GeoXO Update

DCS Baseline & Current Prototyping Efforts

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GOES DCS 128th Technical Working Group

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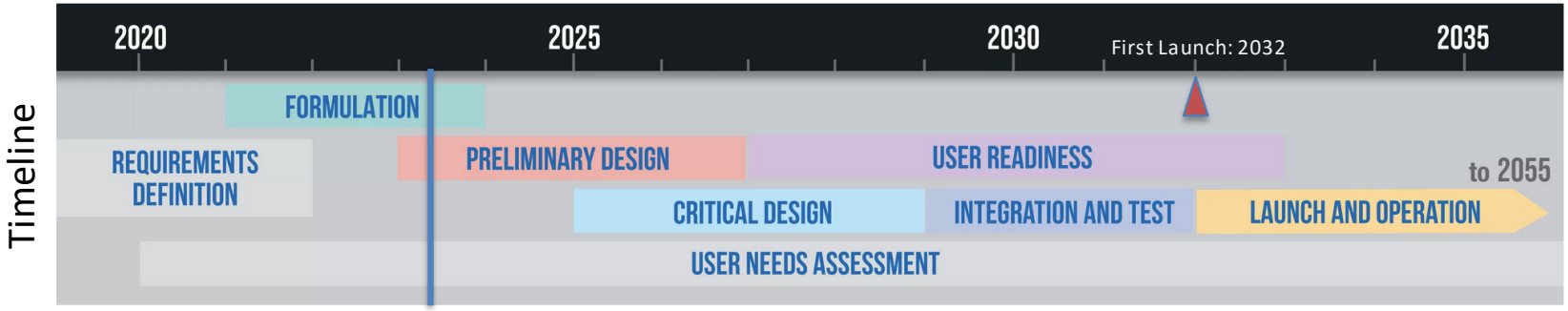
GeoXO / GOES-R Staffing Updates

