Deep Civilisation | Architecture

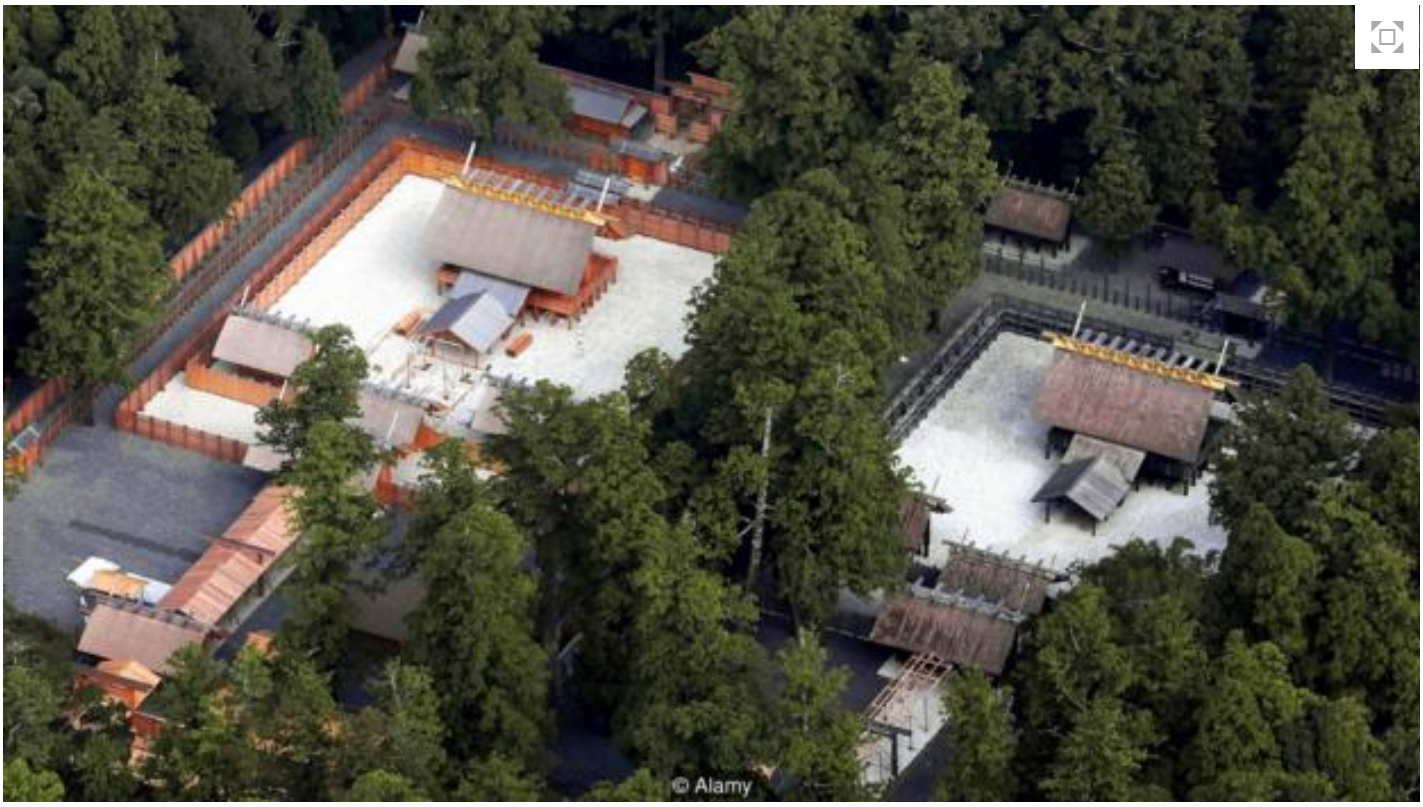
How to build something that lasts 10,000 years

Alexander Rose and a team of engineers at The Long Now Foundation are building a clock in the Texan desert that will last for 10,000 years. He explains what he's learnt about designing for extreme longevity.

By Alexander Rose
11 June 2019

When I visited Japan recently, I witnessed the 66th cycle of a ritual that began more than 13 centuries ago. I watched as Crown Princess Masako led a procession of Shinto priests carrying treasures from the old temple to the new. In Ise, they have been rebuilding the grand Jingu shrine with wood and thatch every 20 years since at least the 7th Century. As part of Shinto ritual, this not only keeps the structures intact even when made out of relatively ephemeral materials, but it allows the master temple builder to train the next generation.

