAVIOR, AND THE ABILITY TO PUSH INFORMATION TO VISITORS.

Through the whole of site study, our team determined that the current pen and paper visitor tracking system did not meet three of our main criteria (labor requirements, convenience to visitors, and reliability) and two of our supplementary criteria (real time access to visitor behavior, and ability to push information to visitors).

The tracks performed with the pen and paper system required an excessive time commitment. Since Melbourne Museum did not have detailed floor level maps, our team had to create them. This took approximately fifty-six hours for our group of four to complete. For the whole of site study, the visitors were tracked for the duration of their stay; therefore, the time requirements were more strenuous. On average, the visitors stayed in the museum for one hour and thirty-four minutes. However, the visits ranged from thirty minutes to two hours and forty-seven minutes. Our team took approximately seventy-two hours to track forty-four visitors. We took approximately twenty-three hours to compile the data and five hours to compare and analyze the results. Therefore, completing a forty-four visitor tracking study took roughly one hundred hours. The museum may not have the volunteers necessary to complete these time consuming studies, and they do not have the funds to pay professional researchers.

Although the pen and paper system does not require visitors to carry any device, this creates an inconvenience for them since they may notice they are being followed. In our research, we learned that a visitor's interaction in the museum might be affected if they know they are being observed. In both studies that our team performed, some visitors noticed they were being followed. During the whole of site study, we attempted to separate ourselves from visitors. Even so, eight out of forty-four visitors noticed they were being followed. This is something that can negatively affect a visitor's time at the museum.

The pen and paper system consists of an observer tracking a visitor's actions, so it is susceptible to human error, which can affect the reliability of the visitor tracking system. The first failure was related to system malfunction. If the observer is not familiar with the museum or if they lose focus, they may record incorrect data. If the observer is not focused or if they have a difficult time multitasking they could also lose the visitor. In our whole of site study, forty-four visitors were monitored; however, four tracks were annulled. These four visitors were lost in the

tracking process. This proved to be a significant setback for the pen and paper system, as each visitor lost represented on average one and a half hours of wasted time. The second failure is consistency. While performing the tracking studies we found that each observer had their own method of recording the visitor behavior data. If the interpreter of the data was unfamiliar with the observer's recording method, then the data would be inconsistent and possibly transferred inaccurately.

The two supplementary criteria that were not met by the pen and paper system were providing real time access to visitor behavior data and pushing information to visitors. The pen and paper visitor tracking system is one of the simplest available; the system uses almost no technological aids. This makes providing real time access to visitor behavior and pushing information to visitors impossible with this visitor tracking system. This visitor tracking system is not able to educate the visitor more about any particular exhibit or exhibition. This visitor tracking system also does not allow visitors to access additional information on the exhibits they viewed in the museum after they leave the museum facilities.

When conducting the whole of site study using the pen and paper system, our group was able to collect the necessary data, but encountered several limitations. These limitations involved lacking the necessary maps and data collection documents. Although the museum had maps for all of the exhibitions, they did not have them compiled into a single map. The museum was also missing data collection sheets. Our team had to create both of these tools before proceeding with our study.

4.3 Findings on Alternative Real Time Locating Systems

To provide Museum Victoria with a recommendation regarding alternative real time locating systems, we performed a literature review. We discovered that the most commonly used real time locating systems were RFID, UWB, Wi-Fi, and Bluetooth. We researched these systems (as described in the background chapter 2.3.4) and evaluated them based on the criteria previously developed.

FINDING #5: IMPLEMENTING A REAL TIME LOCATING SYSTEMS WOULD ALLOW MUSEUM VICTORIA TO ENHANCE THEIR CURRENT VISITOR TRACKING SYSTEM.

We evaluated real time locating systems based on our main and supplementary criteria. We observed that these systems were able to digitally collect visitor behavior data in a time efficient manner. Also many systems we evaluated were able to meet the supplementary criteria developed for the additional needs of Museum Victoria. Tables 2, 3, and 4 show a summary of the results obtained from the evaluations of RFID, UWB, Wi-Fi, and Bluetooth systems.

Affordability: The most expensive technologies were RFID and UWB since they require more expensive beacons and also have a large infrastructure installation cost. Bluetooth and Wi-Fi are less expensive compared to RFID and UWB. However, Wi-Fi nodes are more expensive that Bluetooth beacons. Through this evaluation Bluetooth was deemed the most affordable system.

Accuracy: RFID systems have an accuracy to within 1 to 3 meters. UWB systems have an accuracy to within 0.2 to 1.3 meters. Wi-Fi systems have an accuracy to within 1 to 3 meters. Bluetooth systems have an accuracy to within 0.5 to 3 meters. This data showed that UWB systems would provide the best accuracy. However, Bluetooth was also able to provide the necessary accuracy to conduct exhibit level studies.

Types of data collected: We discovered that all of the real time locating systems were able to provide timing data, tracking data, and demographics. However, none of these real time locating systems are able to collect the situational variable data discussed in Chapter 2.

Labor requirements: All real time locating systems have the capability of collecting data automatically. Therefore, there is no labor requirement for data collection or analyzing data with any of these real time locating systems.

Convenience to visitors: RFID and UWB system were rated as having low convenience to visitors because visitors would have to carry around an extra device such as an RFID tag. With Wi-Fi or Bluetooth, visitors would be spared this inconvenience by not having to carry an extra device. Wi-Fi and Bluetooth systems track the smartphones, or similar devices, that visitors bring with them to the museum. The ability to use a device the visitor already carries makes these technologies more convenient for visitors.

Reliability: RFID and UWB systems were evaluated as being highly reliable, meaning they would have low probability of malfunction. Wi-Fi and Bluetooth signals can be easily interrupted. This interruption could cause inaccurate results, which is why they were ranked as having medium reliability. The Bluetooth systems also use battery-powered beacons that could die and cause incorrect results when conducting a study.

We identified additional criteria that were desired by staff members, but that were not essential to the museum at the time of this study. The supplementary criteria were developed to complement the main criteria and provide additional basis for evaluation; in the event that two technologies were similar based on the main criteria, these supplementary criteria could determine the superior option.

Real time access to visitor behavior: All real time locating systems could provide real time access to visitor behavior.

Ability to push information: All real time locating systems could push information to visitors for educational purposes.

Adaptability: RFID and UWB systems require the implementation of infrastructure, which is designed for a specific exhibition layout. Given these systems limited adaptability, changing the infrastructure would be costly. Wi-Fi systems are able to be adapted to any exhibition since the Wi-Fi network can cover an exhibition space regardless of the configuration. Bluetooth systems require beacons to be placed around the exhibition; however, these beacons can be moved easily if the exhibition were to change.

Technology	Affordability	Accuracy (meters)	Labor Requirements	Convenience to Visitors	Reliability
RFID	$$$	1.0-3.0	Low	Low	High
UWB	$$$	0.2-1.3	Low	Low	High
Wi-Fi	$$	1.0-3.0	Low	High	Medium
Bluetooth	$	0.5-3.0	Low	High	Medium

Table 2: Alternative Real Time Locating System Evaluation - Main Criteria (1/2)

Technology	Types of Data Collected			
	Timing Data	Tracking Data	Demographic Data	Situational Data
RFID	Yes	Yes	Yes	No
UWB	Yes	Yes	Yes	No
Wi-Fi	Yes	Yes	Yes	No
Bluetooth	Yes	Yes	Yes	No

Table 3: Alternative Real Time Locating System Evaluation - Main Criteria (2/2)

Technology	Real Time Access to Visitor Behavior	Ability to Push Information	Adaptability
RFID	Yes	Yes	Limited
UWB	Yes	Yes	Limited
Wi-Fi	Yes	Yes	Yes
Bluetooth	Yes	Yes	Yes

Table 4: Alternative Real Time Locating System Evaluation - Supplementary Criteria

The initial background research conducted by our team focused on real time locating systems available on the market and in use by other museums. Although our group was able to gather a substantial amount of data, our project was limited to the data published electronically. Even though many museums use visitor tracking systems, they do no publish much information about their systems, limiting our knowledge on what systems are currently used by museums.

4.4 Summary of Key Findings

The findings described in this chapter have increased our understanding of the current visitor tracking system used by Museum Victoria and the real time locating systems available. Through our evaluation of the pen and paper system our team determined the system's advantages and disadvantages. The advantages were the following: affordability, accuracy, types of data collected, and adaptability. The disadvantages were the following: labor requirements, inconvenience to visitors, failure in reliability, not providing real time access to visitor behavior, and not being able to push information to visitors. Throughout our study, we also updated the pen and paper system to improve the visitor tracking system for future use by Museum Victoria.

Our team also evaluated real time locating systems. These systems were evaluated to determine if they met the criteria desired by Melbourne Museum and its employees. Through our evaluation, we determined that the technology that best met our criteria was Bluetooth. The implications of these findings are discussed in the next chapter, which will details our conclusions and recommendations.

5. Conclusions and Recommendations

Through interviews with Museum Victoria staff members, trials of Museum Victoria's visitor tracking system, and extensive background research, our team developed a set of recommendations for the future of visitor tracking at Museum Victoria's institutions. This chapter presents recommendations for Museum Victoria to enhance their visitor tracking system. Our first recommendation is for improvements regarding the pen and paper visitor tracking system currently in use by Museum Victoria. The next recommendation will be for future implementation of an alternative digital technology to aid in the process of collecting visitor behavior data. Lastly, this chapter concludes with recommendations for follow-up studies related to visitor tracking for Museum Victoria.

