GIASONE – GNSS Integrity and Authentication Services user-Oriented NEtwork

NAVISP ELEMENT 2 – ESA AO/1-10516/20/NL/MP (Issue 1.0)

FINAL PRESENTATION

30th January 2023 – ESA ESTEC

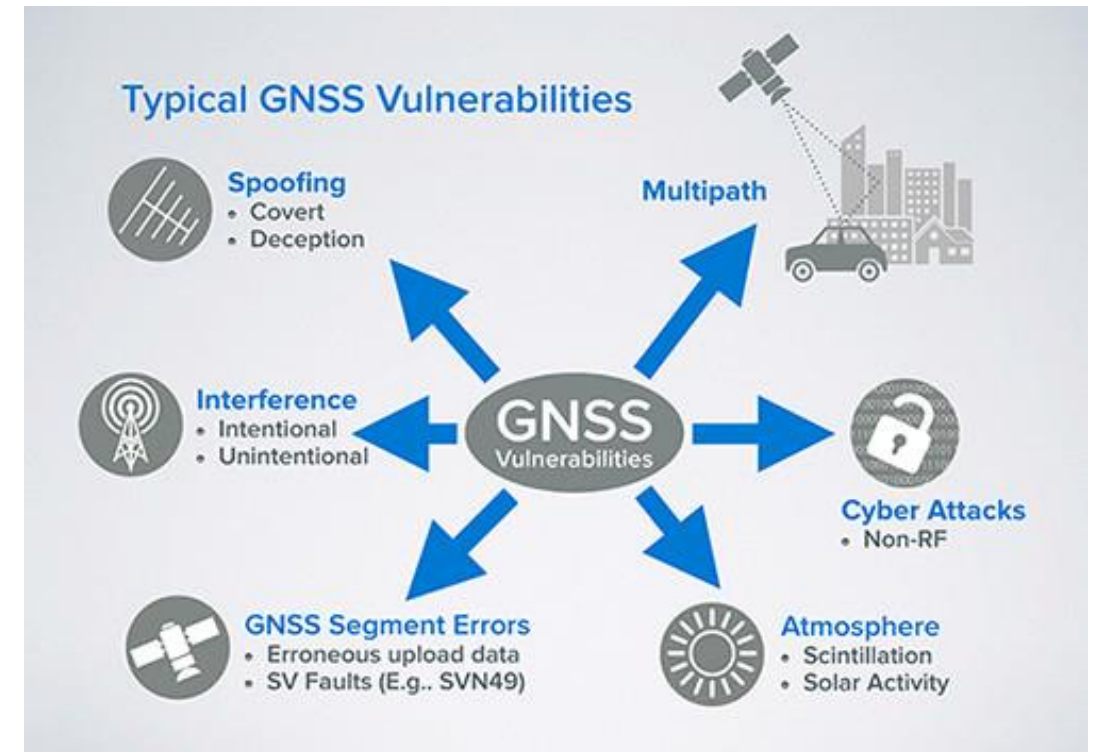Speakers: **S. Barsotti, F. Giuliani, M. Fè**

