GOES-R Satellite Series Audit: Improvements Needed in Testing, Contract Management, and Transparency

Ed Kell
Frank Tersigni
Richard "Krash" Krasner
Katherine Smith

September 5, 2018

Federal Audit Executive Council Annual Conference
Patent and Trademark Office
Madison South Auditorium

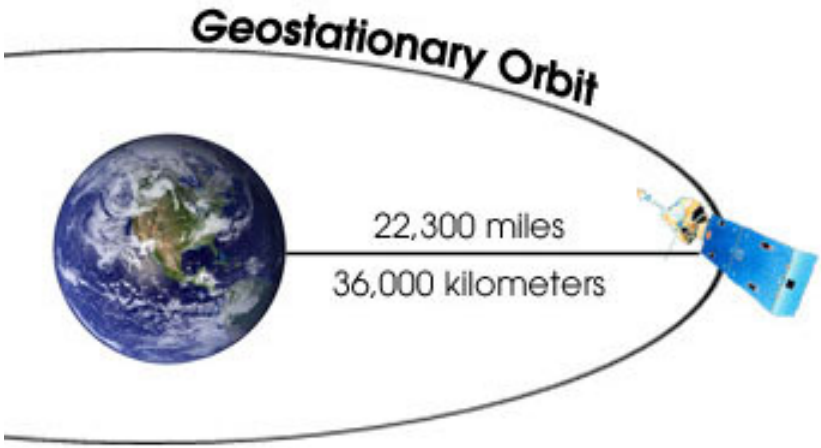
U.S. Department of Commerce
Office of Inspector General
Office of Audit and Evaluation

- **Audit Team**
  - Engineers, physical scientists, and auditor
  - Attend project and program monthly status meetings and milestone reviews

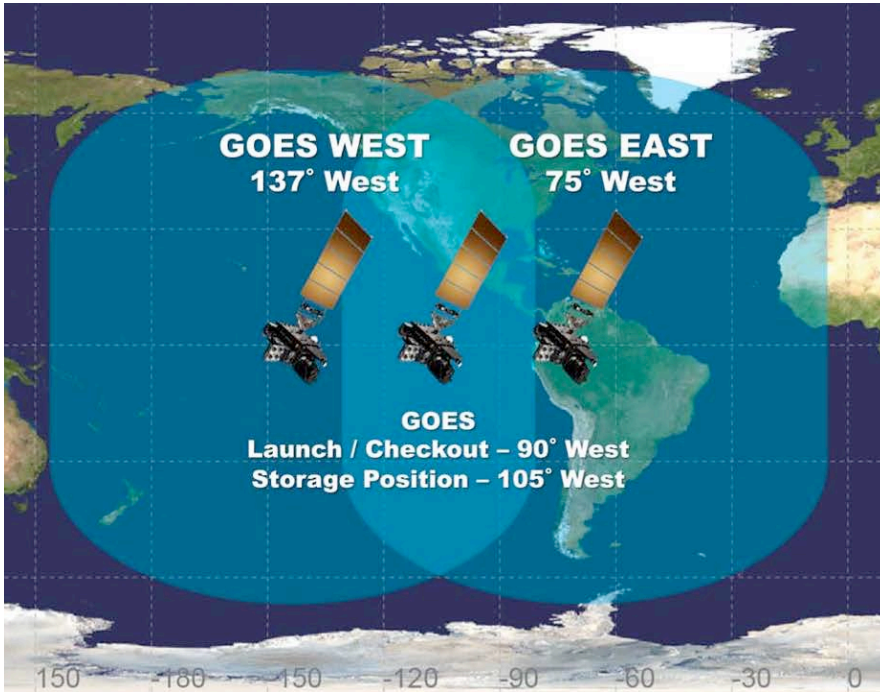
- **Audit Objectives**
  1. Assess the adequacy of GOES-R development as the program completes system integration and test activities for the flight and ground system in preparation for launch and data distribution, per NOAA and NASA standards
  2. Monitored the program's progress in developing and reporting on flight and ground segment contracting actions and changes to minimize cost increases

GOES-R Series Satellites

- NOAA's latest generation of Geostationary Operational Environmental Satellites (GOES) is the nation's most advanced fleet of geostationary weather satellites.



