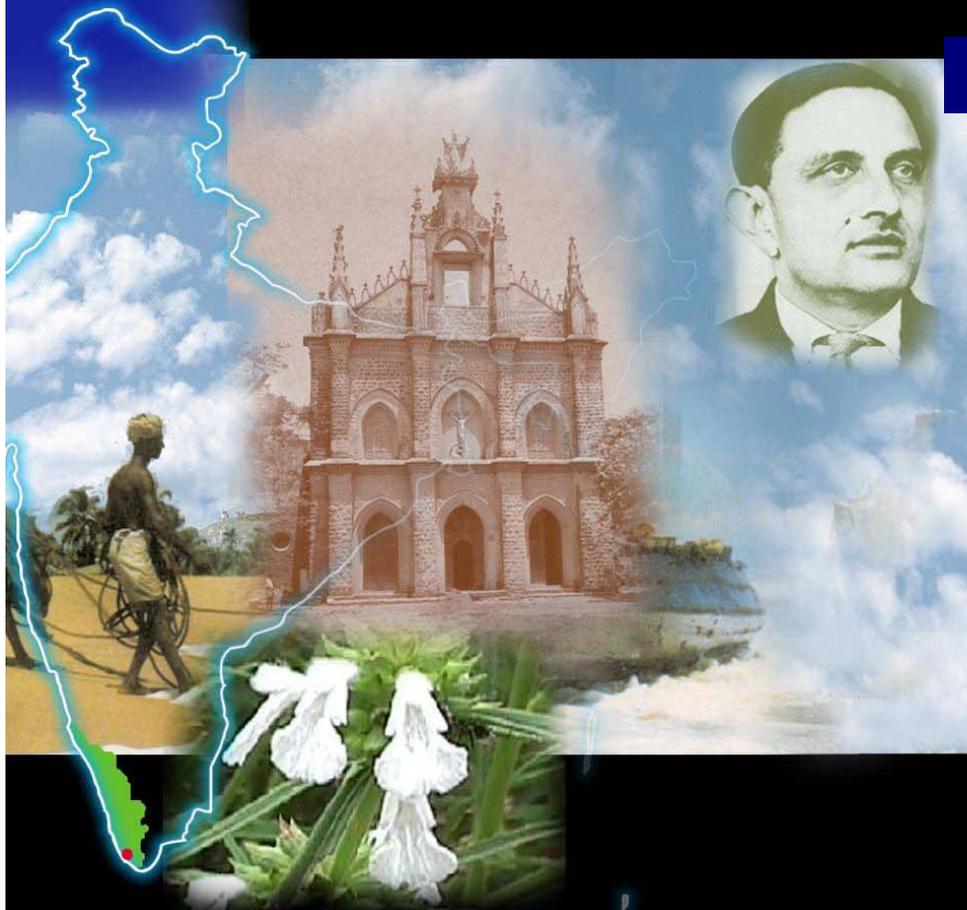




Indo-US Cooperation in Civil Space

Virender Kumar
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Washington DC

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THERE ARE SOME WHO QUESTION THE RELEVANCE OF SPACE ACTIVITIES IN A DEVELOPING NATION

.....IF WE ARE TO PLAY A MEANINGFUL ROLE NATIONALLY, AND IN THE COMITY OF NATIONS, WE MUST BE SECOND TO NONE IN THE APPLICATION OF ADVANCED TECHNOLOGIES TO THE REAL PROBLEMS OF MAN AND SOCIETY."

