International Cooperation in Operational Environmental Satellites: The U.S. Experience

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On April 1, 1960, the United States launched TIROS-1, the first environmental satellite –

- Orbit 450 miles above the earth
- 50 degree inclination
- 122 kilograms
- 2 television cameras
- 2 video recorders
- Power and communications systems

Provided weather forecasters first view of cloud formations as they developed and moved across the globe.
In the 50 years since TIROS-1, the United States has
– Expanded from visible to infrared imagery
– Added vertical temperature and moisture profiles (soundings) using infrared and microwave instruments
– Added space weather sensors
– Added ozone sensors
– Developed a series of data products used in weather forecasting and climate monitoring
– Fielded high altitude geostationary satellites (1975) to complement the satellites in low altitude polar orbit
Evolution of Polar Satellite Capabilities

1970
- Soundings
- Snow / Ice Imagery

1980
- Soundings
- Sea Sfc Temp
- Snow / Ice Imagery
- Winds
- ERB
- Ozone
- Precip
- Veg Index

1990
- Soundings
- Sea Sfc Temp
- Snow / Ice Imagery
- Winds
- ERB
- Ozone
- Precip
- Veg Index
- Aerosol
- Clouds
- Microwave

2010
- Future Systems

Future Systems
Today's Polar Satellites

- 5 Channels
- Sensitive to Visible/near IR and IR
- Improved over 49 years

Image from NOAA-19 polar-orbiting satellite taken February 22, 2009 from the AVHRR sensor
Evolution of Geostationary Satellite Capabilities

1950
ATS 1-3

1970
SMS-1/2
GOES A-H

1990
GOES I-M

2010
GOES NOP

2030
GOES R-U

First image from Geostationary (ATS-1, 1967)

Today's GOES Visible image

First GOES-14 full disk visible image
27 July 2009 1730-1800 UTC
Geostationary Imaging GOES Imager Products: North America, 4 February 2010
Satellite Requirements for U.S. Weather Forecasting

- Two polar satellites - One with a mid-morning (09:30) equatorial crossing, one with an early afternoon (13:30) equatorial crossing
- Two geostationary satellites - One at 75 degrees West (over east coast of the U.S.) - One at 135 degrees West (over west coast of the U.S.)
Challenge of Maintaining Continuity of Satellite Observations

Continuity of satellite observations is critical because:
- Satellite data is an important input to numerical weather models.
- Satellite products are used by local weather forecasters.
- Satellite data supports watches and warnings of severe weather.

Continuity is threatened by:
- Launch failures
- On-orbit failures prior to the completion of satellite design life
- Launch delays caused by satellite development problems
- The rapidly increasing cost of satellite development.

- **International collaboration has proven to be a means of mitigating the threats to satellite continuity**
U.S.-European Geostationary Backup Arrangement

- In 1986, lightning struck the GOES-G launch vehicle, destroying the satellite.
- GOES-I, the first of a new generation of satellites, had major development problems causing a 5 year schedule slip.
- These events caused the GOES constellation to drop to a single satellite on orbit in 1990.
- **International collaboration provided the solution.**
- From 1991 to 1995, the European Meteosat-3 was operated, first at 50 degrees West, then at 75 degrees West, in support of the U.S.
- Data from Meteosat-3 was especially important in forecasting the landfall and intensity of Hurricane Andrew in 1992.
U.S.–Japanese Geostationary Backup Arrangement

- MTSAT-1, the intended replacement for Japan’s geostationary GMS-5 satellite, had a launch failure in 1999.
- **International collaboration provided the solution**
  - In 2002, the U.S. agreed to provide backup for GMS-5
  - The U.S. moved GOES-9 westward to 155° East in 2003
  - Japan launched MTSAT-1R in February 2005
  - GOES-9 continued to operate at 155° East until November 2005
Satellites have been growing in cost and complexity. Even with no performance improvements, satellite costs have grown dramatically in recent years. Users demand higher resolutions and new capabilities.

The U.S. and Europe want data from polar satellites in mid-morning and early afternoon orbits.

Yet the cost of maintaining satellite continuity in two polar orbits is more than either the U.S. or Europe wants to shoulder on its own.

**International collaboration provides the solution.**

Europe has responsibility for the mid-morning orbit, and the U.S. has taken responsibility for the early afternoon orbit. Each is flying some of the other’s instruments on its satellites. Full two-way data exchange has been happening since 2007 when the European METOP-A satellite became operational.
Multilateral international collaboration is essential for Earth observations

- Growing need for Earth observations
- No nation can afford to collect all the observations it needs
- Multilateral international collaboration is vital to divide up this massive task amongst space-faring nations
- International environmental satellite organizations are working to achieve “virtual constellations” and environmental data sharing
  - Group on Earth Observations (GEO)
  - Committee on Earth Observation Satellites (CEOS)
  - World Meteorological Organization (WMO) Space Program
  - Coordination Group for Meteorological Satellites (CGMS)