Draft Report

Science on a Sphere Front-end Evaluation

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Introduction

The Maryland Science Center contracted with RMC Research Corporation in June 2004 to conduct a front-end evaluation of Science on a Sphere, a new spherical film technology developed by the National Oceanic and Atmospheric Administration. The Maryland Science Center mounted Science on a Sphere for a two-week exploratory period, between June 15-30, 2004. The front-end evaluation aimed at assessing the educational strengths and potential of Science on a Sphere as exhibit technology in the museum setting.

Science on a Sphere is a six-foot diameter sphere that is suspended from the ceiling (or a specially designed frame). Driven by a bank of computers, four video projectors arranged around the Sphere display spherical images created from a potentially limitless number of data sets. Data sets used in the Maryland Science Center presentations included images of Earth and other bodies in our solar system. Some of the Earth projections include infrared satellite data depicting the development of storm systems as they move across the globe, sea surface temperatures depicting el niño and la niña events, an animation depicting 600 billion years of continental drift, and images of Earth's topography and bathymetry. Additional data sets depicted the surface of the Sun, Moon, Mars, and other bodies in our solar system.

Evaluation Questions

The evaluation plan developed by RMC was designed to address the cognitive and affective aspects of the Science on a Sphere for learning experiences, and was based on consideration of three aspects of the exhibit:

- visualization of data on the sphere
- interpretive program scripts
- sphere placement in the museum

Evaluation questions were developed for each of these areas.

The Visualization of Data on the Sphere

- What are visitors' first impressions of the Sphere? Do visitors understand the purpose and content of the Sphere? Do the visualizations convey the intended meanings? What kinds of supporting information are needed to make it both comprehensible and engaging?
- How do visitors respond to the visual presentation of data on the globe? What kinds of images are most provocative, memorable and engaging?

Interpretative Program Scripts

- What kinds of information and stories are most suitable for presentation in this format? What are its strengths and weaknesses in comparison to the presentation of information on a flat screen, in written text or via other media?
- What specific visual and narrative techniques are most effective in conveying both conceptual and factual content? How can complex ideas such as different time scales be best presented?
- How can the Sphere and accompanying scripts be used most effectively for depicting global systems and interconnectivity? For instance, how can information about the global nature of weather patterns be best presented given the visual and auditory aspects of the program?
- How do the visual and audio components of the program interact, and what are the best techniques for ensuring that the audio text supports and enhances the visual, and minimizing the degree to which it is inhibitive or over-prescribed?

Sphere Placement

- What are visitors' behavioral patterns of interaction with the Sphere, i.e. do they walk around it? Do they settle on a particular position or angle?
- What effect does the placement in the museum, including such factors as the size of the room, amount of traffic and noise level, on visitors' experiences?
- How might auxiliary information be presented in association with the Sphere?

Interview protocols were developed out of these broad evaluation questions, tested and refined as described below. During this process, it was decided that the first of the evaluation questions, that about the Visualization of Data on the Sphere, was the most important for this pilot exhibition.

Methodology

The evaluation plan developed for Science on a Sphere included the collection of observational and interview data during the two week stay of the Sphere. Data were collected in two phases, as follows:

Phase One (June 15-16) – During the first two days of the exhibit, an RMC staff member collected observational data, and conducted oral interviews using draft interview protocols developed prior to viewing the presentations. These interviews were intended as an opportunity to test the protocols, but are valuable as the only data collected of school group visits due to the timing of the exhibit. Interviews were conducted by an RMC staff member with the assistance of MSC and visiting science center personnel. Small groups (3 to 6 individuals) were interviewed, including student groups, their teachers, and the general public.

Phase Two (June 18-30) - Survey instruments were revised based on considerations described below and used for the remainder of the exhibit period. Two versions were again created to allow a wider range of questions to be asked. At the conclusion of each of the approximately eight presentations a day, visitors were asked by the presenter to

complete written surveys which had been placed on the projector stands around the Sphere on clipboards.

Interview protocols were revised based on the actualities of Sphere presentations, preliminary data, feedback from project principals, and availability of MSC staff for data collection, as follows. Contrary to expectations prior to viewing NOAA presentations, visitors were expected to move around the Sphere, sometimes as many as six times during a single presentation to see particular images on one part of the Sphere. As a result, issues originally built into the survey instruments were no longer meaningful.

In addition, no program scripts had been developed specifically for the exhibit. Rather presenters would be using a script developed by NOAA, or speaking extemporaneously on topics well-known to the presenter. Thus, project principles requested that the evaluation focus on capturing viewer responses to the Sphere as a medium of presentation, rather than on the Interpretative Program Scripts.

Preliminary data and evaluation goals were reviewed at a workshop with Maryland Science Center and collaborating museum staff. MSC and visiting museum staff members were primarily concerned with how visitors responded to the Sphere, and issues such as whether the Sphere could be used without a presenter, and how to think about guided presentations in the science center day.

The goal of the evaluation of this pilot exhibition of Science on a Sphere in the Maryland Science Center was to understand viewer responses to the Sphere as an educational medium. Towards this end, visitors were asked open-ended questions as a way of surfacing the range of viewer responses to the medium. Written surveys that could be completed by visitors without the assistance of data collectors were developed for use.

