

# ***WINDOWS ON EARTH:***

Center for Earth and Space Science/TERC  
Cambridge, MA

Summative Evaluation Report  
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***P***ROGRAM ***E***VALUATION AND ***R***ESEARC***H*** ***G***ROUP  
AT LESLEY UNIVERSITY

Windows on Earth  
Summative Evaluation Report

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# CONTENTS

**INTRODUCTION..... 4**

Project Description ..... 4

Evaluation..... 5

**FINDINGS ..... 10**

**MUSEUM EXHIBIT ..... 10**

Visitor Experiences ..... 12

Partner Museums..... 25

**WEBSITE..... 29**

Introduction..... 29

Viewer Experiences ..... 29

**CHALLENGER CENTER WORKSHOP ..... 37**

Teacher engagement at the workshop ..... 37

The impact of the workshop ..... 38

**SUMMARY AND DISCUSSION ..... 40**

Museum Exhibit..... 40

Website..... 44

Comparison of Visitor Options..... 45

Challenger Centers ..... 46

# INTRODUCTION

## PROJECT DESCRIPTION

Windows on Earth (WinEarth) is a project funded by the National Science Foundation to “help people see Earth in a new way and [help] museums integrate visualization technology.” (Project proposal)

The Center for Earth and Space Science Education (CESSE) at TERC has led the project and worked with several development partners on the images and visualizations, software, and design for the museum exhibit components. TERC also worked with four museums in the development and evaluation process—Boston’s Museum of Science, (MOS), the Smithsonian Air and Space Museum, (A&S), the St. Louis Science Center (SLSC), and the Montshire Museum of Science (MM) in Vermont. The project also coordinated some programming with the Challenger Centers.

Windows on Earth’s original goals were to present high quality images of the planet and to create engaging Earth visualizations related to the astronaut experience based on new digital imaging technology. In addition to the museum component (with the help of supplemental funding), the project created a website in order to provide more in-depth opportunities for viewing and interacting with these images. The website features photographs from the 2008 Garriott space mission, when Richard Garriott used technology developed for Windows on Earth to help locate particular geographic targets to photograph while orbiting the Earth on the International Space Station (ISS).

The museum exhibit consists of a component with a large screen and high quality images of the Earth, which simulates the view from the space station. Navigation tools include a joystick, zoom buttons, back to start button, and touch pad map, as well as buttons to enable visitors to add information about borders and cities, elevation, night-lights, and clouds. An information band at the bottom of the large screen provides some information about locations on the screen. Animations about Earth processes are also part of the software. There is some customization of content at different museums, such as where the ‘back to start’ button goes and higher resolution images around the home location.

The WinEarth website allows viewers to follow the path of the actual International Space Station, to ‘go anywhere’ along the orbital paths, and to see photographs at different resolutions that have been taken from the Space Station. The website also compares photographs from the same sites taken 35 years apart, in 1973 and 2008, by Owen and Richard Garriott, a father and son pair. In addition, there are links to other resources for educators and information about the museum exhibits. There are also ten brief animations, which display information about various Earth processes, such as the

formation of the Great Lakes, the formation of the Hawaiian Islands, and the development of oxbow (U-shaped) lakes.

## **EVALUATION**

### **EVALUATION APPROACH**

The Program Evaluation and Research Group (PERG) at Lesley University was contracted to provide both formative and summative evaluation work for WinEarth. The evaluation plan was developed in conjunction with project staff, and revised according to changes in project activities and timelines. The evaluation's focus included the museum component and the website, but not the development process itself. The project-related work at a Challenger Center, which consisted of one professional development workshop for teachers, was also included in the evaluation. Prior evaluation work supplied formative feedback for the project. This report provides a summative evaluation for the Windows on Earth project.

The primary evaluation questions addressed in this report are:

- What is the impact of Windows on Earth museum exhibits, website, and activities on the knowledge, attitude and behavior of users related to:
  - Spirit of exploration
  - Visual literacy
  - Earth literacy
  - Planetary stewardship
- How does the experience of Windows on Earth compare across the museums in terms of goal outcomes, visitor engagement, contextual factors, development process, and impact on each museum site?
- How do the different types of options for visitors/users compare? What are the key benefits and challenges of implementing the project within different settings?

### **DATA COLLECTION AND ANALYSIS**

Data for this report was collected through observations and interviews with visitors at the Museum of Science in Boston, the Smithsonian Air and Space Museum, and the St. Louis Science Center as they used the museum exhibit and immediately afterward. The website data was collected primarily at the MOS with visitors who were asked to use the site. Some data was also collected at the Montshire Museum. (The exhibit was not finalized at Montshire until shortly before the end of the project, which did not leave time to gather or analyze visitor data. Evaluators visited the exhibit there in order to understand the context, and to observe for any obvious differences in visitor experiences at that site.) In

addition, evaluators observed a Challenger Center teacher workshop, interviewed teacher participants, and interviewed administrators at each of the four museums as well as key project staff. (All protocols are available from PERG.)

After piloting several interview protocols, evaluators determined that the most effective way to collect data about the visitor experience with the museum exhibit was through a combined interactive observation/ interview protocol. Each visitor group was asked for (written) permission to observe their interaction with the exhibit, and when agreeable, also encouraged to share their observations, thoughts, decision-making processes, etc. Evaluators also asked specific questions from an interview protocol if they were not answered during the interactive observation, either while visitors interacted with the exhibit or afterward. (Evaluators collected data from children only if a parent was present or nearby to also give approval.)

As noted above, website data was collected from visitors at the Museum of Science. Evaluators observed visitors as they explored the website. After they had spent five to fifteen minutes on the site, respondents were asked a series of questions related to site navigation, learning, and their overall interest in the website.

During the first round of 21 website interviews, the evaluators provided minimal guidance to the respondents. In the second round of 10 interviews, the evaluators gave web users additional assistance in navigating the Windows on Earth website, which enabled some users to engage more deeply with the site and explore it more thoroughly than first round respondents.

Finally, an evaluator observed a teacher workshop at the Christa McAuliffe Challenger Center in Framingham, Massachusetts and four follow-up interviews were conducted with workshop participants.

All data was analyzed using standard evaluation procedures, in relation to project goals and evaluation questions, with evaluators identifying recurring themes and trends.

### **VISITOR SAMPLE**

PERG evaluators conducted formal museum and website observations/interviews with a total of 187 people in 102 visitor groups between the summer of 2009 and the summer of 2010. Evaluators also conducted several informal observations of visitor groups at the Montshire Museum in July, 2010, after the analysis of the visitor sample was completed. As noted above, Challenger Center teachers were observed in May, 2009 and interviewed in August and September, 2009

### **Museum Exhibit**

Evaluators collected data from a total of 145 people in 71 visitor groups at three museums. The following charts show the museum exhibit visitor sample from each

museum: total number of visitor groups and individual visitors; approximate age of visitors; gender; and home location in relation to the museum.

**Table 1: Total Number of Visitor Groups and Individual Visitors**

<b>Museum</b>	<b>Total # of Group Observations/Interviews</b>	<b>Total # of Visitors Observed/Interviewed</b>
MOS	20	35
A&S	38	80
SLSC	13	30
<b>TOTAL</b>	<b>71</b>	<b>145</b>

**Table 2: Approximate Age of Museum Visitor Sample**

<b>Age</b>	<b>MOS</b>	<b>A&amp;S</b>	<b>SLSC</b>	<b>TOTAL</b>
6-10	9	12	4	25
11-17	3	6	7	16
18-29	5	16	0	21
30-45	12	28	7	47
46-59	3	8	7	18
60+	3	10	5	18
<b>TOTAL</b>	<b>35</b>	<b>80</b>	<b>30</b>	<b>145</b>

**Table 3: Gender of Museum Visitor Sample**

Gender	MOS	A&S	SLSC	TOTAL
Female	20	29	14	63
Male	15	51	16	82
TOTAL	35	80	30	145

**Table 4: Home Location of Museum Visitor Sample**

Location	MOS	A&S	SLSC	TOTAL
LOCAL	11	1	21	33
OUT OF STATE	14	37	9	60
INTERNATIONAL	6	40	0	46
UNKNOWN	4	2	0	6
TOTAL	35	80	30	145

**Website**

PERG staff conducted 31 web interviews with a total of 42 visitors at the Museum of Science in spring 2010. Most of the web interviews were with individual visitors, though some took place with two respondents. The sample consisted of 16 men and 23 women over the age of 18. Three boys between the ages of 13 and 17 took part in an interview.

**Table 5: Home Location of Web Visitor Sample**

Web Interviews	MOS
LOCAL	8
OUT OF STATE	22
INTERNATIONAL	6
UNKNOWN	6
TOTAL	42



**Table 6: Approximate Age of Web Visitor Sample**

<b>Web Interview Ages</b>	<b>Number of respondents</b>
11-17	3
18-29	12
30-45	17
46-59	4
60+	2
Unknown/not recorded	4
<b>TOTAL</b>	<b>42</b>

**Challenger Center**

Evaluators observed a teacher workshop at a Challenger Center with nine teachers, and conducted follow-up interviews with four of them.

**Table 7: Challenger Center Workshop Observations and Interviews**

<b>Challenger Center</b>	
Teachers observed at workshop	9
Teachers interviewed	4

## FINDINGS

### MUSEUM EXHIBIT

It's a nice way to explore the Earth... You could spend a lot of time doing this.  
(Museum visitor)

It's a pretty nifty tool. (Museum visitor)

It certainly is something that the visitors gravitate to. It's very popular. It was a very positive thing to do. ((Museum administrator))

The project installed the museum exhibit component in four museums. Due to a delay in installation at one museum, evaluators gathered summative data about contextual factors and visitor experiences at three of those museums, primarily through interactive observations and interviews. The evaluators added contextual information and conducted a few informal observations of visitors at the fourth museum shortly before the end of the project.

The Windows on Earth project leadership articulated four primary goals for visitors who engage with the exhibit:

*Spirit of exploration*—experiencing the joy, fascination and personally-driven curiosity that drives further Earth exploration.

