

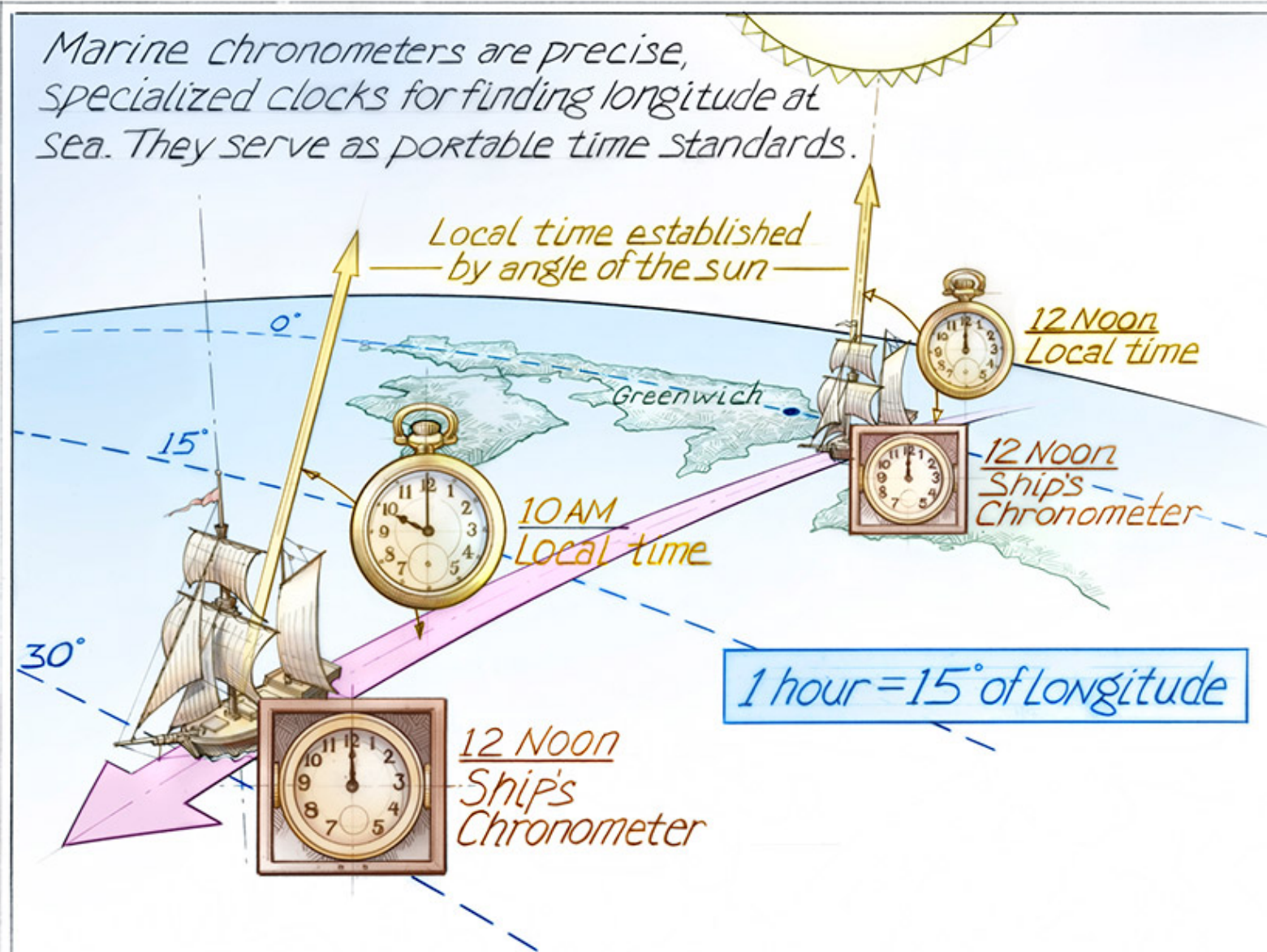
The Longitude Problem



Charlie Loyd
Himawari-8

USING A MARINE CHRONOMETER

Marine chronometers are precise, specialized clocks for finding longitude at sea. They serve as portable time standards.



