CLAIMS

1. A method for acquiring, positioning and tracking of vehicles travelling in airspace, sea and land travel routes via a constellation of small satellites, the method comprising:

(a) detecting a first signal from a vehicle travelling along a vehicle travel path;

(b) detecting an anomaly from the first signal;

(c) determining whether the anomaly occurs (i) inside a first radar mode coverage area or (ii) outside the first radar mode coverage area;

(d) activating (i) a first radar mode if the anomaly occurs inside the first radar mode coverage area for detecting a second signal from the vehicle or (ii) a second radar mode if the anomaly occurs outside the first radar mode coverage area for detecting a third signal from the vehicle for positioning the vehicle independently;

(e) cueing a third radar mode by the first or the second radar mode to (i) refine the second signal, or (ii) refine the third signal from the vehicle,

wherein the steps of (a), (b), (c), (d) and (e) are sequentially performed by each satellite in the constellation of small satellites.

2. The method of claim 1, wherein the vehicle comprises non-distressed and distressed vehicles, wherein the distressed vehicles is/are vehicles detected with an anomaly.

3. The method of claim 1, further comprising sequencing the first, second and third radar modes repeatedly to simultaneously provide surveillance, positioning and tracking of all fast and slow moving vehicles with or without anomalies in the airspace, sea and land travel routes.

4. The method of claim 1, wherein the first signal comprises a transponder signal utilizing a cooperative technique comprising ADS-B and AIS system.

5. The method of claim 1, wherein the second signal comprises a coarse positioning of the vehicle utilizing a non-cooperative technique comprising a Low Frequency Wide Swath Radar.

6. The method of claim 1, wherein the third signal comprises a transponder signal and/or a Bistatic signal reflected from the vehicle utilizing a Passive Coherent Radar technique.

7. The method of claim 1, wherein refining the second and third signal comprising utilizing an active high resolution Microwave Imaging Radar to perform high resolution imaging and tracking of the vehicle.

8. The method of claim 1, wherein detecting an anomaly from the first signal comprises:

(a) decoding the first signal;

(b) checking the integrity of the first signal; and

(c) deriving an outcome by comparing the expected positioning with the measured positioning of the first signal.

wherein the detected anomaly is sent to the satellite which is closest to the area of the vehicle.

9. The method of claim 1, wherein activating the first radar mode comprises utilizing the Low Frequency Wide Swath Radar with information on anomaly to re-indicate the coarse positioning of the vehicle.

10. The method of claim 1, wherein activating the second radar mode comprises activating a first gap filler mode or a second gap filler mode to detect the vehicle.

11. The method of claim 10, wherein activating the first gap filler mode comprises activating a Semi-Cooperative Technique to detect the third signal from the vehicle transponder, wherein the third signal is a false transponder signal indicated by the positioning data of the third signal being incoherent with the positioning data detectable from a fourth signal emitted by another onboard sensor from the vehicle.

12. The method of claim 10, wherein activating the second gap filler mode comprises activating the Passive Coherent Radar for receiving the opportunistic Bistatic signals, wherein the vehicle transponder is switched off or destroyed.

13. The method of claim 12, wherein the Passive Coherent Radar comprises:

- a Passive MIMO SAR Imaging Radar configured to detect and locate the vehicle in a MIMO configuration and

- a Passive HF Skywave Radar configured to receive the HF signals that bounced off the vehicles when they are illuminated by a global network of sea, land and airborne transmitting stations.

14. The method of claim 13, wherein the Passive MIMO SAR Imaging Radar re-utilizes signals of opportunities such as the ADS-B signals from multiple transmitting vicinity fast vehicles to illuminate the vehicle under tracking to provide the second gap filler mode when the distressed vehicle is outside the first radar mode coverage due to a sparse satellite constellation.

15. The method of claim 13, wherein the Passive HF Skywave Radar utilizes HF signals emitted from ground based transmitting stations to strike the ionosphere at the F2 layer at a low grazing angle between10º and 20° and to detect the HF signals reflected from the vehicle at an incidence angle of 20º or less.

16. The method of claim 15, wherein the ground based transmitting stations comprise at least:

- HF Broadcasting Sites having a typical transmitting power of 500KW with a transmitting gain of 20dB, a beamwidth of 20° and a transmitter efficiency of 70%;
- Relocatable Transmitting Sites over remote ocean areas such that 500KW Broadcast HF transmitting systems can be deployed on ships or offshore oil/gas platforms; and
- Mobile Transmitting Sites such as the High Frequency Data Link ("HFDL") enabled aircrafts flying in the vicinity for which the reflected vehicle echoes from these illuminations are intercepted by the HF receiving satellite constellation.