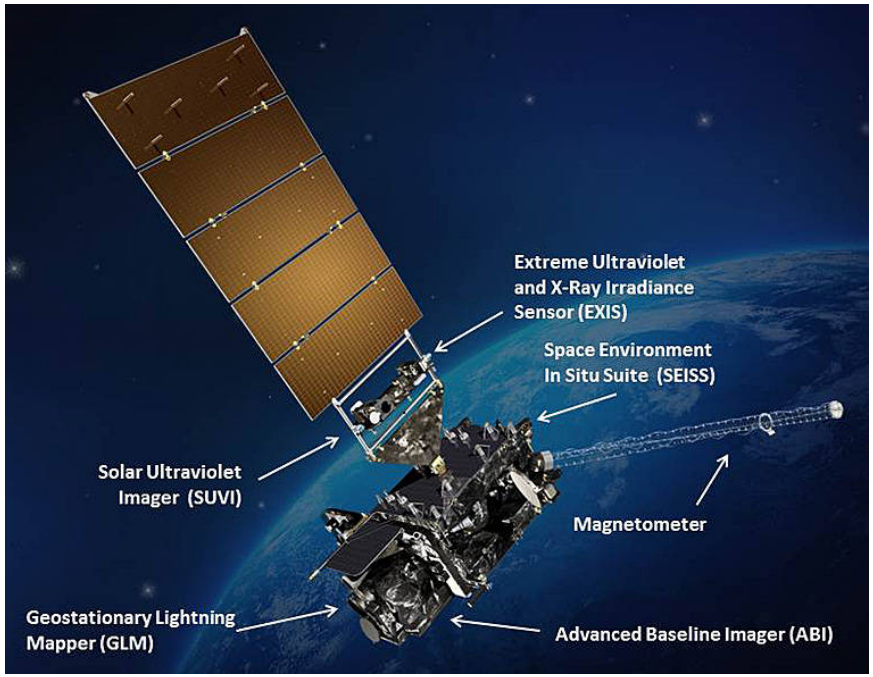
Credit: University of Wisconsin-Madison



Credit: NOAA, GOES-R program documentation

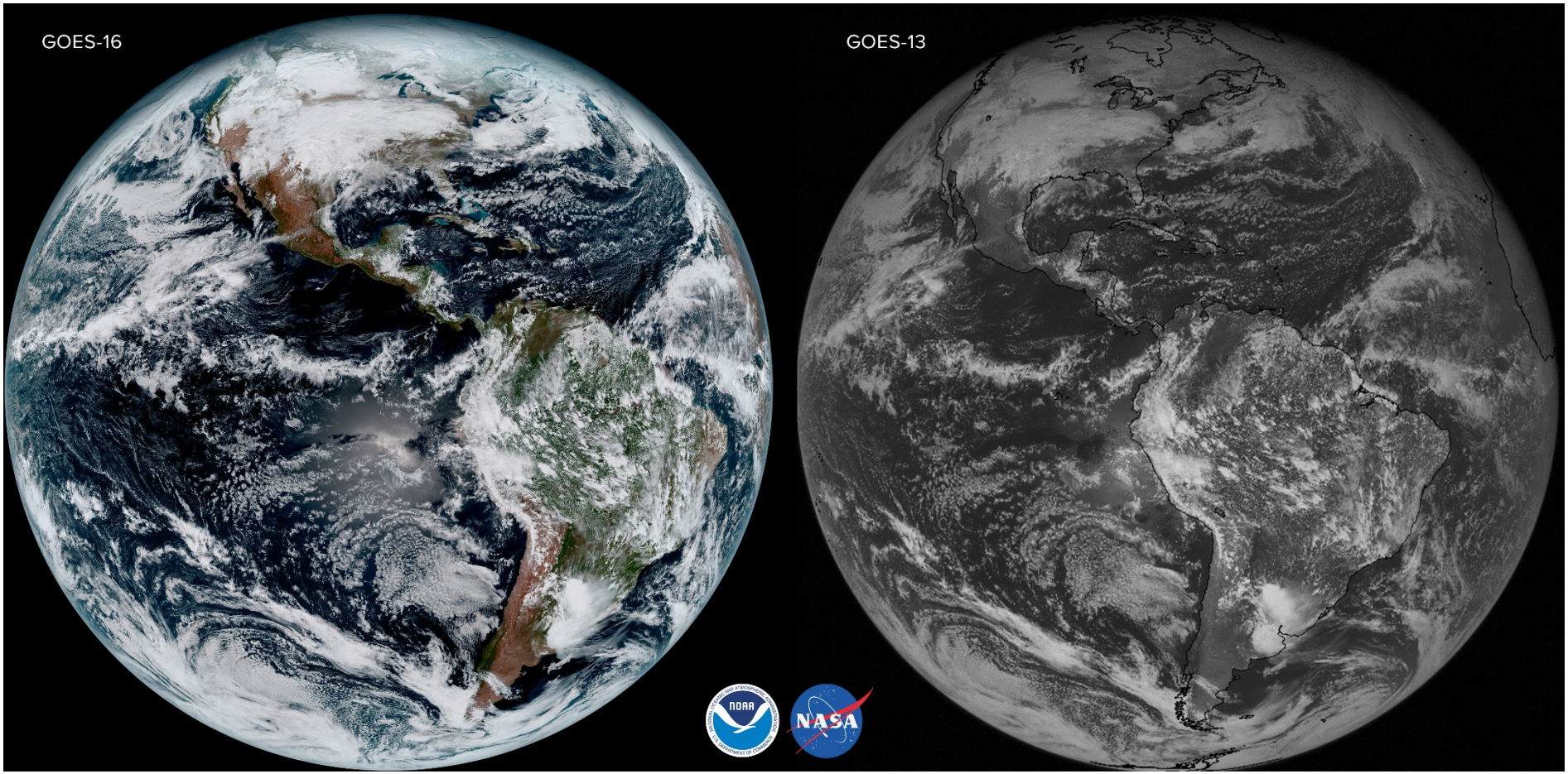
GOES-R Series Satellites

- **GOES-R (GOES-16)**
  Launched November 19, 2016
  (operates as GOES-EAST)
- **GOES-S (GOES-17)**
  Launched March 1, 2018
- **GOES-T**
  Q4 FY 2020
- **GOES-U**
  Q1 FY 2025