Japan is also home to most of the oldest companies in the world, and has a singular affection for maintenance that allows it to sustain structures and rituals for millennia. But many other cultures have created long lasting artefacts and buildings, and each one can teach us something.



The Ise Grand Shrine in Japan where the buildings are rebuilt every two decades (Credit: Alamy)

Over the last two decades, I have been working at The Long Now Foundation to build a monument-scale “10,000 Year Clock” as an icon to long-term thinking, with computer scientist Danny Hillis and a team of engineers. The idea is to create a provocation large enough in both scale and time that, when confronted by it, we have to engage our long-term future. One could imagine that if given only five years to solve an issue like climate change, it is very difficult to even know where to begin because the time scale is unreasonable. But if you reset the scale to 500 years, even the impossible can start to seem tractable.

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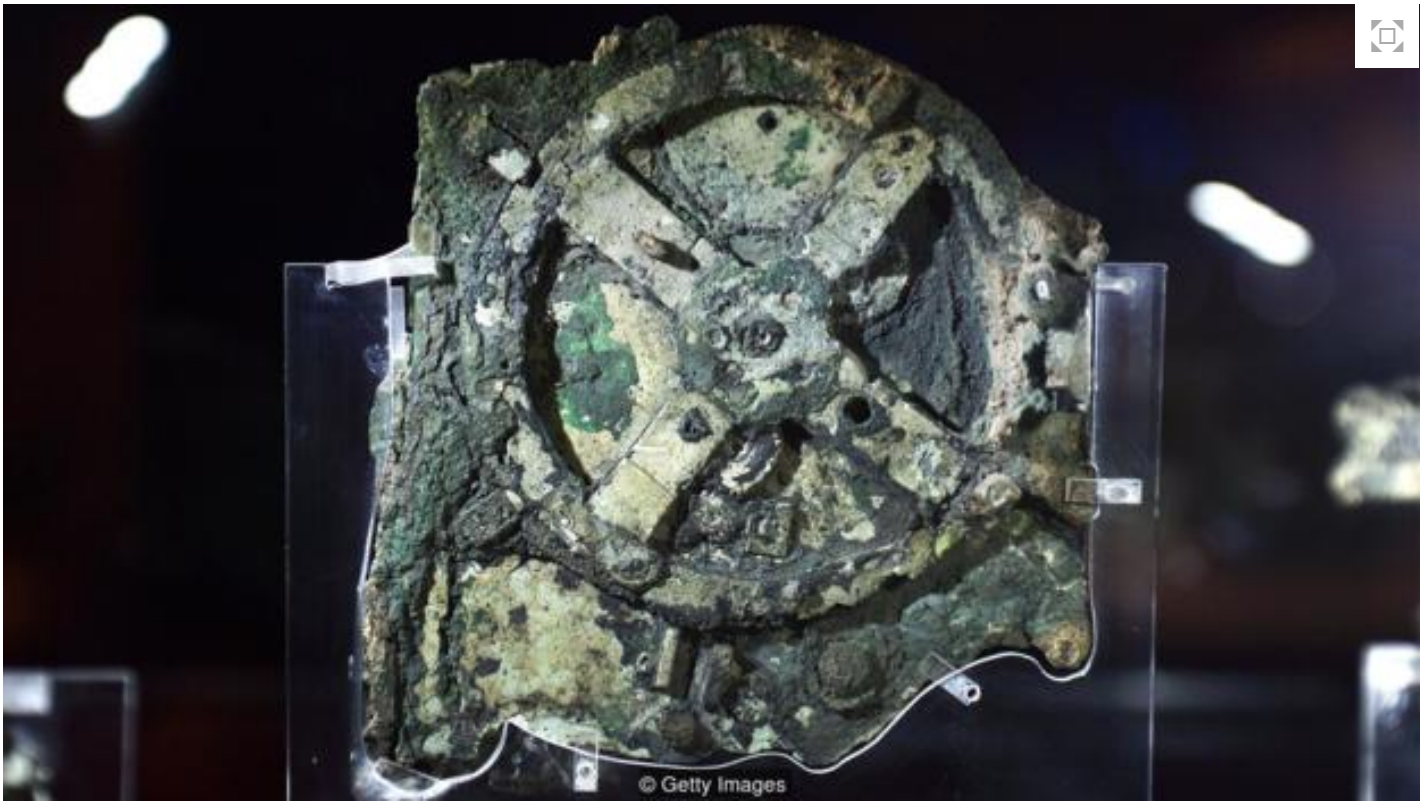
Building a 10,000-year machine required diving into both history and the present to see how artefacts have lasted. While we can slow the workings of the clock itself down so that it only ticks as many times in 10,000 years as a watch does in a person's lifetime, what about the materials and location? Over the last 20 years I have studied how other structures and systems have lasted over time, and visited as many of them as I can. Some sites have been conserved by simply being lost or buried, some have survived in plain sight by their sheer mass, others have had much more subtle strategies.

