



NOAA

GEO-XO Program Formulation

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September 30, 2020



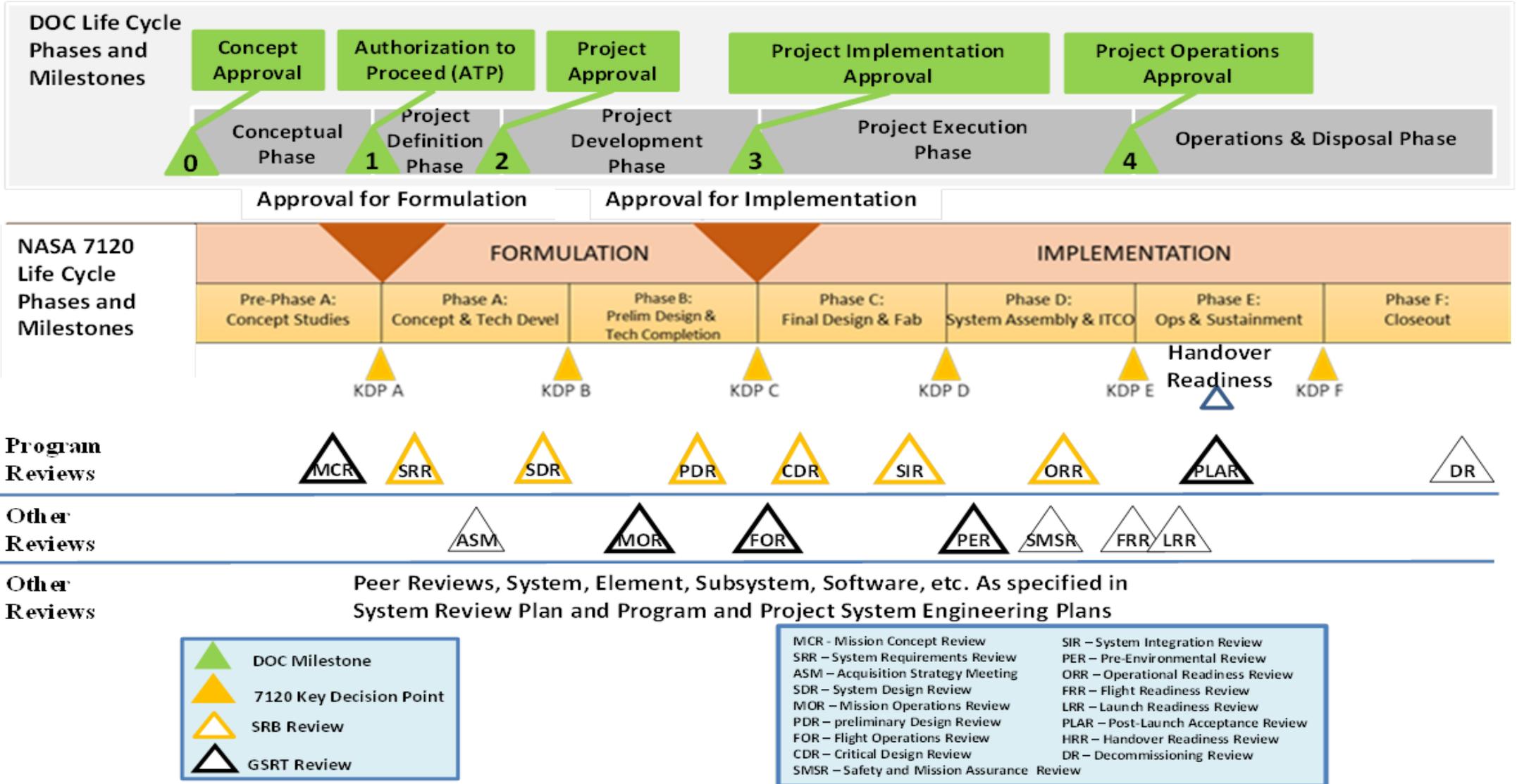


GEO-XO Formulation Topics

- 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



GEO-XO Formulation Milestones FY21-23



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



GEO-XO Program Schedule

(Notional pending Approval/Funding)



