POLAR METEOROLOGICAL SATELLITES

I Review of lecture 1

- Evolution of operational U.S. metsats in polar orbit.
  - TIROS
  - TIROS wheel with magnetic steering/torquing of spin axis gave global coverage.
  - ITOS with momentum wheel - 3 axis stabilization flew more sensors, added IR scanners for day and night imaging.
  - TIROS, N larger spacecraft for more sensors, especially improved soundings by the TIROS Operational Vertical Sounder (TOVS) and data collection and location system (ARGOS).

* In this lecture we will look in more detail at the TIROS N and Advanced TIROS N systems.

II. TIROS N spacecraft.

Figure 3-1 (Vu-graph) - Drawing of spacecraft.

A. Launch configuration:
- Solar array folded and arm back along body.
- Antennas folded along body.

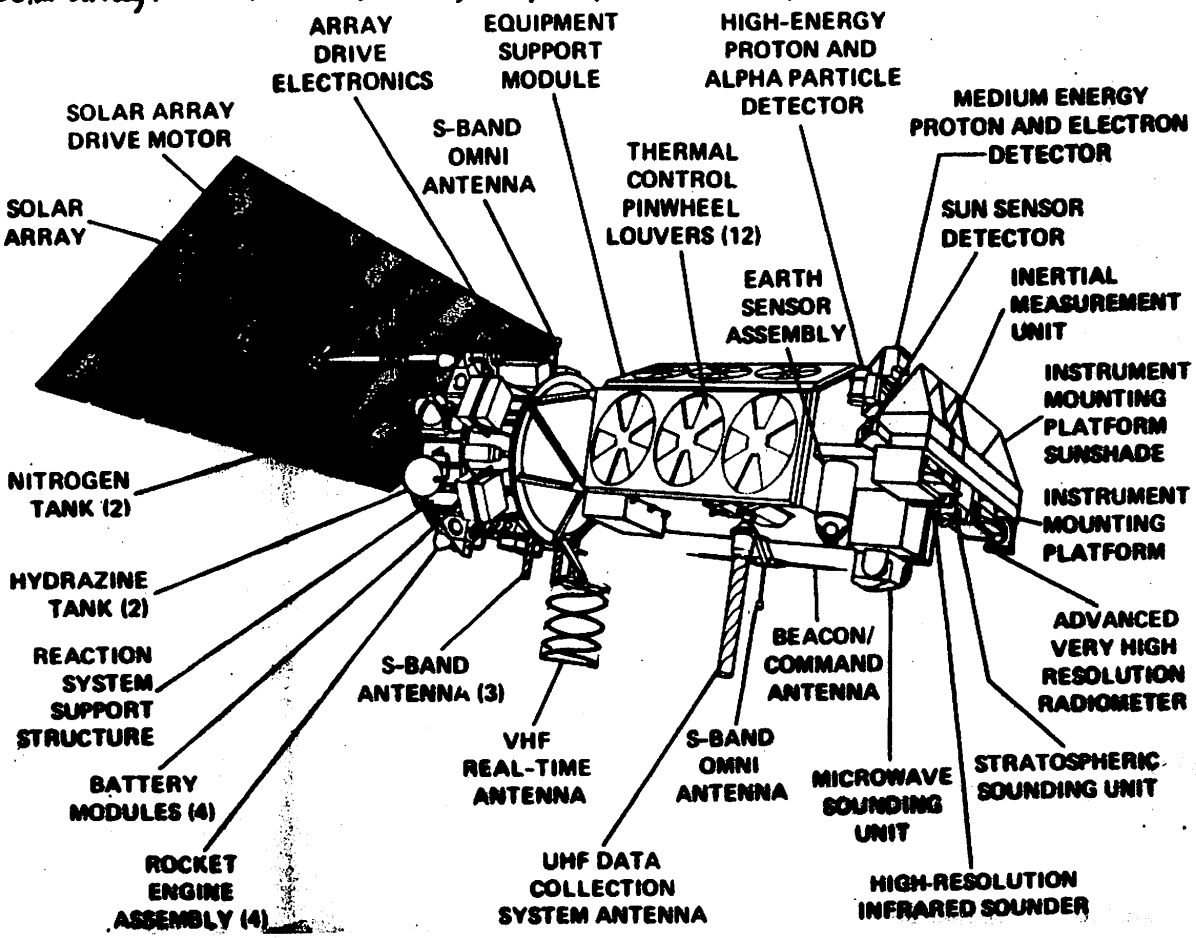
B. The main components:
- Solar Array (SA)
- Equipment Support Module (ESM)
- Instrument Mounting Platform (IMP)
- Reaction System Support Structure (RSS)

