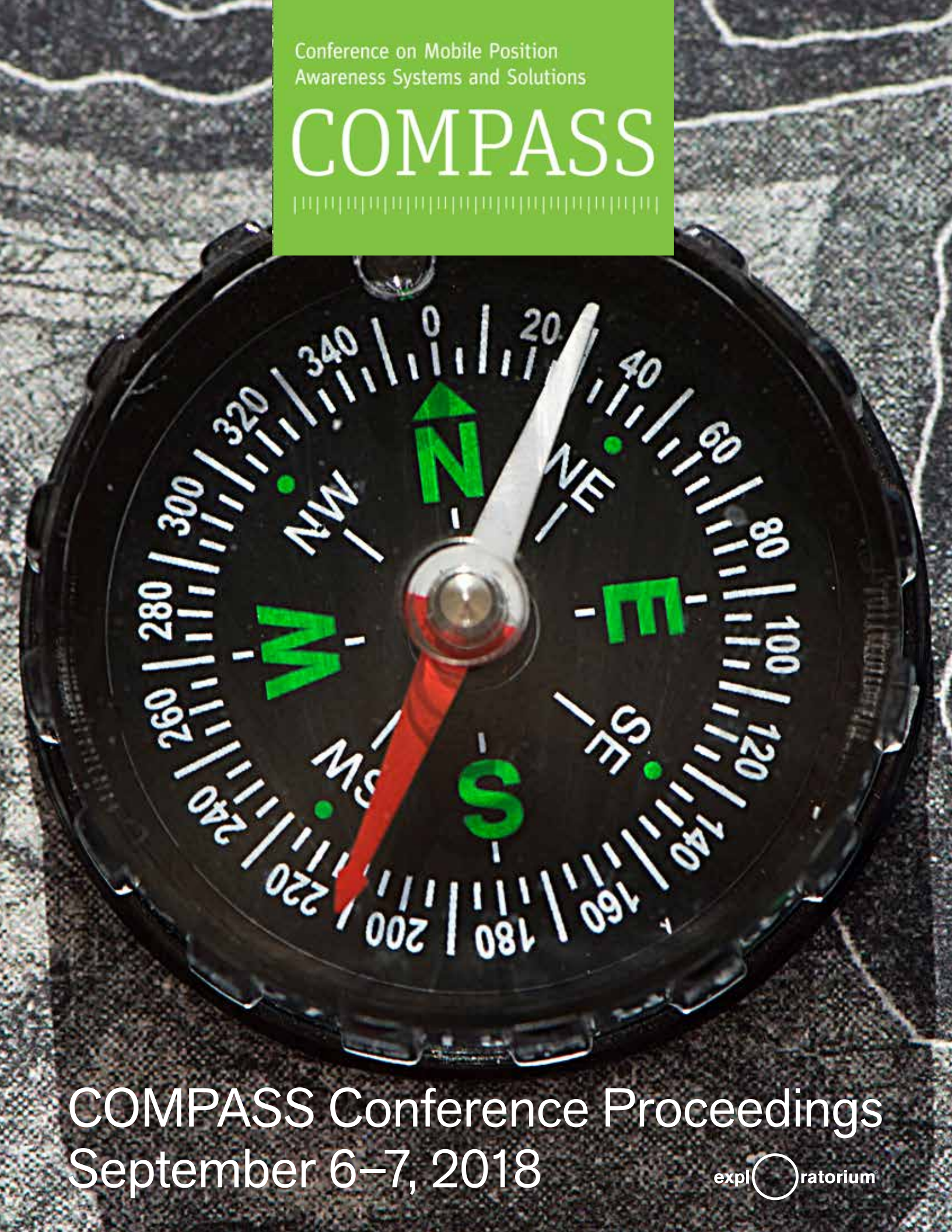
Conference on Mobile Position Awareness Systems and Solutions

COMPASS



COMPASS Conference Proceedings
September 6–7, 2018

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This material is based upon work supported by the National Science Foundation under Grant No. 1712808. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Introduction and Welcome

Chris Flink and Claire Pillsbury

On September 5–6, 2018, the Exploratorium hosted the Conference on Mobile Position Awareness Systems and Solutions (COMPASS). The 80 attendees were from throughout the United States, and from Canada, Australia, New Zealand, the United Kingdom, and Sweden. Speakers and panelists from museums, academia, industry, and research discussed indoor location projects related to informal learning, increasing accessibility, addressing privacy, and understanding visitor behavior.

This publication presents the conference proceedings, with summaries of each session organized chronologically.

Exploratorium Executive Director Chris Flink and COMPASS Principal Investigator Claire Pillsbury welcomed participants and thanked the National Science Foundation for supporting this project [NSF Award #1712808]. Flink acknowledged the many attendees who had traveled from inside and outside the United States to be part of the activities. He then outlined the goals of the COMPASS conference:

- Promote dialogue between informal education practitioners, academic researchers, and technologists.
- Share results of experimentation in developing and deploying location-aware mobile apps in informal education environments.
- Identify challenges of tracking and timing data collection, consent, anonymity, and privacy.
- Review strategies for implementing this technology, understanding constraints, and assessing current technical parameters.

Pillsbury explained that the project originated with the Exploratorium's own efforts to test and use location-aware technology beginning in 2010. They repeatedly ran into technical problems, which they tried

to understand and solve, tried again, asked for advice from colleagues, and tried alternative techniques but had mixed results. There were many theoretical scenarios of how the technology should work but very few accounts about actual museum and visitor use. These experiences underscored the value of convening interested parties inside and outside of museums to share insights and exchange ideas to advance this work. To that end, the COMPASS conference was designed to explore a range of topics and questions that the broader informal education community has been grappling with such as:

- What kinds of software and hardware are needed?
- What is an ibeacon, an RFID chip, an AP radio, and a heat map?
- Can we use this in visitor research and what about privacy issues?
- Who can I talk to the next time I have a question or want to think through an idea?

Pillsbury thanked her colleagues at the Exploratorium, the expert advisors who helped plan the conference, the speakers for agreeing to candidly share their work, and all the conference participants.

Keynote: Museums and Mobile Tech

Aaron Cope, SFO Museum (formerly Cooper Hewitt Museum, Mapzen)

Aaron Cope started by noting his past work in museums and digital mapping and contrasted that with his current work at the SFO Museum (San Francisco International airport). He observed, ". . . when it comes to the future of indoor location and positioning technologies, the museum sector would continue to benefit from looking at what's going on in airports. These days I am exposed to a daily stream of airline and travel industry trade publications and in their headlines it is possible to see the near future of consumer-grade location and tracking technologies being deployed to a mass audience."

He also asserted that, "an airport remains a useful space to watch technology being introduced and normalized or not and can serve as a useful guide for museums."

Cope recommended resisting the frequent temptation to cite Disney as a model or a reference point for museums using technology, "But Disney does it! is like the trickle-down economic theory of technology development in museums." Until the museum sector can create Disney-scale infrastructure for cultural heritage, "talking about Disney does nothing to address [the] day-to-day needs we face."

He suggested that museums might be overvaluing and overinvesting in the newest technologies. He told a story about a museum that was considering a story-recording booth for visitors. His colleague Seb Chan suggested that instead of this plan, a few phone lines and answering machines could serve the same purpose and be less disruptive to the visit. Another example he gave of more economical technology solutions was an Android watch app developed for the Barnes Museum in Philadelphia.

He suggested that readymades that retail for less than $100 are more feasible than custom electronics given the budget limitations of most museums.

Cope identified two broad problem areas for museums in which location technology is frequently proposed as a solution:

- Where am I and what am I looking at? (navigation and object identification)
- What now? (prompts for visitor engagement)

He then added a third problem area, post-visit engagement and return visits. Cope suggested a solution that is a variation on the traditional audio guide: a customized audio composition based on what the visitor did in the museum and that also gives reasons to return. He noted that this audio production would be similar in form to a podcast and need not be much more complex.

Using this idea as a segueway, Cope posed the following "awkward questions."

Is repeat visitation a lie? Do we really believe that most people will ever visit an exhibition or museum twice? Repeat visitation is not a given, especially for museums if the audience is primarily tourists. Does technology designed to enhance and deepen the visitor experience send the unintended message that the museum is a single-use space?

Is spectacle the new common language of museums? Does technology start to mediate the visit with the language of spectacle? Should the emphasis be only on what is remarkable and provoking a strong emotional reaction?

Is "remembrance of things past" a primary goal? Witness the success of Color Factory or the Ice Cream Museum, spectacular one-offs that guarantee a specific type of experience that "manifests itself in a collection of selfies." While it is personalized and a tangible remembrance that visitors can create to explore post-visit, it is also devoid of any deeper relevance.

Who is this for? If we ask people to participate and use this technology we need to be aware that "all location technology trends toward identification" and understand the privacy, trust, and ethical issues related to exploiting or protecting the identity of visitors using it. Cope closed his talk with the caution that before implementing this technology throughout our own and other institutions, we should ask, "whether museums are simply going to be the carrot to the surveillance capitalism stick or something else."

Eight Case Histories of Location-Aware Technology Projects

Robert Rutherford, Matt Tarr, Scott Brewer, Desi Gonzalez, Leilah Lyons, Dia Felix, Bernd Holtwick, Sean Pathasema, and James Williams

Case History 1: Robert Rutherford, San Diego Natural History Museum, California

Robert Rutherford was hired to manage the development of a third-party indoor location-aware app for the San Diego Natural History Museum (TheNAT). It was "a grant project to demonstrate the feasibility of using indoor location-aware technology that might be more broadly adopted in Balboa Park, a museum complex in San Diego that houses seventeen other cultural institutions. . . . We were using this as a feasibility model because most of the buildings in Balboa Park have a lot of inherent wayfinding challenges."

When Rutherford joined the project, the app developer had been hired, but no one had articulated the project goal. Rutherford composed the following: "Use this project to deepen a visitor's sense of place for the San Diego Natural History Museum and the region through digital wayfinding and narrative tools that complement our exhibition spaces and provide access to collections curatorial/institutional expertise and to relevant external resources."

The app was intended to be both a wayfinding solution for the five-story museum and to provide innovative ways of engaging with a new permanent exhibition.

"We used a third-party vendor who would install the Bluetooth beacon infrastructure. We would manage the fairly basic CMS (content management system) software. [We] deployed a total of 90 Bluetooth beacons. The content on the app was accessed via a free Balboa Park Wi-Fi infrastructure. We had 17 commercial grade Wi-Fi access points in our building."

Using the app for navigation depended on continuous device location awareness to provide turn-by-turn directions. To provide new engagement experiences, the staff created 28 localized "points of interest" with multimedia content, audio, video, and text with images.

"Now this is the part where I tell you how many lives we transformed with this work. That STEAM grades in San Diego went through the roof and everyone who used our app left the museum in a daze of satiated calm, filled with knowledge and quoting Darwin and listing off the scientific names of all of the flora in San Diego in perfect Latin. Nope, people totally hated this app."

After the launch, user testing revealed the problems:

- Visitors didn't want to "opt in" when the app asked for access at installation. The default response was to not allow access to their phone features, even though the app needed that access to function.
- The navigation experience was not intuitive and it was unreliable. The screen image rarely matched the visitor's actual location. The museum's central atrium space confounded the Bluetooth beacon triangulation calculations leading to incorrect locations.
- Visitors did not want to look at their phones constantly during their visit and wanted to access the app on their own initiative.

Nearly every visitor who started using the app abandoned it early in their visit. "This revealed the fatal flaw of the entire undertaking. We launched this project, excited to be a part of this emerging technology in cultural spaces, thinking about all the ways that we can actually enrich people's museum experience with this but we didn't put in the work before we started—to ask our visitors what they need. Do they need wayfinding? The answer they gave us (after we built this) was "no." They told us, 'You've got five galleries around a central atrium. I can look right over there and say hey, there's the mammoth. I'm going to the mammoth now. '"

Given this response, TheNAT shut down the app project and repurposed their interpretive multimedia content for use on their social media.

Case History 2: Matt Tarr, American Museum of Natural History, New York City

"The American Museum of Natural History [AMNH] in New York City has half a million public square feet, 45 permanent halls, 25 buildings, 150 years of construction. Big place and definitely, people need wayfinding. That's the first thing that they say when you ask them what they need. They are lost, they are overwhelmed, and they can't find their way around."

Efforts to enhance the AMNH experience with technology began in 2007 with funding from Bloomberg Philanthropies. In 2010, the *Explorer* app was launched as the first location-aware museum mobile app "to much acclaim and not a ton of satisfaction from visitors." In response to privacy concerns with the original app, AMNH changed the app technology to the then-emerging (2012) technology of BTLE [Bluetooth Low Energy] and installed 800 beacons in the museum.

The goal was to provide a satisfying tour for visitors. "We have volunteer-led tours that are massively successful and people love them. We built this multimedia guide to see if that would crack the nut and be more like the tours and less like an audio guide." They also added Google Analytics to the app to collect data on usage patterns. Google Analytics revealed that people went to the first stop in the app's tour and then stopped using the app. "Literally the drop-off was more than 90%. It's just not captivating enough to follow no matter how well your blue dot tracks."

User surveys and the analytics revealed that visitors were interested in finding specific exhibits and content in the museum (intentional), but they were also interested in unintentional wandering (serendipity). "How people behave in our museum is that they come in initially with some intent and subsequently they wander. In fact, wandering or getting lost in a museum like the American Museum of Natural History is not at all a bad way to

spend a day . . . . So we reframed the app around serendipity or what we like to call 'smart serendipity'."

The strategy was to support both the intentional "Take me to . . ." and serendipitous "Look at this . . . did you know?" moments. The core of the *Explorer* experience is like a concierge offering recommendations based on visitor interest or preferences, and their location in the museum. It creates an interface that treats the visitor's current location as the starting point to call out what is near and what is worth walking a little further to see. "[When] I set out to envision what *Explorer 2.0* was going to be, I would leave my office with a felt tip pen and a white notepad that was about the size of my phone. I would stand in the museum, and I would ask 'What do I need right now that's not already here?' I would draw it on the piece of paper and think about it further. 'What is near me that I need to be aware of?'"

Staff also redesigned the app installation and onboarding of (learning how to use) the app to get visitors to turn on location services and Bluetooth. Most visitors first gravitate to the museum map view. *Explorer* offers visitors the option to flip the script and instead of a choice of destinations, they can choose where to go by reviewing suggestions of exhibits that are nearby. The app also alerts you if you will be late for a program or event.

