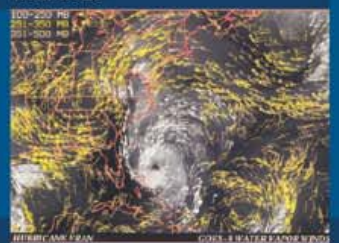
Aerospace/Communications Division

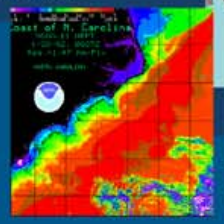
A Tough Decision in Tough Times

Larry Goshorn

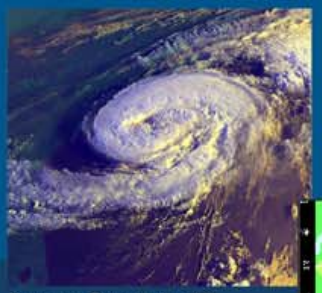
(below) Water Vapor Winds, 1996, from GOES



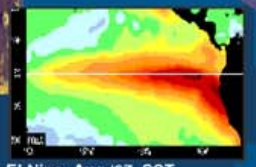
(below) Gulf Image, Jan '92 from AVHRR



Fires in Alaska, 1996, from AVHRR



Hurricane Bonnie, Aug '98, from GOES



El Nino, Aug '97, SST from AVHRR

ITT Industries

Engineered for life

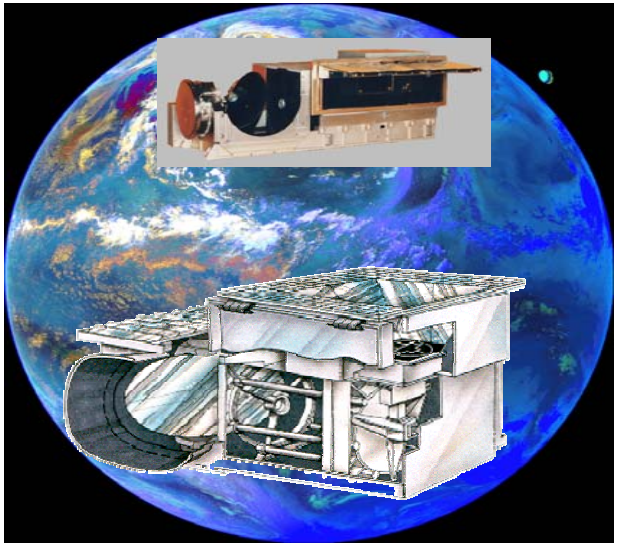
Setting the Stage

- **ITT's Remote Sensing payloads have long been the primary, "workhorse" sensors on the GOES (GEO) and POES (LEO) meteorological satellites used by NASA and NOAA to protect lives and property from severe weather threats**

- **We are very proud of our on-orbit performance history!**

- **This is a story about a difficult decision that needed to be made during a time when the project wasn't doing very well**