An RMC staff member returned to the Maryland Science Center for the final two days of presentations. During this time, additional observational data was collected on visitor behavior, and randomly selected visitors were asked to respond to additional interview questions following completion of the written questionnaire.

School Group Interviews

Interviews were conducted during Phase One of the evaluation in order to gather initial feedback before refining study instruments. Due to the timing of the exhibition, these were the only opportunities for feedback from visiting school groups attending Science on a Sphere demonstrations. These included two visiting groups of fourth graders and one group of eighth graders. At each of these a handful of adult or family visitors also joined the presentations.

Surveys

A total of 326 surveys were collected. Visitors who completed surveys included 74 visitors under 18; 28 visitors between 18 and 25; 127 visitors ages 26-49; and 97 visitors ages 50 and older.

Instruments used in both interviews and survey are included in Appendix A. The data obtained using both sets of instruments is included in Appendix B.

The following discussion draws on survey, observational and interview data collected throughout the Sphere exhibition. Responses across survey instruments and method were very consistent.

Summary of Findings and Recommendations

Introduction

The Maryland Science Center hosted hourly free presentations using Science on a Sphere during the days of the SOS exhibit. Presentations were announced 15 minutes prior to the start of the presentation, and varied in length from 20 to 40 minutes.

The Sphere was located on the third floor, near a group of interactives and on the other side of the floor from the children's room. Although the Sphere was not located in a part of the science center conducive to visitors spontaneously joining presentations, visitors did occasionally do so, or return for a presentation after seeing the Sphere.

The Sphere was located in a relatively cool, quiet, dark corner of the museum. The projector stands acted as unintended benches for visitors to sit on both during presentations, and frequently to stop and relax while watching the globe "turn" between presentations. A few visitors commented that they would like seats all around, or "better seating"; and a few others suggested a darker room. There were also a few comments that the PA announcements were distracting. While these are all suggestions for ideal conditions for placing the Sphere, nothing about the Sphere's placement at MSC detracted seriously from the experience.

Presenters

Five different presenters gave presentations during this time. This included three presenters from NOAA and two from the Maryland Science Center. NOAA staff presentations followed a shared script, using the same sequence of databases. The programs conducted by MSC staff covered areas in the presenter's expertise.

The NOAA presentations followed a shared script. These programs included images of Earth's topography and the lights at night, global weather showing the formation of storms, several decades of surface water temperatures depicting *el niños* and *la niñas*, views of the surface of the Sun, Moon, Mars and Earth (NASA's "Blue Marble" view of Earth as seen from space), and concluded with an animation of 600 billion years of continental drift. Some presentations also included a projection of future global warming. The NOAA presenters covered largely the same information, though each presenter had a distinct style and sense of humor, and varied to the degree to which they shaped their presentations in response to particular audiences. These NOAA presentations constituted the far majority of presentations conducted over the two-week period.

Presentations conducted by MSC staff members covered two sets of topics – one focused on Earth's topography and geography and the second on the solar system. The first used data sets depicting Earth during the daytime, with the Earth's topography highlighted on one side, and lights at night on the other, thermal data depicting storm formation, continental drift, and finally the Blue Marble. In this presentation, the facilitator played with the tilt of images of Earth, allowing viewers to get a clear view of both poles. The solar system presentation began with the view of Earth from space, then two different kinds of imaging of the Sun, the Moon, Mars, Venus, Jupiter, Io and back to Earth.

Although evaluation questions did not directly ask about the presentations or presenters, there were several comments on both. Visitors appreciated having a live presenter and found it helpful for focusing. For instance, one viewer wrote, "The presentation helps focus your eye and mind. Even so, it is awesome even if you are just looking at it." A number of visitors commended the presenters for their knowledge of topics covered, use of humor, and attentiveness to children. One viewer wrote, "The interpreter was excellent!! He is very knowledgeable and communicates very well. Maybe a waste of time with no interpreter." These two quotes were unique in praising as well the value of having a presenter for making sense of the images on the Sphere.

Level of Engagement

Structured observation of Sphere programs during the opening and closing days of the exhibit, as well as visitor comments suggest visitor engagement during presentations was very high. Maryland Science Center staff had originally planned on 20 minute presentations, but when the NOAA staff held audiences for 40 minute presentations, that became the norm. Presentations were free and maintained a constant number of visitors – with the few who left during a presentation replaced by others who joined. The far majority of individuals who began a presentation, stayed through to the end. In most cases, people were engrossed throughout. In one case, two presenters did back to back presentations lasting nearly 2 1/2 hours. Some visitors stayed over an hour, and others came and went to catch pieces of more than one presentation. Visitors often asked questions, and after almost every presentation, visitors stayed to talk either about the technology, the Sphere's value as an educational tool, or about the content of the presentation.

Parents and teachers frequently commented on how engaged their children were throughout the demonstration, which was generally longer than what they had come to expect in the Science Center. One parent was impressed that "My kids held on for 30 minutes." Another parent described how the Sphere had captured the attention of her twelve year-old son. "My son was feeling bored when we were going through some of the rest of the museum. He didn't want to come today. He sat through the sphere exhibit spellbound."

All of the classroom groups observed were highly enthralled throughout the forty-minute presentations. In these programs, the facilitator did tailor the content and level of interactivity (asking questions) to the school group. In any case, teachers were impressed. "They were into it," noted one teacher, "even some of the more active ones."

