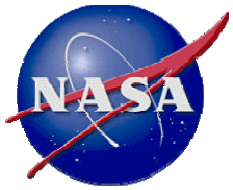
National Aeronautics and Space Administration



USA Space Debris Environment and Policy Updates

Presentation to the 44th Session of the
Scientific and Technical Subcommittee
Committee on the Peaceful Uses of Outer Space
United Nations

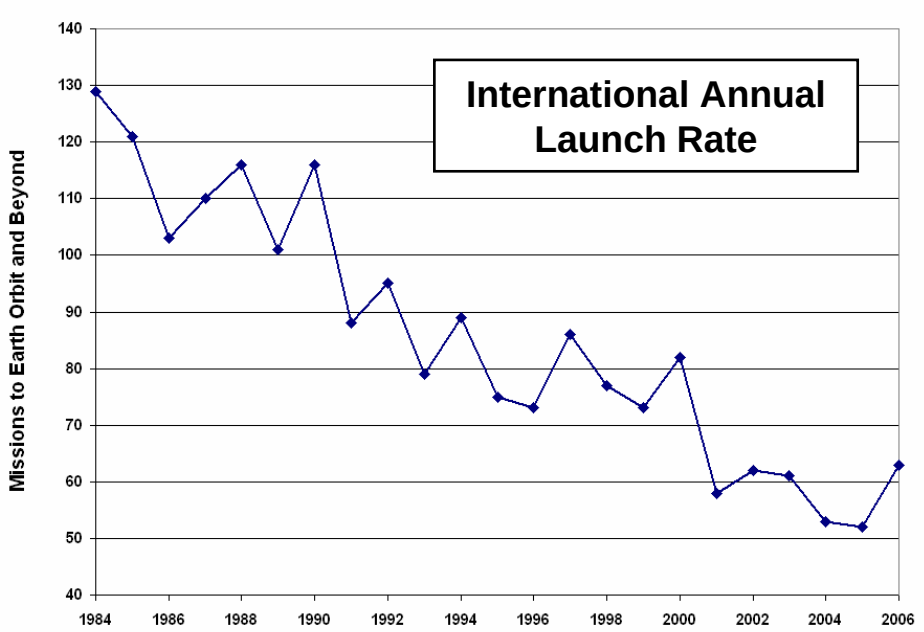
12-23 February 2007

Presentation Outline

- **Satellite Launches and Reentries in 2006**
- **Controlled Reentry of Delta IV Second Stage**
- **Collision Avoidance**
- **Retirement of USA GEO Spacecraft in 2006**
- **Satellite Fragmentations**
- **Orbital Debris and U.S. National Space Policy**
- **Solar Dynamics Observatory**
- **Design-to-Demise Program**

Satellite Traffic in 2006

- **The number of world-wide space launches in 2006 to reach Earth orbit or beyond was 63:**
  - Russian Federation 24
  - USA 17
  - China 6
  - Japan 6
  - France 5
  - Sea Launch 5



- **Cataloged Objects in Earth Orbit (from USA Space Surveillance Network):**

	Total	USA
1 January 2006	**9430**	**3881**
1 January 2007	**9944**	**4070**

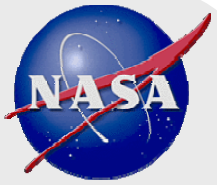
NASA Space Missions of 2006

- **Seven NASA space missions were undertaken in 2006.**

Mission	Launch Date	Destination	Other Objects Produced
New Horizons	19 January	Pluto	No objects left in Earth orbit
ST-5 (A, B, C)	22 March	Elliptical Earth Orbit	One rocket body and one mission-related debris in short-lived orbits
Cloudsat / Calipso	28 April	LEO	Rocket body decayed; one mission-related debris to decay within 25 years
STS-121	04 July	LEO (ISS)	No debris left in Earth orbit
STS-115	09 September	LEO (ISS)	No debris left in Earth orbit
STEREO A and B	26 October	Heliocentric Orbit	One rocket body and one mission-related debris in short-lived orbits
STS-116	10 December	LEO (ISS)	Six small payloads and three mission-related debris in short-lived orbits

- **All spacecraft, rocket bodies, and mission-related debris residing in or passing through LEO have already reentered or will reenter within 25 years.**

Reentry of Satellites in 2006



- **Due to low solar activity and few low altitude satellite breakups, the number of known satellite reentries remained at a relatively low level in 2006.**

