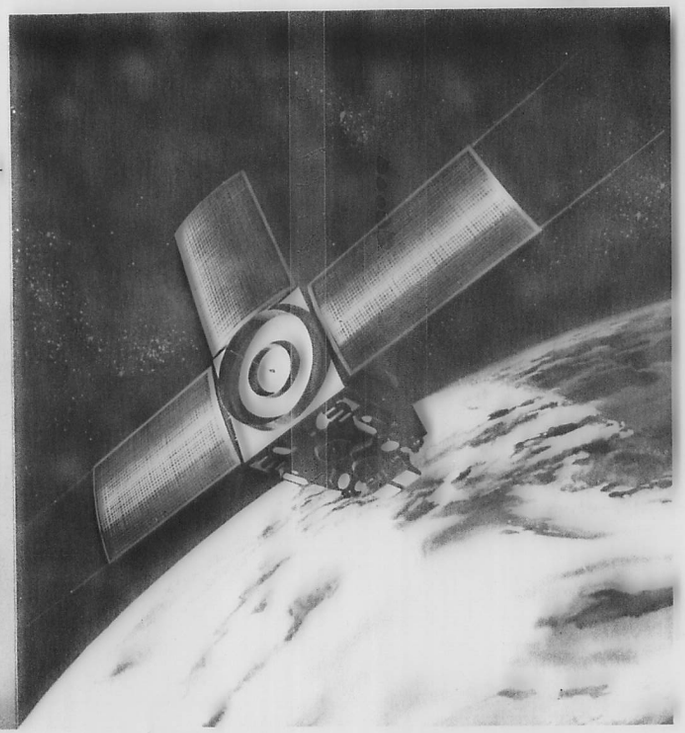
Fig. 1-3

RCA

ITOS

CUSTOMER	NASA/NOAA
MISSION	OPERATIONAL, METEOROLOGICAL
ORBIT	790 TO 820 nmi
DESIGN LIFE	1 YEAR
BOOSTER	DELTA 2310 (CONTRACTOR LAUNCH)
WEIGHT, S/C TOTAL	750 LB
PAYLOAD	225 LB
AVERAGE POWER, TOTAL	145 W
PAYLOAD	105 W
MAXIMUM ARRAY POWER	400 W
ATTITUDE CONTROL	MOMENTUM BIAS
LAUNCHES	8



Thus, the original problem of TIROS I and the "cartwheel" approach of ~~TIRO~~ TIROS IX have been married to produce a simple 3-axis stabilization system!

- Add three solar panels for more power.
- Flexible box with hinged sides for ease of assembly and repair.
- Evolution of Delta launch vehicle allowed
  - Higher orbit for better viewing angles. [Radiation hardening!]
  - Heavier s/c in sunsynchronous orbit. Could have full redundancy of both AVCS and APT in <u>one</u> spacecraft instead of two, with space for new sensors.

<u>Added</u> ~~Very High Resolution Radiometer (VHRR)~~ Scanning Radiometer (SR) to provide medium resolution, global operational coverage both day and night. (AVCS and APT continued temporarily for operational transition and to prove reliability of ~~VHRR~~ SR.)

Why scanning radiometers instead of TV?

- Precision of measurements of radiation intensity.
- Superior sensitivity and stability of reflective optics + detectors.
- Can measure throughout the visible and IR spectrum.

Figure 1-4 (Vu-Graph) - ITOS evolution.

Point out bottom of ITOS 1 - NOAA-1 s/c with 2 each AVCS, APT cameras and ~~VHRR's~~ SR's.

ITOS-D design (NOAA 2-5) dropped all TV cameras. APT signal derived from ~~VHRR~~ the SR. Could now add Very High Resolution Radiometers (VHRR) with

Fig 1-4

RCA

TIROS Satellite Evolution

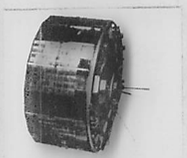
NOAA

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

TIROS R & D

2 FT, 283 LBS

TIROS IX (Wheel)