*Visual literacy*—using images and interactive visualizations as sources of information and insight.

*Earth literacy*—learn about Earth's processes and understand Earth as a dynamic integrated system.

*Planetary stewardship*—embracing and internalizing our connections with home planet Earth and our individual roles in taking care of it.

This section will address each of these areas along with other aspects of the visitor experience related to the museum exhibit.

### **PATTERNS OF VISITOR USE**

In general, Windows on Earth visitors were eager to engage with the exhibit in meaningful ways at each museum. The exhibit also encouraged a high level of interactive behavior within visitor groups.

Visitors interacted with the exhibit alone, in pairs, and in larger groups. Children used it both with and without adults present. The majority of visitors stayed long enough to have significant engagement with the images (at least a few minutes), while many stayed for extended periods of time. It was rare for a visitor to leave the exhibit after spending less than a minute at the component.

Multiple visitors were able to experience Windows on Earth in meaningful ways simultaneously. The exhibit prompted conversation and discussion within almost all viewing groups, usually enhancing the experience for each member of the group. Groups would ask questions of each other, exchange knowledge of different places and features, discuss experiences related to those places, and share their excitement at viewing the images—pointing and exclaiming were common occurrences at the components. These interactions normally took place among pre-existing groups, but occasionally visitors watching from behind would also add comments.

Woman: There's Iceland. Reykjavik. Man: We were on this glacier. Woman: We were like right here. Wow! Go to Reykjavik. There were two articles in the paper about Reykjavik today. (Museum visitor)

[*Woman and man watch while a different group explores Macedonia.*] Woman: All these places like Serbia, I tuned them out when they started changing names. Man: I was there when it was part of Yugoslavia. [*Points at the screen.*] All the places being broken up. That's fascinating. (Museum visitor)

Young man showing local college friend his hometown: This is all Seattle. This is Mercer Island. This is Lake Washington. It's a fake island, they have a bridge. That's the harbor, it's great for inner tubing. The most intense inner tubing trip I ever took, I started here and ended up in Tacoma, there. The ferries go here too. You have no idea what kind of wake the ferries throw. (Museum visitor)

Mom: It was a nice interaction between the two of us. He can steer it and keeps saying, where am I going? Where am I going? And I can tell him. It keeps him engaged. For a four-year-old, that's a long time. (Museum visitor)

Parents (and grandparents) would often use the interaction for teaching their children. Sometimes the adults would ask the questions, and sometimes the children would raise them. Occasionally the teaching would happen in the other direction, with children sharing knowledge with the adults.

Girl: There's the city. [*Scrolls to the river.*] Does the river have a name? Grandfather: That's the Mississippi. (Museum visitor)

Boy to Dad: I think that's Lake Eyre. Dad, would that be Lake Eyre? Dad: That would be all sand dunes. I think that's it. [*Points*] It tells you what terrain you're looking at. (Museum visitor)

## 12 Windows on Earth

Grandmother: There are those little squares. What are they? Boy: Concrete and houses and sidewalks. Grandmother: Remember I told you about farms? Those are great big huge fields that have corn and soybeans and all the stuff we are going to eat sometime. (Museum visitor)

Groups of visitors often collaborated in using the exhibit. In large groups, visitors worked together to figure out how to navigate and explore the exhibit. Two visitors at a time would often share the controls—one primarily using the joystick and zoom and the other primarily using the touch screen and other button features. Parents often let one or more children use the controls, and offered verbal assistance when necessary. However, at some point during their use of the exhibit, the adults almost always tried it out for themselves.

Although the context for the exhibit varied at each museum, the patterns of visitor use were similar across the sites. In two museums, the Air and Space Museum and the St. Louis Science Center, the exhibit is in galleries with other space-related exhibits. In the Montshire Museum of Science, it is surrounded by other Earth-science related exhibits. In the Boston Museum of Science, it is in a gallery devoted to exhibits about sensory perception.

## VISITOR EXPERIENCES

### OVERALL VISITOR RESPONSE

[I like] that I got to control stuff and look around the world. (Museum visitor)
It's fun to try to identify things, it's a different perspective... You're so high up and the angle is interesting. I'm not used to seeing the curvature of the Earth. (Museum visitor)

The overall response to the exhibit was positive for most visitors across the museums. It was extremely engaging for a variety of reasons:

- **Fun, Interesting, and Interactive**

This is cool, the coolest thing we found all day. [*Man in his 60's*] (Museum visitor)

It's interesting. I would never look into it normally, but having it here makes you interested. (Museum visitor)

So it's on a screen and not in a book. I like it on the screen. It's fun. I don't like reading so it's a really good alternative. (Museum visitor)

This is pretty fun to be able to move it around and choose where you want to fly to. (Museum visitor)

- **Views of the Earth**

The quality of the images are amazing. (Museum visitor)

It's nice to see the view of the Earth, an aerial view. I studied geography in school and if you don't have access to some of the regions, you forget where everything is geographically a lot of the time. (Museum visitor)

It was really neat to see the different vegetation types meet up, to see the Gobi Desert and see the changes [in vegetation] when you go around the world (Museum visitor)

- **Feel of being in Space**

I like this exhibit. It's like you are almost flying the space shuttle or something like that. (Museum visitor)

To see the various surfaces of the Earth, from way up in space. It's like being an astronaut almost. (Museum visitor)

- **Ability to Travel**

I could go to my home state and look at the Grand Canyon without actually going there. (Museum visitor)

Daughter: It's like you are traveling the world and can see everything.  
Mother: It's neat to use it to go to different places, and interesting to see what it looks like from space. (Museum visitor)

- **Features and Speed**

...You don't have to wait long for it to load. You get to touch borders, lights, colors. I like the touch screen and the zoom. (Museum visitor)

Pretty impressive how easy it is to move around and how fast you get to places. (Museum visitor)

- **Love of Geography**

I love geography, I love maps. This was like a map I could move anywhere. (Museum visitor)

It's a great way to learn about geography. It makes it seem very tangible. (Museum visitor)

- **Educational**

I thought it was great. [I liked] finding out where things actually were, because you don't remember where things are. (Museum visitor)

I like how it gives a little information about where you are. We enjoyed it. It's fun, interactive, and educational at the same time. (Museum visitor)

- **Unique**

Visitors felt that the experience was different than looking at maps, images on television, in books, or on computers, or even on Google Earth. Depending on their prior experience with any of these resources, they cited a number of advantages of Windows on Earth, describing it as more engaging, more real, providing the ability to look more closely, and offering a chance to view Earth from space. (More findings on visitor comparisons to Google Earth can be found later in the report.)

It was neat to see how humans affect the Earth. Usually maps [show] what it looks like because of nature. (Museum visitor)

Looking at [Earth] from space gives you a whole new perspective than what you can see on a paper, on a map. (Museum visitor)

I've only seen square maps, globes a little bit. When I looked at the Antarctic Circle, I thought it was just a bunch of ice. I didn't realize there were all those mountains around it. I got a different perspective of it, not so spread out. (Museum visitor)

I see [the Earth] better now. Because when do we ever get to see the Earth from space? We don't really. The plane has a nice view, I've seen some shows on Discovery. Typically we don't get to see this elaborate mapping and geography. (Museum visitor)

I think [my sense of the Earth] changed. This is more real than a globe. (Museum visitor)

## **SPIRIT OF EXPLORATION**

*Experiencing the joy, fascination and personally-driven curiosity that drives further Earth exploration.*

I like the freedom to play over the planet. (Museum visitor)

That's cool. You are going all around the world and it tells you about it. (Museum visitor)

Visitors enjoyed using the Windows on Earth exhibit to explore the planet. Their explorations included areas close to home as well as distant parts of the globe. They spent time examining images close-up and in-depth as well as more broadly, traveling across the oceans and continents, and getting a more global perspective. Most often, they "visited" familiar places, places with personal meaning for them, and places they had heard about. Occasionally they explored new places out of pure curiosity.

### **Familiar Places**

I go to places I know, rather than places totally new. How would I know how to find it if I didn't know where it was? (Museum visitor)

Everyone traveled to places that they were familiar with, almost always starting with their current hometown. They also looked for former homes, homes of relatives, vacation destinations, and places where they had worked or served in the military.

I had lots of fun trying to find places I knew. (Museum visitor)

At first I was looking for my house, I have a cottage on the Cape. Now, I'm just having fun. (Museum visitor)

Mom: Redding is part of California. That's where we used to live. [*Son navigates to San Francisco.*] We lived closer to Modesto than San Francisco... Want to see where we lived? [*Points.*] And when Daddy and I met we lived here. [*Points.*]

Son: We lived in San Jose. Wow, California is big. (Museum visitor)

Many visitors looked for places where they had vacationed, or were hoping to visit in the future.

He's trying to get to Venice. We traveled there 2 years ago.... (Museum visitor)

I want to do a pilgrimage, across northern Spain... [This] gives me information about the places I might travel... The night lights are really good. I can see the best places to go. (Museum visitor)

My brother lives near Amistad National Park. I went there many years ago and it was so bloody hot down there. I go down there now from October to February. I don't like flying, I take the train....There we go, National Amistad Reservoir [*reads from info band*]. He lives right about there, about 2 miles away.

(Museum visitor)

International visitors particularly enjoyed visiting their home countries using Windows on Earth.

[I looked at Bulgaria] because I'm from there and I haven't been in a while. (Museum visitor)

### Places with Personal Meaning

Visitors often went to less familiar places that held personal meaning for them. People showed friends or relatives meaningful sites that were familiar to them but new to their companions. Sometimes this included information about their heritage, as well as other stated educational purposes.