Very young children were the most difficult audience members to hold. In several cases, one parent left with a very young child (varying in ages, but often under 6 years) and could be seen at the interactive exhibits just beyond the Sphere area, while other family members continued with the presentation. When there were a sizeable number of children in the group, some of the presenters kept children engaged by asking questions of the audience throughout the program.

There was little communication between visitors during the presentations. One notable exception was observed. A presentation about Earth's topographical features, with a slowly revolving earth, inspired considerable pointing and discussion among visitors. A

combination of the slow spin of the globe and the discussion of a familiar topic - Earth's topography - seemed to offer an experience that the viewers could participate in and share information among themselves.

Presenters asked audiences to move around the Sphere several times during the course of the program. In most cases, visitors responded positively to this, both in action and in their comments. For instance, a group of fourth graders said they, "liked moving around the globe, it was fun to look at." A few were not as comfortable moving about. One visitor commented, "Like sphere - didn't like having to move - wanted to sit down." On occasion, visitors simply chose not to move.

Sometimes a particular image or data set would inspire even those passive audience members to rejoin the group at a particular vantage point. Images of the formation of Hurricane Isabel, which had hit Maryland the previous summer, was one of these. Segments of the continental drift animation were also captivating. For instance, two young boys were sitting on the sides, but when the presenter started talking about an asteroid striking the earth during the time of the dinosaurs, the boys moved from their benches to look at the image of the asteroid's impact. In another case, a couple who had been relaxing on the side got up to see the formation of North America during the plate tectonics demonstration.

Visitor Ratings

Visitors responded very positively to Science on a Sphere. On a 5-point scale from poor to excellent, an overwhelming 98% of visitors across all age groups, rated the sphere as either very good (67%) or excellent (31%). Less than 2% (6) gave the Sphere a rating of Average and less than 1% (1) gave it a rating of Fair. A detailed chart of responses is included in Appendix B.

First Impressions

Responses to the question "what most impressed you about the Sphere?" offer an overview of viewer reactions to the Sphere presentation. Responses to this question reflected three main themes heard throughout the evaluation. These include appreciation for the Sphere as:

- an innovative piece of technology,
- an aesthetic experience, and
- a versatile educational tool for adults and children.

Sphere Technology

Visitors were very impressed with the technology of the Sphere. One exclaimed that "The technology is amazing!" and another said, "Magnificent! How do they do it? I spent some time trying to figure out how it's done." Other visitors marveled about "The dynamics of setting it up and getting it perfectly placed to effectively show the presentation," and "that two thin wires could hold a sphere that size." They were impressed by "how you can project something onto a sphere," "the ability to see

everything to scale," and the resolution, clarity, color, and ability to depict historical change.

Others commented on the way in which the projections were made to appear realistic, and were impressed by "How it looks like it rotates," and "How it was exactly the same tilt as the earth." "At first you think the globe is moving. But it's not. It's definitely different…Good not to have distortion." One visitor described the Sphere as "modern" and "up to date." Many more responses dealt with the unique ways in which data was visualized on the Sphere. These will be addressed in a section below.

Aesthetic Experience

While many of the children spoke of the Sphere as "cool," adult visitors described the Sphere as "beautiful" and "riveting." "The beautiful colors [are] like an abstract painting. The globe is gorgeous to look at," "It's so amazingly beautiful and we are SO small in the scheme of things!" "Beauty, reality, content, storytelling by the presenter. Comparisons. History. Scale. Simply awed," wrote one visitor. While another explained that she was impressed "Simply by the idea of it - never seen anything like it! I'm not even much of a science person - it's just very cool." One visitor suggested "I think you should have a cocktail partly around it. It's very engaging. It moves." Others noted that it appeared to float in mid-air.

Even outside of formal presentations, visitors often stopped to rest and watch the "Blue Marble," global weather data, and other images. "It's also very relaxing to just look at it," commented one such itinerant visitor. A few visitors described the Sphere as "tangible," "Much more comprehensive and tangible," "It think it becomes very tangible to see the actual planets rotating." This tangible experience of the Sphere was reinforced by the numerous passing children who ran up to the Sphere to touch it, to the chagrin of NOAA staff. Another visitor described the experience as "intimate."

Educational Tool

Across all age groups visitors mentioned the educational value of Science on a Sphere. Among the many visitor comments were that "It makes the images more relevant," "I think it is a great educational tool," and "It shows dynamism, complexity, weather and economic development. Very informative and insightful." One visitor was impressed by "The amount of scientific information that was presented," and another noted that "It's a great visual learning tool."

A few of the more extensive comments gathered in interviews suggest the enthusiasm of educators and some of the myriad ways they were imagining using the Sphere. A former aerospace engineer from Arizona, who will be teaching high school in the coming school year, was very excited about the Sphere as a learning tool. He said, "There is so much there to learn. So much of presentation you could focus on - Mars, Sun, history of Earth…." He found it helped him to understand his local weather, "Watching weather over Arizona vs. other locations, you can see why Arizona is desert." And said he "would love to be able to take a group of 7th and 8th graders… This would stimulate kids."

