



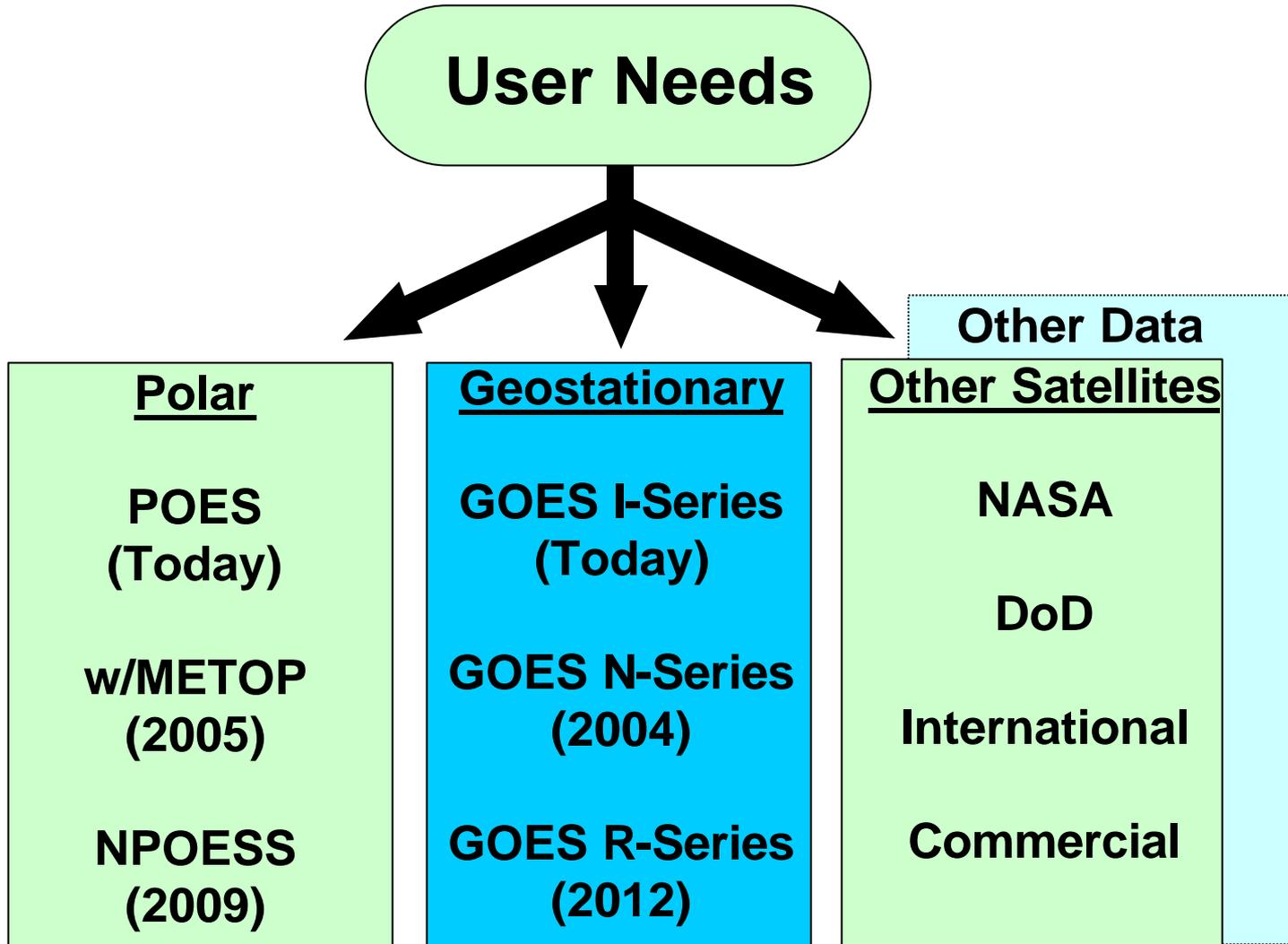
# **GOES R Introduction and Overview: The Requirements Process**

**Satellite Direct Readout Conference for the  
Americas**

**Miami, FL  
December 12, 2002**



# Integrated Approach to Observations





# GOES Launch Planning



<u>Satellite</u>	<u>Availability Date</u>	<u>Planning Launch Date</u>
<b>GOES N</b>	<b>Jan 2004</b>	<b>Apr 2004</b>
<b>GOES O</b>	<b>Apr 2005</b>	<b>Apr 2007</b>
<b>GOES P</b>	<b>Apr 2007</b>	<b>Oct 2008</b>
<hr/>		
<b>GOES R</b>	<b>Apr 2012</b>	<b>Apr 2012</b>
<b>GOES S</b>	<b>Apr 2013</b>	<b>Apr 2015</b>

