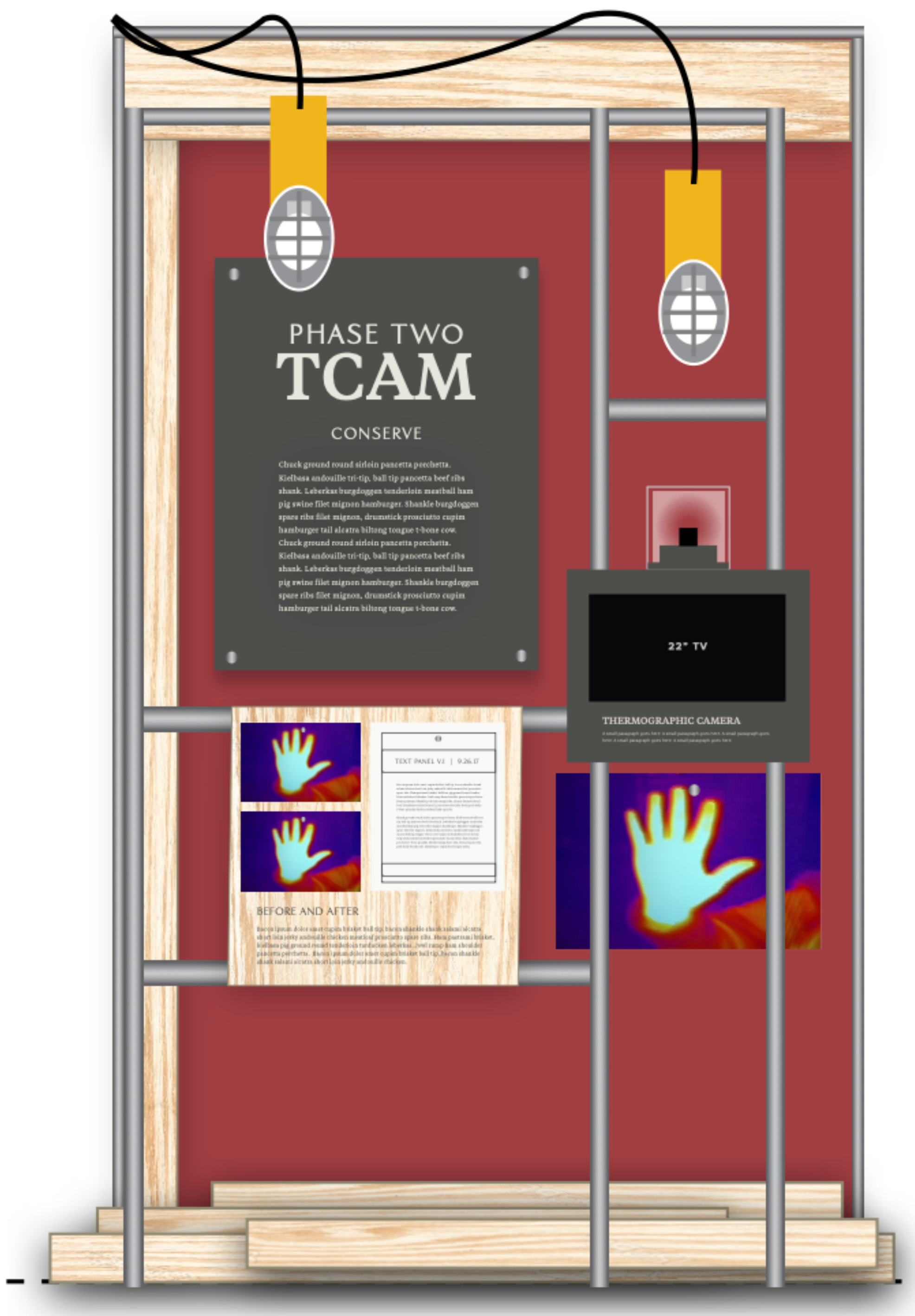
Erin Branigan—Writing Sample
Tomb of Christ: Church of the Holy Sepulchre (National Geographic Museum)