5.1 Recommendation for Pen and Paper Visitor Tracking for Museum Victoria

This section presents our recommendation for Museum Victoria to implement immediately in regards to visitor tracking studies conducted at Melbourne Museum using the pen and paper system, and a brief summary of relevant findings.

1. *We recommend that Museum Victoria implement an improved methodology for future visitor tracking studies at Melbourne Museum.*

Through background research, our team was able to determine that a visitor tracking system needed to accomplish three main tasks. First, it needed to be able to observe where a visitor was inside a designated museum space. Secondly, it needed to be able to observe how long a visitor was inside a designated museum space. Lastly, it needed to be able to record these data for future analysis. From this research and interviews conducted at Melbourne Museum, our team developed criteria that would allow us to identify the strengths and weaknesses of Museum Victoria's visitor tracking system. From Findings #1 and #2, our developed criteria were the following: affordability, accuracy, types of data collected, labor requirements, convenience to visitors, reliability, real time access to visitor behavior, ability to push information to visitors, and adaptability.

Through our evaluation of Museum Victoria's visitor tracking system, we were able to identify the following weaknesses from Finding #4: high labor requirements, low convenience to visitors, and limited reliability. While the current visitor tracking system also had no access to real time display of visitor behavior data and no ability to push information to visitors, these weaknesses would not be able to be fixed without implementation of a digital visitor tracking system. However, until Museum Victoria can implement a digital visitor tracking system, our team developed a methodology for Museum Victoria to conduct future visitor tracking studies with lower labor requirements, higher convenience to visitors, and improved reliability. The following paragraphs provide a brief summary of the proposed methodology located in Appendix H.

The first update to the visitor tracking system will significantly reduce the time requirements for setting up visitor tracking studies. To accomplish this, our team developed a set of maps for Melbourne Museum, a timing and tracking data collection sheet, and a demographics survey. With implementation of these maps and documents, Museum Victoria will be able to reduce the labor requirements for the preparation of a visitor tracking study from over eighty hours to just a few hours. Additionally, these documents will reduce the labor requirements of data processing due to their organized display of collected data. Our team found these new

collection documents to be easier to process compared to the First Peoples study we conducted earlier in our project. The documents eliminated the need to reorganize the data after completion of the visitor tracking study in order to transfer the data to a computer. Eliminating multiple steps from both the front end and back end of a visitor tracking study, as outlined in our methodology, will significantly reduce the labor requirements of conducting a visitor tracking study.

The next update to the visitor tracking system addressed the limited reliability of Museum Victoria's visitor tracking system. In order to reduce variations in the data collection process due to multiple observers, our team created a standardized data collection procedure. With this standardized procedure, and the standardized documents mentioned above, all future visitor tracking studies conducted by Museum Victoria at Melbourne Museum will record and process the necessary data in the same manner.

Lastly, in order to address the weakness of low convenience to visitors, our team included in the methodology a dress and behavior guide. While the ability of a visitor to realize they are being tracked is an inherent flaw with the pen and paper visitor tracking system, having this guide will limit future studies from being corrupted due to improper tracking. While our team did not specifically record our behaviors, we created this guide based on our background research as a preventative measure for future studies.

By following these guidelines presented in our methodology, the process for collecting visitor behavior data at Melbourne Museum will be more time efficient, more reliable, and have a lower chance of causing an inconvenience to visitors. However, when creating this updated pen and paper visitor tracking system, time constraints limited our testing on how time efficient and reliable the new process was. While the large sample size for the whole of site study provided a solid foundation for our methodology, future studies will be required to confirm our results. Additionally, as this visitor tracking system was created exclusively for Melbourne Museum, changes may be required for implementation in Museum Victoria's other institutions. These limitations to our project formed our final recommendation for follow-up studies that are presented in the final section of this chapter.

5.2 Recommendation for Digitalized Visitor Tracking for Museum Victoria

This section presents our recommendation for a digitalized visitor tracking system for Museum Victoria and a summary of relevant findings.

1. *We recommend that Museum Victoria implement a Bluetooth system for visitor tracking within Melbourne Museum.*

Upon evaluation and analysis of the different systems presented in this report, our team indicated in Finding #5 that a Bluetooth system was best technology for Museum Victoria to implement for visitor tracking with respect to our criteria. The first criterion we evaluated each technology on was affordability. Bluetooth was clearly the best technology in this category. The setup costs for a Bluetooth system are significantly less than other real time locating systems due to its small infrastructure requirements and easy installation. Many of the other RFID or Wi-Fi systems had large costs just for the third party installation of required sensors or nodes. Bluetooth systems are comprised of inexpensive beacons, costing around $20 AUD each, that can be easily setup without hiring a third party. Additionally, these beacons are easily replaceable, allowing for a lower maintenance cost than other real time locating systems. As

affordability was one of our main criteria, the low cost of Bluetooth systems was important to our evaluation of alternative visitor tracking systems.

The next criterion upon which our team based our evaluation on was accuracy. In order for a system to be able to provide more detailed data than the pen and paper visitor tracking system to exhibition designers, the system would need to provide accurate visitor tracking to within 1 meter of error. Of the companies that we received information from, Bluetooth and Ultra-wideband systems were able to produce an accuracy to within 1 meter. While an Ultra-wideband system that we investigated proposed that it had an accuracy to within 0.2 meters, the costs associated with this system were considerably more than other systems. For a much lower cost, the accuracy to within 0.5 meters of the Bluetooth system was much more cost effective. As for the RFID and Wi-Fi systems, our team was unable to find systems that had accuracy within 1 meter. However, during our research, we found that these real time locating systems were similar to the Ultra-wideband systems; in order to have such high accuracy, they became exponentially more expensive due to infrastructure installation costs. Although our research was limited to material published on the internet, from the similarities of the product data that we did receive on RFID and Wi-Fi systems, we determined that they would not be affordable for Museum Victoria even if they could produce the required accuracy.

The next two criteria, types of data that can be collected and labor requirements, were similar for all systems that we evaluated. In our background research, we identified the following four categories of data that museums can collect on visitor behavior: timing data, tracking data, demographic data, and situational data. Each of the technologies that we analyzed had the potential to collect digital data in each category except situational data. Although no real time locating system that our team researched currently had the capability to collect this situational data, many companies informed us that they could easily add this option their software package. The ability of these real time locating systems to collect the data digitally significantly reduces the labor requirements associated with visitor tracking studies.

Our final main criterion was convenience to visitors. When evaluating the different systems we found that a system using RFID or Ultra-wideband technology would require Museum Victoria to give visitors tags that sensors could read in order for the real time locating system to track the visitors. Having a visitor need to carry something extra around during their museum visit could prove to be an inconvenience, and could negatively influence their experience. Real time locating systems that incorporate Bluetooth and Wi-Fi technology have the potential to solve this issue. As many visitors to Museum Victoria's institutions already have a mobile phone or smart device that includes Wi-Fi and Bluetooth technology, they would not need to carry around an extra device for the museum to track a visitor during their stay. While some people do not have these functions turned on, the museum can assume that a large percentage of the close to one million visitors per year will have these settings enabled. This will allow the museum to gain more than the forty data points provided by the pen and paper system, which is what their current studies are limited to due to large labor constraints.

Our last main criterion was reliability. This included both hardware reliability and the reliability, or consistency, of the real time locating system to track visitors. While every real time locating system that we investigated had good hardware reliability, Wi-Fi and Bluetooth failed to meet our sub-category of consistency. The signal used by Wi-Fi and Bluetooth systems can be easily distorted. However, even though Bluetooth systems have this potential problem, with such a large sample size to select data from, the museum could ignore these minor problems with signal interruption.

Overall, our team selected Bluetooth over other technologies due to its lower cost and high accuracy. Additionally, Bluetooth systems were able to meet our three additional criteria developed from interviews conducted at Melbourne Museum. These three criteria were real time access to visitor behavior data, the ability to push information to visitors, and adaptability. While each system that we evaluated had the ability to push information to visitors and provide real time access to visitor behavior data, only Bluetooth and Wi-Fi systems we found were easily adaptable. Many RFID and Ultra-wideband systems are installed for a specific design. The cost and labor requirements to change this designed infrastructure is much larger than simply moving a Bluetooth beacon from one exhibit to another.

In conclusion, our team found that a Bluetooth system was not only superior to other real time locating systems based on our main criteria, but it also was able to meet additional desires of Museum Victoria. Because of the reasons presented above, our team is confident that a Bluetooth system used for visitor tracking in Museum Victoria institutions would provide the best results. Through implementation of a Bluetooth system, Museum Victoria would be able to put more confidence in their ability to evaluate their programs and exhibitions. While our team did not focus this study on finding individual products for Museum Victoria and was limited to exclusively internet research, our team did uncover numerous systems that could be used in Museum Victoria's institutions. A table of these companies and their respective systems and technologies is located in Appendix G.

5.3 Recommendations for Follow-Up Studies for Museum Victoria

Listed below are areas our team identified for follow-up studies on visitor tracking for Museum Victoria.