"Explorer is about the visitor experience; it's not just about the wayfinding. We thought about the content that would go along with this experience and what people needed. The keys were to not repeat label text; the label is in front of them, that's the authoritative voice. We use the app to 'push the boat out' or experiment with a less formal narrative and to tell stories. Primarily stories that get you to look back at the exhibit with fresh eyes and new perspectives."

Explorer also includes turn-by-turn navigation. In the process of developing the wording of these instructions the terms were often negotiated because they were direct, unconventional and informal, i.e., "turn left at the giant mosquito." To show visitors when they had reached a destination, the app would display a big picture of the object or gallery.

Despite all the work on location accuracy Tarr stated "99% of what people need is room-scale location; except Google has set this expectation of a blue dot (precise position). We are spending all of our time and money to mimic a blue dot, which is unnecessary for the visitor experience, but we're kind of stuck with it. I'm almost coming around now to, you just got to be the same as Google in that regard. I would rather highlight the hall you're in and then show you the four things in that hall that you need to see. . . . The app tells you where you are. But somebody said that in all their years of evaluating audio tours, no visitor had ever complained about having to type in a number [to access content about an exhibit]. . . . I think that's why you've really got to be thinking about serendipity and context and letting people know what's around them that they don't know is there yet. "

The team also spent hundreds of hours developing accurate floorplans of the AMNH interior and recording the positions of different features and amenities. Though they hadn't anticipated this need, they learned that

most of the existing documentation was not accurately dimensioned so Tarr advises other teams to take this into account when launching a location-aware project.

Throughout the process, they strived to keep in mind the goal of "solving [the visitors'] problems and not ours."

Explorer has been downloaded more than one million times since it's 2010 launch. Evaluations reveal that 49% of AMNH visitors are aware of the app. *Explorer* users are more satisfied with their overall visit and more likely to describe the museum as thought-provoking. "When Laura Mann [of Frankly, Green, and Webb] and I talked about my goals for this app it was not that people would use the app, leave the museum, and say, 'Man what a great app!' It was that people would use the app, leave and say 'What a great museum!' We have statistically significant evidence for that now."

***Explorer* App by the Numbers**

800 beacons

300 Wi-Fi access points

12 developers

10 writers

4 photographers

3 illustrators

4 designers

6 scientists

2 platforms

4 APIs

190 stories

900 pictures

Case History 3: Scott Brewer, Art Processors, Museum of Old and New Art (MONA), Hobart, Tasmania

When museum founder David Walsh was planning the Museum of Old and New Art (MONA) his goal was to present the art in an aesthetically pleasing environment and promote more interaction. He chose to have the art displayed without labels to encourage visitor engagement. Scott Brewer was part of a team that worked on developing a location-aware modified consumer mobile device that would provide digital access to interpretive content including the information that would normally be on wall labels. MONA opened in 2011 and the team that developed the location-aware technology spun off to become the company Art Processors.

"We did not start out to be a company that was expert in location awareness. We accidentally found that path because we wanted visitors to have this incredible experience. MONA quickly became the state's number one tourist attraction with over 350,000 visitors a year. Eighty percent of those visitors prefer our solution to that of a traditional museum. I'm not here to tell you all to get rid of your wall labels but—get rid of your wall labels. People hate them. They really just want to enjoy the art."

Six years later (2017), David Walsh asked Art Processors to come up with a queuing solution because he didn't want visitors to spend their time at the museum waiting to see an artwork. The new dynamic system guides visi-

tors to spend their time where the art is available so they are engaged throughout the visit.

An unusual feature of the app is that visitors can "vote" with a "+" or "–" to indicate what art they like or dislike. Museum staff can observe the voting in real time during the day and the data can be analyzed over any past time period. From the beginning, the app also had a simple backend management tool that allowed updating when artworks change location or go on or off display. The app updating is done internally by MONA program staff rather than specialized IT consultants

After MONA, Art Processors carried out innovative work in 40 other institutions. "In every single one of them it has been indoor location that has driven us from being able to produce something that is static to something that is fluid. In Melbourne Zoo there was work we did with a theater company where people were walking through the space for an interactive theater piece. There were live actors involved and there was audio on devices. Eureka Skydeck is a project that used indoor location to have you walk around the sky deck and solve a crime. . . [A] crime gang was stealing jewels from the City of Melbourne down below and you could either join that crime gang or you could turn them into the police. . . . Indoor location is a really incredible technology and it really does enable another level of interaction and interactivity that people can have with the physical space that they're in."

Case History 4: Desi Gonzalez, Independent Consultant (Previously The Andy Warhol Museum)

Desi Gonzalez was Manager of Digital Engagement at The Andy Warhol Museum, one of the largest single artist museums in the United States. As part of the museum's "Warhol for All" accessibility initiative, the museum carried out in-house development of *Out* Loud*,* an inclusive location-aware audio guide that launched in 2016 after considerable trial, error, and formative evaluation working with community advisors. "It's an audio guide that we offer to everyone who walks into the museum but we worked specifically with community members who are blind or have low vision to produce something that's accessible to them."

Out Loud was designed to work with iOS screen reader *VoiceOver*, which turns screen text into audible speech. The audio guide brings together in-depth descriptions of objects (for low-vision visitors) with more traditional interpretive content (for sighted visitors). *Out Loud* is complemented by tactile versions of signature artworks installed throughout the permanent collection galleries. The app uses a location technology system that incorporates Bluetooth beacons to push content based on the visitor's current location. It operates at room level with "Near Me" functionality. If a visitor with low vision walks into the gallery with *VoiceOver* switched on, *Out Loud* will alert them to the nearby artworks.

Gonzalez reflected on the installation and testing process, "We definitely had many moments of the 'Why isn't it working?' The technology is not perfect and we did this all in-house. We've been iterating on the beacon installation. This year we had the opportunity to pilot a new system that I was really excited about—something that would really up our game location tech-wise. "

Gonzalez then described a 2018 partnership between The Warhol and Carnegie Mellon University to try *NavCog*, an indoor navigation system developed by blind computer scientist, Chieko Asakawa. *NavCog* provides very precise navigation allowing visually impaired people to independently experience the Warhol (or any new space) without relying on a companion. The partnership offered Asakawa the chance to test her technology in a new, content-rich context and gave The Warhol a potential new option for increasing accessibility. The Warhol piloted *NavCog* on the seventh floor of the museum and conducted a user study. "And the surprising thing was that it really worked."

Gonzalez ended on an optimistic note about the success of *Out Loud* and *NavCog*, and about the transformative potential of these technologies more broadly. She said, "This is a quote I really love, 'I don't usually go to museums because they aren't designed for me. If a tool like this was available I would start to go to museums by myself.' I'm excited to see how indoor technologies might open museum doors for people with disabilities who have historically been ignored by these kinds of spaces."

Case History 5: Leilah Lyons, New York Hall of Science

Leilah Lyons prefaced her remarks by pointing out the common misunderstanding that "tracking is tracking is tracking." In fact, different tracking technologies have different strengths and limitations. Lyons emphasized the importance of selecting the tracking technology based on the goals, purposes, and constraints, such as the size of the space, presence of material barriers, and type and level of spatial accuracy that is needed. Whether the technology will be primarily used for evaluation purposes or for interaction design can also be a factor. The technical considerations include sampling frequency, identity fidelity, and temporal accuracy. Other tradeoff issues in selecting the right technology include the intrusiveness of the tracking experience for the visitor, equipment loss, and vulnerability to damage.

Lyons reported on two projects that supported multiuser interactive experiences with indoor tracking technology. Both required high sampling rates, high spatial accuracy, and high identity accuracy. CoCensus was a data visualization experience that invited visitors to interact with U.S. Census data. "We were trying to make an exhibit that had the look and feel of something like Hans Rosling's Gapminder software. Gapminder's user interface lets you manipulate how data is being visualized in real time. We wanted people to do that with their bodies and have them embody different aspects of the U.S. Census data. As you moved closer to the display your data would become more prominent."

The CoCensus project began in 2009, when there were no plug-and-play technologies for tracking people in space, so Lyons and her colleagues started by experimenting with RFID tags. Initially they used passive RFID tags, which had poor signal strength and, "ended up being a not very productive way to drive an interactive experience." They tried again with active RFID tags (battery powered), which had good signal strength within eight feet. The active RFID tags functioned well, improving identity and location information, but latency issues (delays in location calculation) kept it from being a smooth real-time experience.

When Kinect (Microsoft gaming motion sensing interface platform) became available, the project team tried it to solve the problem of latency in tracking location and identifying unique users. Unfortunately the unique user identity still needed to be provided by active RFID. Lyons and her colleagues ended up building their own system that combined active RFID with a Kinect system. Lyons remarked that developing this customized system required "a lot of tuning. . . . It was good enough to get a bunch of research papers out, but ultimately not the greatest approach in the world." The experience illustrated the tradeoffs between reliable location and reliable identification, and the challenges of achieving both within the constraints of museum environments.

"This is one of the things that we constantly confront in the Human Computer Interaction (HCI) community, how can you have both very reliable location spatial sensing and reliable identification. The answer is throwing multiple sensors at it but that's not always the easiest thing to do in a museum exhibit space."

Her second tracking project began in 2013 at the New York Hall of Science with the Connected Worlds exhibit. The goal was to track visitors as they experienced a complex, immersive simulation that required them to collaboratively make decisions on water allocation across different biomes in an ecosystem. Their challenge was to track and support 30 users at a time. Using Kinect and infrared cameras did not provide reliable identification fidelity of individuals. They then tried a computer vision system and had visitors wear colored vests with binary number patterns on the vest back. The video projectors in the installation necessitated low light levels, however the dim light was problematic for the computer's vision system to identify vest colors. An additional challenge was installing cameras in the gallery space which is a protected historic site and structure.

As Lyons explained, "this is one of those projects where we had grand visions" but due to all the unanticipated technical challenges and related expenses, they ran out of money before achieving their goals.

Case History 6: Dia Felix, SFMOMA

In 2016, the San Francisco Museum of Modern Art (SFMOMA) launched a visitor app that incorporated a unique location-aware functionality. The location-aware app resulted from a two-year collaboration between museum staff with the San Francisco–based startup company Detour.

The iPhone-based app offered both a selection of a la carte interpretive audio for individual artworks and 10 location-aware guided tours. Each tour had turn-by-turn navigation guidance. There was a group audio sync option that allowed visitors to synchronize their audio or tour with their companions to experience content together. App users could also save a record of their visit as an online timeline, including artworks they saw and any photos they took.

The guided tours were narrated by a variety of engaging hosts, many were not "the usual museum guide suspects . . .. these were unexpected, unorthodox voices, some serious and others respectfully irreverent." One tour featured Martin Starr and Kumail Nanjiani of the TV show *Silicon Valley,* talking about modernist artworks by artists such as Marcel Duchamp and Kiki Smith. Another tour was led by the granddaughter of a woman whose family was trapped in East Germany after the wall was built and featured post-war Germany as depicted in art.

The SFMOMA app reached 6.8% of the museum's visitors. Felix explained this a "comparatively high take-up rate for a permanent collection guide at a modern and contemporary art museum, where usage rates are historically between 2 and 5%." More visitors chose to download and use the app on their own iPhone rather than renting a preloaded iPhone from the museum. In terms of visitor satisfaction, while "a vocal minority could not get past the technical barriers . . . many other visitors told us that the app felt more personal, welcoming, and responsive to their needs compared to other apps."

Typically tourists are the primary audiences for museum mobile guides but at SFMOMA, nearly 60% of the app users were locals. Felix said that these high levels of use supports the museum's strategic objective of growing their local audiences and finding an opportunity to encourage repeat visitation and fuel positive word of mouth for the app and the museum.

Post-Conference Case History 7: Bernd Holtwick, DASA Museum, Dortmund, Germany

DASA is Germany's museum about the world of work. It used to be called by the rather awkward name of the "German Exhibition of Occupational Safety and Health" (DASA is an acronym of the German name of the museum). DASA's permanent exhibition is 13,000 square meters (140,000 sf) and consists of 12 exhibitions that focus on different industrial sectors and workplaces. The large size is not the only and maybe not the greatest problem for visitors. The building itself and the exhibition's scenography make orientation a real challenge. Where am I? Where is the next highlight exhibit? How can I get to the museum café?

Questions like these were familiar to DASA's staff. At the same time we were looking to update and replace our audio guide system, which our visitors tended to ignore. So, in 2011 we were ready to start with a totally new system. We had heard about indoor navigation, but it took us about two years of market research to work out a realistic scenario for a navigation system based on Wi-Fi.

Based on the analysis of strengths and weaknesses of our existing audio guide, we defined the requirements of our new multimedia guide. It should be (1) easy to operate and (2) reliable. It should (3) support individual discovery of DASA permanent exhibition by selecting the information according to the user's position, and (4) by providing means to facilitate orientation.
(5) It should be sustainable, regarding data privacy and

upgrading software and platform. It should (6) have flexibility for new content and different media channels while hosting the important (200) audio files of our original system. And it should be (7) attractive for our visitors and accessible to all, even those without a mobile phone.

The list turned out to be a good starting point for the project. But we needed help to take the next important step: The call for tenders (RFP's). We hired an IT consultant to support us and together we worked out a list of 44 criteria and defined their specific weighting factors. On that basis, we tried to gather detailed information from system providers about their content management system, the hardware for the visitors, i.e., that is, mobile phones and tablets, the design and graphics of maps, the software (including navigation system and statistical tools) and the necessary equipment such as charging points. Of course, a decisive criterion was the price. Each bidder was obligated to prove that their system was already working successfully in a museum or comparable institution.

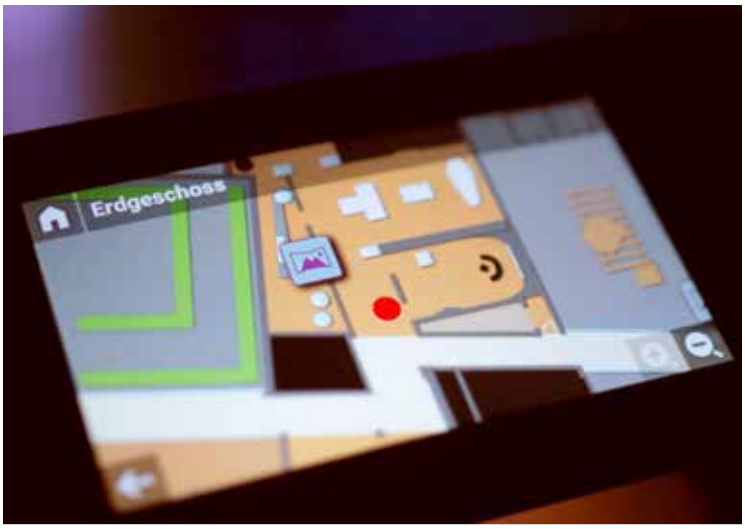
We finally (in spring 2014) chose the North German company Informationsgesellschaft Bremen which based their navigation system on Awiloc. Work started in autumn 2014 and took about one year. So in January 2016 we proudly presented our multimedia guide to the public.