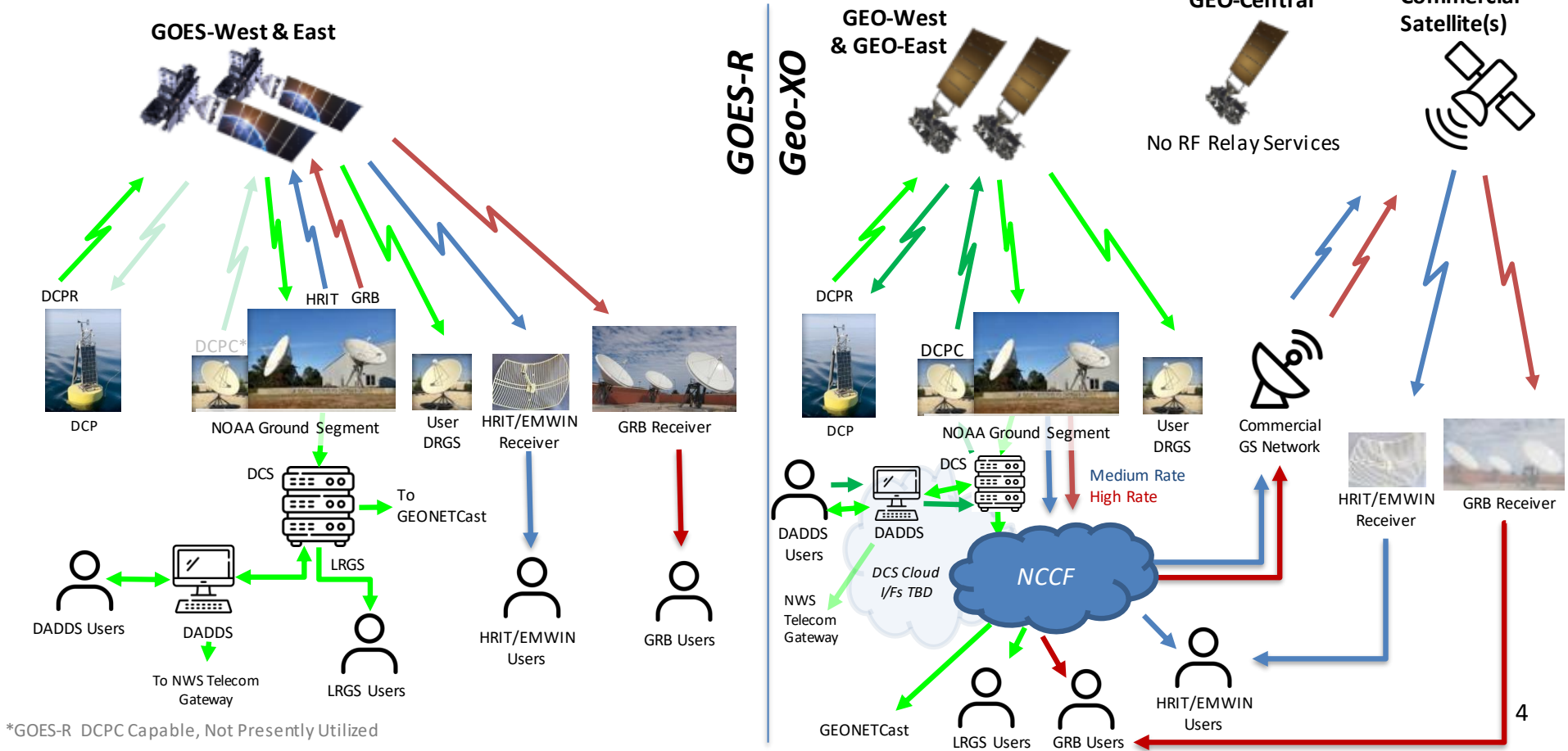
- Craig Keeler retiring later this year
- Daniel Gillies (me) is new Deputy Program Systems Engineer
  - DCS Related Focus Areas
    - RF User Services (DCS, HRIT/EMWIN, GRB) & Requirements
      - FWD Link Architecture, CONOPS, and Prototyping
      - Commercial Rebroadcast
      - GeoXO to Cloud Services
    - Support GeoXO Data Distribution Studies & Implementation w/ Office of Common Services (OCS) & Office of Satellite & Product Ops (OSPO)
    - Program Office RF Licensing Focal
  - Contact Info: daniel.gillies@noaa.gov

What is GeoXO?

- ***GeoXO = Geostationary Extended Observations***
  - GOES-R follow-on to provide continuity for geostationary environmental observations
    - Continues and improves observations for weather forecasting
    - Extends observations to ocean and atmospheric monitoring
    - Provides environmental data broadcast via commercial satellite services
- NOAA-NASA Partnership
- Series of six satellites, operated in a constellation of three:
  - East + West locations: Imager, Lightning Mapper, Ocean Color, **DCS**
  - Center location: IR Sounder, Atmospheric Composition

