

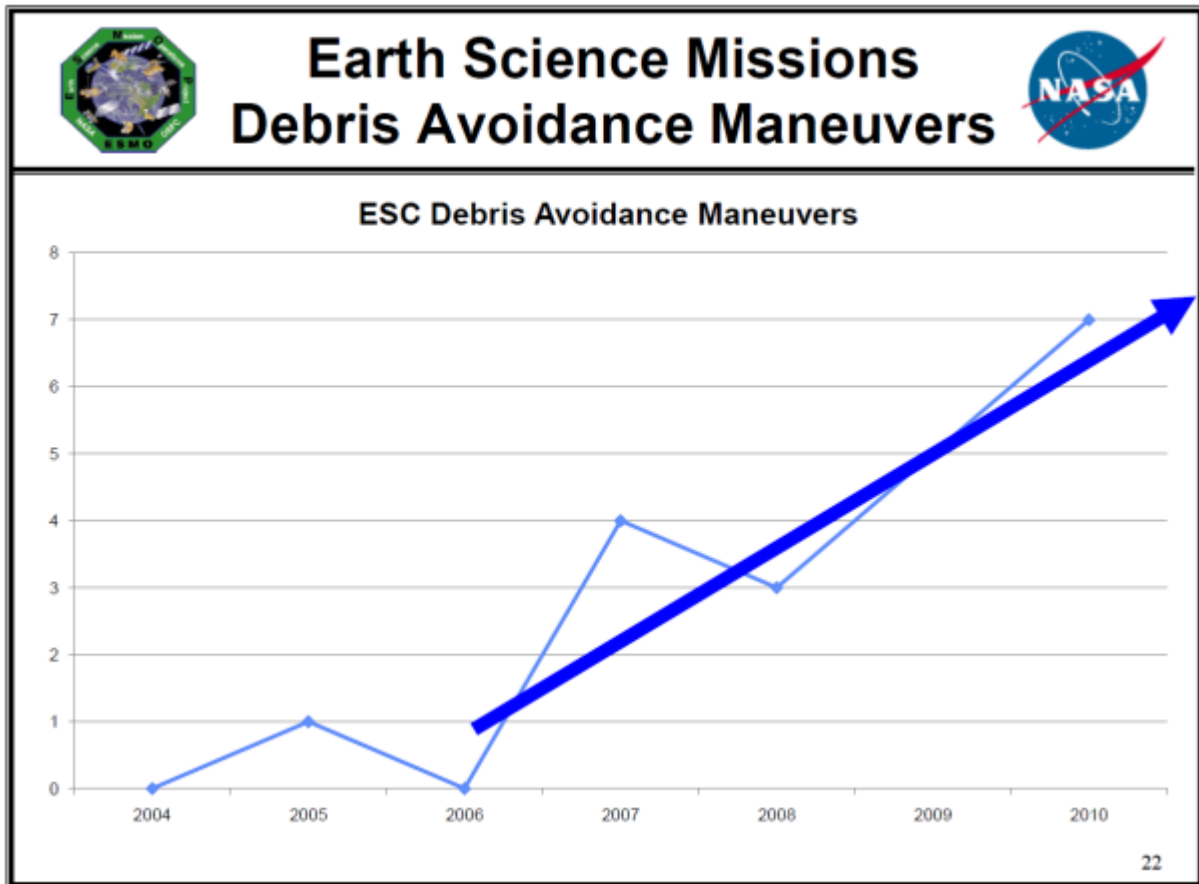
## NASA Current Missions

NASA currently operates 15 Earth Science missions (Table 1). All missions are currently producing data, but several also show signs of aging. Except for SAC-D/Aquarius, recently launched in June 2011, all missions have passed their nominal design life, and are currently in extended operations. Signs of battery aging have been observed in GRACE, CloudSat, and SORCE, all of which require intensive battery management and duty-cycling of instruments, which can reduce both quality and spatial/temporal coverage of the datasets. Aging mechanisms on the Aura TES instrument have restricted spatial coverage. Instruments with reduced capability (noted in RED) are the Landsat-7 ETM+ (failed Scan Line Corrector), QuikSCAT's SeaWinds (antenna no longer rotates so that the data are used primarily to cross-calibrate with other on-orbit scatterometers), Terra's ASTER (SWIR module is no longer functional), and Aqua AMSU (Channel 4 has failed). Instruments that no longer provide data (noted in RED) are TRMM's CERES, Jason's TRSR, Aqua's HSB, and Aura's HIRDLS. All other sensors are fully functional and are producing standard products that meet or exceed specifications.

Although all missions were conceived as research missions, it has turned out that the efficiency of the communications and ground data handling systems has supported operational and near-real-time applications. Our interagency partners have rated all NASA missions as High Utility for operational applications, with Terra, Aqua, and OSTM rated Very High. All missions have met their original success criteria and are meeting the objective for sustained measurements on decadal time scales. This objective is met not only due to the satellites' longevity, but also to the sustained calibration/validation program and the data systems tools which enhance data quality and access. Continued operation of the missions is determined through a biennial science review process, called the "Senior Review", which evaluates the continuing science value. Operational uses of the missions are considered in the review, but science remains the defining factor for continuation. The most recent Senior Review, conducted March-May 2011, found that all of NASA's missions currently in extended operations are still producing valuable science datasets for research, and should be extended for at least another 2 years. The next Senior Review is scheduled for early 2013.

