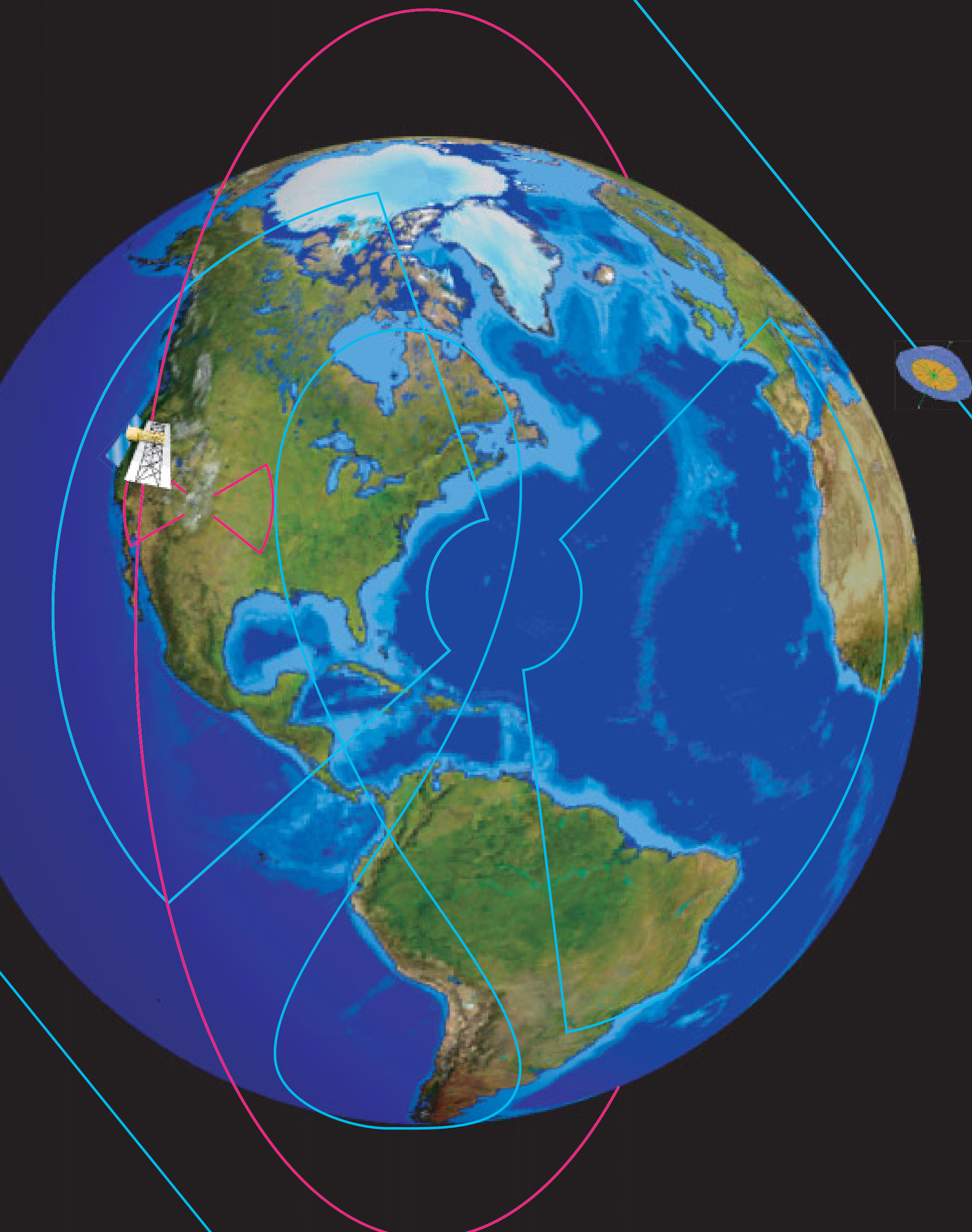
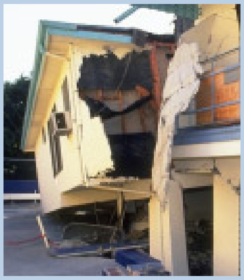
GESS