Agenda

1. Context & Rational

2. Outcome of the project

   - Project Description: services, key features and architecture

   - Pilot Results

3. Product Opportunities

4. Benefits of working with ESA
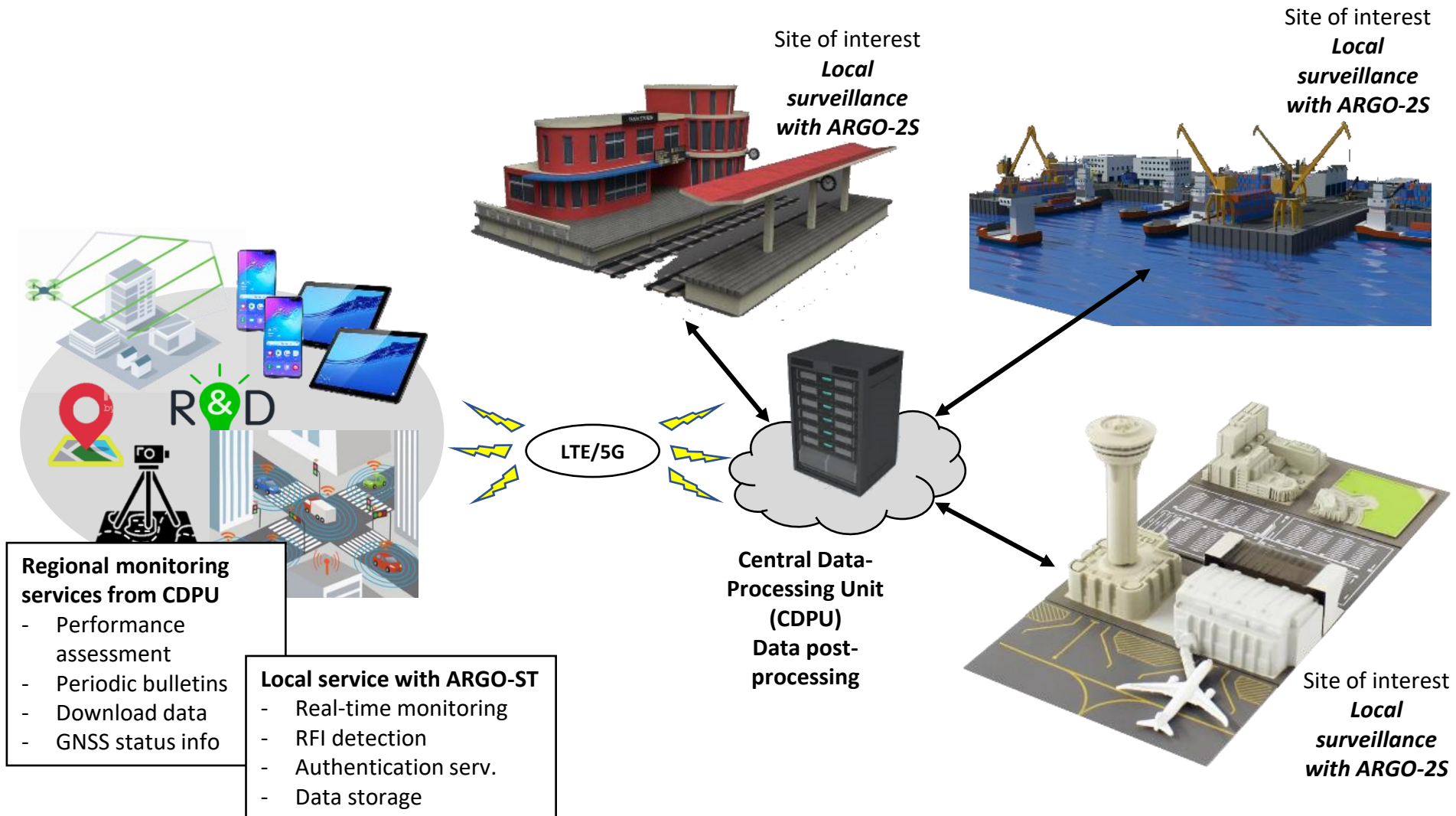
Context & Rational

GIASONE is a ground infrastructure conceived to provide a continuous monitoring of the main GNSS positioning services, including the signal authentication service developed in the framework of G-PASSION project. The mission of GIASONE is to improve the awareness on GNSS status including the detection of possible anomalies that may affect the GNSS, and the consequent emission of timely warnings to notify this event to the user.

The services offered by GIASONE may be grouped in three clusters:
- GNSS monitoring;
- RFI monitoring;
- Authentication.

Product description: Applications & Services

Site of interest
Local surveillance with ARGO-2S

Site of interest
Local surveillance with ARGO-2S

LTE/5G

Central Data-
Processing Unit
(CDPU)
Data post-
processing

Site of interest
Local surveillance with ARGO-2S

Regional monitoring services from CDPU
- Performance assessment
- Periodic bulletins
- Download data
- GNSS status info

Local service with ARGO-ST
- Real-time monitoring
- RFI detection
- Authentication serv.
- Data storage

Product description: services provided

Type of service	Local or regional
Local monitoring of GNSS positioning services	Local
GNSS spectrum monitoring	
RFI classification	
DoA estimation and localization of RFIs	
G-PASSION authentication (also referred to as centralized authentication)	
Diagnostic and anti-tampering protection	
Timely warnings emission in case of detected anomalies	
Legal recording	
Regional monitoring of GNSS performance	Regional
Centralized monitoring of ARGO-2S network	
Bulletin emission in case of anomalies	
Generation of periodic performance reports	
Central repository & download service	

Product description: safety critical applications

Services		Railways	Air-navigation	Maritime	Dangerous freight transports	Critical GNSS infrastructures
Local surveillance	Real-time monitoring	✓	✓	✓	-	✓
	Spectrum surveillance	✓	✓	✓	-	✓
	Legal recording	✓	✓	✓	-	✓
Remote support to navigation	Real-time info on GNSS status	✓	✓	✓	✓	-
	Periodic performance bulletins	✓	✓	✓	✓	-
	RAIM predictions	✓	✓	✓	✓	-
	Legal recording	✓	✓	✓	✓	-

Product description: non-safety critical applications

Non-safety-critical applications that may benefit from GIASONE services are listed below.