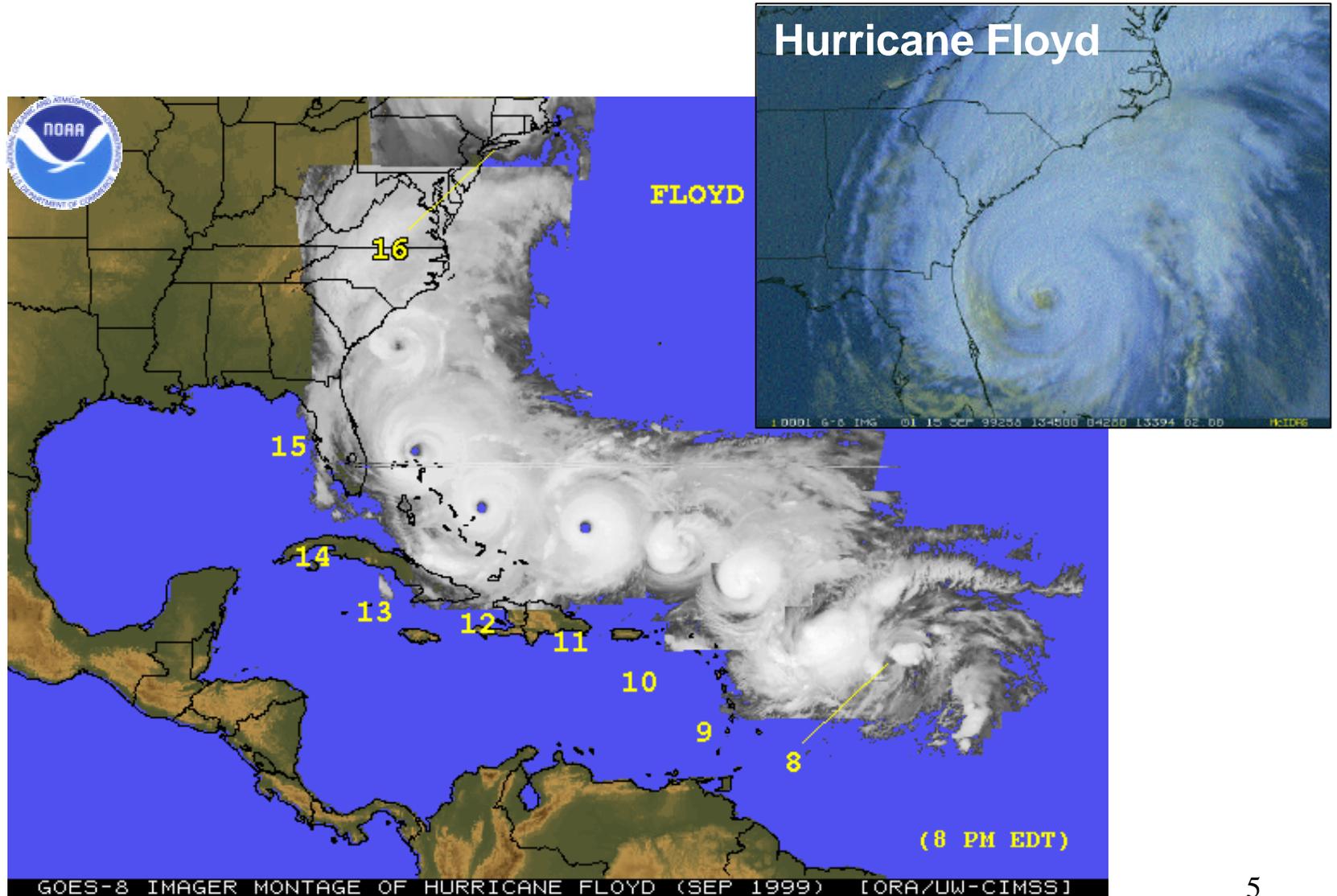


# Need for GOES R Advanced Instruments

- **Current Imager cannot monitor developing severe local storms and still provide simultaneous global surveillance and products**
- **Current Sounder cannot see CONUS and ocean area in time required**
- **Imager resolution insufficient to see details of storm formation; wind accuracy too low for new model requirements**
- **Vertical moisture structure inadequately measured – improvements needed for flash flood forecasts and severe weather information modeling**
- **Current Imager has limited ability to monitor volcanic ash, aviation icing hazards, snow/cloud discrimination, mid-level moisture tracking**
- **Current instruments technology and parts obsolescence**