- **A total of 237 spacecraft, launch vehicle orbital stages, and other cataloged debris reentered during the year. No instances of injuries or property damaged were reported.**

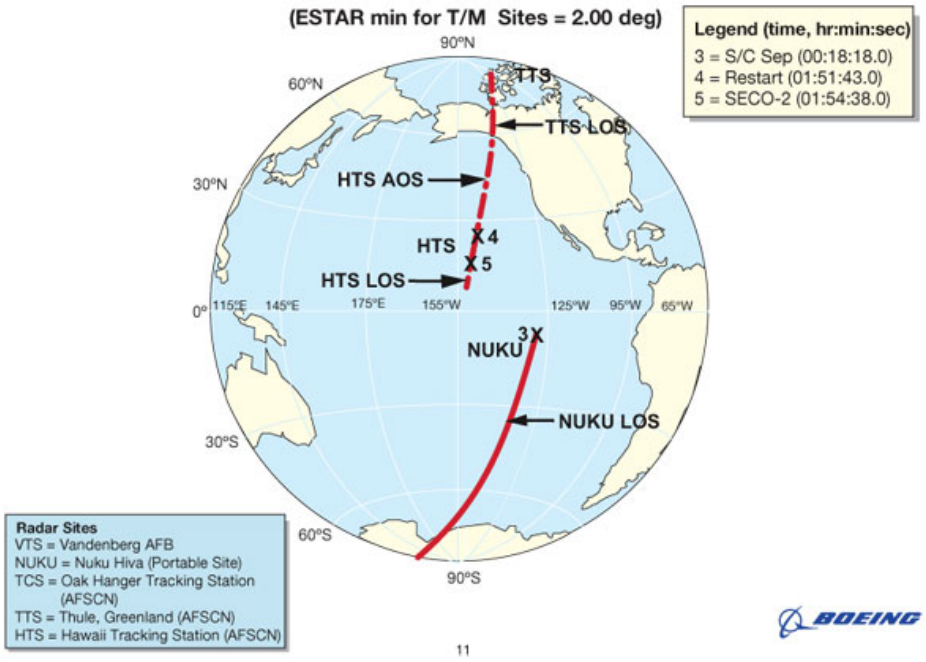
- **The total number of uncontrolled reentries was 223, including 13 payloads and 31 launch vehicle orbital stages with a total mass of about 70 metric tons.**

- **On three occasions a launch vehicle orbital stage was commanded to execute a controlled reentry following successful payload delivery.**
  - Russian Fregat stages from the METOP and COROT missions
  - USA Delta IV second stage from the DMSP 5D3-17 mission

Controlled Reentry of Delta IV Second Stage

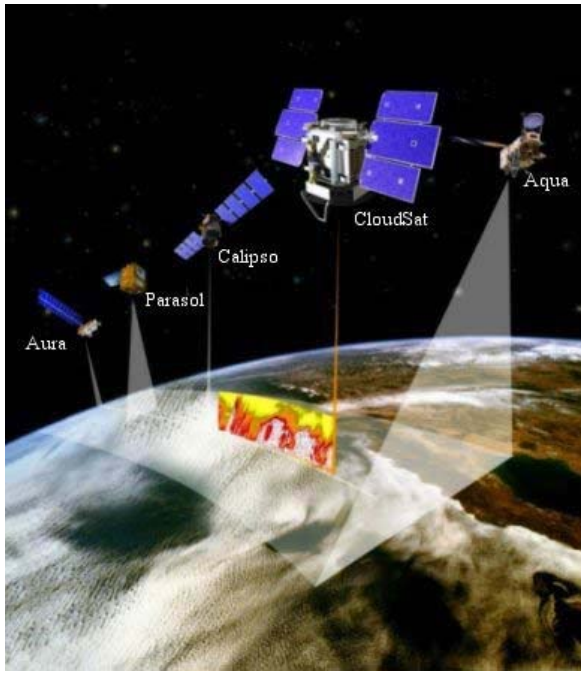
- **In 1996 the USA demonstrated the ability to significantly reduce the altitude of a launch vehicle stage to limit its time in low Earth orbit.**
  - The MSX Delta II second stage was maneuvered from a payload delivery orbit of 900 km to a disposal orbit of 225 km by 870 km; reentry occurred only 9 months later.