- Unmanned systems, autonomous vehicles, and other GNSS-oriented applications may take advantages from: near real-time information of GNSS status, periodic bulletins on GNSS performance, RAIM predictions, positioning authentication, etc.
- Road Transport, in particular insurance services, which may be interested in the authentication and data storage (legal recording) services provided by GIASONE.
- Scientific, geodetic applications, and R&D may consider useful the possibility to download raw or pre-processed data from GIASONE archive.
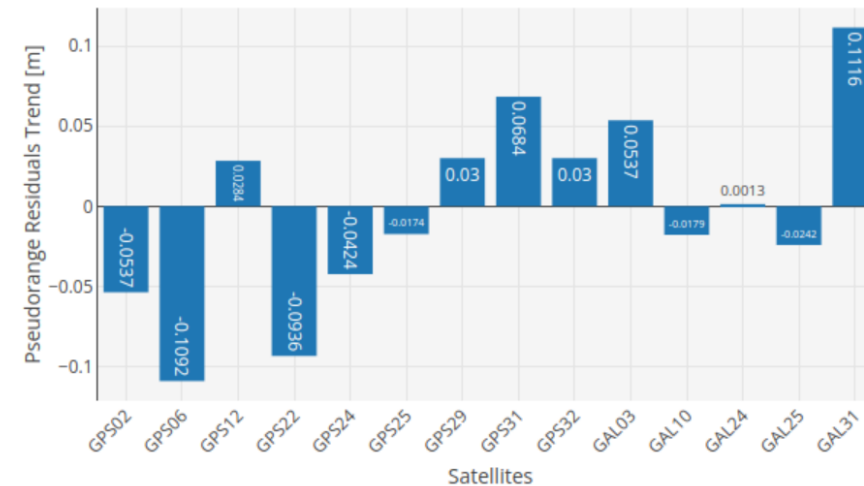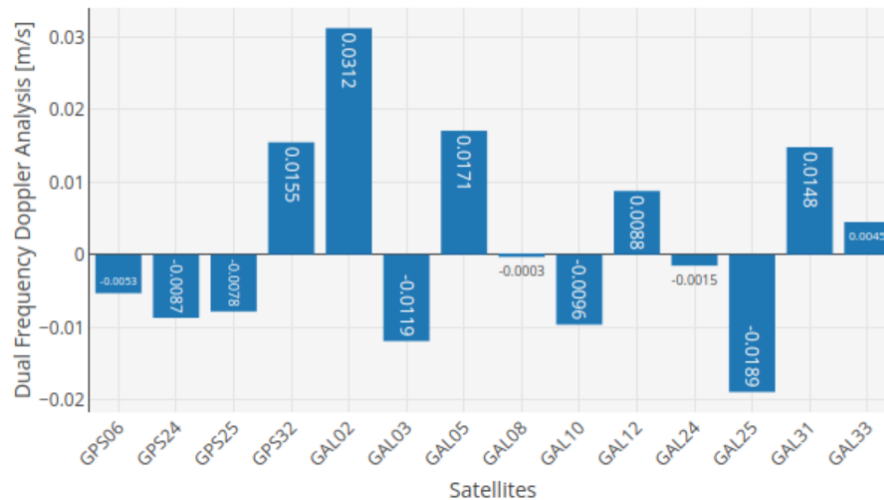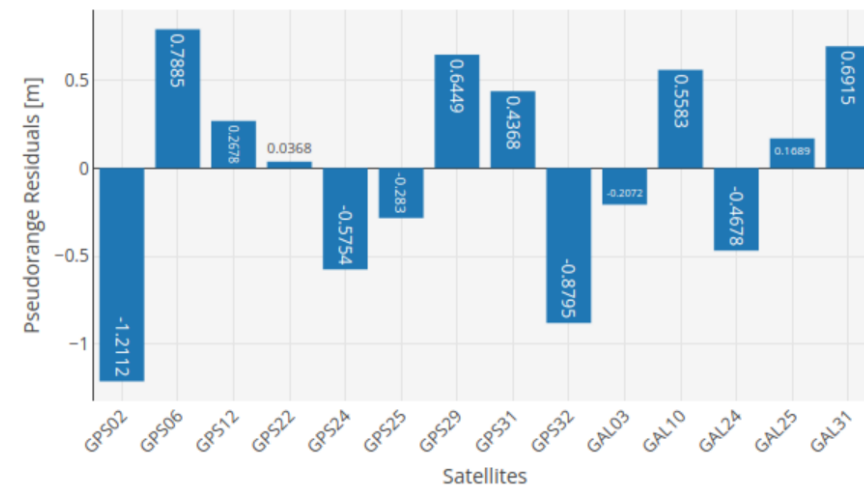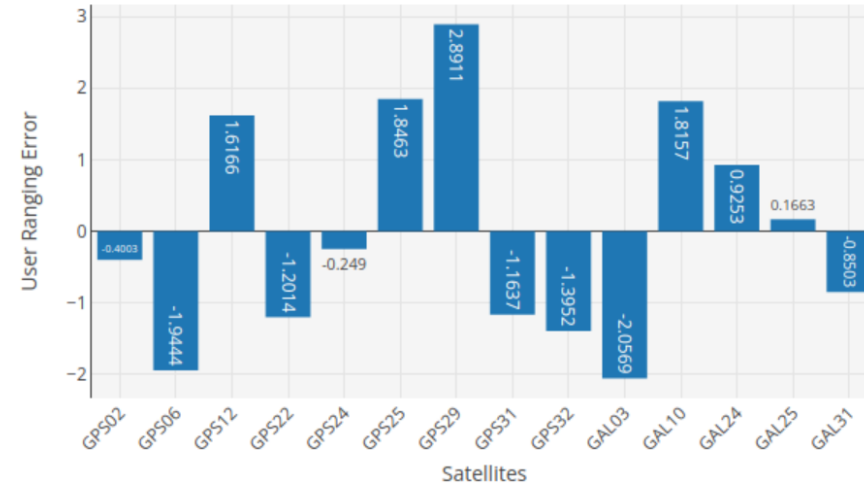
Product description: innovations