2 FT, 320 LBS

TOS

ESSA-AVCS

2 FT, 340 LBS

ESSA-APT

2 FT, 300 LBS

ITOS

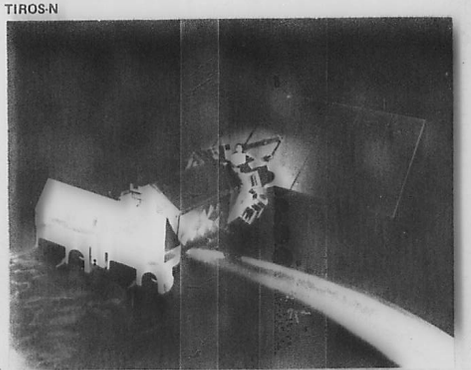
ITOS-1

4 FT, 690 LBS

NOAA-2

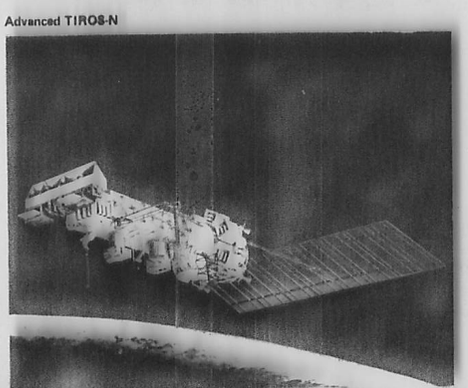
4 FT, 750 LBS

TIROS-N



12 FT, 3,127 LBS

Advanced TIROS-N



14 FT, 3,800 LBS

High Resolution Picture Transmission (HRPT). Also first operational sounder: the Infra-red Temperature Profile Radiometer (ITPR).

The ITOS ~~series~~ s/c served the operational system faithfully from 1970 to 1978-79 when the TIROS-N series was introduced.

Main driver for TIROS N was to improve the temperature soundings and sea surface temperatures needed for numerical weather prediction, including the Global Weather Experiment and the WWW.

These dictated a larger s/c and more solar power. To save the cost of developing a new s/c, an existing design for a military weather satellite was adopted but with entirely new sensors. The use of this s/c forced two compromises: It was designed for use at an altitude below about 900 km, thus it was not radiation-hardened for use at the higher altitude of the ITOS series. It was not large enough to carry fully redundant sensors and subsystems for reliable, continuous operation.

Therefore, the existing design necessitated:

1. Two s/c in orbit for reliability (and coverage, because of lower altitude).
2. Some sacrifice in viewing angle in the tropics at point of contiguity of coverage between adjacent orbits

A bonus of the two-s/c system is more frequent coverage when both s/c are operational.

Figure 1-4 (Vu-Graph): Comparison of ITOS - TIROS N - Adv. TIROS N. Advanced TIROS-N has a "stretched body" to accomodate more systems than TIROS N and providing "growth capability" for experimental or new sensors.

	TIROS-N	Advanced TIROS-N
Operational	AVHRR (Advanced Very High Resolution Radiometer)	AVHRR
	TOVS (~~HRR~~ HIRS, MSU, SSU)	TOVS {TIROS Operational Vertical Sounder}
	ARGOS {Data Collection & Location System}	ARGOS
	SEM (Solar Environment Monitor)	SEM
		SBUV
Experimental		Search + Rescue (SAR)
		ERBE {Earth Radiation Budget Experiment}

The need for more frequent observations, especially of severe storms, led to the desire for a geostationary satellite for meteorology.

- Uniqueness of geostationary orbit, 36,000 km high.
- Problem of detector ~~stab~~ sensitivity + spacecraft stabilization in the mid-1960's.
- Suomi's idea and Newell's (NASA's) gamble. The "pin-hole" spin-scan camera, "retrofitted" on ATS-1. Single visible channel, launched ~ 1966, provided the remarkable sequences of images which permitted the continuous tracking of serious storms such as typhoons.

  Use of VHF transmitter on ATS-1 also demonstrated WEFAX system of broadcasting pictures and

weather charts to low cost receiving stations adapted from those suitable for APT reception.

- A three-channel version of the camera, for color images, was also flown on ATS-3 in 1967. While the color failed after a short time, the black and white images from ATS-1 and 3 were used for several years until operational system introduced in 1974.
- Discovery by Suomi: Stability of the spacecraft (spin-stabilized) + camera scanning system (s/c spin plus stepped mirror) permitted "moving pictures" of clouds with sufficient precision to obtain useful estimates of upper air winds.
- Dramatic results for storms led to prompt government approval to introduce operational, two-s/c system.
  - Spin stabilization still used.
  - New spin-scan camera: The Visible-Infrared-Spin Scan Radiometer (VISSR).
    - Added thermal infrared channel for 24hr. viewing
    - Increased visible resolution to 1 km.
  - Added Data Collection System (DCS). (Puerner)
  - Implemented in 1974 with launch of Synchronous Meteorological Satellite (SMS)-1. Followed by SMS2 and GOES (Geostationary Operational Environmental Satellite)-1 through 6. Two more are being built.

This brief historical summary shows the importance of unexpected events and discovery, coupled with the ingenuity of individuals in the government, universities and industry in shaping the ~~evolu~~ evolution of the operational meteorological satellite system of the United States.

In the next two lectures, I will ~~look~~ cover in more detail the polar and geostationary satellites respectively. In the fifth lecture, I will present my (prejudiced) views of the outlook for future developments of the operational systems.