

## DISCUSSION CONCLUDING AAS 11-665

Neil deGrasse Tyson jested that the Long Now should put some signage on the 10,000 Year Clock so that a post-apocalyptic Earth will not think that the world will end when the clock stops working. Rob Seaman replied that they had discussed the long-term signage designed for nuclear waste dumps. Tyson noted that an entire religion might develop around the discovery of such a device.

Tyson said that he considers time-keeping devices not just within the context of telling correct time, but within their capacity of measuring intervals of time. An elaborate mechanism for chiming local noon is not needed; the shadow of a stick in the ground suffices for making that determination. The 10,000 Year Clock wouldn't actually predict the phase of the moon, but rather it displays it; however, the phase of the moon can be determined just by looking up. Tyson therefore wondered about the motivation for building this clock. Seaman reiterated from his talk that was he was not in a position to speak authoritatively on the motivations of the project, but in his opinion the Clock was a philosophical statement, particularly on long-term engineering. Tyson surmised that the project was therefore more of an exercise in engineering rather than an exercise in horology. Steve Allen noted that James Lick left his fortune to build a pyramid on Market Street, but that is not what happened.

Steve Malys asked if the project was entirely privately funded or if tourism would contribute to its financing (and also asked in jest whether the property taxes had been paid for the next 10,000 years). Seaman said he thought it was all privately funded by the leadership of the Long Now and encouraged people to visit the web pages for more information.\* He added that this is not the only project of the Long Now. There is a Rosetta-stone project related to language preservation. They host a series of seminars on long-term thinking. Seaman said it possible to join the Long Now organization; he is a member and members receive a stainless-steel membership card. The fundamental philosophy is that there are so few areas today that think long term. Seaman mentioned New York City, from where Tyson grew up, noting that it is constantly reinventing itself. The Long Now attempts to be something entirely different than that. Tyson supposed that the Earl of Orrery was a wealthy chap who just decided to make the orrery as an engineering curiosity, so perhaps this project is similar: "rich people wanting to do something really cool with gears."

Frank Reed said that he had a long connection with some of the contributors to the project as customers of his software. He said that they are the wealthy "Silicon Valley intelligentsia" and these types of projects are basically public art. Seaman noted that talking to Danny Hillis was not like to talking to most people he knows; astronomy is full of clever guys and Hillis is a *really* clever guy.

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\* <http://www.longnow.org/>

Paul Gabor noted that Clavius predicted the Gregorian calendar only to the year 5000 because the calendar would likely need to be reformed before that time. Unfortunately the calendar does not have a built-in mechanism for reform, such as dropping out one the leap day, but it will clearly be in need of reform within the next one- to two-thousand years. Seaman noted that there has been some debate as to whether to include another correction every 4000 years which is not yet part of the official calendar. The thinking may be to not include that aspect within the design of the clock in order to give future generations some historical insight regarding the origins of clock, which makes for an interesting problem of symbolism. As an aside, Seaman noted that the colloquium was organized such that the earlier presentations should evoke broad cosmic concepts related to timekeeping to lay the foundation for more technical presentations later.

Mark Storz asked if the Clock displayed the occurrences of solar eclipses. Seaman replied that he had inquired explicitly about eclipses and believed the response was negative, but agreed that would be an interesting aspect to such a device. Seaman said the project would likely welcome expert feedback on their design.

Ken Seidelmann noted that the design included a star map that accounted for precession, and asked if it would account for proper motion. Seaman replied that he had suggested this possibility to Hillis, who seemed intrigued with the notion of possibly including the path of Barnard's Star over the lifespan of the clock on the face of the planisphere, guessing that it might travel almost 30 degrees. Seidelmann said that over that time period, many stars will have moved significantly. Seaman agreed it was an interesting question, particularly because the planisphere will be depicting the brighter stars which tend to be closer and thereby are more prone to exhibit proper motion.

Seaman said that one aspect of the project was to invoke an interesting conversation, which the clock certainly does; Gabor concisely characterized the Clock as "a conversation piece".

George Kaplan noted that 10,000 years is over one-third of the precession cycle and the obliquity of the ecliptic would be expected to change over that amount of time, which effects the equation of time. Allen said that the final model for the gears will be based on the calculations of Jon Giorgini of JPL who is running integrations of the JPL Development Ephemeris 422 (DE422) for a full 10,000 years. Tyson said that each gear is in some sense like an epicycle; each cycle within the system has to be represented by another gear. Seaman added that the final clock intends to have two orreries: one Copernican and one Ptolemaic.

Storz asked if the Clock will attempt to synchronize itself with the Moon like it does with the Sun, because it would seem that lunar motion would be hard to predict in the very long term. Seaman noted that the lunar model seemed to be one of the greatest challenges but there is no known way to synchronize to the Moon. He added that the solar synchronization of a purely mechanical device is already challenging.

Wolfgang Dick asked if the Clock is expected to run for 10,000 years without any maintenance. Seaman said that the philosophy is to not build a device to which no one pays attention, so there is a notion of human interaction in the design. If there is no sunlight, then the clock will need to be wound, for example. But the Clock is being designed to minimize wear such that it will not require substantial maintenance to operate. If the clock required some tweaking in the future, then that would not be considered a "design failure." Also there is some idea of making the mechanism extensible such that features could be added in the distant future as desired, such as different chimes. Reed asked if any security measures would be in place; Seaman said that issue gets back to Tyson's issue of signage.

Malys asked if there was an engineering issue driving the massive size of the Clock, such as the length of the weight drop, or was that an artistic decision. Seaman replied that big things ob-

viously tend to survive longer. Tyson added that a 10-second pendulum would require a certain size. Seaman added that the “tick rate” is thirty times longer than the pendulum rate, but admitted that he was not sure how the final dimensions were arrived at. Seidelmann noted that John Harrison learned that more accuracy could be obtained from a smaller mechanism.