1. *We recommend that Museum Victoria modify and implement the visitor tracking methodology developed for Melbourne Museum at Scienceworks and Immigration Museum.*

During our time in Melbourne, our team was able to visit Scienceworks and Immigration Museum, two additional components of Museum Victoria's organization. We observed small differences within each of the museums. For example, Immigration Museum had much more open space within their exhibitions compared to Melbourne Museum. In Scienceworks, exhibits were spaced farther apart than in Melbourne Museum. However, with the standardized methodology our team developed for Melbourne Museum, Museum Victoria can easily modify the visitor tracking system for use throughout their institutions. Through development and implementation of the visitor tracking methodology in these other museums, Museum Victoria may uncover additional procedures they wish to make a part of their enhanced visitor tracking methodology. Additionally, this will provide an opportunity for Museum Victoria to verify the decrease in labor requirements, the increase in reliability, and the decrease in visitor inconvenience from use of our developed methodology.

2. *We recommend that Museum Victoria conduct pilot tests of the Bluetooth technology recommended in this report before attempting a full-scale implementation.*

Due to time and budget limitations with our project and Museum Victoria, our team was unable to implement demonstrations of systems presented in this report. Through this project,

our group has uncovered Bluetooth as the ideal technology for Museum Victoria to implement in order to enhance visitor tracking at Melbourne Museum. However, during our background research, our team identified several Bluetooth systems that the museum could purchase. These are included in the list of products presented in Appendix G. A follow-up study that incorporates trials of Bluetooth systems will allow Museum Victoria to identify which Bluetooth system is best suited to their needs. Using criteria developed in this project, along with additional new criteria, will allow Museum Victoria to evaluate each system. A thorough review of proposed Bluetooth systems would provide Museum Victoria with a clear choice as to which Bluetooth system would best enhance their current visitor tracking system.

5.4 Conclusion

The goal of this project was to evaluate the current pen and paper visitor tracking system used by Museum Victoria, and propose updates to the current visitor tracking system as well as an alternative digital update for future implementation. Through our background research and first-hand experience with visitor tracking at Melbourne Museum, our team was able to identify areas of improvement for Museum Victoria's visitor tracking system. Our team provided Museum Victoria with recommendations regarding upgrades to their pen and paper system, a possible digital real time locating system that they could implement in the future, and possible follow-up studies. Through these recommendations, our team has provided Museum Victoria with confidence in their ability to understand visitor behavior and evaluate the quality of their programs and exhibitions. With the development of indoor positioning systems in the near future, organizations such as Museum Victoria will have the ability to not only understand visitor behavior, but will also be able to implement systems that include maps, security alerts, and access to additional information archives. With such a system, museums and many other organizations could predict where visitors are likely to circulate and provide a better visitor experience. Museum Victoria will be able to use the information presented in this report to improve their evaluation of their goals, specifically, dispersing knowledge throughout their community.

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Appendix A: Visitor Tracking Survey

* Required

What is the name of your museum? *

Where is your museum located? *

City, State

On average, how many people visit your museum each day?

- 1-500
- 501-1000
- 1001-3000
- 3001-5000
- >5000

Do you track visitors in your museum in order to gather information to help improve exhibits? *

- Yes
- No

Please briefly describe your tracking methods and any technology you use to assist in the tracking process. *

Would you be willing to provide us with additional information about your tracking system? *

- Yes
- No

Please provide the following information so that we may contact you:

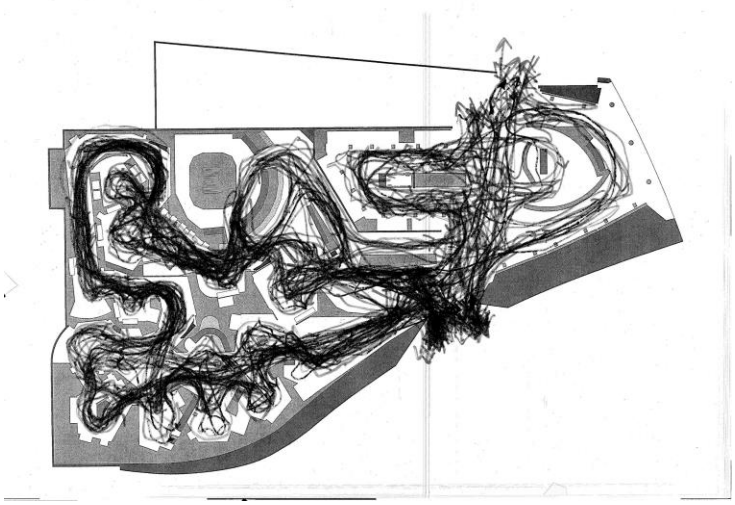
Name: * Job Title: * Phone number: * Email: *

Appendix B: Melbourne Museum First People Exhibition Study Summary

- Layout:
  - 30% did not follow chronological order
- Language Map:
  - 82% interacted with the map
- Activity Table
  - 33% of families interacted with table
- Penetration:
  - Minimum: 17% (1 of 6 Sections)
  - Maximum: 100% (6 of 6 Sections)
  - Average: 64% (4 of 6 Sections)
- Stops:
  - Minimum: 3
  - Maximum:45
  - Average: 17

Section	Total Stops	Average Stops	Total Time (min)	Average Time (min)	Penetration
1 - Wominjeka	84	3	102.5	3.2	82%
2 - Our Story Upper	178	6	140.5	4.8	74%
3 - Creation Cinema	23	1	54	2.7	51%
4 - Our Story Lower	270	9	311	10	79%
5 - Many Nations	93	4	84	3.8	56%
6 - Generations	36	2	72	4.5	41%

Visitor Paths: N=40

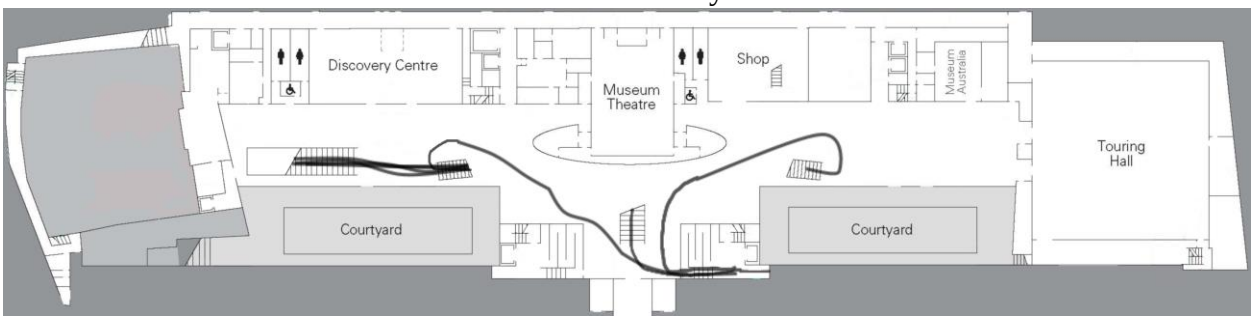


Appendix C: Melbourne Museum Whole of Site Study Summary

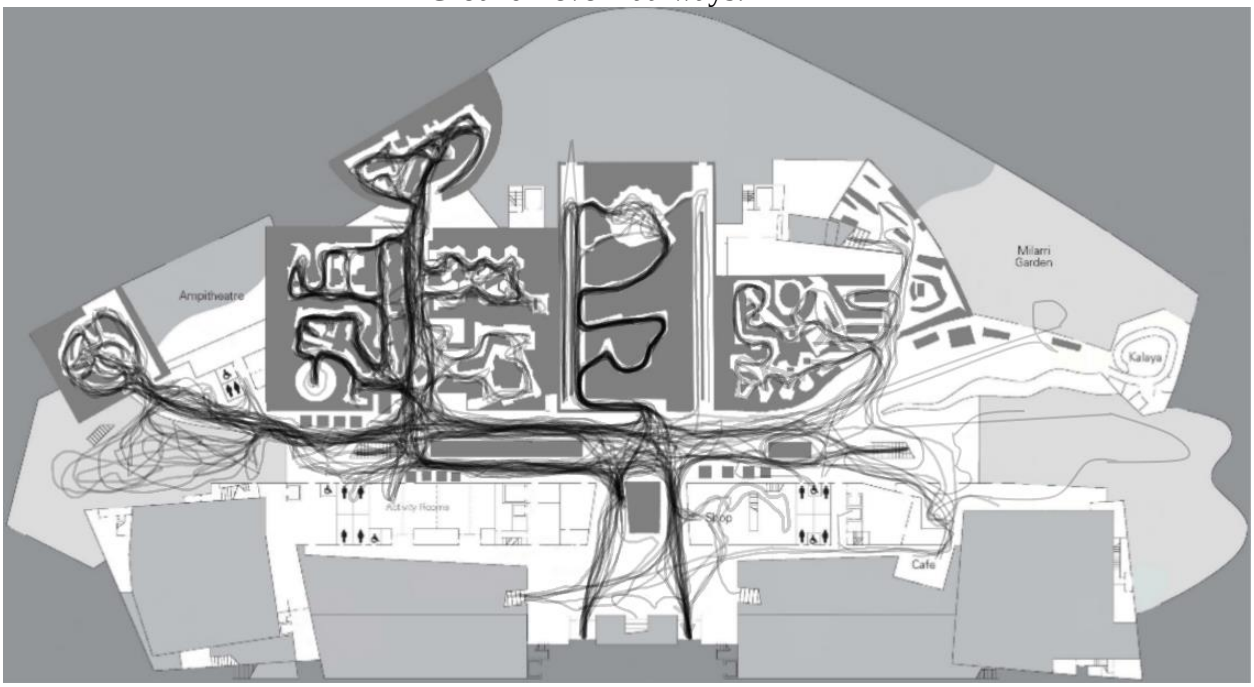
- Visitor Demographics
  - By age
    - 0-8 years old represented 32%
    - 9-18 years old represented 14%
    - 18-45 years old represented 30%
    - Older that 45 years old represented 24%
  - By type and gender
    - 48% of visitors were adults
      - 33% of them were males
      - 67% of them were females
    - 52% of visitors were kids
      - 60% of them were males
      - 40% of them were females
  - By nationality
    - 66% of the visitors were Australians
    - 5% of the visitors were English
    - 5% of the visitors were New Zealanders
    - 2% of the visitors were Americans
    - 2% of the visitors were Mexicans
    - 20% of the visitors did not provide this information
  - First time visitors
    - 45% of the visitors were first timers
    - 32% of the visitors were not first timers
    - 23% of the visitors did not provide this information
  - Museum Victoria Members
    - 11% of the visitors were Museum Victoria Members
    - 66% of the visitors were not Museum Victoria Members
    - 23% of the visitors did not provide this information
- Orientation Bias
  - Center Entrance (32.5%)
  - Right Entrance (0%)
  - Left Entrance (67.5%)
- Favorite Gallery
  - Science & Life (24%)
- First Gallery Visited
  - Science & Life (46%)
- Most Stops per Gallery
  - Science & Life (554)
- Most Stops per Exhibition
  - Dynamic Earth (140)
  - Bugs with (139)
- Most Visited Gallery
  - Dinosaurs Walk (75%)
  - Marine (41%)
  - Dynamic Earth (41%)