GEO-XO Program Schedule (Notional pending Approval/Funding)																																																																
	FY20				FY21				FY22				FY23				FY24				FY25				FY26				FY27				FY28				FY29				FY30				FY31				FY32				FY33				FY34				FY35			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4				
Launches									▲ GOES-T												▲ GOES-U												▲ GEO1												▲ GEO2																			
Milestones	▲ MS0				▲ MS1				▲ MS2												▲ MS3												▲ MS4																															
KDPs									▲ KDP-A				▲ ASM												▲ KDP-B				▲ KDP-C												▲ KDP-D				▲ KDP-E																			
Reviews									▲ MCR				▲ SRR												▲ SDR				▲ PDR				▲ CDR				▲ MOR				▲ SIR				▲ FOR				▲ ORR				▲ GEO2 SIR											
Imager	PreF Study				Proc. Reqts				Procurement				▲ SRR				▲ PDR				▲ CDR				▲ PER				▲ FM1 Del.												▲ FM2 Del.																							
									Ph A Study				Phase B-D Development (6.5Yr)																																																			
Other Instruments	PreF Studies				Procur. Reqts				Procurem.				▲ PSM				▲ SRR												▲ FM1 Del.				▲ FM2 Del.																															
									Ph A Study				Phase B-D Development (6.5Yr)																																																			
GEO Spacecraft	Arch Studies				Reqts				Procurement				▲ PSM				▲ SRR				▲ PDR				▲ CDR				▲ Opt PER Rdy				▲ Opt Lnch Rdy																															
									Phase A-D Development												I&T/Launch				I&T/Launch																																							
GEO Ground									Data Delivery Prototyping/Pilots				Reqts				Procurement				▲ PSM				▲ SRR				▲ PDR				▲ CDR				Operation																											
									Ph A Study				Phase B-D Development (5Yr)																																																			



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

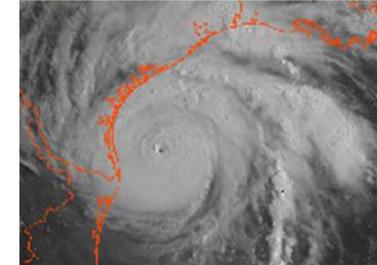
L1 Requirements Evolution	Timeframe/Use	Description/Content
Pre-formulation	Developed in 2019; used for BAA studies	Observational requirement range tables
★ Initial	Developed in 2020; used for MCR & Phase A	Program requirements for MCR content
Baseline	Baselined at SRR in 2022 for Phase B/C/D	Full program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



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

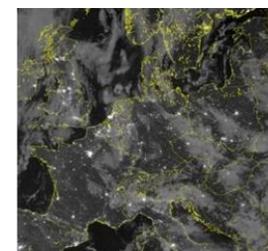
Visible & Near-IR Imagery



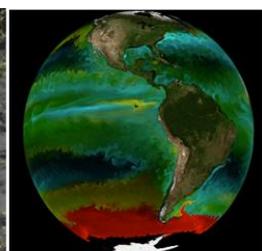
Lightning Mapping



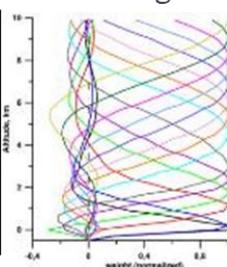
Day/Night Imagery



Ocean Color



Sounding





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

MILESTONE	DATE (assume 1 st day of quarter)
Flight Contract Award	Q3 FY23
Flight Model 1 Pre-Ship Review (PSR1)	Q1 FY30
Launch 1 Readiness Date	Q1 FY32
Flight Model 2 PSR (PSR2)	Q3 FY32
Launch 2 Readiness Date	Q4 FY34