LIDAR LAYOUT

GPR LAYOUT



THERMOGRAPHY LAYOUT

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Area	Number	Description	Content Type	Text	Notes
INTRO					
A	1.1	Intro to Scene 4	Fabric Print	**A SHRINE IN PERIL** Jerusalem's Church of the Holy Sepulchre is a place of great historical and spiritual significance. Worshipped as the site of Jesus Christ's burial and resurrection, millions of pilgrims and tourists flock to this sacred spot each year. But by 2016, the Edicule at the center of the church—the holiest place in Christendom—was in danger of collapse. Since its construction in 1810, the current Edicule was beset by destructive forces. An earthquake in 1926 caused major structural damage. A fire in 1929 further compromised the building. The oculus in the rotunda's dome let water drip on the shrine, causing erosion. Smoke from candles and oil lamps burned in the church blackened the shrine's walls. And the steady stream of visitors meant there was no good time to make repairs. With the structure weakening by the day, an ambitious plan was launched. Restorers from the National Technical University of Athens, Greece, were given one year, between Easter celebrations in 2016 and 2017, to scan, clean, and reinforce the shrine—without ever closing the church to visitors. Here, you can follow along with their work as they race the clock to meet their deadline.	
A	1.2	Why Restore Now	Panel	**WHY RESTORE NOW?** Destructive forces constantly wear down ancient monuments like the Church of the Holy Sepulchre. Regular care and restoration are critical to keep sites like the church's Edicule from sustaining permanent damage. However, from the time the Edicule was rebuilt in 1810 until 2016, no major restoration work was carried out on the building, allowing the ravages of time to take their toll on the sacred shrine. But why? A plan for the custody and maintenance of the Edicule was spelled out in the Status Quo agreement of 1852. From that point forward, any changes to the Edicule had to be agreed upon by unanimous decision of the church's major stakeholders. As the Edicule accumulated damage over the years, nothing could be done to reverse it until everyone was able to agree on a plan to intervene. In 1959, the stakeholders agreed that the Edicule could be restored under two conditions: that the restoration work would not stop pilgrims from visiting the shrine, and that the restoration work would be completed between two Easter celebrations. It took until 2015 for the church's leaders to receive a proposal for the restoration that met both demands and would be successful in stabilizing and cleaning the Edicule. That same year, an American philanthropist named Mica Ertegun made a major financial gift to the church to support the shrine's repair. This gift spurred church leaders to seriously consider the restoration proposal they received. Finally, work began in 2016—57 years after an agreement to restore this structure was first reached. Philanthropy was the catalyst that brought about action to conserve this cultural heritage site for future generations.	**Images:** CAPTION 1: *Mica Ertegun receives the medal of the Holy Sepluchre from the Patriarch of Jerusalem.* CAPTION 2 (Include only if space): *This is a copy of the consensus agreement signed in 2016.* NTUA Images—Must Include Copyright: © Copyright NTUA, 2016-2017. All rights reserved.