A educational grant writer in Texas marveled at her own daughter's learning, explaining that "When he [the presenter] held up the nickel [demonstrating the relative sizes of the

Earth and Sun], my daughter said, "Think how small we are."" She felt that this lesson in perspective would be valuable for the inner-city students she works with in Texas, and said "We have inner city kids. The Sphere would help them to see outside of their world - help them to see beyond Waco." She recognized, however, that the program would have to be more interactive to hold the attention of the students. She also shared a number of ideas for how to use the Sphere for a GPS data project. She marveled, "To hook this up to geological and cultural systems data would be cool. With global information systems, you can show whole civilizations growing. Could show it on this. Could combine this with global positioning system activities. Kids would make a cognitive leap."

Another teacher was enthusiastic about using the Sphere for teaching Earth Science as well as biology and chemistry. She suggested the integration of children's animated characters as a way of appealing to very young children. "You could have the Magic School Bus which just had an episode on Venus, for school presentations to reach the age of kids like her 5 year old."

One teacher suggested more lessons/more information, including a lecture on all four oceans. "Make it more interactive, visual aids of dinosaurs etc for changing earth."

Versatility: Visitors were also impressed by the versatility of the Sphere. Some of these responses noted the "Richness of the technology and data sets presented," "The ability to show many different topics and time periods," "The way it could be used to show various data sets in their native global format," and the "Ability to switch views and interactively observe events and objects, planets, and their atmosphere."

Responses to the question of what impressed visitors most about the Sphere also included a number of mentions of the knowledgeable presenters and appreciation of having a live presentation. Many visitors also mentioned particular images, data sets, or facts that they were particularly impressed by. These are all addressed in subsequent sections.

Overall, visitors were very impressed with the Sphere. Many took still or video footage of the Sphere. One of the children interviewed liked the sphere so much that he said "I want to come for my birthday."

Most Memorable Image

In surveys, visitors were asked to name the image most memorable to them. Virtually every data set was mentioned, suggesting that all of the data sets were of interest to at least some of the visitors. However, some data sets, particular facts, and images stood out for large numbers of visitors. Keep in mind that the various programs included different data sets. For instance, with the exception of the presentations exclusively on the solar system, the continental drift animation was given considerable time and shown three times in most presentations, while images of other bodies in the solar system were covered relatively quickly compared to their treatment in the presentation exclusively on the solar system. Thus the different numbers of people listing each segment doesn't necessarily mean that some images are inherently more interesting than others, but may reflect the varying amounts of time and attention given to them in different presentations.

Continental Drift: Almost one third of the visitors mentioned the animated sequence on plate tectonics in response to the question about the most memorable image. As one

viewer wrote, "The most memorable image was rather a series of images – the animation of plate tectonics and continental drift through millions of years. It gave an easily understandable, broad view of continental drift." The combination of a global view, with a historical view - "Pangaea to the present day" - and the visual excitement of seeing such dramatic change in the Earth's plates were all factors in making this memorable. . Several viewers mentioned in particular the visualization of time. Some of these comments included, "600 million years to present! Time-warp – one of the best learning tools I've seen," and "The continental drifts. Just seeing them. This is 3-D (vs. map). Books are books. You see it – passage of time." This sequence was mentioned in response to questions about what most impressed visitors, and what they learned, as well as the most memorable image.

Responses throughout the surveys also noted specific occurrences in the plate tectonics animation, such as "Indiana moving," and "India crashing into Asia." Also of interest to many visitors was the discussion of what the Earth looked like in the time of the dinosaurs, the story of the comet crash during that time, and changes in Earth's vegetation. Interestingly, none of this information had visual components, yet were mentioned throughout the survey responses.

Global Warming: The global warming data set was the second most frequently mentioned in response to the question of most memorable image, but also came up as a significant area of learning, and as what some visitors found most impressive. A group of students gasped as global warming was projected into the future. One viewer wrote, " I learned how global warming will affect the earth in 500 years." Other viewer comments suggested concern with the implications of what they saw, "How global warming is a reality and will have scary consequences." And the display left one viewer wondering, "If we know about global warming, why isn't anything done about it?"

Weather: Also frequently mentioned were the images of the weather, including the formation of hurricanes and specifically of hurricane Isabel. Several mentioned the image of "Storms forming in Africa," and "The storms coming across the oceans." Several others mentioned being impressed by the ability "To actually see weather systems in real time." Also mentioned were the images of *el niños*, and *la niñas*. A discussion with one of the visiting class teachers spoke to the memorable storm images. She said the presentation was good for her students. In particular, "The model of Earth and tracking storms is good for them. They'll remember the eye of the storm. It was a great experience."

A number of visitors in both interviews and on surveys were taken by a range of images, and could not pick out a particular image as most memorable. Some of these comments include "All of the images were fascinating," "All of them were great," and the "Entire presentation was interesting."

Earth at Night: Smaller numbers of people mentioned the image of Earth at Night – "The way it showed the earth at night and how the light on earth can be seen in space" and were impressed by the mapping of human use of electricity. "The presentation was very thorough. The human use of electricity was mind blowing."

Mars: Several visitors mentioned images of Mars as among the most memorable images. Several noted in particular the large canyon and mountain described in presentations and

compared with features on Earth. Others mentioned the poisonous gas on Jupiter. The Sun, other planets, and moons (Earth's and Jupiter's) were also mentioned, though noting somewhat less detail. This may be because with the exception of a few presentations exclusively on the solar system, these images constituted a much shorter portion of the presentation.