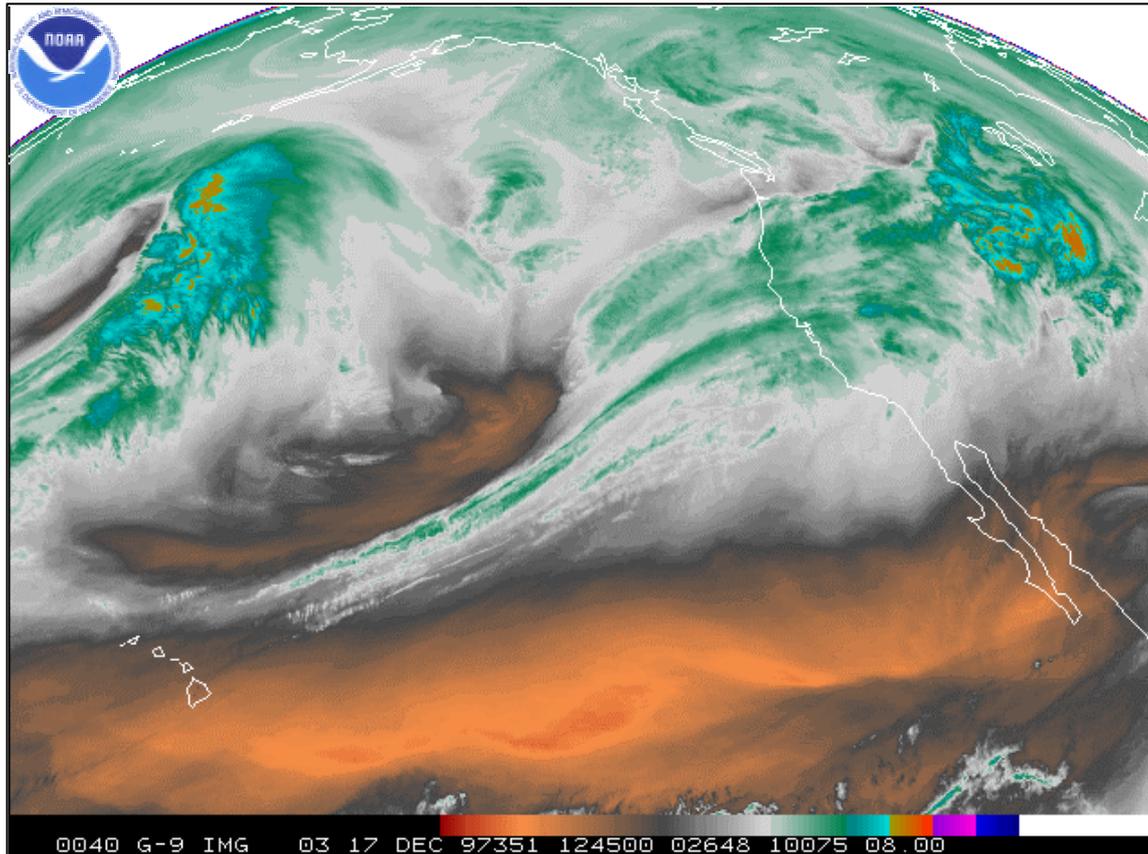


# GOES: A Critical Asset in Hurricane Forecasting





# 1997-98 El Nino Winter Storm Forecasting



**GOES Atmospheric moisture during El Nino Winter Storms of December 1997**



# 2 Satellite GOES-R Architecture

## West

**Advanced Baseline Imager  
Hyperspectral Environmental Suite  
Space Environment Monitor  
Solar X-ray Imager  
Services**

## East

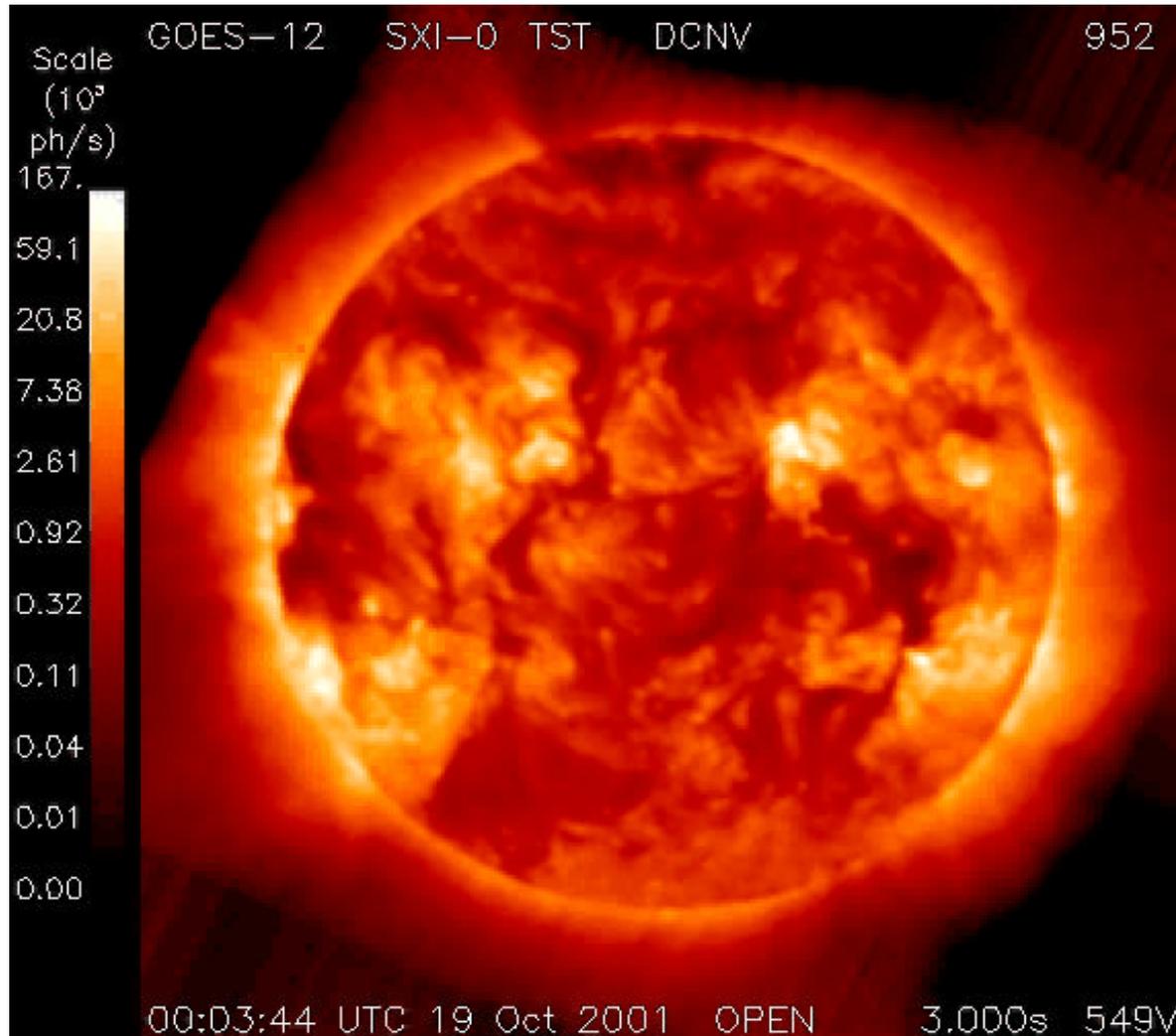
**Advanced Baseline Imager  
Hyperspectral Environmental Suite  
Space Environment Monitor  
Solar X-ray Imager  
Services**