- **In 2006 the DMSP 5D-3 F17 Delta IV second stage was completely de-orbited from a circular orbit of 850 km.**



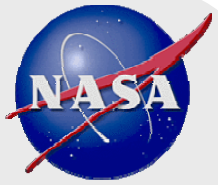
Orbital Debris Collision Avoidance

- **NASA continues to conduct satellite conjunction assessments on a routine basis to avoid accidental collisions with resident space objects.**
  - Assessments are performed for the International Space Station, Space Shuttle, Earth Observation System (EOS) spacecraft, and the Tracking and Data Relay Satellite (TDRS) system



- **Each of the eleven EOS spacecraft average 2 conjunctions per month within 1 km and nearly 1 conjunction per month within 500 m**
- **A close approach to NASA's TDRS-1 spacecraft in GEO by a resident space object was predicted to occur on 4 January 2006. The spacecraft conducted a maneuver on 2 January to ensure no possibility of collision.**
  - Normal station-keeping maneuver scheduled for 12 January was conducted early

Disposal of USA Geosynchronous Satellites in 2006



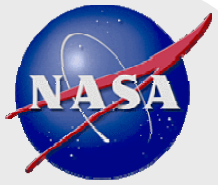
- **Four USA commercial GEO spacecraft completed operations in 2006.**

- **SPACENET 4 (also known as ASC 2) was launched in 1991 when the recommended GEO disposal altitude was only 150 km above GEO. North-South station-keeping was terminated in 2003 to conserve propellant. In April 2006, after 15 years of service, the spacecraft used all remaining propellant to maneuver into a disposal orbit of 195 km by 200 km above GEO.**

- **GALAXY 1R, launched in 1994, was retired in March 2006 and maneuvered into an orbit of 295 km by 300 km, meeting the IADC recommendation for the disposal of GEO spacecraft.**

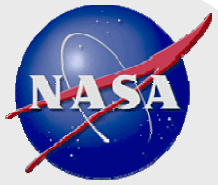
- **GALAXY 3R, launched in 1995, suffered a failure of its spacecraft control processor in January 2006. Attempts to recover control of the spacecraft were unsuccessful. Therefore, the spacecraft operator was unable to boost the vehicle into a disposal orbit above the geostationary arc.**

Disposal of USA Geosynchronous Satellites in 2006 (continued)



- **DIRECTV 6 (also known as TEMPO 2), launched in 1997, completed its mission in August 2006 and was initially placed in a planned disposal orbit of approximately 385 km by 410 km above GEO. However, during passivation operations to burn all residual propellants, an unanticipated disturbance caused the spacecraft to be perturbed into a final orbit of 235 km by 470 km.**
  - The cause of the perturbation has been identified so that future occurrences can be avoided

Satellite Fragmentations in 2006



- **A total of 10 spacecraft and launch vehicle components experienced minor to severe fragmentations during 2006, the greatest number of satellite fragmentations in more than a decade.**

- **More than 300 debris larger than 5 cm in diameter were detected, and approximately half of these debris were in orbits with likely lifetimes of many years.**

Type	Common Name	International Designator	Orbit Type	Debris Detected	Debris Lifetime
Spacecraft	Vanguard 3	1959-007A	Low, eccentric	1	Long
	SARA	1991-050E	Low, circular	2	Moderate
	Cosmos 2423	2006-039A	Low, circular	>30	Short
Launch Vehicles	Tsyklon Third Stage	1985-108B	Low, circular	~50	Short
	Proton Ullage Motor	1989-039G	High, eccentric	>100	Long
	Delta 2 Second Stage	1989-089B	Low, circular	>30	Short
	Proton Ullage Motor	2000-036E	High, eccentric	~10	Short
	H-2A Second Stage	2006-002B	Low, circular	20	Short
	H-2A Second Stage	2006-037B	Low, circular	~20	Short
	Delta 4 Second Stage	2006-050B	Low, circular	>60	Moderate

Fragmentations of USA Satellites in 2006

- **In February, the 45-year-old Vanguard 3 (1959-007A) released a single piece of debris with very low velocity while in an orbit of 510 km by 3310 km. The release velocity was very small, and the likely cause was the impact of a small (untracked) particle or surface degradation of the spacecraft.**

- **In November, shortly after reaching an orbit of approximately 850 km circular on 4 November 2006, a Delta IV second stage unexpectedly released more than 60 debris in a retrograde direction with velocities mostly in the range of 0-50 m/s . The vehicle did not suffer a loss of function and was able to conduct a successful de-orbit maneuver on the next revolution. The source of the debris is under investigation.**