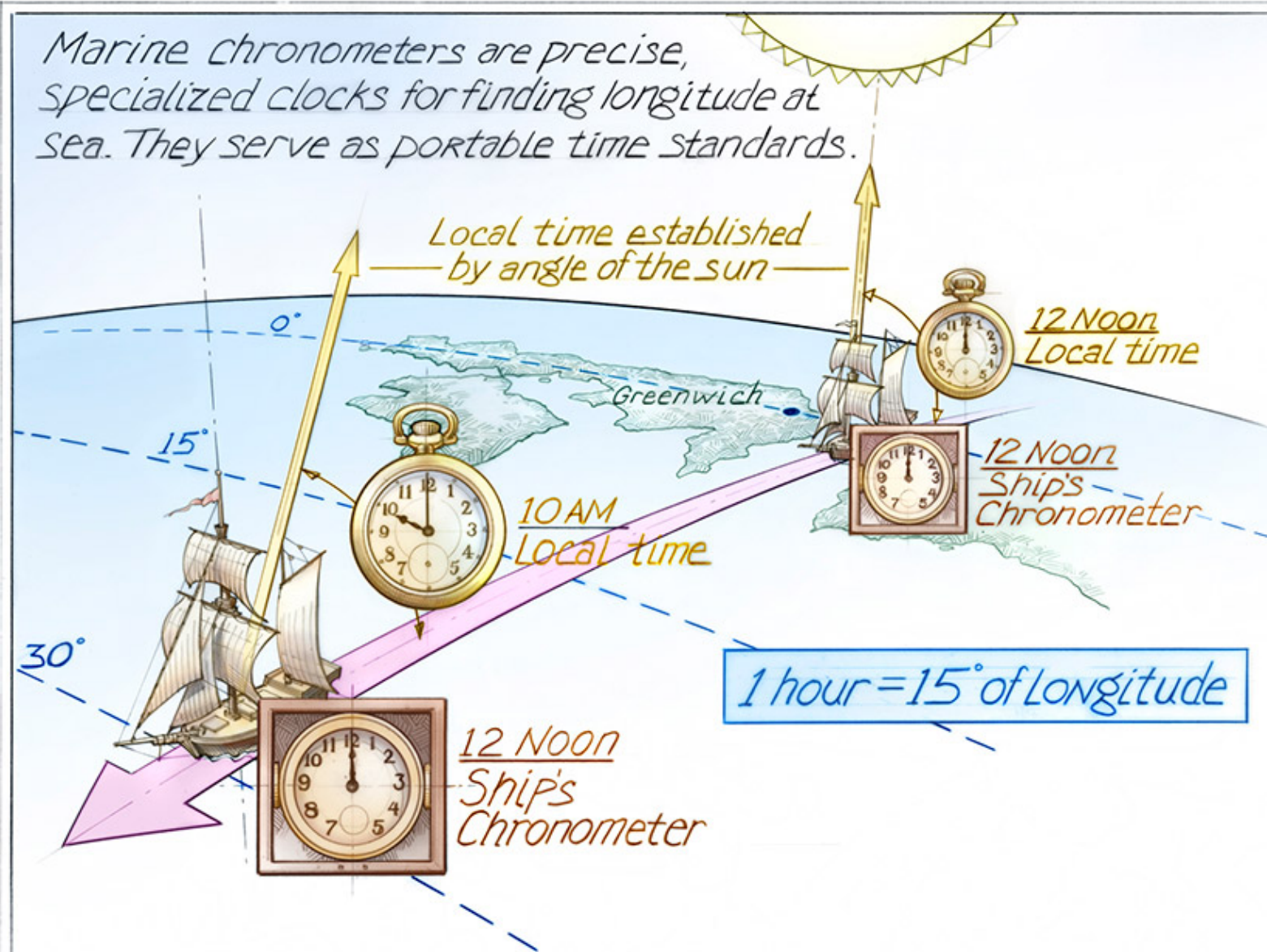
Simultaneous observations

- If two observers see where the stars (or sun) are above the eastern horizon at same time, they can determine their longitude
- But all measurements of the day (stars, sun) are local
 - Can be rephrased as difference in local time provides difference in longitude
- Problem is how to know observations are happening simultaneously



USING A MARINE CHRONOMETER

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Things that almost work

Wait for a lunar eclipse




Lunar eclipse

- Was used in ancient times
- Too rare for use at sea
- Hard to use accurately (when did it start, etc.)