## Additional Instruments Under Consideration

- **Multi-Function Sensor**
- **Lightning Mapper**
- **Microwave Sounder**
- **Coronagraph**



# First Solar X-Ray Imager (SXI) Image September 7, 2001

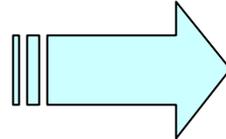




# Opportunities & Challenges for GOES-R

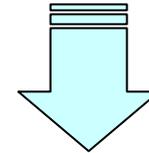


**User Needs**

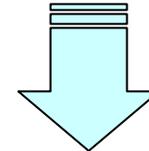


## Observation Requirements

- Temporal Resolution
- Spectral Coverage & Resolution
- Spatial Resolution
- Radiometric Performance



**Architecture Solutions**



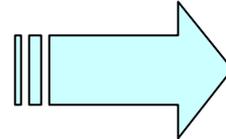
## Opportunities & Challenges

- Instruments
- Processing & Communication Technologies
- End-to-End Architectures



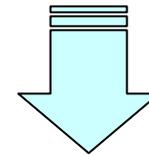
# Opportunities & Challenges for GOES-R

**User Needs**

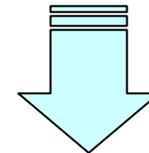


## Observation Requirements

- Temporal Resolution
- Spectral Coverage & Resolution
- Spatial Resolution
- Radiometric Performance



**Architecture Solutions**



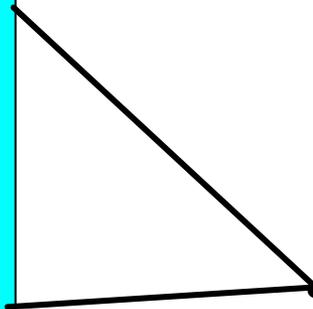
## Opportunities & Challenges

**Instruments**

- Processing & Communication Technologies
- End-to-End Architectures

## Instruments

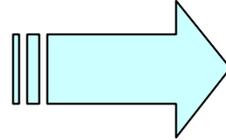
- Multispectral
- Hyperspectral
- Passive Microwave
- Active
- Multi-mode suites





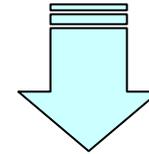
# Opportunities & Challenges for GOES-R

**User Needs**

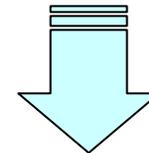


## Observation Requirements

- Temporal Resolution
- Spectral Coverage & Resolution
- Spatial Resolution
- Radiometric Performance



**Architecture Solutions**

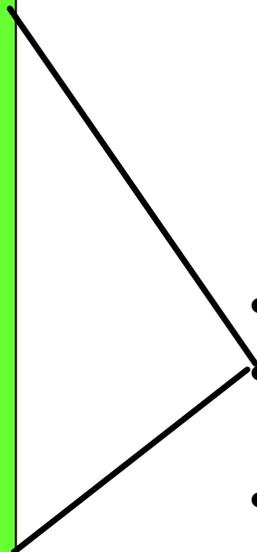


## Opportunities & Challenges

- Instruments
- Processing & Communication Technologies
- End-to-End Architectures

## Communications & Processing

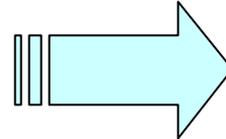
- 2 Orders of Magnitude increase in instrument data throughput
  - Product distribution and throughput
- Integration of multiple instruments & platforms
- On-board processing options





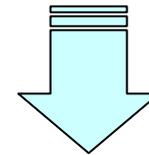
# Opportunities & Challenges for GOES-R

## User Needs

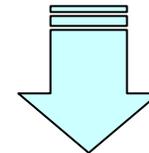


### Observation Requirements

- Temporal Resolution
- Spectral Coverage & Resolution
- Spatial Resolution
- Radiometric Performance



### Architecture Solutions



### Opportunities & Challenges

- Instruments
- Processing & Communication Technologies
- End-to-End Architectures

### End-to-End Architectures

- Formation vs single satellite
- Multi-mode operations
- Replenishment & sparing strategies
- Distribution between on-board & ground processing
- Data distribution options



# Multi-Satellite GOES-R Architecture



## West

**Advanced Baseline Imager  
Solar X-ray Imager  
Services**

**Hyperspectral Environmental Suite  
Space Environment Monitor  
Multi-Function Sensor  
Services**

## East

**Advanced Baseline Imager  
Solar X-ray Imager  
Services**

**Hyperspectral Environmental Suite  
Space Environment Monitor  
Multi-Function Sensor  
Services**

- **Additional Instruments could be flown on existing satellites or as free-flyers**
  - **Microwave Sounder**
  - **Lightning Mapper**
  - **Coronagraph**

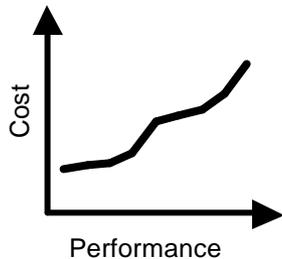


# Requirements Flow to GOES-R Architecture Development

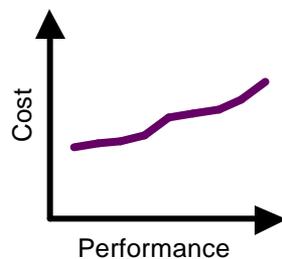
**User Needs**

Potential solutions to fulfill mission needs

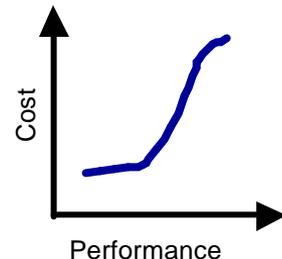
**Architecture I  
2 GEO Satellite Constellation**