There was a kid Carlos we knew from Spain. He was a foreign exchange student from Barcelona. [*They look for Barcelona unsuccessfully.*] (Museum visitor)

I went to the Czech Republic .... Because I am Bohemian which became Czechoslovakia, which became the Czech Republic. (Museum visitor)

Our children are adopted from Kazakhstan and from China. [*The family looked for the cities their children were from.*] That was educational. The border and city names helped. (Museum visitor)

Grandma to grandson: Go to Oklahoma City. That's where your mom was born.  
(Museum visitor)

### Visiting Unfamiliar Places

Some travel to new places was deliberate--visitors went looking for unfamiliar sites they had heard about in school, on TV, on the news, or in books. Other times the exploration was more random.

I'm going to try to find the Cascades Mountain range. We were learning about that in geography.  
(Museum visitor)

I just like playing around on it, exploring the world and seeing all the different places. Sydney is a pretty famous place for the Sydney Opera House...The places I went to are famous, to check it out and see what's there and learn some things about it.  
(Museum visitor)

Hey, there's a place named Knoxville, Tennessee! [*Girl from Australia*]  
(Museum visitor)

The unfamiliar places often sought by visitors included the North and South Poles, the Himalayan mountains, and Mt. Everest. Several visitors looked for the Great Wall of China without success. Many children and some adults traveled out of curiosity, looking for places they knew nothing about. This would sometimes lead to a more in-depth investigation of a totally new place.

What's that tiny thing? ... Nihoa. [*From info band.*] What is that? Let's go there. Imagine going there....How big is it?  
(Museum visitor)

### VISUAL LITERACY

*Using images and interactive visualizations as sources of information and insight.*

I'm trying to see some of the patterns so we know where we live.	(Museum visitor)
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You don't think about the Earth being so big.	(Museum visitor)
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The Windows on Earth exhibit encouraged visitors to use visual literacy skills to interact with and interpret the images of the Earth in a variety of ways. Almost all visitors were able to recognize particular features such as mountains, cities, lakes, snow, rivers, deserts, and continents. They confirmed prior understanding about the Earth and gained new information and insight.

The closer you get in, you can pick out land forms and pick out where you live in reference to the world.  
(Museum visitor)

I didn't realize the creek [near our house] was that long.  
(Museum visitor)



It's nice because you can see from space and the astronaut's view of the planet. It's amazing. ... It's really awesome, the diversity of the ecosystems. You can see the difference between the Amazon and the Sahara Desert. The diversity of the Earth is really amazing.  
(Museum visitor)

### Using Earth Features To Explore

Visitors identified features of the Earth using shapes, colors, patterns, textures, prior knowledge and their experience with maps. Most used this visual information to help them navigate and explore. They also used their experience with maps and highways to help locate familiar places.

You can tell that's a road line right there. [*He follows the road.*] I know where we live in relation to that. All that is trees. [*Scrolls to a green mountainous area.*] This is agricultural [*points to square plots*], and that looks like a congested area right there.  
(Museum visitor)

I know there are some bays around the state line. The state line is just a land boundary, not like a river. ... We live close to the naval air station. That might be the airstrip. [*Points*] Pensacola beach is on one of these barrier islands. There's a bridge. It could be near there.  
(Museum visitor)

I'm looking for Disney World. I think it's in Orlando. I know it has a bunch of lakes. It's probably near the lake area...It's probably populated a lot.  
(Museum visitor)

Visitors also made use of the additional exhibit features—elevation, night-lights, clouds, and borders—to provide more specific visual information about some locations, and to further help with navigation.

[I like the elevation feature.] You could tell where mountain ranges started.  
(Museum visitor)

It's amazing how lost I was without borders...just trying to use rivers.  
(Museum visitor)

I want to find Yellowstone... We came in through Idaho. These are the Grand Tetons. ... We would have had to go through a pass. ... I can't see where they would have put the interstate...[*Puts on night-lights*] We had to come along somewhere where there were lights. That looks like a route. [*Points to a string of lights.*] ...There are more dots in Wyoming that I thought there would be.  
(Museum visitor)

### New Discoveries

Seeing [the land] without the boundaries gives you an idea of what the regional characteristics are of where you live.  
(Museum visitor)

Visitors made new discoveries and gained new insight about the Earth by looking closely at the images on the screen. Most of these discoveries involved land formations, size and

distance, population density and light, and facts about the Earth. For some, these discoveries impacted their mental picture of the planet in important ways.

- **Land formations**

One thing that struck me, I didn't know the Sahara would cut off so strongly in Africa [that it forms almost a straight line from West to East]. (Museum visitor)

I didn't know there were so many islands in the Arctic and getting to see that up close was neat. (Museum visitor)

I thought it was interesting to see the coastline. And so much coastline compared to anywhere else, as opposed to Ireland, where [the coastline] is straight. [*Visitor from Maine.*] (Museum visitor)

There are a lot of different elevations in the sea floor. There are a lot of trenches. I didn't know that there were that many. The world map just shows the major ones. (Museum visitor)

[I learned] that England doesn't have any high mountains. [*Englishwoman*] (Museum visitor)

It's interesting to see the valleys and the mountain areas—wow. ...The up and down, the 3-D, our forefathers had to climb a lot of mountains to get to California. (Museum visitor)

- **Size and distance**

Denver isn't that big. I thought Denver would be bigger. (Museum visitor)

I didn't know the Pacific was that big. It makes it look so much bigger. (Museum visitor)

Look at the distance between Russia and Alaska. Wow, it's thinner than I thought it would have been. (Museum visitor)

It gave me a lot of perspective. It took me a long time to get to Hawaii. It made me think of how far Hawaii is. (Museum visitor)

- **Population density and light**

If you have flown from along the coast, you never fully appreciate what they mean about a megalopolis, until you can see city lights. (Museum visitor)

[I discovered] how much light our town gives off. That was kind of cool. (Museum visitor)

I thought the whole country would have lights, but there are still places without them. [*Talking about native Spain.*] (Museum visitor)

There are a lot more uninhabited areas than you would think, like Wyoming and southern Mexico. (Museum visitor)

- **Facts**

All that ocean area is labeled the Hawaiian marine. I didn't know that.  
(Museum visitor)

I was born and raised in the Philippines, and I have friends in Guam and Palau. At first I thought Guam was north of the Philippines, but it's south.  
(Museum visitor)

Man: A lot of these cities I've never heard of before. Woman: This is not the USSR the way you learned it. It's smaller. See that border...it's Kazakhstan, not Russia.  
(Museum visitor)

We have to find the Baltic Sea...No, that's the Barents Sea. [*Reads from info band*] I didn't know there was such a sea.  
(Museum visitor)

It was interesting to see around Baghdad. It was greener than I thought. And Kabul, it doesn't even appear as a city.  
(Museum visitor)

- **New Mental Picture of the Earth**

[The Earth] is bigger. In my head it's small, but here it's bigger.  
(Museum visitor)

[It makes me think] about how small we are.  
(Museum visitor)

It feels like I'm in a different world. [*6 year old child*]  
(Museum visitor)

It seemed a little bit different from the usual pictures of the Earth from space. From space it looks a lot more flat. [Pictures from space] don't have the terrain...Places you usually thought were forested were more cleared.  
(Museum visitor)

### Stories Prompted by Windows on Earth

Looking at places and geographic features prompted some visitors to tell each other or the evaluators about important experiences in their lives. These events included tours of duty in Afghanistan and Iraq and a remote island posting during WWII. This was not the first time at least some of these visitors had shared this information, but the size and quality of the images added to the depth of visitors' stories.

*Spanish visitor telling friend and evaluator:* I was in Afghanistan, three times. And in Iraq too. I was in Kabul, and then here. [*Points*] This is very rough. Mountains. Now the Spanish troops are here. [*Points*] There is a pass between the mountains, I think maybe it is here. [*Spent a lot of time looking for it.*]... I'm looking for the pass. A very dangerous one. Maybe this is it. [*Points*] It's the only pass to go from the south to the north. The terrain is very very rough, very high mountains, and the people are not very friendly.  
(Museum visitor)

*Man looking for and pointing out places where he was during WWII, showing his wife:* All these islands aren't big enough. They are all volcanoes... That could be it. I know because here is your post, that's where the ships came in. There's the base. The Coast Guard station was right here, the old sub base was here. This is where the processing boats would tie up to the old sub place... You hiked. It was 58,000 men on this island during WWII. We went snow skiing here, you could hike to the other side of the island here. Somewhere in one of these peaks, that's where radar early detection was. (Museum visitor)

### Visual Literacy Challenges

Visitors frequently found it difficult to recognize certain geographic features, often due to a lack of prior knowledge of those particular areas. Visitors often confused rivers and roads. In addition, though some visitors found them helpful, several of the special features sometimes increased confusion; night-lights were sometimes interpreted as clouds, clouds were misunderstood, and the elevation colors were frequently misinterpreted as actual Earth tones.

Many visitors did not know their location at some point while exploring the images. This often occurred when they did not have the borders feature on, and while they were trying to navigate from one point of interest to the next. The information band, when consulted, would often provide assistance in these situations. However, the information was not always correctly matched to the pictures, and could add to visitor confusion. (Also, not all visitors made use of the information band).

This thing is confusing... I can't zoom out of it so I can't tell where I'm at. (Museum visitor)

[*Looking at an unknown island in the Pacific.*] It looks like a volcano right in the middle. I don't think it's desert, but the orange and brown make me think it is. This is a forest up here...[*follows the green*] It's a pretty big mountain or volcano. [*Looks at information band and addresses questions posed there—doesn't see what the text is referring to.*] I don't see any human presence. I don't see anything that would look like a city or anything. (Museum visitor)

## EARTH LITERACY

*Learn about Earth's processes and understand Earth as a dynamic integrated system.*

It gives you a real good view of where you live. You see it from the ground and you don't realize how interconnected it is. (Museum visitor)
--

The exhibit images and visualizations provided confirmation for visitors' pre-existing knowledge about Earth processes and interconnectedness and sometimes helped visitors arrive at new insights. The elevation feature occasionally prompted visitors to talk about their knowledge about the Earth, especially in the context of teaching someone in their group. For some, the night-light feature prompted comments on interrelationships between settlement patterns and natural features, while the cloud feature led to occasional

insights about weather. Animations, which were specifically designed to teach visitors about Earth's processes, were only viewed a few times during evaluator observations, largely due to limitations of the exhibit.