Imager Baseline Requirements & Prioritized Options for Phase A Study



Baseline Requirements				Optional Improvements											
				Priority 1 - Mission Focused				Priority 2 - Mission Optimal				Priority 3 - Mission Enhancing			
Band Center (um)	Band-width (um)	SNR/ NEDT	Spatial Reso. (km)	Band Center (um)	Band-width (um)	SNR/ NEDT	Spatial Reso. (km)	Band Center (um)	Band-width (um)	SNR/ NEDT	Spatial Reso. (km)	Band Center (um)	Band-width (um)	SNR/ NEDT	Spatial Reso. (km)
0.47	0.04	300	1	0.47	0.04	300	1	0.47	0.04	250	0.5	0.41	0.02	300	1
0.55	0.02	300	1	0.55	0.02	300	1	0.55	0.02	250	0.5	0.443	0.02	300	1
0.64	0.1	300	0.5	0.64	0.1	250	0.25*	0.64	0.1	250	0.25*	0.47	0.04	250	0.5
0.86	0.039	300	1	0.86	0.039	300	1	0.86	0.039	300	1	0.55	0.02	250	0.5
1.38	0.015	300	2	1.38	0.015	300	2	0.91	0.02	300	1	0.64	0.1	250	0.25*
1.61	0.06	300	1	1.61	0.06	300	1	1.38	0.015	300	2	0.86	0.039	300	1
2.25	0.05	300	2	2.25	0.05	300	1	1.61	0.06	300	1	0.91	0.02	300	1
3.9	0.2	0.15	1	3.7-3.9**	0.2	0.15	1	2.25	0.05	300	1	1.24	0.02	300	1
6.185	0.83	0.1	2	6.185	0.83	0.1	2	3.7-3.9	0.2	0.15	1	1.38	0.015	300	1
6.95	0.4	0.1	2	6.95	0.4	0.1	2	5.1	0.2	0.15	2	1.61	0.06	300	1
7.3	0.2	0.1	2	7.3	0.2	0.1	2	6.185	0.83	0.1	2	2.25	0.05	300	1
8.5	0.4	0.1	2	8.5	0.4	0.1	2	6.95	0.4	0.1	2	3.7-3.9	0.2	0.15	1
9.61	0.38	0.1	2	9.61	0.38	0.1	2	7.3	0.2	0.1	2	5.1	0.2	0.15	1
10.35	0.5	0.1	2	10.35	0.5	0.1	2	8.5	0.4	0.1	2	6.185	0.83	0.1	2
11.2	0.8	0.1	2	11.2	0.8	0.1	2	9.61	0.38	0.1	2	5.5/6.95****	0.4	0.1	1
12.3	1	0.1	2	12.3	1	0.1	2	10.35	0.5	0.1	2	7.3	0.2	0.1	2
13.3	0.6	0.3	2	13.3	0.6	0.3	2	11.2	0.8	0.1	2	8.5	0.4	0.1	2
								12.3	1	0.1	2	9.61	0.38	0.1	2
								13.3	0.6	0.3	2	10.35	0.5	0.1	1***
												11.2	0.8	0.1	2
												12.3	1	0.1	2
												13.3	0.6	0.3	2
* 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.															
Change Relative to ABI:				Priority 1 changes relative to Baseline:				Priority 2 changes relative to Priority 1:				Priority 3 changes relative to Priority 2:			
- 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				- Improve components for true color imagery to 0.5 km resolution				- 0.41 & 0.443um improve aerosol retrievals			
- Reducing 3.9um resolution improves fire detection				- Raise Tmax improves fire detection				- 5.1um monitors low level water vapor				- 1.24um helps cloud retrievals over snow			
				- Higher resolution in 2.25um improves daytime land/cloud imaging & matches EUM FCI				- 0.91um matches EUMETSAT's FCI and helps with low level water vapor				- Reduced 10.35um resolution helps with multiple applications			
												- 13.6 band helps cloud property retrievals			