Galilean moons

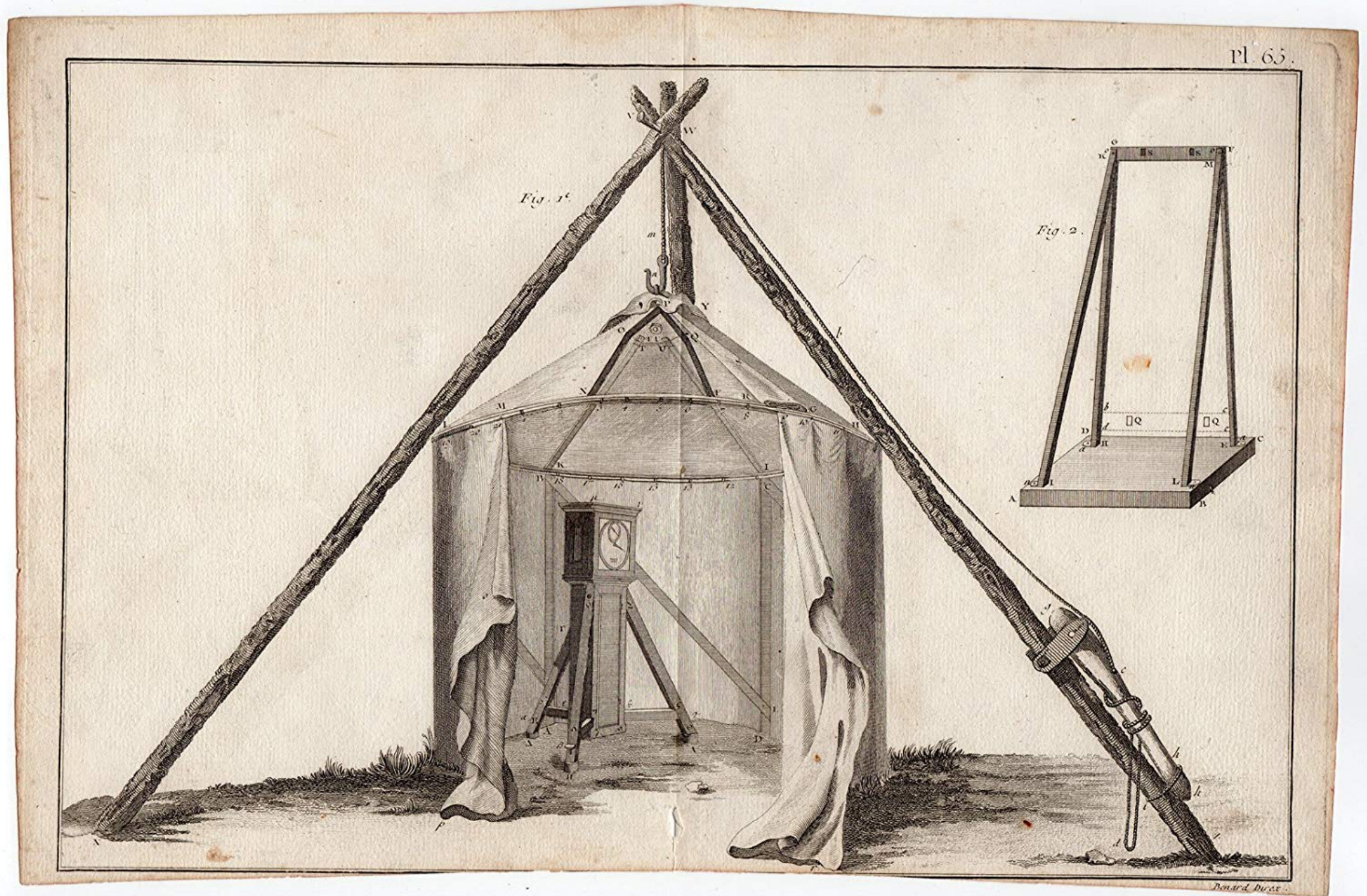


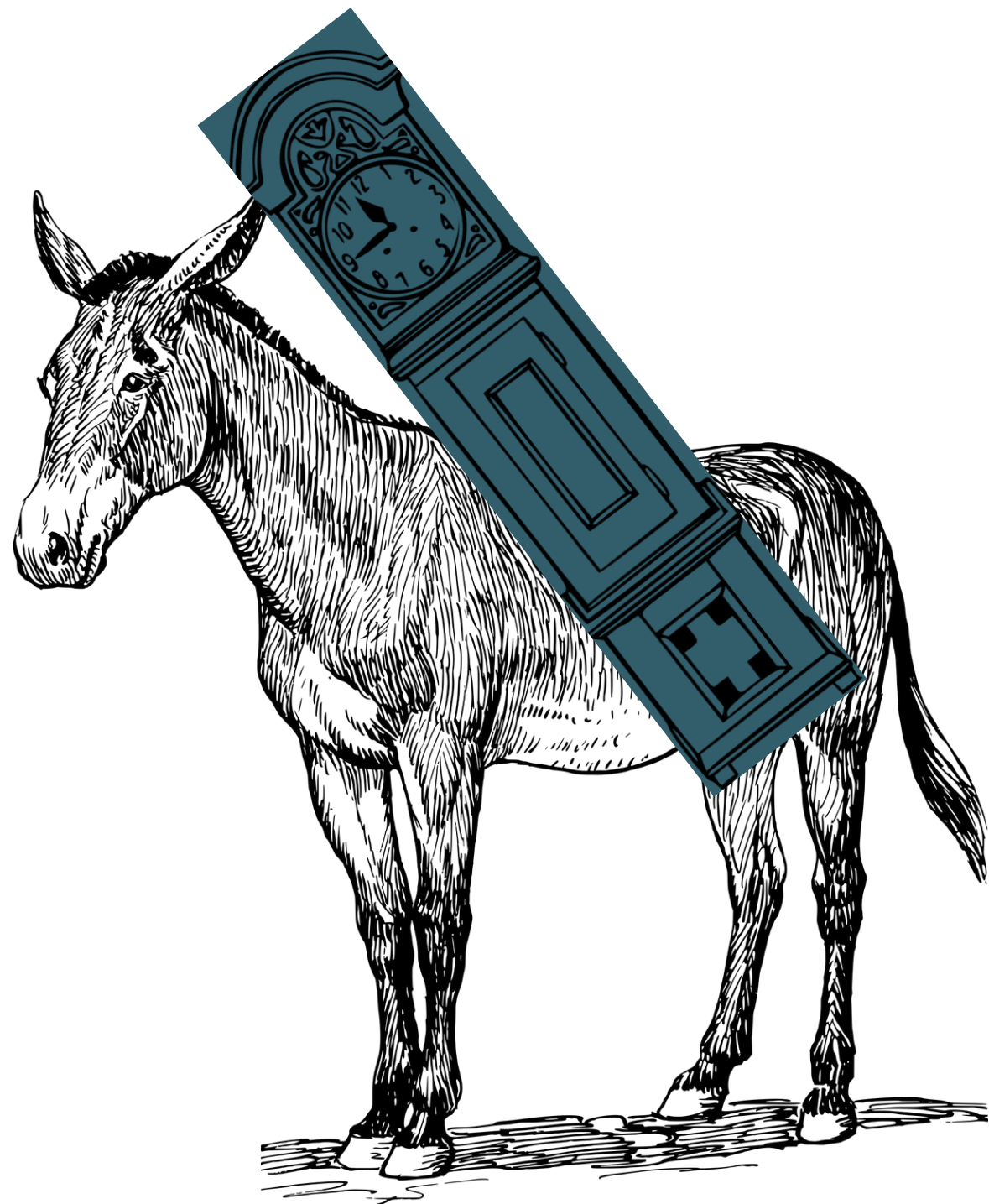
Galilean moons

- Works great on land
- Widely used to make land maps
- Predictable eclipses (speed of light...) 