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LIDAR					
B	7.1	LIDAR: How It Works	Panel	**LIDAR** *Purpose: 3-D Modeling* *Technology: Lasers* LIDAR is a surveying technique that measures the distance from a LIDAR sensor to a target by illuminating that target with a pulsed laser light and then measuring the reflected laser pulses with a sensor. Differences in return times and wavelengths are recorded and used to make a digital 3-D model of the target. LIDAR gets its name from a combination of the words "light" and "radar," but it also stands for "light detection and ranging." LIDAR has many useful applications. Airborne LIDAR sensors mounted to the bottom of an aircraft can help cartographers make more accurate maps or assist archaeologists in examining remote or dangerous terrain for long-buried or overgrown evidence of human activity. LIDAR on the ground can be either stationary or mobile. Mobile LIDAR is helping to make self-driving cars a reality. And stationary LIDAR is the type restorers used in the Church of the Holy Sepulchre.	
B	7.2	LIDAR: How It Was Used	Panel	**LIDAR IN THE RESTORATION** *Restoration Phase One: Study* The conservation team used a LIDAR unit like this one during the restoration process. The unit is placed in a fixed location. The top of the unit rotates, sending out intermittent laser pulses 100,000 times a second. When the laser pulses hit a solid object, like a wall or a column, the energy bounces back to the unit and is recorded. Together, the billions of recorded data points were used to build a virtual replica of the Edicule and other parts of the church that are accurate to the millimeter. Before beginning any hands-on restoration work, the team first took detailed LIDAR scans inside and outside the Edicule. The 3-D models have had a number of uses. They helped the team plan their approach to the restoration, and they serve as an important archival record of this fragile, threatened building. They are also useful as an educational tool. LIDAR scans of the church were used to develop the immersive portions of this exhibition. They will also be used to build an online model of the church that students and scholars can access from all over the world.	
B	7.3	LIDAR: Touch Prop	Tabletop—Panel	**TOUCHING HISTORY** This 3-D print of a Crusader-era cross matches the one on the wall, which you can scan with the LIDAR unit by pressing the button on the table. The LIDAR unit sweeps side to side, sending laser pulses to the carving and recording the time and wavelength of the return signal. The data collected is used to create a point cloud that scientists can use to create a 3-D digital representation of the original. Touch this carving, then press the button and look at the screen to see a digital representation of the cross being created, accurate to the millimeter. *[Goes with button]* Press the button to scan the carving.	

Area	Number	Description	Content Type	Text	Notes
B	7.4	LIDAR: Video	Video Bezel—Vinyl	**LIDAR IN ACTION** Press the button below and watch as the carving on the wall is digitally re-created as it is scanned by the LIDAR unit to the right.	
B	7.5	LIDAR: Wall Image	Panel	[No Text]	**Image:** NTUA Image—Must Include Copyright: © Copyright NTUA, 2016-2017. All rights reserved.
GPR					
B	8.1	GPR: How It Works	Panel	**GPR** *Purpose: Noninvasive Imaging* *Technology: Radar* Ground-penetrating radar, or GPR, is a noninvasive technique that uses radio wave pulses to create an image of what is hidden below the surface of the ground or behind the walls of a building. A GPR transmitter emits electromagnetic radiation into the ground or other surface to be scanned. When the energy encounters a hidden object or a boundary between materials of different density or conductivity, that energy is reflected back to the surface. A receiving antenna records the variations on a radargram, creating a picture of the subsurface. GPR is noninvasive and nondestructive, so it is useful across a number of fields. Earth scientists use it to study bedrock, soils, groundwater, and ice. The military searches for unexploded ordnance with GPR. And archaeologists and restorers employ GPR to examine fragile historical sites like the Edicule. The electrical conductivity of the material to be scanned has a significant impact on the effectiveness of this technology, however, so location can severely limit its performance.	
B	8.2	GPR: How It Was Used	Panel	**GPR IN THE RESTORATION** *Restoration Phase One: Study* Ground-penetrating radar transmitters are available in a variety of sizes and shapes. Larger GPR units may be mounted on wheels for use across a larger site, such as an entire field. Smaller, handheld GPR units are used in tighter quarters, like to examine what's behind part of a wall. While the small model on display here has wheels, restorers working on the Edicule used a handheld unit with no wheels so they wouldn't damage the shrine's fragile walls. The NTUA team scanned the entire Edicule with a handheld GPR transmitter to determine what was enclosed inside the walls of the shrine. The resulting radargrams revealed something fascinating. The exterior walls, which were built in 1810, were constructed around masonry fragments from an earlier Edicule that stood on the spot. And inside those, remnants of the original limestone walls of the tomb still stood. Restorers used the information gathered from their GPR scans to plan how best to reinforce the walls of the Edicule with liquid mortar.	