- Time Spent Inside Museum (HH:MM:SS)
    - Average: 01:36:38
    - Minimum: 00:30:23
    - Maximum: 03:25:00
- Time Spent Inside Museum without Circulation Space (HH:MM:SS)
    - Average: 01:27:05
    - Minimum: 00:15:30
    - Maximum: 02:47:52

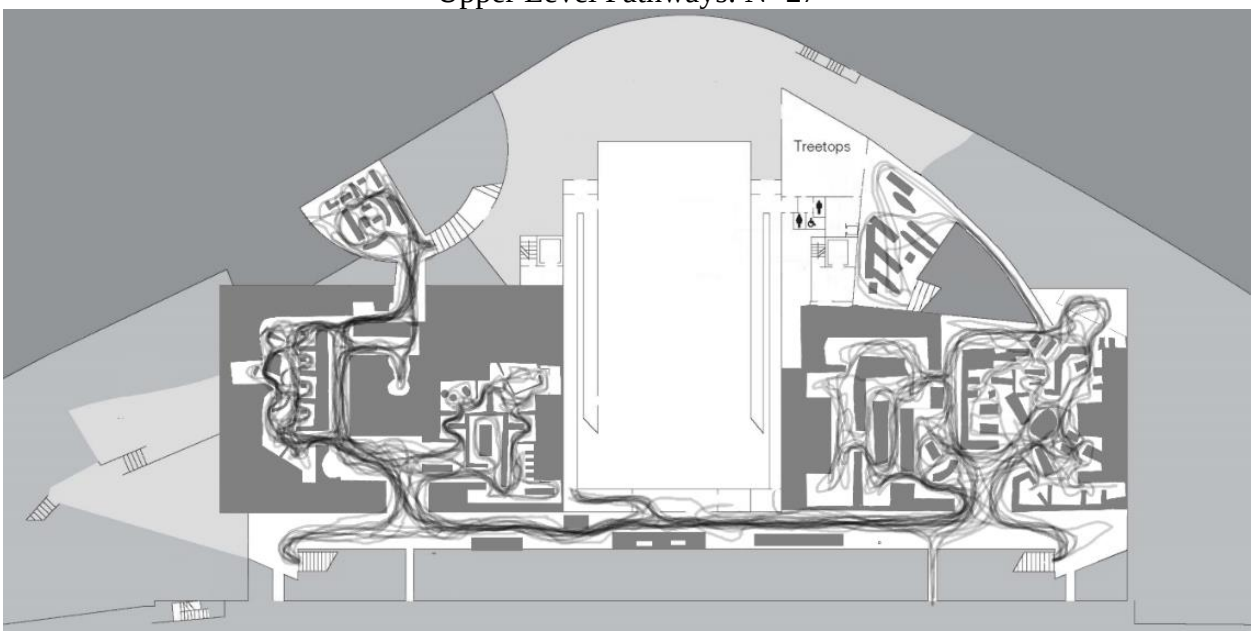
Lower Level Pathways: N=6



Ground Level Pathways: N=44



Upper Level Pathways: N=27

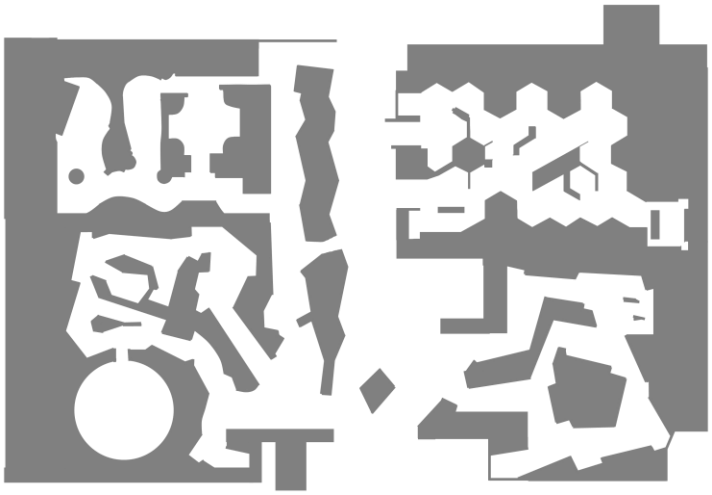


Appendix D: Melbourne Museum Exhibition Level Visitor Tracking Maps

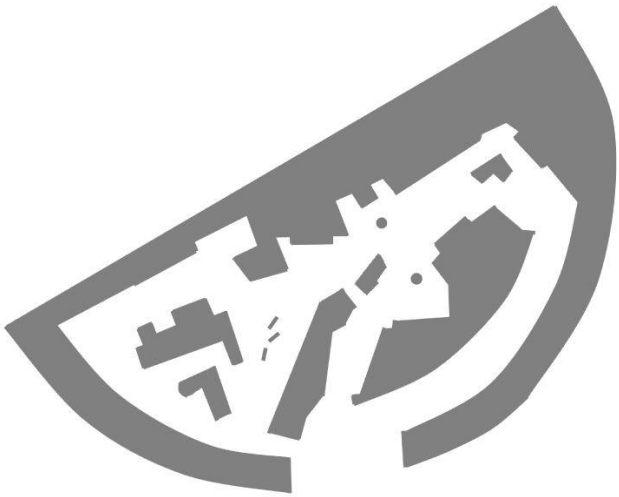
D1 Children's Gallery

D2 Gallery Walk & Foyer

D3 Science and Life Gallery



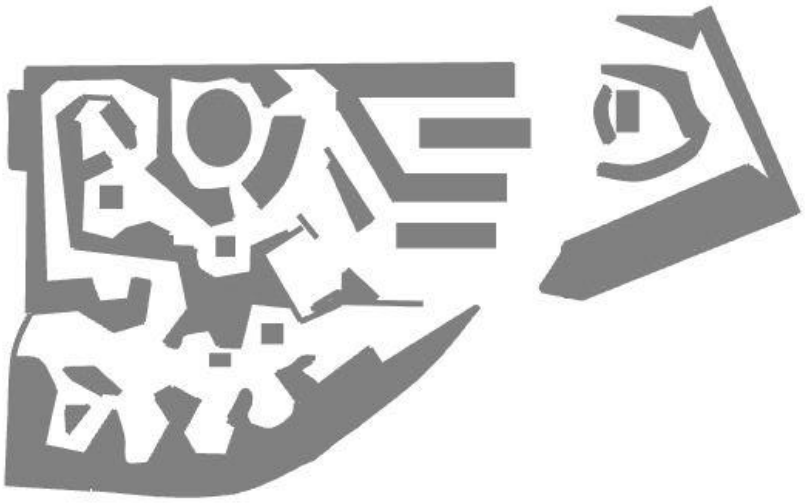
D4 Level 2 Evolution Gallery



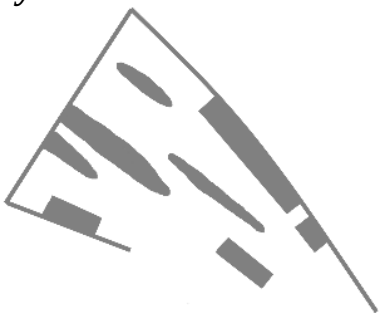
D5 Level 3 Evolution Gallery