Few human-made objects or organisations last more than a handful of centuries, much less millennia. Stories, myths, religions, a handful of institutions, as well as some structures and artefacts have lasted this long. Most of these were not built with the intention of extreme longevity, but are accidents of history. More recent efforts such as nuclear waste sites, genealogic repositories and seed vaults, are being designed explicitly to last for thousands – or even hundreds of thousands – of years. There are a series of lessons we can learn from the past and present, ranging from material science and engineering, to the ideological. I will cover several of these as well as discuss how they have influenced our work on the 10,000 Year Clock.

Lost & found

Some of the most unique and meaningful objects from history have survived not by intention, but by being lost and then found at an opportune moment. The Dead Sea Scrolls, the Rosetta Stone, and the Antikythera Device never would have made it to modern times without first being lost. The Antikythera Device has been of particular interest to me because it was also a planetary clock of sorts – centuries ahead of its time. It was discovered as chunks of oxidised gearing in a 2,000 year-old shipwreck near Antikythera, Greece.

No similar device has ever been found from that era. Its workmanship and understanding of gearing and celestial events are remarkable in that many of the ideas and mechanical principles would not be seen again until Europe emerged from the dark ages 1,300 years later. In addition, it would have taken many iterations to build such a device, so it is a further mystery that we don't have any other examples of devices like this. Clearly the only reason this one survived was because it was lost. But even after being found, it languished for decades in storage before X-ray studies revealed its true complexity and purpose as a working astronomical model.

