

## Celestial Navigation vs Satellite Navigation

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Whether Celestial or Satnav is better was the topic of a friendly debate conducted by CMMI Chennai on 6th April '18 and the consensus that evolved from the plenary forum was an unsurprising 'both'!



Capt Ganesh Ramachandran sailing with MOSK opined that

celestial is beyond salvage, given the practices that have transformed aboard on responsibilities from navigation to 'reporting'. He confessed that he doesn't guide or impose celestial nav as a fall-back option on his officers, as their minds he is afraid are overloaded -even when on watch- with tasks to be done during and after watch, especially 'reporting' that has become de rigueur and raison d'être, and time consuming, demanding and overwhelming! It is a lost cause he said as the current crop of navigators are not adept at it -Indians had been, but not other nationalities replacing Indians ad infinitum!

Given the plethora of knowledge and data to be called upon: Spherical triangle, complex formulae, constellations, stars, almanac, azimuth, altitude, sextant, navigational tables etc, the 250 year old history has become redundant. From Transit Sats to geo-stationary ones positioned by countries like US, Russia, China, Japan, India and EU, GPS that is relied on in defence and widely ashore, has the last word at sea too. Safety of Navigation, Humans, Harbours, Security etc is well served with GPS and that against rogue ships and criminals too; ECDIS, primarily dependent on Sats also! Risks are of malfunction (Solar flare), jamming, hacking eg with E-loran operated from shore, free of these.

Satnav fix accuracy can be compared to Radar direction/range fixes he averred for accuracy against celestial and terrestrial. Underscoring that it is only an aid, he stressed the cost economy of voyages in terms of fuel usage, weather routing, safe carriage of cargo etc is better managed, and keeps owners, managers, charterers informed in real time -managers fulfilling responsibilities under ISM.

Satnav aids/supports Portable Pilot unit freeing pilotage from human error risks, ECDIS E-Navigation with all info on a single screen, Man over board retrievals tracking work vest with signal device and helps authorities track rogue ships, monitor pollution, safe navigation etc. The clinching factor to close, was highlighted as the autonomous ships soon to become a reality.

Commander Venkat Ramakrishnan IN (ret'd) pointed out that navigation blends art and science for the sake of safety, and that Celnav can be improved from its under-rated and suspect reliability. Citing that the main elements of Celnav are knowledge, its application, observations, calculations and position fixing, he conceded that all are prone to human, instrument and their application errors, with weather and visibility playing truant too! Stating that it remains mandated in STCW, he opined that its practice must be ensured by Masters and managers. He emphasised that it is

critical to principles and foundation of maritime skills: of concept of time UTC, nautical astronomy, spherical trigonometry all related to seamanship that are crucial for safety and success of ocean passage.

Shortcomings of Celnav, be they human, instrument or weather, he assured, can be overcome by technology. As Inertial Navigation can be coupled with sextant, to complement Celnav, digital technology with updated chips could be used for automatic star tracking to overcome human delay in instant computing. As jamming, hacking etc are severe risks of Satnav, he called for change from LOP (Line of Position) to COP (Circle of equal altitude position) using advanced spherical coordinate system with inputs of altitude of celestial bodies wherein COP equation is solved using Cartesian Coordinate System instead of spherical coordinate system, and position worked out applying 'Vector Calculus' used to find relationship between ship position and Great circle Azimuth of celestial body.

Observational and Computational hardware such as Night vision monocular, Digital encoder, Embedded calculators, Software, specific algorithms etc should ease the process and futuristic ideas from Space navigation to improve Celnav was his well-considered view. Integrating Inertial nav with celnav for tracking dynamic dead reckoning is a perfect idea was the takeaway from him. After initialization, INS is self-contained with no link to external reference systems. Celnav provides direct link to the INS and it is autonomous; INS is weather free whereas Celnav is not. Both are passive, jam proof and are not dependent on shore or space components. Combining Star trackers with INS is a synergistic match he underscored.

Redesigning Star tracker of Space nav for Marine nav was seen as futuristic thought. An interesting alternative was explained, quoting foreign research papers: Under Azimuth method for fixing position under Celnav, azimuths of few stars are observed simultaneously against time to obtain spherical coordinates; then Cartesian coordinates of stars are found by using converted formula; nonlinear system of working out ship position is conducted then by Newton's iteration method. On obtaining ship's position in the Cartesian coordinate system (X,Y,Z) is transformed to coordinates of spherical coordinate system by software. Without sextant, usable at night -overcoming horizon problem, its accuracy matches conventional celnav for feeding to INS! Using AI and IT, Genetic Algorithm for solving Celnav fix, revolutionising Sight reduction Table was also pointed out.

As Celnav weather dependent, prone to equipment and human: observational & calculation errors, prudence calls for improvements and alternatives. This the rule makers, enforcers and practitioners should bear in mind and practise was the wisdom shared. Think tanks and research work to integrate modern technology with Satnav, especially given risks to Satnav through interference, malfunction, denial, shut down etc, should be pursued was proffered. Capt Vivekanand the moderator round off by adding that a passage through a narrow strait was done with celestial sights, for want of nav aids!

In the post presentation open house discussion, oozing nostalgia, the veterans for preserving sextant and its utility, if not as an antique, but for its 'spare' value for fall back method when in maritime agony in the wide open ocean -literally lost at sea, some having had to buy satnavs to get promoted as 2nd officers in the '60s!. Such

sentiments aside, as Satnavs overriding usage with technology is imposing, settling for `both' was the arbiter eventually settled for. Perhaps insurers can plead for Celestial's preservation was an afterthought that emerged as a hindsight.