Visualization of Data on the Sphere

Visitors were asked "What is the point of the Sphere?" This question was meant to get at whether visitors understand the purpose of the Sphere and its unique value in visualizing data. Visitors unequivocally grasped the unique ways in which the Sphere allows for data to be presented, and expressed it through a variety of phrases, capturing the significance of the imaging on the Sphere through contrasts with other media. Some offered a broad view. For instance, as one visitor stated, "It gives a different perspective that you can't get from other media." Others found more detailed ways of describing the imaging. And some found social and political meaning in the global views.

3-dimensional views: The most common term to describe the uniqueness of the Sphere's imagery was to call it 3-D and to contrast it with "normal" 2-D views of maps and videos. "The point of the Sphere is to give the audience a 3-D image of the information being relayed. It's more lifelike," "It makes the images normally portrayed in a flat, 2-D manner more tangible, thus making them more "real." "Sphere approach makes presentation much more "actual" – as the components of the solar system really are huge steps beyond flat screen approach which we've seen all our lives."

Realistic or "alive": As noted earlier, visitors commented on the movement, color, size and detail of the imagery, as well as the tilt, rotation and ability to see planetary features to scale. Numerous visitors described the Sphere's imaging as "more realistic" or "lifelike." These included comments such as "It gives a more realistic impression of the planets, moon, sun, etc," "You get to see things like they are," and "It brings the image to life." It also "reflects how alive our planet is." "It's more like real life with the sphere." "Shaped like Earth – realistic perspective of relationships." "It gave us a real feel for the shape and events happening on the surface of the planets."

Lack of distortion: Visitors spoke of the lack of distortion of the images on the Sphere, and contrasted them with a map or video. "On a map or video, you can not walk around the image and [on the Sphere] the image isn't distorted. The point of the sphere is to teach people about Earth in a new and innovative way." "One is really seeing the true shapes and sizes of images opposed to flattened distorted images found on 2D maps and computer screens."

Global views: Visitors spoke about seeing the whole planet and the whole picture. Some of these comments include: "You can actually see all around," "You can view the earth in its totality," and "Map doesn't show other ways around. Globe shows it better than a flat map." Many viewers commented on the particular systems for which it was valuable to see a global view. These include, "Gives a world view of geological phenomena," "Gives full view of planet weather, plate shift," and "Very realistic – Can't possibly present this on a flat surface – i.e. night and day."

Global interrelationships: Visitors noted that the Sphere "shows the relationship of events on Earth," provides an opportunity "To represent various interactions (weather, electricity, topography) involved with the planet," and "To understand how connected the earth is; to demonstrate that to people. The sphere allows you to see the interaction of weather around the globe," And "The way weather patterns move from the equator to the hemispheres."

Several visitors believed this global perspective valuable: "Global perspective is new and important in a nationalistic society," And that it's "Good to get out of the North America – the storm systems begin in Southern Hemisphere. It shows that what happens on other continents affects us." Others noted that it provides context, or the big picture, "Ability to visualize effects on a global basis. The big picture."

New Perspective: A number of visitors described the Sphere as providing a new perspective, suggesting that the images projected on the Sphere challenged how they see the world. Several visitors likened this to seeing the view of an astronaut. One student noted the value of this view, "being an astronaut allows you to see these things, how it rotates, electricity at night – we use a lot of lights, volcanoes in the ocean." Another visitor said, "With the "Earth" suspended in "air" it felt as if I was in "outer space" looking in."

In some cases, visitors noted simply the value of having things visualized that hadn't been visualized before. An 8th grade teacher explained that her students "Knew about Earth's formation billions of years ago, but it was new to see it. Also new was how the earth looks at night, and how people use electricity." She continued that it in fact answered questions children had previously asked. She said, "The visual is good for them. To see from the astronaut's view. "What do they [astronauts] see?" That's a question I've had in class… Seeing nighttime and daytime is interesting.

In addition, a few visitors noted the value of having time and space visualized, such as the visitor who was impressed by, "The perspectives over time and the spatial perspective ("the big picture")."

The Local in the Global

While noting the value of a global perspective, visitors were often drawn to images of places with personal relevance. Maryland visitors generally marveled at seeing the path of hurricane Isabel, while visitors from Burma to Arizona eagerly looked at weather patterns near their homes. Another visitor commented on the highlighting of Indiana in the plate tectonics animation, and noted the value of having local places noted. " [The Sphere] is unique for getting a world wide perspective, though it's always good to point out particular places. [In the animation of continental drift] show Maryland not Indiana"

Other viewers found relevancy and connection based on criteria other than place. A woman who commented on why she selected Mars as among her favorite images noted it was because Mars had been in the news recently. She explained that she had difficulty choosing between Earth and Mars as her favorite image. First she described what appealed to her about the image of Earth. "For Earth, you get so caught up in your life - I live in Maryland. When you see the Earth so far away it puts life into perspective. You see the whole thing you think about all the wars going on… This is 3-D and puts it more

visually into perspective." In contrast, her connection to Mars came through following events in the news. "When we look at Mars it's interesting because of the activity going on with the Rovers." These comments suggest that specific details provide a focus, relevancy, and personal connection within this global view.