The proliferation of objects in Earth orbit has led to increasing operational complexity as well as concerns for the safety of NASA's on-orbit assets. NASA has developed a Conjunction Assessment Risk Analysis process which monitors all NASA operational assets against known orbital objects, and recommends evasive maneuvers when a conjunction appears likely. A record of conjunction events and of actual avoidance maneuvers has been maintained for the high-value 705km Earth observing orbit where the Landsat, Terra, and A-Train satellites are

located (Figure 1). The trend is disturbing, from no maneuvers in 2004 to 7 maneuvers in 2010, a number which itself is only a fraction of the number of potential conjunctions requiring intensive monitoring and analysis. In addition, the desirability of some orbits for Earth observation has led to multiple on-orbit assets in a constrained space, causing systematic conjunctions where 2 operational satellites pass within meters of each other twice a day for several days at a stretch. The A-Train and the Landsat-5 satellite have been experiencing systematic conjunctions for the last 7 years. This has required routine long-lead orbital analysis and multiple maneuvers to manage the conjunctions before they become a hazard event (these maneuvers are NOT included in Figure 1). To prevent a re-occurrence of this situation with LDCM, an iterative orbit analysis is now underway to balance science and operational objectives against orbit safety. For high-value orbits such as the 705km sun-synchronous orbit, NASA is investigating establishment of an international orbital registry, to minimize systematic conjunctions.



**Figure 1. Frequency of Earth Science Missions Debris Avoidance Maneuvers**

Mission	Launch	Partners	Instruments	Science
TRMM	27-Nov-1997	JAXA	11S, PR, CFRFS, VIRS, TMI	Atmospheric dynamics, water and energy cycle, lightning, precipitation, radiation
Landsat-7	15-Apr-1999	USGS	FTM+	Earth resources, land surface, environmental and disaster monitoring, agriculture and forestry, ice and snow cover
QuikSCAT	19-Jun-1999		SeaWinds	Sea surface wind vectors
Terra	18-Dec-1999	JAXA, CSA	ASTER, MODIS, MOPITT, MISR, CERES	Atmospheric dynamics and chemistry, water and energy cycle, clouds, aerosols, radiation, GHG, carbon and water, air-land exchange
ACRIMSAT	20-Dec-1999		ACRIM-III	Total solar irradiance, solar constant
NMP EO-1	21-Nov-2000		AlI, Hyperion, I FISA AC	Land surface and earth resources
Jason	7-Dec-2001	CNFS	LRA, JMR, DORIS-NG, POSEIDON-2, TRSR	Oceanography, geodesy/gravity, climate monitoring, marine meteorology
GRACE	17-Mar-2002	DIR	Gravity, GPS	Ocean currents and mass, ice sheets, GPS (P,T, humidity)
Aqua (EOS PM-1)	4-May-2002	JAXA, BNIS, INPE	MODIS, AIRS, CERES, AMSU, AMSR	Atmospheric dynamics, water and energy cycle, clouds and aerosols, radiation, GHG, air/sea fluxes, precipitation
SORCE	25-Jan-2003		SIM, SOI STICF, TIM, XPS	Total solar irradiance
Aura	15-Jul-2004	NSO, FMI, BNSC	MLS, TES, HIRDI S, OMI	Chemistry and dynamics of atmosphere, O <sub>3</sub> , GHG, aerosols
CALIPSO	28-Apr-2006	CNFS	CALTOP	Aerosols and clouds
CloudSat	28-Apr-2006	DoD (USA), CSA	CPR	Cloud vertical profiling
OSTM (Jason-2)	20-Jun-2008	NOAA, CNES, EUMETSAT	LRA, JMR, DORIS-NG, POSEIDON-3, AMR, GPSP	Oceanography, geodesy/gravity, climate monitoring, marine meteorology
SAC-D / Aquarius	10-Jun-2011	CONAF	L-Band Radar, MWR, NIRST, ROSA	Sea Surface Salinity

**Table 1. Current NASA Missions**

Table 2 lists the NASA-developed instruments on non-NASA missions. All of the instruments listed below are GPS Radio Occultation instruments focused on the measurement of atmospheric temperature and humidity.

Mission	Launch	Lead	Instrument(s)	Earth Science
Orsted	23-Feb-1999	DNSSC	GPSRO	Atmospheric temperature and humidity
CHAMP	15-Jul-2000	DLR	TRSR	Atmospheric temperature and humidity
SAC-C	21-Nov-2000	CONAE	GOLPE	Atmospheric temperature and humidity
COSMIC (1 to 6)	14-Apr-2006	NSPO	GOX	Atmospheric temperature and humidity
TerraSAR-X	15-Jun-2007	DLR	GPSRO	Atmospheric temperature and humidity

**Table 2. NASA-developed Instruments on non-NASA Missions**