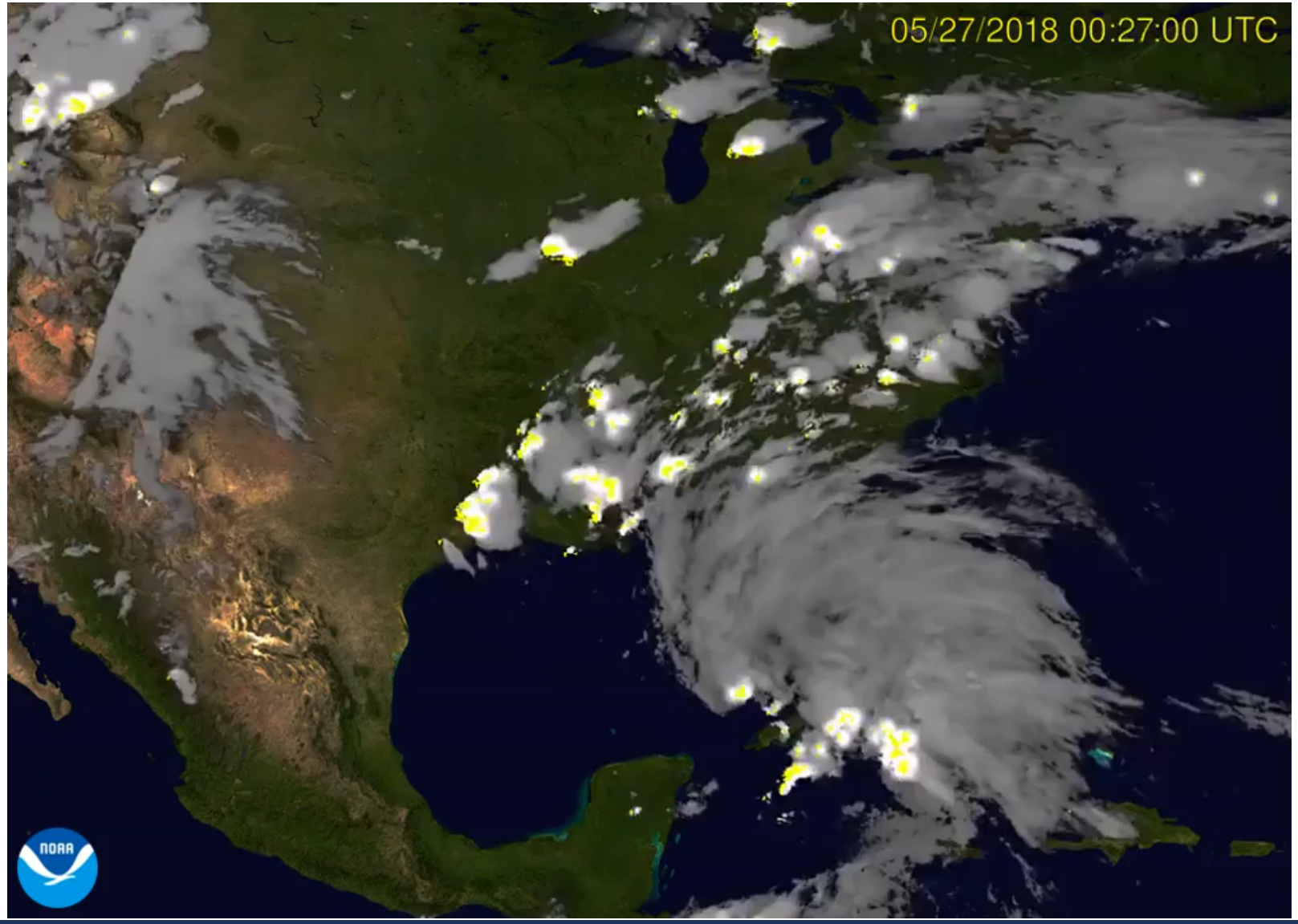
Credit: NASA

Old vs. New GOES Imagery



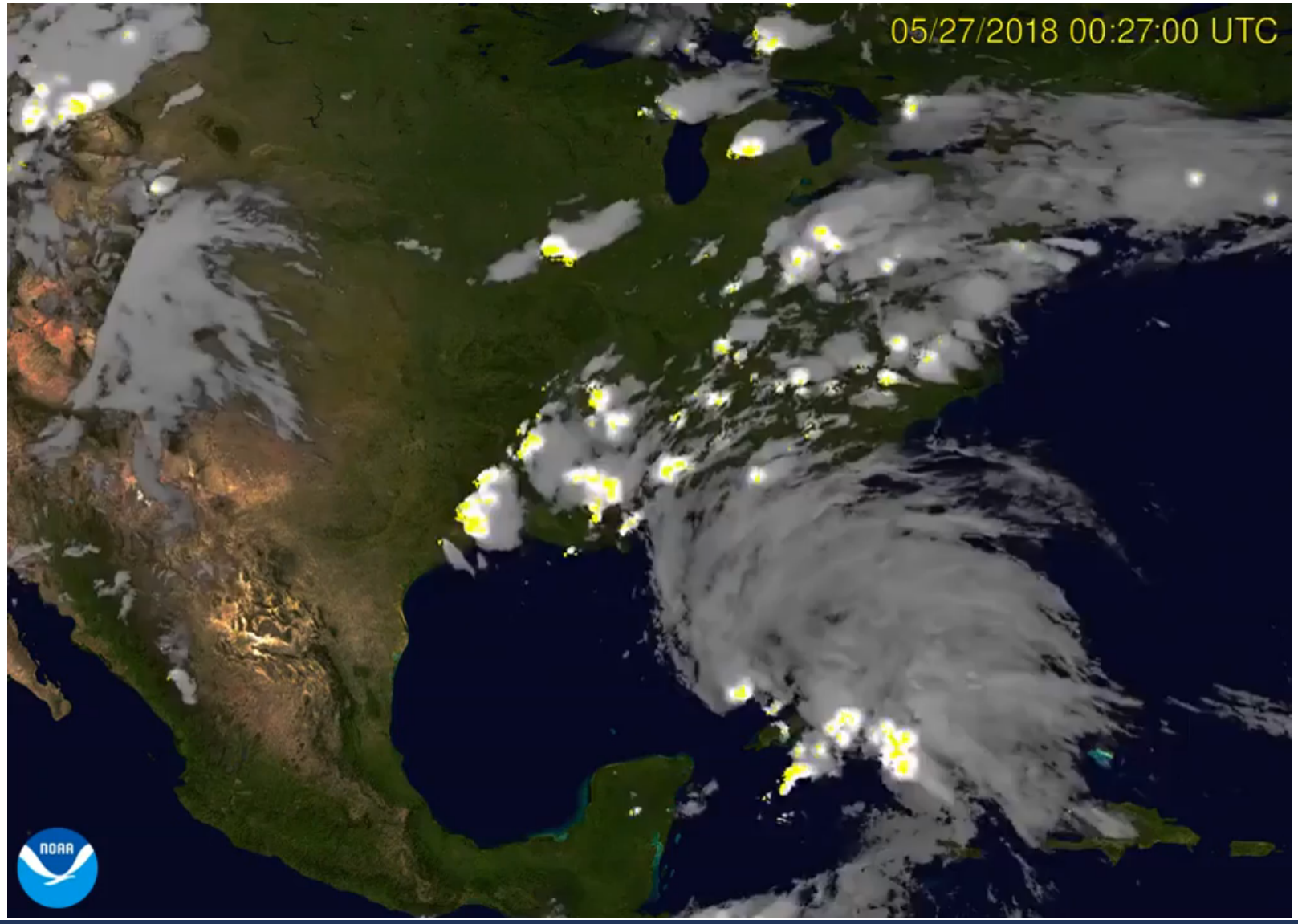
Credit: NOAA Public Images

GOES-16 in Action (video)



