

CLAIMS:

1. A system for generating estimates of location and time from passively received non-GNSS communications signals not designed or intended or readily usable for location and time extraction by ground terminals:
 - 5 a. an electrically-steered multi-beam antenna, each beam from the multi-beam antenna steered to track and receive a signal from a separate satellite;
 - b. a receiver for each beam of said multi-beam antenna;
 - c. a processing device configured to determine a location of said system based on the signals received by each beam of said multi-beam antenna, and by said
 - 10 receiver, and based on ephemeris data for the satellite.
2. The system of claim 1, said processing device configured to estimate an angular position of the satellite based on a direction of arrival of the signal as determined by the steering angle of the beam, said processing device further configured to triangulate the location of said system.
- 15 3. The system of claim 1, said processing device extracting a current time from the signals.
4. The system of claim 3, further comprising an onboard atomic clock to supplement and stabilize the current time extracted from the different links.
5. The system of claims 3-4, said processing device determining time-of-flight and distance from each satellite based on the current time and received non-GNSS signals.
- 20 6. The system of claim 5, where the distance from each satellite is used to determine the position of the receiver.
7. The system of claim 1, where doppler shift of signal channels is used to infer relative velocity and trajectory of each satellite relative to the receiver
8. The system of claims 1-7 where angle of arrival, time of flight, and doppler shift
- 25 measurements are combined to improve position estimate accuracy.
9. The system of claims 1-8 where multiple measurements of the same satellite over time are used to establish an estimate of the satellite trajectory to improve estimated location and accuracy.
10. The system of claims 1-9 where a local IMU sensor is used to correlate signals received
- 30 at different times to improve estimated location and accuracy.

11. The system of claim 1 where one or more bidirectional general-purpose communications links with the non-GNSS satellites are established to obtain orbital ephemeris data on all of the other non-GNSS satellites being tracked.
12. The system of claim 1 where a cooperative satellite broadcast is transmitted by one or
5 more of the target satellites to distribute orbital ephemeris data on all of the target satellites.
13. The system of claim 1 where a terrestrial data connection is used to obtain orbital ephemeris data on all of the target satellites.
14. The system of claim 1 where ephemeris data for potential target satellites is preserved
10 in local data storage for access.
15. The system of claim 1-15 where the uncertainty of each independent measurement is used to estimate the overall position uncertainty.
16. The system of claim 1 where the antenna is a VSAT antenna
17. The system of claim 16 where the antenna is a phased array.
18. The system of claim 16 where the antenna is a lens antenna array.
19. The system of claim 1 where the satellites are in LEO.
20. The system of claim 1 where the satellites are in MEO.
21. The system of claim 1 where the satellites are in GEO.
22. The system of claim 1 where the satellites are in multiple orbits.
23. The system of claim 1 where the TT&C links are transmitted at Ka band.
24. The system of claim 1 where the TT&C links are transmitted at Ku band.