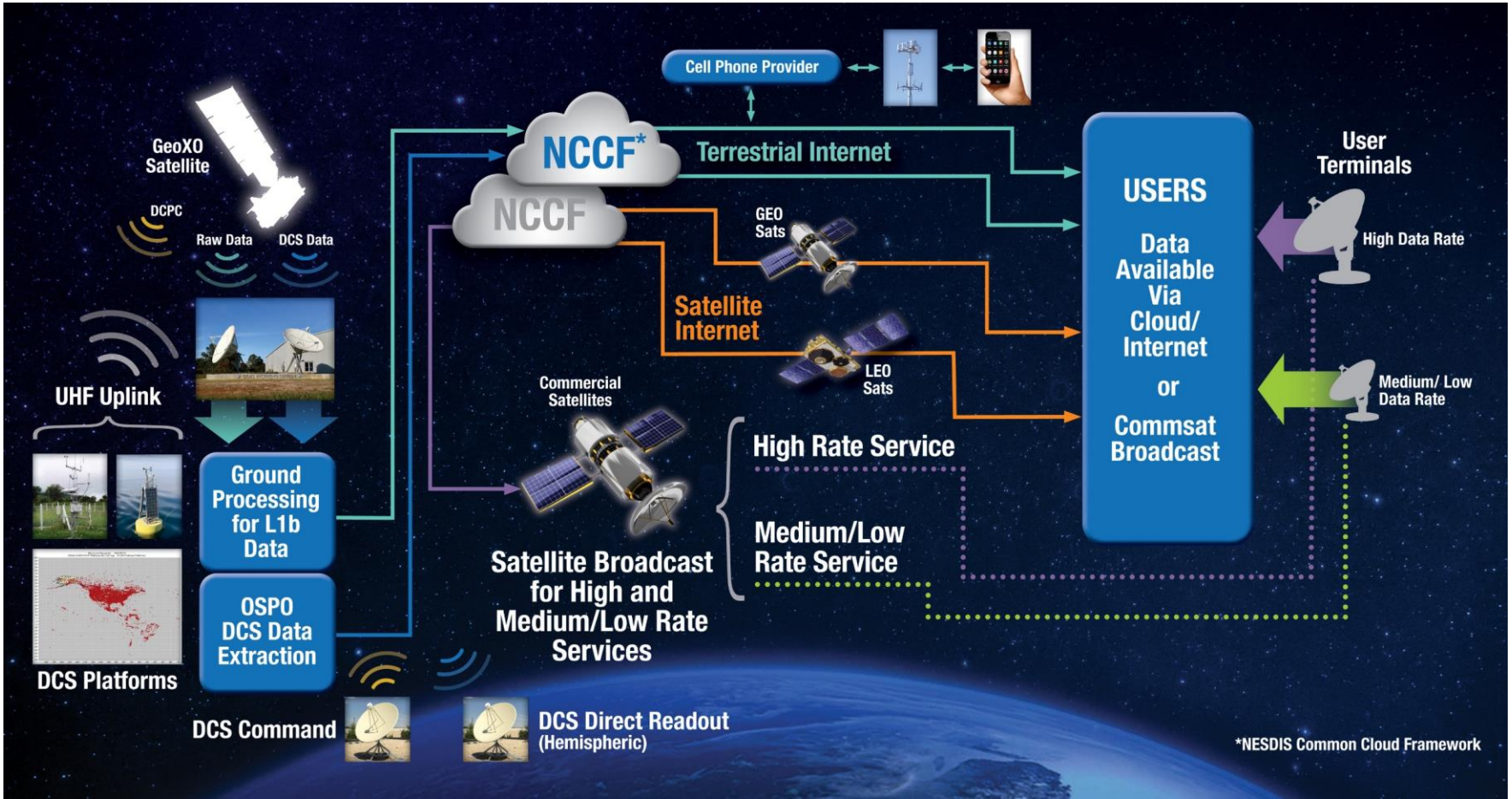


GOES-R vs. GeoXO
RF Data Relay & Distribution Services



*GOES-R DCPC Capable, Not Presently Utilized

GeoXO Data Distribution O/V



GeoXO – Cloud Prototyping

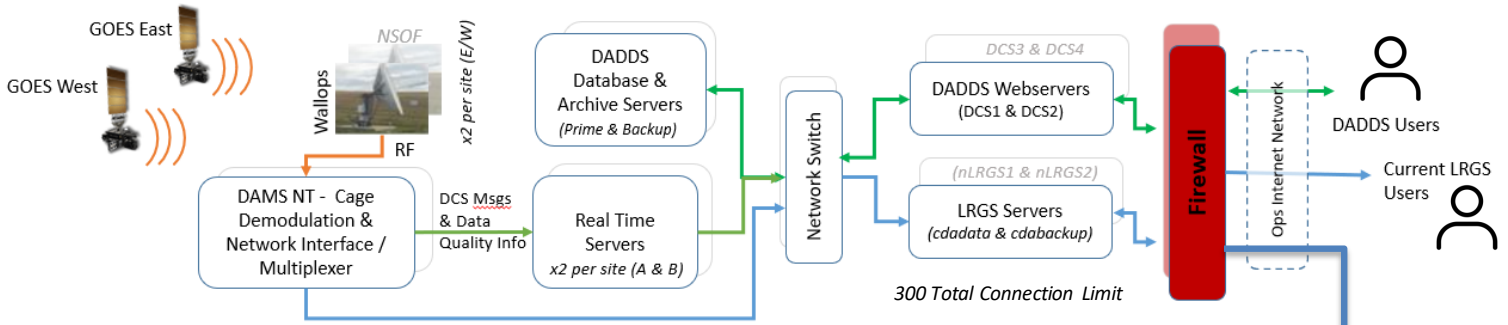
- Currently conducting proof of concept activities for the provision of DCS data via terrestrial cloud services
  - Cloud distribution allows for significant scaling of maximum concurrent users
  - Cloud services allow for data 'topic' subscription and notification services
    - Example: Users subscribe to only their agencies data and obtain an alert when new data has been received from their DCPs
  - Cloud storage allows archiving and query based data retrieval that can be scaled to user needs