**Architecture II  
Multi-Satellite Constellation**



**Architecture III  
Med Earth Orbit Constellation**



**End-to-End Systems**

- Space & Launch
- Command & Control
- Product Generation & Distribution
- Archive & Access
- User Interface & Assimilation

**Recommend Alternative(s)**

**Comprehensive assessment with Cost Benefit Analysis as cornerstone**



# Cost and Benefit Analysis Strategy/Methodology



- **Focus analysis on determining**
  - **Linkages from improved GOES-R sensors to economic benefits**
  - **Avoidable economic losses due to improved *advanced warnings* of events and improved forecast *accuracy***
- **Characterize information flow from sensors to "end-users"**
- **Determine impacts of the instrument improvements on our products - current emphasis on ABI/HES**
- **Identify key benefit domains**
- **Hold user forums to elicit insight into improved product benefits**



# Benefit Areas Investigated

## Agriculture

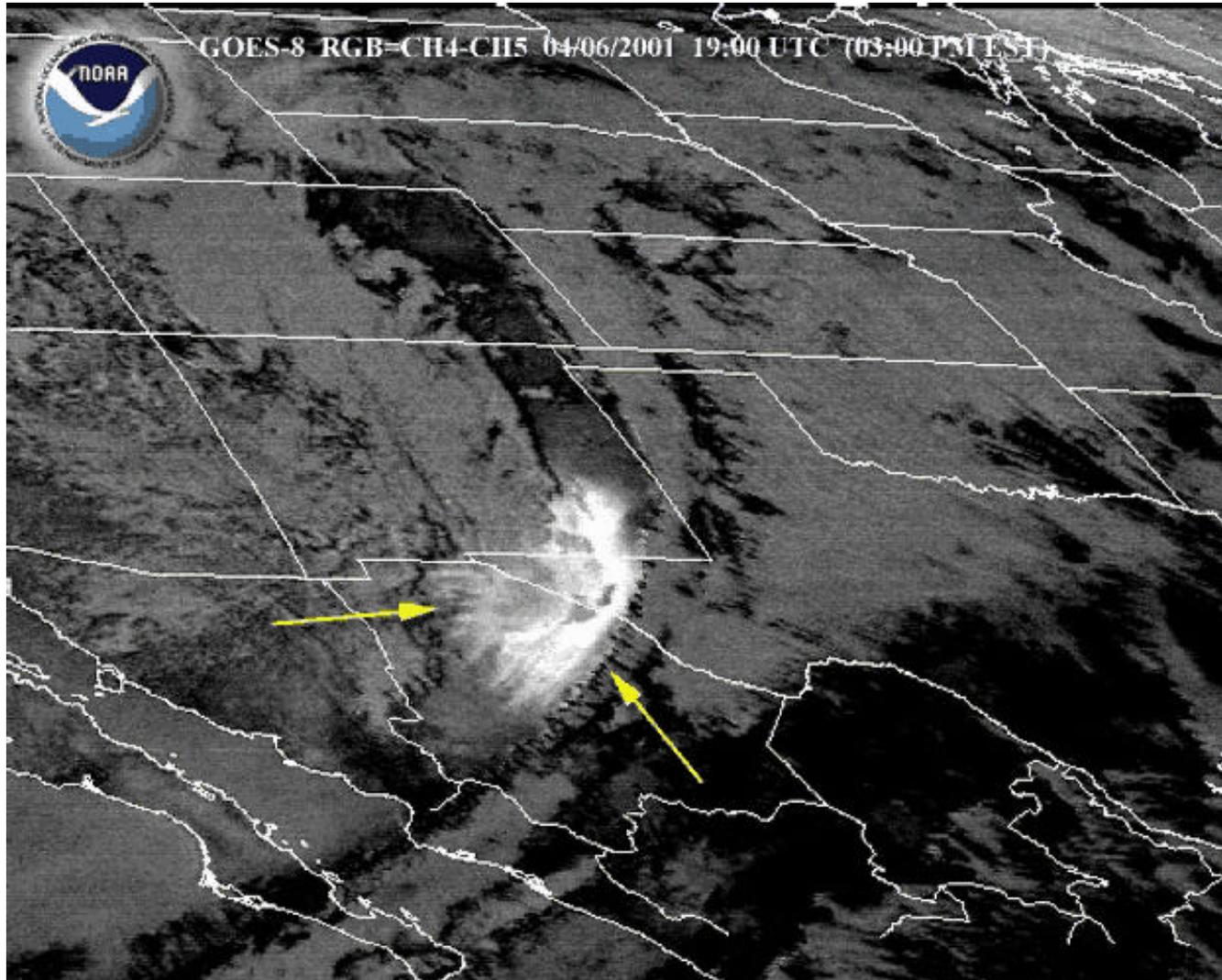
- **Reduction of temperature error**
  - Reduce unnecessary and expensive frost/freeze mitigation activities
- **Improved soil moisture measurement accuracy**
  - Reduce over-irrigation

## Aviation

- **Improve convective weather forecasts**
  - Improve route planning
  - Reduce delays/deviations/cancellations; reduce fuel consumption
- **Volcanic Ash Avoidance**
  - Reduce \$M in damage and potential loss of lives