FIG. 3-1

RCA

TIROS-N Spacecraft

Solar array: 5.13 x 2.39 meters; body length: 3.78 m.; orbit weight: 745 kg.



C. Reaction System Support

- Final stage of propulsion (solid-stage + hydrazine velocity-trim + initial orientation) to place spacecraft in proper orbit; controlled by on-board computer in ascent mode.
- Nitrogen plus gas jets are part of stabilization system to unload momentum wheels. (Magnetic coils work as well.)

(Battery modules - 4 - also mounted on RSS.)

D. Equipment Support Module

- Houses transmitters, receivers, computers, control units, momentum wheels, etc., and supports the antennas.
- Thermal control by 12 "pin-wheel" louvers which vary the absorptivity to emissivity ratio for nearly constant temperature inside the box.

Fig. 3-2A

Listing (Vugraph)

- The Attitude Determination and Control System (ADACS)
  - Provides stabilization in all three axes to ± 0.2° (for 3σ)
  - Determines actual departure to ± 0.14°
- The Command and Control Subsystem - includes two (redundant) computers which is the nerve center of the satellite: controls the operation of satellite in orbit and issues commands for attitude control.
- The Data Handling Subsystem composed of
  - TIROS Information Processor (TIP) (low bit-rate data)
  - Manipulated ~~Rate~~ Information Rate Processor (MIRP) → TIR + AVHRR combined to produce GAC, LAC, HRPT. Also produces APT.
  - Five Digital Tape Recorders. → Each has one electronics unit + two tape drives. Each drive can store 4.5×10^8 bits of data.

TIROS N - EQUIPMENT SUPPORT MODULE (ESM)

- ATTITUDE DETERMINATION AND CONTROL SYSTEM (ADACS)

  3-AXIS CONTROL TO $\pm 0.2^\circ$ (3σ)

  DETERMINE DEPARTURE TO $\pm 0.14^\circ$

- COMMAND AND CONTROL SYSTEM

  TWO (REDUNDANT) COMPUTERS

- DATA HANDLING SUBSYSTEM
  - TIROS INFORMATION PROCESSOR (TIP)
  - MANIPULATED INFORMATION RATE PROCESSOR (MIRP): TIP + AVHRR COMBINED TO PRODUCE: APT, HRPT, GAC, LAC
  - 5 DIGITAL TAPE RECORDING SYSTEMS, EACH WITH ONE ELECTRONIC UNIT + 2 TAPE DRIVES. TOTAL STORAGE CAPACITY = 4.5×10^9 bits.

- POWER SUPPLY
  - SOLAR ARRAY DRIVE (ONE AXIS)
  - TWO NI-CAD BATTERY CHAINS (4 MODULES)

Fig 3-2A

Fig. 3-2B (Vu graph)

- Communications Links (All digital except APT)
  - HRPT: 1698 or 1707 MHz
  - APT: 137.5 or 137.62 MHz
  - GAC/LAC: 1698, 1702.5 or 1707 MHz to CDA stations
  - Beacon/DSB: 136.77 or 137.77
  - Commands up: 148.56 MHz
  - Argos up: 401.65 MHz
- Power supply
  - Solar array drive (one axis) rotates the array one revolution per orbit to keep the array oriented toward the Sun. Two nickle-cadmium batteries (each in two ~~packs~~ modules).
- Thermal control system
  - Passive: Blankets, finishes, insulators, sun shades.
  - Active: Pinwheel and vane louvers, heaters, control electronics.