Would Recommend to Others or Return

Visitors overwhelmingly said they would recommend the Sphere to others, or return to see other presentations. A response from one of the students visiting with his class was, "Yes [I would return]. It was awesome, coolest, the best." Other visitors said they would return because "it gets you up and about to view the various quadrants of the sphere rather than just lectures you while you sit in one spot," and "Absolutely! Very visually stimulating from a macro/"God's-eye" view of the world." And one young woman said simply, "It's bitchin'."

Several also gave it superlative ratings among museum exhibits, including "Yes, it's informative. The magnitude, the size of the globe is impressive. This is one of the best exhibits right now," and "Best presentation I have seen in any museum in quite some time." Others spoke of how the information came to life. "Definitely - makes history and general conditions of earth come alive," and "Absolutely. Brings science to life."

The most common responses were that the Sphere is interesting and informative. A few of these many comments include, "Absolutely - it's phenomenal," "Yes, superb instruction," "Yes - extremely enlightening and educational. This variety of information is amazing!," "it is much easier to understand complex ideas with visual pictures and a live explanation," and "Yes, because it is very informative. This sphere that constantly changes, goes back in time, can predict the weather, changes from earth to Mars and I've never seen anything like it before. It's awesome."

Others elaborated on the educational value of the Sphere in being able "to see these things up close. A typhoon actually forming, landmasses forming, differences among planets, etc. Great idea for presenting a lot of science," and to help "people to actually feel the changes that planet has gone through."

Several said they wanted to return to learn more. For instance, "Too much to see in one visit," "a lot of information to absorb - would retain and learn more if repeated," "[would come back] just to keep learning, lots of information, and it was very cool to watch," and "Would come back as often as possible. Wonderful learning experience."

Visitors felt the Sphere provided a valuable learning experience for children and adults. They said it was "Very educational for all ages," "[an] excellent tool for children. Brings all the data to life," and "This is excellent material to understand the earth and Mars! I am not good at the science, but it's easy to understand for me! You should show all children in the world. Everyone loves it." Others mentioned with whom they would return. "This time I would bring children especially, so that they could see how everything is connected," and "I would bring my Earth Science class to see this."

There were a few negatives. One visitor said, "It is entertaining but not factual." And another said they would come back, "but would prefer home computer version." And one student said he wouldn't return "because we do not need to know all that stuff yet."

Learning

When asked about what they had learned, several individuals in both written surveys and interviews following presentations were unable to specify particular things they learned or overwhelmed. Some of these comments include, So much - absorbed like a sponge - will have to take time to decipher," "Quite a bit too much to list. Maybe a prop(s) to help illustrate the scale - the earth is so large and the time covered so vast. It is a GREAT IDEA/exhibit," and "Too much to list here. The earth to sun perspective. Information on Mars. Formation of the various countries. Explanation of why the crust moves."

Some provided lists of what they had learned and mentioned disparate ideas from several different data sets. One wrote "Clear view of Pangaea and movement of plates through time. Weather near the South Pole is really turbulent. South Korea has a lot more electricity than North Korea. Denver was underwater around the time of the dinosaurs," and another," and another recalled the following: "I never realized the degree of movement of the continents. That there's water on Mars [at] the Polar Ice Cap. Some of the details - long canyon, high mountains, hot spots." One woman contrasted the things her daughter learned, " about Mars and weather on earth" and the things she had learned," about the sun's weird rotation pattern."

The animation of plate tectonics was again mentioned by a large number of visitors, followed by global warming, weather, and features of the solar system. Visitors comments suggest that they learned big ideas, mechanical explanations, and gained an ability to visualize global views, time and scale, and scientific events. These are described below, with examples drawn particularly from the plate tectonics animation.

Big Ideas: Visitors gained an appreciation for the earth as dynamic, and made comments such as that "The Earth is always changing," and "The earth is constantly evolving."

Mechanical Explanations: Visitors commented on gaining new understandings of things like how the continents formed, "Seeing the continental drift and the "million years ago countdown" - it explained the concept to me, for once it was clear!," that " The world is liquid rock and how the world was long ago," "The way the continents moved through the years and what happened to the life on Earth," and "Why Mt. Everest is getting higher."

Visualization of global views: Visitors noted visualizing a variety of global views and processes. This included global views of geographic features, "Pacific Ocean covers nearly half of the planet," storm patterns, such as "liked seeing the storm patterns – can see where the storm activity is. Parts of the world get more, I can't say enough about it," and "Didn't know where all the storms came from, where weather patterns come from," among other images.

Visualization of time and scale: Several people noted that they were unaware of plate tectonics prior to Pangaea, "Didn't know there was a continent before Pangaea," and others noted the extent of continental movement, "I never realized the degree of movement of the continents," and "Earth movements over time have been much more dramatic than I realized." Visitors noted learning about scale in relation to some of the planetary comparisons, "I learned how big earth is compared to the sun," and they also

realized the scale of global warming, “I learned about the degree to which the Earth is getting warmer, which was the most impressive for me.”

Visualization of significant events: Visitors noted that the Sphere helped them to visualize a variety of events, including “what earth was like long ago and prognosis to come and why,” “What land masses looked like in prehistoric times,” “Extinction of dinosaurs. It was very photogenic in regards to how comet hit the earth. Easier to understand when you saw it on the globe,” and “How the world was 600 million years ago and also where Indiana was located.”