Credit: NOAA Satellite YouTube

GOES-16 in Action (image)



Credit: NOAA Satellite YouTube

GOES-R Program

- **Lifecycle Cost—$10.8 billion**
  Includes development and deployment of four satellites through FY 2036

OIG-17-013-A: Summary of Findings

1. Unapproved test change damaged the satellite
2. Delays led to costs and risk increase
3. Lack of transparency
4. Inconsistent coverage gap probability reporting

OIG-17-013-A: Finding 1

An unapproved test change damaged the satellite and exposed weaknesses in cost estimation that informed award fee determination

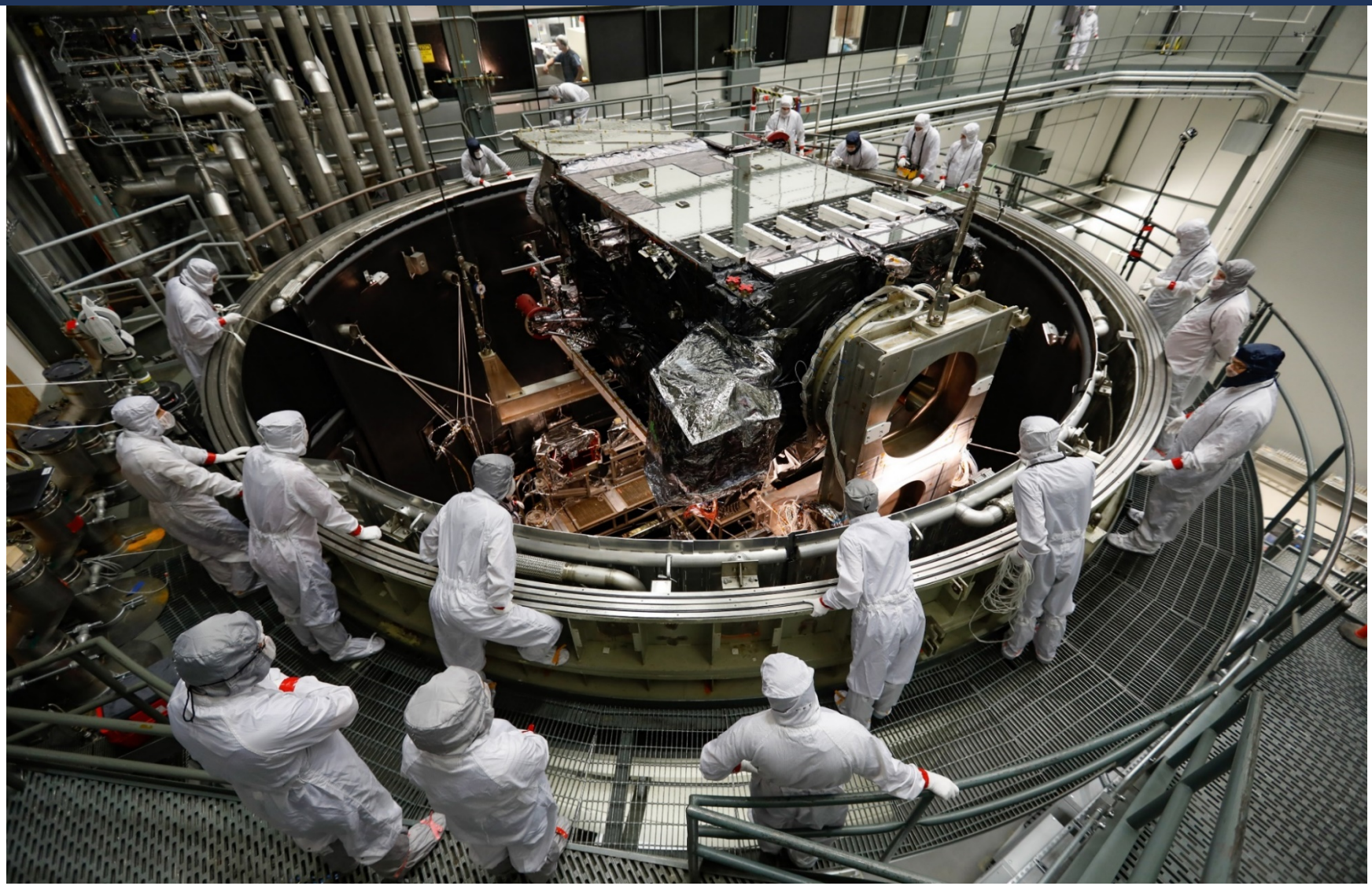
What is a Thermal Vacuum Test?

- Thermal Vacuum (TVAC) Test
  - Environmental test that provides confidence that design will perform when subjected to environment more severe than expected during mission
  - Satellite tested inside sealed chamber designed to simulate extreme hot and cold conditions of space, in order to assess performance in that environment
- What Happened
- What We Found