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

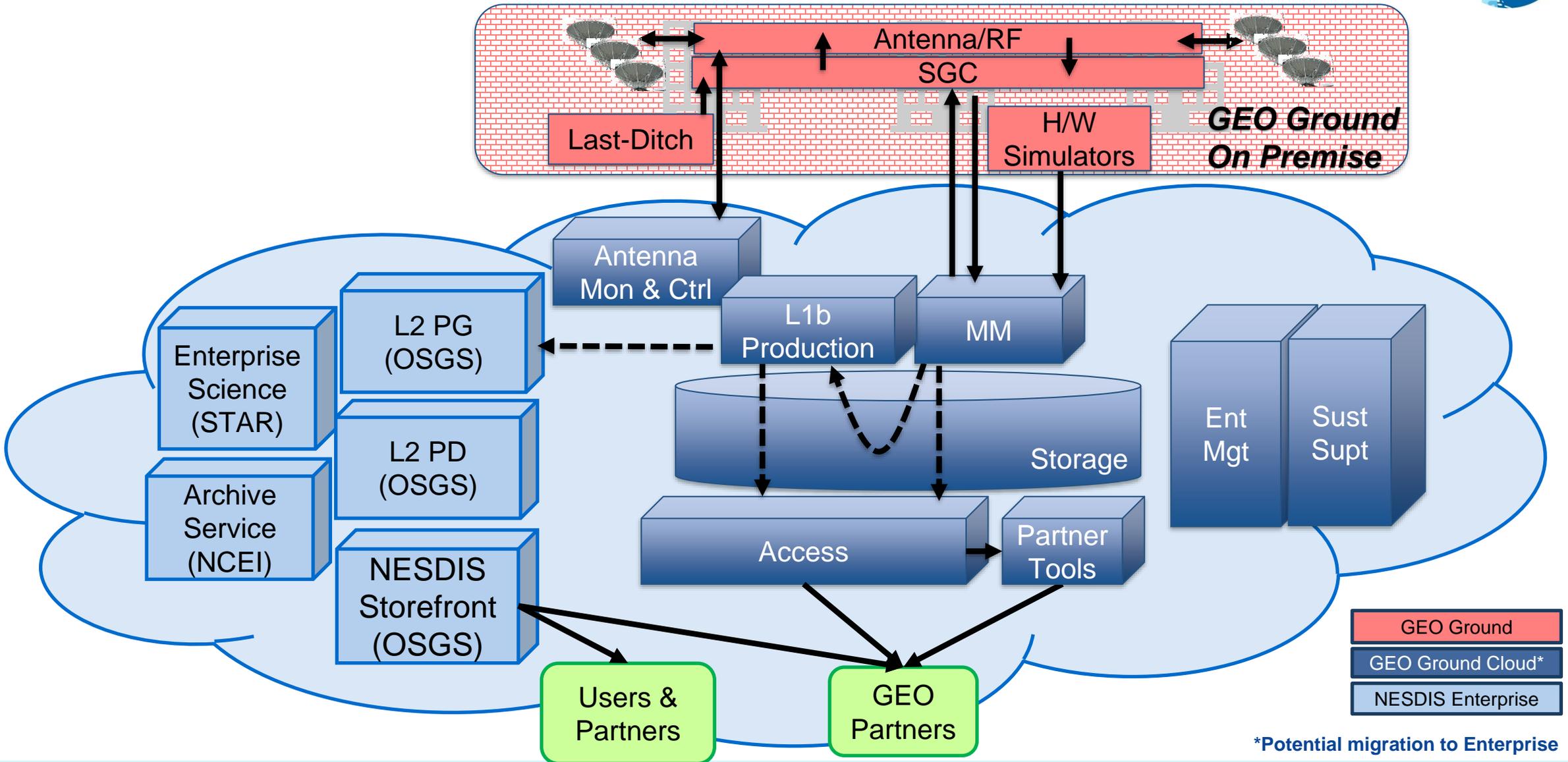




Ground System Formulation

- 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

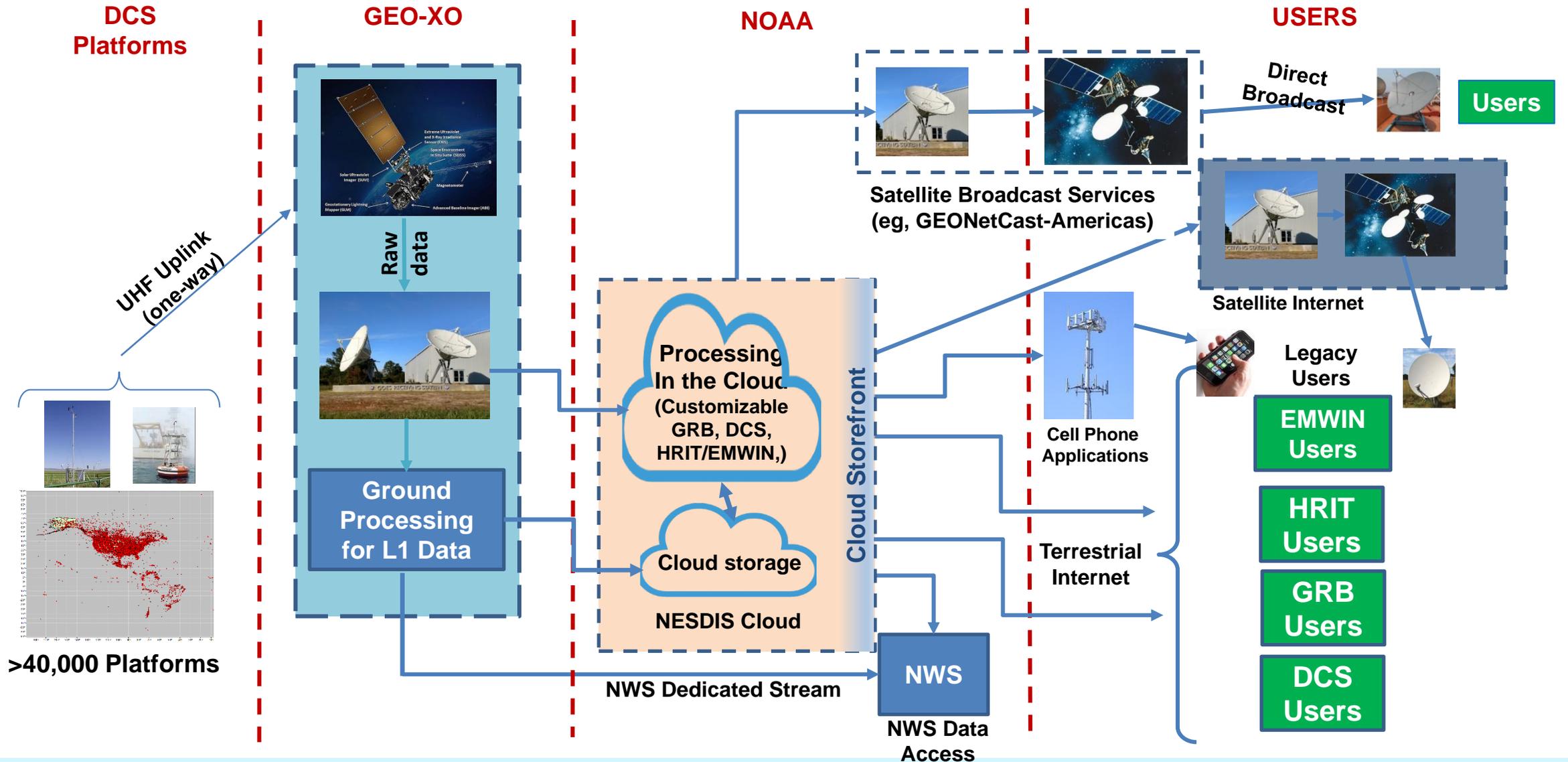


*Potential migration to Enterprise

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



Anticipated GEO-XO Data Distribution



Anticipated GEO-XO User Readiness Activities during Formulation