Particular facts and specific examples: There were numerous facts and specific examples mentioned by visitors, including “That India "crashed" into Asia,” “That the Earth got as cold as it did during the Perma-extinction,” that “Indiana used to be underwater and the Niobra Sea was much bigger than I thought,” and “that Mars has a North Pole made of ice.”

In some of these cases, visitors were struck by aspects of the visuals that were not specifically articulated by presenters, such as the amount of plate movement over the 600 billion years of Earth’s history, while in other cases they picked up on particular details mentioned by the facilitator. For instance, individuals mentioned the formation of the Himalayas, watching Indiana move, India crashing into Asia, following Hurricane Isabel and the size of the Valles Marinas canyon.

Interestingly visitors consistently incorrectly remembered the time span of the plate tectonics animation. They consistently wrote that the animation depicted 600 million years, when in fact it depicted 600 billion years of continental drift. It is unclear what exactly led to this confusion.

Comments and questions during and after the presentations suggested how closely visitors were listening to the presenter, and following the imagery on the Sphere. For instance, a little girl asked at the end of one presentation whether Mt. Everest will ever get high enough to fill the Marianas Trench, piecing together disparate bits of information provided in the presentation.

Clarity

In response to a question whether there was anything confusing in the presentation, the responses were overwhelmingly no. Many stated that the presentation was clear. In every presentation, visitors freely asked questions, and some even commented on written surveys that they had no questions because they had been able to ask them directly. “The presentation was not confusing -- answers (to our questions) were immediate” A teacher noted, “The presenter answered questions well and gave good information. It was clear. He respected kids’ questions and had a good understanding of kids.”

In a few cases, visitor comments suggest that they were initially confused by a visual, but a satisfactory explanation had been provided by the facilitator. These comments include, “Weather patterns - but it was explained,” “Temperature rise because of CO2 over the next 140 years - but then he explained it more.”

Two visitors noted that the representation of elevation on the Mars image was counter-intuitive and though they understood the image, felt it was worth pointing out. “One

image of Mars looked reversed. Meaning high areas looked depressed and low stood out." This was the only misleading visual noted by visitors.

There were a few remaining questions which visitors indicated on surveys. One visitor wrote "*El Niño*- What is it exactly?" and "What was confusing was the thing of the hurricanes." Another visitor seemed to want more in-depth explanations, and wrote, "Yes. About as informative and simultaneously confusing as weather descriptions on TV. Too much, too fast, without making clear what is happening, what the causes/effects are."

A few visitors questioned some of the scientific data presented, particularly the reconstruction of continental drift reaching back 600 billion years. For instance, ""Scientific" theory of continental drift reaching back more than 200 million years seems to be reaching too far."

One noted that the presentation would have to be changed for children, "The information shared verbally was very geared to adult language and understanding. To make the exhibit more interesting to kids the information needs to be refined some to their level."

Suggestions for Modifications

In an effort to see how visitors could imagine changes in the presentation, or if they considered other interactive modes for the Sphere, visitors were asked what they would do if they could control the images on the Sphere. "Would they slow them down, speed them up? And what else would they like to see?"

There was little consistency in their responses. Visitors were divided between those who said the image speed was good, or wanted either faster or slower images. In some cases they suggested that some images should be slower and others faster. There were a handful that requested that the images of weather be speeded up to highlight patterns, such as: "I would speed it up, especially the weather to see patterns or irregularities. It would be interesting to have more pictures to see different occurrences at different times. One visitor suggested slower animation in the recent years of Earth's evolution. "I would like to see the images change over shorter time periods as it nears present day (i.e. - instead of 1 million year increments, go by 50K increments for past few million years, then 5 K increments, so can see effects of recent ice ages, human development, etc."

Visitors suggested a number of other modifications to the images. These included repeating images, tilting images, and zooming in or augmenting with illustrative images. These are described below.

Repeating Images: A few mentioned the value of repeating or stopping animations, as presenters did, frequently in the tectonic plates demonstration, but in others as well. For instance, "Replay them and include maybe some more pauses."

Tilt: Others noted the ability to tilt images and suggested incorporating this effect to a greater extent. "Be able to tilt the images on the earth's axis for a different perspective." "Rotate the image so all sides are seen."" Bring the poles to the side (so equator runs N to S) for some of the views." This was in fact done in the presentation on Earth's topography.

Zoom: Several recommended zooming in on geological features or providing additional information through close up shots. A few of these comments include: "I would zoom in to see evolution and weather," "Could one zoom in on various parts of the planets? Heavenly body anatomy from core outwards - possibly on display on walls as posters or diagrams," "Zooming features - zoom in while rotating. Zoom out while rotating," and "Any possibility to zoom in? That would be interesting. I like geography so continent identification is possible."

Height of Sphere: A few viewers suggested placing the sphere closer to the floor. One explained that this would make the Northern Hemisphere easier to see.

Selecting Images: Only one visitor suggested including the ability of visitors to select images.

Content Suggestions: Visitors made a number of suggestions of additional images they would like to see. These included requests for additional planets," How storms and other weather patterns develop, more detail of ocean depths," "Ice cap melting and coastal changes," and "real-time earthquakes." Also mentioned were "global warming trends going back in history," "images of life on particular continents," "View of spacecraft in space near earth," "more about U.S. geography," and "projected continental drift." Another visitor suggested that "It might be interesting to see how pollution travels around the globe and ozone depletion."