GOES-S and Thermal Vacuum Chamber, Littleton, CO August 2017

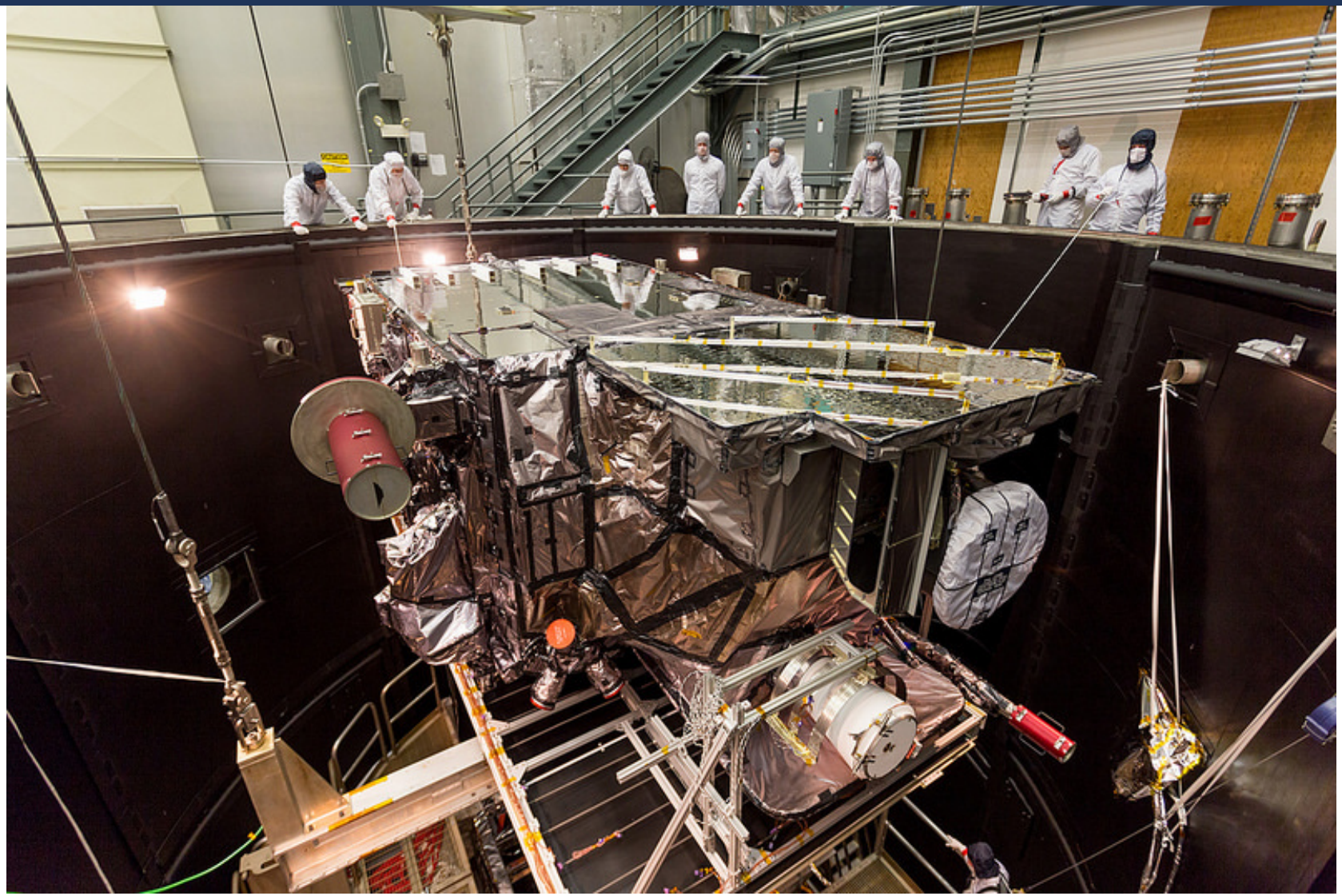
Credit: Lockheed Martin Corporation

GOES-S and Thermal Vacuum Chamber, Littleton, CO August 2017



Credit: Lockheed Martin Corporation

GOES-S and Thermal Vacuum Chamber, Littleton, CO August 2017



Credit: Lockheed Martin Corporation

Finding 1a: Lack of Configuration Control Put Satellite at Risk During Test

- TVAC Test equipment design change was not fully reviewed and approved per plans
- GOES-R program did not document its actions that determined contamination of instruments to be of minimal risk
- Configuration control improvements are needed

Finding 1b: Low Priority Given to Completing TVAC Mishap Cost Estimate During Award Fee Period

- Damage exceeded $1 million threshold for "Breach of Safety" as specified in Contract's Performance Evaluation Plan (PEP)

Exceeding $1 Million Damage Threshold → No Award Fee Paid for That Period

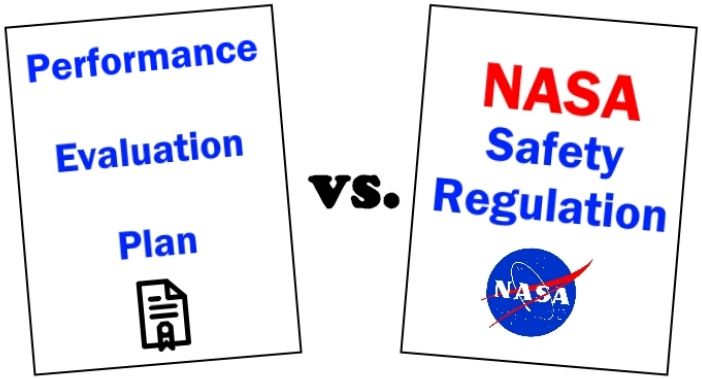
- Damage estimates were slow to develop over a year, but award fee determined almost 3 months after incident

Contract	Costs of the Mishap
Spacecraft	$476,400
ABI Instrument	$628,212
GLM Instrument	$19,920
Total	**$1,124,532**

Source: OIG summary of GOES-R project estimation of costs

Finding 1b: Low Priority Given to Completing TVAC Mishap Cost Estimate During Award Fee Period

- OIG notified GOES-R program that accumulated costs exceeded the PEP's $1 million Breach of Safety threshold
- The program reduced their total cost estimate by $315,000, citing a NASA Safety Regulation that separates direct and indirect costs
- Slow cost development and lack of communication caused questionable $10.3 million award fee payment, and made $3.9 million of future award fee available to contractor



Finding 1c: Lack of Cost Estimate Coordination Restricts NASA's Mishap Classification Level

- Initial damage estimate $301,000 determined the NASA mishap classification level and process

Mishap Classification	Greater Than Or Equal To	Less Than
Level A	$2,000,000	—
Level B	$500,000	$2,000,000
Level C	$50,000	$500,000
Level D	$20,000	$50,000
Close Call	—	$20,000

Source: OIG adaptation of NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping

- Later damage estimate increases not fully communicated

- Sharing data as it developed could have meant different mishap board products, resources, visibility

Finding 1: Recommendations

We recommended NESDIS Assistant Administrator:

- Ensure TVAC procedures account for configuration changes
- Establish mishap cost reporting cross-feed mechanism
- Modify contract PEP to specify direct and indirect costs are used for determining a major breach of safety
- Ensure GOES-R program provides timely mishap cost data to NASA to ensure proper classification as early as possible

We recommended NOAA Deputy Under Secretary for Operations:

- Determine whether award fee payment was proper

OIG-17-013-A: Finding 2

Delay in definitizing core ground system re-plan resulted in increased costs and risk

Finding 2a: NOAA's Acquisition and Grants Office (AGO) Does Not Have Policy for Timely Disposition of Requests for Equitable Adjustment (REAs)

- NOAA's AGO provides contracting support to GOES-R
- GOES-R ground system (GS) Contracting Officer required to follow AGO policy
  - AGO policy change in April 2013 – requires unpriced change order (UCO) be definitized by 180 days
  - GS re-plan a REA, above requirement didn't apply

Finding 2a: NOAA's AGO Does Not Have Policy for Timely Disposition of REAs

- However, NOAA incrementally funded work after REA submission
- Government lost opportunity to negotiate $91 million of contract mod cost while incrementally funding during definitization delay

Incremental Funding, Contract Ceiling Increases, and Time to Definitization for Latest Ground Re-Plan (ETC-15) ($ in thousands)

Date	Core Ground System Contract Modification Number	Incremental Funding Amount	Cumulative Funding Amount	Contract Ceiling Increase Due to ETC-15	Time Since Submission of Initial Proposal (December 2013)
August 2014	076	$31,000	$31,000	$54,419	8 months
September 2014	081	$10,023	$41,023	$0	9 months
February 2015	091	$20,000	$61,023	$20,000	14 months
April 2015	098	$20,000	$81,023	$20,000	16 months
June 2015	0102	$10,000	$91,023	$10,000	18 months
September 2015	0105[a]	$68,908	$159,931	$85,578	21 months
Total Contract Ceiling Increase Due to ETC-15				$189,997	
Core Ground System Contract Value as of July 2016				$1,249,584	

Source: OIG analysis of GOES-R program documentation

[a] Re-plan definitized on September 3, 2015, with contract modification 0105.

Finding 2b: Prolonged delay in Definitizing Re-plan Resulted in Added Cost and Increased Risk to Core Ground System Development

- Contractor submitted several re-plan proposals resulting in additional cost for proposal preparation
- Government/contractor had to account for substantial increased cost due to escalation
  - Government included $9,586,935 for escalation and $154,424 for proposal preparation
  - We considered these as questioned costs due to prolonged delay in definitizing re-plan

Finding 2b: Prolonged delay in Definitizing Re-plan Resulted in Added Cost and Increased Risk to Core Ground System Development

- Government/contractor not able to use earned value metrics to measure GS cost/schedule performance
- GOES-R GS project stated: contractor's proposal needed to be finalized to determine if contractor's execution was in accordance with its re-plan baseline
- Contractor took on risk by performing re-plan changed work before knowing total government funding

Finding 2: Recommendations

We recommended that NOAA Deputy Under Secretary for Operations direct AGO to:

- Develop policy for timely disposition of REAs
- Provide more detailed status of REAs/UCOs* for NOAA /NASA Program Management Council (PMC) programs
- Develop mechanism to regularly communicate non-PMC REAs/UCOs* status to senior NOAA leadership

*REAs/UCOs unresolved >6 months

OIG-17-013-A: Finding 3

Spacecraft project management reviews are not conducted in a transparent manner

Finding 3a: Spacecraft Business Reviews Conducted As Internal Contractor Meetings, Resulting in Lack of Transparency to Independent Oversight Bodies

- Spacecraft project experienced large cost growth/schedule slips
  - Contract valued at $1.8 billion (as of June 2016), including 8 million in cost overruns since April 2013

  - Prior to 2013 cost overrun, schedule delays resulted in re-plan
  - Major cost overrun of $162.8 million attributed to unanticipated complexity of subsystems

  - Independent oversight important to ensure costs understood
- GOES-R contractors conduct regular project management reviews to inform government on projects' technical/business status (including cost/schedule), however…

Finding 3a: Spacecraft Business Reviews Conducted As Internal Contractor Meetings, Resulting in Lack of Transparency to Independent Oversight Bodies

- OIG oversight wasn't permitted to observe GOES-R spacecraft business meetings
  - Meetings conducted internally by contractor
  - GOES-R project management attends/participates
  - No meeting minutes/action items were produced

- OIG oversight was limited in understanding actions needed/ taken to control cost and schedule

Finding 3b: Spacecraft Contract Lacks Project Management Review Best Practices

- Spacecraft contract does not require meeting minutes or action items
- By comparison, GOES-R core GS contract requires meeting minutes, including action items
- *Project Management Body of Knowledge** guide states meetings should be
  - prepared with well-defined agendas, purposes, objectives, and timeframes
  - documented with meeting minutes and action items

**A Guide to the Project Management Body of Knowledge* is a primary publication of Project Management Institute, a global standard for project management, and provides best practices for conducting meetings.

Finding 3: Recommendations

We recommended Under Sectary of Commerce for Oceans and Atmosphere and NOAA Administrator direct GOES-R to:

Ensure business meeting portion of spacecraft project management reviews are conducted in transparent manner by allowing independent government oversight attendance