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B	8.3	GPR: Radargram Explanation	Tableto—Panel	**UNDERSTANDING RADARGRAMS** A radargram is a digital cross section created from data gathered by a GPR unit in the field. The surface is at the top, and the wavy lines below show where energy has been reflected back to the unit. The shape and intensity of the waves are caused by the reflection of energy from objects or materials of different densities or conductivities. Restorers used radargrams to determine the location of the remnants from the original tomb walls hidden within the structure of the Edicule. They also used this data to find voids left in the Edicule's deteriorating mortar, indicating where they should inject new liquid mortar to reinforce the walls.	**Image:** *This radargram shows what's hidden behind the walls of the Edicule.* NTUA Image—Must Include Copyright: © Copyright NTUA, 2016-2017. All rights reserved.
B	8.4	GPR: Video	Tabletop—Vinyl	**GPR IN ACTION** Grasp the GPR unit's handle and slowly run it along the track. The screen shows a radargram of what the unit is scanning. The bowed areas indicate hidden objects of a different density than the surrounding material. *[In vinyl on the unit]* Please Touch Gently	
THERMOGRAPHY					
B	9.1	Thermo: How It Works	Panel	**THERMOGRAPHY** *Purpose: Heat Detection* *Technology: Infrared Imaging* Thermography, or thermal imaging, uses a heat-sensitive camera to detect infrared radiation and to produce an image of that radiation called a thermogram. All objects above absolute zero emit infrared radiation, and the amount of radiation emitted by an object increases with temperature. When viewed through a thermographic camera, warm objects stand out against cooler backgrounds, making them easily visible, even when there is no visible light. Thermography has many practical applications, but it is especially useful in revealing things that cannot be seen by the naked eye. Firefighters use thermographic cameras to see through smoke. Builders can use thermography to see heat leaks in a building, using the results to improve the building's insulation. The military uses thermography in the field to visualize targets, and security cameras sometimes employ thermography in low-light conditions. Archaeologists use aerial thermography to reveal the presence of buried structures.	

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Area	Number	Description	Content Type	Text	Notes
B	9.2	Thermo: How It Was Used	Panel	**THERMOGRAPHY IN THE RESTORATION** *Restoration Phase Two: Restore* Every day, the faithful burn devotional candles and oil lamps inside the Church of the Holy Sepulchre, particularly around the Edicule. Over the centuries, soot from these flames have caked the walls, hiding many beautiful paintings and inscriptions. Restorers used a thermographic camera with a live video feed, like the unit displayed here, to examine the walls of the Edicule and the surrounding walls in the rotunda. These scans revealed what was hidden behind the thick layers of soot and grime. Darker pigments absorb more heat and release more infrared radiation than lighter ones. Although the paintings were hidden behind thick soot, when examined with a sensitive thermographic camera, the paintings' patterns stood out clearly to restorers. Using this information, the restorers determined where and what to clean, revealing these works of art to visitors once again. The results were dramatic, as you can see in the photos shown here.	
B	9.3	Thermo: Before and After	Image Label	**BEFORE AND AFTER RESTORATION** The top image shows a thermogram of one of the paintings inside the Edicule's dome before it was restored. Darker colors like purple are cooler areas of the image, and lighter colors like orange are warmer. This thermogram reveals gilding on the painting that was long obscured by soot, as well as the extent of cracks in the wall behind the art. The bottom image shows a thermogram after that painting was restored.	**Images:** NTUA Images—Must Include Copyright: © Copyright NTUA, 2016-2017. All rights reserved.
B	9.4	Thermo: Video	Video Bezel—Vinyl	**THERMOGRAPHY IN ACTION** This video screen shows a live feed from the thermographic camera above. The different shades represent different intensities of thermal radiation (heat). Stand in front of the camera to see your own heat signature onscreen.	