We had 100 Android based mobile phones and 10 tablets to lend. To enjoy the films and audio files, multimedia guide users also need to borrow earphones. Visitors could choose between German, English, and French languages. They may stroll around in DASA's permanent exhibition or they can choose only to view points of special interest. In both cases, users find a red dot on the map indicating their actual position. If visitors want more information about a special part of the permanent exhibition they have to press a symbol that appears near the red dot. A 360º panorama photo appears and offers further symbols for pictures, films, and audio files.

In summer 2018 we added audio tracks (simple language descriptions) and films with sign language about the exhibition's highlights. The multimedia guide and choice of other languages has become the key tool to facilitate the visit for those who cannot read the German texts in the permanent exhibition.

But some problems occurred.

Users need to understand how to use a fixed map, which is not as common a skill as we expected. The Awiloc system does not automatically orient the map north, and it cannot detect the visitors' walking direction. The map on the display does not rotate or reorient when the user turns. This is unlike the intuitive map reorientation in a car navigation system, that turns in the direction in which the car is moving, or that maintains orientation northward and turns the car symbol around. This presents a challenge for those accustomed to a dynamic digital map that reorients as the device is turned or as they move.



We debated extensively the pros and cons of lending devices to the visitors and finally decided to do so. We still consider this the right decision, but we knew about potential problems and faced a few of them. Although we properly chose the smartphones and did not simply buy cheap ones, the batteries had to be replaced after nearly two years of operation, just a few months before the warranty period was over. We had strictly obeyed the producer's operation instructions, so this expense was covered under warranty.

We were conscious that updating the content (and especially the maps) of our app, would be a burden, so we did not even consider using the app for temporary exhibitions. But changes in the permanent exhibition (we rebuild one of the twelve parts every year) means more work and takes more time than expected.

The CEO of our provider, the Informationsgesellschaft Bremen, remarked in one of the last meetings before the navigation system was launched, to "Keep an eye on the cashiers. They determine the system's success." The cashiers were supposed to hand out the devices to the

visitors. So we nodded, although we did not really understand, but at least we kept it in mind.

It turned out that the sentence was quite an understatement, and that it pointed to a problem that we are still struggling with. The fact is: The cashiers try to minimize the effort for lending the devices to the visitors (because together with the necessary earphones, it takes too much time, especially when there are lines of visitors waiting). And that means that they tend to hand out the smartphones only if the visitors specifically ask for it. User numbers rise, as long as somebody from DASA management watches the cashiers' activities and user numbers go down immediately afterward. As recompense, the management is provided with a colorful variety of explanations for the visitors' alleged lack of interest. So this is still a challenge to be addressed.

Our navigation app is not a simple solution for all our problems, but is in fact an ongoing project, that will require ongoing efforts to keep going. On the other hand, it still seems to be worth all the money and work, because some benefits would be not be gained otherwise.

- The navigation app is attractive and helpful for many visitors, especially families and children.
- The app offers statistics that help us understand our visitors' interests and behavior better. The most important feature is a kind of heat map of our permanent exhibition that shows the hot spots, where visitors stay for the longest time.
- The navigation app is for us the easiest, cheapest, and "text-space saving" tool to provide the necessary information in foreign languages.
- The app supports our inclusion strategy, because we can easily add films with sign language for deaf people and spoken texts in simple language for those with cognitive impairments or with limited capabilities in German.

Post-Conference Case History 8: Sean Pathasema and James Williams, Birmingham Museum of Art, Birmingham, Alabama

Setting the Stage

Online collection databases, audio guides, digital publications. These systems can be expensive, are often complicated, and many are proprietary systems. Visitors have come to expect more from cultural institutions, while at the same time, visitors may have less context for their visits than ever before. The Birmingham Museum of Art (BMA) needed to bridge that gap and bring our scholarship forward via new methods to encourage greater engagement. BMA needed systems that would be easy to adapt for a variety of collections and exhibitions and available on a wide variety of technology platforms.

Digital interpretation should be available to those who want it and unobtrusive to those who don't. Content needs to be accessible. That is to say, written, or presented in a way that is relatable and readable to as large an audience as possible. Not dumbing down the content, but presenting it in a way the broadest possible audience can understand it.

BMA is also moving forward with an Open Access initiative. We wanted to align our digital interpretation initiatives with this desire to provide open access. This would also facilitate accessibility to as many visitors, virtual and in person, as possible.

Let's Make an App 1.0 (2012)

In 2012 the BMA launched an exhibition of "lover's eye" miniatures. These antique paintings of eyes were very small, very detailed, and behind glass—a less than optimal viewing experience. We felt a means of looking at the existing high-resolution photography, alternate views, and even videos of objects being manipulated would be ideal.

The museum developed an iOS app, the *Look of Love*, formatted for iPads using jQuery mobile, Phonegap, and the tourML XML format from IMA Labs (Indianapolis Museum of Art). After attempting to set this up using IMA's TAP (mobile tour software tools), we built our own front end for the existing XML format. The museum provided iPads to all visitors with the app preloaded with

all content. This avoided relying on Wi-Fi, and did not require visitors to download the app at home or provide their own device.

Let's Make an App 2.0 (2012–2015)

BAM's second attempt was *artsBMA*. This was a standalone web application developed as a general museum app, covering temporary exhibitions and the permanent collection. Visitor information, maps, and an events calendar were also included.

The initial goal was the development of an iOS native app, but that was beyond the budget. Though the BMA website was Joomla based (an open source content management system) we made the strategic decision to build *artsBMA* as a standalone app on WordPress 3.5. It was designed to display properly on iPads and iPhones. Visitors could use their own devices, and BMA would have iPads to check out. Whereas the *Look of Love* app had a menu-based interface that users navigated (much like using a printed exhibition catalog within the space), we shifted to a numerical input for *artsBMA.* A three-digit code was included on object labels and the user entered that number into a search field. A menu selection interface was also available.

Let's Make an App 1.0 and 2.0 Issues

Supporting additional systems was a struggle. With *Look of Love* we committed to iOS and we were unable to keep up with iOS and Apple hardware updates. It also meant leaving more and more users out by not supporting the Android operating system. BMA didn't have the resources to develop for both iOS and Android.

In contrast, with *artsBMA,* WordPress security updates happened quickly. Switching from iOS to a web application got us around the need to develop for multiple platforms, but it introduced the confusion of nomenclature. *artsBMA* was referred to as an app, which brought questions, such as "how do I find it in the iTunes store?" We struggled for years to differentiate between a web app and a native app, though it isn't clear how widespread the confusion was.

Native mobile apps can utilize device hardware such as the camera, speaker, and microphone that the web browser is often restricted from using—at least on iOS. This forced us to keep things simple in the web-based *artsBMA* and prevented us from chasing emerging technologies that we didn't have the resources to gamble on. At the time, we fielded a number of sales calls regarding beacons and location-aware technologies. But the costs were greater than we could risk, and a simple number search and entry is a familiar task for many museum visitors from using hardware-based audio guides.

For App 1.0, content was added by directly editing an XML file in tourML. Likewise, entering content for a responsive web app in 2013 was a tedious system of manually resizing, uploading, and referencing media files for different screens (even while limiting ourselves to iPhones and iPads, those specs changed over time).

Moving Forward

The BMA went through a lot of trial and error and mispent effort getting to this point. *Look of Love* was the first real foray into digital interpretation, and was only possible with generous support from the exhibition donors. This was also the dawn of apps for museums. It felt like all the major institutions were launching apps. Directors and curators were getting iPhones and they wanted apps. *artsBMA* was a stopgap solution. It included some limited visitor information and content from the main website, but this was difficult to keep up to date, as any content change on the main site's Joomla (an open source content management system) had to be duplicated to the app's WordPress CMS. Likewise, on the conceptual front we struggled to identify and provide useful interpretive content, often just repeating printed in-gallery didactic material. It was a mess.

Considering the issues we faced in 1.0 and 2.0, we decided to continue development of a web application. However, we decided to bring the app within our main website. Working with local WordPress development talent, we had already made the decision to switch the main BMA website from Joomla to WordPress and we had a service agreement with our WordPress developer to manage hosting. This meant we could bypass the need for hosting and technical support for the app since it would just be content on the BMA's main site. The BMA would continue to offer iPads for visitors who wanted them, but we would begin to encourage visitors to use their own devices in earnest. We would also set the stage with more robust content guidelines.

Let's Make an App 3.0 *Smartguide*: Third Space

By 2017 the beta version of the *Smartguide* was ready for implementation and was launched in conjunction with *Third Space*, a contemporary exhibition that would be up for two years. With artworks that many on staff deemed potentially difficult for casual visitors, or those not familiar with contemporary art, a primary function of the *Smartguide* would be to bring community voices into the gallery. Short audio clips were used to contextualize pieces with voices not typically heard in the BMA—community leaders, local celebrities, patrons, and even children. This created a much stronger conceptual framework for the initial launch of the *Smartguide,* receiving very positive feedback from our Board of Trustees, staff, and visitors.

Details

The beta version of the *Smartguide* launched as a web application, installed as part of the main BMA website, alleviating many of our previous app support issues. When switching from Joomla to WordPress, the BMA site was redesigned to be responsive. Thus, the *Smartguide* would now work on all devices, becoming more accessible to anyone who wanted to use their own device in the galleries.

On the technical side, *Smartguide* was designed with HTML5 and the React JavaScript library. Dependencies are a WordPress installation and the Advanced Custom Fields Pro plugin. Typekit (now Adobe Fonts) is optional. As such, *Smartguide* is accessible on most current mobile devices and desktop browsers.

Accessibility

As a municipal institution we feel an obligation to make our collection and interpretation as accessible to the public as possible. Versions 1.0 and 2.0 didn't uphold that mandate very effectively. We refocused with 3.0 to correct course and improve accessibility. Significant funding opportunities become available when accessibility to underserved visitors is incorporated in app design.

On a longer timescale, we hope to tie the *Smartguide* more deeply into the collection database section of the BMA website. The collection database is part of our larger commitment to open access. Avoiding the trap of our content being locked into proprietary systems has been another driving factor of choosing to continue developing the visitor guide as a web app.

We also wanted to bypass the iOS vs. Android debate. iOS devices have traditionally been considered more of a luxury device. We've found many schools have opted for Android tablets or Chromebooks for classroom use. Also, with Android having a larger user base, we don't want to limit our reach just because we're more familiar with iOS devices. And lastly, we wanted to maintain low friction for usage of the *Smartguide.* No downloads, and no accounts to create. Keeping the system mobile friendly and eliminating as much friction as possible is an important contributor to accessibility.

Beyond 3.0: Broader Implementation

By the end of 2018, roughly two years since the implementation began with *Third Space*, the Smartguide content had expanded to nearly 200 stops incorporating permanent galleries and temporary exhibitions. Content was being delivered in short digestible chunks, featuring audio, video, additional images, and more.

Beginning with *Third Space,* the BMA's content philosophy shifted, contributing to the initial success and buy-in from BMA staff. Content became king and "users" included visitors as well as content creators. This is reflected in the nature of the WordPress plugin, which is much easier to navigate and use from a content creation perspective. It also encourages modular thinking, aiding the effort to keep content short and digestible from a visitor perspective.

Expanding the Platform

In the lead up to the reinstallation of a permanent gallery space, we began to brainstorm how we could bring interactive content into the gallery. A highlight of the gallery is a *vanitas* (a type of still life painting that represents the transience of life), loaded with symbols and allegorical content. Working with a developer we added the ability to create an interactive image component to the *Smartguide* in which the visitor is presented with the image and allowed to click on "hotspots" that bring up content related to that detail of the painting. This feature was implemented on an iPad in a standing kiosk in front of the painting. Because the *Smartguide* was designed to be responsive, this required very little additional work, and it added an interactive feature that can work on smartphones as well. This has become a hallmark

of the system—incremental feature addition and cross-platform compatibility. We've now implemented *Smartguide* in multiple kiosks and added a large screen layout that has been implemented on 42 inch touch-screens in the galleries.

Fun and Experiments

The simplicity of the system has allowed the BMA to create off-the-cuff, quick turnaround projects. For a casual after-hours event with a summer camp theme, our Assistant Curator of Education "hijacked" existing stops to create a scavenger hunt to find Sasquatch. After finding Harry (of *Harry and the Hendersons*), participants could return to camp and receive a "merit badge" button. There were five stops, most with quickly shot smartphone video to tease the next clue. From idea to implementation was roughly one day, and it only took a few hours to build out the content. She shot a few videos with her phone, loaded them into the stops, and added a bit of copy to suggest Sasquatch's path between objects.

After the success of that initial scavenger hunt, it has become a highlight of the monthly program. Each time, a new hunt based on the theme of the evening can be developed quickly and implemented with minimal staff time.

Another experiment allowed us to work out a case study for replicability of the *Smartguide.* The University of Alabama at Birmingham's visual art gallery, AEIVA, exhibited the work of an artist also featured in the BMA's *Third Space* exhibition. With a logical connection between the two institutions, we approached them to test using *Smartguide* outside the BMA to establish how an implementation might work, and test for bugs or kinks in the system. The result was an extensive *Smartguide* introduction to the artist featuring behind the scenes photos of the installation, videos, and an interview with the artist.

All of the A/V content was collected in one visit, consisting of just a few hours. The buildout of the stop took about a day. An organization like AEIVA could implement *Smartguide* outside of the larger institution for the cost of a WordPress installation and hosting. This creates a relatively cheap solution, particularly if the external staff member has the technical skills to set up WordPress.

Extra Credit: Development Roadmap

The current WordPress plugin and interpretive system is Phase One of a broader digital plan. Phase Two is an additional plugin that sets up the BMA's collection database on our website. We currently import object data and media to WordPress from Piction, which pulls that object metadata from the collection management system. Currently this is live, but the systems operate independently.