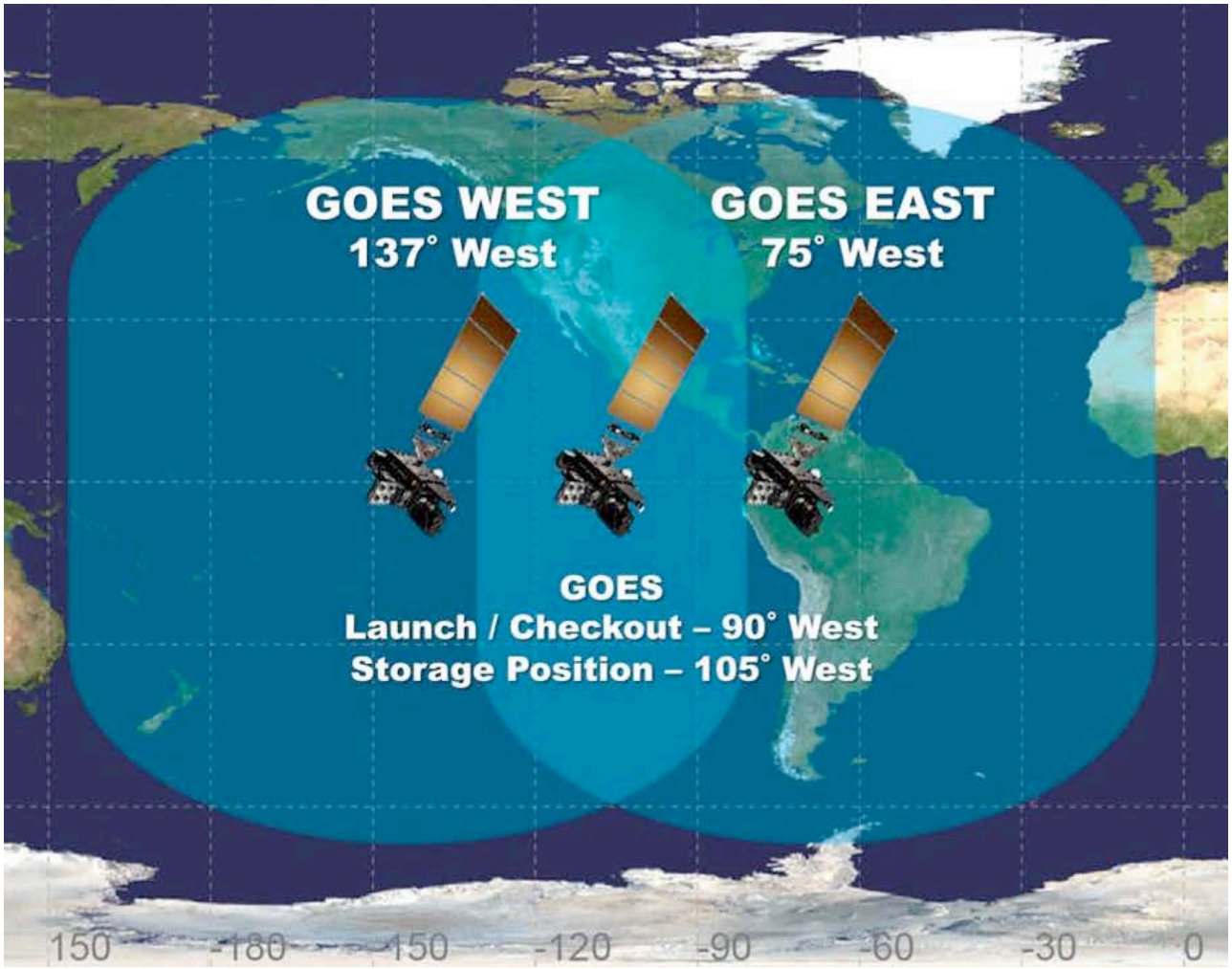
We recommended NESDIS Assistant Administrator ensures that:

- GOES-R program captures meeting minutes for project management reviews identifying action items, decisions, and significant points of discussion
- All future NESDIS funded contract meeting and review deliverables require minutes

OIG-17-013-A: Finding 4

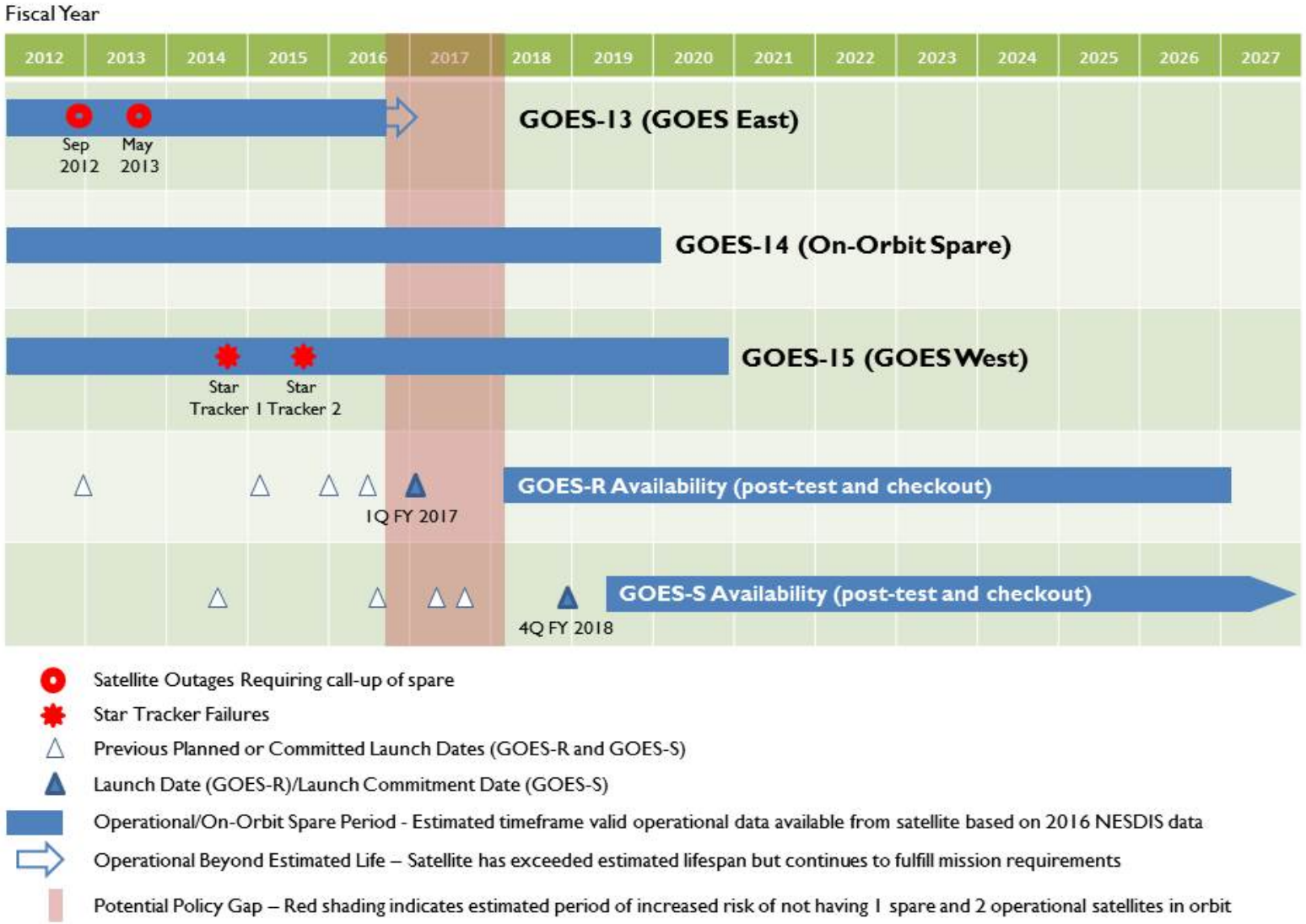
NESDIS does not consistently calculate or report geostationary satellite coverage gap probability