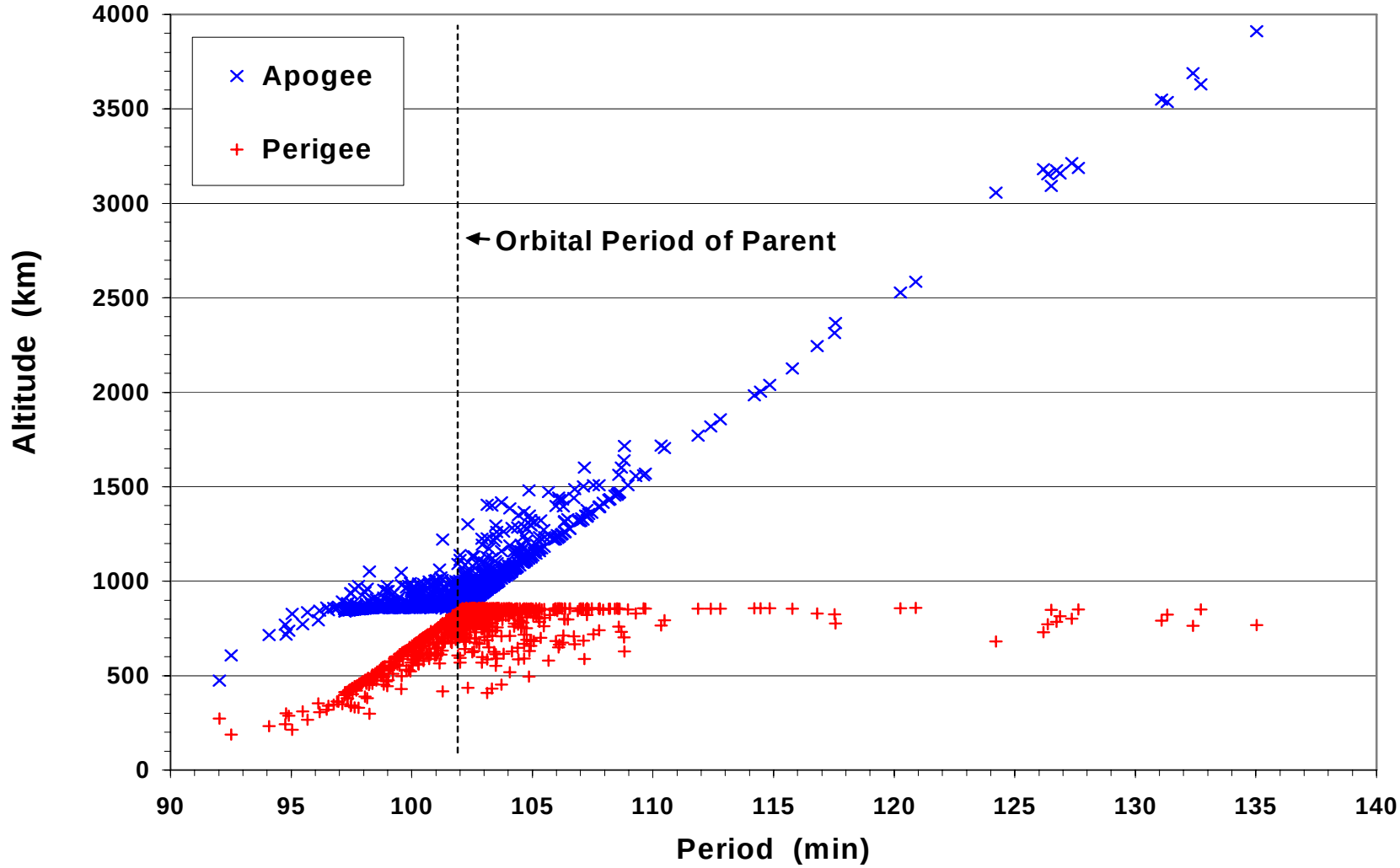
- **In December, a 17-year-old Delta second stage (1989-089B) released as many as 36 tracked debris from an orbit of 685 km by 790 km. The stage had been passivated soon after delivery of its payload in 1989. The debris exhibited orbital decay rates higher than normal and all but three have already reentered. An investigation into the cause of the breakup is underway.**