Most innovative contributes coming from GIASONE project:

- **Mission** – One the most innovative aspects behind GIASONE concept is to enlarge the audience of users enabled to receive info on the GNSS status, permits to also keep informed those users that everyday exploit GNSS for professional or recreational purposes.

- **SDR-based technology** – SDR approach is considered the enabling technology to permit the implementation of a GNSS equipment able to analyse the entire GNSS stack by harmonizing aspects of performance and reliability with those of configurability, flexibility and upgradability.

- **User-oriented services** – As stated before, GIASONE aims at providing a plenty of user-oriented services in order to reach, as much as possible, the widest audience of GNSS users. Table 2–2 provides a preliminary matrix service vs users.

Product description: GNSS monitoring

GIASONE provides a set of metrics to monitor the behaviour of the GNSS positioning system. Some metrics are evaluated in the measurement domain while others are provided in the position domain.

Product description: RFI monitoring

GIASONE monitors the GNSS spectrum to identify the presence of eventual interferers. In case of detected interference, the system attempts to determine its category

If the ARGO is equipped with a DF unit the DoA of the RFI source is provided and, if it is seen by multiple DF units, its location is shown on the map.

Actions	Refererence Time	DF Unit	Interference Id	Frequency	Bandwidth	Interference Type	Azimuth	Status
	08:33:51.169		99					Select...
✓ ✗	2022-11-28T08:33:51.169Z	ARGO	99	1576450000	23272	Cw	0	Closed

Product description: authentication

Ref. Time	Authenticated Satellites	Estimated Probability of Detection [%]	Max Snapshot delay [ms]	Authentication Results
Ref. Time				Select...
2022-12-22T09:24:00.000+00:00	13	1.2042 - 99.9482 (**52.576**)	0.7406	AUTHENTICATED
2022-12-22T09:22:00.000+00:00	12	1.1579 - 99.417 (**49.3072**)	0.592	AUTHENTICATED
2022-12-22T09:20:00.000+00:00	10	16.6783 - 99.9607 (**64.982**)	0.5956	AUTHENTICATED
2022-12-22T09:18:00.000+00:00	11	5.6034 - 99.8189 (**60.4067**)	0.5919	AUTHENTICATED
2022-12-22T09:16:00.000+00:00	11	1.2335 - 99.9117 (**59.3182**)	0.6109	AUTHENTICATED
2022-12-22T09:14:00.000+00:00	7	1.4842 - 96.9282 (**53.4899**)	0.8734	AUTHENTICATED
2022-12-22T09:12:00.000+00:00	11	1.1969 - 97.1184 (**40.7169**)	0.785	AUTHENTICATED
2022-12-22T09:10:00.000+00:00	9	6.4643 - 96.882 (**53.5797**)	0.5872	AUTHENTICATED