Remember NOAA Policy for Geostationary Satellite Coverage



Credit: NOAA, GOES-R program documentation

Finding 4a: Reported Status of the GOES Constellation Altered by New Satellite Lifetime Assumptions



Source: OIG graphic analysis of NESDIS documentation

Finding 4b: NESDIS Gap Calculations Do Not Adequately Inform Stakeholders

- NOAA doubled its satellite operational lifetime assumption, which made calculation of NOAA policy adherence more optimistic

Date of Estimate	Based on GOES-R Launch in:	GOES-13, -14, -15 Lifetime Estimate	Program's Calculation of Gap Probability (goal ≤ 20%)
September 2014	March 2016	5 years	43%
August 2015	October 2016[a]	10 years	15%

Source: GOES-R presentation slides to Standing Review Board

[a] At the time of the estimate, the proposed launch date was October 2016

- GOES-R program reliability calculation resulted in lower gap probability even though there was a launch delay

Finding 4: Recommendation

We recommended the NESDIS Assistant Administrator:

- Create a documented, periodic, and consistent geostationary imagery gap probability summary for comparison with policy

Our reports can be found on Office of Inspector General website:

https://www.oig.doc.gov/

The report discussed in this presentation (OIG-17-013-A, issued February 2, 2017) can be found at the following OIG website:

https://www.oig.doc.gov/OIGPublications/OIG-17-013-A.pdf

Questions?

Backup

GOES-R Instruments

Instrument	Functional Purpose
Advanced Baseline Imager (ABI)	As the primary instrument, the ABI will enable forecasters to use the higher resolution images to track the development of storms in their early stages; it will offer a wide range of applications related to weather, oceans, land, climate, and hazards such as fires, volcanoes, hurricanes, and storms that cause tornadoes.
Geostationary Lightning Mapper (GLM)	The GLM will provide early indication of storm intensification over land and ocean areas, severe weather events, and improved tornado warning lead time of up to 20 minutes or more, as well as data for long-term climate variability studies. NOAA anticipates that the GLM will have immediate applications to aviation weather services, climatological studies, and severe thunderstorm forecasts and warnings.
Space Environment In-Situ Suite (SEISS)	The SEISS sensors will monitor the proton, electron, and heavy ion fluxes at geosynchronous orbit; assess radiation hazard to astronauts and satellites; and provide warnings of high flux events which will mitigate damage to radio communications.
Solar Ultraviolet Imager (SUVI)	The SUVI will allow users to observe the sun in the extreme ultraviolet (EUV) wavelength range, characterizing complex active regions of the sun, and solar flares and eruptions—space weather that could disrupt power utilities, communication and navigation systems, and potentially damage orbiting satellites and the International Space Station.
Extreme ultraviolet/X-ray Irradiance Sensor (EXIS)	The EXIS will monitor solar flares that can disrupt communications and degrade navigational accuracy, affecting satellites, astronauts, high latitude airline passengers, and power grid performance.
Magnetometer (MAG)	The MAG will provide measurements of the space environment magnetic field that controls charged particle dynamics potentially dangerous to spacecraft and human spaceflight. In addition, it will provide alerts and warnings to many customers, including satellite operators and power utilities.

Source: OIG adapted from GOES-R program documentation

GOES-R ABI Bands

Bands 1-6 (Visible/Near-IR)

ABI Band	Wavelength (µm)	Wavelength Range (µm)	Descriptive Name
1	0.47	0.45 – 0.49	"Blue"
★ 2	0.64	0.60 – 0.68	"Red"
3	0.864	0.847 – 0.882	"Veggie"
4	1.373	1.366 – 1.380	"Cirrus"
5	1.61	1.59 - 1.63	"Snow/Ice"
6	2.24	2.22 - 2.27	"Cloud Particle Size"

★ Indicates channels GOES-13, GOES-14 , and GOES-15

GOES-R ABI Bands

Bands 7-16 (IR)

ABI Band	Wavelength (μm)	Wavelength Range (μm)	Descriptive Name
★ 7	3.90	3.80 – 3.99	"Shortwave window"
8	6.19	5.79 – 6.59	"Upper-level Water Vapor"
★ 9	6.93	6.72 – 7.14	"Mid-Level Water Vapor"
10	7.34	7.24 – 7.43	"Lower/Mid-level Water Vapor"
11	8.44	8.23 – 8.66	"Cloud-top Phase"
12	9.61	9.42 – 9.80	"Ozone"
13	10.33	10.18 – 10.48	"Clean longwave window"
★ 14	11.21	10.82 – 11.60	"Longwave window"
15	12.29	11.83 – 12.75	"Dirty longwave window"
★ 16	13.28	12.99 – 13.56	"CO_2"

★ Indicates channels GOES-13, GOES-14 , and GOES-15

GOES-R ABI Bands