D6 Forest Gallery

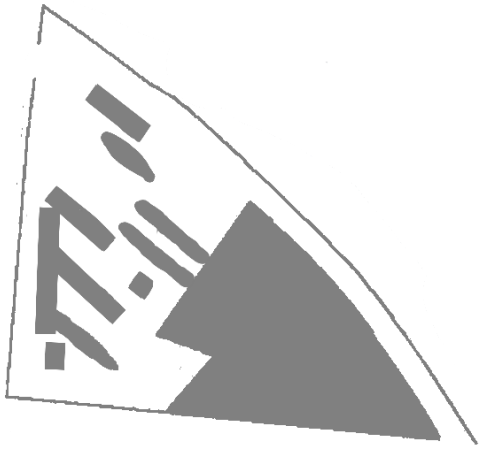
D7 First Peoples Gallery



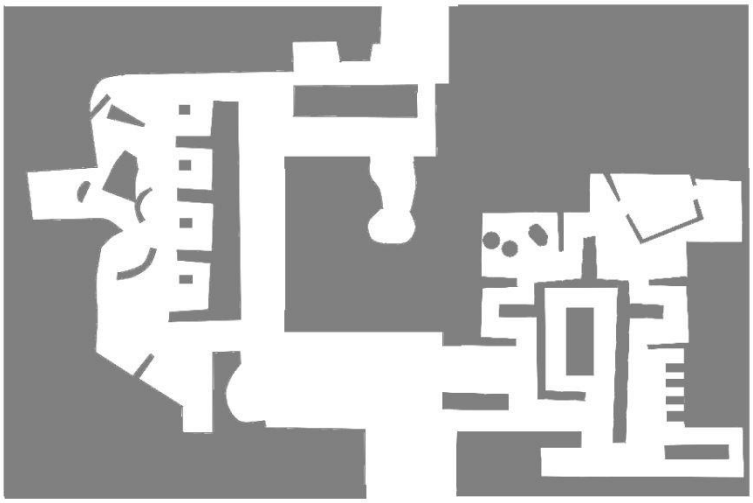
D8 Level 2 Te Pasifika Gallery



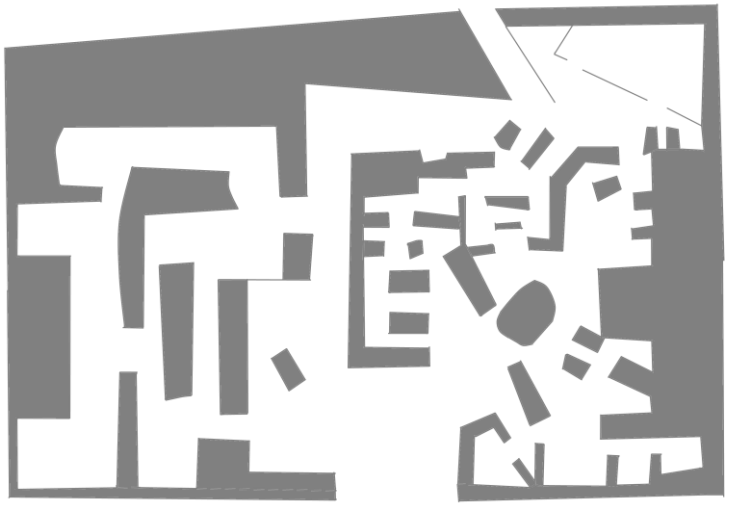
D9 Level 3 Te Pasifika Gallery



D10 Mind and Body Gallery



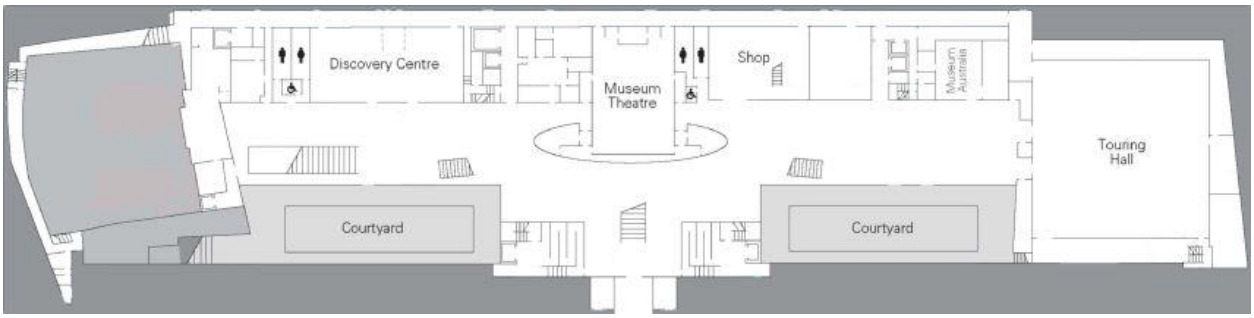
D11 Melbourne Gallery



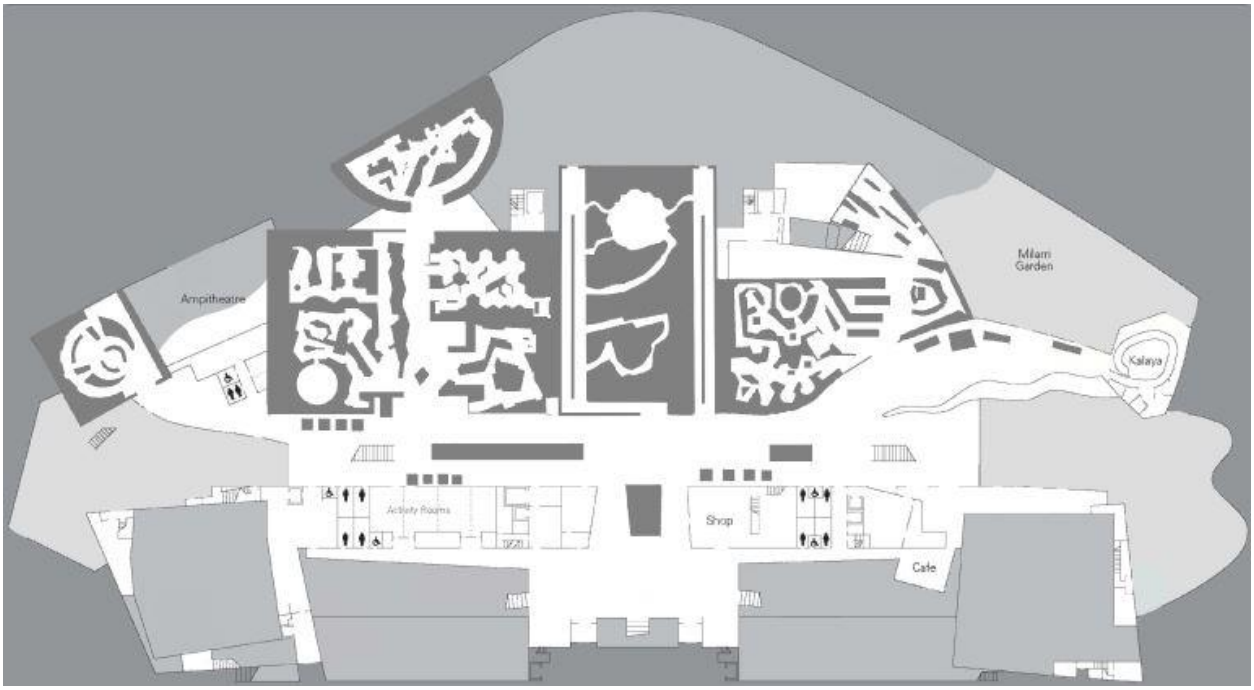
D12 Balcony

Appendix E: Melbourne Museum Whole of Site Visitor Tracking Maps

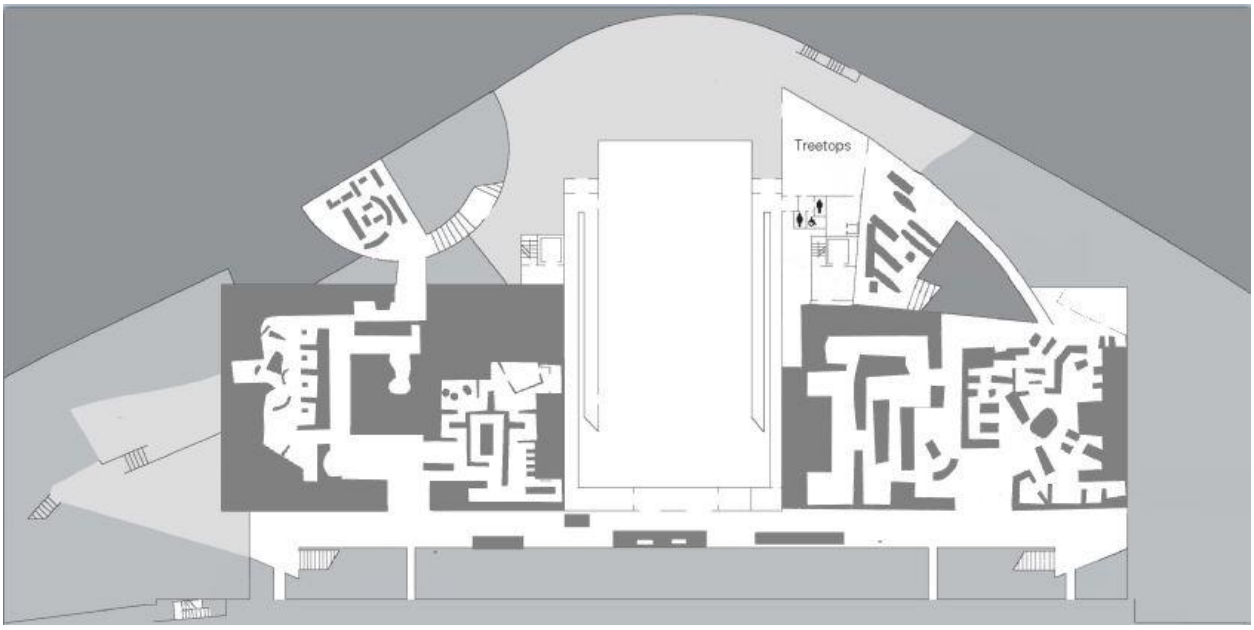
E1 Level 1



E2 Level 2



E3 Level 3



Appendix F: Interview Minutes

F1 Carolyn Meehan & Erica Chin

Date: January 27th, 2014 / 8:35PM
Location: WPI Gordon Library, Tech Suite 112A, Via Skype
Interviewer(s): P. Escuer, A. Mateo, C. McConnell, J. Schutes

