GEO-XO Program Formulation

Pam Sullivan, GOES-R and GEO-XO Program Director

September 30, 2020
GEO-XO Formulation Topics

- Agency guidance
- Formulation milestones
- Program schedule
- Program definition at formulation start
- Formulation plans
  - Instruments
  - Spacecraft
  - Ground
  - User Readiness
  - Partnerships
- Summary
Program Planned to DOC & NASA Guidance

DOC Life Cycle Phases and Milestones
- Concept Approval
- Authorization to Proceed (ATP)
- Project Approval
- Project Implementation Approval
- Project Operations Approval

NASA 7120 Life Cycle Phases and Milestones

Program Reviews
- MCR
- SRR
- SDR
- PDR
- CDR
- SIR
- ORR
- PLAR
- DR

Other Reviews
- ASM
- MOR
- PER
- SMSR
- FRR
- LRR

Other Reviews
Peer Reviews, System, Element, Subsystem, Software, etc. As specified in System Review Plan and Program and Project System Engineering Plans

Key Milestones:
- DOC Milestone
- 7320 Key Decision Point
- SRR Review
- GSRT Review

Key Processes:
- MCR – Mission Concept Review
- SRR – System Requirements Review
- ASM – Acquisition Strategy Meeting
- SDR – System Design Review
- MOR – Mission Operations Review
- PDR – Preliminary Design Review
- FOR – Flight Operations Review
- CDR – Critical Design Review
- SMSR – Safety and Mission Assurance Review
- PER – Pre-Environmental Review
- ORR – Operational Readiness Review
- FRR – Flight Readiness Review
- LRR – Launch Readiness Review
- PLAR – Post-Launch Acceptance Review
- DR – Decommissioning Review
## GEO-XO Formulation Milestones FY21-23

<table>
<thead>
<tr>
<th>GEO-XO Formulation Event/Activity</th>
<th>Timeframe</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO BAA &amp; Aerospace Instrument Studies Complete</td>
<td>Fall 2020</td>
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<tr>
<td>User Requirements Finalized</td>
<td>Nov 2020</td>
<td>Observations Defined</td>
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<tr>
<td>Constellation Trade Study Complete</td>
<td>Dec 2020</td>
<td>Architecture Defined</td>
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<tr>
<td>Program Level 1 Requirements Approved</td>
<td>Mar 2021</td>
<td>Requirements Defined</td>
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<tr>
<td><strong>Mission Concept Review</strong></td>
<td>Mar 2021</td>
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<tr>
<td>Program Cost Revision based on MCR Definition</td>
<td>Mar 2021</td>
<td>Align to MCR Scope</td>
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<tr>
<td><strong>DOC Milestone 1 Review</strong></td>
<td>3QFY21</td>
<td><strong>Program Initiation</strong></td>
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<tr>
<td>Imager Phase A Study Contracts Awarded</td>
<td>Mar 2021</td>
<td>Up to 3 Contracts</td>
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<td>Remaining Instruments Phase A Contracts Awarded</td>
<td>1QFY22</td>
<td>Up to 3 per Instr. Type</td>
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<td>Ground System Studies and Data Pilots Begin</td>
<td>1QFY22</td>
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<tr>
<td><strong>System Requirements Review</strong></td>
<td>3QFY22</td>
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<tr>
<td>Implementation Phase Acquisition Strategy Meeting</td>
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<tr>
<td>Update Program Cost Estimate and Perform ICE</td>
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<tr>
<td><strong>DOC Milestone 2 Review</strong></td>
<td>1QFY23</td>
<td><strong>Program Approval</strong></td>
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<tr>
<td>Spacecraft and Instrument Implementation Phase Contracts Awarded</td>
<td>3QFY23+</td>
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# GEO-XO Program Schedule
(Notional pending Approval/Funding)