The beginning



Aravamudan and Kalam work on a rocket payload at Thumba in 1964

Indo-US Cooperation in Civil Space

- Dates back to the beginning of the Indian Space Program
- On Nov 21, 1963 the Nike-Apache rocket was launched from Thumba in Southern India

The famous SITE experiment

- NASA repositions ATS-6 satellite over Indian Ocean in mid 1970s
- ISRO deployed TV sets across 2400 villages to receive educational programs
- It was a grand success-first taste of what space technology could do for societal benefit

The first MOU

- 1997-MOU signed between Department of Space, Govt. of India, DST and NASA/NOAA
- Joint research in earth and atmospheric sciences
- Scientific Data sharing

The INSAT-1980s



- Indian National Satellite System
- Geostationary communication Satellites
- First four satellites built by then-Ford Aerospace to ISRO specifications on commercial basis
- Launched by US launchers-including INSAT-1B by the shuttle Challenger

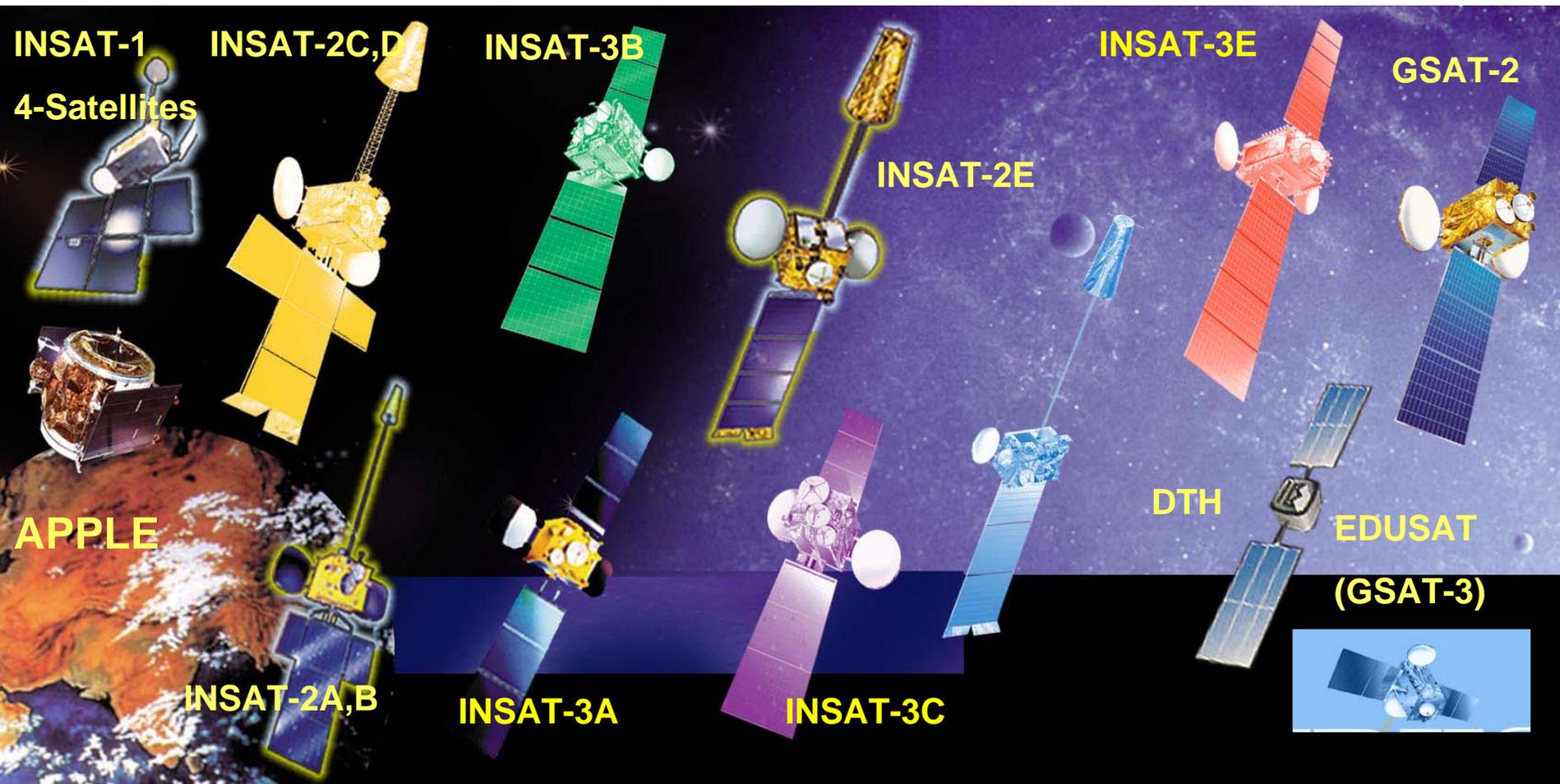
US places sanctions on ISRO

- US restrictions were imposed on nearly all ISRO entities in 1998
- ISRO - NASA/NOAA relations continued to be cordial
- Indirectly benefited ISRO-spurred to develop indigenous capabilities

INSAT SYSTEM

- ***ONE OF THE LARGEST DOMESTIC SATCOM SYSTEMS - Ku, C, S BANDS***
- ***MULTI-PURPOSE : TELECOM, TV, METEOROLOGY***
- ***160 TRANSPONDERS, GLOBAL/DOMESTIC BEAMS***
- ***TO ACHIEVE 250 TRANSPONDERS CAPACITY BY 2007***

EVOLUTION OF THE INSAT FAMILY



Earth observation Systems

- India was one of the first countries to establish receiving station from NASA's Landsat Satellite
- Number of joint programs undertaken

The Indian Remote Sensing -IRS system

- Today-one of the biggest system