Cook transit of venus 1778






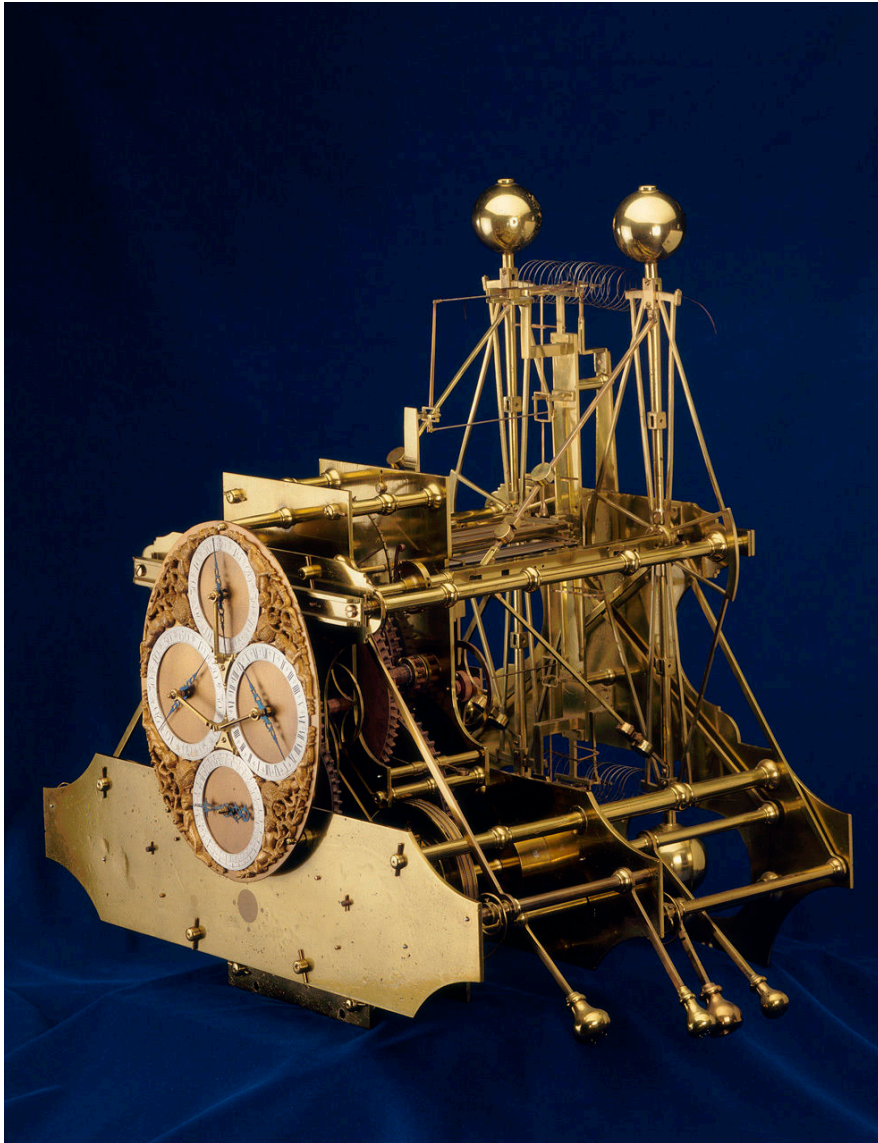
Problems of sea

- Jupiter is not visible all the time
- Can't see the moons on a pitching deck
- Need a simple observation (bright star, etc.), and need to know the time