We are in the process of building a direct link between the *Smartguide* content and the collection database. This would add the robust *Smartguide* content to the object pages in the collection database, making the content more discoverable by visitors to the BMA website and expanding accessibility to the interpretive content. Once this system is working, we hope to make the collections plugin available along with the *Smartguide* (which is already available on GitHub). Though the BMA's implementation uses Piction, it will not be required. We plan to support manual entry of *Smartguide* content, as well as XML or CSV imports.

This will lay the groundwork for deeper digital and scholarly publications. We are trying to absorb lessons from the Online Scholarly Catalogue Initiative as we move forward, working toward permanent links and citations. If we achieve this, it will allow dives as shallow or deep as a visitor (in gallery or online) wants with interpretive content from the *Smartguide* for quick snacks and longer form scholarly content for bigger appetites.

Collaborate

Smartguide can serve the museum community by lowering the technical investment required to implement mobile content in galleries and can be improved as a collaborative effort as more museums join in conversation and experimentation. We welcome your comments, questions, and feedback.

Much of this case history was adapted from the "Cheap and Replicable: Building a New System for Digital Engagement in Small to Mid-Size Museums" presentation at MCN 2017. That slide deck and additional information related to the *Smartguide* project are available online.

Reliable Low-Cost Timing and Tracking Visitor Studies

Dr. Theano Moussouri, University College London

Theano Moussouri stated at the outset that "location-tracking visitors outdoors has been around for a while" and that these tracking systems can be used for a variety of goals, such as enhanced interpretation, but that her focus is collecting visitor path data for visitor research.

Until recently it has been difficult to track people indoors. GPS doesn't work in indoor spaces so different approaches are needed. Often the strategy is wireless sensing such as Wi-Fi or Bluetooth, but in practice, these systems interact with materials in the building, metal structures, and glass. With reflections and distortions from the building and signal absorption when visitors crowd the gallery spaces, wireless signals are unreliable for museums. Carefully tuned wireless systems usually involve proprietary technology, but these systems are cost prohibitive for most museums and as a rule of thumb, "you need three PhDs to run them."

Recently, a new generation of indoor systems has emerged that are reliable, affordable, and usable for visitor tracking. Rather than depending on one sensor modality, these new systems combine different location-sensing signals and achieve greater accuracy. Combined system techniques could include Wi-Fi for triangulation, proximity sensing using Bluetooth, accelerometers for step counting, direction identification with a compass, floor identification using altimeters, and geofencing constraints on position by using floor plans.

A new ingredient in these combined sensing systems is the geomagnetic fingerprint. Each building has a unique geomagnetic fingerprint because the metal in its structure interacts with Earth's magnetic field. Metal gives detail to a fingerprint that enhances, rather than interferes with, location tracking. Geomagnetic fingerprinting is accurate up to 1 meter (3 feet) and accuracy is not reduced by crowds of visitors. Moussouri's study used Indoor Atlas, developed in Finland. It was available at no cost via a developer account which allows limited use for experimentation and research.

To use geomagnetic fingerprinting you must carry out a site survey to measure magnetic variations and construct the map. Next is ground truth testing to verify the accuracy of your map. Once the map is developed, it must be linked to a location-tracking app (Indoor Atlas includes map creation and location-tracking tools).

Moussouri and her colleagues conducted a test at the Science Museum, London. The research took place in July 2018 in a large, third floor gallery with lots of metal structure and components. Two researchers loaned out and collected back six Android phones with the Indoor Atlas tracking software installed and carried out 15 hours of data collection. During this time, approximately 100 visitors were tracked resulting in 96 useable track records.

Some visitors only used the exhibits on the periphery while others only used the displays in the center of the gallery. There was a subset of visitors that went in and out in less than a few seconds and others who engaged deeply with only a few exhibits in the large gallery. In addition to creating maps that show specific visitor paths, the data can be grouped to start to understand these different patterns of visitor use.

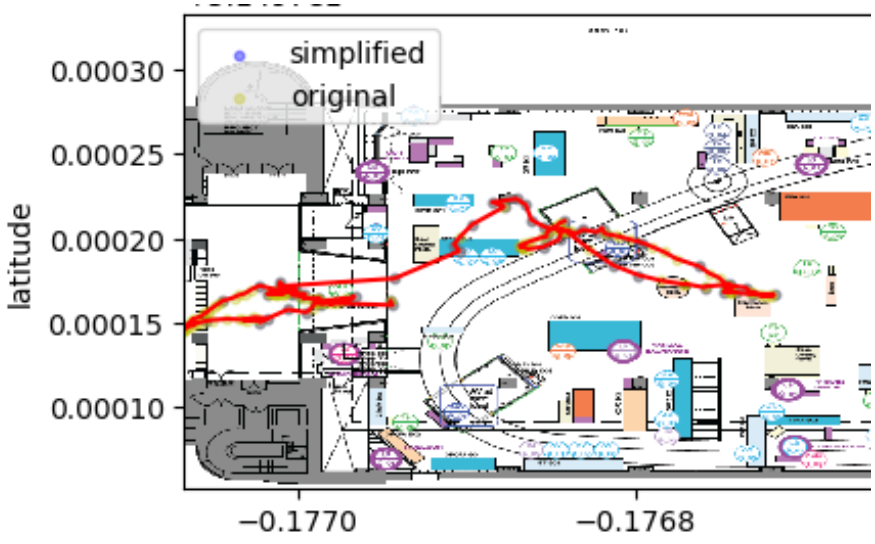
This tracking study was very different than the normal tracking experience because the researcher is not directly observing behavior such as conversations within a visitor group. The data produced is just the details of

the path taken and the time spent as the visitors stopped or lingered in certain areas.

Summarizing the lessons learned, Moussouri concluded that the Indoor Atlas app use of geomagnetic fingerprinting is a reliable technology that enables the automated collection of accurate and precise tracking and timing data with minimal cost and effort compared to previous visitor tracking techniques. The next step for Moussouri and her team is to develop an open-source toolkit for data analysis that would be tailored to museum use.

Moussouri shared more details about the project and process in response to questions after her talk.

- For 15 hours and 100 visitors of data collection it took 1.5 hours to create the heat map with that data.
- Indoor Atlas can work in combined indoor-outdoor spaces and will record a continuous track from indoor to outdoor and back again.
- If you add large metal objects to the gallery, move walls, or add something in a floor above or below, you need to update the map. The program corrects what is already there, so it doesn't take as long to generate the new map.
- This study used Android phones, but the system will also work with iOS phones.



Bits and Bytes: Indoor Location-Aware Mobile Research

Niranjini Rajagopal, Carnegie Mellon University

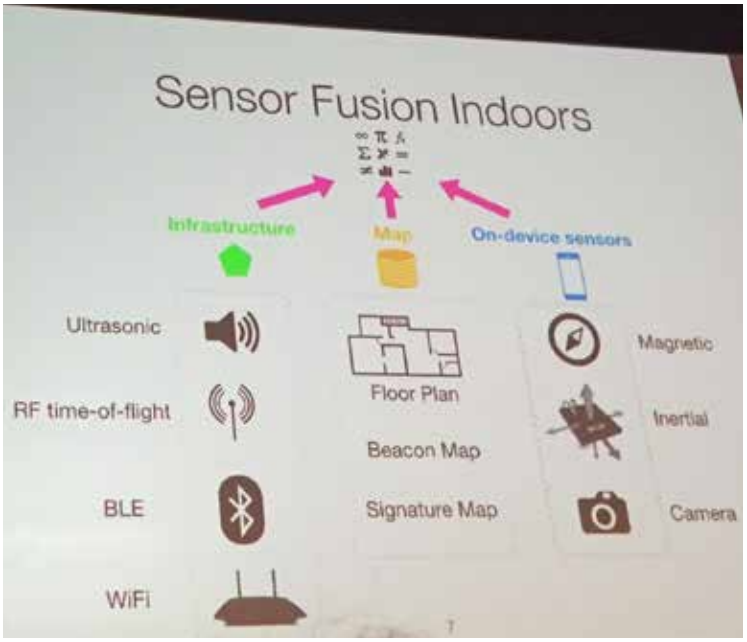
Niranjini Rajagopal first described the general indoor localization "ideal" requirements (not specific to the museum context). "We want localization to be free. We don't want infrastructure. A need for remapping or calibration is not desirable. And we want accuracy." She went on to explain that "these requirements come from the way we are used to using GPS outdoors" and our familiarity with the Blue Dot as our exact location.

Even though we perceive GPS as free, the reality is that GPS localization comes from very expensive government investment in infrastructure and R&D. The data must be fused or combined with sensors on your smartphone including accelerometers, gyroscope, magnetometer/compass, and map information to filter and refine the location estimate and increase accuracy.

One approach to indoor localization is to fuse data from an infrastructure system with the different sensors on the phone and map information. There are many different types of infrastructure systems used for indoor location. Some examples are acoustic (ultrasonic), RF beacons, Bluetooth Low Energy (BTLE), and Wi-Fi. Your phone already has magnetic field sensors, inertial sensors (accelerometer and gyroscope) and a camera. Map information can include floor plans, 3-D geometry, beacon locations, Wi-Fi radio locations, and magnetic fingerprints of floor space.

The international Microsoft Indoor Localization Competition has been held yearly since 2014. Rajagopal has attended and competed twice in this competition that presents the newest technology emerging from academic and industry research. The contest gives each team one day to set up their systems in the test space and develop their maps. The specific location points for the test are not revealed until after the setup on the test day. She candidly shared "you see that everyone is facing the same kinds of problems. It's really messy and ugly, despite the systems looking nice in all the research papers. It's very painful to do the deployment." The competition has two award categories—infrastructure-free and infrastructure-based systems. Because Wi-Fi systems have become ubiquitous, they are now usually considered infrastructure-free. However, beacons, acoustic stations, or other installed systems would be considered infrastructure-based systems.

In 2015, the infrastructure-free systems that did well in the competition used Wi-Fi and the floor plan information (limiting positions to the accessible indoor space), combined with inertial sensors and magnetic field sensors. For Wi-Fi and Bluetooth signals the phone/tracking device uses the signal strength as an indication for distance or location. The inference for using signal strength is that a stronger signal means you are closer and a weaker signal means you are further away. Unfortunately the accuracy varies because the signal strength does not vary proportionately to distance. The Wi-Fi or Bluetooth signal strength that is measured varies in an unpredictable manner based on the paths traveled by the signal inside the building.



In her work with BTLE the same signal strength measure could mean you are anywhere from 2–15 meters (6–50 feet) from the beacon. Only if you are very close to the BTLE beacon does the signal strength vary proportionately and predictably with distance. Accuracy is limited for approaches that are based on signal strength because it is difficult to model the path that the signal takes indoors. Though it might be tempting to expect a nice model where signal strength is proportional to distance, the reality is very different.

With geomagnetic field sensing, the magnetic-strength pattern acts as a signature that can be used to identify location, although it requires the user to walk around and collect measurements to uniquely identify a location. When changes are made, such as installing or moving large metal objects or structures, the metal can affect signal strength and your measurements for geomagnetic tracking and Wi-Fi or Bluetooth. Even though this can cause changes in the specific pattern of the magnetic fingerprint, in her experimentation magnetic fingerprints have been more stable than beacon signal strength. These changes in the indoor space require recalibration of the system.

There is also variation between phones even when they are the same model and manufacturer because each device is trying to optimize and receive the highest power signal. Variation in hardware antenna and amplifiers among different phone models and brands contributes to the challenge of developing reliable indoor location systems. Rajagopal explained that some systems only work with iOS devices because Apple has tight control over their hardware. The Android phones can come from many different manufacturers (Motorola, Sony, Samsung, etc.) and are in many different models so there is much more variation of hardware components.

Summarizing the infrastructure-free systems, Rajagopal said, “We all have Wi-Fi and BTLE on the phone, they are free, there’s not much maintenance, but there’s some need for recalibration and the accuracy depends on the application,” and accuracy ranges from 1–5 meters (3–16 feet).

The 2015 competition winners for infrastructure-based systems included Rajagopal’s team, which won first place with an ultrasonic beacon system that had a 31-centimeter (12-inch) accuracy. The second- and third-place teams used ultrawide band (UWB) beacon technology. Rajagopal explained, “the underlying principle is similar for all of these.” Each beacon sends its signal to the phone and estimates the distance between the phone and the beacon based on the time it takes the signal to travel. Multiple beacons make it possible to calculate the phone’s position by trilateration. There must be coordination between multiple beacons to determine the time they will send their signal. This “problem of multiple access” is critical to whether systems can scale up and support multiple users and their phones. Relying on these estimates of distance from “time of flight” rather than signal strength gives beacon-based systems an advantage for accurate positioning. She also noted that with beacon-based systems, the startup time to the first location calculation is nearly instant if enough beacons are nearby.

Because localization is becoming more important, standards are emerging for future consumer smartphones and tablets. She mentioned the newest standards of 802.11mc for Wi-Fi and Bluetooth 5 for BLE. While UWB beacon systems are great for localization, they are not yet compatible with phone sensors so UWB sensing and standards may be added in the future.

As in GPS, all these calculations depend on precise time measurements. GPS satellites have extremely precise clocks compared to what is on our phones. While phones are not able to synchronize their time with the beacons, phones can measure the “time difference of arrival” and carry out multilateration measures.

Rajagopal then described two different types of beacons developed in her research group and how they work. The ultrasonic beacons they designed operate just above human hearing frequency (tops out at 20kHz) but the phones can hear up to 22kHz. UWB beacons are much easier to work with now that they are available as a commercial hardware package. UWB has a very high bandwidth, which enables more precise measurements and better localization, however current consumer phones are not designed to detect UWB frequencies. Rajagopal commented, "In the future if this becomes part of the infrastructure there's a lot more than just localization that needs to be addressed. Localization signals and communication signals have to coexist; different [technology] standards organizations have to come together to decide how this would happen. But it is possible."

At the 2018 Microsoft Indoor Location Competition, camera-based systems were becoming more popular. Rajagopal's team won first place in the infrastructure based competition using UWB beacons, a camera, and inertial sensing (visual-inertial fusion). They were able to do this by using an Augmented Reality API (application program interface); both Google and Apple with ARCore and ARKit respectively, released these AR API tools for developers in 2017. With the AR tools, smartphones or tablets and their cameras and inertial sensors can be used to select and "recognize" unique features of the indoor environment for landmarks and this offers very precise tracking.