E. Instrument Mounting Platform

Includes:

Fig. 3-3 LIST (Vu-graph)

- High-Resolution Infrared Sounder (HIRS)
- Advanced Very High Resolution Radiometer (AVHRR)
- Stratospheric Sounding Unit (SSU)
- Microwave Sounder Unit (MSU)
- Solar Environment Monitor (SEM)
- Sun- + Earth-Sensors for attitude control.
  - Medium Energy Proton + Electron Detector (MEPED)
  - High Energy Proton + Alpha Detector (HEPAD) - (Through NOAA-7 only. Moved to GOES since GOES 4 in 1980)
  - Total Energy Detector.

[ARGOS - The data collection and location system is in the Equipment Support Module.]

TIROS N - ESM (CONTINUED)

- COMMUNICATIONS LINKS
  - HIGH RESOLUTION PICTURE TRANSMISSION (HRPT): 1698, OR 1707 MHz
  - AUTOMATIC PICTURE TRANSMISSION (APT) ANALOG SIGNAL: 137.5 OR 137.62 MHz
  - BEACON AND DIRECT SOUNDER BROADCAST (DSB) -- TIP DATA: 136.77 OR 137.77
  - STORED DATA TO CDA STATIONS: 1698, 1702.5, OR 1707 MHz [GAC, LAC, TIP]
  - COMMAND RECEIVER: 148.56 MHz
  - ARGOS RECEIVER: 401.65 MHz

- THERMAL CONTROL SYSTEM
  - PASSIVE: BLANKETS, FINISHES, INSULATORS, SUN SHADES.
  - ACTIVE: PINWHEEL AND VANE LOUVERS, HEATERS, CONTROL ELECTRONICS.

Fig. 3-2B

Fig. 3-3

TIROS N SENSOR SYSTEMS

- TIROS OPERATIONAL VERTICAL SOUNDER (TOVS)
  - HIGH-RESOLUTION INFRA RED SOUNDER (HIRS)
  - STRATOSPHERIC SOUNDING UNIT (SSU)
  - MICROWAVE SOUNDING UNIT (MSU)
- ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR) 4 CHANNEL AND 5 CHANNEL
- SOLAR ENVIRONMENT MONITOR (SEM)
  - MEDIUM ENERGY PROTON AND ELECTRON DETECTOR (MEPED)
  - HIGH ENERGY PROTON AND ALPHA DETECTOR (HEPAD) -- THROUGH NOAA-7 ONLY
  - TOTAL ENERGY DETECTOR (TED)
- ARGOS - DATA COLLECTION AND LOCATION SYSTEM (ON ESM)

ADD ON ADVANCED TIROS N

- SEARCH AND RESCUE (E, F, G, I, J)
- SOLAR BACKSCATTER ULTRAVIOLET (SBUV) SPECTROMETER (FOR G, H, J)
- EARTH RADIATION BUDGET EXPERIMENT (ERBE) (F AND G)

B (9-19-83)

III Advanced TIROS-N (ATN) Spacecraft

First one launched was NOAA-E, now called NOAA-8
Launched 28 March 1983

A. S/C enlarged to provide more space and power for additional sensors.

Fig. 3-4 ATN spacecraft.

Vugraph B. Equipment Support Module lengthened by 48 cm., and a fourth set of "pinwheel" thermal control louvers added.

C. Power supply increased:
- "Standard" solar cells replaced by high-efficiency, violet cells.
- Added third 26.5 ampere-hour ni-cad battery chain (now six modules)
- Total average load capacity is about 435 (515?) watts under worst-case conditions (e.g., sun angle) at the end of 2 years in orbit.

D. Add new subsystems:
- Search and rescue system (NOAA E, F, G, I, J)
- Solar Backscatter Ultraviolet (SBUV) spectrometer (afternoon sats. NOAA F(?), H, J.)
- Earth Radiation Budget Experiment (NOAA F & G)
- All have been added to the Equipment Support Module.

Vu-graph Fig. 3-5 PHOTO OF ADV. TIROS N'S IN RCA PLANT

Fig. 3-6 Vu-graph Chart showing instruments to be flown on different NOAA S/C.

