# Machine-Based Navigation Accuracy Table

This document summarizes the evolution of machine-based navigation systems, their accuracy, methods, and reliability across different eras—from early mechanical devices like the Antikythera Mechanism, to modern digital and space-based systems.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Navigation System / Device | Era / Date | Accuracy (Range / Precision) | Method Used | Notes on Reliability & Errors |
| Antikythera Mechanism | ~100 BCE (Ancient Greece) | Days–weeks (planetary & lunar cycles) | Mechanical gears + cosmic cycles | Remarkably advanced; required manual calibration; accuracy degraded without adjustments. |
| Magnetic Compass | ~1100s CE (China → global by 1200s–1300s) | 5–15° | Earth’s magnetic field | Simple, reliable; subject to local magnetic anomalies and variation. |
| Marine Chronometer | 1700s CE (Harrison, 1760s) | ≈0.1 s/day drift → ~2 nautical miles | Precision clock + celestial navigation | Solved the 'longitude problem'; accuracy limited by mechanical drift and sea conditions. |
| Sextant | 1700s CE – present | 1–2 nautical miles | Stellar / solar angular measurement | Depends on operator skill, clear skies, horizon visibility. |
| Gyroscopic Compass | Early 1900s CE (~1908 Sperry) | 0.1–0.5° | Gyroscopic inertia | Independent of magnetism; drift accumulates over time, needs correction. |
| Inertial Navigation System (INS) | 1950s CE – present | 0.6–1.8 nm/hour drift (unaided) | Accelerometers + gyroscopes | Highly precise short-term; drifts without GPS/stellar updates. |
| LORAN (Long Range Navigation) | 1940s (WWII) – 2000s (retired in most regions) | 0.25–0.5 nautical miles | Radio signal timing | Widely used before GPS; limited by signal range and station geometry. |
| GPS (Global Positioning System) | First launch 1978; fully operational 1995 – present | 3–10 m (civilian); <1 m (military/augmented) | Satellite signals + atomic clocks | Highly accurate, but vulnerable to jamming/spoofing; backbone of global navigation. |
| Atomic Clock Navigation | 1960s CE – present | Nanosecond precision (~30 cm spatial) | Atomic resonance timing | Foundation of GPS and deep-space navigation; highly reliable. |
| AI / Quantum Navigation | 2020s – emerging | Predicted <1 cm | Quantum sensors, AI-enhanced INS, cosmic background mapping | Still experimental; could bypass GPS dependency; potential for deep-space resilience. |