Rajagopal showed a video of proof of concept localization and navigation project, an AR cartoon robot you could view on your phone or iPad screen that could guide you through the office area at the university. The AR robot would stop walking forward if you didn't follow closely and it looks back to encourage you to follow. The system was based on precise estimation of the position of you and your phone and an understanding of a map of the 3-D office space.

She highlighted three current challenges of localization:

1. While mapping beacons precisely is difficult, another strategy uses algorithms and robotics and simultaneous localization and mapping (SLAM). A person walking around the space with a device gradually builds up a map of the beacon locations by incremental estimates. This process can reach accuracies of 30 centimeters (1 foot).
2. The representation of floor plans is a complex problem. How much detail should be included and how can you verify the accuracy of your floor plan?
3. Many location systems can be hacked or spoofed. For example, you can impersonate someone else on the system, which could be a security concern in some buildings.

Looking ahead, Rajagopal described an emerging third paradigm in which the device is not actively localizing, but the infrastructure knows where the device is. She concluded, "the vision of my work is to . . . bring location awareness indoors in a seamless manner that can make indoor spaces efficient, intelligent, and also secure."

Sharing Protocols, Collaboration Advice, and Open Source Potential, Panel Session

Kate Haley Goldman, Halsey Burgund, Dave Patten, and Eric Siegel

The potential gains and challenges of collaboration and open sourcing were discussed by four speakers who shared their experiences and advice with others.

Kate Haley Goldman, Haley Goldman Consulting

Reflecting on her experiences as an evaluator for different projects over the years, Kate Haley Goldman shared that an NSF Program Officer had remarked that evaluators like her bring ideas and insights from each project to the next one and are thus able to both share and get a wider view of work in the field.

From her experiences in the field, she made these recommendations:

- Ask what problem you are trying to solve at your institution with technology. There may be different ways to solve the problem and technology is not always the best solution.
- Start with your goals. Those goals can then shape discussions about different systems and their capabilities and your decisions.
- Beware of overcommitting because tech firms may disappear and grad students move on.

Open source can be more complex than you think. It's also not necessarily usable by the smaller and medium-sized institutions that don't have staff expertise in house to set up and maintain systems.

Haley Goldman concluded by reflecting on the prevalence of nondisclosure agreements (NDAs) for location-aware technology projects. While the original rationale for NDAs was that a breakthrough was just about to happen, "We've been hearing that for at least 3 or 4 years. . . This conference is a sign that we don't need to have that level of secrecy." Haley Goldman suggested, "we have to stop thinking we're going to be the one institution that solves this and rather, think about how as a field are we going to solve this for different needs."

Working Together to Work Together: Halsey Burgund, Halsey Solutions

Halsey Burgund declared himself the "open source proponent" and spoke about Roundware, an open-source audio AR platform he has developed over the years. He originally developed the software for his sound artwork and it evolved into a co-creation platform as he used it for projects with cultural and educational institutions.

Roundware has two basic user modes for a defined geographical space: SPEAK allows people to make recordings on their phone and upload those recordings to share (the recording is tagged to their location in the space). LISTEN allows people in the space to hear a mix of audio from a dynamic location-based ambient audio soundscape and vocal recordings made by others in the same location.

"The Scapes project was at the DeCordova Sculpture Park (2010). For that project I was able to integrate the location awareness into Roundware. . . . With the 3GS iPhone (2009) we had GPS . . .that allowed me to add location-based components to Roundware."

Burgund noted that because Roundware is open-source this has led to further development of the platform and its use for different purposes. The program has been used for art education, an alternative to an audio tour, public theater, indoor location-aware prototyping, and other experimental projects. In his view, each successive project benefits all current and future projects, and being open source has led to a continuous string of improvements.

He listed the pros of open source: "the rising tide raises all boats and you're not hostage to proprietary systems. I have heard from many museums that proprietary systems are frustrating when the only person who knows how things work is not available or leaves the company and you don't have access to the code." And he noted the cons: "It is often slow progress, not always commercial quality" and given the scarcity of funding for open source, "open-source projects can go away, they can wither on the vine very easily" without support.

Mobile Phones and Museums: Dave Patten, Science Museum, London

Dave Patten discussed research that the Science Museum commissioned on the use of mobile phones in and out of museums. Patten explained, "we've been interested in mobile phones for a long time and have done lots of experiments with mobile phones. When apps became a thing our board got very excited and so we made lots of apps because we thought we would make lots of money and we didn't make lots of money for all sorts of reasons. We commissioned Frankly, Green, and Webb to look at how people use mobile phones in museums, what the barriers to use are, the things they might want to do in museums, and also what they're doing outside of museums that we need to take note of."

The first study was in 2013 and they reran it in 2016. The goal was to better understand how the museum might benefit from visitors' use of mobile phones. About 97% of the museum's visitors have a smart phone, which is about 20–25% higher than the overall U.K. population. In 2013, iPhone users outnumbered Android users, but the majority shifted to Android by 2016.

In both 2013 and 2016, the three most common uses of mobile devices in the museum were the same.

1. Using the smartphone camera: taking photos of the objects, friends, and family
2. Finding basic information: visit-related information
3. Sharing their experience: social media or sending photos

As Patten paraphrased the overall message of the findings, "don't expect us to learn new behaviors. . . . We're prepared to do the things we do everywhere else. So build applications around the things that we do in everyday life. Don't expect us to do something special just because we come to the museum."

The perceived barriers to using smartphones in the museum were found to be:

Phone battery life

Availability of free Wi-Fi

Cost of data

Lack of headphones

Privacy of personal data and security of the Wi-Fi system

A museum app taking up precious space in phone memory

The Wi-Fi issue has been an ongoing challenge. Patten explained that the museum has a great free Wi-Fi system with good signal strength and there are reminders throughout the museum about the Wi-Fi. From 2013 to 2016, there was only a 5% increase in the number of people who are aware of the free Wi-Fi and "people still don't recognize it as a utility" in the museum. The museum is struggling to increase use so that visitors can download the museum apps that might enhance their

experience. As Patten lamented, "If you can't get on the Wi-Fi you're probably not going to experience any of those things [in the apps]."

In 2016, more visitors were using their smart phones in the museum, but the primary use was still to record their personal experience. From these patterns, Patten concluded, "there is nothing in their behavior that makes us think there's a great appetite for museum-generated mobile experiences. . . . They certainly weren't telling us they wanted a navigation app and an orientation app. They certainly weren't saying, 'We want more content.'" In fact, visitors reported that there was too much content in the museum already.

He concluded, "When we're talking about building geolocating systems in the museum so that we need visitors to be using their smartphones, we need to think about how are we going to do that successfully. We need to think about whether we make the apps or whether we really do need to wait for companies like Google and Apple to solve the problem because we're all using Google Maps and Apple Maps (which is what people generally use) when they navigate outside of the museum."

The links to the mobile research decks are 2013 and 2016.

The Heat ⟷ Light Continuum: Eric Siegel, UC Botanical Garden at Berkeley

Eric Siegel remarked, that he has always thought of collaboration as "a balance between heat and light." He shared examples of three models of collaboration, collaboration within a museum, between a museum and consultants, and finally collaboration between museums.

Collaboration Within a Museum

The Connected Worlds project at the New York Hall of Science was a "very, very large scale, location-sensitive, interactive digital exhibition." It was based on systems science and used a novel set of digital tools. The entire room was touch-sensitive, and location-aware. Connected Worlds involved an extraordinarily large team of internal staff. Siegel said it was critical over the 3–4 year project that everyone in the museum—board members, people who reported to Eric, marketing, and fundraising—were actively engaged. For him, that deep and widespread engagement was a central component of the collaboration.

Collaboration Between a Museum and Consultants

Even though Connected Worlds involved many internal staff, Siegel observed that there are "no projects that . . . are entirely in-house projects." The Connected Worlds project involved collaboration with multiple external consultants. The team paid careful attention to communication and coordination with the different consultants throughout the project. Siegel remarked, "Communication with consultants is something we spent a lot of time agonizing over, we fail at as frequently as we succeed. This particular project was characterized by just brilliant communication with the designers as well as within the staff."

Collaboration Between Museums

NISE Net (2010–2015) was a large-scale STEM project about nano science funded by NSF and co-led by the Exploratorium, the Museum of Science in Boston, and the Science Museum of Minnesota. It was very complicated science content and front-end evaluation found that most people did not care, were not concerned, and had no interest in nano science, which posed both a challenge and an opportunity. Because of the large scale of the project, many science centers and informal education organizations were able to join in the network activities. Siegel credited the lead institutions for great communication with the participants. He commented that one of the most important things the lead institutions did for communication was, "they got people together face to face. . . . It's expensive, it's not environmentally sound, but the value of getting people in the same room and sharing ideas is substantially significantly different in developing a collaboration than trying to do it remotely."

Plenary Session: Sharing Reflections on Day 1

Day 2 of the COMPASS conference began by inviting participants to share reflections on ideas that raised new questions or concerns, inspired them or worried them, what they might want to share when they return to their organization and any other impressions they had from the first day's discussions and activities.

A key takeaway for many was that the technology challenges are solvable and confidence that they will be solved.

> The technical hurdles are being addressed so even if not ready for prime time, in three or four years there will be significant advances and new options.

> I think the conversation needs to be about what's the proposition for our visitors? What are we doing and what services can we deliver that will make visitors' lives easier in the museum? The technology problems are on their way to being solved.

> We're in the pregame. This is batting practice for us. It's time for us to learn how to interact with location-enabled guests in preparation for when Google and Apple solve that problem and put that tool in everyone's hands.

Another important theme was to understand and accommodate what visitors are already doing as well as engaging directly with visitors to find out what they might like to use devices for.

> The hardest part of the problem, which is location awareness, might not be the most important part of the problem.

> The research on how visitors want to use their phones was enlightening—they want to do what they normally do with their phones, which is take pictures.

> We had a similar research project done on our mobile app at the Natural History Museum of Utah with the very same results. Visitors want to use their phones in the same way that they always do. The other result is that the majority of our visitors are not looking for more, more, more. I think that's something that we have to remember and that came out a lot yesterday is that we have to really be talking to our visitors and they are not looking to be overwhelmed.

> We're not going to replace Instagram for the 90% of people who are doing those kind of activities. So let's go down the next rung of things that people want to do and help them solve what hasn't been solved by social media or other platforms.

How often do you actually go talk to someone in the museum? There's an idea for a project, all this money and funding, and people talking and planning, but nobody actually goes and talks to a visitor. It's very easy to prototype these things on paper. Take the core idea and go talk to people.

The AMNH identified a specific visitor pain point they knew visitors were having— being lost and confused—and set out to solve that. Having seen a lot of mobile programs that don't work so well from the visitor standpoint, if there's one thing that we should all bear in mind moving forward: figure out what problem you are trying to solve on behalf of your visitors. It's not often a problem that your board, donors, or other stakeholders are aware of, or recognize as important. Are you solving an actual problem or creating a clear, measurable enhancement to the experience?

People are using location, our locations, for things that have nothing to do with us (e.g., Pokémon Go). Is there a way to engage with that in some meaningful way?

Many attendees observed that these projects could be very time and resource intensive and the return on these investments was lower than, and sometimes different than, initial expectations.

If you do it, make sure your audiences actually care about it. If you do it, it's going to be really really hard and take a ton of resources. We have to think more about the marketing of the thing so that people will use it. It's been really eye opening to see how much work goes into these things and then we get low adoption rates.

One of the things that I really wish we had done from the beginning was build a strong geographical information systems underneath all of this. I think about the visitor experience and how much value we could generate if we knew where all the water fountains are, where the benches are, what's the farthest point from an exit. Spend money to get your plan right.

Detail map the whole museum. We know where the outlets are now! There are some serendipitous side benefits to messing around with technology. Share those lessons learned with the rest of the community.

One thing that I am interested in talking about more is the difference between a larger institution with a lot of resources and smaller or medium-sized institutions doing location-awareness technology. Can smaller institutions even keep up? I think you can get into a really negative place. I do think that you can do it as a smaller or less resourced institution. One thing that would be nice that comes out of these two days is, it's not "can you do it" but rather "how" or what are tools and resources that you can provide for smaller institutions. That might be something like, how to talk to your senior staff or your board about the need to really focus on one problem rather than trying to go "all in" or think that its going to be the solution to everything.

A number of individuals spoke about the tantalizing potential for this data to inform evaluation research with the caveat that the techniques are still being refined and data should be used in conjunction with direct observation.

We can't forget about the tremendous value that this can offer us for evaluation and research purposes. These technologies can help us embrace aspects of these informal learning experiences that are true and genuine and really speak to the value of informal learning institutions.

Without observation in gallery you won't be able to actually fully understand the data that you're evaluating. The technology is really just one part of a toolkit.

There is an exciting opportunity to look at visitation patterns and combine that with other methods so you can look at how interests develop and progress, what drives those interests and then develop the apps. That's my main idea, a way to do it in reverse order.

Location-based systems are not a one size fits all. It depends how accurately you need to locate people.

Other participants spoke about their interest in the potential use of app's beyond a single institution or branching out beyond wayfinding and interpretation to universal design and artist-directed projects.

We had an interesting conversation yesterday that was really inspiring from the standpoint of a children's museum. What can we provide our visitors when they leave the building? There is a connection to be made when they leave the facility so that can deepen that connection with the museum.

I'm here for the opportunity of collaboration across cultural institutions. What you're doing here potentially impacts not just science museums but libraries and performing arts centers and the opportunity to do interdisciplinary focuses. I think there's a lot more here that hasn't been fully explored. I like hearing that some of the conversation is not just about how it is in your institution but also how it's outside your institution.

There is an approach of universal design where if you treat accessibility as a fundamental part of the experience, that you figure out techniques and approaches that solves it for everybody and makes everybody's experience better, not just people with disabilities."

I'm super excited to see what artists and creative technologists might do in an institution that's equipped with technology like this. I think that's probably far outside the realms of our imagination. I think there are conversations and connections that could be made between artists and visitors that can be really interesting that we haven't even touched on.

There were some cautionary remarks addressing the challenges of privacy, trust, and expecting too much from visitors.

> We know we want to remove the barriers so we can have this seamless experience. And most people are really willing to sacrifice privacy for convenience. But we have a special relationship and trust we built up with our visitors. That's really super, super important.
>
> There is a tendency to confuse the technology with an actual problem. People like their phones because they are good for answering selfish questions. Everyone's on their laptop here. We're not all having a shared laptop experience! I think the focus on apps and these sort of communal heads down experiences indoors are . . . I'm not sure how well it's been working out.