Fig. 3-7 Vu-graph SCHEMATIC OF TIROS DATA SYSTEM

- CDA'S + LANNION, FRANCE (FOR BLIND ORBIT)
- COMSATS + GOES TO RELAY DATA TO NESS/SUITLAND.
- DIRECT BROADCAST (HRPT, APT, DSB)
- ARGOS — balloons, buoys, etc. — Processed at CNES/France

Fig. 3-4

ATN Spacecraft Configuration (NOAA-E, -F, & -G)

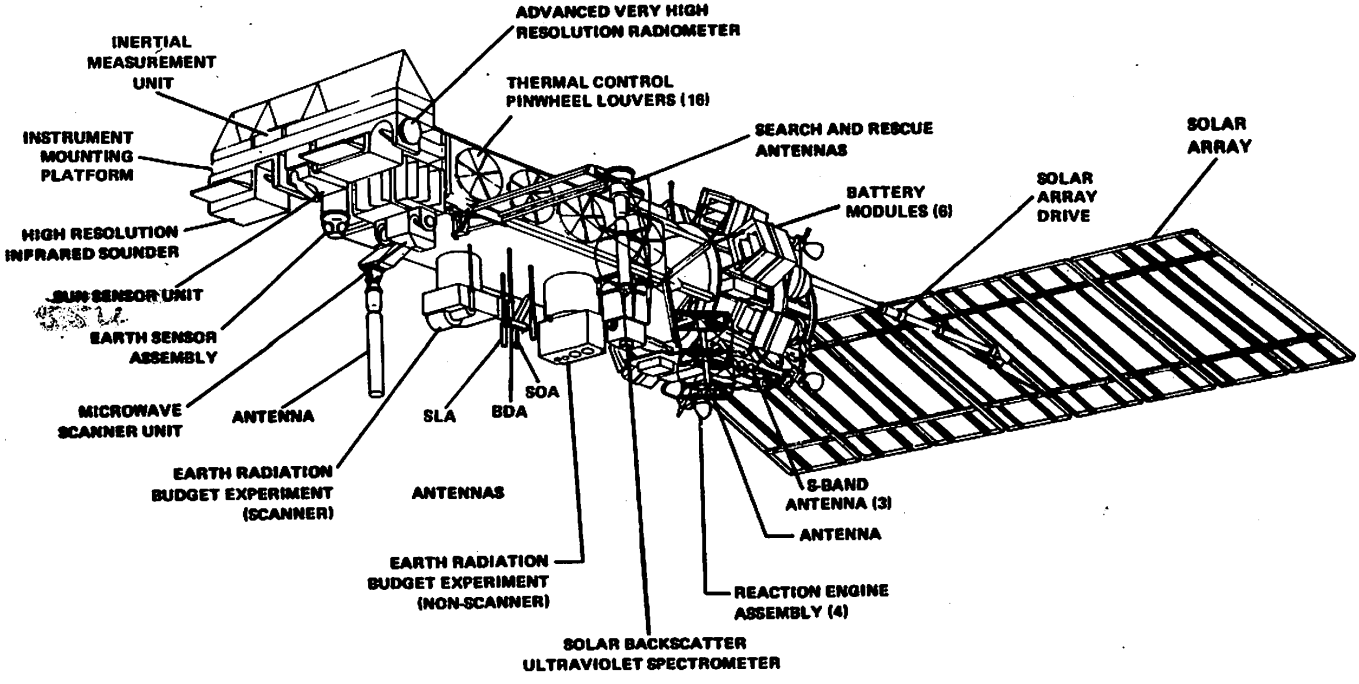
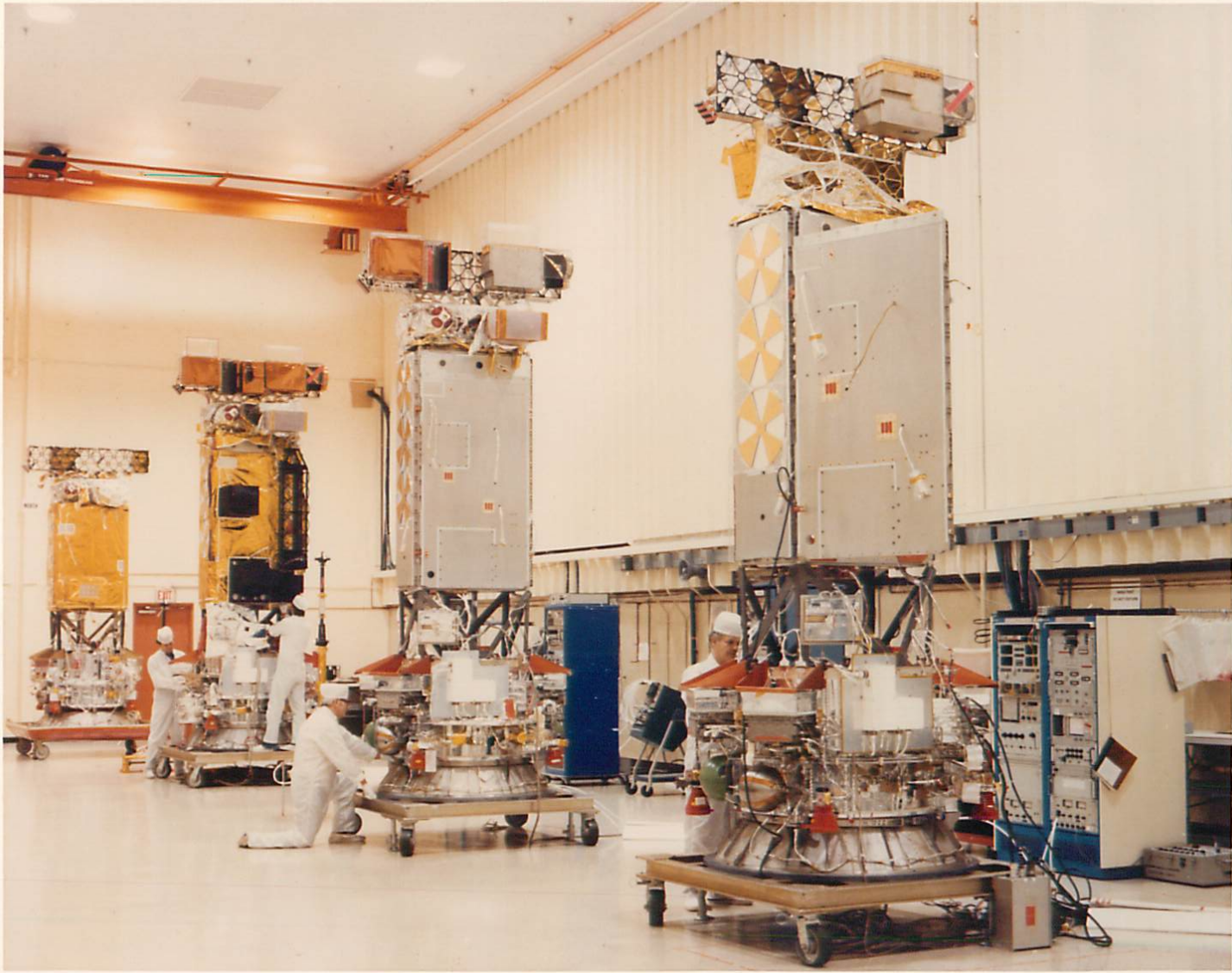