ITT A/CD is a Leading Supplier of Specialty Payloads

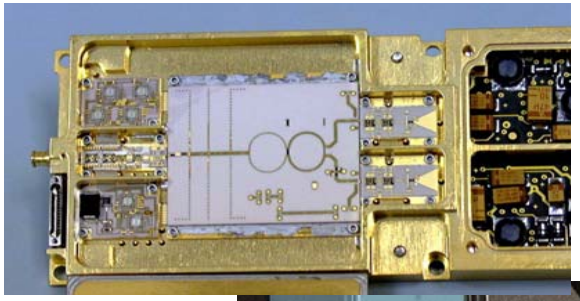


Meteorological Satellite Payloads

Commercial Payloads

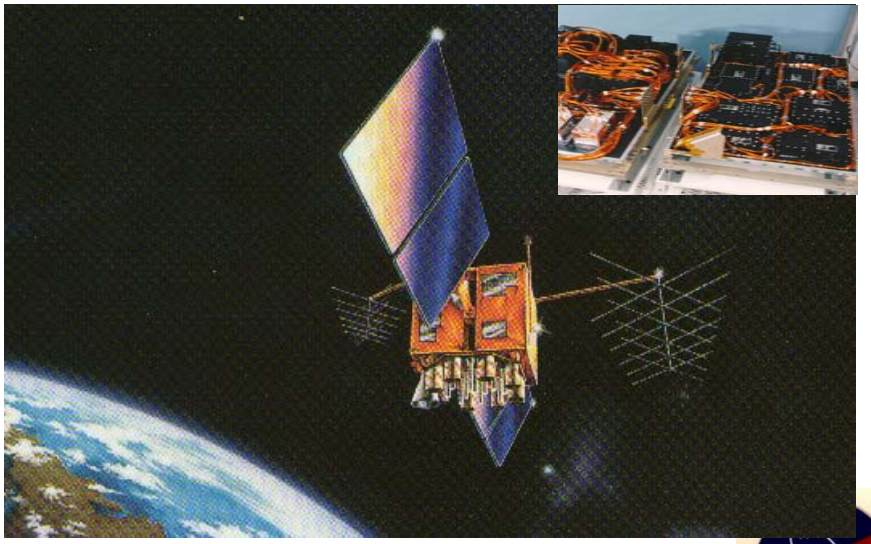
EARTHWATCH Incorporated

DIGITAL GLOBE
Your Planet On-Line®



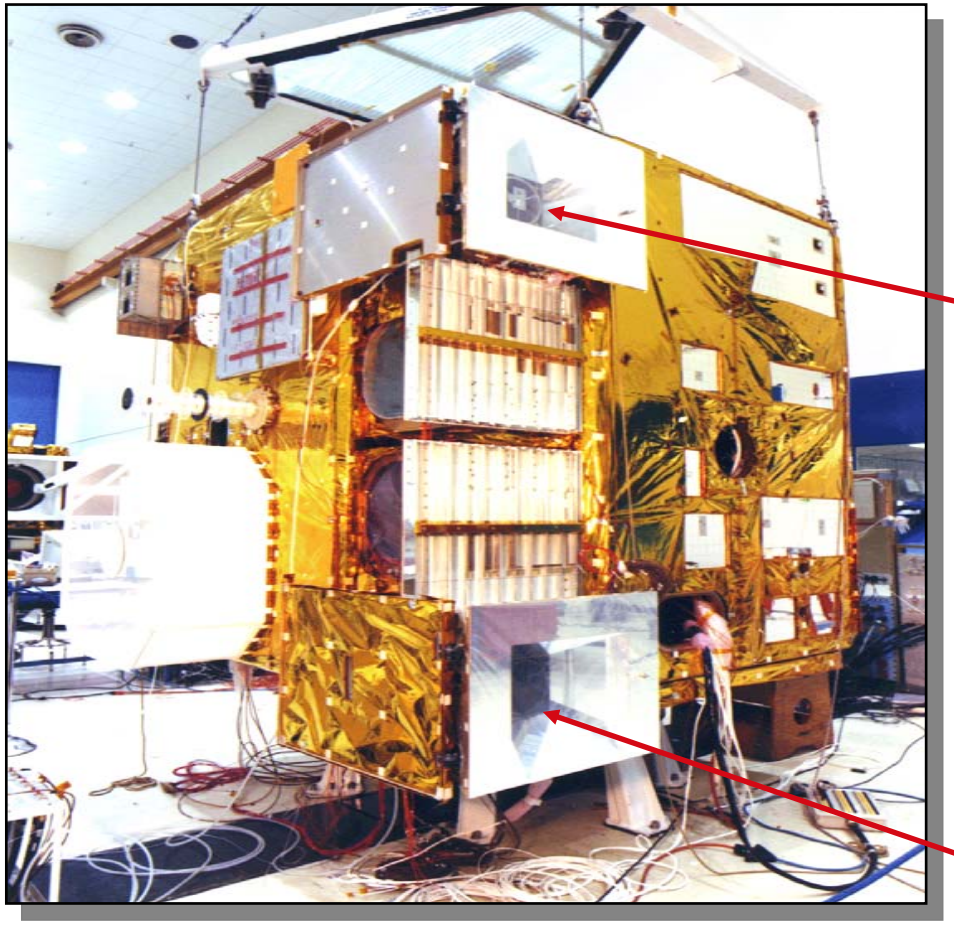
Special Programs Payloads

GPS Navigation Payloads



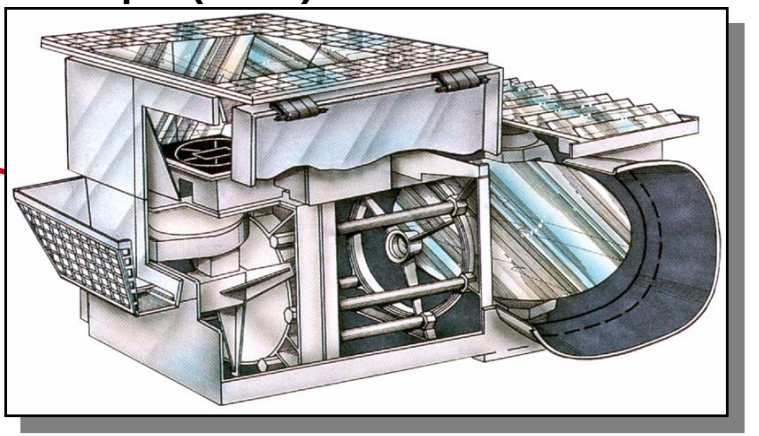
NASA

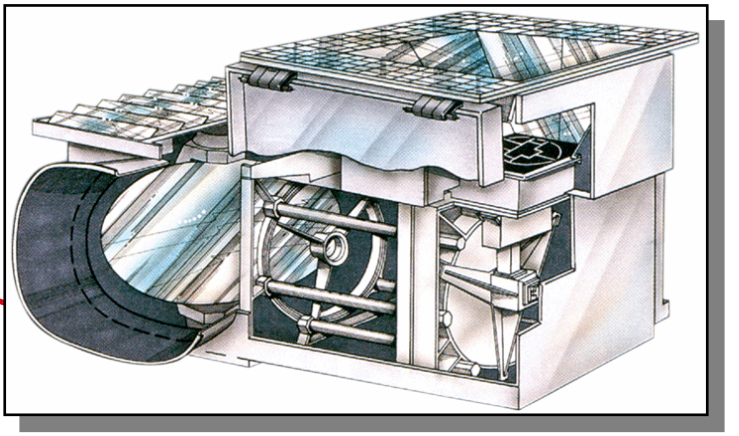
ITT Provides the Visible and Infrared Imager and Sounder for the GOES Program



Sounder (vertical profiles of atmosphere temperature and moisture)