Keynote: Moving Beyond the Obvious

Dr. Yvonne Rogers, University College London

Yvonne Rogers introduced her talk as "coming from an academic perspective but also very much about how we can think of technology as inspiration for coming up with new experiences that extend, enhance, and empower people."

Many companies are offering apps for museums proclaiming they have the latest technology with apps focused mainly on navigation and content. For Rogers, this is all too obvious and "We can do a lot more than . . . the obvious."

She pointed out two big issues with the apps commonly available from commercial vendors:

The oversell. The companies promise more features than they can deliver. The app can be an expensive solution to enhance a single visit experience for a subset of your visitors, and the vendors overestimate what visitors are willing to do (such as download the app to their phone).

The overlook. If an app ends up compelling visitors to look at their screen rather than the exhibits it negatively impacts the experience.

While mobile audio (in the form of audio guides) has been around since 1952 (see Timeline on pages 46–47), we now have other options and can present audiences with room-level soundscapes. She described a recent exhibition at the V&A Museum (2017, *Opera: Passion, Power and Politics*). Though the music was amazing, she felt that it was ultimately too immersive and even distracting from the experience of looking at the displays. She was concerned that the soundscape inhibited visitors from talking to their companions and if one did talk they were admonished to be quiet. She feels that "museums should be about sharing your experiences, not just being in your own digital bubble."

Turning to her own work she stated that she has found "working with people from very different backgrounds" on new experiences inspiring. As an example, she described collaborating with Extant, the low-vision theater company. Extant, Rogers' group, and a theater set designer worked together on the project. The "motley crew" of the theater company, its set designers, and hardware and robotics developers set out to create a new experience about accessibility. They ended up designing a kinetic tactile guide device that they named the Haptic Lotus to be used by both blind and sighted audience members inside a completely dark installation. The Lotus opened and closed using indoor positioning to detect its location and guide the individual audience member into one of four tactile zones for exploration. One of Extant's goals was to create "a more authentic experience of theatre for visually impaired people."

Rogers showed video clips of blind, visually impaired, and sighted people using the devices in the dark and describing their experiences afterward. Visually impaired people were more favorable about the experience than sighted audience members, saying that they enjoyed trying things "without any fear of knocking anything over or getting in the way of someone." And "when you're blind you don't often get opportunities to wander freely in a space physically and to play with things you encounter."

This theater project, exemplifies her groups' hands on and user-centered approach to research. She also stated

that her groups' work has five design principles that could be relevant to museum mobile projects:

- Provoke curiosity
- Support social interactions
- Prompt playfulness
- Provide different voices
- Allow users to create and share content

Rogers also shared a 2002 project designed for children to hunt for an imaginary creature named the Snark (after the Lewis Carroll poem). Smartphones were not available at that time, but they were able to use PDAs, RFID reader technology, and ultrasonic beacons in the ceiling for rudimentary indoor positioning. The goal was to promote curiosity and each child had a PDAs to use as a "snooper device." Children explored the space using their PDAs to find hidden plastic food that they would "feed" to the Snark. They had to judge by the Snark's reaction what food it preferred. There were also spaces where children could interact with the Snark in other ways (walking, flying, singing) and learn more about it.

She explained that they coined the term "ludic engineering" to describe this process and work. [Ludic definition: Showing spontaneous and undirected playfulness.] "We see that we are learning through this novel playful vision of technology and using the new technologies as a source of inspiration. . . . Without our playful exploration with the technology, we wouldn't have been nearly as creative. I think that's really important—let's not just think of technology as a solution but something to be inspired by."

In each of these projects, cross disciplinary teams of technologists, designers, actors, artists, and others combined their skills and ideas in an egalitarian and collaborative process.

The final topic Rogers addressed was how to share content between users, not just from a single expert dispersed to all users. She referenced an experimental project she tried at the Exploratorium that offered visitors a selection of different voices and different experts to hear from and enabled visitors to record and share their own insights with others via this smartphone-based system.

The co-creation model was also a strategy her group used in the project Pinsight. The 3-D physical device resembled the teardrop-shaped pin markers on Google Maps and they were mounted in public places for a simple interactive public display. Rogers' group made physical pins and placed them in public spaces where they invited people to create content about the local community. The web-authoring interface is constrained to a simple question and answer template. Anyone can create content, and upload it into the Pinsight device.

Rogers and her colleagues ran workshops to teach volunteer authors how to write the interactive Q&A content and then placed the Pinsight devices in locations such as outside a pub, on park benches, and inside shops. After installation and usage, the evaluation study conveyed that both the content creators and the users rated it favorably. "'The Pin communicates—that's what I like about it.' People engage with this much more than the computer . . . there is also a real sense of achievement for the content creators."

Rogers' group also looked at the content-creation activity and collaborative efforts in content creation, "we found that there were some quite long branching stories with complex structures about a topic, for example the history of a street . . . , and that people could build on each other's content, it wasn't just one person creating it. . . . One . . . had five different people build on each other's content." The way Pinsight allowed them to communicate prompted individuals "to think differently about how to present content to others in their community."

In summary she emphasized that these three case studies show the need to "go beyond the obvious by working with others, communities, people themselves, visitors, and audiences and to learn from each other, to work together, and to be inspired by technology."

Rogers shared additional user experience design principles that she feels are essential in her work:

- Design to enhance rather than over steer
- Design to engage rather than simply guide to a place
- Design to enchant
- Encourage curiosity rather than content consumption
- Combine playfulness with local interest
- Design for memorable experiences

Taking Into Account Privacy, Anonymity, and Consent

Dr. Jennifer King, Center for Internet and Society at Stanford Law School

Jennifer King spoke about information privacy and related issues to consider when you try to learn more about visitors with this technology. While visitor-tracking technology is "useful knowledge for you to improve their experience," museum staff should also consider that "technology today can tell you precisely where your visitors are. But it's not only where they are, it's who they are . . . not just rough demographics, it's precisely [them] as individuals." Museums need to find a balance between "knowing enough about your visitors to benefit your organization but not so much that you violate their privacy."

Dr. King started by describing what people care about in regard to privacy. Information privacy is difficult to define because it is both "individually relative" and "culturally specific." In the United States, individual privacy has been legally described as "the right to be let alone as well as the right to control information about you."

Dr. King also considers privacy to have value to the larger group and to us as a society. She explains that if we are willing on an individual basis to trade away privacy, those actions can erode privacy at a societal level. In a data rich and digitally connected world one person's candor or revelation can unveil private aspects of other people's lives. For example, consumer genetic testing allows an individual to choose to share their genetic code. However, this means family members who share similar genes are exposed to potential risk as commercial DNA companies make their databases searchable.

Personal disclosure is a core aspect of privacy and a normal part of human behavior. This routine disclosure of information does not mean that people don't care about privacy. Disclosure is governed by the context in which we are disclosing the information. For example, one context may be a conversation with our doctor and another context is a Google search—each context shapes our expectations about what will happen to the information we share. The use of social media clearly has potential to record and disclose much more but rather than indicating we don't care about privacy, King asserts, "we've designed a technological system that doesn't reflect our social norms."

Disclosure decisions depend on the extent to which people trust the person or institution with whom they share information. This is an especially important consideration for museums, which are already highly trusted pubic institutions. This "is a testament to organizations that stand by their mission to educate and inspire audiences." While consumer trust has been declining due to numerous privacy violations, museums rank much higher than commercial companies in regard to trust.

Dr. King cautioned museums not to risk losing "the trust of your visitors and members by engaging in behaviors that make them question this hard-won trust." Engaging

in obtrusive data collection can shift your relationship with your visitors. "You are all in this together." If a few museums move aggressively toward the types of data collection practices that are common in the private sector, the public's trust in the entire museum sector may suffer.

Research shows that people care about their privacy and every demographic of the United States cares, including young adults. People commonly use different strategies to minimize their data exposure, such as fake email addresses, private browser windows, or fake names.

Two categories of information privacy concern most people. The first is that people do not want and do not expect to be personally identified. They "believe that they are protected by obscurity, that of the hundreds of millions of users in a database, they are not of any special interest to anybody." The second category of concern is qualitative or subjective information that tells something about their interests or mood, such as a list of search queries, all their Facebook posts, and data about their emotions.

People consider their location data to be private, but some locations are judged as more private than others. Another concern is collecting that data over time, and having a sequenced history is a much greater concern than occasional location/position data being accessed. Dr. King encouraged COMPASS participants to be thoughtful about how they implement location tracking, and recommended using four design principles.

1. *Data minimization.* What is the minimum amount of information you need? If you are tracking with smartphones, keep in mind that "smartphone APIs allow you to access a broad swath of information." Do you need personally identifiable information? Do you need it only while visitors are in the museum, or do you also need it after they leave? How will you let people opt out?
2. *Data retention.* How long do you need to keep the data? You should have plans to delete it after a reasonable time period.
3. *Data anonymization.* Can you anonymize the data you collect? What uniquely identifies each smartphone device can also be used to identify a person so this is not a simple task.
4. *Notice and consent.* How will you provide notice of data collection and how will you obtain meaningful consent? Given that most people don't read privacy policies this is clearly an area with room for improvement.

Elaborating on the issue of notice and consent, Dr. King first shared several "worst practices" examples of notice and consent forms (Facebook, Brightest Flashlight Free, etc.). "The standard for consent today is to put a long document created by lawyers for lawyers in front of consumers and expect them to read it and understand it. And for good measure, the terms they offer are just 'take it or leave it.'" She pointed out that this kind of consent form could not be considered meaningful consent.

She also described the initiative Privacy by Design, which consists of seven core principles. It is a collaborative effort by different stakeholders to ensure privacy protections are considered at all stages of the tech design process. Museums can inform external vendors, legal counsel, or other consultants that they want to adhere to the 7 Principles of Privacy by Design before signing a contract.

Her final topic was face recognition. She shared two apps to contrast the consent issues associated with this technology. One app stated in plain language that the image would be deleted after finding artwork matches and the other implied that a third-party service may store the image but it was not possible to find more specifics on how long the image was kept or how it was used. These two very different approaches to notice and consent illustrate why museums need to carefully vet any third-party service they are considering.

Dr. King recommended museums "tread carefully in this space" and be skeptical of the sales pitches that "everyone is doing this" and "nobody cares" about privacy. Museums need to be vigilant and not assume that someone else is thinking about privacy when designing these experiences. She advised, "I would be very respectful of the social capital that you've built up with your visitors both through your own institution and what other institutions have built up as well. Those are very precious

relationships." She concluded with the recommendation to make sure "your users have a good substantive experience that respects them and realize that you can do a lot better than the defaults that I've shown you today as institutions that are supporting public knowledge and the dissemination of information. I really hope you'll take on that challenge."

In a preface to her main presentation, Jennifer King made a "plug" for university information science schools (aka library schools) that have cohorts of Masters students interested in doing "public interest research projects on user-centered design including building prototypes of apps." Keeping in mind that this free resource of students requires that you allocate "small discrete projects" that can be worked on within a half year or less to be completed within the academic semester or year.

What Does it Take?, Panel Session

Keir Winesmith, Matt Tarr, Scott Brewer, and Desi Gonzalez

Rules of Thumb: Keir Winesmith, UNSW Art & Design (formerly SFMOMA)

Winesmith introduced his presentation by stating, "each individual project, each individual institution, each individual within that framework, has a different set of opportunities and resources, I'm going to talk more generally. I'm going to talk about balancing resources."

Balancing Resources Mnemonic

At the beginning of the project you "have stories you want to tell, technology that can be used to tell us stories, and then infrastructure makes that technology possible."

Aim for a project budget that divides up roughly into thirds:

- $^1/_3$ on infrastructure
- $^1/_3$ on UX/software
- $^1/_3$ on content

Build it Yourself or Hire it Out?

"In many cases there is someone or something out there that can do the work that you're trying to do much more efficiently than you can. Using them, or using an existing tool or service, allows you to get straight to the storytelling and leaves time so you can ensure your infrastructure can support that storytelling."

Rarely does it make sense to build something yourself. Someone has done it or can do it so much more efficiently.

Museums should be leveraging open and available technologies whenever possible.

Winesmith then shared the tale of SFMOMA's app "we helped build what I think was an exceptional product and an exceptional experience, one that was incredibly well received, millions of minutes of listening time, but we didn't do it ourselves. We couldn't have built it ourselves; we didn't have the skills or the capacity to build it ourselves. However, someone bought (the application) out from underneath us and then our app simply disappeared." This is the danger in not building it yourself. And to build it in-house they would have had to compromise on the user experience.

The Art of Communication

Decision-makers and executives can be persuaded by a "show and tell." Museum staff may need to provide that compelling "show and tell" to communicate the end product but at the same time should be cognizant of the critical need to allocate the grant funds and budgetary resources to the infrastructure. Everything in the present and future rests on having a *solid infrastructure*. Consider starting with smaller proof of concept projects if necessary.

After the Launch 6/18/36

Plan your budget and schedule according to this rule of thumb.

- In the first six months evaluate how it's working, what users have issues with and make adjustments as needed for the user experience.
- After 18 months add, delete, and edit content as needed to improve the experience
- At 36–48 months, the technology has probably changed so much that you will have to be ready to replace or do a technical redesign of the system.

Explorer: Matt Tarr, AMNH, New York City

Tarr shared his thoughts on "what is" *Explorer* as well as "what it took."

Explorer is not just an app, it is:

- two apps, one for interpretive content, another for ticketing.
- on two platforms, iOS and Android.
- a marketing strategy, a maintenance plan, an actual map(!), and a key piece of our overall digital strategy.
- a third-party platform (or two), a physical infrastructure of 800 beacons, a new vendor relationship to manage, and new content.

"It [also] represents the potential and possibility of working across departments to get the entire museum thinking about the visitor experience and how technology is part of that."

What it Took

- More than 5 developers
- 10 writers/researchers
- 3 editors
- 2 illustrators
- 2 content coordinators
- 1 photo researcher
- Scientific reviewers, spreadsheets, and PPT templates
- 70 exhibits
- 45 halls
- 800 images
- 120 custom illustrations
- 49 videos
- 14 audio clips
- 280 individual story modules

Tarr commented on the content-production process, "We had these SNL-style writer rooms. Every week we would sit together and sort of pitch ideas. These people know what's interesting and funny. . . . Others have said that visitors aren't asking for more content and I guarantee that's true. Because they don't know what they don't know. . . . They don't want [more of] what's on the label. That [the label] is what's important to say about the object. Sometimes it's entertaining, sometimes it's authoritative, but what we knew, what was interesting about the object, we added that to the mix and we use the app to do that. . . . We didn't have to get rid of the labels to do that because we had this app. So people . . . are delighted by the content, the little snippets, or stories."