<table>
<thead>
<tr>
<th>Milestones</th>
<th>KDPs</th>
<th>Reviews</th>
<th>Launches</th>
<th>Imager</th>
<th>Other Instruments</th>
<th>GEO Spacecraft</th>
<th>GEO Ground</th>
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<td>FY20 1 2 3 4</td>
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<td>▲ SRR</td>
<td>▲ GOES-U</td>
<td>▲ GOE1</td>
<td>▲ PSM</td>
<td>▲ PDM</td>
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<td>▲ SRR</td>
<td>MS1</td>
<td>▲ PSM</td>
<td>FY22 1 2 3 4</td>
<td>MS2</td>
<td>▲ PDM</td>
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</table>
Program Definition at Formulation Start

- Defined at Mission Concept Review:
  - Initial Program Level 1 Requirements
  - Observations planned, from NOAA systems and commercial sources
    - Instrument performance baseline and options
  - Space architecture
    - Number of NOAA spacecraft, their orbits and payload complements
    - Use of commercial hosts
  - Ground system roles and feasible system concepts
  - NOAA-NASA partnership and roles
  - ROM cost and schedule for defined requirements and selected architecture

<table>
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<tr>
<th>L1 Requirements Evolution</th>
<th>Timeframe/Use</th>
<th>Description/Content</th>
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<tr>
<td>Pre-formulation</td>
<td>Developed in 2019; used for BAA studies</td>
<td>Observational requirement range tables</td>
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<tr>
<td>Initial</td>
<td>Developed in 2020; used for MCR &amp; Phase A</td>
<td>Program requirements for MCR content</td>
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<tr>
<td>Baseline</td>
<td>Baselined at SRR in 2022 for Phase B/C/D</td>
<td>Full program requirements for SRR content</td>
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<tr>
<td>Updated</td>
<td>Finalized for M/S3 (KDP-C) in 2025 for Phase C/D</td>
<td>Full program requirements for implementation, consistent with baseline cost and schedule</td>
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GEO-XO Instruments Formulation

• Planning to conduct competitive industry studies for each candidate instrument
  • Prioritizing the instrument studies ahead of spacecraft and ground, as they are expected to be critical path
  • Imager Phase A study planned first, starting in 3QFY21
  • Others will follow in early FY22, pending available funds
• For each candidate instrument, the Phase A study will:
  • Study baseline instrument design
  • Study optional improvements to understand feasibility
  • Show that development timeline can be met
  • Answer specific trade studies
  • Advance needed technologies
• Phase A studies will inform requirements for implementation phase contracts, planned to be issued in FY23
• User needs assessments continue to inform instrument designs
Imager Phase A Industry Studies

Planned Studies
- Up to three study contracts valued at up to $5M
- Target award: March 2021
- Study duration: 1 year

Instructions emphasize GEO-XO Program priorities:
- Continuity of GEO Imagery: need to replacement capability by 2032
- Continuity of ABI-class Imagery
  • Optional improvements encouraged if implemented within schedule

Scope of Work:
- Instrument Design
- Assessment of performance against specified requirements
- Technical analysis, cost analysis, notional development schedule
- TRL Assessment, Tech Development Plan, Heritage Assumptions
- Identification of Development Risks
- Execution of work in proposed tech dev/risk reduction
- Trade studies: Data Compression; EDU fidelity/scope; Performance Options; Day/Night Band

Imager Performance requirements:
- Threshold performance = ABI + essential upgrades (1km 3.9um, green channel)
- Optional Improvements, binned into three priority levels

Program and Imager Timeline

<table>
<thead>
<tr>
<th>MILESTONE</th>
<th>DATE (assume 1st day of quarter)</th>
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<tbody>
<tr>
<td>Flight Contract Award</td>
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<tr>
<td>Flight Model 1 Pre-Ship Review (PSR1)</td>
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<td>Launch 1 Readiness Date</td>
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<tr>
<td>Flight Model 2 PSR (PSR2)</td>
<td>Q3 FY32</td>
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<tr>
<td>Launch 2 Readiness Date</td>
<td>Q4 FY34</td>
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Program and Imager Timeline
## Imager Baseline Requirements & Prioritized Options for Phase A Study