Authentication Report. Reference Time: '2022-12-22T09:24:00.000+00:00'   —   ×
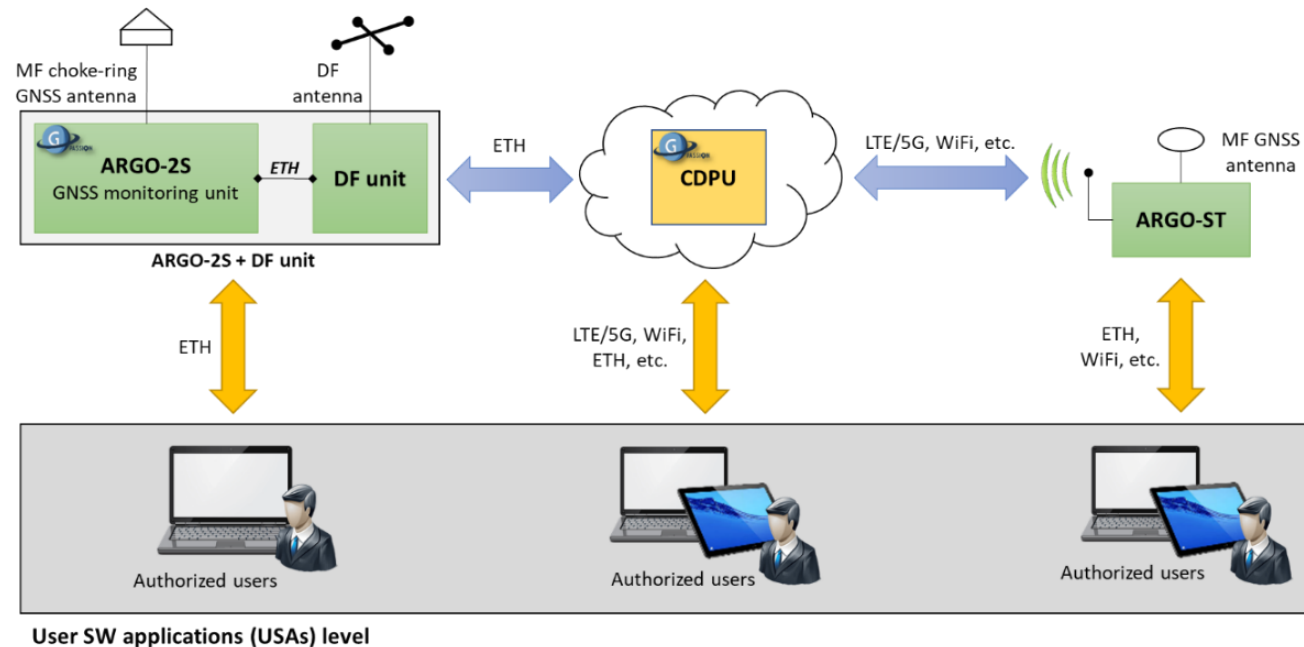
Satellites	ARGO-2S Pisa 192.168.31.21 - Estimated Probability of Detection [%]	ARGO-2S Pisa 192.168.31.21 - Snapshot delay [ms]	ARGO-2S Pisa 192.168.31.21 - Alignment	ARGO-2S Pisa 192.168.31.21 - Authenticated
GAL03	79.6981	-0.5801	✓	✓
GAL05	99.568	-0.5801	✓	✓
GAL09	77.7729	-0.58	✓	✓
GAL15	-	-	⊖	⊖
GAL24	99.9482	-0.58	✓	✓

«   ‹   1   2   3   4   ›   »

GIASONE provides the authentication service by means of authentication reports.
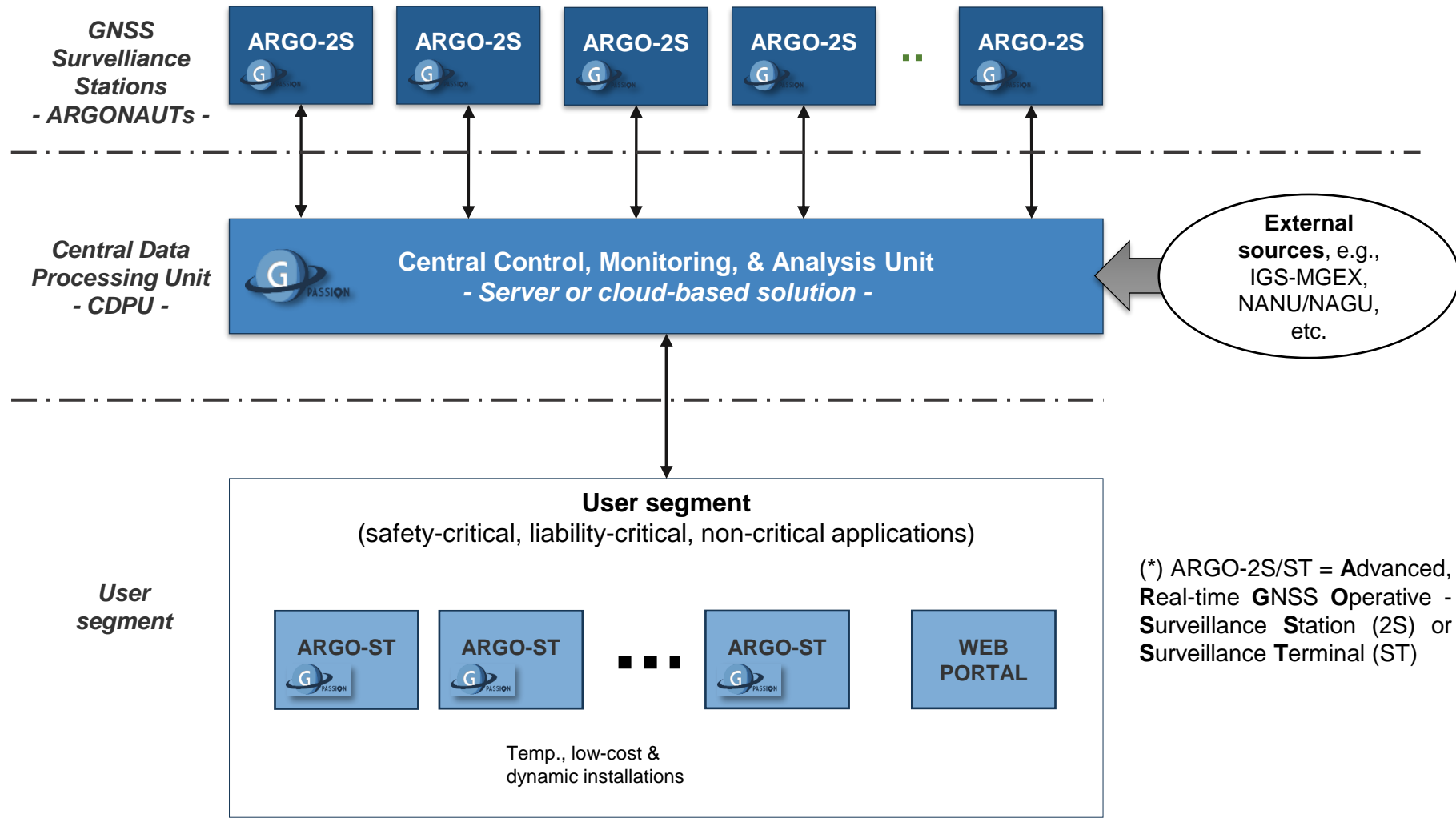
Product description: subsystem identification