Tarr went on to explain that it took the creation of a detailed map with thousands of map segments that had to be created. "These are human beings we're directing. We're not directing Roomba's around the museum, we're directing people. What people need to know is which exit to go out of to get to their destination and then they need to know where to turn and when to turn. We built it around that idea."

It took an intensive maintenance plan to keep their beacons in operation by checking them and replacing batteries of the 800+ BTLE beacons in the museum. "Raphael and I love our time together wandering the museum with a ladder and a lot of batteries."

It also took significant funding and they were fortunate to have Bloomberg Philanthropies support for *Explorer 1.0*. Following that they had four years of no support but with a renewal of support in 2015, they were then able to produce and launch *Explorer 2.0*.

What it Takes

- A reason for being. You have got to have a real problem to solve. You have to be able to solve it.
- Updates
- Constant evaluation and research
- Ongoing institutional commitment
- Ongoing funding

Scott Brewer, Museum of Old and New Art

Scott started by saying the question of what it takes is really difficult to answer.

He wanted to speak in more general terms about how Art Processors gets through projects with the caveat that indoor location for them is only one potential "piece of the puzzle" of their app development.

There are six key phases, all of which are necessary and important.

1. *Strategize.* Create a feasibility-value matrix of your digital experience.

   This should be articulated by a mix of museum stakeholders to identify what is feasible and will pay off in value.

2. *Design.* Investing upfront in software architecture design can help save time and money later.

3. *Prototype.* Work things out cheaply and figure out if they have value to the visitor. Test your prototype with your visitors before proceeding and be ready to hear them if they hate it or tell you it is a terrible experience. "Sometimes visitors know what they want, sometimes they don't know what they don't want" It's well worth testing a prototype rather than simply asking visitors to react to a verbal description.

4. *Develop*. The bulk of costs typically go to software and developers are expensive.

5. *Install/test*. Make sure you test the software intensively and thoroughly so you can address problems before launch.

6. *Launch/monitor*. Make sure you have something left in the budget to fix the new problems that arise.

And prepare to refresh in 3–5 years because the technology ages quickly.

Out Loud App Development and an Option to Enhance the App: Desi Gonzalez, Independent Consultant

Desi spoke about the nuts and bolts and numbers of her Warhol project and shared that it was important to keep in mind that medium and smaller museums necessarily had proportionately smaller budgets to spend on technology but it was possible. She also shared their process to test the integration of the research app *NavCog* with *Out Loud.*

The Warhol Context

- Budget of $6M/year
- Staff of 35 full-time people
- Lots of part-time people
- 35,000 square feet of gallery space

Limitations

- Small budget ($50K for the first round of development)
- Limited staff resources, digital team of one person but they worked with Carnegie Museum of Pittsburgh's Innovation Studio for less expensive software development.

Strategy

- Built version 1.0 as beta
- Started small to get it right. They began with the seventh floor gallery of the museum to help understand how to use the beacon technology.
- Found partners to share expertise, and be advisors.
- Small core team of five persons: UX design and project lead, two software developers, one content specialist, and one education department staff with experience in accessibility programming.
- Advisory group that met with core team monthly included museum senior staff, an expert in assistive technologies from Conversant Labs, and Sina Bahram, an expert in accessibility.

- A consultant produced the tactile reproductions.
- User experts/product testers (compensated) from the Pittsburgh disability community tested during development.
- The Pittsburgh Accessibility Meetup group were invited to hold a meetup at the museum and give feedback near the end of development and before the launch.

Process

- Inclusive design with advisory group and disability community
- Research trip to Guggenheim to try out *Near Me* app and learn from their staff
- "Tons of user testing"
- Agile development
- Feedback and iteration over a fast seven months and then soft launch
- Follow with working out IP copyright issues, training frontline staff how to offer app to visitors

After the soft launch of *Out Loud,* the Warhol staff looked at the potential enhancement and integration of the Carnegie Mellon University research app *NavCog* (for indoor navigation) with the *Out Loud* app. Gonzalez helped to test *NavCog* with *Out Loud* The Warhol and shared her scoping outline for what it would take to fully integrate *NavCog* with *Out Loud.*

***NavCog* Implementation Requirements**

- Sustainability and growth
- Fundraising for custom development (software developer) because they would be adapting *NavCog* software developed for research into more general use
- The content management system would need to be adapted for nontechnical museum staff
- Special training for frontline staff to assist visually impaired people in using an unfamiliar tool

Emerging Prospects in Informal Learning Environments, Panel Session

Seb Chan, Kate Haley Goldman, Willie Hartman, and Dave Patten

What is on the technology horizon for museums and other informal learning environments? Speakers from Australia, the UK, and the United States shared their perspectives and predictions.

Seb Chan, ACMI, Melbourne, Australia

Seb Chan described his first implementation of location-aware technology, which was in 2008 using QR codes at the Powerhouse Museum in Sydney. He conducted other experiments with an app that tagged photos with their location and were then used for a city tour, and another city tour that utilized an audio story narrative. He tried Wi-Fi tracking at the Powerhouse Museum but it never worked well.

He left Australia and the Powerhouse to work at the Cooper Hewitt in New York City. The Cooper Hewitt had committed to making the museum a physical and digital interface for art. The Cooper Hewitt Pen has attracted much acclaim, but Chan maintains the "real change wasn't the Pen, it was what the Pen made possible." Developing a technology experience that would be used by nearly all visitors was challenging given that Cooper Hewitt has a half million visitors annually.

After completing the Cooper Hewitt project he moved back to Australia and is now Chief Experience Officer at the Australian Centre for the Moving Image (ACMI). The ACMI presents film, TV, video games, and related art. One challenge for them is figuring out why visitors would

come to the museum when the same material (videos, games, etc.) is available on their smartphone.

The ACMI also has many experiences that are time intensive. For most museums, Chan makes the point that the "currency is time." When visitors spend more time, and look more closely, it is a measure of their appraisal of the value of the experience. We should be more aware of how time is an important measure for the museum experience.

The ACMI is undergoing a programmatic change, a cultural change around how staff work, and a physical change with a $40M renovation. They created a co-working space and an "accelerator" project to have the consultant companies making the technology, work within their building. They are using their current exhibitions to pilot and test new kinds of design and technology. And he emphasized that all of the changes start with observing what visitors do and analyzing the sequenced experience of visitors in journey maps.

After reviewing all the elements of the entire visitor experience, Chan decided to move away from apps. One reason he became disenchanted was that every time a visitor wanted to take a photo, they had to switch out of the app to photograph and then go back into the app. When they rent an exhibition with an audio guide, they make that content available by mobile web and 40% of their visitors engage with it. This solution has already been adopted by 16 other museums that he knows of and this open source, simple interface doesn't require a high-level tech staff to install or maintain.

For their most recent exhibition *Wonderland* (based on *Alice in Wonderland*), the printed paper map offers wayfinding and it "comes to life" using radio frequency tags embedded in the paper at different near-field communication (NFC) stations throughout the exhibition allowing you to trigger videos and more.

It both engages visitors and gives the museum tracking data on how visitors use it and where they go. The map was used by 88% of visitors for more than one interaction and 10% visit the *Wonderland* website after their museum visit. More information on the process and experience is in an article by Lucie Patterson.

Chan recommends keeping the following in mind before designing experiences that involve location-aware technology:

- Value the time that people give museums and aim to multiply the return on their time.
- Value visitor intention.
- Consider the effort and time cost of "onboarding" required by apps.
- It's much easier to fix problematic wayfinding with better environmental design than with an app.
- Fix your existing interpretation issues by working on labels and with interpretive staff.
- Pay attention to the design for the inside of the institution as a whole interconnected experience.

Chan ended with the "best location-based experience I've ever had." Door into the Dark was presented in 2014 in the United Kingdom and in 2015 in New York City. Visitors wore blackout goggles and followed the smartphone controlled narrative in their headphones, described as a "documentary for one." iBeacons triggered instructions to participants, and they must rely on the narrator and their own sense of touch and smell to navigate through the space. The production has received awards and much media coverage for its innovative production.

Kate Haley Goldman, Haley Goldman Consulting

Kate Haley Goldman offered a few lenses through which COMPASS participants might view their projects and used some of her current and past projects as illustrative examples.

- *Transparency.* This can mean that the technology is invisible and that the visitor is simply having a delightful experience.
  Example: AR Sand Box project created by UC Davis in collaboration with two science centers.
- *Delight.* Pieces that can delight and surprise.
  Example: The Hirshhorn Eye using a smartphone app image-recognition functionality to link artworks to artist video interviews at the Hirshhorn Museum
- *Low-tech "tracking."* The visitor journey starts before visitors enter the museum and continues after they leave it.
  Example: AMNH visitors create a "diary" starting when they plan to visit and then recording their impressions through the planning, the visit, and post-visit back at home
- *Co-creation.* Shift authority from defining the visitor outcomes to working side by side in extended partnerships with community advisors and/or target audiences and having them define the outcomes.
  Examples: Working with POC millennials as advisors on a digital game; creating noise pollution app with community representatives for Cornell Ornithology Lab

Willie Hartman, Ubiquity6

Discussing the future of rich mobile augmented reality (AR), Willie Hartman said several pieces of technology are becoming available that will make it possible for precisely located, geostatic, persistent, multiplayer content to be loaded dynamically on demand, such as through a website. These are not compiled apps, rather they are more akin to content management systems—a 3-D endpoint for a piece of content that can be changed in real time. The future of rich mobile AR could be seen as part of the next 5-years of consumer AR headsets (Magic Leap, etc.) becoming more common.

Examples of what you might do with mobile AR are place virtual objects in space, play a game with others, create or build something with other AR participants.

Several trends are converging that will make it possible to serve up rich AR experiences in the next couple of years. First, sensor technology is converging rapidly. Within the next year, most high-end smartphones will have sophisticated integrated sensor technology. Those sensors, combined with GPS and the stereo cameras, are "all you need to take those things we all have previously experienced as installations . . . and put them in people's hands or use the devices that people bring with them."

Several companies are working on mobile AR but even with the popularity of games like Pokémon Go there is a clumsiness to it. However, progress is being made and it will become more intuitive and user friendly. Some apps will allow users to easily go in and out of AR so

it won't be so difficult to navigate. Hartman sees this kind of "occasional" AR mode as potentially useful for museum experiences and it could be less intimidating for users. Because many people buy a new phone every three years, more people will be easily able to access an AR experience. Potentially 80% of the people living in wealthy metropolitan areas would have mobile AR capability on their device, which means that mobile AR experiences will not require any special hardware to be provided.

With many companies investing in the infrastructure, authoring AR experiences will not require a full game development team to develop rich content. It will cost money to produce the digital 3-D models, but several companies are "making it easy" to organize those elements into a rich mobile AR experience, making it a similar level of effort to producing and publishing a website. He believes the process could be handled by internal media staff and will be available to museums within a few years.

Dave Patten, Science Museum, London

Dave Patten described four current projects at the Science Museum, London, which are taking place as part of the process of redeveloping all the museum's permanent collection galleries.

Developing a New History of Medicine Gallery

With 3,000 square meters (32,292 sf) of exhibition space, it is the largest single exhibition in the museum's history. The design will include a mobile app that enables blind and partially sighted people to navigate and listen to descriptions of the objects in the exhibition space. The location technology requires knowing where people are and knowing which direction they are facing to be able to tell them how to move around the space.

Digital Lab

This is an initiative for more experimental digital work, some of which will end up in the plans for renovating the permanent galleries. The museum is experimenting with new forms of interpretation, including the use of VR. For example, one Hackathon experiment created a tracking device they named the "Digital Egg." Visitors wear the egg on a neck lanyard during their visit and it tracks where they go. At the end of their visit, the system sends them a souvenir postcard based on their path and interests. It is likely they will continue to develop this thinking.

Historic Sites

The Science Museum is actually a group of museums, two of which are located at historic sites. One site in Manchester is the birthplace of the Railway Age. They are exploring how they might use geolocative devices and systems to tell this story inside and outside the museum. They would like to use location-based systems and "augmented reality to bring that site back to life and help people explore that site more fully."

Immersive Digital Experiences

Contingent on receiving funding, the Science Museum is planning to build a large-scale interactive immersive space. They would commission 6–8 productions a year for this space that 30–40 persons could experience at one time.

Patten closed his remarks by describing two locative experiences that he felt were exceptional.

1. The "Magic Band is absolutely awesome" because it reduces "friction" and improves your experience while "scarily" knowing exactly where you are.
2. The Lost Palace (2016) developed by Tim Powell, Chomko & Rosier, theater consultants Uninvited Guests, and app developers Calvium. This award-winning London production brought together the techniques of an audio tour, haptic interactivity, and location-aware tracking. He called it "a stunning piece of immersion," and urged attendees to look it up.

What Is the Broader Context?, Panel Session

Dr. Sherry Hsi, Dr. Theano Moussouri, Dr. Yvonne Rogers, Seb Chan, and Aaron Cope

Five speakers offered closing reflections on the contexts of society, technology, and museums that surround and shape the work discussed at the conference.

Dr. Sherry Hsi, Concord Consortium, Emeryville, California

I am going to take you back in time before we go forward, to talk about context-aware computing for inquiry because supporting inquiry is what we are about in K–12 education and lifelong learning. Twenty years ago we were doing experiments with Palm Pilots and probes. We were sending kids out to creeks to collect data, understand their environment, and form questions that they would answer using these devices. At the same time we were formulating this idea that inquiry was not just something you did in the classroom but that you could do it everywhere supported by nomadic computing.

It was an approach to learning that supports the exploration of natural, virtual, and material worlds, that leads to deeper discussions, deeper questions, and making discoveries. You would imagine that there was a landscape of resources and information and expertise that a kid could use and ask their peers for information. They may collect data and construct an explanation. Their learning was really through conversation, collaboration, and interaction with others. In this process there might be some formative assessment as well.