Credentials: Manager, Audience Insights, Museum Victoria (Meehan) Research Analyst, Audience Insight (Chin)

Introduction: Beginning with our team, everyone present during this interview introduced themselves. Carolyn Meehan introduced herself as the Manager of Audience Insight for Melbourne Museum. Erica Chin works with Carolyn Meehan as a research analyst. Our team explained that we had received the project brief and would be working over the next seven weeks on background research before coming to Melbourne for the last seven weeks of our project.

Q*: *What is the goal of this project, and what systems are currently in place that we will be investigating?

> ***A*:** The goal of the project is to optimize tracking of visitor's pathways. The museum currently tracks visitors using pen and paper. Staff has a map of the exhibit and they use tracing paper and a pencil to identify the direction in which the visitors go. Along with the map, they have an observation sheet where they record any interactions such as where they stop, how long they stop for, if there is any notable visitor behavior. The museum has used this method for many years.

Q*: *In the project brief you mentioned something about a technology called the GECKOmmender. What is it, and why did you stop using it?

> ***A*:** In 2005, Melbourne Museum worked with the University of Melbourne and that project was exploring the possibility of predictive analysis. They wanted to see that if a visitor went to exhibit X and exhibit Y, they also might be interested in exhibit Z. They organized an electronic digital program (GECKOmmender). With the Gecko they were able to record where the visitors stopped and how long they stopped for. This method did not work because it was too complex. When they left, no one at Melbourne Museum had the capability to conduct a study using their system. It has not been used since, however we will try to send the information and program to your group. We know that it has been a long time since 2005 and part of this project deals with gaining information on what else might be out there, similar to something like the Gecko, that can enhance the capabilities of our current visitor tracking system.

Q*: *What are the uses of the collected visitor behavior data?

> ***A*:** Collected data is sent to the museum curators in charge of developing the exhibits. It is a way to inform them of what is happening on the floor. They can then decide if they

need to implement a better design element to have a better layout of the exhibits. A better layout would ensure visitors enter the right way and are able to get the full experience. It also shows which exhibitions are the most popular. With that information the museum decides to spend the money wisely (what interest the visitors). Overall, it gives us feedback on the success of each exhibition. We can then understand what funding, design decisions, and information went into that exhibition and use it for future planning.

***Q*:** *What is your main concern with the current pen and paper visitor tracking system?*

***A*:** With the current method the staff member will spend about two hours tracking the person with pen and paper. Once you have done that the track must be scanned, put it into Photoshop, layered on top of the other tracks. Additionally, the data on stops and times must be transferred to an excel spreadsheet. After all those steps are completed, the data is then analyzed. We have to do that with every single track. There is a lot of backend data entry. With Gecko by the time you were done tracking the person, you already had the number of stops, the amount of time at each stop, and the time across each area of the exhibit.

***Q*:** *What would your ideal visitor tracking system be?*

***A*:** A future tracking system should surpass the capabilities of the pen and paper system. To accomplish this, it must not be time consuming and data should be displayed in an organized manner. It should also not impose any inconvenience to the visitors. Since the pen and paper system is inexpensive, it would be preferable if the future system does cost too much and still provide the necessary information: number stops, time of each stop, and time in each gallery, exhibition, and exhibit.

Q: *Will the system we develop be used in Museum Victoria's other institutions?*

A: The hope is to eventually be able to incorporate this into all the museums, however this project will only deal with Melbourne Museum.

Q: *Can you provide us with some basic information on Melbourne Museum?*

A: About four to five thousand people per day come to the museum on school holiday. Public holidays are also very popular. Overall, the museum sees around eight hundred thousand to one million visitors per year.

Q: *Are there any laws in Australia different than the United States regarding tracking people?*

A: We have a sign at the front desk saying that visitors may be observed during their stay for research purposes. So far there has only been one issue in the past with a tracker who was following a visitor too close. If a visitor was to say anything, we would just stop the tracking and discard the information if they asked us to.

Q: *Does Museum Victoria have a budget for this project?*

> ***A***: Currently we do not know yet, however, we can put you in contact with our IT department to see what we already have and if anything can be used for your project. What I am thinking we can get out of this project is not only an update to our current system, but being able to have a plan to move forward. We would have something that in the future, we could ask for funding from the right people and get something moving along.

Closing**:** Ms. Meehan asked the group what our expectations of the project were. We explained that we going to be working on a way to create a more time efficient visitor tracking system for Melbourne Museum while at the same time, looking into alternatives that they could implement in the future. Carolyn Meehan also asked what about our current project timeline and if we thought the project would be able to be completed in a timely manner. We explained that during the first seven weeks, we will be doing research here while completing our other classes. Once we get in Melbourne we can work on enhancing the new system and looking into possibly implementing some pilot studies. Our group thanked them for their time and concluded the meeting with the reminder to send along the information requested throughout the interview.

F2 Gordon White

Date: April 10th, 2014 / 4:00PM
Location: Melbourne Museum, Old PR Room Level 3
Interviewer(s): P. Escuer, A. Mateo, C. McConnell, J. Schutes

***Credentials*:** Manager, Melbourne Museum

***Introduction*:** We began by individually introducing ourselves and providing information on what we are researching. We explained to Mr. Gordon the current progress of the team. We showed him some of the changes made to the current pen and paper system and which systems we were in the process of investigating to make our recommendation to the museum.

***Q*:** *In your opinion, what is the goal of tracking visitors? How do you think the museum benefits from this?*

> ***A*:** By tracking visitors the museum is able to understand visitor behaviors as well as gain knowledge to what exhibitions and galleries are really popular. By knowing the holding power of each gallery, the museum is able to leave these gallery longer or incorporate galleries of equal interests in the museum. By knowing all these things the museum is able to increase visitor attendance.

***Q*:** *What attributes do you think an ideal tracking system should contain?*

> ***A*:** An ideal system would be one where the data can be organized and displayed immediately computer or even accessed through a smartphone.

***Closing*:** We thanked Mr. White for his time and valued help. He said he was glad to meet with us and asked that we keep him informed on our progress.

F3 Ursula Smith

Date: March 31st, 2014 / 11:30AM
Location: Melbourne Museum, Old PR Room Level 3
Interviewer(s): P. Escuer, A. Mateo, C. McConnell, J. Schutes

***Credentials*:** Sciences Collection Online Coordinator

***Introduction*:** We began by individually introducing ourselves. Then we began explaining what the goal of our project was and what we have been working on to accomplish it.

***Q*:** *Are you familiar with any visitor tracking technologies?*

***A*:** Not much knowledge to what technologies are on the market.

***Q*:** *What attributes do you think an ideal tracking system should contain?*

***A*:** It would be interesting to incorporate social media and visitor tracking. This can be accomplished through the use of smartphone applications. Ideally it would be nice to have a system that guides the visitors through the museum. If they want to go to a particular exhibition it would tell them what the quickest path is. This would probably be best through smartphones. This method would prove to be more interactive for the visitors.

***Closing*:** We thanked Ms. Smith for her time and valued help. She said she was happy to assist.

F4 Johnny Brownbill

Date: March 21st, 2014 / 3:30 PM
Location: Melbourne Museum, Gerry Gee Room Level 1
Interviewer(s): P. Escuer, A. Mateo, C. McConnell, J. Schutes

***Credentials*:** Manager, Online Development

***Introduction*:** We began by individually introducing ourselves. Then we began explaining what the goal of our project was and what we have been doing to accomplish it.

***Q*:** *Are you familiar with any visitor tracking technologies?*

> ***A*:** Familiar with technologies ranging from RFID to GPS based. The MONA Museum in Tasmania has currently incorporated the use of smartphones as a method of providing visitors with information on each exhibit and guides them through the museum. He is currently working on a project in Melbourne Museum where the visitors will use smartphones and Bluetooth beacons in order to provide extra information to their future visitors during the World War I exhibition. This will also provide the visitors with a more interactive exhibition. This technology could be programmed to show where and when the visitors interacted with the exhibitions. Later on, staff would have to create the pathways the visitor followed.