### **Earth Processes**

Except for the few visitors who watched one of the animations, Windows on Earth did not appear to increase visitors' understanding of Earth processes. The exhibit did offer confirmation and reinforcement of visitors' prior knowledge. It also offered opportunities for teaching others about Earth processes.

*[After watching the animation]* I learned how the Himalayas were formed. I sort of had an idea. I have a better idea of how they are formed. (Museum visitor)

Dad to children: Remember when we were flying in, remember those mountains. Those ridges are the Appalachian Mountains. That happens when rocks are forming... (Museum visitor)

The topography was interesting. Landforms you knew were there but ... like that ridge. The ridge [near our house] is probably from the Earthquake [in 1826 that caused the lake.] (Museum visitor)

### **Interrelationships**

Visitors occasionally noted evidence of the Earth as an integrated system.

Man: *[Pointing to southern Louisiana]* This was all land. These are the barrier islands. They don't make a full chain anymore. *[Points to islands further out.]* These are remnants. They don't protect the coast anymore. We had huge barrier islands. Storms destroyed them....The barrier islands kept the salt water from intruding. Woman: ... It will be interesting to see, in 10 years, what it will look like. (Museum visitor)

You really get a strong sense of the integration/saturation of landscape with water, how land and water are mixed together. (Museum visitor)

More often, they commented on interrelationships between humans and the Earth's terrain.

I've been reading a book about the wars in Iraq and Afghanistan and I was curious about the terrain. I was trying to get a more tangible sense of where things are located. I like to look at the relationship between where people live and the geologic patterns in the area. (Museum visitor)

I like to watch the night-lights. It's interesting. There are a lot of lights. There are some places where you don't see lights, in wide areas. It kind of makes you wonder what is there. (Museum visitor)

## Weather

Visitors sometimes used the cloud feature to confirm or extend their understanding about general weather patterns in different parts of the world.

Scotland's high up, that's why it's bloody cold. ... It confirms things I already knew, like Scotland is notorious for being cold. [I put] on the cloud coverage, it was high and cloudy combined. (Museum visitor)

## Human Impacts

The exhibit prompted visitors to compare the current images with their existing knowledge, and to comment on changes related to human activity.

There are not as many agricultural areas as there used to be. The farms are small. I can see cities getting a lot bigger. (Museum visitor)

The main thing [I saw] was the light pollution on the East Coast and in the Canadian Rockies. We have a home down here in the Blue Ridge, and you can see more light than 10 years ago. (Museum visitor)

One of the things I thought was interesting was the way...[there were] different colors between urban areas and green areas. I could see how much things have changed over the years. It used to be bright green down to the river but it's not bright green [now.] (Museum visitor)

## PLANETARY STEWARDSHIP

*Embracing and internalizing our connections with home planet Earth and our individual roles in taking care of it.*

Visitors were engaged with and often fascinated by the particular images of Earth displayed by the exhibit component, both those from afar and up close. Some visitors (when asked) were able to identify changes in their mental picture of the Earth as a result of the exhibit. It is possible that these experiences helped visitors to “embrace and internalize” their connections with the planet as a whole; however, they did not discuss this concept, either among themselves or with the evaluators.

(An early prototype of Windows on Earth allowed visitors to zoom out far enough to see the entire planet. While these visitors often paid less attention to land features, it seemed to encourage a more emotional connection with the planet as a whole.) There was no indication that Windows on Earth (either version) encouraged visitors to feel any increased responsibility or interest in “taking care of” the planet.

## EXHIBIT FEATURES AND GENERAL USABILITY

The museum exhibit console includes a joystick, zoom buttons, touch screen with world map, and ‘return to home’ button. It also has four other features—borders, night-lights, elevation, and clouds--sometimes controlled by buttons on the console, and sometimes by

buttons on the touch screen. In addition, a small map is projected on the side of the large screen, helping visitors who used it understand their location. While all of the features were very easy to use, many visitors were slow to discover them, or never found some of them at all. (Consoles were improved for the final two installations, which appeared to help visitors discover the features more quickly.)

### **Touch Screen, Zoom Buttons, Scale**

Visitors enjoyed navigating using the touch screen (although not all discovered it.) Visitors liked zooming in and out, but often wished they could zoom in closer than Windows on Earth allowed. Finally, the legend/scale presented on the main screen was misunderstood by visitors. This scale was designed to show distance on the ground (in the image) but virtually all visitors thought it showed distance from the Earth.

### **Borders, Night Lights, Elevation, Clouds**

These four special features often added interest and information for visitors. They could also be a source of confusion, especially if some were turned on simultaneously or already activated when a visitor first approached the exhibit. Most visitors found the borders feature to be particularly useful in helping them to identify their location and to navigate to new locations. They had much more difficulty navigating with the boundaries turned off. (This feature was often requested by visitors who did not realize it existed.)

Visitors had a positive response to the night-lights, which some used to find cities in familiar and unfamiliar regions. For some, the elevation feature added greatly to their experience with the exhibit, although not for the majority. In some cases, especially when visitors were not aware it was turned on, the elevation colors were a cause of confusion, especially when visitors were viewing the ocean floor. The cloud feature provided useful insights for a few visitors, but was generally not of interest, and confused some respondents. Visitors often asked whether the clouds were in real time. Sometimes the night-lights and cloud features were confused, especially if both were turned on simultaneously.

### **Information Band and Console Pictures**

The information band at the bottom of the large screen provided a few lines of brief text and was very useful to many visitors, although ignored by many others. It provided information about location and landforms, and sometimes asked questions or prompted visitors to use special features.

It tells me to try to turn on and off the night-lights and I don't know how to do that. [*She looks around the console, then finds the button and tests out the features.*]  
(Museum visitor)

The information band also had limitations. The information it provided was sometimes frustratingly vague and not always correct, and site labels often only showed up while scrolling over a very limited area. In addition, the console at some sites included some pictures and written information that were ignored by the overwhelming majority of visitors.

### **Animations**

The museum exhibit included some short animations designed to educate visitors about different Earth processes. In some of the museums, the locations of these animations were indicated by a question mark. Evaluators observed a handful of visitors engaged with animations on volcano, island, and mountain formation. Most visitors did not realize that the animations existed. Sometimes visitors would click on a question mark, but the start-up time was so slow in at least one museum that viewers usually moved on to other locations before the animation finished loading. Sometimes they did not work at all.

The Montshire Museum worked with the project to animations on local land features. The WinEarth exhibit at this site also included the best access to other animations, enabling visitors to view them more readily.

### **COMPARISONS WITH GOOGLE EARTH**

Since the initiation of the project, there has been a great increase in the number of people from the general population who have experienced Google Earth, including large numbers of museum visitors, as well as an expansion in the features available using Google Earth software. For most visitors, familiarity with Google Earth did not diminish their eagerness to engage with the exhibit. However, a handful of visitors cited the similarity of the exhibit with Google Earth as a reason not to explore Windows on Earth.

Many visitors commented on advantages of the Windows on Earth exhibit in relation to Google Earth. These included:

- Additional features
- Ease of use
- Large screen
- Rapid joystick and touch screen maneuverability
- Night-lights view
- Elevation and topographical information
- Information provided by information band
- Seamlessness of images
- Views from space
- Higher resolution in some parts of the Earth
- Touch screen map which helped visitors visualize their location in relation to rest of the world
- More interactive



It's never enough. Seeing the same thing is always awesome for me. It's not boring. [This has] night-lights, that's awesome to see the Earth at night. When I travel by plane I like to travel at night, to pass over the cities. It's really beautiful.  
(Museum visitor)

The primary negative factor cited by visitors was the inability to zoom in as far as is possible on Google Earth. (This was a deliberate decision.) This was exacerbated by an occasional software problem that produced very blurry images for many of the closest views allowed by the exhibit.

## VISITOR SUGGESTIONS

Visitors provided a variety of suggestions for improving the exhibit.

These included:

- Date the images
- Show comparison images from different dates for key changing areas of the Earth
- Add additional data like ocean currents, cloud movements, infrared scans
- Add more specific data in the information band
- Add specific points of interest, such as Mt Everest, Grand Canyon, etc.
- Include real time information about things like fires; track smoke from fires
- Include the real time view from the space station
- Indicate altitude above the Earth for each view
- Link to points of interest
- Add the ability to zoom in closer, and to zoom out farther
- Show clouds and other weather features in real time

## PARTNER MUSEUMS

I'm amazed how much people love it....It's an excuse to talk about geography. We're real big on inspiring visitors to have conversations...It's rare not to see two or three people sitting and talking....This is what we were hoping for.  
(Museum administrator)

It's definitely added a bit of richness to the visitor experience. One of our big things is to have interactive experiences. [Windows on Earth] is a really interactive tool. ... It's been really useful in connecting ... with visitors.  
(Museum administrator)

The imagery is beautiful and the interaction visitors get to have, flying around and changing parameters, we weren't going to be able to provide that level of interaction. It's richer than we could put in that spot on our own...It's a nice piece. It's appealing and draws visitors over.  
(Museum administrator)

## CONTEXTUAL VARIATIONS

The context for the Windows on Earth exhibit is different at each museum. However, Windows on Earth appeared to provide an immersive experience unaffected by surrounding exhibits. Regardless of the context and small differences in the exhibit console, museum visitors experienced Windows on Earth in similar ways at each site in terms of engagement and outcomes.

In the Smithsonian Air and Space Museum, WinEarth is in the *Looking at Earth* gallery, which is devoted to aerial and space observation and its uses. It is the only site with two exhibit components. This is also the museum where the interactive nature of the exhibit stood out the most (in a positive way) in relation to the majority of other exhibits at the museum.

At the St. Louis Science Center, the exhibit is located in the *Boeing Space Station*. As part of the planetarium, only visitors who have tickets to a planetarium show have access to this large exhibition area dedicated to space science. The exhibit here is uniquely configured with the control console separated from the large screen by a model of a space station galley table over a view from space of Missouri.

