Metric tracking of launch vehicles for range safety purposes is currently based on redundant radars, telemetry receivers, and uplink command transmitters at the launch site with additional assets deployed downrange in order to maintain line-of-sight communications with the vehicle as it passes over the horizon to orbital insertion.

The vision of space-based range architecture is to assure public safety, cut the costs of launch operations, enable multiple simultaneous launch operations, decrease response time, and improve geographic and temporal flexibility by reducing, or eliminating, these assets. In order to achieve this, a number of advancements in tracking and telemetry are required. Some of NASA's needs are:

GPS/IMU Metric Tracking and Autonomous Systems

Realization of a space-based range requires development of GPS receivers that incorporate:

- Low power consumption;
- Low mass/volume;
- Compliance with range safety standards;
- Flexible tracking loop programmability;
- Programmable output formats; and
- Operability in high G environments.
Other highly desirable GPS specific characteristics include open architecture supported by development software and the capability of being incorporated onto circuit boards designed for multiple functions.

Tactical grade inexpensive expendable IMUs are needed which can function on spin-stabilized rockets (up to 7 rps) and reliably function during sudden jerk and acceleration associated with launch and engine firings and can be coupled with GPS receivers.

Also needed are approaches to processing and merging the independent outputs of GPS and Inertial Navigation Sensors and combining them with rule-based systems for autonomous navigation and termination decision making.

**Space-Based Telemetry**

Small, lightweight, low cost transceivers capable of establishing satellite communications links for telemetry and control during the launch and assent stages of flight are required to provide unbroken communications throughout the launch phase. These may enable use of the NASA TDRSS, or commercial communications satellite constellations. These transceivers are needed for use on suborbital and orbital platforms as well as for launch operations. While the communications support for launch vehicle operations may require continuous support for short durations in the order of less than 30 minutes other applications will be on platforms which require support for the duration the mission which could last for more than a month. Additionally it is highly desirable to limit the user burden to provide adequate EIRP and G/T for providing acceptable link margins between the constellation and the transceiver. Hence use of communications constellations in lower than GEO will be advantageous.

Techniques for multiplexing narrow bandwidth channels to permit increased bit rates and improved algorithms for ensuring smooth transition of support between communications satellites are also needed.

**GPS Attitude Determination for Launch Vehicles**

Investigate using inexpensive arrays of GPS antennas and receivers on small, expendable launch vehicles to determine the attitude angles and their rates of change as an alternative to traditional inertial measurement units.

The system should be contained entirely on the vehicle and not rely on ground-based processing. The attitude accuracy should be comparable to gyroscope-based systems and should be free of drift and gimble lock. The system must be able to maintain attitude output during periods of high dynamics and erratic flight. The attitude
must be determined at a rate of least 10 Hz with minimal processing delay and must be output in a format compatible with vehicle telemetry systems.

Integrated small, low mass, low power consumption transceiver/sensor packages are needed which can provide bidirectional communication interfaces between flight platforms such as weather balloons via the internet for the purpose of measurement of wind profiles, and atmospheric weather parameters such as temperature, humidity and ozone levels.