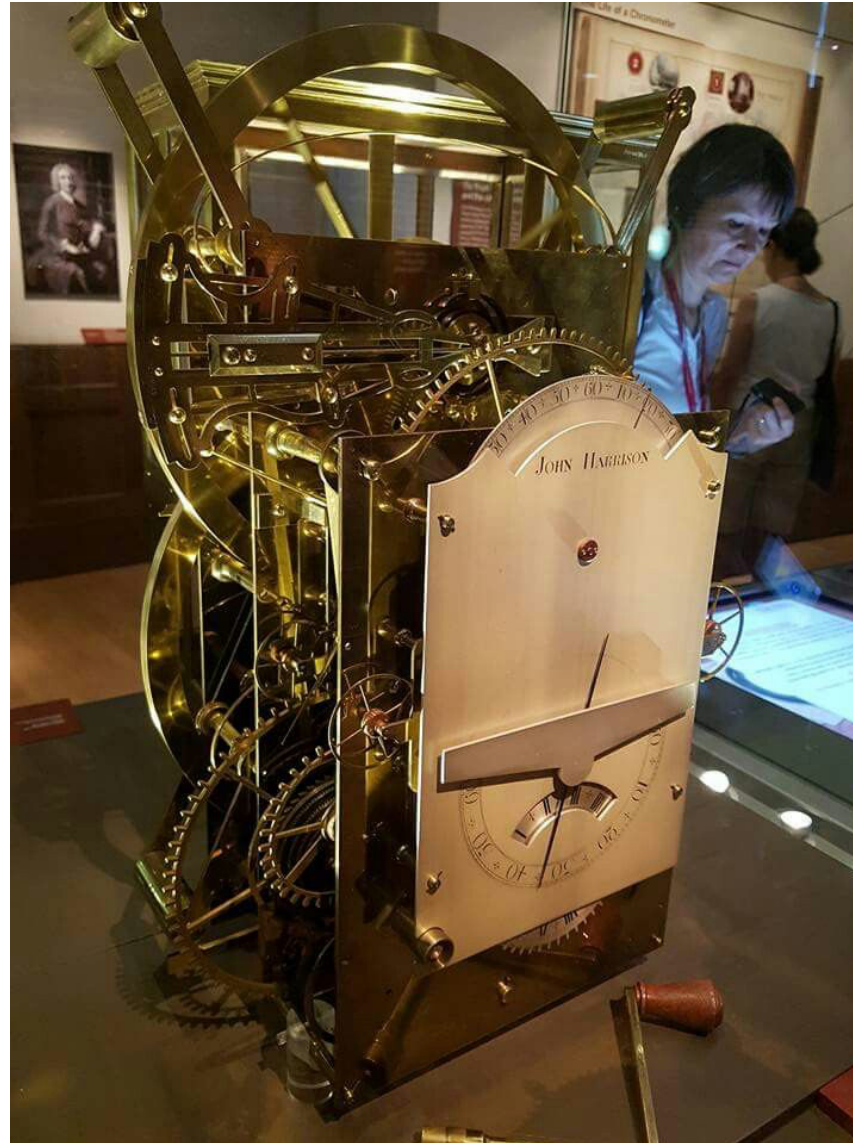
Two approaches

- Lunar distance to stars
 - Requires calculating in advance where the moon will be 
- A better clock
 - A clock that can accurately keep time on a moving ship