### Baseline Requirements

<table>
<thead>
<tr>
<th>Band Center (um)</th>
<th>Band-Width (um)</th>
<th>SNR/NEDT</th>
<th>Spatial Reso. (km)</th>
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### Optional Improvements

**Priority 1 - Mission Focused**

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<tr>
<th>Band Center (um)</th>
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<th>Spatial Reso. (km)</th>
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**Priority 2 - Mission Optimal**

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<tr>
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**Priority 3 - Mission Enhancing**

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### Change Relative to ABI:

- 0.55 um band provides the green component needed for true color imagery
- Improving VIS to 0.25 km helps severe wx detection of small cumulus clouds
- Raise Tmax improves fire detection
- Higher resolution in 2.25um improves daytime land/cloud imaging & matches EUM FCI
- Improve components for true color imagery to 0.5 km resolution
- 5.1um monitors low level water vapor
- 13.3 band helps cloud property retrievals
- 12.3 band provides the red component
- 13.3 band provides the blue component

* MTF spec relaxed to 0.3 km equivalent.
** Increase Tmax to 500K; may include multiple gains and/or channels as needed
*** MTF spec relaxed to 1.5 km equivalent.
**** Increased resolution to 1km; wavelength may be either 5.5 or 6.95 to meet spec.
Spacecraft Formulation

- Anticipated Spacecraft solution
  - GEO SC in East and West; potentially 3rd in Center
    - With 2 or 3 Earth-viewing instruments
    - With 3 Solar-viewing instruments
    - With 2 In-situ Space Weather instruments
    - DCS communications relay payload
  - Additional instrument(s) on hosted on commercial GEO SC

- Work planned over formulation phase 2021-2025
  - Finalize instrument manifest and interfaces
  - Finalize comm relay payload manifest
    - Anticipate industry interaction on comm alternatives
  - Evaluate alternate opscons with goal of lowering O&M costs
    - Anticipate industry input and benchmarking
  - Develop space to ground interfaces
  - Develop and implement spacecraft acquisition strategy
    - Anticipating award of implementation phase contract without preceding formulation phase study
  - Develop host acquisition plan
    - Collect lessons learned from previous host missions
  - User needs assessments to inform comm payload decisions
Ground System Formulation

• Anticipated Ground System solution
  • GEO-XO part of NESDIS enterprise using mix of NESDIS common and mission unique elements
    – Command & Control: evolve existing, accredited system to include new spacecraft
    – Ground data receipt with new Ka-band antennas
      • Needed to support increased data rates driven by new and advanced GEO-XO instruments
    – L1b data production by mission unique system in NESDIS cloud
    – Product generation, distribution, and archive per NESDIS enterprise solution
      • Multiple delivery options including dedicated land line, cloud to internet (land, cell, satellite), and commercial satellite rebroadcast
  • Ground for hosted payloads provided by Host entity; data ingested to NESDIS enterprise PG/PD

• Work planned over formulation phase 2021-2025
  • Learn from experience incorporating SWFO command & control into GOES-R over 2021-2024
  • Evaluate options for new ground Ka-band receive antennas
  • Develop Space-Ground interface requirements to support GEO-XO SRR in 2022
  • Learn from ongoing NESDIS cloud ingest and PG projects to develop/evolve enterprise solution
  • Benchmark data delivery models and options
  • Pilot cloud-based data delivery services
    • Offer cloud-based “GRB” to existing users beginning in 2022
  • Focus user needs assessment activities on data delivery methods and data products and services
Ground System Concept

Note: Users and Partners may or may not be in Cloud

*Potential migration to Enterprise
Anticipated GEO-XO Data Distribution

**GEO-XO**
- Raw data
- Ground Processing for L1 Data
- NWS Dedicated Stream
- NWS Data Access
- Cloud Storefront
- Processing In the Cloud (Customizable GRB, DCS, HRIT/EMWIN,)