Fragmentation in January 2007

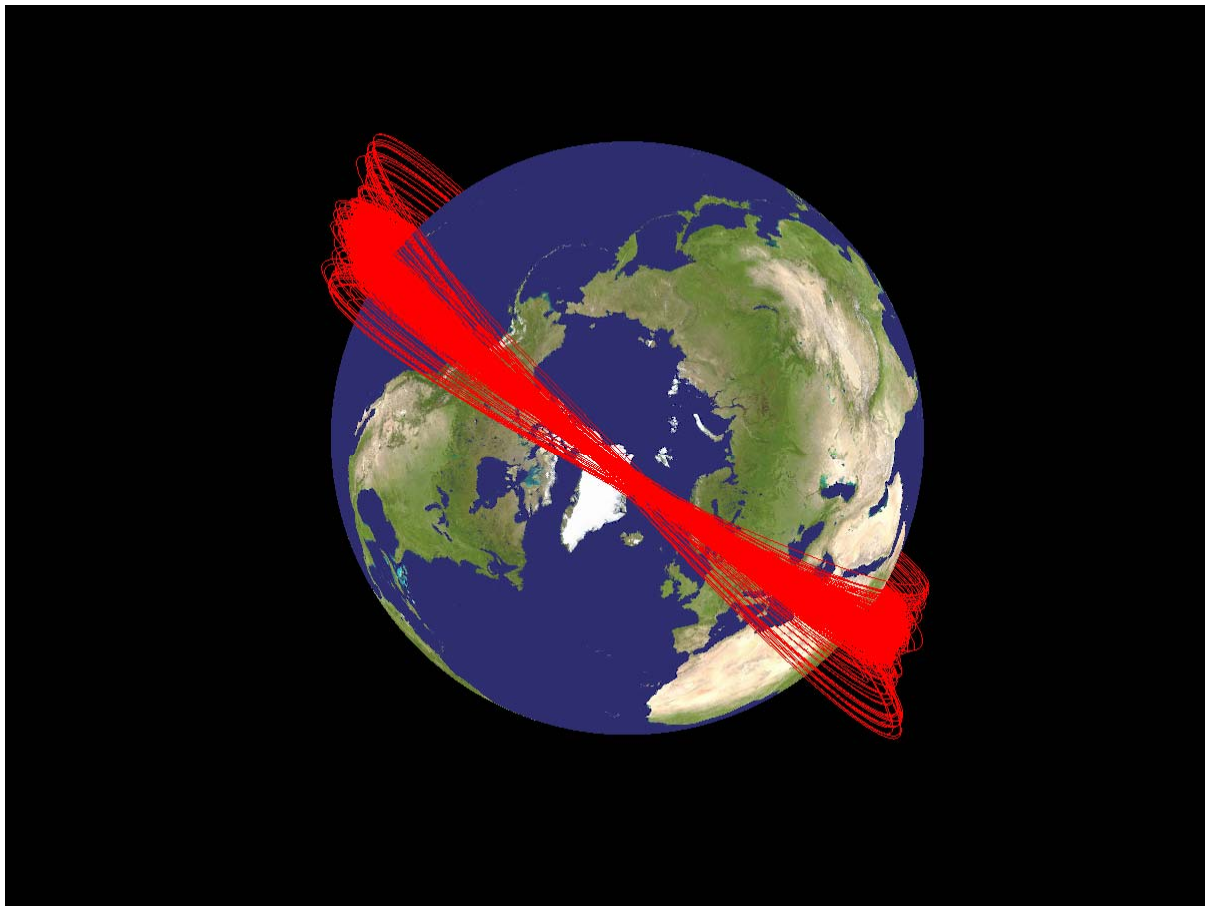
- **On 11 January 2007 the Fengyun-1C satellite (International Designator 1999-025A) suffered a severe breakup in an approximately circular orbit near 850 km with an inclination of 98.6 degrees.**
- **The USA Space Surveillance Network is tracking more than 900 debris with sizes of 5 cm and larger.**
- **Special tracking of small debris by the Haystack radar indicates a much larger population of objects less than 5 cm in size.**
- **The orbits of the debris ranged from less than 200 km to more than 3800 km.**
- **The majority of the debris reside in very long-lived orbits.**

Debris Distribution from Fengyun-1C

- **Data from USA Space Surveillance Network: 949 objects as of 11 February 2007**



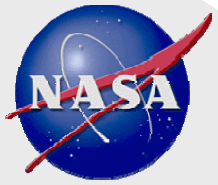
Dispersion of Fengyun-1C Debris Planes



Orbital debris planes as of 11 February 2007.

Globe will be completely encircled by Fall 2007.