17. The method of claim 1, further comprising employing a multilateration technique via a set of at least three satellites orbiting in a non-periodic spacing to check the integrity of the positioning provided by cooperative techniques utilizing a ADS-B or an AIS transponder.

18. The method of claim 7, wherein the Microwave Imaging Radar performs high resolution imaging operations in the C, X, Ku or Ka frequency spectrum.

19. The method of claim 2, further comprising halting the first, second and third radar modes sequencing if a distressed vehicle is imaged and activating an emergency sequence by the third radar mode to continuously tracked the distressed vehicle.

20. The method of claim 8, wherein the decoding utilizes PPM modulation for ADS-B and GMSK modulation for AIS.

21. The method of claim 1, wherein the third radar mode further comprises analyzing motions of a vehicle with anomaly by combining at least one of

- multiple hypothesis tracking matched to at least one kinematics of the vehicle to obtain an ISAR image of a dived trajectory/vehicle, and
- imaging to detect the positioning of a crash point or mid-air explosion of the vehicle by an Inverse SAR imaging technique.

22. The method of claim 21, wherein imaging to detect the positioning of a crash point or mid-air explosion of the vehicle comprises utilizing

- an Inverse Synthetic Aperture Radar (ISAR) imaging process based on the angular and linear motions of the vehicle;
- Synthetic Aperture Radar imaging (SAR) imaging of the sea and land surfaces for suspicious disappearances such as a crash or an immediate floating debris; and
- combination of both the (a) ISAR and (b) SAR techniques.

23. The method of claim 1, wherein a second satellite in the constellation is automatically activated to track and provide positioning of the vehicle under the first and/or third radar modes when the first satellite has moved out of the first radar mode coverage area of the vehicle travel path, wherein the first satellite is automatically de-activated.

24. A system for acquiring, positioning and tracking of vehicles travelling in airspace, sea and land routes via a constellation of small satellites, the system comprising:

- a first detecting means for detecting a first signal from a vehicle travelling along a vehicle travel path;

- a processing means for detecting an anomaly from the first signal and determining whether the anomaly occurs (i) inside a first radar mode coverage area or (ii) outside the first radar mode coverage area;
- a second detecting means for detecting a second signal from the vehicle under a first radar mode if the anomaly occurs inside the first radar mode coverage area;
- a third detecting means for detecting a third signal from the vehicle under a second radar mode in order to position the vehicle independently if the anomaly occurs outside the first radar mode coverage area;
- a fourth detecting means for (i) refining the second signal or (ii) refining the third signal from the vehicle under a third radar mode,

wherein the first, second, third and fourth detecting means are sequentially activated to detect the first, second and third signals by each satellite in the constellation of small satellites.

25. The system of claim 24, wherein the vehicle comprises non-distressed and distressed vehicles, wherein the distressed vehicles is/are vehicles detected with an anomaly

26. The system of claim 24, wherein the constellation of small satellites comprises at least three satellites comprising Nano-Satellites, Micro-Satellites or Mini-Satellites.

27. The system of claims 24 or 25, wherein each satellite further comprises:

- A wideband receiver for receiving electromagnetic (EM) waves and/or signals from either (i) transponder signals from the vehicles, or (ii) Bistatic echo signals reflected off the vehicles;
- A low frequency wide swath radar with a transceiver operating in the low frequency band of either HF, VHF or UHF for detecting a distressed vehicle when it has moved randomly from a last known position;
- A high resolution Microwave Imaging Radar with a transceiver operating in the X-band microwave frequency for refining the positioning of the distressed vehicle using imaging functions;
- A storage/buffer unit for transmitting vehicle information from each satellite to a master ground station, for example, directly or via a geo-sat com service;

- A synchronization unit (time/frequency) for synchronizing of three radar modes; and
- A processor for operational control of the functional units and processing of information such as detecting first, second and third signals from the initial detection, decoding and verification of anomaly, first, second, third and fourth detecting means, as well as performing the vehicle imagery and distress/emergency classifications.

28. The system of claim 24, wherein the first detection means comprises an Automatic Dependent Surveillance-Broadcast (ADS-B) or an Automatic Identification System (AIS) operating in a cooperative system environment.