- **19 spectral bands: 0.7 to 15 μm**
- **10 km sample (nadir) from GEO orbit**

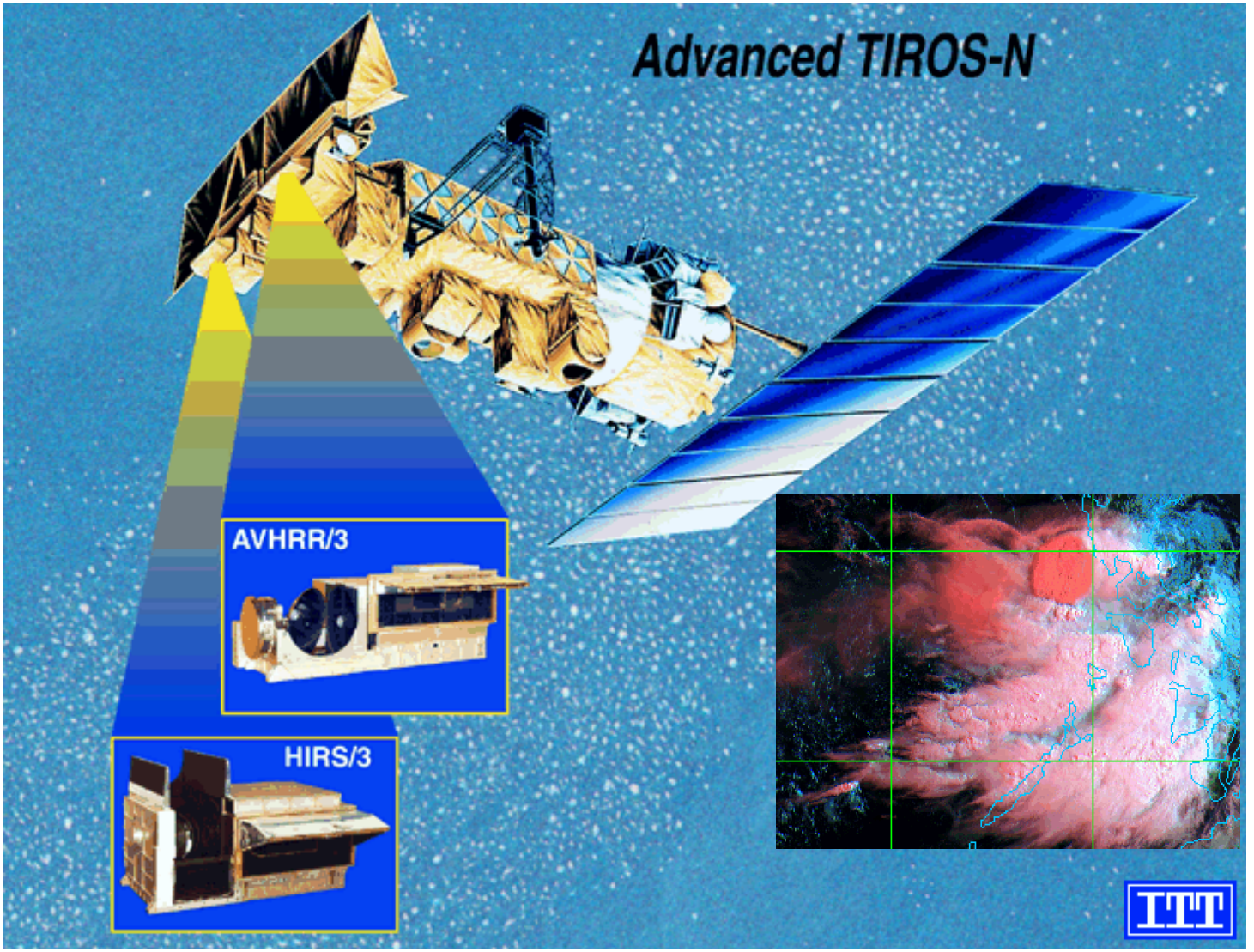




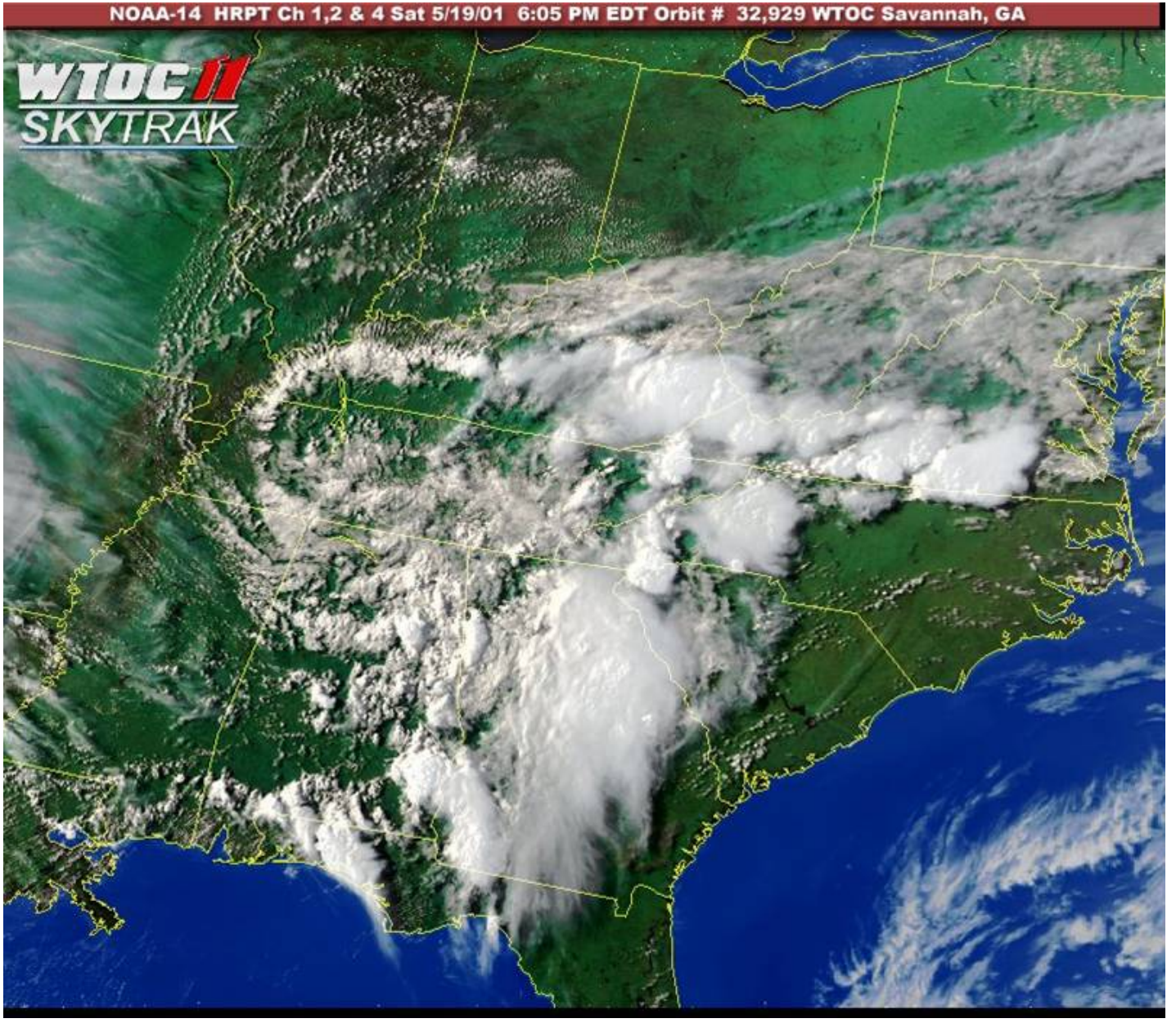
Imager (continuous images)

- **5 spectral bands: 0.7 to 12 μm**
- **High resolution: 1, 4, & 8 km**

As Well As the Visible and Infrared Instruments for the POES Program

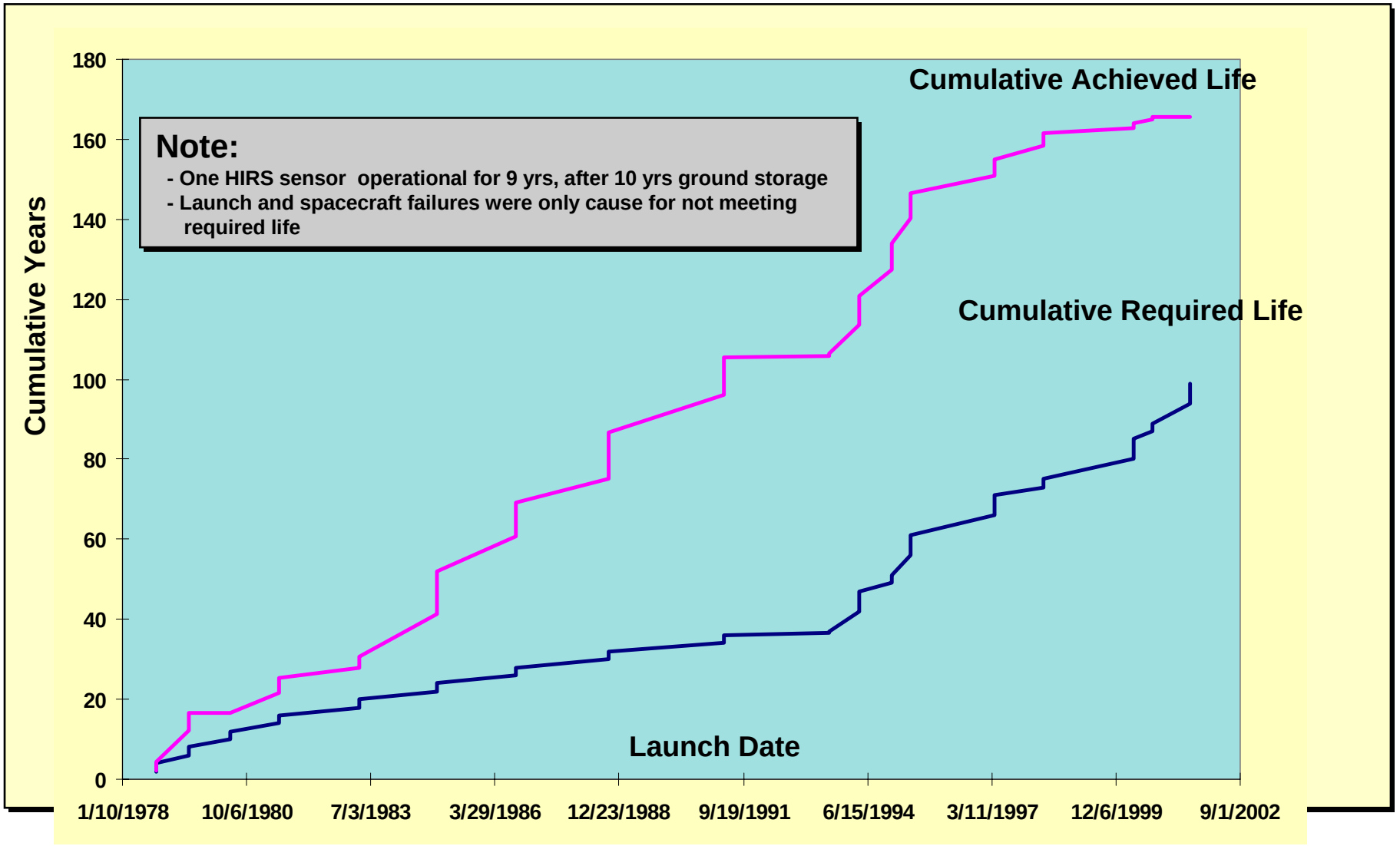


POES is An Excellent System that Produces Weather Images Like This!



And, when coupled to the Geo system (GOES) … Produces Images like this!

ITT sensors consistently exceed operational life requirements



But things have not always been “Rosy”

There was a time .....

