How do we know where we are,
and how do we know where we are going?

POSITION

defined by course and distance from some known point, such as port

DIRECTION

Stars, Sun,
magnetic compass & sextant
(magnetic vs. geographic North pole)

DISTANCE

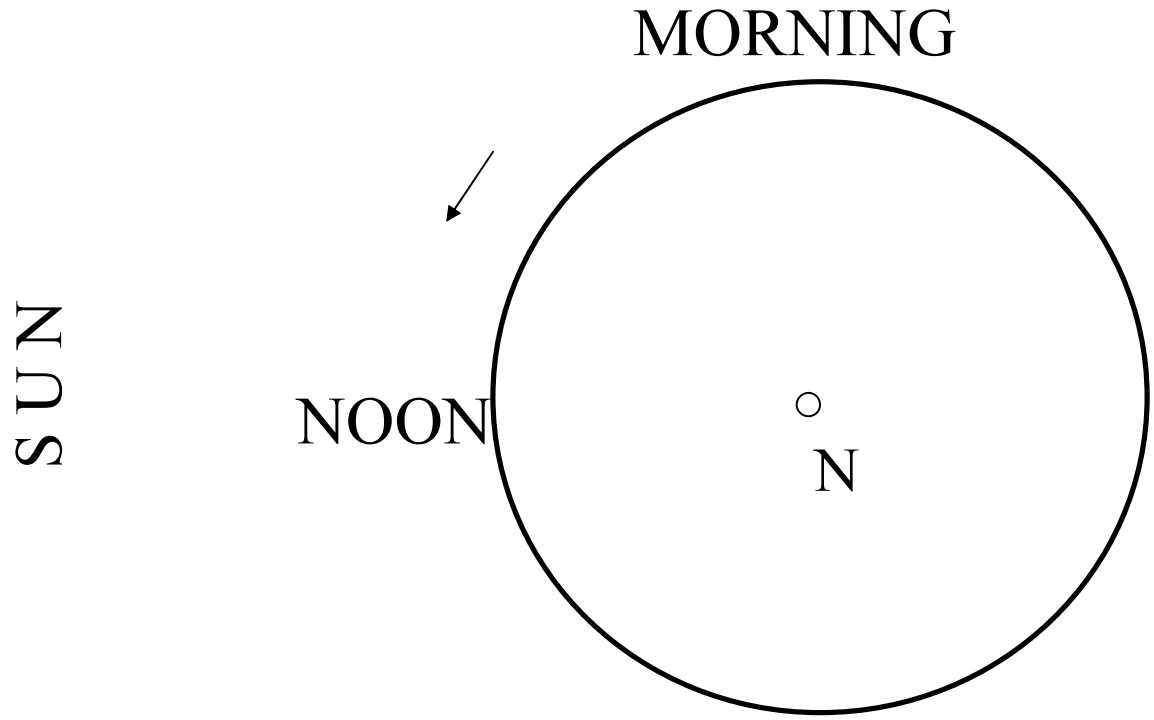
Speed x Time

Latitude and Longitude grid

Latitude – measured by sextant

Longitude - extremely hard to determine
- it is TIME driven
- **Greenwich Mean Time**
(Zulu time, Universal Time)

John Harrison, 1735 – **chronometer**
- a seagoing clock



Earth circumference 24, 000 miles
24 hours / day → 1000 miles / hour

Modern navigation

sextant and chronometer
(To check the sophisticated electronic devices)

Radar
Loran (Long range navigation)
Satellite navigation system
- computer controlled
  - based on frequency shift of the signal received on ship from the passing satellite

U.S. GPS

24 satellites and 5 ground stations

- 4 satellites needed to pinpoint the receiver's location
- computer controlled
- based on a time lag between when the receiver generates a specific signal and receives the same signal from the satellite

GLONASS – former Soviet Union GPS