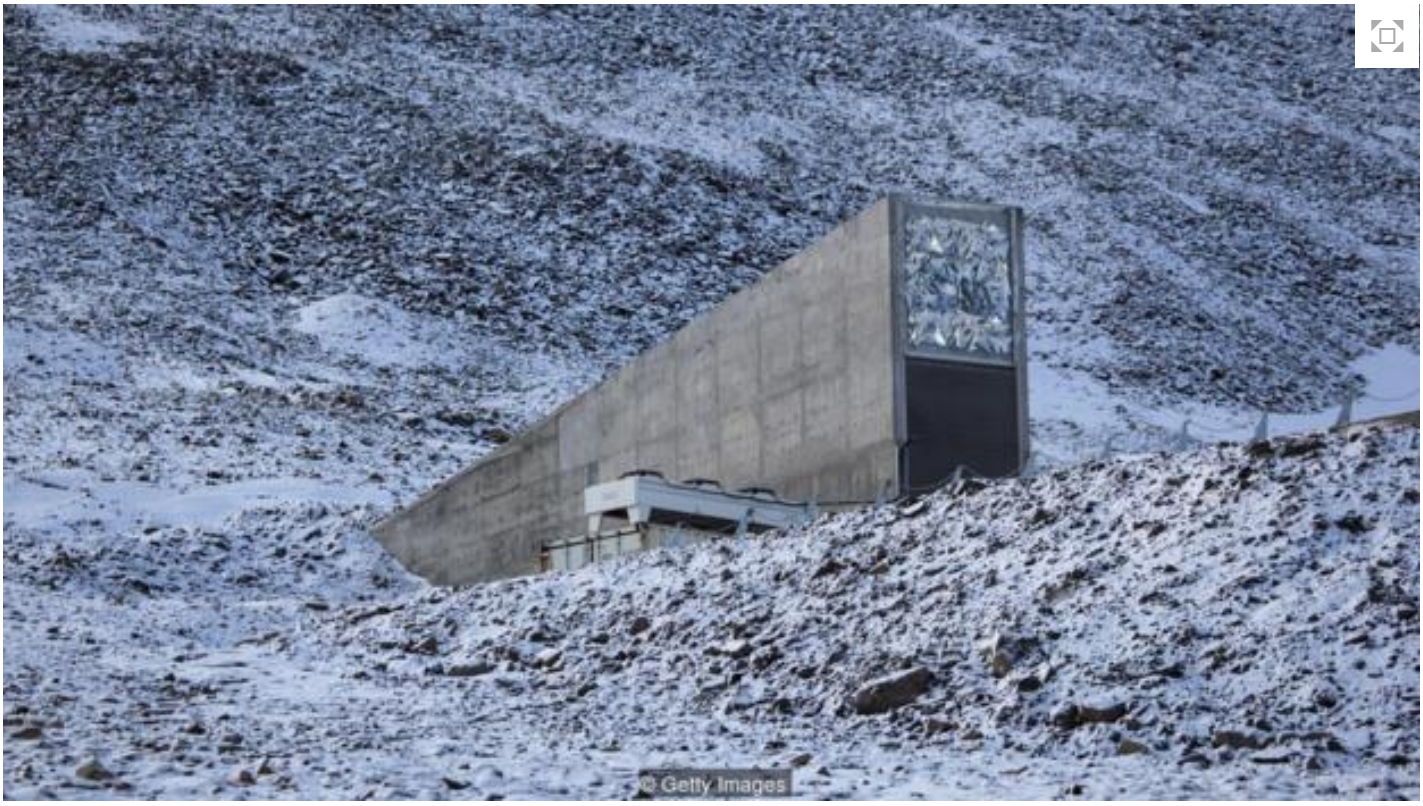


The Antikythera Mechanism, an ancient mechanical device from the 2nd Century BC (Credit: Getty Images)

The other lesson learned for our 10,000 Year Clock project is that mechanical objects are much better at self-documentation for a future archaeologist than electronic ones. You could imagine if they had found a modern electronic device at the bottom of the Mediterranean after 2,000 years, it would be almost impossible to determine the intentions of its silicon circuits. This is one of the main reasons that we are building a large mechanical device. Even if only parts of it survive the entire 10,000 years, it is likely that people could determine its purpose and even repair it if needed.

Remote places

Cities are defined by churn. Cities themselves can often thrive for more than 1,000 years, but the contents within them turn over with each passing decade. For every urban artefact that has lasted over a millennium, there are countless more that were destroyed by war, civic changes, or accidents. Remote places generally have created much more opportunity for long-term survival. Spectacular sites like Petra and Machu Picchu were most certainly preserved due to their distance from modern cities.



The Global Seed Vault in Svalbard, nestled inside a mountain, can only be rarely visited (Credit: Getty Images)

> *As I signed the guest book I saw the names of Jimmy Carter and Ban Ki-moon*

Remoteness can also lend a more mythic presence to a site. Several winters ago I travelled to the Global Seed Vault located in Svalbard, the most northern permanently inhabited place on Earth at 78 degrees latitude. The vault was designed to last for over 1,000 years as a backup repository of the world's crop seeds. However, in building it, the designers failed to realise how much it would capture the imagination of the world. It was not designed for visitation, and they found themselves telling dignitaries who travelled there from around the world that they could only see the outside of it. In the case of our trip we had timed it to one of only two times a year they open the vault to deposit seeds. As I signed the guest book I saw the names of previous delegations that included people like Jimmy Carter and Ban Ki-moon, I realised that the remoteness of the site made it only more interesting to the outside world.