***Q*:** *What attributes do you think an ideal tracking system should contain?*

> ***A*:** An ideal tracking technology would be one that provides the visitors with additional information of the exhibit they are in much like what the Mona is doing.

***Closing*:** We thanked Mr. Brownbill for his time and valued help. He was happy to assist and said that if we have more questions not to hesitate to contact him.

F5 Herb Lim

Date: March 21st, 2014 / 3:30 PM
Location: Melbourne Museum, Gerry Gee Room Level 1
Interviewer(s): P. Escuer, A. Mateo, C. McConnell, J. Schutes

***Credentials*:** Manager, Information Technology

***Introduction*:** We began by individually introducing ourselves. Then we began explaining what the goal of our project was and what we have been working on to accomplish it.

***Q*:** *Are you familiar with any visitor tracking technologies?*

***A*:** There were many known technologies, ranging from RFID to Wi-Fi. However, it would be necessary to evaluate the impact that these technologies could have in the museum, and it they are feasible. List of technologies that could be applied in order to track with more accuracy visitors. New technologies may require installation of new infrastructure in order to operate properly. Wi-Fi doesn't not yet have the necessary capabilities to operate a technology

***Q*:** *What attributes do you think an ideal tracking system should contain?*

***A*:** It would be ideal if there were a tracking technology that did not require much infrastructure set up. The museum is not at a stage where the infrastructure could easily be added.

***Closing*:** We thanked Mr. Lim for his time and valued help. He said that he was glad to meet and to contact him if any questions present themselves.

Appendix G: Company and Product Information

Company	Product	Technology	Information Link
Nextome	Nextome	Wi-Fi	http://www.nextome.org/index.php
Navizon	Navizon Indoor Triangulation System (I.T.S)	Wi-Fi	http://www.navizon.com/product-navizon-indoor-triangulation-system
Real Time Location	MerlinView	Ultrasonic ID	http://realtimelocation.co.uk/
TRX Systems	Neon Sensor Fusion and Mapping Technology	Inertial Systems & RFID	http://www.trxsystems.com/GPS-Denied-Navigation-Products/
Roodin	Roodin	Wi-Fi	http://roodin.crs4.it/
AeroScout	AeroScout MobileView	Wi-Fi, RFID	http://www.aeroscout.com/mobileview
ESSENSIUM	Location for Sensor Tracking (LOST)	Wi-Fi	http://www.essensium.com/Documents/LOST_Technology_Flyer.pdf
NEC Engineering, Ltd.	SmartLocator	RFID	http://www.nec.com/en/global/techrep/journal/g06/n02/pdf/060221.pdf
TeleTracking	TeleTracking Real-Time Locating System	Infrared	http://www.teletracking.com/rtls/
Ekahau	Ekahau Vision RTLS Software	RFID	http://www.ekahau.com/real-time-location-system/technology
CenTrak	CenTrak Real-Time Location System	Infrared & RFID	http://www.centrak.com/SmarterRTLS.aspx
Zebra Technology	Visible Value Chain	RFID	http://www.zebra.com/us/en/solutions/location-solutions/location-solutions-overview.html
Vizbee	V-LOC	RFID	http://www.vizbee-rfid.com/
Sonitor Technologies	Sonitor Sense RTLS	Wi-Fi, RFID	http://www.sonitor.com/application-patient-flow.html
Ecived	Ecived RTLS	RFID	http://www.ecived.com/en/product_show.aspx?id=7
GAB	GAB RTLS Wi-Fi Tracking	Wi-Fi	http://www.gab.de/en/produkte/gab-rtls-wi-fi-tracking/
Meridian Apps	Medirian	Wi-Fi	http://www.meridianapps.com/industries#museums
Bluenion	Bluenion	Bluetooth, Wi-Fi, RFID	http://www.bluenion.com/solutions.php?id=8
Redpin	Redpin	Wi-Fi	http://redpin.org/

Peacock Bros LTD	Sky-Trax Indoor GPS Vehicle Tracking System	Indoor GPS, RFID	http://www.peacocks.com.au/skytrax.html
Ubisense	Ubisense Ultra-Wideband RTLS	Ultra-Wideband Radio	http://www.ubisense.net/en/products-and-services/rtls-products.html
IBM	TagMyMuseum	QR Codes	http://www-03.ibm.com/able/europe/Public/TagMyMuseum.html
ZONITH	ZONITH Indoor Positioning System	Bluetooth	http://www.zonith.com/products/ips/
Guardly	Guardly Indoor Positioning	Bluetooth	https://www.guardly.com/technology/indoor-positioning-system
Motorola	Wi-Fi Indoor Location Solutions	Wi-Fi	http://www.motorolasolutions.com/US-EN/Business+Solutions/Network_Technologies/Wireless_IP_Networks/Indoor+location
Jolly	Lobby Track	RFID	http://www.jollytech.com/software-and-systems/visitor-tracking-software.php
inLogics	inLogics RFConnect.NET RFID	RFID	http://www.inlogic.com/home/home.aspx
APSIMA	APSIMA	Bluetooth	http://www.apsima.com/
Wifarer	Wifarer	Wi-Fi, Bluetooth	http://www.wifarer.com/technology
Apple	WifiSLAM	Wi-Fi	https://angel.co/wifislam
Teldio	Indoor Positioning System (IPS)	Bluetooth	http://www.teldio.com/products/ips/
WiLocate	WiLocator	Wi-Fi	http://www.wilocate.net/index.html
Navisens	motionDNA	Mobile Device Inertial Systems	http://www.navisens.com/
Indoor Navigation Systems	Indoorgo	Wi-Fi, RFID	http://www.indoorgo.com/
Art Processor	Enso Locate	Bluetooth	http://ensolocate.com/#beacons
Pole Star	NAO Campus	Bluetooth	http://www.polestar.eu/en/nao-campus/indoor-positioning.html
Quuppa	HAIP Mobile Centric	Bluetooth	http://quuppa.com/solution/technology/mobile-centric/
iinside	iinside	Bluetooth	http://iinside.com/technology/

Appendix H: Methodology for Visitor Tracking at Melbourne Museum

Preparation for the study

1. Create exhibition / gallery / museum maps (only necessary if maps do not exist for the area being studied)
    a. Acquire current floor plans for the galleries and exhibitions (see Figure 1)
    b. Mark solid objects in exhibition (see Figure 2)
        i. Go to exhibition
        ii. Use a bold face marker to trace all objects that obstruct a visitor's motion (walls, exhibits, seats, etc.)
    c. Trace outlines of solid objects onto clear copy sheets (see Figure 3)
    d. Scan copy sheets and save as .jpg file
    e. Create digital map using Paint.NET (see Figure 4)
        i. Open map scan in Paint.NET
        ii. Create a new layer
            1. Layers – Add New Layer
        iii. In the new layer, draw in shapes of solid objects in the floor plan
            1. Commonly used tools are the paintbrush, line / curve tool, rectangle tool, and paint bucket
            2. Lowering the opacity of the background layer to 120 can make it easier to see the new shapes
                a. Layers – Layer Properties
        iv. Delete background layer
        v. Save the remaining image as a .png file
        vi. Paint.NET will ask if you wish to flatten the image.
            1. Accept
    f. If necessary, combine maps to create a composite map
        i. Open each map in Paint.NET
        ii. Copy each map as a new layer in Paint.NET onto the composite map
            1. Position the layers using known reference points on the underlying map
    g. Resize image to fit on A4 paper without distortion
        i. Image – Canvas Size
2. Create data collection sheet (See Figure 5 for Example)
    a. Create boxes at the top of the page to record the following: Date, Time, Tracking Number, Weather, and Additional Programs Running
        i. Add additional boxes for any extra data you wish to collect
    b. Create a table with eight columns.
    c. Label the columns as follows: Area, Time In, Sub. Area, Sub. Time In, Sub. Time out, Sub. Stops, Time Out, and Stops
        i. Add additional columns for any extra data you wish to collect

d. Define what each Area and Sub. Area is (i.e. each gallery is an Area, while each exhibition is a Sub. Area)
    i. Using a shorthand naming convention for the areas can simplify this process
3. Create demographic collection survey (See Figure 6 for Example)
    a. Include questions asking for gender and age, country of origin, and other demographic information pertinent to your study.
    b. Include questions on whether they have been to the museum before and if they are a Museum Victoria member
    c. It is helpful to design the survey so that you can hand it to the visitor and ask him or her to fill it out, rather than ask the questions verbally.
        i. Most visitors were willing to answer a short, 5-6 question survey when exiting
4. Develop intended study
    a. Decide whether to perform an exhibit, exhibition, or gallery level study
    b. Decide who you will be observing (i.e. families, students, internationals)