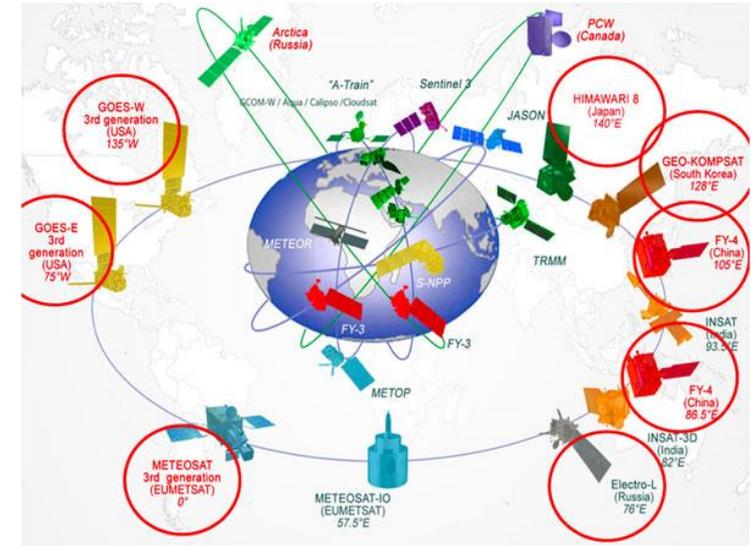
- New GEO-XO data delivery options will be piloted
 - Cloud-based data delivery option as alternative to GOES Rebroadcast (GRB) and Emergency Managers Weather Info Network/High Rate Info Transmission (EMWIN/HRIT) streams
 - Plans to start piloting cloud-based options using GOES-R data in ~2022
 - Run 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