At the Boston Museum of Science, Windows on Earth is in the *Take a Closer Look* gallery, which is devoted to exploring the world using the senses and aided by technology. The content of each exhibit is extremely varied. This is the only site where the exhibit is not in a gallery focused on Earth or space science. (The Museum has Earth and space science-related exhibits elsewhere in the building.)

The Montshire Museum of Science in Montshire, Vermont is a much smaller museum than the others, with a more local focus and visitor population. The museum worked with the project to create several animations relating to nearby land features. The exhibit is currently part of a special exhibition called the *Dynamic Earth*.

## MUSEUM GOALS AND OUTCOMES

Each museum added its own goals for Windows on Earth to the project. These were related to the nature of each museum overall and the specific gallery where it would be placed.

For the Air and Space Museum, the exhibit replaced a very out-of-date video installation that contained a few images from each state. Hence, one major goal was to provide a current, more comprehensive and high quality interactive presentation, a goal that WinEarth has easily met. The exhibit fits well thematically in the larger gallery and is very popular. In addition, WinEarth demonstrated that a highly interactive exhibit would not create problems during high visitor periods, which may encourage the addition of more such exhibits. However, the museum was also hoping the exhibit would educate visitors about satellite imagery, a goal which has largely been unmet.

I'm not sure that we actually increased people's understanding of the imagery in a really big way, the science of it. But I think it did help folks get more familiar with and more comfortable with that perspective. (Museum administrator)

For the St. Louis Science Center, the primary goal was to offer a view of what the Earth looks like from the space station, and to provide visitors with the ability to explore those views under their own control.

In the planetarium, we look from Earth up into space... When [astronauts] go into space...they look back on the planet. I think [Windows on Earth] is pretty effective in that way. (Museum administrator)

The museum places a high value on interactive experiences, and WinEarth is seen as a strong addition to their offerings. The exhibit component closely matches the surrounding exhibits thematically, replacing a very static, rarely used component—the galley table that has been incorporated into WinEarth.

The Museum of Science ultimately decided to place the exhibit in their newly remodeled *Take a Closer Look* gallery, which shaped their primary goals for it-- to encourage visitors to “see in new ways”, to look closely with the help of technology, and to use or build observational skills. WinEarth has met these goals. It fits with the other exhibits in the gallery in terms of a focus on sensory perceptions, but there is no shared content focus across the exhibits. The museum may try to connect the exhibit thematically to other exhibits elsewhere in the museum through virtual means. With WinEarth as their model, they may also pursue other exhibits based on software that can be updated remotely.

The Montshire Museum believes that learning science is a social activity. Given their visitor base, they were especially interested in something that would support intergenerational conversations, which WinEarth has done well. The museum was also interested in a very local focus, and worked with the project to create several custom animations based on land features around New England, which the museum is very pleased with. Montshire did not have any permanent exhibits that addressed geography or Earth science at the start of the project, and expects the Windows on Earth component to be a lasting feature at the museum, in different configurations. They recently received a NASA grant that has enabled them to create a new exhibition, with Windows on Earth as a key component. The grant will also support a new middle school exhibition guide and teacher workshops.

## **MUSEUM CHALLENGES AND ISSUES**

Museum administrators appreciated the opportunity to be part of the project, and were generally pleased with their interactions with the project staff and with the final product. However, the development process was longer and more complicated than any had anticipated.

All of the museums experienced various technical challenges setting up the Windows on Earth component, which were solved either by the project, local museum staff, or a collaboration of the two groups. The component continues to experience occasional problems at each museum, and requires a high level of in-house technical expertise to keep it up and running. (The Montshire Museum is the only site that still has a support agreement with TERC.) These problems have sometimes resulted in inexplicable crashing of the component, which in one case took three weeks to resolve. In addition, even the most recent version of the software continues to have some incorrect place names and other usability issues. Because of the complexity of the software, along with the fact that it is owned by TERC and leased to the museums, the sites are dependent on TERC for updates and improvements. As one administrator stated:

We're not in a position to become programmers. I don't know what the long-term outlook is for something like this that takes high technical expertise to keep going. We would love to ...tweak it. ...If it's a physical exhibit you can get out a saw. (Museum administrator)

Each museum worked with project staff to customize their component. Initially the project hoped to provide much more customization than the final units provided. Museum administrators each have unmet wish lists for the exhibit. For most, the top of their list is the ability to zoom in closer with higher resolution over more places. Other requests voiced by one or more museum administrators include better instructions for the controls, more information and guidance for exploration, more customized animations, a bigger screen, and a return to the original plan of a literal window framing the screen.

I understand why we didn't stick with that conceit, but I really liked that aspect of it, the literalness of the window on Earth and that way of transporting the visitor without words... I might have gone in that direction rather than zooming in completely. As Google Earth has become ubiquitous, that's not special about Windows. I might have chosen a big other-worldly look and feel, the ambiance of astronauts, and sacrifice some of the software capabilities, but it's a hard sacrifice. (Museum administrator)

One anticipated issue that did not materialize for the museums concerned Google Earth. The museums were aware of the similarities of the exhibit with the web program, which became much more popular over the course of the project. However, museum administrators were relieved to observe the high level of interest in Windows on Earth for most visitors, regardless of Google Earth experience. As one administrator commented:

My worry, with Google Earth, was why would people bother with it....Why do an exhibit you can have at home? But lots of us grew up with a map in the house, on the wall. In my house, we had a map on the wall in our bedroom. People don't necessarily have that anymore. Computer screens are small enough that you don't have that constant something there that people can go by and point to. This exhibit functions as that community map that people can point to. (Museum administrator)

## **WEBSITE**

### **INTRODUCTION**

#### **GOALS OF THE WEBSITE**

The Windows on Earth website was designed to stimulate viewers' interest in our planet, engage them by providing a sense of an astronaut's view of Earth, and enable them to explore points of interest from space. The website was also designed to promote viewers' understanding of the Earth through increased Earth and visual literacy, increased interest in exploring the planet (spirit of exploration) and a greater sense of caring and ownership about the Earth (planetary stewardship).

#### **THE CONTEXT OF THE WEBSITE IN 2010**

According to project staff, the Windows on Earth website was conceived before a number of new innovations/tools were available on the Internet, particularly Google Earth. Since development and implementation of the website took several years, the context of the site as it exists today is quite different than it was five years ago. Many of our respondents use Google Earth regularly and were used to the features it provides; for example, most expected to be able to click and zoom in to see high resolution images of the Earth in almost all locations, a feature that is not available on the Win-Earth website.

### **VIEWER EXPERIENCES**

#### **THEME AND PURPOSE OF THE WEBSITE**

Many of our respondents were unsure of the theme or key message behind the Windows on Earth website. Several viewers asked the evaluators, "What is this site about?" as they were exploring it. Among those who could identify a theme, many said the site was about taking pictures of the Earth from space.

I think this site is about pictures taken by astronauts of the Earth.  
(Website viewer)

About Garriott taking pictures and he made this site, sort of like Google Earth.  
(Website viewer)

Seeing what things look like from space.  
(Website viewer)

I knew about the ISS, [but] it's nice to see what [astronauts] do.  
(Website viewer)

Others, particularly those who visited the Garriott pages of the website, said the theme related to viewing the Earth's topography, identifying changes over time, and technological advances.

Seems like it's trying to communicate what the world looks like from a distance and also the changes humans made over time. (Website viewer)

The piece that caught my eye—technological advances over the last 30 years, photographs and digital technology as advancement. (Website viewer)

It feels like education and visuals on how the Earth came to be, the history of the Earth incorporating animations and space view. (Website viewer)

When asked directly what the site was about, several respondents said they were uncertain, and some expressed a sense of confusion on this topic. (This was particularly true for Round 1, unaided respondents, who did not usually find the Garriott portion of the website.)

I'm not 100% sure...the initial presentation is about seeing the Earth from the ISS. I'm seeing that, but I don't see weather, just topography. (Website viewer)

If [the purpose of the website] is to see something in the Earth, I'm not seeing it. (Website viewer)

Is it trying to increase support for the Space Station? (Website viewer)

I'd want to explore the site more before answering that question. Like is there a mission statement on the home page? (Website viewer)

## NAVIGATION AND USABILITY

After viewing and listening to a short (one minute) introduction in which an astronaut (Richard Garriott) communicates his satisfaction with the Windows on Earth technology which he used while taking pictures of the Earth from the ISS (this is done via a brief conversation between the astronaut and Mission Control) respondents were free to explore the website. The introduction, which referred to "this software tool," did not give viewers a clear sense of what the website was about, as noted above.

Most users, even those who were somewhat tech-savvy, were initially unsure how to use the site, as noted in the comments below.

The usability could be better—it's a little complicated to get started. (Website viewer)

I would like the interface to be more friendly; it's not intuitive. (Website viewer)

So far I can't find my way around it. I love maps, Google maps and street maps, but I'm not able to transfer my skills. (Website viewer)

Most viewers went to the ‘launch’ command, skimmed the instructions, and then went to either *Go Anywhere* or *Orbital* modes. A pop up screen appeared, which gave viewers basic instructions on how to use the site. Most viewers skimmed the instructions and began using the site; few appeared to read and retain most of the information contained in the pop up window.

Those viewers who went into *Orbital* mode generally did not find much of interest. Often the ISS was over water, and there was little to see. Many viewers were confused by the orbital path, which was displayed on the lower screen; about half of our respondents were unsure what the track meant, and many did not realize that the numbers presented on the lower screen represented the time it took for the ISS to circle the Earth. In general, viewers often seemed to not retain the concept of looking at the Earth from the Space Station as they used the website. Many were confused by the ISS window; some thought it was a camera lens, others had no idea as to its function. While some viewers assumed that the blue in *Orbital* mode represented water, a surprising number were unsure what the color meant. Viewers in both modes had great difficulty finding their location (the location of the ISS) on the lower screen. (Often, when the ISS was over land, it was almost impossible to locate the small circle that pinpointed the location of the ISS).