In 2000,

On the POES project,

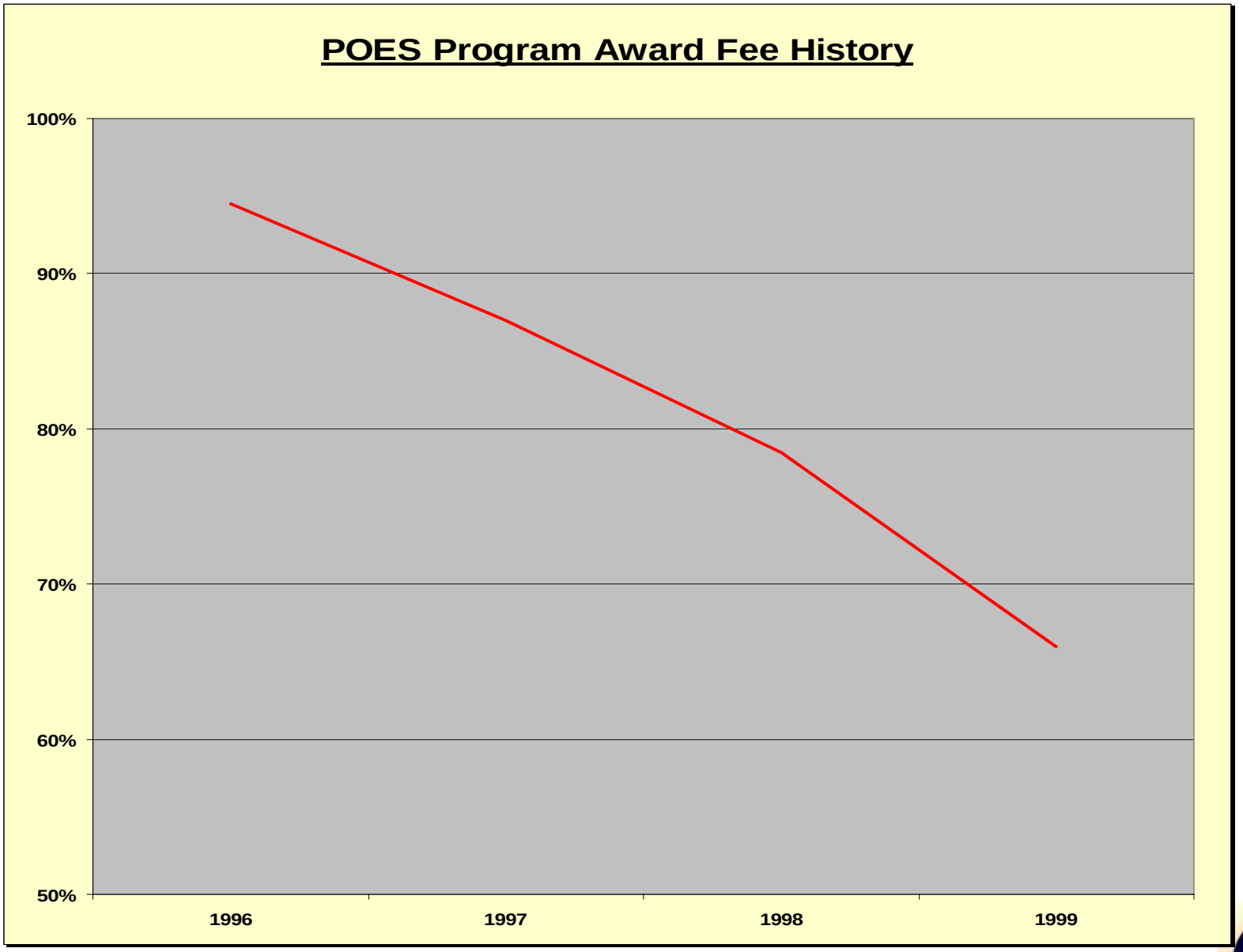
When we had a “bit” of a problem

POES Program Issues in 2000

- **Design Improvement Implementation issues**
- **Subcontractor Performance Issues**
- **Deliveries Behind Schedule**
- **Potential Cost Overrun**
- **Degrading Customer Relationships**

All resulting in eroding NASA confidence .....and eroding award fee ratings

Negative Performance Rating Trend



Changes were Made to Improve the Performance

- **Changes were made to project team personnel in order to improve performance**
  - **Working relationships began to improve, however-**
- **Within a few months of these changes, an instrument was damaged in test (Electrical Overstress)**
  - **Cause was thought to be understood….corrective action was put in place and testing was resumed**
- **Then another instrument was damaged in test – we didn't know why – we were in trouble !**

The Dilemma

- **Two Instruments damaged for unknown reasons**
- **External and Internal pressure to hold Schedules**
- **New, unknown project team leadership**
- **Wavering customer confidence**
- **Negative business implications of further cost/schedule erosion**
  - **Past Performance assessments**
  - **Award Fee ratings (profit)**
  - **Future Business Opportunities**

??????????

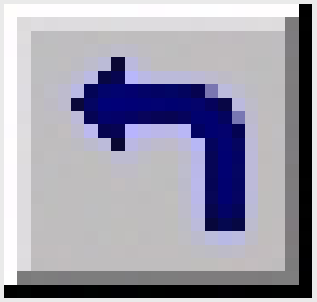
What to Do ? – The Tough Decision

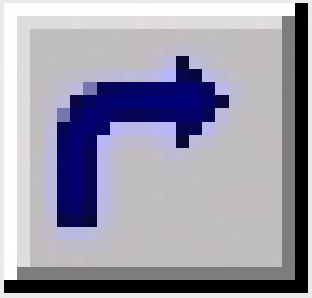
1. **Continue to carefully test flight hardware to make as much schedule progress as possible while troubleshooting the root cause of the instrument damage?**

2. **Shut-down acceptance testing operations to fully troubleshoot the instrument damage issue?**
   - **Knowing that the cost and schedule position will continue to erode for _____weeks**
   - **Not knowing what the Customer reaction might be to shutting ourselves down?**

In the Proverbial Pickle

Another Easy PM Decision!





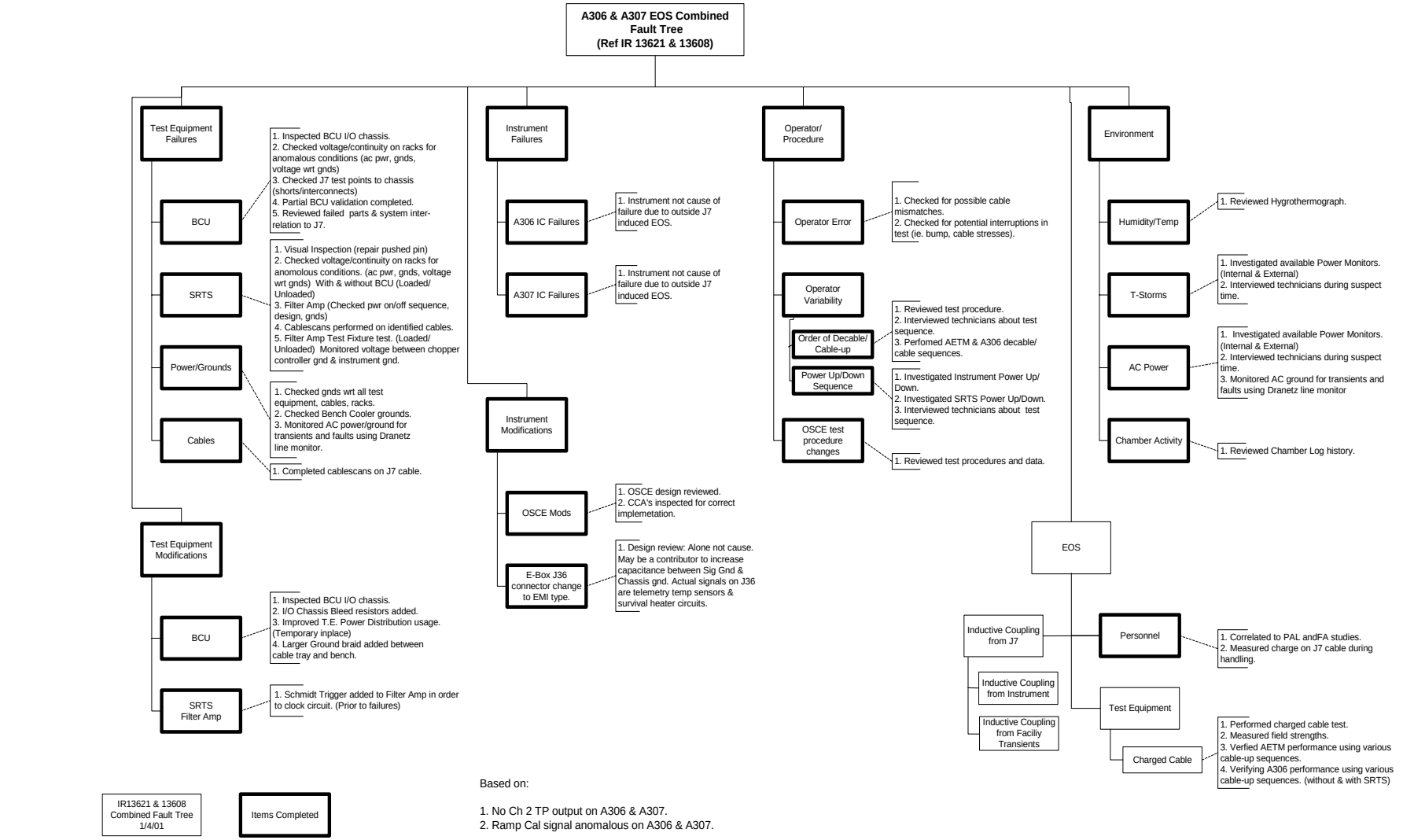
Project Managers:

Please Choose the Best Option!

The Chosen Course of Action

- **Discussed options with the project team….all voices were heard. A team recommendation was made with total buy-in**
  - **Shut down the Acceptance Test portion of the program**
    - **We could not put additional flight hardware at risk….*no matter what!***
- **Formed an Anomaly Resolution Team with ITT and NASA experts**
- **Worked many long days using a logical problem solving process and uncovered three most probable causes of the Electrical OverStress (EOS)**

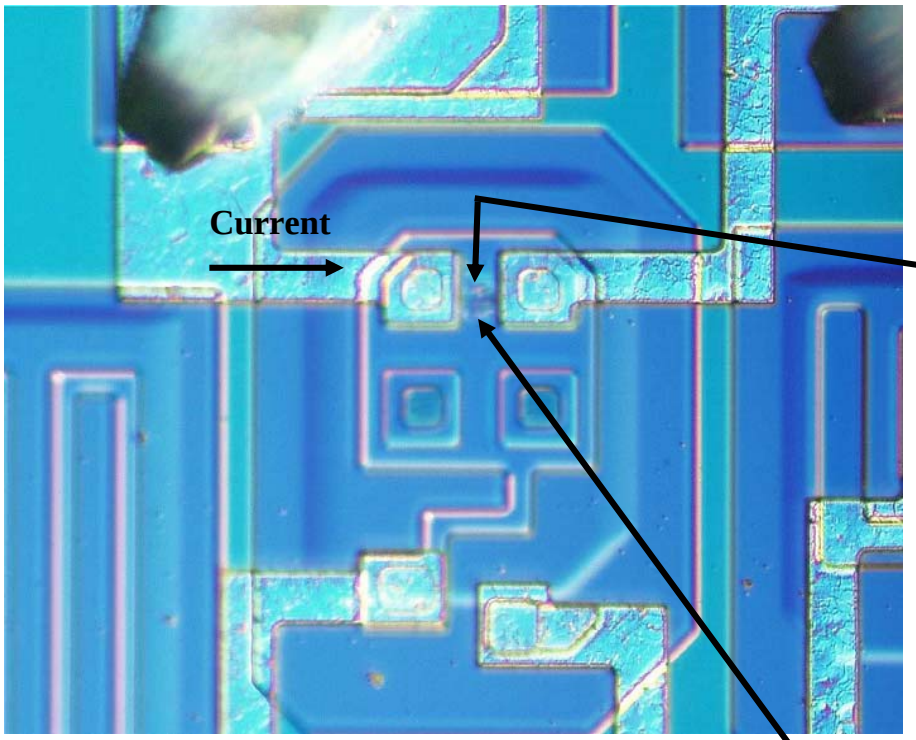
Fault Tree Analysis and Empirical Testing

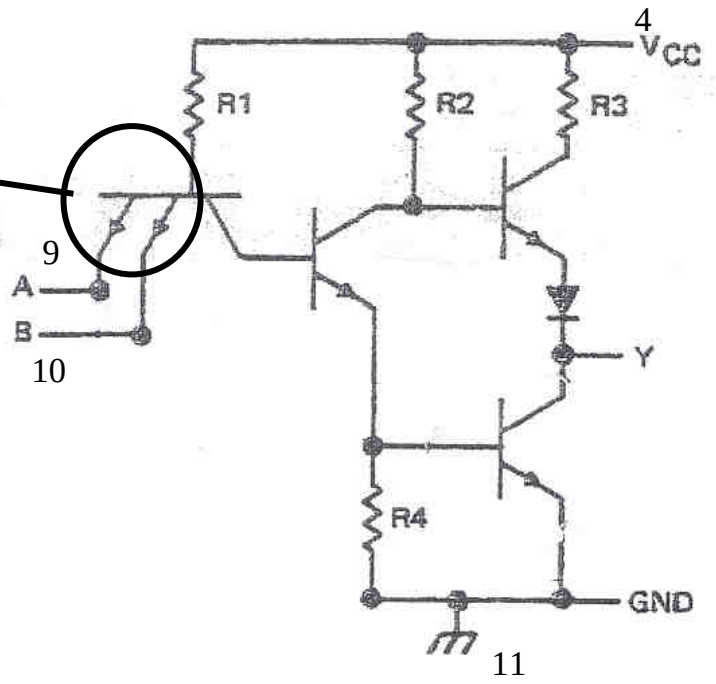


Direction of Current Flow Was Determined by Physical Inspection of Failed Parts

Pin 10

Pin 9





U14 NAND Gate Damage (A307)

(Location: Motor Logic CCA)

Aluminum that has flowed across contacts

Evaluation of Circuit Schematics Confirmed J7 as the Source of the EOS

U14 NAND Gate:

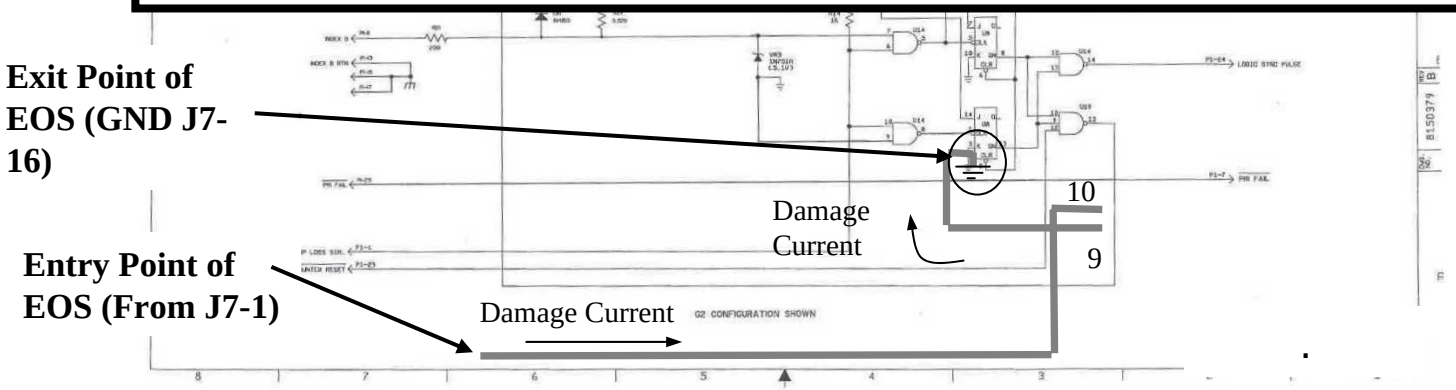
TTL input pins 9 and 10 are shorted together and to V+.