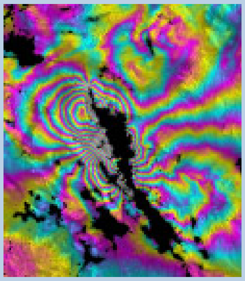
GLOBAL . EARTHQUAKE . SATELLITE . SYSTEM



A 20-YEAR PLAN TO ENABLE EARTHQUAKE PREDICTION

MARCH 2003





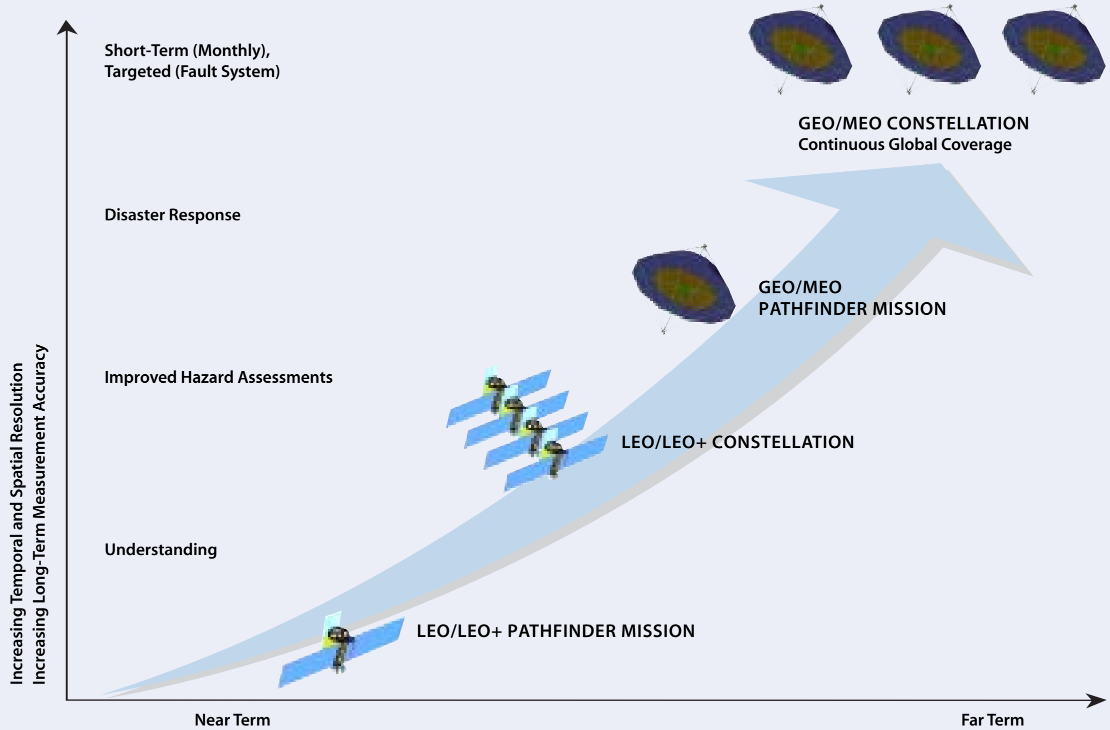
The 20-Year Plan

EARTHQUAKE SCIENCE IS POISED to capitalize on a revolutionary capability for observing global crustal deformation. The concurrent improvements in seismic monitoring networks, high-performance computing, and geodetic measurement of crustal deformation have yielded significant advances in knowledge of fault behavior and crustal stress during the past decades. A major leap forward will be enabled with the ability to monitor crustal deformation with high temporal and spatial resolution. That capability will extend the observational spectrum into the realm of transient and aseismic deformation. These fast but seismically quiet deformation processes, which are at present poorly understood components of the strain budget, are key to developing a complete understanding of earthquake physics. Community models of earthquake physics and seismic hazards, developed in a data-rich environment, will rapidly evolve in response to the data. These new models are expected to yield future earthquake forecasts of useful dimensions that will feed decision-support tools to mitigate losses from future large earthquakes.