In *Go Anywhere* mode, some viewers had more success in navigating through the website. Many discovered either the ‘click and drag’ feature or used the lower screen to jump from one destination to another. (But many did not find both modes of travel without assistance). Several users suggested having some instructions on the main screen, explaining how to use the website—particularly the map on the lower screen.

Initially, users often needed some guidance in knowing what to do in the *Go Anywhere* mode. On a laptop screen, the camera icons were difficult to see, and sometimes viewers were over areas (such as Massachusetts) where no pictures were available. Our respondents were confused by the “green striations” that indicated where pictures had been taken. Once viewers discovered how to move within *Go Anywhere*, they often enjoyed exploring areas both familiar and new. With some assistance, most of our respondents used the high-resolution feature, which enabled them to view selected pictures in greater detail. Initially users had difficulty getting back to the main screen; the evaluators had to show them how to close the new window, since the site had no ‘back’ button.

Our respondents naturally used the navigation tabs from left to right; most did not find the *How to Navigate* screen until after they had tried out *Go Anywhere* and *Orbital* modes. Those who did find the navigation screen found it somewhat dense, and most did not go beyond the first or second informational bullet on this screen.

These navigation and other usability challenges significantly limited viewers’ experiences of the website.

## OVERALL REACTIONS

About half of our respondents generally liked the website, describing it as “interesting,” “intriguing” and “cool.”

It’s interesting, being able to see [the Earth] from far off, it’s cool.  
(Website viewer)

For people with a curiosity about the Earth, or history, sociology, cultural development, you could have all kinds of fun with this. (Website viewer)

The pairs [comparison pictures] are interesting. *Go Anywhere* doesn’t do that much for me...photos are not that interesting. (Website viewer)

I like the site—it feels smooth—the way it transitions, finding a new place to go to.....the loading of photos [waiting for something to happen] would probably confuse me. (Website viewer)

The *Go Anywhere* tab—you can see different parts of the world. I like that you can pan around and go wherever you want. (Website viewer)

Some viewers were somewhat neutral. Others compared the website (unfavorably) with Google Earth, found it difficult to use, or found the information was difficult to find.

It’s OK. As far as ISS mapping, there’s a lot out there already. (Website viewer)

This feels like a lesser version of Google Earth. (Website viewer)

There’s a lot to digest here—I’d have to spend hours on the site to digest this. (Website viewer)

## SPIRIT OF EXPLORATION AND POINTS OF INTEREST

Viewers often went to familiar places at first, including where they lived/where they were originally from, and places they had visited. Many viewed some of the pictures in *Go Anywhere* mode in California (the default starting point). Those who figured out how to travel on the website often came to the Boston area (where there were no pictures) and then explored other states and continents. Our respondents were often frustrated by difficulty in navigation, as noted earlier, and by a lack of images over their areas of interest, such as the Grand Canyon, cities like Rome or Cairo, and geographic features like the Himalayas.

Those viewers who took the time to click on and observe the high-resolution images often found them interesting, but many were frustrated by the lack of labels. (Many images were identified by number but not by location.)

A few respondents specifically wanted to view particular landscapes from a different point of view, as noted below, or were simply curious to see new places.



I started by going home toward the East Coast, then to places with a lot of terrain, like the Andes Mountains. (Website viewer)

[I went to] where I'm from, where I am....and then Africa, I wanted to see a totally different landscape. (Website viewer)

## VISUAL LITERACY

Those viewers who traveled around the United States or around the world—particularly those who investigated the high resolution images, used their understanding of visual literacy, including borders, cities, and geographic features such as mountains and rivers, to find their location and to identify places of interest. Often, our respondents used features they were already aware of to confirm their location or view familiar places.

Man: Let's go to the pyramids of Giza. There's the Nile River. [*They can't find the pyramids*]...[*Man looks for the Grand Canyon but can't find it; they find Las Vegas.*] Woman: It looks so small! [*Man identifies local lakes and mountains, they find Lake Mead.*] (Website viewer)

A relatively small number (about one-eighth) of viewers gained new insights as a result of viewing the images on the website.

[It reminds me] how tiny we are in the scope of things...there's so much out there beyond our own lives. (Website viewer)

You forget the Earth is mostly water...how tiny we are in the scope of things...there's so much out there beyond our own lives. (Website viewer)

It drives home technological advancement and how much technology is part of how we experience the Earth. (Website viewer)

During some interviews (particularly in Round 2 when users were given more assistance with the site) the evaluators encouraged respondents to read about the Garriott mission. Most of the viewers who explored the Garriott portion of the website and examined the pictures found the comparisons between the 1973 and 2008 photos to be engaging and thought-provoking. Several suggested adding more pictures, and emphasizing the story of the father/son astronauts.

As noted above, viewers found some of the pictures engaging, particularly the high-resolution images.

It's the detail available—the resolution is amazing. I could tell you who owns the property [in some of the Utah pictures]. (Website viewer)

To see the images [in *Go Anywhere*], and I like watching the *Orbital* [mode], just seeing things go by...[I was wondering] if that was all you could see [from space], wondering where you are. (Website viewer)

Topography and seeing the perspective [of the Earth] from that distance. Being able to go around the world and click is a step up from Google Earth.

(Website viewer)

I like how the picture comes up on the left, so you can keep going.

(Website viewer)

Others said the pictures were not particularly informative or interesting.

It's more interesting to see space, no 'wow' factor.

(Website viewer)

Once you've seen that photo, what are you supposed to do with it, what's the end result?

(Website viewer)

## EARTH LITERACY

Most viewers did not discuss or seem to focus on Earth processes while using the website. However, several respondents said the Garriott pictures reinforced the impact of humans on our environment, and some commented on changes in technology over time. A few respondents also noted the differences in the pictures from South America, which showed evidence of the erosion process in Argentina.

We see it from one level to see how [the coast is] shaped and where it's eroding—you only get so much from a map.

(Website viewer)

The comparison and the mission—the changes you can see—how the human race has changed the landscape in a certain area, and a change in technology. There's a huge difference in the pictures.

(Website viewer)

Those viewers who spent time looking at and comparing the Garriott pictures made comments based on those pictures and their own observations. The two images from South Florida garnered the most interest—viewers commented on the growth of the cities and the contrast between the 1973 and 2008 photos.

[*Looking at Garriott-Florida pictures*] You can see the development.

(Website viewer)

Woman to evaluator: Before, [my husband] was explaining the Earth is constantly changing. This one—[*points to Florida pictures*] shows how cities expand, years later you see how things are growing.

(Website viewer)

Finally, several viewers enjoyed the animations and found them engaging. (Most did not find them, as the *Animations* tab is on the far right of the main screen.) A few viewers appeared to expand their knowledge of Earth processes by watching one or more animations. These visitors learned about the formation of Oxbow lakes and the Great Lakes, the development of the Hawaiian Islands, and other topics.

The animations are clear and to the point.

(Website viewer)

I like the animations, and I like being able to look at the photos.  
(Website viewer)

## PLANETARY STEWARDSHIP

Based on evaluator observations and respondents' comments, the website did not engender a sense of planetary stewardship among users, though several viewers did comment about the relatively small size of the Earth, how humans are connected, and our need to consider humans' impact on the environment.

## VIEWER QUESTIONS

A small percentage (less than one-fourth) of viewers had questions or insights stimulated by the website. A few wondered about the astronauts' experiences of being in space.

What would it be like to be in the space station? (Website viewer)

It makes me wonder about [Garriott's] experience, his take on it.  
(Website viewer)

No questions, but it would be cool to see happenings inside the ISS.  
(Website viewer)

I'm still wondering about space and what you can do with telescopes.  
(Website viewer)

Others wondered about changes to the Earth's landscape over time, and the view from the night sky, or simply wanted to explore specific areas in more depth.

I wondered how things would change, like the edge of Mexico, you can see if something has gone into the ocean [erosion]. (Website viewer)

I'm curious to look at the St. Lawrence more. I have family from there, I'm a genealogist. (Website viewer)

I'd be interested to see night pictures, to compare the differences.  
(Website viewer)

Did he take pictures in the other direction [toward space]? That would be interesting to see. (Website viewer)

## RETURN VISITS

We asked viewers if they would be likely to return to the site at home. About half of respondents said they would or might return to the Windows on Earth website, although many said they would return only if the site were improved.

I would [return] because it's interesting to see the world in another way.  
(Website viewer)

At home yes, if I had more time. This stuff is interesting to me. (Website viewer)

If I happened upon it, I don't know if I'd stick with it so long. I may go back for animations, but I wish there were more—more places to look at. It would be cool to have more games, make it more interactive. Add to it more current events, like the Earthquake in Haiti. (Website viewer)

Five years ago we might have [come back], but now it's been there, done that. (Website viewer)

I probably wouldn't [return to the website]. I keep talking about Google Earth, even news media use it. It comes back to my question—what is the major difference [between this site and Google Earth]—how is this special? (Website viewer)

## VIEWER SUGGESTIONS FOR THE WEBSITE

Respondents shared a variety of suggestions for improving the website.

These included:

- Improved navigation and overall usability of the website, including a basic tutorial on how to use the site, a “back” button to return visitors to the main page, and an ability to click on pop up screens for more information.
- Better orientation for viewers to the web site on the home page, including clarification of the key themes
- Additional features and more interactivity to increase interest
- Labels and more interesting information about the pictures in *Go Anywhere* mode
- “Points of interest” labeled on the site, along with an option to zoom in and explore those locations.

The following comments were typical:

Have a clear statement up front about what they're trying to get across, like deforestation—that would influence how I look at the pictures. (Website viewer)

Make the tabs more clear. Have a concise, 1-2 line explanation of what you'll find and how to navigate. (Website viewer)

Right after you click on the camera [icon] it should give locations. It's confusing to use. (Website viewer)

[I want to] go to major landmarks, points of interest, it needs more interaction to make me stay [on the site]. (Website viewer)

More of a legend, like what the green [photo icons] means, and where coverage is at [where pictures have been taken]. (Website viewer)

One viewer suggested having a live feed to help users understand the difference between looking at digital pictures and looking at the real thing.