Destructive current entered pin 10 and exited pin 9 that was tied to ground externally.

Destructive overstress voltage
- 7 volts above ground (min)
- 100-1000 volts probable

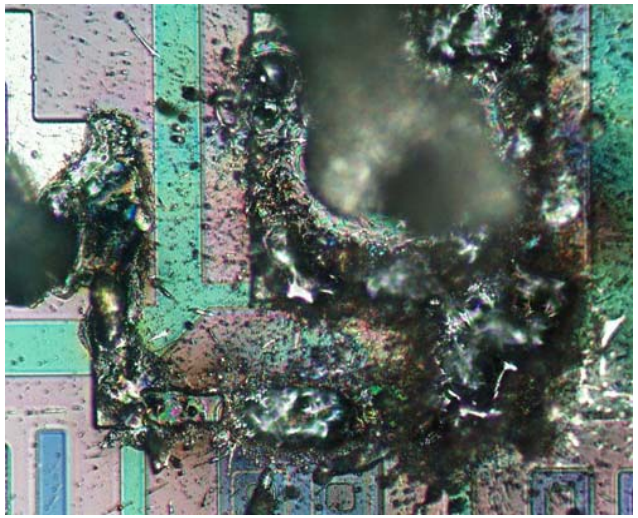
Short duration EOS event

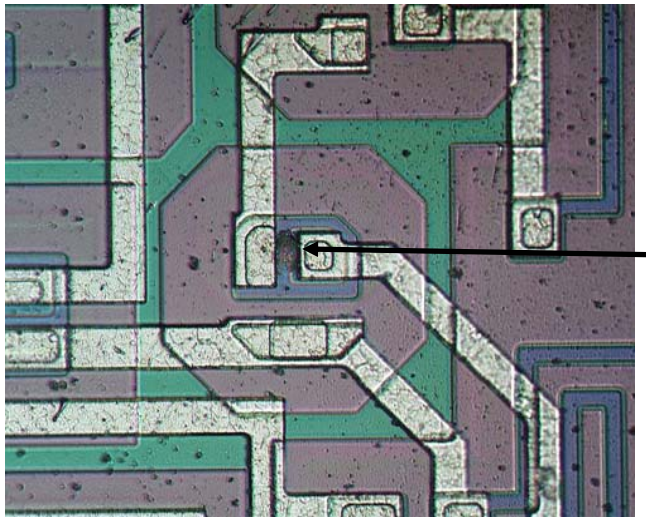
The short to V+ is secondary damage.

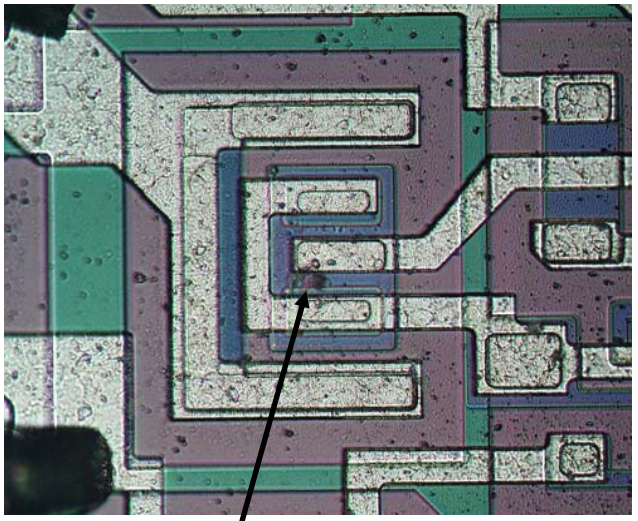


SEM Analysis of Damaged Parts

EOS Initiated …..Bulk of Damage Caused by Power Supply Short



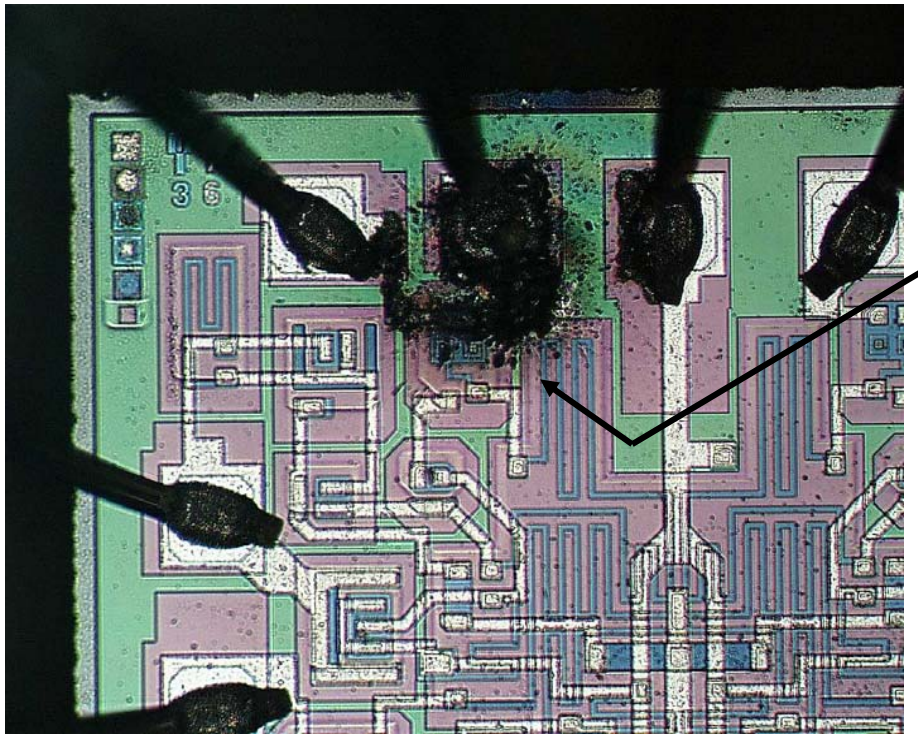


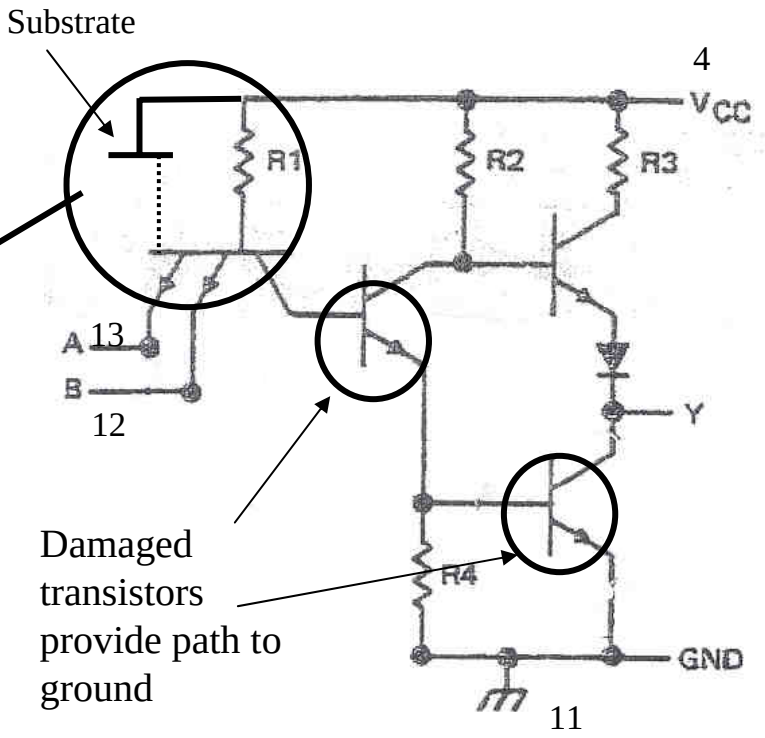


Damage to Other Gate Transistors Provides a Shorting Path to Ground

EOS Induced Short to the Die Substrate Initiates More Extensive Damage After Power Up