  - Cloud architecture allows for processing of data within the cloud

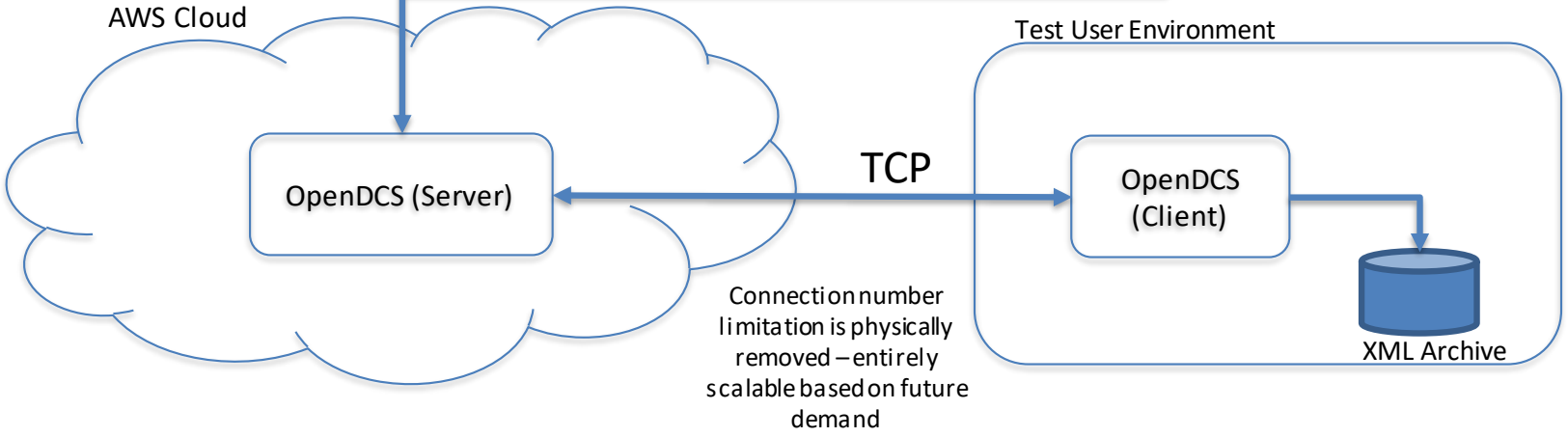
- Initial demonstrations are utilizing LRGS data (NOAA LRGS server → AWS Cloud)
  - NOAA National Ocean Service already utilizing a similar architecture; acting as test user for proof of concept
  - OpenDCS installed in cloud environment to ingest and host data to external OpenDCS client
  - GeoXO proof of concept evaluating new distribution streaming protocols (Kafka), topic subscription, performance

- Future Work
  - Generating architecture, CONOPS, and requirements to support DADDS cloud compatibility
  - Expanding number of LRGS cloud test users in further proof of concepting
  - Hosting of LRGS server (i.e. cdadata, cdabackup, nlrgs1, nlrgs2) in cloud environment