It should be an option. An actual live feed might be good to see, if only for a few minutes, you get [an understanding]. (Website viewer)

Finally, several respondents suggested that the Garriott story be emphasized, and easier to find on the website. Those viewers who read about Garriott's mission and/or looked at the pictures found the story to be interesting.

Play up the story, about his Dad and how he [Richard Garriott] was there [on the ISS] 35 years later, looking at what we've done to Earth. (Website viewer)

## **CHALLENGER CENTER WORKSHOP**

Initially, a number of Challenger Center-sponsored activities were planned to coincide with the Garriott Mission and the Windows on Earth supplement. However, most of these activities did not take place due to logistical and scheduling issues. The project did offer one workshop for teachers in the spring of 2009, described below.

### **DESCRIPTION OF THE WORKSHOP**

A free workshop for teachers was held at the Challenger Learning Center at Framingham State College on May 5, 2009. The workshop was led by the [former] project PI and involved 9 educators from various districts and grade levels. The workshop featured an inquiry-based approach, which enabled participants to explore astronaut photographs and other images of the Earth, and was clearly aligned with the primary objectives of Windows on Earth, particularly on expanding educators' knowledge of Earth and visual literacy.

### **TEACHER ENGAGEMENT AT THE WORKSHOP**

All participants appeared engaged by the workshop. The hands-on techniques used by the instructor encouraged discussion and allowed teachers to find images of interest to them, and to speculate on the various features evident in those images (astronaut and satellite photos). There was considerable discussion of "false color," and some of the technical aspects of creating Earth imagery. The instructor led teachers through a range of activities, pointing out teaching strategies, as noted below.

*[During a discussion of Mt St Helen after teachers had looked at an 'after eruption' photo:]* This is embodying visual literacy and Earth literacy. Understanding the scale and features, that's visual literacy, but knowing about Mt. St. Helens and knowing it erupted, that's Earth literacy.

(Workshop instructor)

As the workshop continued, the instructor presented an activity in which the group looked at a space view of Charleston, South Carolina. As teachers examined the photo,

the instructor asked a series of questions designed to promote reflection and spark curiosity among the teachers.

What do you think this looked like before humans entered the scene?...which way does water flow and why? [*Discussion continues among participants.*]  
(Workshop instructor)

Once again, the instructor emphasized the importance of understanding Earth processes, which he defined as Earth literacy. He also presented teaching strategies, such as using a picture as a “detective story” to stimulate student interest.

So this is Earth literacy—what do you understand about Earth components...like if you know these are the highlands. How else could you know the direction of the flow of that river?  
(Workshop instructor)

Throughout the workshop, teachers explored pictures of interest to them, and noted various features contained within those images. They noted physical features, such as rivers, mountains, large cities, volcanoes, etc., and made conjectures as to what was happening in those pictures. For example, one teacher found a picture of the Himalayas, and discussed how one can figure out where the glaciers are going downhill. The instructor frequently encouraged teachers to make inferences about their pictures, modeling how the teachers might use these images with their students.

Teacher: I have one question—what time of year is it?  
Instructor: What time of year do you think it is?  
Teacher: I think it would be summer because there is melt water  
Instructor: You inferred that, you did a great job inferring that from the image.  
(Workshop instructor and teacher)

In addition, the instructor demonstrated the Windows on Earth website, and talked about the upcoming Garriott mission. He explained that students could view pictures taken by astronauts, and that the color in the images was adjusted based on astronauts’ experiences.

## THE IMPACT OF THE WORKSHOP

### TEACHER LEARNING

In late summer/fall of 2009, the evaluators interviewed four educators who had attended the workshop. All found the workshop interesting; three of the four found it relevant to their teaching and professional work. Several teachers commented on the benefit of using books with beautiful pictures as a way of engaging students, as demonstrated at the workshop.

One teacher said the workshop required prior knowledge; she could not bring much material back to her students, since she did not understand how to use that material.

I thought the pieces were very interesting, and loved looking at the books. I felt I really lacked the knowledge to interpret the pictures. We were told to look at physical features and I had no idea what I was looking at. For me to take it back into my classroom, I would have needed more guidance. (Teacher)

A broad range of experience was evident among teachers; some had extensive knowledge of Earth science, while several others were elementary teachers with limited content knowledge. For example, one participant was a K-12 science coordinator for a suburban school district who was also working on a NASA-funded science education grant; another was a high school teacher who taught Earth Science to juniors and seniors. However, all respondents learned something new, either content or new teaching approaches, as noted below.

[I learned] more approaches rather than factual material. I liked what he did with Charleston, South Carolina—putting the image out there and having people figure out what they were seeing, which way the water was flowing. They were simple questions but caused you to think about what you’re looking at, that was neat. (Teacher)

The whole idea of the windows—taking pictures from the ISS...I never thought of scientists getting pictures from precise locations up in space. (Teacher)

I think the colors and the photographs were interesting, I didn’t realize they added colors later on. Most interesting for me was being at the McAuliffe [Center], and I booked a field trip and went to a professional development session there. (Teacher)

While the teachers had seen similar images before, one had an “ah-hah moment” while viewing some of the pictures at the workshop.

I have my image of what the Earth looks like and looks from space, but [the workshop] gave me more detail and I didn’t realize how poorly people perceive things on Earth—I’ve never looked at it so much from so far up. Some I could nail because I was familiar with North America, the landform, but for some the angle image or lighting was different, that was an ‘ah-hah’ moment, looking from a new perspective. (Teacher)

## **CLASSROOM USE**

Two of the three respondents who were currently working in classrooms had used ideas and activities from the workshop by fall 2009, and were planning to do additional activities with their students.

For example, one upper-elementary teacher had used the website during a summer rocketry program and with college students, and he planned to develop some activities for his 5<sup>th</sup> grade students. A high school science teacher created an inquiry-based activity sparked by her experiences at the workshop, as explained below.

We looked at pictures of the Earth from space, some with false colors. I had students pick one they liked and explain why, we talked about why it was important to view the Earth as a whole.... [Then] we will use satellite images where there's been coal mining and where cities have grown, and talk about what colors mean, and false colors. And to talk how it's only been 50 years that we've seen Earth so far away, before that we never had that perspective.... (Teacher)

The teacher quoted above said that the picture activity was “a good hook” in getting students interested in Earth science. She also emphasized the importance of using pictures from books—as demonstrated in the workshop—to give students a bigger sense of how various Earth features fit together.

It seems like when you look at a big book, the kids feel the pictures have more power to them [as opposed to looking online]....I'm going to explore more, using different mapping systems—you can see differences with human civilizations but also how we can see plate tectonics, that we can see Earth changing. You can see things happening, like a whole mountain range, not just one part of a mountain. (Teacher)

## **SUMMARY AND DISCUSSION**

The Windows on Earth project developed a museum exhibit component and a website, and sponsored one related workshop for teachers at a Challenger Center. The content of the exhibit and website were originally intended to be closely related, but this was not possible due to unanticipated technical issues. Currently, the two platforms are related primarily through the concept of looking at the Earth from the space station and through the technology used to provide the images. The museum exhibit is very popular with visitors, while the website is not. Each provides a distinct experience but is limited by particular challenges. With improvements, both have the potential to offer even greater visitor learning opportunities. The teacher workshop also showed good potential for useful applications of aspects of Windows on Earth with students.

### **MUSEUM EXHIBIT**

The Windows on Earth museum exhibit offers an extremely engaging and enjoyable experience for visitors. It encourages a high level of interaction, both with the exhibit and among members of visitor groups, and provides extensive teaching opportunities within visitor groups. Visitors appreciate the large and high quality images, easy navigation, and special features that enhance the views of Earth. While almost all visitors have viewed the Earth in maps, on television, in books, or on the internet, especially with Google Earth, they felt that this experience was different and had advantages over each of the other formats.



Each museum provided a very different type of context for the exhibit. Nonetheless, visitor experiences using Windows on Earth appeared to be generally similar across the museums. It appears that the exhibit experience is not dependent on its location in a particular type of gallery. However, different galleries offer the potential, as yet largely unrealized, of increasing learning by making connections across exhibits. (At the Air and Space museum, visitors often consult the Windows on Earth component during the annual *Geography From Space* contest held in the gallery. The Montshire Museum will be developing materials for docents, teachers, and students that will relate exhibits within the gallery. The Museum of Science may try to link the exhibit virtually with others across the museum.)

Although it is very popular and provides a useful experience for museum visitors, it is the opinion of the evaluators that the exhibit has not yet fully realized its potential as a learning tool related to the original goals of the project. Improvements and additions to the component (as discussed below) might provide additional opportunities for visitor learning, especially in the area of Earth literacy. In addition, continuing technical challenges and constraints on updating the software pose potential limitations for long-term and more widespread use of the component.

## GOALS

In terms of the four major visitor goals of Windows on Earth, the museum component results were mixed:

***Spirit of Exploration***-*experiencing the joy, fascination, and personally-driven curiosity that drives further Earth exploration:* The exhibit provided visitors with an opportunity to explore familiar and unfamiliar places across the planet, which they often did with great enthusiasm. While the majority of exploration involved familiar or known places, visitors were fascinated with the large and high quality images. For some, this was the first time viewing these sites from above, while others had seen similar views before. Regardless, visitors eagerly pointed, explored, and shared new and old destinations with each other. Children were the most likely (although not the only) visitors to follow their curiosity and randomly explore across the Earth.

Windows on Earth offered adult visitors a welcome chance to experience the “spirit of exploration” during their time spent with the exhibit. However, there was no evidence that this would carry over beyond the exhibit for those who were not already engaged with similar activities on the internet. Based on the curiosity shown by many children in using Windows on Earth, the experience may have positive long-term effects, but this is not known.