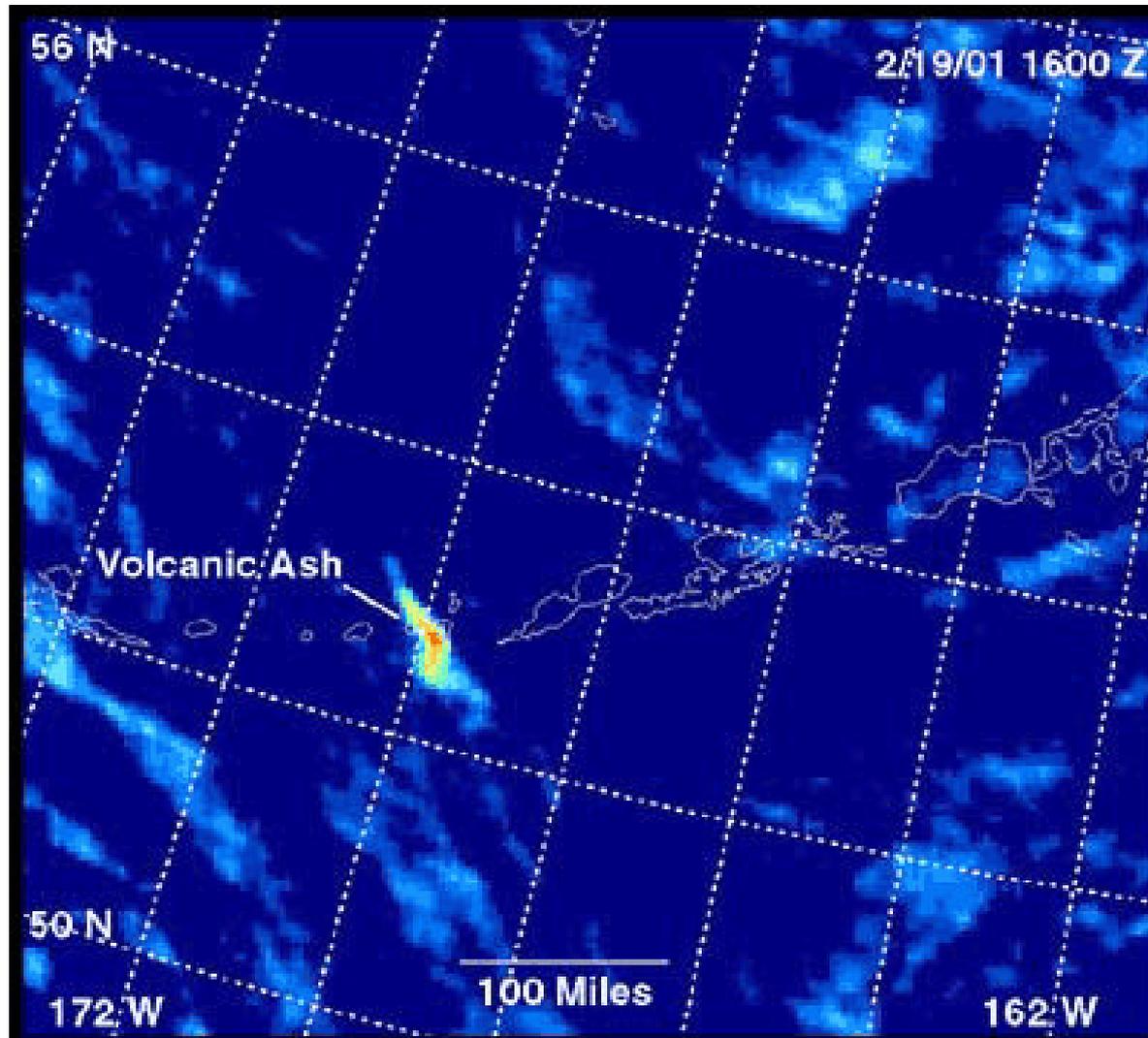


# Dust Over Southwest U.S.





# Volcano Detection & Tracking



February 2001, Mount Cleveland Eruption



# Benefit Areas Investigated

## Recreational Boating

- Improve hurricane lead time: Reduce boat loss and damage

## Trucking

- Improve severe weather lead time / location: Reduce # of accidents/deaths

## Utilities (Electric, Natural Gas)

- Improve temperature accuracy: Improve load forecasting and reduce expensive spot purchases



# Ongoing Benefit Areas Analysis - Not Yet Included in Report



## Commercial Shipping

- Improve tropical cyclone track and intensity forecasts; Improve ship routing

## Emergency Management

- Increase lead time on severe weather forecasts and hazardous environmental matter; Improve planning and deployment \*