Simplified Cloud Proof of Concept Architecture

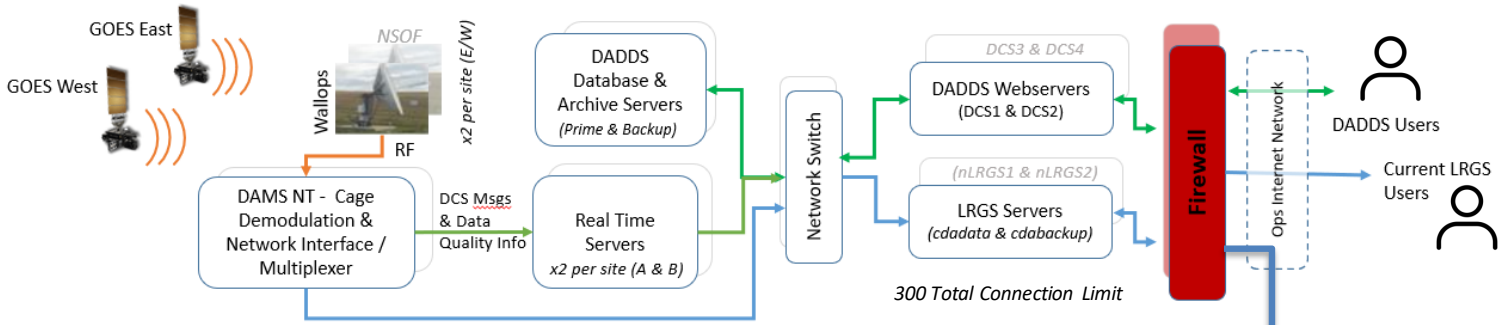
Demonstration 1

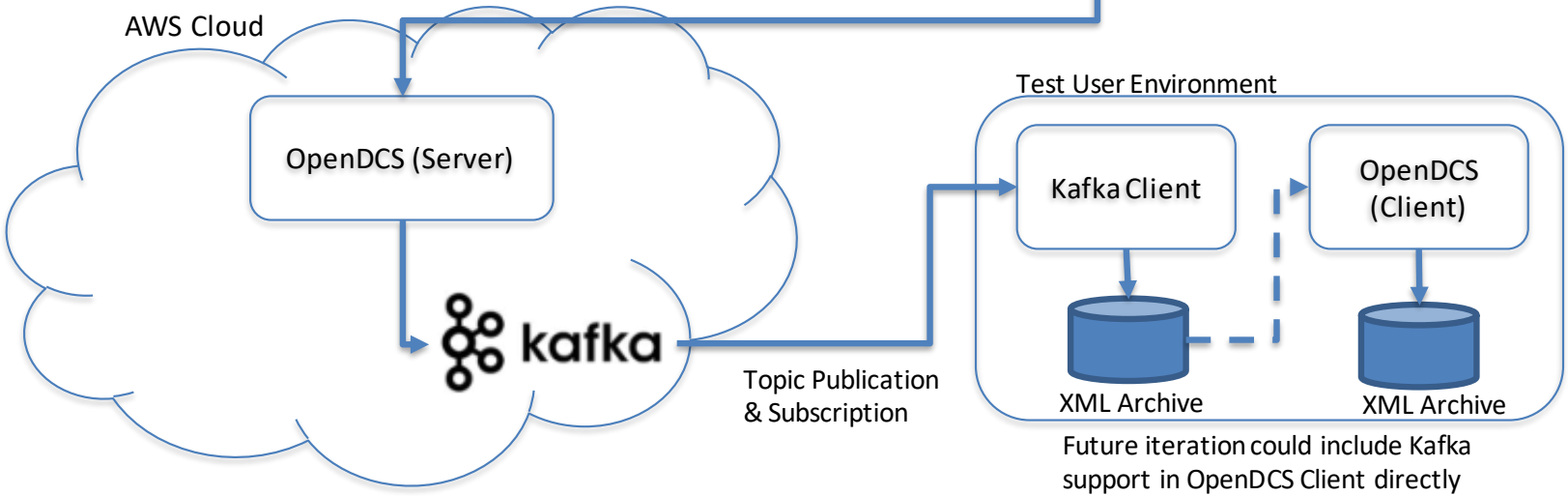




Simplified Cloud Proof of Concept Architecture

Demonstration 2





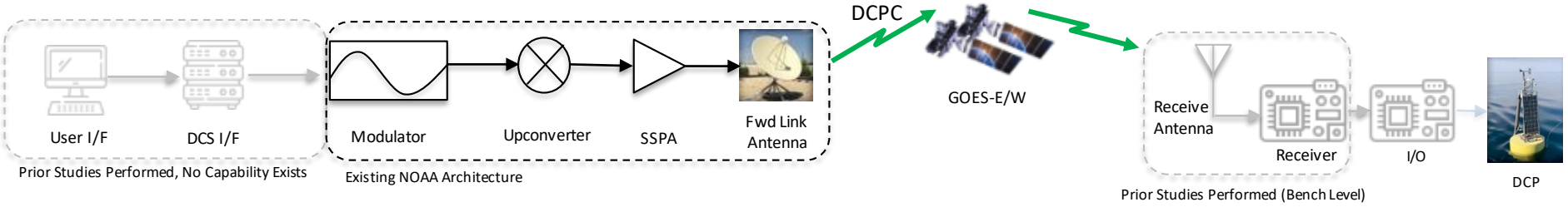
GeoXO – Forward Link

- GeoXO has added baseline DCPC forward link requurements to the GEO-West and GEO-East Spacecraft
  - Capability is intended to match current GOES-R latent capability
  - Forward link demonstrations performed by Sutron and Microcom in the past
  - GeoXO prototyping a fieldable, low cost ($500 - $600), modern DCPC receiver
    - Reference design for DCP developers
    - Performance benchmarking and functional tests using GOES-R