Pin 13 Pin 12 Pin 11





Gate Damage (A307)

Findings

1. Facility grounding issues due to re-wiring of Labs (Transients)

2. Test Equipment Issues
   - Charge accumulation (>200v) on Long test cable which discharged into instrument during connector mate/de-mate

3. Inductively coupled “cross talk” through test cables of transients or static discharges during cable mate/de-mate

Summary of Actions Taken

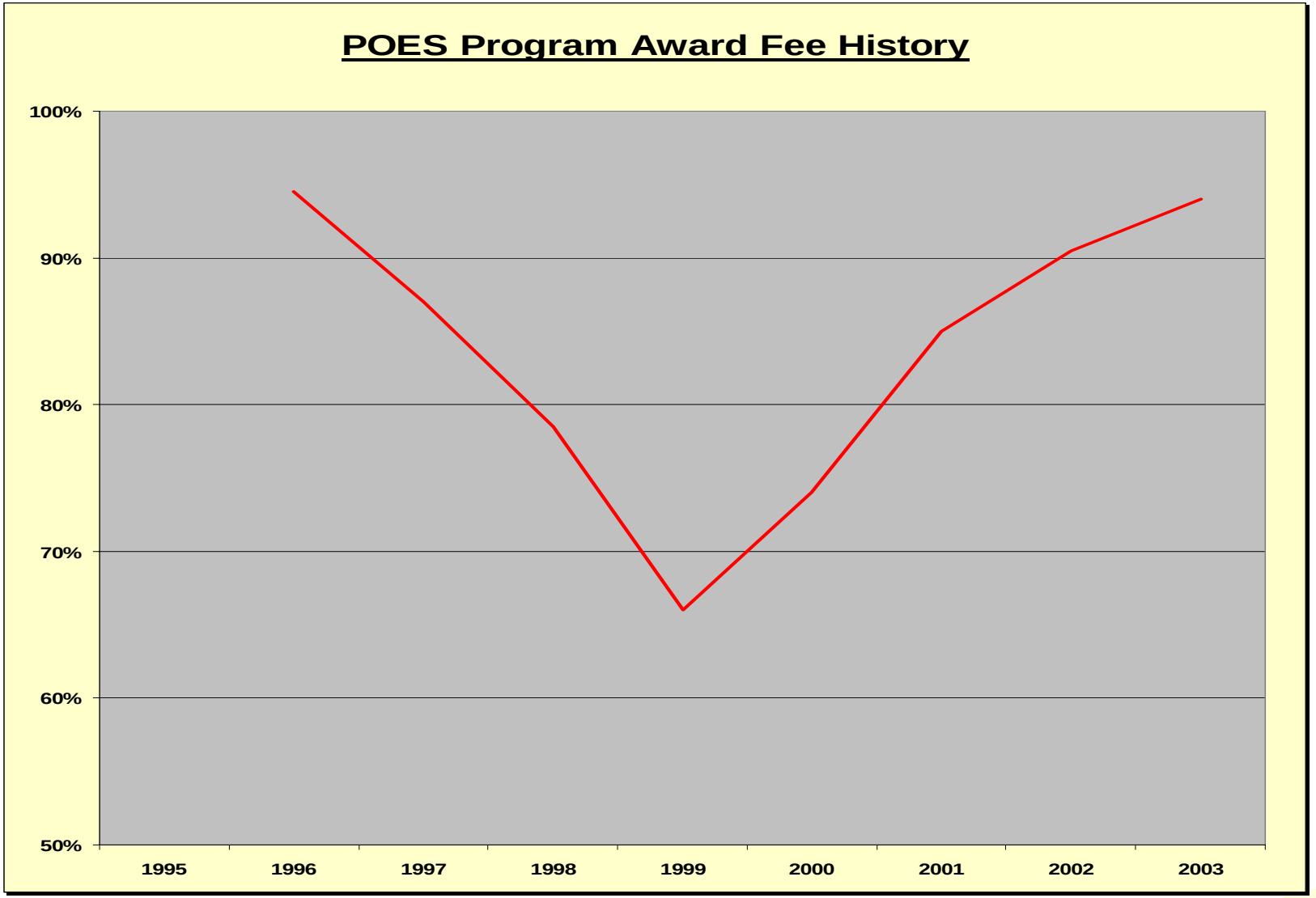
- **Testing was stopped for approximately *12 weeks* for troubleshooting, analysis and repair activities**
- **Corrective actions (table) were planned for all three probable causes as a worst case scenario**
- **Presented findings and a "Return to Test" rationale to a NASA review board – which was accepted**

Corrective Action	Purpose	Already in Place?	Applicability
Bleed resistors on BCU	Prevent accumulation of charge on cables	Yes	AVHRR/HIRS
Resistor Bleed Box	Dissipate any accumulated charge prior to cable-up	Yes	AVHRR/HIRS
Facilities Ground Mods	Ensure all safety grounds are tied back to common transformer panel	Yes (temp)	Yes (temp)
Surge Suppressors at all outlets	Protects against A/C line surges	Yes	AVHRR/HIRS
ESD stations added to BCU	Provides for operator grounding	Yes	AVHRR/HIRS
Advanced ESD training	Increase operator awareness	Yes	AVHRR/HIRS
Proceduralize Cable Sequences	Protects against inductive coupling through cables	Yes	AVHRR/HIRS
SRTS modified to provide bleed path	Prevents accumulation of charge on J7 "special" test cable	Yes	AVHRR
Switch debounce circuitry added to BCU	Prevents transients during power-up	ECD 1/15	AVHRR/HIRS
Modify 5V & 10V BCU power supplies	Allows for safe power up of instrument with BCU in powered state	ECD 1/15	AVHRR/HIRS
Current shunt circuits at J7	Provides protection for any high voltage inputs on J7 cable	TBD	AVHRR
Additional monitoring at J7	Capture any anomalous signals on the J7 test cable	ECD 1/15	AVHRR

The Results

- **Following repairs to the Test Facility, Test Equipment and review of the ESD Prevention Processes - Testing was successfully resumed……**
- **No additional instances of overstress have occurred since**
- **There was no impact to the Spacecraft- level Test Schedule**
- **Because we were all working together – confidence in our approach and results remained high**
- **Lost schedule (and cost overrun threat) was recovered within ~10 months!**

Positive Performance Rating Trend



Lessons Learned

- **Involve your team in critical decision making**
- **Do the right thing…..no matter what**
- **Open, honest communication with your customer (and we *all* have customers) is essential**
- **Even some of the most "ugly" situations can be recovered with the right:**
  - **Leadership**
  - **Teamwork**
  - **Application of Logical Problem Solving Tools**
  - **Persistence**

