

Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis of Low Latency Data Access from LEO Meteorological Satellites

Presented to CGMS-54 Working Group I session, agenda item 6.5

Presentation prepared in response to CGMS Action WGI/A52.02

TG	AGN item	Action #	Description	WP
LLDA	5.6	WGI/A52.02	Identify concrete CGMS actions based on the LLDA SWOT, including priority areas and demonstration cases in agencies. E.g. cloud, TT&C, relation with private sector, etc.	CGMS-54-EUMETSAT-WP-03

Associated CGMS HLPP:

- **2.8 New technologies for satellite systems**
 - 2.8.1 Assess the Internet-Of-Things technology for inter- and intra-connections between satellite and ground network;
 - 2.8.2 Explore improvements to LEO satellite systems low latency data access from both a global and regional perspective, harnessing common emerging technologies and taking account of the evolution of the commercial and agency space systems.

SWOT Analysis of Low Latency Data Access from LEO Meteorological Satellites

Scope

The core meteorological satellite systems in LEO orbits, and other operational satellite systems where applicable, should ensure low latency data access of imagery, sounding, and other real-time data of interest to users. Application areas where low latency and availability is suitable include Severe Weather Monitoring, Nowcasting and Short and Medium-Range Numerical Weather Prediction. Other application areas could also benefit from very low latency products, e.g. ionospheric monitoring.

Today, LEO meteorological satellites have two distinct services for providing low latency data to users:

- Global service: where the full orbit data is stored on-board and served at the pole(s);
- Regional or local service: real time dissemination of instruments data to a network of direct broadcasts stations.

The goal of this CGMS paper is to analyse the Strengths, Weaknesses, Opportunities, and Threats (SWOT) of current LEO weather satellites systems to identify how low latency data access solutions could help in improving timeliness globally.

Coordination Group for Meteorological Satellites - CGMS

<h2>S Strengths</h2>	<h2>W Weaknesses</h2>	<h2>O Opportunities</h2>	<h2>T Threats</h2>
<p><u>Maturity:</u></p> <ul style="list-style-type: none"> Well established LEO weather space segment Well established ground segment worldwide for local and global missions Well established coordination at CGMS, DBNET and WMO levels. Well established standards and best practices Well established data distribution mechanisms to users <p><u>End2End ownership of data chain:</u></p> <ul style="list-style-type: none"> Owned space and ground equipment, giving more control over assets. Limited reliance on private sector in the data chain. 	<p><u>Downlink and Latency:</u></p> <ul style="list-style-type: none"> High latency over regions without direct broadcast, e.g. gap over oceanic regions Duplicated products between regional and global products Data rate limitation in direct broadcast X band <p><u>Cost:</u></p> <ul style="list-style-type: none"> Owned / dedicated ground equipment leading to higher costs. Communications links to multiple ground stations required. <p><u>Commanding:</u></p> <ul style="list-style-type: none"> No uplink outside polar regions Limited monitoring of space assets outside of polar regions 	<p><u>Commercial LEO weather data:</u></p> <ul style="list-style-type: none"> Commercial radio occultation data from LEO satellites (Spire, PlanetiQ). Plan for commercial microwave sounding by 2030. <p><u>Satellite data relay services:</u></p> <ul style="list-style-type: none"> GEO relay services. LEO relay services. <p><u>Ground stations services:</u></p> <ul style="list-style-type: none"> Ground stations as a service, which may offer phased array technology. <p><u>Cloud services:</u></p> <ul style="list-style-type: none"> Cloud service offering processing and dissemination within most latency requirements. <p><u>Satellite Platform:</u></p> <ul style="list-style-type: none"> Satellite Platform as a Service (SPaaS), covering launch to operations. 	<p><u>Dependence on private sector:</u></p> <ul style="list-style-type: none"> Reliance / dependence on a commercial service for the end2end ownership of data chain Volatile relay satellite operators market <p><u>Cost:</u></p> <ul style="list-style-type: none"> Relay constellation bandwidth cost, particularly GEO <p><u>Frequency protection:</u></p> <ul style="list-style-type: none"> Relay constellation increase pressure on the frequency spectrum <p><u>Security:</u></p> <ul style="list-style-type: none"> SPaaS and relay satellites: Increased security risks with commanding access to satellite. <p><u>Coordination & Standards:</u></p> <ul style="list-style-type: none"> Role of CGMS inter agency coordination unclear for data mechanism which may change (e.g. commercial, cloud) Standards needed for inter-satellite communications.

Legend: SWOT Priorities Areas

For further details on SWOT Table refer to: CGMS-54-EUMETSAT-WP-03

SWOT Priority Areas: Commercial LEO weather data opportunities

Commercial LEO weather data

- Commercial radio occultation data market:

Company	Number of Satellites	RO Occultations / Day	Customers
Spire Global	~110+ total CubeSats in constellation	~20,000	NOAA, NASA, EUMETSAT
PlanetiQ (GNOMES)	~5 operational with plans for ~20 total (GNOMES constellation)	~3,000–5,000+	NOAA and commercial
GeoOptics (CICERO)	~8–24+ CubeSats in CICERO & CICERO-2 constellations	Hundreds per day	NOAA and research customers.