# Economic Benefits\* Summary for GOES-R Series (2013-2027)

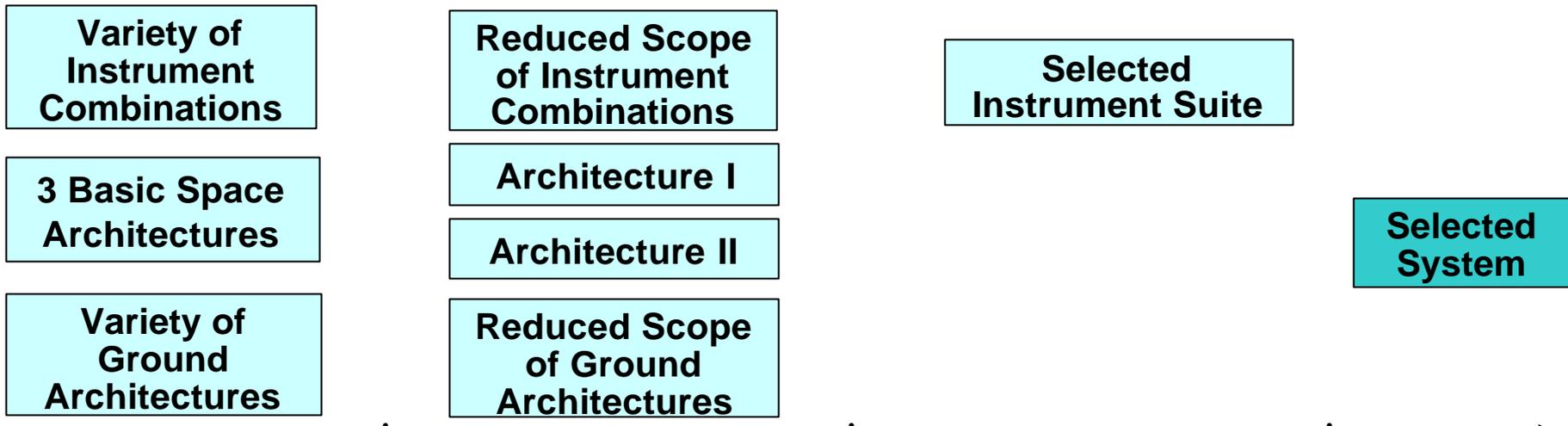


Application/Benefit Areas	Marginal Annual Benefits \$M (2002)	Present Value (discounted) Sum of Marginal Benefits \$M (2002)
Commercial Aviation	\$55	\$205
Commercial Trucking	\$28	\$103
Recreational Boating	\$29	\$108
Utilities	\$486	\$1,915
<i>Electric Power Fuel Cost Reduction</i>	\$479	\$1,891
<i>Natural Gas</i>	\$7	\$24
Agriculture	\$37	\$619
<i>Orchard Frost Mitigation (in Washington State)</i>	\$9	\$33
<i>Irrigation Efficiency (CONUS)</i>	\$28	\$586
<b>Total</b>	<b>\$635.0</b>	<b>\$2,950.0</b>

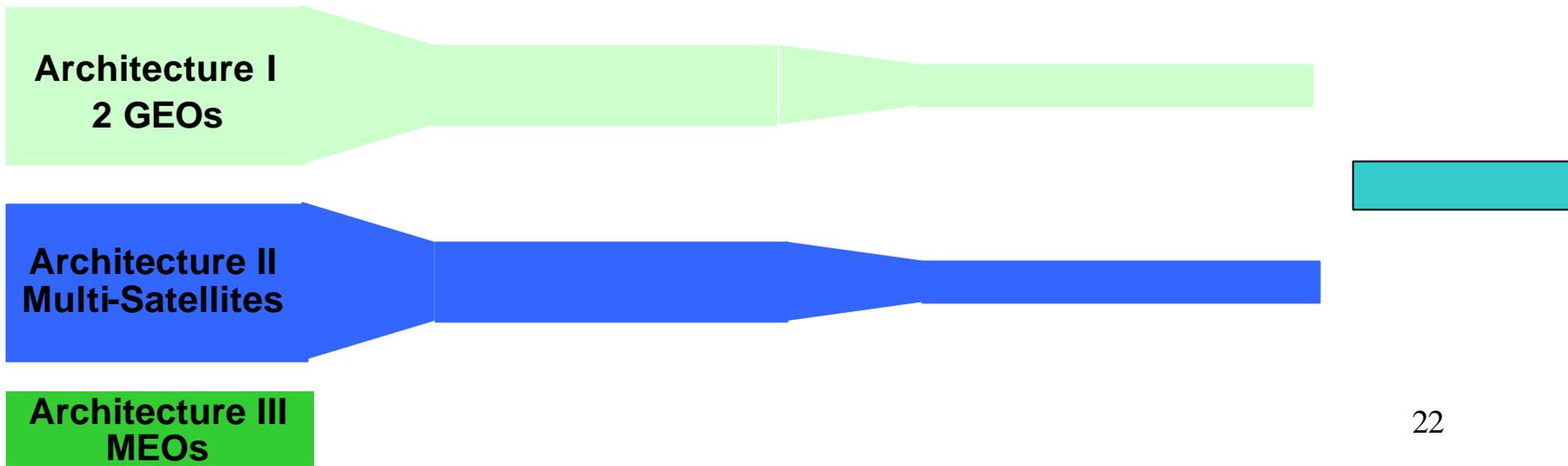
**\*These benefits are *over and above* those achieved by the current GOES baseline**