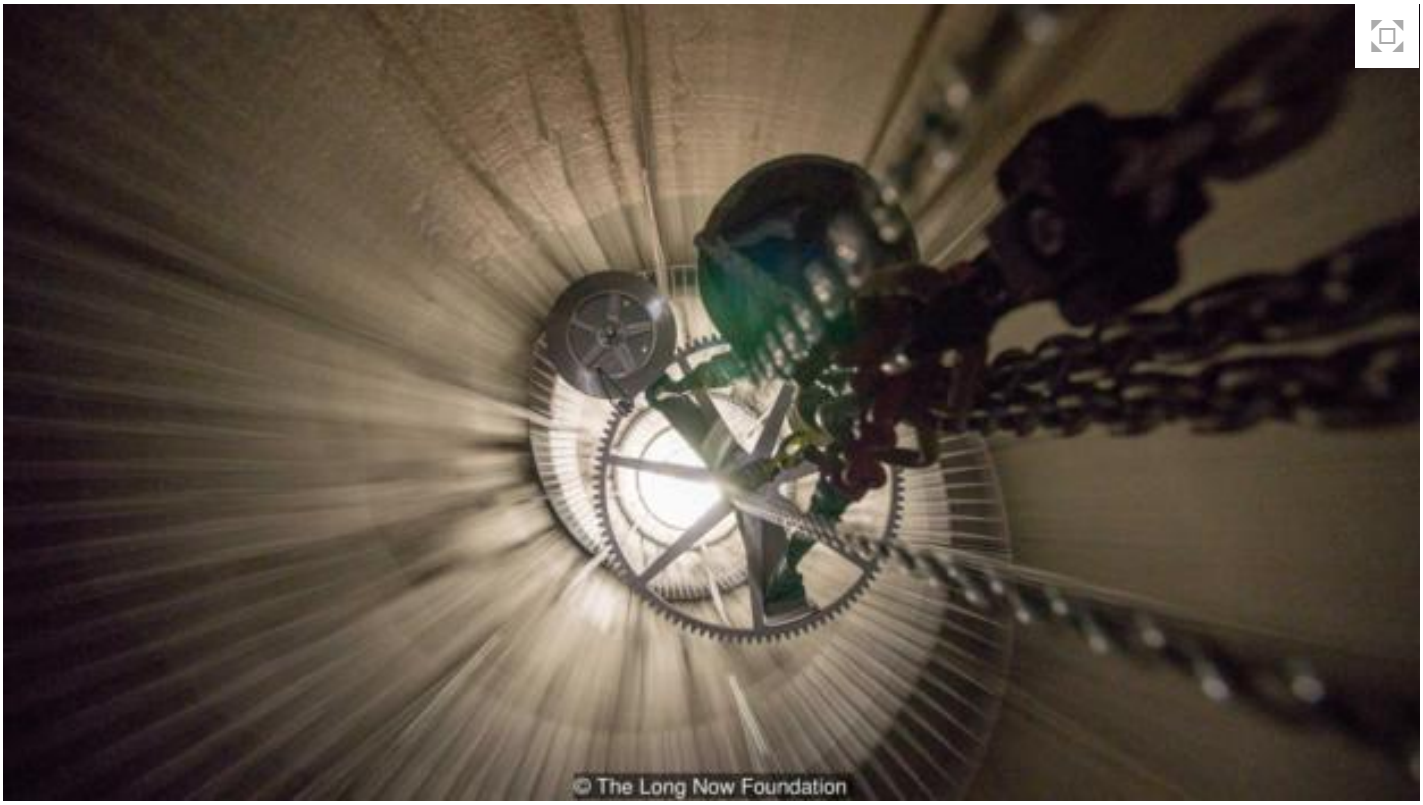
Remote sites also require intention and time to reach rather than being a "drive by" location. Travelling to a specific destination means that people who visit it get transition time as they voyage there, and most importantly on their way back. For the 10,000 Year Clock site we have selected a site in far West Texas that is many hours from airports and that will require a day of hiking to visit. Since

the clock project is meant to change the way people think about time, the remote site gives both anticipation and time to process the visit, making the isolation as crucial to the mythic qualities as it is to preservation.

Underground

Many of the best preserved artefacts probably spent most of their time underground. The subterranean environment protects them from sunlight and generally keeps a very stable temperature. The rise and fall of temperature accelerates oxidation and aging. In fact, when manufacturers do rapid aging tests for materials, it is done largely through cycling temperatures up and down (and chemical effects, which we will get to next).

The ornate tombs of Luxor, Egypt, cave paintings such as Lascaux in the Les Eyzies valley of the Dordogne in southwestern France, and even delicate artefacts such as the Dead Sea Scrolls were all preserved underground for thousands of years. It is no wonder that modern efforts of preservation such as the Global Seed Vault, nuclear waste repositories and archives are all built beneath the surface.



Parts of the 10,000 Year Clock being installed (Credit: The Long Now Foundation)

There is, however, one serious drawback to trying to preserve things underground – water. I have visited nuclear waste sites in the US and Europe, the Global Seed Vault, and the Mormon Genealogical Archive – and in every case they are fighting a losing battle to keep water out. Over

centuries and millennia, water will always find a way in. The only successful mitigations of water I have seen are when it is redirected rather than blocked. The ancient rice paddies of Asia are a testament to the effectiveness of carefully directing water over thousands of years.