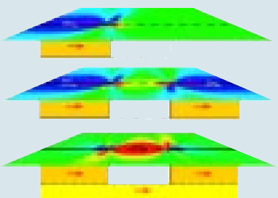
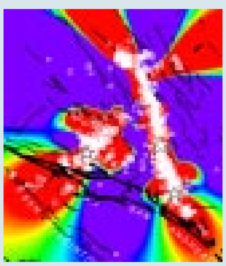
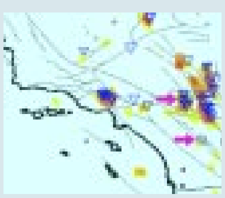
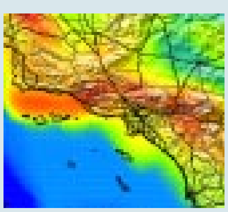
The Global Earthquake Satellite System study responds to the clearly articulated need within the solid-Earth science community for dense surface deformation data. It is a detailed implementation plan in alignment with the recommendations of the SESWG, and charts the course for NASA to make major contributions to the interagency EarthScope program, while broadening those goals to a global scope. In the GESS study, we explored the requirements space for various components of an integrated system, but focused our mission architecture studies on systems that deliver high-accuracy, high-resolution surface deformation using InSAR. Detailed science requirements were gathered from the wider community to guide the studies. The major conclusion of the architecture studies is that a constellation of InSAR satellites is needed to address the requirements for monitoring a spectrum of steady and transient deformation processes. To ensure the ability to access any area on the surface of the Earth within 24 hours would require two LEO satellites in orbits above 1000 km. A few MEO or GEO satellites would be equivalent to many spacecraft in LEO and would fully characterize the known transient processes such as postseismic relaxation, slow earthquakes, creep events, and accelerated slip, with full global coverage. It is expected that new discoveries of even faster processes than are recognized today will accrue as crustal deformation measurements extend into the subdaily time scale. The spectrum of transient deformation processes known at present includes surface deformation due to ground water storage, and hence, the hydrologic cycle. Thus, the opportunity for synergistic interaction of hydrology and tectonics, especially with regard to liquefaction susceptibility, is an exciting area of interdisciplinary research that is an added benefit of the high spatially and temporally resolved deformation measurements.

The GESS integrated science and technology plan shown on the opposite page maps the desired scientific knowledge to observational and modeling requirements and to technology investments needed to achieve the vision. Measurements from LEO orbits are within reach at present. Higher vantage points, such as MEO or geosynchronous, require investments in inflatable, deployable antennas and structures, high-efficiency lightweight electronics, and new processing schemes to account for varying atmospheric and ionospheric conditions during the long integration times required to achieve the synthetic aperture from a slowly moving platform. These investments should be made now to ensure that NASA is ready to respond to the wealth of new discoveries that will be returned by a near-term LEO InSAR constellation.

GESS Roadmap



GESS Integrated Program

CAPABILITY TIMELINE	OBSERVATIONAL SYSTEM NEEDS	MODELING REQUIREMENTS	TECHNOLOGY INVESTMENT NEEDS
2003–08 **Understanding earthquake physics** 	Single LEO InSAR satellite (EarthScope) Radar-equipped UAVs for disaster response	Time-dependent models of interacting fault systems Development of distributed community modeling environment	Deployable antennas and lightweight radar electronics Trade studies of MEO vs. GEO vantage points
2008–2013 **Mapping crustal stress** 	2–3 satellite LEO+ InSAR constellation	High-resolution atmospheric models ingesting radar data to correct atmospheric delay Integrate tectonics, hydrology, and human influence into comprehensive surface deformation model	Large-aperture membrane antennas Large inflatable/ deployable structures Radiation-hardened, low-power electronics
2013–2018 **Experimental short-term (< 1 yr) earthquake forecasts** 	GEO or MEO InSAR demonstration Continue LEO+ constellation	Data-mining and pattern-recognition techniques to detect anomalies Rapid verification and assessment of potential earthquake precursors	Integrated thin-film solar arrays Membrane-compatible electronics and signal distribution
>2018 **Monthly hazard assessments at scale of fault systems** 	Build GEO or MEO InSAR constellation	Evaluation of streaming InSAR constellation data to recognize emerging system behavior Seamless integration of data analysis and decision-support	Reconfigurable antennas, calibration, and metrology Large-scale, low-cost manufacturing

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