# GOES-R System Selection Timeline

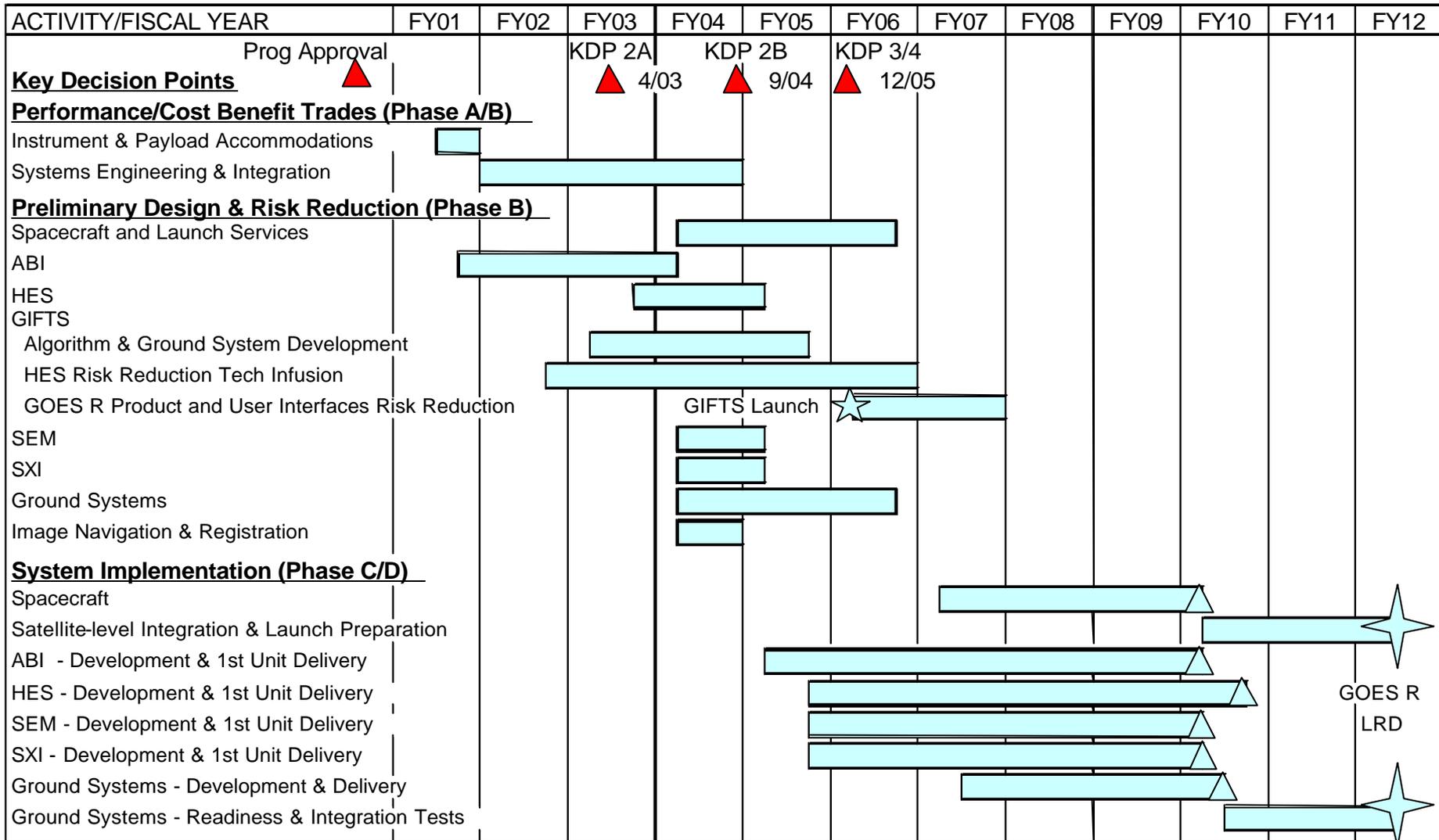


Cost & Performance Spectrum





# GOES R Planning Schedule



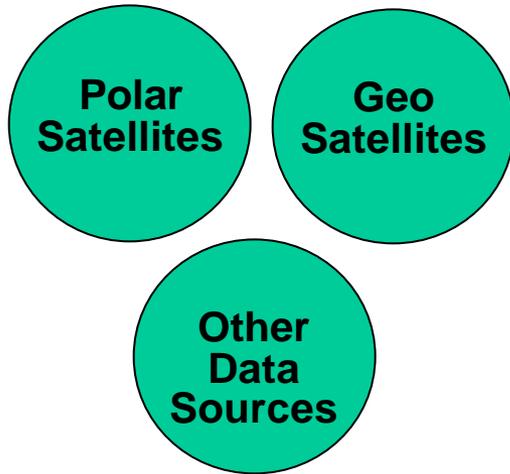
GOES R  
LRD



# Goal - Transition from Individual Systems to “System of Systems” Architecture

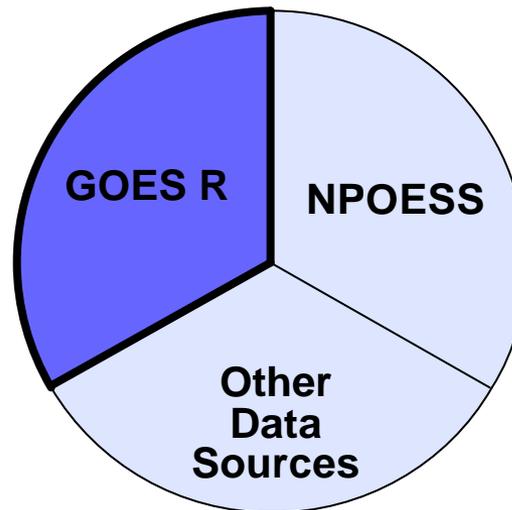


**Today**



**Programs formulated independent of one another**

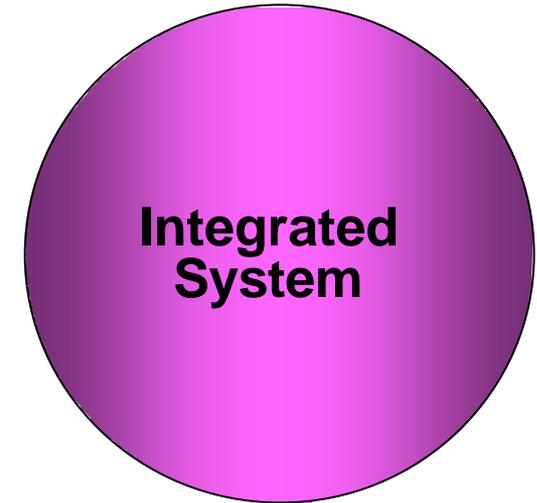
**2012**



**Formulate integrated system – GOES R with**

- **Defined NPOESS**
- **Structured approach to including Other Data Sources**

**2020+**



**Programs formulated as one integrated system**