John Harrison & Longitude



H1



Arnold chronometer

The full process

Observing stars
to measure local
time



Time ball to tell ships the time



Finding local longitude



Technical state of the art ~1780s

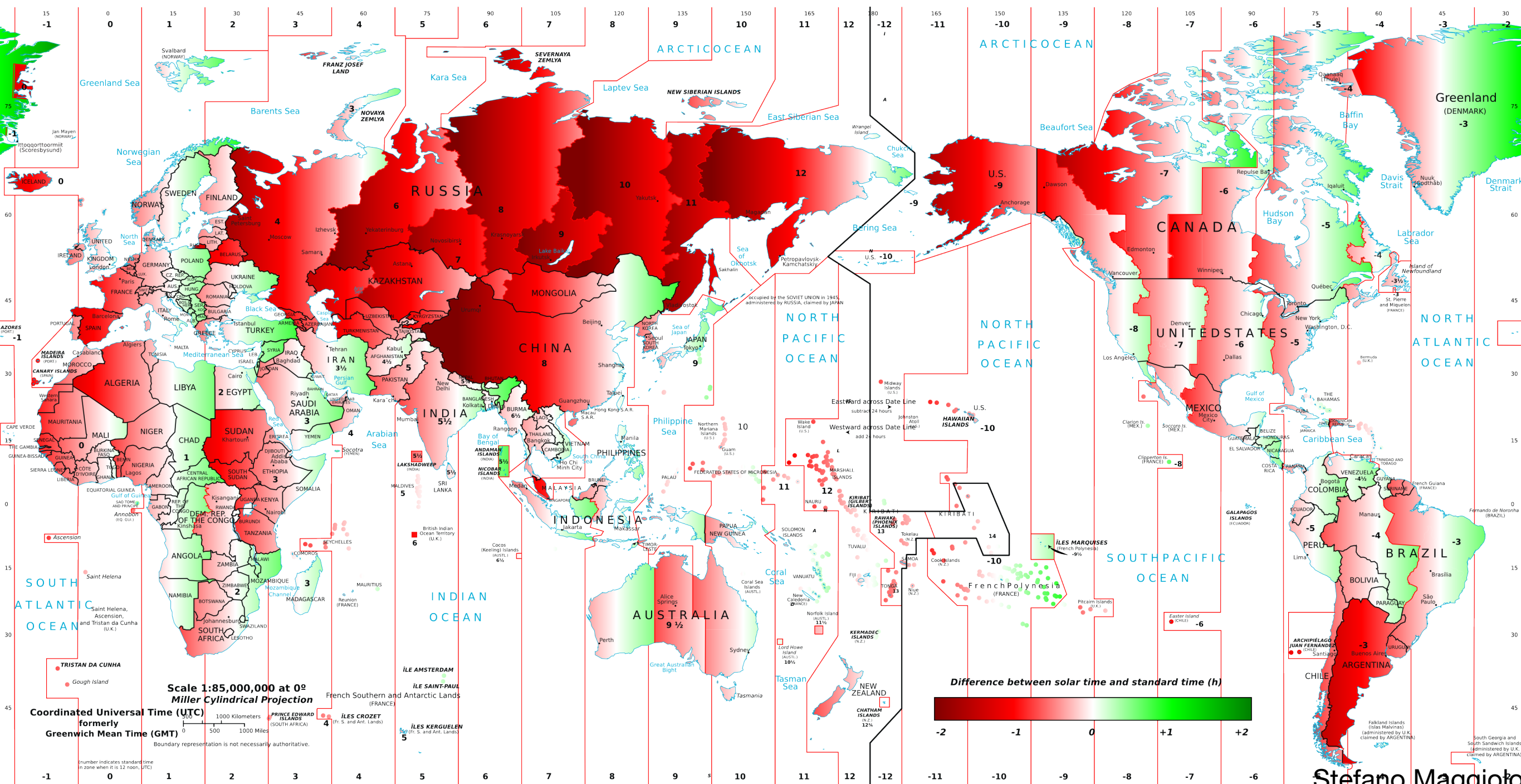
- Pushed what could be done, invention of caged ball bearings & bimetallic strip
- Arnold, Earnshaw, Emery, Brequet, worked to make chronometers in 'production'
- Expensive but crucial instrumentation

Trains and time zones

Train chronometer

- Trains used time to avoid collisions (!)
- Keeping accurate time became important
- Set up time zones (initially in Canada)
- Transition from local time (stars) being primary to a transferred time being paramount