- Spire Global announced plans to add microwave sounders to its existing satellite constellation by 2030;
- NOAA is developing a next-generation microwave atmospheric sounder program “Sounder for Microwave-Based Applications” (SMBA) for its Near Earth Orbit Network (NEON), which is planned to be provided by a commercial entity:
 - For further information, refer to [NESDIS NEON future program](#) and [NEON Factsheet](#).

SWOT Priority Areas: GEO and LEO data relay services opportunities

GEO and LEO data relay services

- All current satellites programs from the CGMS agencies foresee the use of global and direct broadcast.

CGMS agency	Satellite Series with Direct Broadcast System	Launch window	End of Operations
CMA	FY-3E, F, H, I, J	2021 - 2027	~2034
NOAA	JPSS2, 3 and 4	2022 – 2038	~2043
EUMETSAT	EPS-SG	2025 – 2037	~2042
	EPS-Sterna	2029 – late 2030s	~2042

- Although not foreseen in current plans, the use of satellite relay constellations can reduce data latency, improve coverage in regions lacking direct ground contact, and provide resilient network architectures for LEO weather missions, complementing existing ground stations coverage.
- Live connectivity to the LEO satellite provides the potential to perform TM&TC uplink operations outside ground segment coverage
- Standardisation of protocols and interfaces may be required as the technology matures (e.g. CCSDS ISL standards).

SWOT Priority Areas: ground station services opportunities

Ground station services

- Commercial offers providing ground station as a service (GSaaS) has been growing during the last decade:

Company	Estimated Number of Antennas	Geographic Reach	Core Focus
KSAT (Kongsberg)	300+ Antennas	28+ Global Locations	Largest global footprint; dominant in polar regions.
EQT (formerly Eutelsat)	~1,400 Antennas	100+ Global Locations	Primarily heritage GEO/OneWeb support, now pivoting to commercial GSaaS.
ATLAS Space Ops	50+ Antennas	34+ Global Locations	Federated network; focus on rapid data delivery (<60s latency).
Leaf Space	40+ Antennas	16+ Global Locations	Agile SmallSat support with automated, API-driven scheduling.
SSC (Swedish Space Corp)	~35+ Core Antennas	10+ Primary Sites	High-latitude specialists; second largest commercial network at Erange.
AWS Ground Station	12 - 15 Locations	Global (AWS Regions)	Integrated directly with AWS Cloud; typically 2-3 antennas per region.

- CGMS agencies are making use of GSaaS (CMA with SSC, NOAA with KSAT);
- NOAA currently testing phased array acquisitions in Svalbard in Ka band. Report to be available in mid 2026, findings can be presented in CGMS-55 (action suggested).

Concrete CGMS actions and recommendations based on the LLDA SWOT

CGMS HLPP 2025	Opportunities	Actions / Recommendations
<p><u>2.8 New technologies for satellite systems</u> 2.8.1 Assess the Internet-Of-Things technology for inter- and intra-connections between satellite and ground network. 2.8.2 Explore improvements to LEO satellite systems low latency data access from both a global and regional perspective, harnessing common emerging technologies and taking account of the evolution of the commercial and agency space systems.</p>	<p>Commercial LEO weather data</p>	<p><u>No further actions needed:</u></p> <ul style="list-style-type: none"> WGI satellite data and code already in place to manage commercial data format. Dissemination of commercial LEO weather data covered within existing WGIV activities.
	<p>GEO and LEO data relay services</p>	<p><u>No further actions needed:</u></p> <ul style="list-style-type: none"> Direct Broadcast and global mission to remain the low latency data access mechanisms for the programs. Data relay opportunities captured in SWOT analysis and covered in “Future Information Technologies - Internet-of-Things” CGMS-52-WGI-WP-06.
<p><u>3.3 Coordinated global data exchange</u> 3.3.1 Develop Best Practices for Global Data Exchange <u>3.8 Application of Cloud Technologies</u> 3.8.1 Develop best practices for cloud services interoperability</p>	<p>Cloud services</p>	<p><u>No further actions needed</u> within WGI, covered by WGIV scope (Cloud services interoperability CGMS-53-WGIV-WP-04).</p>

Conclusion

TG	AGN item	Action #	Description	WP
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Recommendation 1: No further actions needed regarding action WGI/A52.02

No further actions required on commercial sector, data relay constellations and cloud services (refer to slide 8).

Action 1: Enhance SWOT analysis for CGMS-55

- Report on feasibility and applications of phased array;
- Identify artificial intelligence applications opportunities within scope of LLDA task group, in coordination with WGII.

Thank you for your attention

END