DEEP CIVILISATION

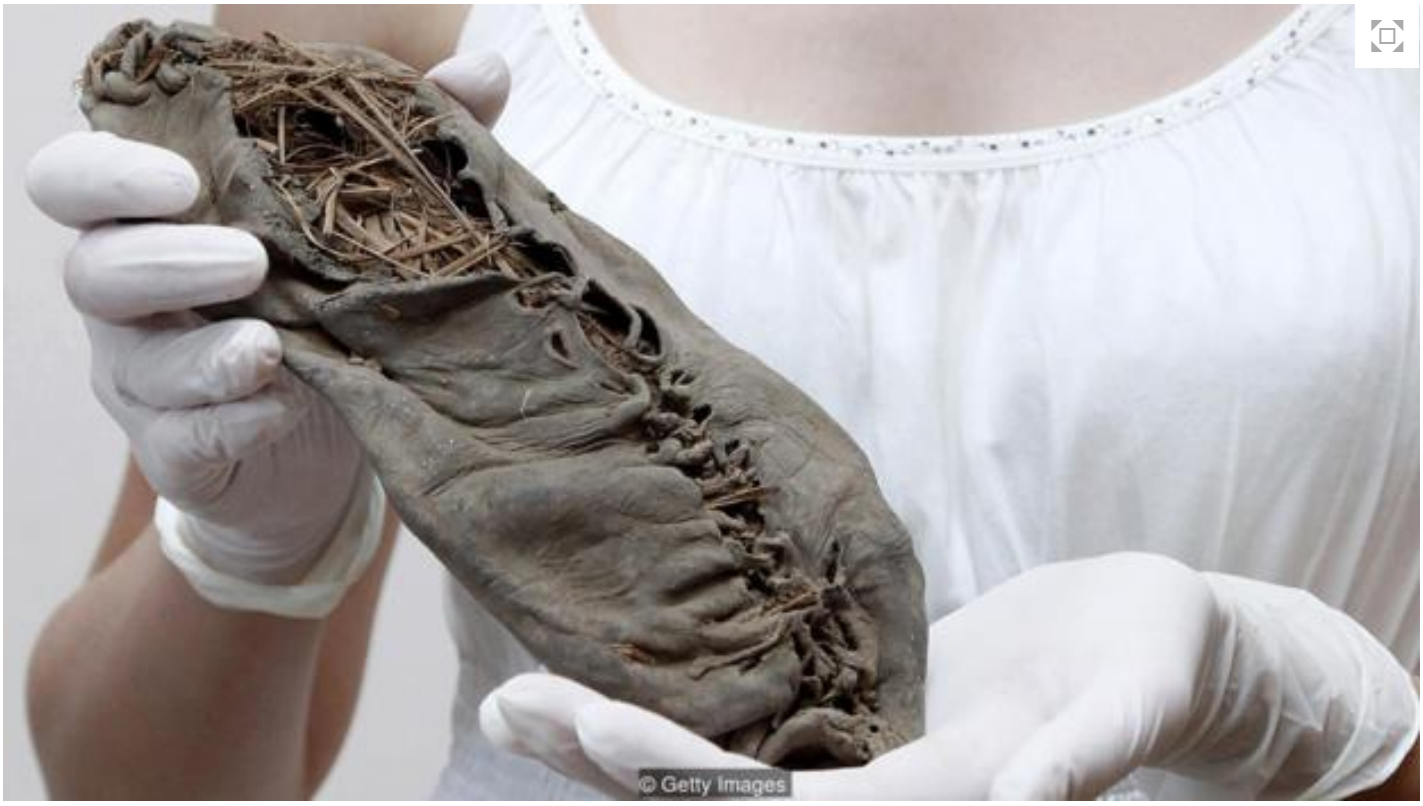
This article is part of a **BBC Future series about the long view of humanity**, which aims to stand back from the daily news cycle and widen the lens of our current place in time. Modern society is suffering from "temporal exhaustion", the sociologist Elise Boulding once said. "If one is mentally out of breath all the time from dealing with the present, there is no energy left for imagining the future," she wrote.