Most visitors explored a wide variety of places that held some meaning for them, whether familiar or not. More visitors would likely explore more unfamiliar places if given a reason to go there, possibly by prompts of some kind.

***Visual Literacy—using images and interactive visualization as sources of information and insight:*** All visitors who were observed and interviewed by evaluators were able to interpret most of the images they saw on the screen, recognizing many land features and cities. They used their ‘reading’ of these images to help them navigate and explore. And many examined images more closely by adding elevation, night-lights, and cloud cover. While many visitors could recognize their location by looking at the geography alone, others spent some time lost until activating the borders feature. A small proportion of visitors noted the visual effects of Earth processes, such as erosion. Almost no one understood the scale indicator, and there was no assistance to help them understand it.

In general, visitors relied on their prior knowledge when viewing the exhibit, using the images to confirm that knowledge. And while the exhibit itself provided only limited information, visitor group interactions included an abundance of teaching and learning opportunities when one member of the group asked a question or shared new information. Many visitors made new discoveries as a result of these interactions and from looking closely at the images—about land formations, size and distance, population density and light, and various pieces of factual data. For some visitors, interacting with the exhibit prompted a change in their mental picture of the Earth. It is not known whether or how these changes in perception of the Earth might affect visitors in the future.

***Earth Literacy—learn about Earth’s processes and understand Earth as a dynamic integrated system.*** Similar to visual literacy, the exhibit provided an opportunity for visitors to confirm pre-existing information about Earth’s processes and interconnectedness. But the images alone were not able to offer visitors many new insights in this area, and the animations rarely worked as intended. Those visitors who did view animations often gained new information about Earth processes. In addition, there was less sharing among visitors of this type of information. Some visitors did wonder aloud about the causes of different features in the images, and some connected aspects of the images to human activity.

***Planetary Stewardship—embracing and internalizing our connections with home planet Earth and our individual roles in taking care of it.*** While visitors indicated a sense of connection with specific locations and an interest in certain Earth features, they did not discuss feelings of connection to the planet overall. Windows on Earth also did not prompt visitors to talk about taking care of the Earth, either among themselves or in response to evaluator questions. It is possible that some visitors did feel a stronger sense of connection with the Earth after using Windows on Earth, but this was not mentioned by respondents.

## EXHIBIT RECOMMENDATIONS

Visitors enjoyed interacting with Windows on Earth in a variety of ways and profited from the experience. Nonetheless, the exhibit would benefit from improvements and further development, which might help it to provide even greater learning opportunities for museum visitors.

- **Provide additional information**  
 Project staff carefully considered how much information to provide in the small information band at the bottom of the screen. Additional information about images is also often shared among members of visitor groups. Nonetheless, visitors often expressed curiosity about different types of sites, and many would have appreciated more information about them.
- **Improve functioning of animations**  
 Animations were devised as a major Earth literacy teaching tool. When visitors found them and they opened in a timely manner, they often provided new information. Visitors need more assistance to discover them or prompting to look for them, and design and animation technology problems at some of the museums need to be solved.
- **Encourage visitors to explore new locations**  
 The majority of visitors only explored places they or their companions knew or had heard about. Many of these visitors would likely have investigated additional places, such as sites of interesting land formations, if encouraged to do so. Some would have also looked at more geographic points of interest if they had had some help and encouragement to find them, such as the Grand Canyon and Mt. Everest. While some questions were listed on some exhibit consoles, these did not prompt visitor exploration. Therefore, other methods of engaging visitor curiosity need to be developed.
- **Add historical comparative views**  
 There are important sites around the globe that easily show the effect of Earth processes and/or human activity on the planet when viewed over time. Making some of these comparative views available, possibly with an optional click over marked locations, might contribute to both the Earth literacy and planetary stewardship goals of the exhibit.
- **Develop docent, teacher, and student materials**  
 The exhibit could benefit greatly from the services of trained docents, in museums that have docent programs. Docents could ask guiding questions to encourage greater types of exploration, and provide additional information about types of Earth features and formations visible from space. The large screen helps the exhibit to be visible and interesting to groups of visitors, so many visitors could be impacted simultaneously. Training materials might also be made available to teachers to prepare student visitors to use the exhibit and/or website more thoughtfully, and

materials specifically for students might also encourage targeted exploration and increase learning.

- **Improve usability**

Visitors generally found the navigational and other special features easy to use once they discovered them. The museum console, at least at several sites, could be improved to help visitors discover these features more easily.

- **Clarify features**

The exhibit could also benefit from clarifying information about some of the special features--the colors of the elevation feature were sources of confusion for some visitors; visitors often wanted to know if the clouds shown were in real time; and almost no visitors understood the scale presented on the main screen. Visitor experience could be enhanced by clarifying the ground distance scale and adding information about image distance above the Earth.

- **Revisit zoom distance decisions**

The decision of how close/how far to allow visitors to zoom in and out may be the correct one for the exhibit, but it would be helpful to revisit that decision if Windows on Earth undergoes further development. The current levels are mostly related to ISS views, with closer views generally allowed in the home city. While visitors understand that they are viewing the Earth from space, and some realize that these views are related to the ISS, this is not a primary factor of the viewer experience. (Future developers may wish to emphasize this by providing additional contextual information surrounding the exhibit component.)

- **Allow more control at local museum sites**

Some museums would greatly appreciate the ability to augment and update the exhibit software independently. If there were a way to make this possible in future iterations (using on-site technicians), it might help some museums customize the exhibit and keep it more updated.

## WEBSITE

### GOALS

As currently configured, the Windows on Earth website is of limited interest for most viewers. While site visitors did try to explore various points of interest, including their hometowns or countries of origin, they were often frustrated by the challenge of navigating the website. Therefore, though many viewers had some initial curiosity or *spirit of exploration* as framed by the project, they often gave up before reaching their destinations, or found there were no images to explore upon arrival. Some viewers, particularly those who explored higher-resolution images, did make some observations about mountains, islands, and other natural and man-made phenomena, such as irrigation

channels, which related to their knowledge of *visual literacy*. Improvement in the user interface and the addition of labels and suggested points of interest could add to viewers' engagement with the website, and development of visual literacy as defined by project staff. A few visitors did reflect on astronauts' experiences in the ISS and their view of the Earth, but most did not.

Most viewers did not interact with the website in a manner that allowed them to use or develop skills in the area of *Earth literacy*. However, the story of the Garriott mission and the opportunity to compare images from the 1970s and today stimulated viewer interest and encouraged them to make observations about the images. Yet many viewers did not explore the Garriott pictures without prompting from the evaluators and only five pairs are presented on the website currently. Those visitors who did peruse the pictures made observations that utilized their knowledge of both visual and (in some cases) Earth literacy, as when they discussed the development of the Miami area and the city's encroachment on the Everglades, as shown in one set of pictures taken by the Garriotts. Several viewers who watched the animations also appeared to learn new information about Earth processes from some of them; the animations could potentially become a more widely accessed teaching tool.

In terms of *planetary stewardship*, the website was generally unsuccessful in eliciting a sense of strong connection with planet Earth and "our individual roles in taking care of it." Several viewers did comment on how the Earth looked small or "tiny" from space, and some commented on how comparing pictures from different eras could demonstrate humans' impact on our environment.

## **WEBSITE RECOMMENDATIONS**

The evaluators believe, based on our interviews and observations, that the Garriott mission and similar connections to the astronaut experience would provide a unique and compelling way to engage web visitors and connect with project goals. Expanding the number of paired (comparison) pictures and providing commentary from astronauts could engage students and interested members of the general public in looking at the Earth from a new perspective. The website could also serve as a useful teaching tool for educators at all levels, through the expansion of astronaut stories and additional images.

## **COMPARISON OF VISITOR OPTIONS**

Visitors' use of websites, including museum websites, differs markedly from visits to actual museum exhibits. Website visitors tend to look for specific information, and frequently 'surf' from one site to another, based on their personal interests and the ease of navigation, while museum visitors often spend considerable time at specific exhibits.

Therefore, it is somewhat difficult to compare visitors' experiences at the Windows on Earth component and on the related website.

Originally, the website was conceptualized by project staff as providing a similar/parallel experience for web users. However, over time, due to technical and budgetary challenges, the focus of the website changed to emphasize the Garriott mission, and to limit some additional features of the website. (For example, the labeling of points of interest on the site was abandoned, and only five pairs of 1973/2008 Garriott pictures were eventually posted on the website.) Our data indicate that the website was only partially successful in engaging viewers and had limited impact in stimulating their interest in the four stated goals of spirit of exploration, visual literacy, Earth literacy, and planetary stewardship, or in encouraging visitors to reflect on and identify with astronauts' views of our planet. Overall, even though theoretically a website can allow for more in-depth exploration, it was clearly less successful in stimulating viewers' interest and promoting their learning than the Windows on Earth museum exhibit.

## **CHALLENGER CENTERS**

The project workshop at the Challenger Center was a useful venue for deepening teacher knowledge using Windows on Earth-related materials, and for encouraging new classroom practices. The Challenger Centers work intensively with elementary and middle school youth and teachers, and could provide a natural audience for Windows on Earth-related materials, including the website. Teachers could use the website as a teaching tool with their students, and explorations on the website, such as comparing images taken by Owen and Richard Garriott, could lead students to new discoveries and understandings in the areas of visual literacy, Earth literacy and planetary stewardship, as well as a greater awareness of human impact on our planet. In order for this learning to take place, some additional images would need to be added to the website, and some teaching and perhaps student guides would need to be developed as well. Challenger Centers might also be an excellent location for additional WinEarth components, especially if combined with teacher and student educational materials.

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Despite the increase in availability of similar Earth images via the internet, the Windows on Earth museum exhibit has provided an important opportunity for visitors to interact individually and collectively with views of the planet on a big screen. The Windows on Earth website could also provide a useful learning experience for viewers, but only with significant revision to make it sufficiently engaging for casual viewers, and more teacher training to make it a useable classroom resource. Both the museum component and the website have untapped potential that might be realized with further development.