**NOAA**
- NWS
- NESDIS Cloud
- Cloud storage

**DCS Platforms**
- UHF Uplink (one-way)
- >40,000 Platforms

**Users**
- Satellite Internet
- Satellite Broadcast Services (eg, GEONetCast-Americas)
- Direct Broadcast

**Legacy Users**
- EMWIN Users

**Cell Phone Applications**
- Cell Phone Users

**Terrestrial Internet**
- USGS

**GRB Users**
- GRB Users

**DCS Users**
- DCS Users

**NWS Data Access**
- NWS Dedicated Stream

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13
Anticipated GEO-XO User Readiness Activities during Formulation

- New GEO-XO data delivery options will be piloted
  - Cloud-based data delivery option as alternative to GOES Rebroadcast (GRB) and Emergency Managers Weather Info Network/High Rate Info Transmission (EMWIN/HRIT) streams
  - Plans to start piloting cloud-based options using GOES-R data in ~2022
    - Run in parallel to existing data streams to allow comparison and collect user feedback
    - Pilots will inform decisions on enterprise data delivery systems as well as prepare users
- Representative GEO-XO data sets will be produced
  - Data sets will be used to familiarize users, assess new products, and test data systems
  - Depending on GEO-XO Instrument selection and design, we anticipate evaluation of these data sets beginning in the mid-2020s:
    - IR Sounder: EUM/MTG IRS
    - Lightning Mapper: EUM/MTG LI
    - Ocean Color: KMA/GOCI-II; NASA/GLIMR
    - Atmospheric Composition: NASA/TEMPO; KMA/GEMS; EUM/Sentinel 4 UVN
- Proving ground, risk reduction, and satellite liaisons plans will be developed
  - Follow GOES-R/JPSS model but evolved to NESDIS enterprise programs
User Needs Assessments Continue through GEO-XO Life Cycle

<table>
<thead>
<tr>
<th>Launches</th>
<th>Milestones</th>
<th>KDPs</th>
<th>Reviews</th>
<th>Imager</th>
<th>Other Instruments</th>
<th>GEO Spacecraft</th>
<th>GEO Ground</th>
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<tr>
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**User Needs Support Program Approval**

**Inform:**
- Instrument & Constellation Selection
- Instrument Design
- Data Delivery Methods
- Ground Cal/Val
- Data Products & Service Selection & Design
- Data Product & Service Evolution

**Program Approval:**
- M1 Del.
- FM2 Del.
- Opt. PER Rdy
- Opt. Linch Rdy
- I&T/Launch
- Operation
Partnership Formulation Activities

• Formalize GEO-XO support for NESDIS Space Weather Program
  • GEO spacecraft expected to accommodate solar-viewing and/or in-situ instruments
  • GEO ground system may provide services for SWP mission
• Pursuing dialog with NASA on Earth observation cooperation
  • Supports National Academies 2017 Decadal Survey recommendation: “NOAA should establish, with NASA, a flexible framework for joint activities that advance the capability and cost-effectiveness of NOAA’s observation capabilities.”
• Plan to continue data product research activities with joint NOAA-NASA ROSES calls
• Participating in a study with the Canadian Space Agency (CSA) on potential Arctic mission
• Continue to lead and sponsor initiatives in CEOS, CGMS, WMO, WCRP, GCOS and other relevant bodies to advance GEO Ring vision
• Continue dialogue with partners and user needs assessments including partner inputs
GEO-XO Formulation Summary

- GEO-XO builds on NSOSA study results to define NOAA’s next generation satellite systems
- Currently preparing for formal program initiation following MCR and Milestone 1 in 2021
- Formulation Phase A/B is planned over 2021-2025 and will include:
  - Industry studies for candidate instruments
  - Initiation of major flight element acquisitions
  - Definition of partnerships for system elements
  - Opscon development
  - Benchmarking and pilot projects to inform Ground system definition
  - Continued user needs assessments to define system, products, and services
- We look forward to working with the community to develop GEO-XO

GEO-XO will maintain and advance NOAA’s observational capabilities through 2050