  - Field demonstrations @ Wallops planned for Q3 2023 with GOES-R

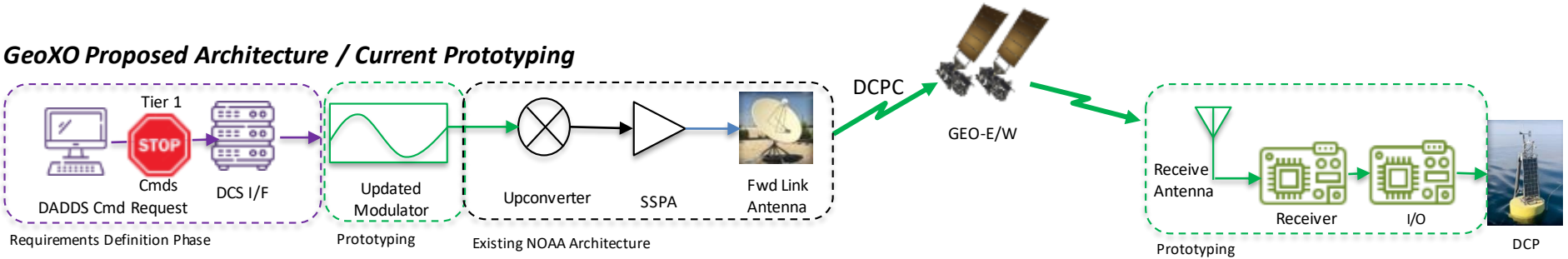
- GeoXO Forward Link is not set in stone
  - Traceable user demand for capability required to justify cost expenditures
  - GeoXO will work with DCS Program Manager & User Engagement on capturing demand in advance of GeoXO PDR (2025)

GeoXO – Forward Link Architecture

GOES-R Current System Architecture / Prior Prototyping



GeoXO Proposed Architecture / Current Prototyping



Commanding CONOPS - GeoXO

User DCP Command Need

User Logs Into DADDS

User Selects DCP(s)

User Selects Command

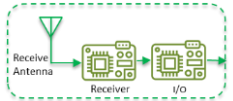
Tier 1 Command
- Effects DADDS Configuration or RF Link (Power, Mode, Timing….)
- Resets or Power Cycles DCP