That's why the Deep Civilisation season is exploring what really matters in the broader arc of human history and what it means for us and our descendants.

Building the 10,000 Year Clock underground is important not only for preservation, but for timekeeping as well. Temperature change causes metals to expand and contract, requiring clever and imperfect schemes to keep devices like pendulums at the same length, and therefore keep regular time. The less temperature change a mechanical clock experiences, , the more accurate it will be. However, after witnessing the struggles with water at nearly every underground site I have visited, we had to think very carefully about how we tackle it. Our underground site is built at the top of a mountain in order to minimise the area of drainage that can collect water, but we still assume that water will get in. To address this eventuality, we angled every underground surface away from the clock and made sure that water would not be trapped anywhere and could escape at the bottom of the site. If we can't stop the water, we can choose where to direct it.

Materials

One of the first material scientists I spoke to about making things that last for thousands of years offered a compelling insight: "Everything is burning, just at different rates." What he means is that what we perceive as aging is actually oxidisation, like rusting. When we imagine materials that may last for thousands of years, most people think of stone or precious metals like gold – because they don't oxidise readily. But even bodies can be preserved for millennia if stored in the right chemical environment, as the mummies of Egypt demonstrate. Not long ago a **perfectly preserved leather shoe** was found in Armenia dating from over 5,500 years ago. The longevity of a material is often less about the object itself, but much more about the environment it is in. In the case of the leather shoe, it was buried in a cave and sealed in by sheep dung, thereby creating the perfect anaerobic, stable temperature environment.



A 5,500-year moccasin said to be the world's oldest leather shoe (Credit: Getty Images)

But to build objects and machines that people interact with over thousands of years, we have limited ability to control that environment. People breathe the same oxygen that degrades materials, and they bring in dust on their clothes, and oil on their skin. To build a working machine that people can visit for 10,000 years, the materials themselves must be long-lasting.

> *Even stainless steel bearings will simply weld together if left for long periods of time*

Probably the best example of this are the bearings that we are using for the clock. All the rotating parts in the clock require some sort of bearing surface in order to smoothly roll with minimal friction. However, there are several problems with traditional bearings, which are usually made of a row of hard steel balls between specially-ground tracks called races. Steel or even stainless steel bearings will simply weld together if left for long periods of time, and they also undergo another process called galvanic corrosion if they are separating two metals with different electrical potential. If you have ever seen the way a penny corrodes when left on another metal surface, this is galvanic corrosion. In addition to these issues, normal bearings require lubrication – but that means regular maintenance – and can attract dirt and grit.

Over 20 years ago when I started this project in researching bearings, we found the perfect solution: an all ceramic bearing created for use in satellites and spacecraft. Made of near-diamond hard industrial ceramics, these bearings were designed to operate without lubrication in the vacuum of space indefinitely. There was only one problem: when I first heard of these bearings, they cost tens of thousands of dollars and were only used in aerospace. Over the course of our project, however, they have become more common and are now used in roller blades and fidget spinners and can cost as little as $10.

Sacrifice

One of the more surprising strategies for longevity is actually to sacrifice some part of the object itself. We see this in nature where a lizard's tail can break off when attacked, allowing the lizard to escape alive.

Some sites have this same quality, like the tombs in the Egyptian Valley of Kings, where the best preserved examples of carvings and colour look like they could have been finished just yesterday. When the grave robbers spent all their time stealing the gold objects out of the tombs, they thought they had extracted all the value, but they left the wall art untouched, which was rare when compared to other sites.

The easily-removed riches in the walls of the Taj Mahal could help preserve the structure itself from looters (Credit: Getty Images)

The jewel-encrusted walls of the Taj Mahal may also have helped preserve the structure by assuming all the value had been taken out with the gems. This poses an interesting question for the site we are creating for the clock. Should we have a relatively easy-to-plunder valuable layer that will not harm the clock if it were to be stolen?

Value and ideology

The final and greatest danger to building anything that lasts is human beings themselves. In recent years we have witnessed some of the world's oldest sites destroyed because their values or ideology were seen as in conflict. One of the more heart-breaking of these was the Taliban's destruction of the massive Buddhas of Bamiyan in Afghanistan. It is hard to imagine a more innocuous religious symbol than a Buddha, but it was threatening enough to the Taliban to spend weeks blasting these amazing artefacts out of the cliffs.