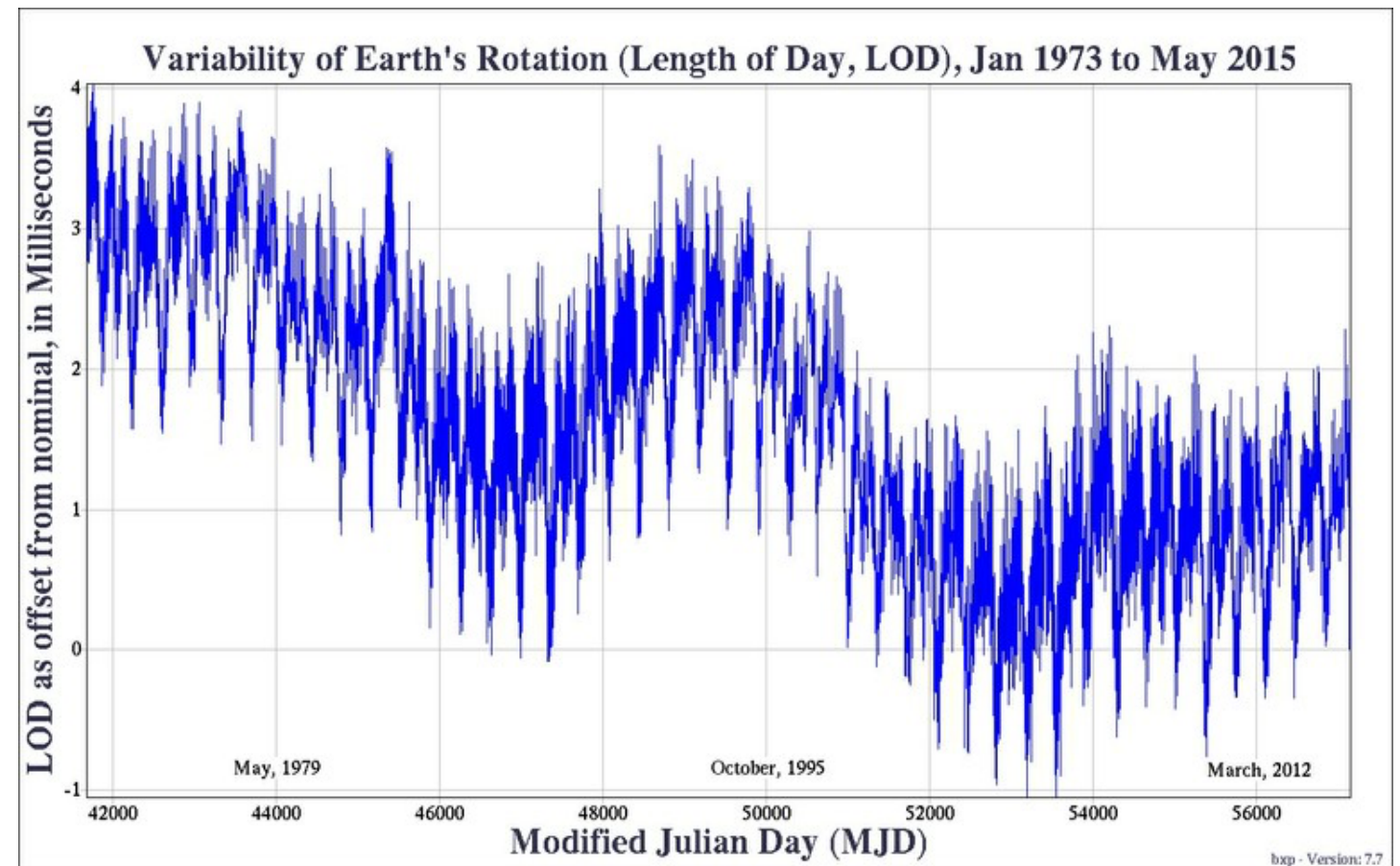


Stefano Maggiolo

For your grandparents

- Time defined by spin of the earth and observations of the stars
- Time at another location can be transmitted. Either by a precision mechanical watch, radio signals, or telegraph/telephone

US Naval Observatory Earth Rotation and Reference Systems Rapid Service/Prediction Center



To understand GPS, we need to understand light.
Next week, what is light, introduction to quantum mechanics...