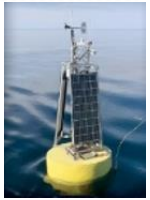
Command Reviewed & Approved by DCS Team

Command Queued & Issued

DCPC

GeoXO Fwd Link Receiver





Tier 2 Command
- DCP Statistics or Status
- Data Queries
- DCP General Configuration (no impact to DADDS config or RF link)

Command Logged, No Approval Required

Command Queued & Issued

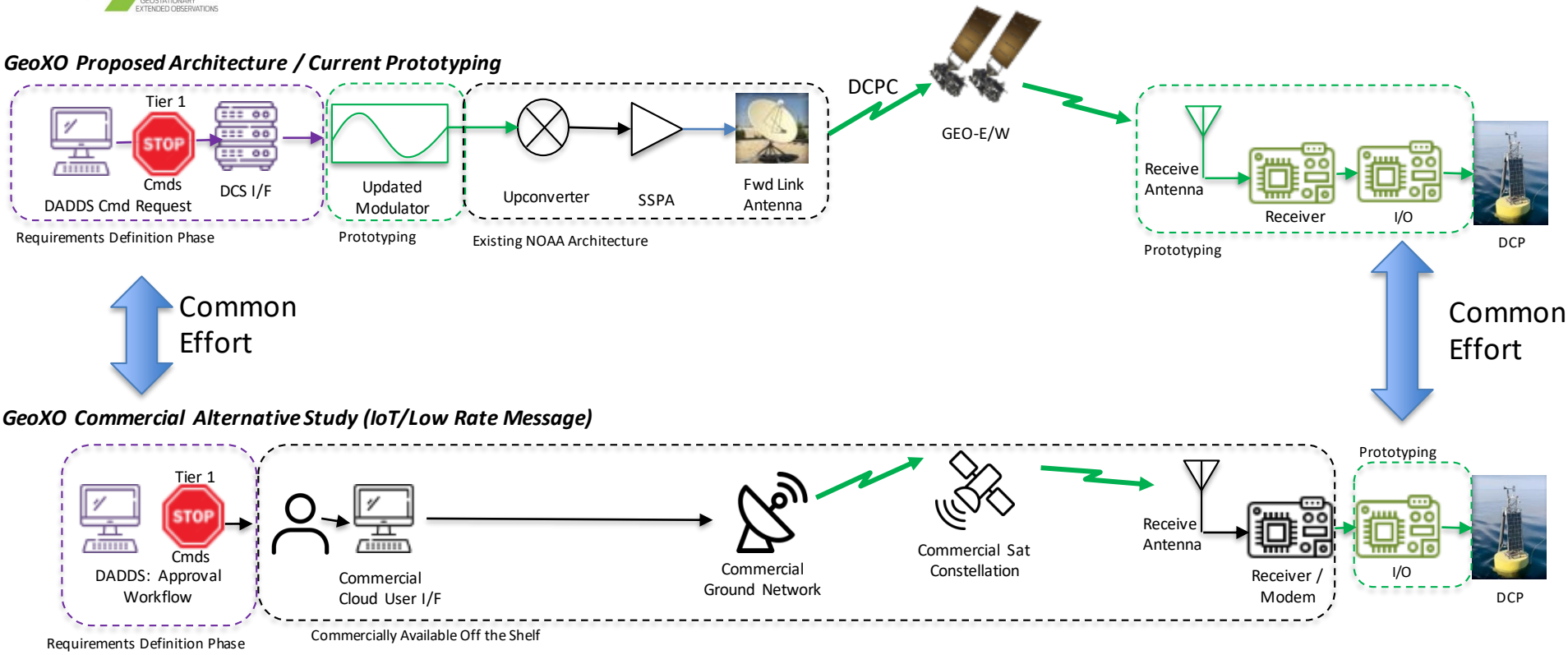
DCPC

Predefined timing (i.e. end of DCPR window) or random – dependent on DCP Receiver Config