Partnership Formulation Activities

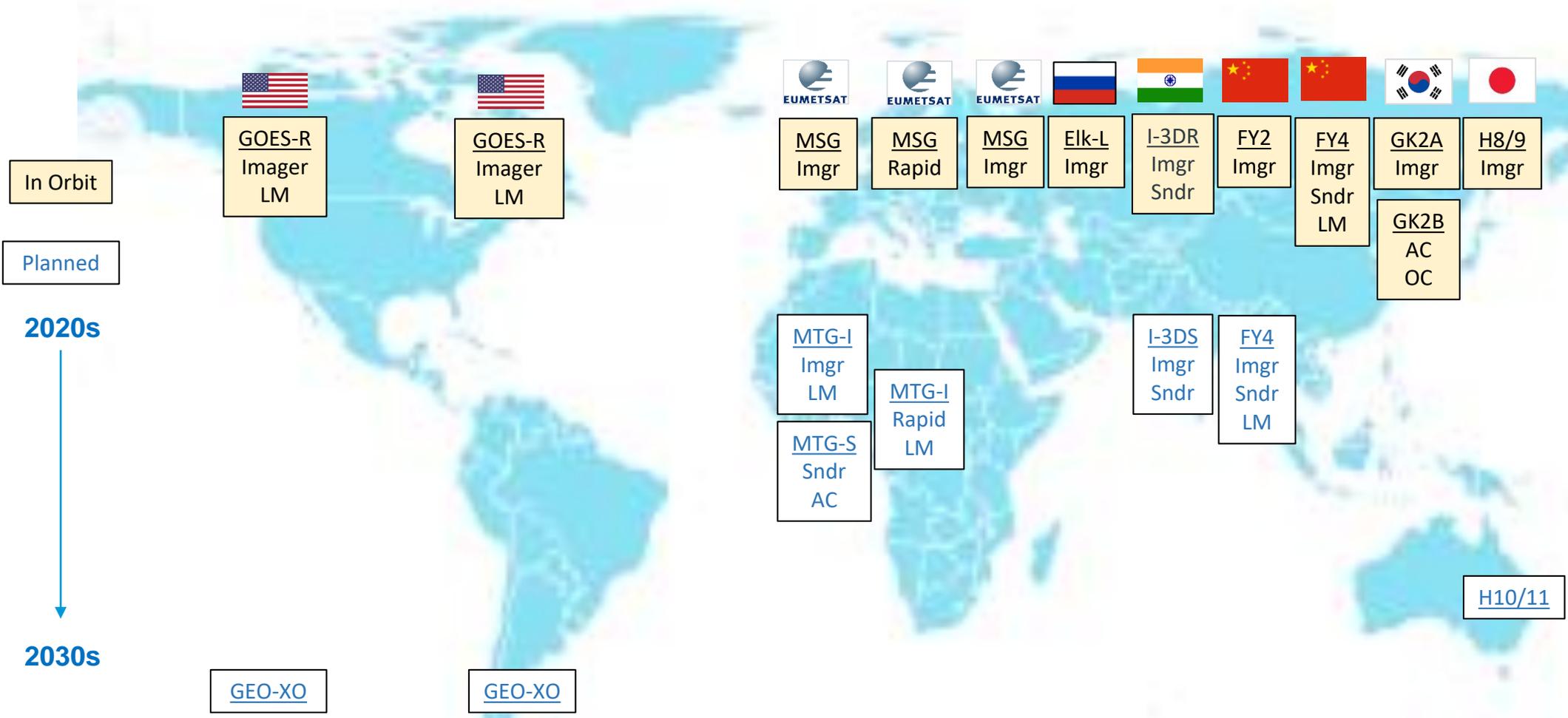


- Formalize GEO-XO support for NESDIS Space Weather Program
 - GEO spacecraft expected to accommodate solar-viewing and/or in-situ instruments
 - GEO ground system may provide services for SWP mission
- Pursuing dialog with NASA on Earth observation cooperation
 - *Supports National Academies 2017 Decadal 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





Geostationary Ring of Meteorological Satellites





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