Ideological political changes in Afghanistan led to the sad destruction at Bamiyan (Credit: Getty Images)

How do we make something of value and cultural significance that will not at some point be stolen or destroyed? This is the true question when we ask how to build something like the 10,000 Year Clock. It is not the engineering of the materials and its workings, but the civilisation around it, which we hope to shape as one that cares for both the present and the future. We hope that by building such things, they challenge us not just technically, but ethically as well. We hope that they challenge us to become **better ancestors**.

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Alexander Rose *is executive director at the Long Now Foundation in San Francisco. He and colleagues are building the* ***10,000 Year Clock****.*

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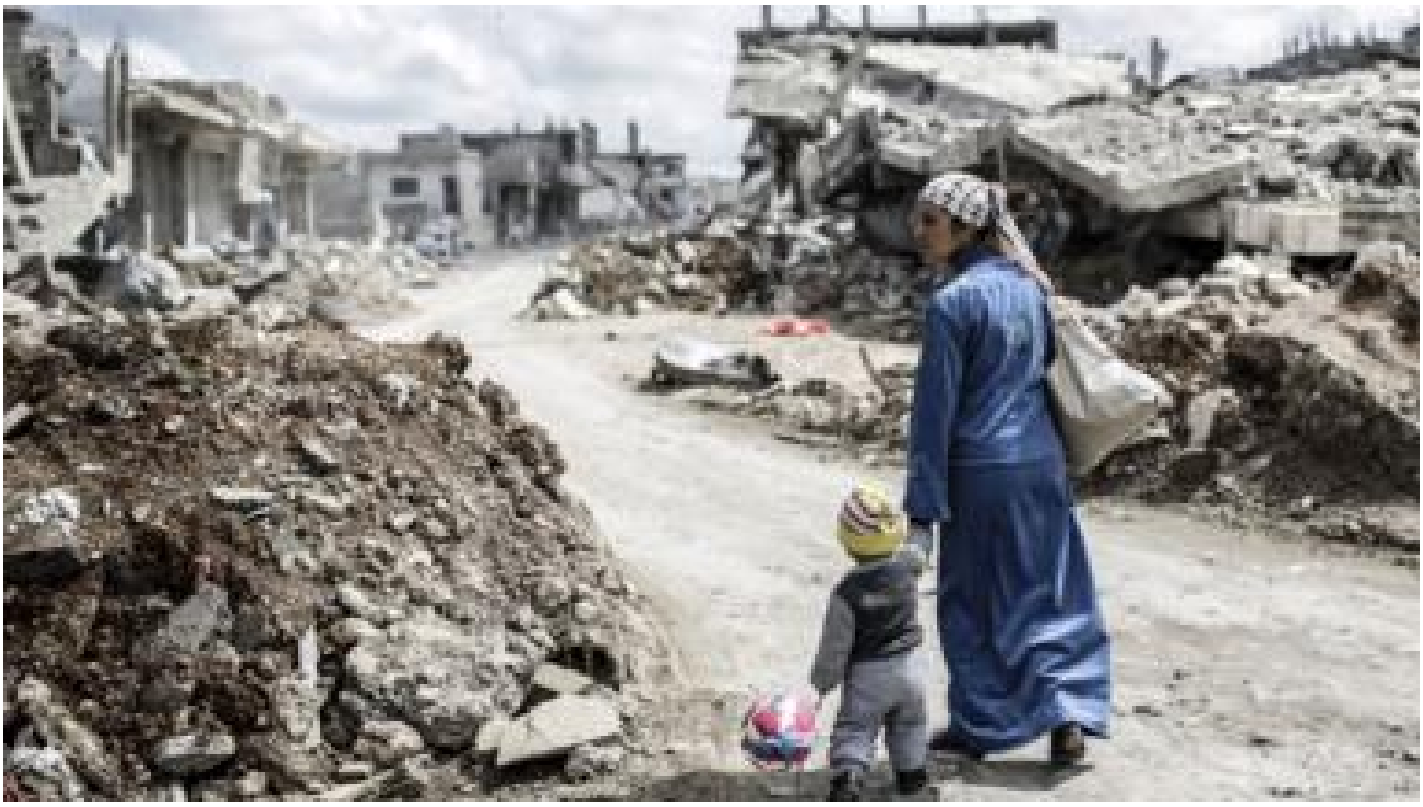

Deep Civilisation

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