Forward Link Commercial Alternative

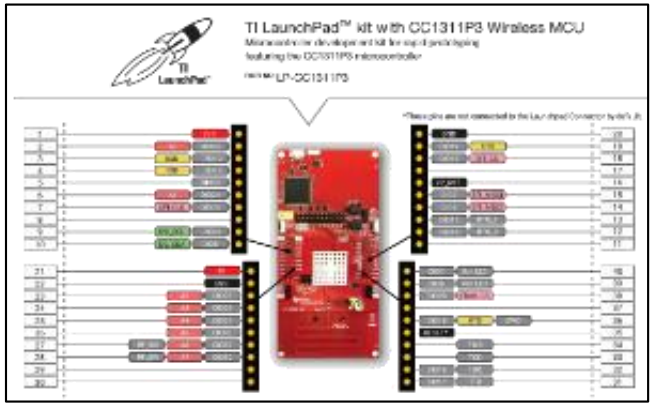
- DCP manufacturers currently offer commercial alternatives for DCP connectivity
  - Cellular: Coverage limited, moderate costs
  - Current Generation Satellite: Adequate coverage, high costs (mode dependent)
- New satellite 'Internet of Things' (IoT) networks may offer low cost forward link alternative
  - IoT Hardware Costs: Less than $100, Commercial off the Shelf (COTS)
  - IoT Network Costs: As low as $60 Year
  - IoT Network Coverage: Hemispheric Coverage – Pass availability dependent on provider
    - Current IoT Networks → Multiple passes per day; Gaps from 15 minutes to 4 hours
    - Future IoT Network (2024/2025) → 15 minute gaps more typical
- Satellite IoT Forward Link is available today
- I/O interface to DCP is equivalent to GeoXO Fwd Link requirements
  - GeoXO evaluating proof of concepting commercial forward link capability

GeoXO – Forward Link Architecture



GeoXO – Fwd Link Receiver Prototyping

- Fieldable Fwd Link Receiver Prototype
  - Based on TI LaunchPad Microcontroller
  - Integrated Sub 1-GHz Radio
    - Will utilize GOES-R Fwd Link Frequency (468 MHz)
  - Prototype costs less $100



- Interested in feedback on proposed configuration (below)
  - Bandwidth differs from prior demos intentionally – we believe we can be more robust to interference while providing East/West satellite forward links simultaneously with overlapping coverage

Sutron 2-Way Demo (DSSS)		Microcom 2-Way Demo (FHSS)		GeoXO 2-Way Demo (FHSS) - Proposed	
Bandwidth	50 kHz	Bandwidth	50 kHz	Bandwidth	100 kHz
Coding Rate	25,000 cps	Number of Hops	60	Number of Hops	64
		Hop Dwell Time	0.1 seconds	Hop Dwell Time	0.1 seconds
		Hop Spacing	12.5kHz/16 = 781.25 Hz	Hop Spacing	50kHz/32 = 1.5625kHz
		Hop Cycle	6 seconds	Hop Cycle	6.4 seconds
Symbol Rate	200 sps	Symbol Rate	200 sps		
Modulation	OQPSK	Modulation	QPSK	Modulation	(G)MSK
Data Rate	400 bps	Data Rate	400 bps	Data Rate	400 bps
				Data Whitening	PN9

Commanding CONOPS - Commercial

User DCP Command Need

Tier 1 Command
- Effects DADDS Configuration or RF Link (Power, Mode, Timing….)
- Resets or Power Cycles DCP

User Logs Into DADDS

User Selects DCP(s)

User Selects Command

Command Reviewed & Approved by DCS Team

User Logs Into Commercial Network Portal

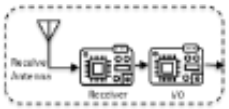
User Selects DCP(s)

User Selects Command

Command Queued & Issued

Commercial IoT Ground Network

IoT Modem, Antenna & I/O I/F



No DCS/DADDS Command Review Required for Tier 2 Commands in Commercial CONOPS

Thank you

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