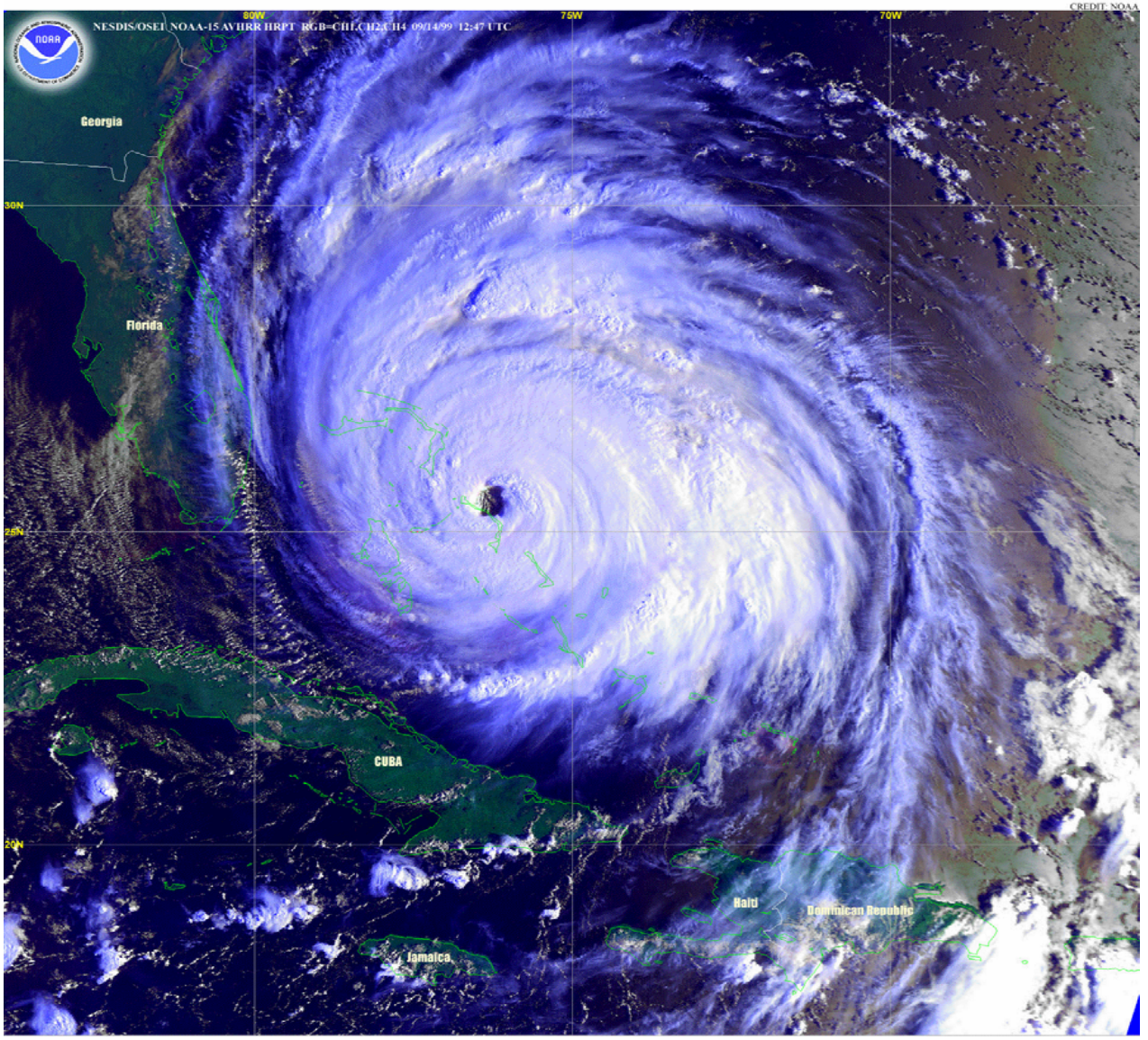
"Hope is *not* a Strategy"

POES Continues to Provide Important Severe Weather Data

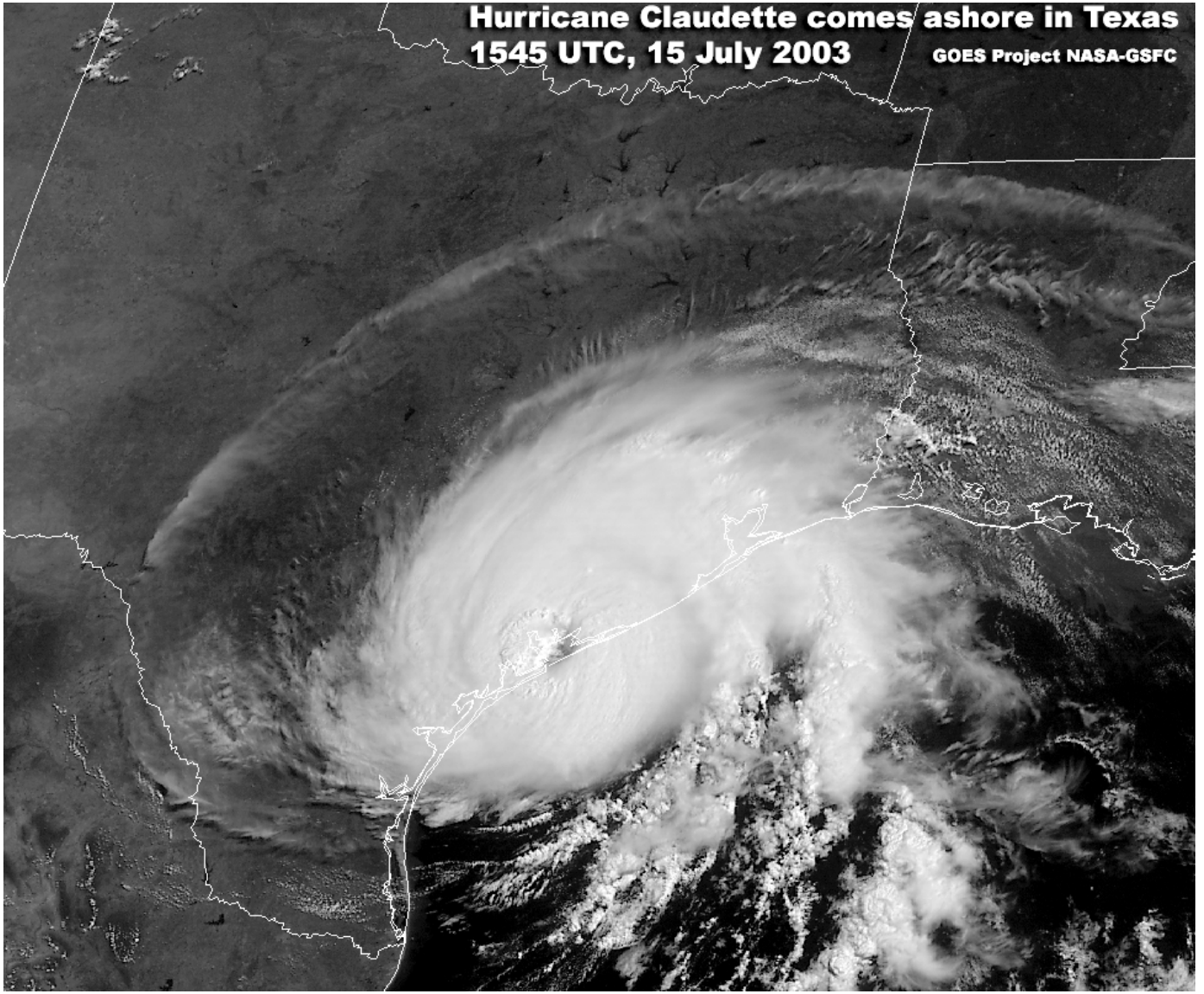
Hurricane Floyd From NOAA 15 AVHRR

Sept. 14, 1999

Hurricane Floyd, a Category 4 storm at the time of this image, is moving to the west-northwest at 12 knots. Winds near the eye are sustained at 125 knots and tropical storm-force winds extend outward about 290 miles form the center. The storm is fluctuating in intensity because of interaction with the Bahams and the increasingly shallow water.



Claudette - July 2003



Web Sites

- **http://earthobservatory.nasa.gov/**
- **http://www.goes.noaa.gov/**
- **http://rsd.gsfc.nasa.gov/goes/text/hotstuff.html**
- **http://www.savannah-weather.com/index.shtml**