- Provides data in variety of spatial resolutions and spectral bands
- Data being received all over the world, including US

1995/1997



IRS-1C/1D LISS-3 (23/70M,
STEERABLE PAN (5.8 M);
WiFS (188M)

1999



INSAT-2E CCD
(1KM RESOLUTION;
EVERY 30 MNUTESS)

2003



RESOURCESAT-1
LISS3 - 23 M; 4 XS
LISS4 - 5.8 M; 3-XS
AWIFS - 70 M; 4-XS

1994



IRS-P2
LISS-2

IRS-P3
WiFS MOS
X-Ray



IRS-P4
OCEANSAT OCM, MSMR

20



CARTOSAT
PAN - 2.5
P



IRS-1A/1B LISS-1&2 (72/36M,
4 BANDS; VIS & NIR)

INDIAN IMAGING SYSTEMS



CARTOSAT
PAN - 1M
2005-2006

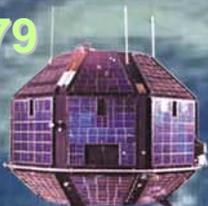
1982



RS-D1

MEGHA-TROP
SAPHIR
SCARAB
MADRA

1979



BHASKARA

IMAGING IMPROVEMENTS

- ◆ 1KM TO 1.0 M RESOLUTION
- ◆ GLOBAL COVERAGE
- ◆ APPLICATION-SPECIFIC

LAUNCH VEHICLE FAMILY



The NSSP

- In January 2004 U.S. President George W. Bush and Indian Prime Minister Atal Behari Vajpayee announced the Next Steps in Strategic Partnership (NSSP)
- It is a bilateral initiative
- Covers expansion of cooperation in the areas of civilian space activities, civilian nuclear programs
- Joint working group on civil space cooperation was set up
- High-technology trade
- Expand discussions on missile defense

Bilateral Partnership further nurtured

- The visit of Indian Prime Minister Dr. Manmohan Singh to US in 2005
- The follow on visit of President Bush to India in 2006

Visit of NASA Administrator to India

- Took place in May 2006
- Highly successful
- Two MOUs were signed for having two NASA payloads into the Indian Lunar mission- Chandrayaan-1

PSLV FOR A LUNAR MISSION



PERFORMANCE CAPABILITY
LEO 3.5 TONNES

LUNAR MISSION
PSLV: 275 kg

MISSION STRATEGY

1. INJECTION TO LUNAR TRANSFER ORBIT ;
2. MIDCOURSE MANOEUVRE;
3. INSERTION TO LUNAR POLAR ORBIT;
4. DEORBIT ;
5. LUNAR LANDING