One of the visiting teachers suggested she "would like to see pictures about under sea volcanoes and landforms, fish related to particular undersea landforms. Connect the Maryland curriculum and images they are used to with what they see on the globe. What would landforms actually look like?"

And several visitors indicated that there was "Too much to list."

Other imaginative suggestions from viewers included "If the sphere could grow into 3-D…." and "Imagine an all-solar system built with spheres."

Satellites and Imaging

There was a striking absence of mention in the surveys of either the satellites which had been used to collect data or the production of the data sets in use. This was despite the fact that the satellites were mentioned in almost every demonstration, and in some cases different satellites and kinds of data were discussed. Further, a handful of comments suggested visitor assumptions that real time data is accessible for weather and other displays. Visitors appear to take the availability of this data for granted. The realism of the images may contribute to this view. The only data set which visitors even mentioned was the entirely computer-generated animation of continental drift – one which visually looked like an animation rather than a realistic image.

These observations suggest some challenges for presenting the Sphere and possible content for accompanying kiosks or materials. Both the challenges to collecting appropriate data and the manipulation of the data to create realistic looking images could be addressed. During a 25-minute presentation for a school group, many of the students' attention began noticeably to drift during an explanation of satellite and data collection. The images on the Sphere are so compelling, it will be a challenge to deliver information,

such as that about the satellites, that can hold up to the images on the Sphere. Visual images of the satellites might be one way of reinforcing their importance and developing a more lasting impression. In fact, a MSC staff member suggested hanging "a geosynchronous satellite at appropriate distance from Sphere."

Presenters noted NASA's Blue Marble inaccurately presents an image of Earth entirely in daylight, in contrast to the representation of the Earth in which one side is in daylight and the other in darkness. Information about the different kinds of satellites, photography, and imaging used in creating the images could all be addressed in ancillary panels or kiosks. For instance, supporting information might include examples of various forms of satellite photography, computer graphics (plate tectonics), color highlighting of topography, and discussion of the various ways in which models represent and distort the truth.

Conclusion

Comments throughout the surveys reflected visitors' enjoyment of the experience and suggest that it was a rich and successful learning experience. Visitors described the exhibit as "cool," "riveting," "fantastic," "fascinating," "magical," "phenomenal," "informational," "educational," and as the "best in the museum." Visitors appreciated the Sphere as an aesthetic experience, a piece of innovative technology, and as a compelling and versatile educational tool for children and adults. Visitor engagement in the presentations was high.

The Sphere powerfully demonstrated the different sides of celestial bodies, such as near and far sides of the moon; and Earth's hemispheres in darkness and light. In all presentations, viewers were impressed by explanations of relative size, such as comparisons of the Valles Marineris on Mars, and the Grand Canyon on Earth, and of the sizes of the Earth and Sun.

The presentations were effective in conveying a range of levels of scientific ideas and facts, from big ideas about the Earth as dynamic, to memorable details such as the poisonous gases of Jupiter. Visitor responses to the presentation of scientific information on the Sphere suggests its strength for introducing global contexts for understanding local issues, understanding global interconnectedness of a range of social and natural phenomena, and presenting global transformations through time.

Visitors commented on the variety of data presented and the many possibilities for other presentations. Teachers imagined a number of possible uses of the Sphere, including conveying ideas in Earth Science, Chemistry, Biology, Astronomy, and Geography. And had novel suggestions from integrating animated characters to designing activities using global positioning systems.

Visitor expectations of what kinds of imaging can be shown are high. In several cases visitors seemed to assume that real time data is readily available. They could also easily imagine the representation of a wide range of geological and social images and processes.

Visitors greatly enjoyed the live presentation, praised the knowledgeable presenters, and the opportunity to ask questions. The presentations were well-crafted; information needed to explain the images on the Sphere was an integral part of the narration. Furthermore, elements like color were effective in highlighting topography, changes in sea

temperature, and other features. The only visualization which visitors continued to struggle with was the representation of altitude on the image of Mars. However, without a live presenter, there may be much more need for supporting information.

In all but a few cases, visitors did not seem concerned by their lack of opportunity to control the Sphere themselves. On a few occasions, when the group was small, visitors were privileged to a more interactive experience, and presenters pulled up data sets in response to particular questions and interests.

Science centers may want to consider automated demos. Depending on the complexity of the text, these would likely require arrows or boxes on the projected images to draw viewers' attention to local events and features. This would of course, take away from the aesthetic experience and sense of transport.

There were as well visitors who enjoyed the aesthetics of the Sphere and found it restful. If the Sphere is located where visitors are passing by it might be valuable to have data sets that are understandable and enjoyable without a presenter, and with no or minimal supporting information on kiosks or displays. This might also be a time to give visitors the opportunity to control the images on the Sphere in a limited way – selecting from a choice of easily understandable data sets, such as Earth's topography, and allowing visitors control of the speed of the images.

From comparisons of the 3-D view to those of ordinary 2-D views, to descriptions of seeing the view of an astronaut, visitor comments suggest that the Science on a Sphere's imaging provided a provocative and challenging experience. Viewers experienced a fresh perspective. A number of visitors further saw scientific and political significance in this global perspective.