The paradigm that we had at the time was "learning everywhere." There was this notion that you would start the inquiry experience at school, then you go to the museum on a field trip, and then you go home. That had a lot of assumptions that were not exactly true. So we dropped the going to school; the primary experience actually happened at the museum where you might be going through experimentation, might have a conversation, might bookmark an experience, and might reflect upon that.

A lot of the deeper work happened back at school. Perhaps it would prompt a further visit or multiple visits and the assumption 20 years ago was that there would be this ubiquitous wireless network and everyone would have wired devices. It's kind of cool that this actually came true!

To support this work there was a body of research around electronic guidebooks at this time. This guidebook project took place at the Exploratorium and started out as an NSF grant with Robert Tinker and Rob Semper. The goal was to support mediated inquiry and there was mobile content that was developed for each of the exhibits. It was innovative at the time with these Point of Information stations (in collaboration with HP Labs) and exhibits equipped with RFID and infrared. As you came within signal range of an exhibit the content would be queued up on your small, very heavy, clamshell computer.

If you wanted to capture and remember your experience you would hold the device, which also had RFID and it would snap your picture. We spent a lot of time focusing on the visitor experience and realizing that this interface was also very isolating and taking away from the actual visit.

We shifted some of our resources to think about the question: How do we support Explainers? We built prototype content about how to facilitate an exhibit and created a digital library infrastructure, providing more information. We did lots of paper prototyping. The design plan was that the Explainer could look at the handheld, put the handheld away when the visitor came up, and then facilitate that inquiry.

Our interest was how could we support extended inquiry. Maybe the museum has opportunities to do inquiry but you want to extend that over time and space. Another experiment we did in that process was to develop the eXspot in collaboration with Intel Labs. Intel provided the RFID technologies and we placed a number of these different eXspot transceivers on exhibits. You would go up and register a device. Then you could walk around and try out exhibits. Then you would go home and look at all the exhibits that you had tried. This work and related work at other institutions was shared in two convenings in 2001 and 2005.

In the eguidebook work we were able to support these activities by documenting and remembering, requesting information and asking questions, exploring, and doing some reflection. But there was this whole slew of other interactions that were not being supported. These could include playing a game, communicating, evaluating, and seeking , the things we still think are very important in informal learning spaces. Do these other interactions belong in a museum or are there other venues and spaces where they could happen?

Now we're going to zoom off to the present. The perennial question is "Do we focus on interaction and look for technology that supports that interaction? Or do we see new technologies as opportunities?" With public Wi-Fi starting in 1996, the growing popularity of the term "Internet of Things" in 1999, and now having voice and face recognition and AR and VR, what do we think is going to make a difference for the future of informal learning? What are the grand challenges going forward? There are many. Museums should be for multiple encounters and for deeper inquiry. It's not a one-time visit. How do you extend engagement to have meaningful inquiry experiences?

Another big question is about data ownership. In K–12 education and schools and school districts you must consider very strict guidelines about privacy and be thoughtful about how you handle online information. How is that going to be handled in the smart museums?

Issues of equity and the digital divide were mentioned earlier today and we should remember that museums can be seen as rarefied spaces and not everyone has mobile devices. How do we meet the needs of a broader community so that more people can benefit from these services? And for disengaged youth, how do we make interaction, location-aware, or context-aware experiences or exhibits and programs that these youth find relevant and interesting to use for their own inquiry?

Dr. Theano Moussouri, University College London

We're going through constant angst: what is the value of museums in the twenty-first century? There are "all these elements that museums need to be representing all and [to] be accessible to all and do research and conserve material culture inherited for the next generation." It is hard to deliver on all of these and that can "put pressure in everyday practice for museum professionals."

These issues can play out in how we develop engagement opportunities for people. Being inclusive and accessible is important, and new technologies may help meet particular needs. Blind and partially sighted people have a need that technology can meet because it can support more independence. People with visual disabilities are just 3% of the population but looking at all types of disabilities can be more than 30% of the population. For example, sensory access can be important for people with memory loss and dementia. It may be possible to create different apps for niche audiences that can also be used for other audiences in unexpected ways.

Dr. Yvonne Rogers, University College London

We are going through a technology revolution in the sense that AI and machine learning are becoming massively influential. All kinds of industries and organizations are working closely with researchers in AI, thinking about how AI shapes the user experience. The broader context in the next five years is for museums to reach out to tech companies and academia to think about what kinds of large-scale projects you can do with this range of technology that will make a difference for society.

What I would like to leave you with is that it's much bigger than indoor location—we should be thinking about all of

the other technologies that are just around the corner that everyone else is starting to look at.

Seb Chan, ACMI, Melbourne, Australia

The museum sector is in an interesting moment, particularly in the United States and the United Kingdom. Technologies that museums wish they had have become ubiquitous among our visitors.

Because we didn't provide them we don't quite know how to address this imbalance. There is a real challenge with the way museums—and particularly contemporary art museums—are merging with and starting to resemble attractions. Museum attendance is high, but museums are viewed as attractions. That is good, but not aligned with where technology and other things are headed. The challenges and funding models are shifting from a capital expense to an operational expense.

Along with the shift to running a museum as a service or an attraction that is running on services, we have huge staff challenges; staff retention, training, and keeping staff engaged around the things that enable us to get better. The passions that people have for museums may not be part of the work they actually do. We are generating a lot of people whose roles are as untrained project managers. What used to be creative work is too often now just project management. Collaborating and working with technology providers requires museums to have in-house technology skills and knowledge to be better clients for the providers.

Aaron Cope, SFO Museum (formerly Cooper Hewitt Museum, Mapzen)

The Cooper Hewitt is a design museum. It deals in objects that people imbue with meaning. One of the questions we constantly asked was, "Why is our Eames chair any more important or different than the Eames chair that is at MoMA, at the Brooklyn Museum, at the Design Within Reach store? And given that the Eames chair was designed to be mass-produced, why is the Eames chair that is produced to spec in 2018 less valuable than the original? You get into this weird thing where the object is about everything that came before the object, and how do you tell that story?

Design museums also collect some things that have no tangible form, such as service/experience design. One thing that museums have always done is make dioramas. "Even before VR we had VR—we had dioramas!" Now we have location technologies to support a new kind of visitor experience. The present vogue is creating experiences, moments that compel people's time and attention in a museum. Do we want to be the object of attention rather than the institution that keeps the objects safe and tells the object stories?

Dr. Sherry Hsi, Concord Consortium, Emeryville, California

My comments are from the perspective of science museums as learning places. Schools are places of learning of a particular style, with particular affordances and constraints. Museums have been able to relax a lot of those constraints to support voluntary learning, to be intergenerational, to have dynamic orchestrations, and more. When you add technology, you want to preserve the things that matter for learning.

It is not just school age youth who come to science museums. These institutions also train educators in a professional learning community. These are community spaces. We have to preserve what's good about them before we start mixing in location-aware technology and other technologies. Artificial intelligence is coming, and it's already invading the school world. We have to decide whether to let it in or how we can use it in a way that supports our educational agenda.

Closing

Claire Pillsbury thanked the Exploratorium team, project advisors, participants, and NSF and she expressed hope that this conference will be the beginning of many conversations that enable members of this community to support each other.

Pillsbury then closed with a quote from William Gibson. “The future is already here—it’s just not very evenly distributed.”

Appendix

MUSEUM MOBILE TECHNOLOGY TIMELINE

1950

1952

De Stedelijk Museum, Amsterdam

Hand-held radio receiver and single ear headphone, closed-circuit shortwave radio; multiple languages (Dutch, French, English, German) broadcast sequentially
1952

1954

1960

American Museum of Natural History

Guide-a-Phone audio tour using a heavy radio receiver on a shoulder strap
1954

It is a fact beyond doubt that a great many visitors like to wander at will, stand and stare, and equally dislike any breath of regimentation. There is a danger that with the wide application of mechanical gadgets the quality of visitors may suffer. There are many who would be dismayed if they saw throughout the building people with black boxes around their necks pass by with a faraway expression in their eyes … guided by some mysterious forces they walk, turn, and stop in almost synchronized precision before exhibit after exhibit.

1960, *Museums Journal* editorial

1961

American Museum of Natural History

Sound-Trek radio receiver and headphones, closed circuit broadcast
1961

Science Museum, London

Telesonic Lorgnette "radio guide"
1961

1966

1980

US National Gallery of Art

Acoustiguide audio tour of *Art Treasures of Turkey*
1966

1985

British Museum, London

Cassette tape guide to Parthenon sculptures on heavy player on a shoulder strap
1985

1987

Alcatraz, National Park Service

Antenna Theater created the Walkman tape tour of Alcatraz for the NPS and later that year for the Steinhart Aquarium
1987

There is no safety in unlimited technological hubris.

McGeorge Bundy, 1987

1991

1993

The Metropolitan Museum of Art

An unauthorized alternative audio tour, *Masterpieces without the Director* was created by two artists and offered free outside of the museum (the project was sponsored by Creative Time). The guide included public commentary, sound collage, and thoughts on the architecture, history, and myths of the institution. Opinions offered by celebrities, politicians, military leaders, and the general viewing audience were incorporated.
1991

Louvre, Paris

INFORM, a digital wand player, first "random access" tour assist device
1993

1996

1997

1999

Minneapolis Institute of the Arts

Apple's Newton early notepad computer tour
1997

Smithsonian Air and Space Museum and American History Museum

Newton MessagePad used to provide audio and additional information about exhibits and objects.
1996

The Metropolitan Museum of Art

Key to the Met Audio Guide, CD-player based,
1999

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2001

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software suite
a CD-ROM player,
display, keypad,
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Exploratorium

Eguide project
with HP PDAs,
tomized software
and beacons
at exhibits
2001

SFMOMA

Points of Departure using PDAs to display video of artists talking about their work
2002

Tate Modern, London

Multimedia guide on adapted PDA
2003

Filoli Gardens

Xerox Parc research project, Sotto Voce using PDA with touch-screen interface and audio interpretation
2002

Museum of Science

Mystery at the Museum was an MIT Teachers Education project and augmented reality mystery game for parents and children to play. Limited release to test for proof of concept and research
2004

It is almost impossible to visit a major art exhibition these days without encountering the evils of the audioguide: a ruse to squeeze an extra few quid from gullible patrons happy to amble around like zombies while a disembodied academic voice tells them what to think.

Alfred Hickling (The Guardian)
2004

J. Paul Getty Museum

GettyGuide had audio interpretation and wayfinding
2005

Walker Art Center

Art on Call features artists and curators discussing selected artworks in the collection. Provides details on current exhibitions, programs, events, open hours and ticket purchases.
2005

SFMOMA

Podcasts developed for special exhibitions and general tour.
2005

SFMOMA

SFMOMA call-up audio soundbites by cell phone for *Matthew Barney* exhibition
2006

American Museum of Natural History

Explorer iPhone app supported visitor navigation, encouraged repeat visits, and provided additional exhibit information
2010

Powerhouse Museum, Australia

QR codes and URL's are incorporated into object labels to link to images and text.
2009

Liberty Science Center

Science Now, Science Everywhere: Visitors can text to receive more information and urls, listen to audio about exhibits, and participate in scavenger hunt
2008

DeCordova Sculpture Park

Scapes, outdoor sound art installation with dynamic music and visitor recordings tagged to location
2010

So much more should be possible. Imagine standing in front of an object with an app that, sensing your location, is already displaying precisely the right information. It might offer historical background or direct you through links to other works that have some connection to the object. It might provide links to critical commentary. It might become, for each object, an exhibition in itself, ripe with alternate narratives and elaborate associations. And, best of all, you could save it for later, glance up from the screen and look carefully at what faces you, all scrims removed, all distractions discarded. Like this! There must be an app for that!

Edward Rothstein (NYT)
2010

Louvre, Paris

Louvre Guide, built on Nintendo 3DS device with wayfinding, pictures, multilingual audio narration, location-aware sensing, and interactive map
2012

The Metropolitan Museum of Art

Murder at the Met: An American Art Mystery mobile app detective game designed for teens
2012

MONA, Tasmania

The O designed for Ipod Touch offered geo-locating, digital labels, audio narration, and the opportunity to rate artwork
2014

Canadian Museum of Human Rights

Ibeacons are the infrastructure for accessible (audio descriptions or sign language interp) audiotours, interactive maps, and wayfinding. Visitors can also share their mood, view panoramas, and purchase membership via the app.
2014

Science Museum, London

InfoAge apps including *AudioEyes* for vision impaired (audio descriptions) and the *InfoAge+* app had interactive learning activities.
2014

Cooper Hewitt, Smithsonian Design Museum

The digital Pen, one end a digital stylus the other an NFC reader, used to interact during visit and create a souvenir collection
2015

Brooklyn Museum

ASK allows visitors to use their mobile devices to ask questions of expert museum staff and get answers during their museum visit.
2015

Science Museum, London

Treasure Hunters iOS or Android app to play at museum in groups or solo, play against others and win badges and treasure
2018

Guggenheim

Guggenheim app featuring *Near Me* using iBeacon technology

SFMOMA

SFMOMA app created in collaboration with Detour
2016

Minneapolis Institute of Art

Overheard app, audio narrative allows you to 'overhear' fictional characters
2016

The Warhol, Pittsburgh, PA

Inclusive audio guide *Out Loud* with screen reader optimization and enlargeable text created in collaboration with community partners
2016

00 2001 2002 2003 2004 2005 2006 2008 2009 2010 2012 2014 2015 2016 2018

RESOURCES

Privacy Guidelines for App Design

Privacy by Design

Museum Specific App Projects

CoCensus (Jane Addams Hull House)

Connected Worlds (New York Hall of Science)

DASA multimedia guide

Explorer (AMNH)

Guggenheim app (Guggenheim)

Hirshhorn Eye (Hirshhorn Museum)

NavCog (Carnegie Mellon University)

The 'O' (Museum of Old and New)

Out Loud (The Andy Warhol Museum)

SFMOMA App (2017)

Smartguide (Birmingham Museum of Art)

Location-Aware Performance/ Experimental Theater

Door into the Dark

Haptic Lotus

The Lost Palace

Templates or Code to Prototype and Experiment

Indoor Atlas

Online Scholarly Catalogue Initiative (OSCI)

Roundware

Smartguide WordPress Plug-in

Static Museum Audio Guide (made by Australian Centre for the Moving Image)

VoiceOver (Mac OS screen reader)

Research

Australian Centre for the Moving Image NFC-enhanced map

Australian Centre for the Moving Image Labs visitor research

Pinsight

Science Museum (UK) mobile phone studies 2013 and 2016