CHALLENGE

SCIENCE GOALS

DEEP SPACE TRACKING & CONTROL

ORBIT DETERMINATION

TECHNOLOGY SYSTEMS :NGC, POWER & THERMAL
MANAGEMENT

Future Missions

Basically five types of future missions are being envisaged
(These are based upon the current thought process within the scientific community and are NOT yet sanctioned projects by the Govt)

- Follow on mission to Moon: Considered time frame- 2011 (Chandrayaan-2)
- Asteroid / Comet flyby mission: Possible time frame- 2015
- Mission to Mars :Timeframe- 2019
- Missions to other planets (Venus, Mercury...Vision beyond 2020)

Chandrayaan - 2



- Mission includes Orbiter and Lander
- Remote Sensing instruments
- Lander includes robotics, rovers and penetrators.
- Preferred landing sites, specific scientific problems and instruments need to be finalised. Far side of the moon, particularly South Pole Aitkin (SPA) basin is a prime candidate.
- Considered time frame : 2011
- Possible instruments on the orbiter:
 - Terrain mapping camera
 - 400-4000nm hyper spectral Imager
 - Low energy X-ray spectrometer (CCD-array)
 - Gamma ray, neutron, alpha spectrometer

Mission to Asteroid

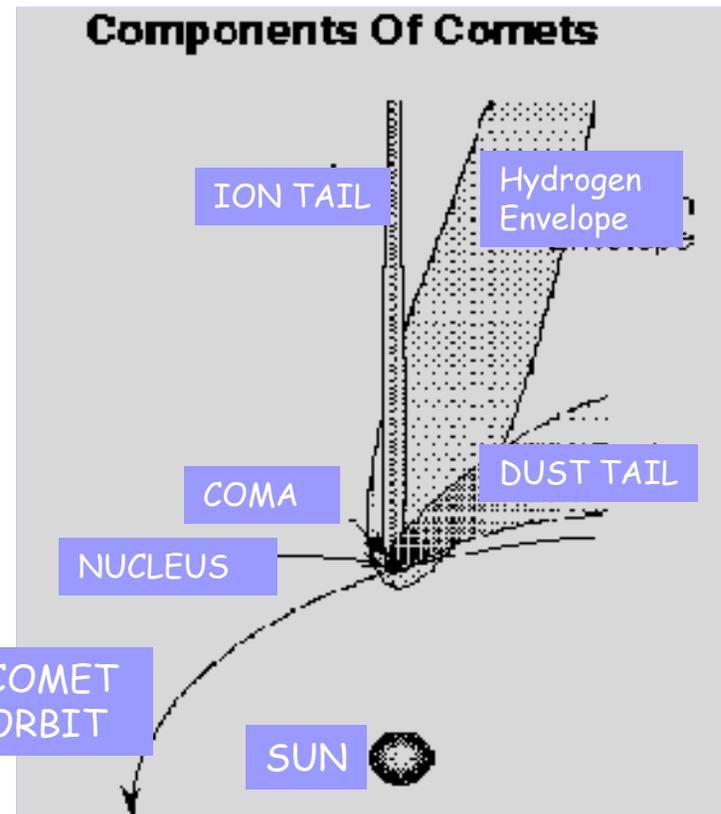
- Orbiter mission to a main belt Asteroid / Comet

OR

- Orbiter mission around a suitable to near earth asteroid coupled with flyby to one or more comets / asteroids

Possible time frame : 2015

Target: Comet



- **Surface and Interior of Comet Nucleus**
- **Composition of dust and gas in the coma**
- **Details of thermal balance and outflow (sublimation of Ice)**
- **Solar radiations & solar wind interaction**
- **Samples of Comet Dust for Laboratory Studies**

Comet mission configuration to be based on the outcome of other such missions

Mission to Mars

- Orbiter mission to Mars to study Mars atmosphere, weather and solar wind-Mars interactions.
- Instruments to be developed are for studying weak magnetic field and plasma
- Timeframe : 2019

Thank You