Orbital Debris and USA National Space Policy



- **Orbital debris has been addressed in all USA national space policies since 1988.**

- **New National Space Policy (signed 31 August 2006 by President Bush) states:**

"Orbital debris poses a risk to continued reliable use of space-based services and operations and to the safety of persons and property in space and on Earth. The United States shall seek to minimize the creation of orbital debris by government and non-government operations in space in order to preserve the space environment for future generations. Toward that end:"

Orbital Debris and USA National Space Policy
(continued)

- **“Departments and agencies shall continue to follow the United States Government Orbital Debris Mitigation Standard Practices, consistent with mission requirements and cost effectiveness, in the procurement and operation of spacecraft, launch services, and the operation of tests and experiments in space;**

- **“The Secretaries of Commerce and Transportation, in coordination with the Chairman of the Federal Communications Commission, shall continue to address orbital debris issues through their respective licensing procedures; and**

- **“The United States shall take a leadership role in international fora to encourage foreign nations and international organizations to adopt policies and practices aimed at debris minimization and shall cooperate in the exchange of information on debris research and the identification of improved debris mitigation practices.”**

Solar Dynamics Observatory (SDO)

- **NASA's SDO is a case study in the implementation of NASA orbital debris mitigation efforts and processes.**

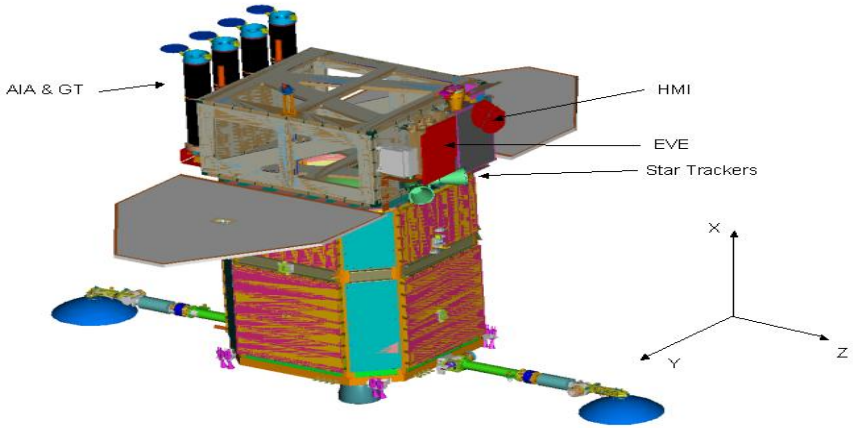
- **The 3200-kg SDO will be launched in 2008 by an Atlas V launch vehicle for a five-year scientific mission in an inclined geosynchronous orbit.**

- **Review of the orbital debris assessment report submitted in March 2004 at the Preliminary Design Review noted potential non-compliance issues:**

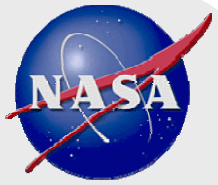
  – Venting of helium pressurant at end of mission

  – Disconnect of battery from charging circuit at end of mission

  – Disposal of launch vehicle upper stage, including reentry risk

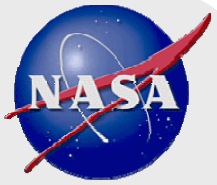


Solar Dynamics Observatory (continued)



- **Design and operational changes adopted by time of the Critical Design Review in April 2005 included:**
  - Bypass valve added to permit venting of helium pressurant
  - Battery disconnect relay control added to power subsystem
  - Centaur upper stage to be left in storage orbit between LEO and GEO.
- **Cost-effective solutions were found to meet orbital debris mitigation objectives without impacting spacecraft reliability or program schedule.**

Design-to-Demise Program



- **For several years the NASA Goddard Space Flight Center has engaged in an effort to reduce the risk to people and property on Earth from satellite reentries.**

- **The focus of the endeavor, called Design-to-Demise, has been to develop components which burn-up during the reentry process.**

- **Case Study: Joint US/Japan Global Precipitation Measurement (GPM) mission (to be launched in 2013)**

  – A demisable reaction wheel assembly was developed for which a patent has now been applied.

  – A propellant tank using an aluminum liner and propellant management device and composite overwrap has been designed. Full development is continuing.

  – With the demisable reaction wheel assembly and propellant tank, the GPM satellite will be compliant with the NASA guideline for limiting risks of human casualty from reentering debris (risk less than 1 in 10,000).