

Physics for the 21st Century
Unit 5 Extra: NIST Atomic Clocks
John Lowe

JOHN LOWE: Hi I'm John Lowe and I'm working with the National Institute of Standards and Technology and here we have a demonstration of the concept of atomic time coordinated to universal time. Up until prior to 1967, we defined the second as the division of the time it took for the Earth to get around the sun. One whole year—you divide that by 86,000 seconds and you would get the definition of the second at that time. But that would change with different years. Some years were longer. Some years were slower. We wobbled. Our orbits wobbled. And so it was a very, very difficult concept to keep in sync year to year to year.

So with the advent of the atomic timekeeper, the atomic standard, it was able to create this very, very stable definition of a second. And so in 1967, it was decided to define the second by the atomic timescale, by an atomic standard, and then accumulate that time and create what we call atomic time.

NARRATOR: In 1967, the 13th General conference on weights and measures adopted a natural quantum mechanical vibration of a cesium atom as the worldwide standard to define the second.

JOHN LOWE: Basically what we have here is a bunch of environmental chambers—they're temperature and humidity controlled—and inside each one of these is a commercial cesium atomic clock. We have a number of them all in this rack here and this rack here. What we do is we take the output of each one of them and we create an ensemble clock. If anyone of them starts to go bad then it can get kicked out. They're all weighted so if one of them starts to go bad then you kick it out. But the idea is that we'll always have this continuous running flywheel. Periodically the main atomic clock across the hall, the F1 fountain clock, will be started up and then we'll do an evaluation and it will compare to this ensemble. It will steer this ensemble so that this group of clocks now creates a representation of the clock across the hall: the standard.

This ensemble of clocks is what we use to now disseminate (time) around the world. We do that a number of different ways: via telephone, via short-wave radio, via long-frequency radio. We have satellite transmission. There are a number of different ways that we disseminate that information out to the end-users. A lot of times it's public for time, but a lot of times it's for frequency. People need to know the frequency—radio stations, TV stations, and telecommunication places need to know frequency very, very accurately and this is what is our flywheel to send that information out.

So one of the most important things is we're keeping track of time so we don't want to lose track of time. Because if we lost track then we'd have to reestablish that and that would be a very, very difficult thing to do. Well if we lose power, we

have to be sure that we don't lose power altogether. If we lose public service, we still have backup power.

We have an emergency diesel generator in the other room that will come on and keep this going for several weeks and in worst-case scenario, we've always got the battery backups.