Fig. 3-5 Advanced TIROS N's in RCA Plant



INSTRUMENTS ON NOAA S/C

SPACE-CRAFT	LAUNCH DATE	TIME OF DAY	AVHRR CHAN.	HIRS	MSU	SSU	SEM	DCS	SAR	SBUV	ERBE
NOAA 6	6-79	AM	4	x	x	x	x	x			
NOAA 7	6-81	PM	5	x	x	x	x	x			
NOAA 8	3-83	AM	4	x	x	x	x	x	x		
NOAA F	9-84*	PM	5	x	x	x	x	x	x	x	x
NOAA G	3-85*	AM	4	x	x	x	(3)	x	x	(4)	x
NOAA H	9-86*	PM	5	x	x	x	x	x		x	
NOAA I	3-87*	AM	5	x	x	(2)	(3)	x	x		
NOAA J	9-88*	PM	5	x	x	x	x	x	x	x	
? NOAA D	(1)		4	x	x	x	x	x			

(1) NOAA D will be used if launch needed before NOAA F, or converted to an ocean satellite, or used later.
(2) One satellite will fly without an SSU.
(3) Two satellites will fly without an SEM.
(4) SBUV will fly only on afternoon satellites.
* Planning dates; will launch when needed.

Fig. 3-6

RCA

Current TIROS Weather System

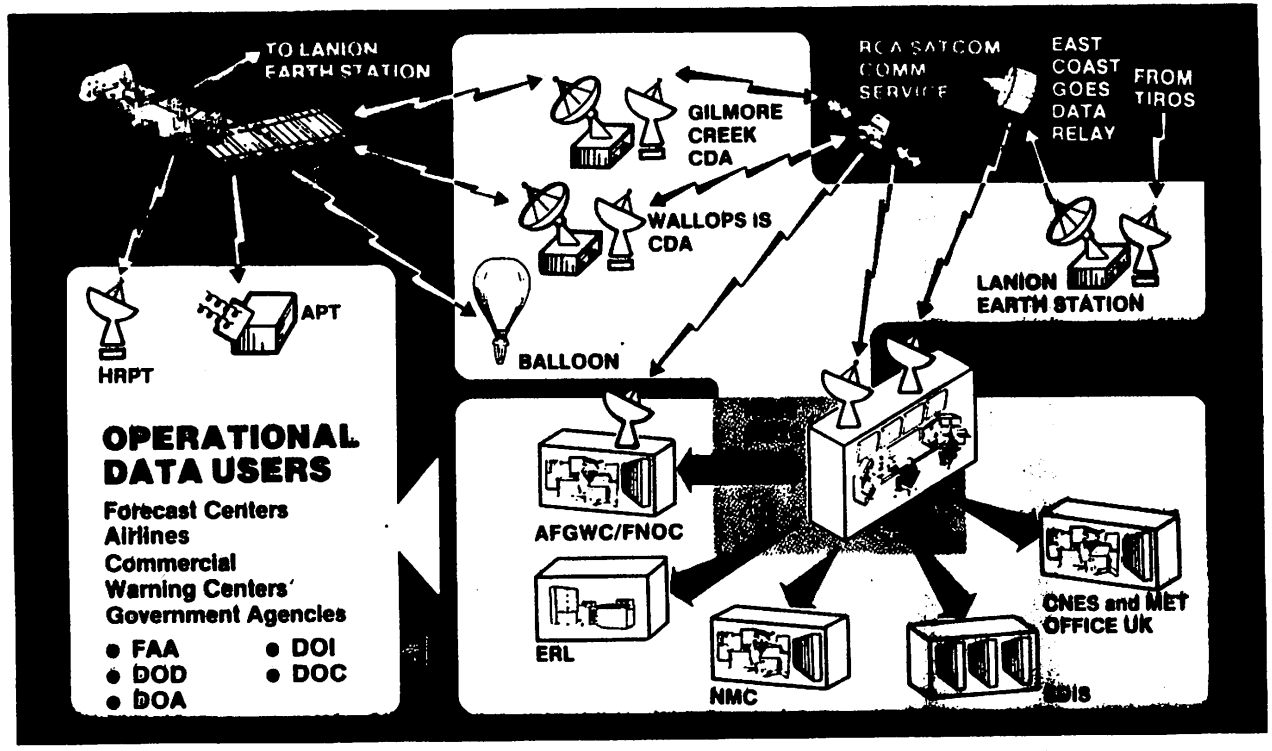


FIG 3-7

- For U.S. needs, most polar sat. data processed centrally: Soundings
  Image extraction (not used much for clouds per se)
  Argos (by France)
  Solar Environment Monitor (by ERL Boulder)