Data Collection

1. Perform visitor observation
    a. Select visitors to track as they enter the museum.
        i. Determine a selection process (i.e. the first visitor that meets the demographic requirements, or every fifth visitor that enters)
        ii. Determine a point to start the tracking process (i.e. main door or ticketing booth)
        iii. Determine a point to end the tracking process (i.e. main door)
    b. Record visitor's path through the museum on the map
        i. Use a 5 mm mechanical pencil to avoid clutter on map
        ii. Mark each stop made by the visitor with a ● with a code next to it (i.e. 1T)
            1. Approximate time stopped
                a. 1: 0-15 seconds
                b. 2: 15-30 seconds
                c. 3: 30-60 seconds
                d. 4: 60+ seconds
            2. Actions
                a. T: Touching
                b. W: Watching
                c. R: Reading
                d. L: Listening
                e. P: Photo
    c. Record the timing data and number of stops of the visitor in each area of the museum on the data collection sheet

i. Record times into each area and subsequent Sub. Area in separate rows
ii. For each stop recorded on the map, place a tally in the "stops" column
    1. Record stops made in the gallery in the "Stops" column
    2. Record stops made in exhibitions within a gallery in the "Sub. Stops" column
        a. If you mark a stop in the "Sub. Stops" column for a Sub. Area, do not mark it again in the "Stops" column for the Area

2. Administer exit survey
    a. Approach tracked visitor and ask them to complete the survey
        i. Use an explanation like: "I'm a member of Museum Victoria staff and I'm conducting a survey on visitor satisfaction. Would you mind taking a moment to answer a quick five question survey?"
    b. If the visitor refuses to take the survey, note this and mark gender of his or her group
3. Dress and Behavior Code
    a. Wear discreet clothing that could blend in easily (i.e. No bright colors, distinct patterns, hats, or flashy jewelry)
    b. Museum ID should be visible
    c. Follow visitor at a reasonable distance
        i. Far enough away to keep a line of sight with the visitor
        ii. Many exhibitions have areas where you can stand and see most of the space
    d. If the visitor confronts you during your study, end the tracking and explain your project to the visitor.
        i. Do not use any further data from this tracking in your report

Compile Data

1. Create composite maps of visitor tracks
    a. Scan all tracking maps as image files
    b. Open image files using Paint.NET
        i. Create a new layer
        ii. Trace over visitor track in the new layer (reducing the opacity of the background layer to 120 helps make the new path easier to see)
        iii. Mark a known point to make it easy to superimpose maps (i.e. a door or a corner of a room)
        iv. Delete the background layer, leaving just the trace of the visitor track
        v. Save trace images as .png files
    c. Combine traces
        i. Open blank map and tracking traces in Paint.NET
        ii. Copy each trace onto the new map as a new layer

1. Edit layer name to tracking number (i.e. Layer 6 - Track #4)
2. Align each layer before opening the next using known point created on each trace
3. Edit layer settings to Opacity: 50, Mode: Color Burn

iii. Save image as .pdn file
iv. Save additional images as .jpg files with certain layers turned on or off depending on needs of project
v. Repeat for each exhibition, gallery, or floor as necessary

2. Enter data in excel sheet
    a. Use the standard Museum Victoria observational study data template
    b. Input all information from timing sheets and exit surveys in the correct fields

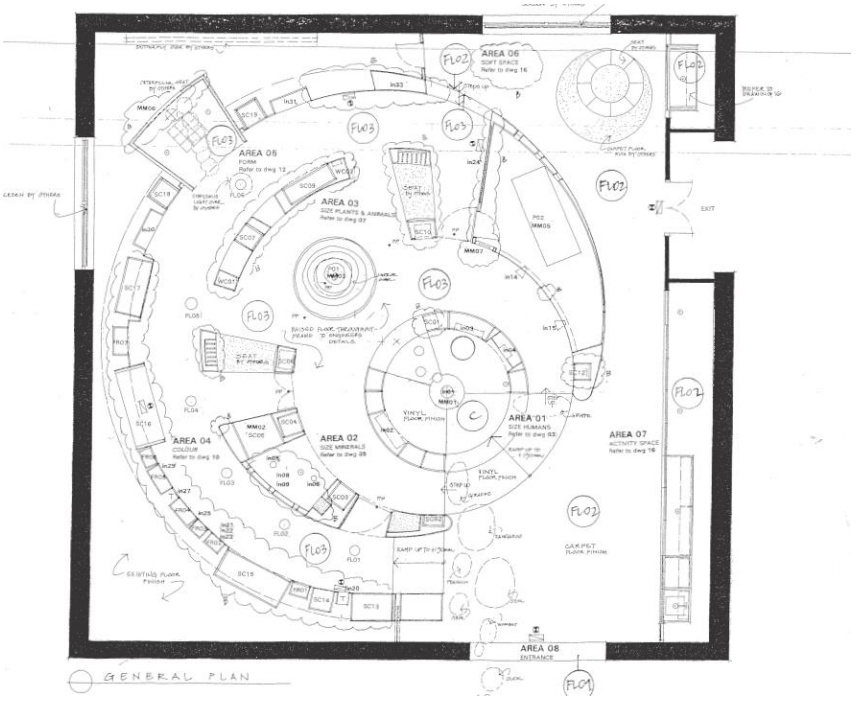


Figure 1: Floor Plans

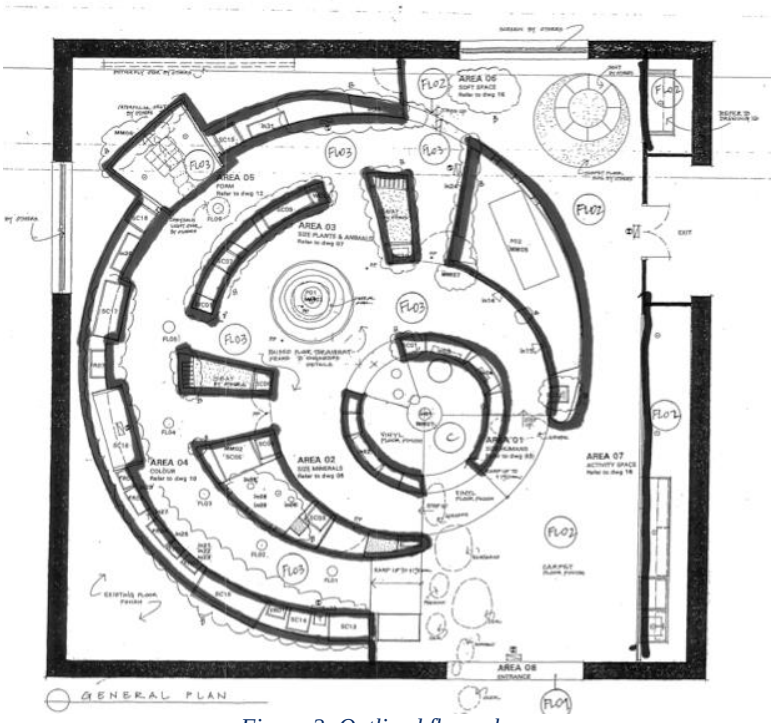


Figure 2: Outlined floor plans

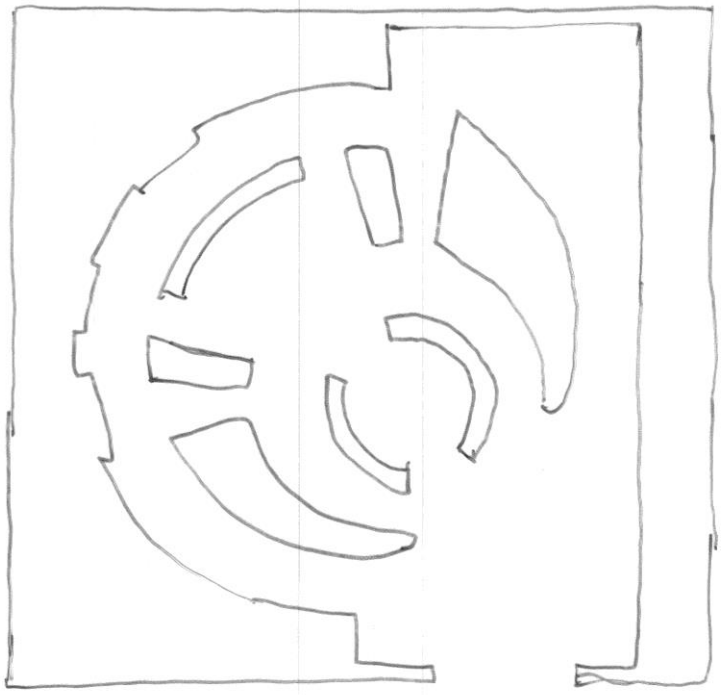


Figure 3: Traced floor plans

Figure 4: Created floor plan

Date: Time of Day: Tracking #:

Legend:	1: <15 s	2: 15-30 s	3: 30-60 s	4: 60+ s	
	P: Photo	T: Talking	W: Watching	L: Listening	R: Reading

Area	Entry T.	Sub-Area	Sub Entry T.	Sub Exit T.	Sub Stops	Exit T.	Stops

Figure 5: Sample Data Collection Sheet

Please provide the following information for yourself and members of your group.

Member 1: Male Female Age: _____

Member 2: Male Female Age: _____

Member 3: Male Female Age: _____

Member 4: Male Female Age: _____

Member 5: Male Female Age: _____

Member 6: Male Female Age: _____

Please answer the following questions.

What country do you live in? _____

If you live in Australia, what is your postal code? _____

Is this your first time visiting Melbourne Museum? Yes No

Are you a MV Member? Yes No

What was your favorite part of the museum?

_____

_____

What was your least favorite part of the museum?

_____

_____

Figure 6: Sample Demographic Survey