29. The system of claims 24 or 27, wherein the processing means comprises the processor for decoding and checking the integrity of the first signal.

30. The system of claim 24, wherein the second detection means comprises a Low Frequency Wide Swath Radar for detecting the second signal if the anomaly occurs inside the first radar mode coverage area.

31. The system of claim 24, wherein the second detection means further comprises a Passive Bistatic Coherent Radar for detecting the third signal reflected off the vehicle travelling outside the first radar mode coverage area.

32. The system of claim 31, wherein the third signal comprises Bistatic signals transmitted from opportunistic emitters which are reflected of the vehicle outside the first area of the vehicle travel path.

33. The system of claim 24, wherein the fourth detection means comprises a Microwave Imaging Radar for performing high resolution imaging operations in the C, X, Ku or Ka frequency spectrum.

34. The system of claim 24, wherein the first signal comprises a unique identification, positioning in x, y, z geographical coordinates, course, and velocity V_x, V_y, V_z of the vehicle.

35. The system of claim 24, wherein the satellite constellation is in a LEO orbit, wherein the small satellites are organized into three different aspect angles with respect to an area of the vehicle travel path.

36. The system of claim 27, wherein each of the satellite receivers are synchronized in frequency.

37. The system of claim 24, wherein each satellite in the constellation is deployed to provide a detection ground surveillance coverage gap between neighboring satellites corresponding to a satellite revisit time gap of two minutes.

38. The system of claim 24, wherein the third signal comprises signals of opportunity from ADS-B operating at 1090 +/-3MHz, AIS operating at 161,975 to 162,025 MHz, High Frequency Data Link (HFDL), FM Broadcast Emitters operating at 87.5 to 108.0 MHz, VOR/DME Emitters operating at 108 to 117.95 MHz, Geostationary Satellite Emitters and Ground-based and Airborne Radars.

39. A method for surveillance, integrity check and tracking of vehicles travelling in an airspace, sea and land routes, the method comprising:

- detecting transponder signals from a plurality of vehicles using cooperative techniques;
- a first step of checking the transponder signals for anomalies of a vehicle;
- a second step of detecting a coarse positioning of a distressed vehicle; and
- a third step of refining the course positioning of the distressed vehicle for positioning the vehicle independently, wherein the distressed vehicle is further tracked for search and rescue operations.

40. The method of claim 38, wherein the first step comprises:

- decoding the transponder signals;
- checking the integrity of the transponder signals using a multilateration technique; and
- detecting an anomaly from the transponder signals, wherein a vehicle with an anomaly is a vehicle in distress.

41. The method of claim 40, wherein the checking the integrity of the transponder signals comprises a multilateration technique comprising:

- Implementing Frequency Difference Of Arrival (FDOA) or Time Difference Of Arrival (TDOA) from a set of at least 3 satellites for measuring either differential Doppler frequencies and/or differential time of arrivals of the transponder signals;
- Computing either differential Doppler frequencies or differential time of arrival or both from the positioning data provided by the cooperative positioning system (transponder under ADS-B or AIS protocol); and
- Computing the difference between the measurements and the computed values to provide an integrity classification comprising a "True", "False" or "Unclassified" category.

42. The method of claim 39, wherein the second step comprises detecting the coarse positioning of a distressed vehicle using a Wide Swath Radar if the distressed vehicle is within the Wide Swath Radar coverage.

43. The method of claim 39, wherein the second step comprises detecting a distressed vehicle using a Passive Coherent Radar if the distressed vehicle is outside the Wide Swath Radar coverage.

44. The method of claim 43, wherein the second step further comprises a first Gap Filler mode of detecting a distressed vehicle with spoofed transponder using a Semi-Cooperative technique.

45. The method of claim 43, wherein the second step further comprises a second Gap Filler mode of detecting a distressed vehicle using (i) MIMO SAR Imaging Radar or (ii) Passive HF Skywave Radar for detecting bistatic signals if the transponder is not detectable.

46. The method of any of claims 39-45, wherein the third step of refining the coarse positioning of the distressed vehicle comprises using a Microwave Radar to further accurately track the distressed vehicle for search and rescue operations.

47. The method of claim 39, wherein the ground area covered by the:

- first step ranges from a diameter of 2000 - 3000km of a circumscribed circle based on semi-cooperative mode;
- second step ranges from a diameter of 1100 - 1600km of a circumscribed circle based on a non-cooperative mode; and
- third step ranges from a diameter of up to 700km of a circumscribed circle based on a non-cooperative mode.