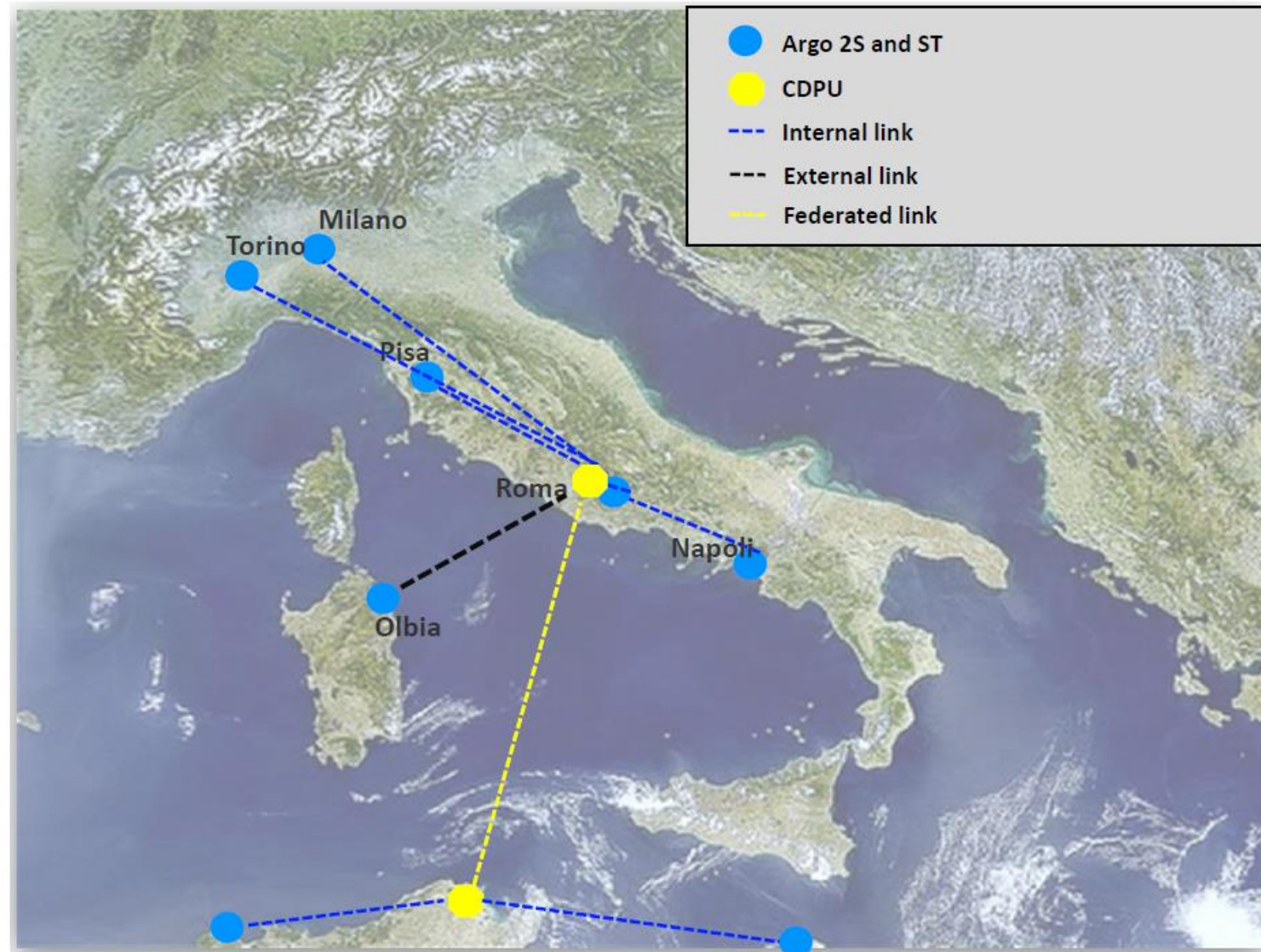The system is composed by the following subsystems:

- A GNSS surveillance segment composed by a network of **ARGO-2S**. Such stations are conceived to provide a service of local surveillance, including RFI detection, classification and localization, and GNSS signal authentication.
- A Central Data Processing Unit (**CDPU**), addressed to gather data from ARGO stations and provide regional monitoring services. CDPU is also connected to external repositories
- User segment which benefits from GIASONE services, including local monitoring, authentication and legal recording by using the **ARGO-ST** equipment.
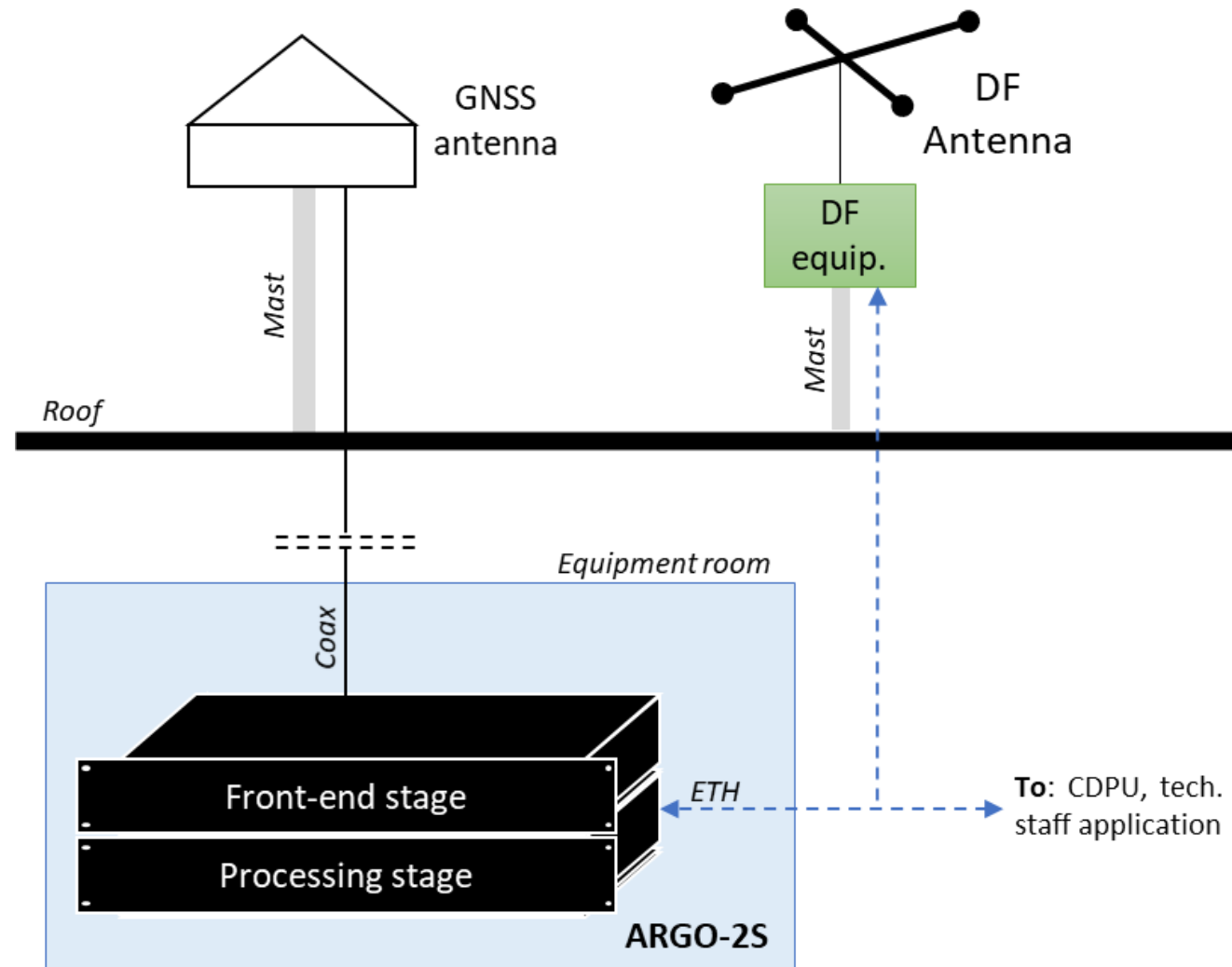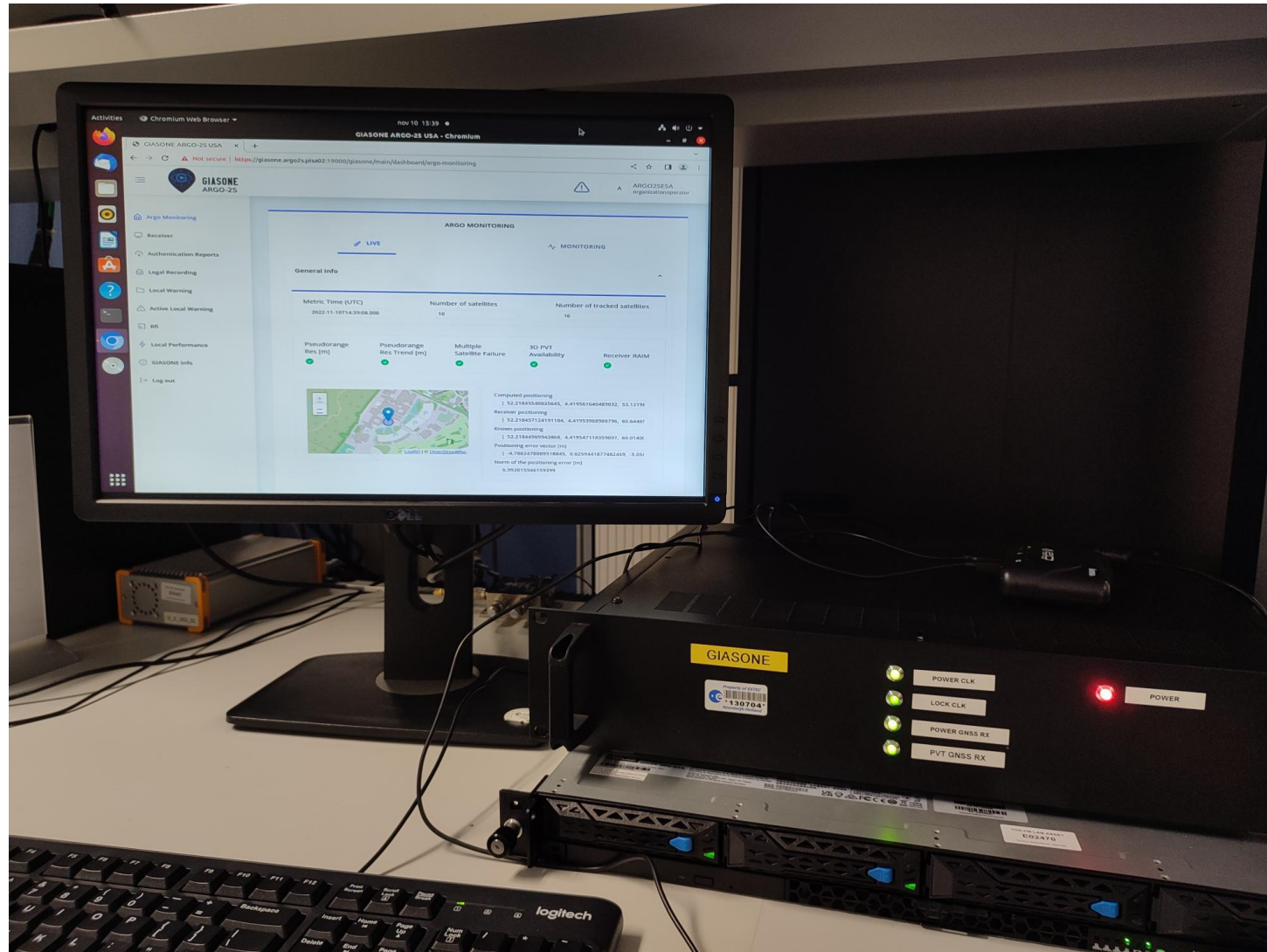
Product description: funcional architecture

GNSS Survelliance Stations - ARGONAUTs -

ARGO-2S ARGO-2S ARGO-2S ARGO-2S .. ARGO-2S

Central Data Processing Unit - CDPU -

Central Control, Monitoring, & Analysis Unit
- Server or cloud-based solution -

External sources, e.g., IGS-MGEX, NANU/NAGU, etc.

User segment

User segment
(safety-critical, liability-critical, non-critical applications)

ARGO-ST ARGO-ST ... ARGO-ST WEB PORTAL

Temp., low-cost & dynamic installations

(*) ARGO-2S/ST = **A**dvanced, **R**eal-time **G**NSS **O**perative - **S**urveillance **S**tation (2S) or **S**urveillance **T**erminal (ST)

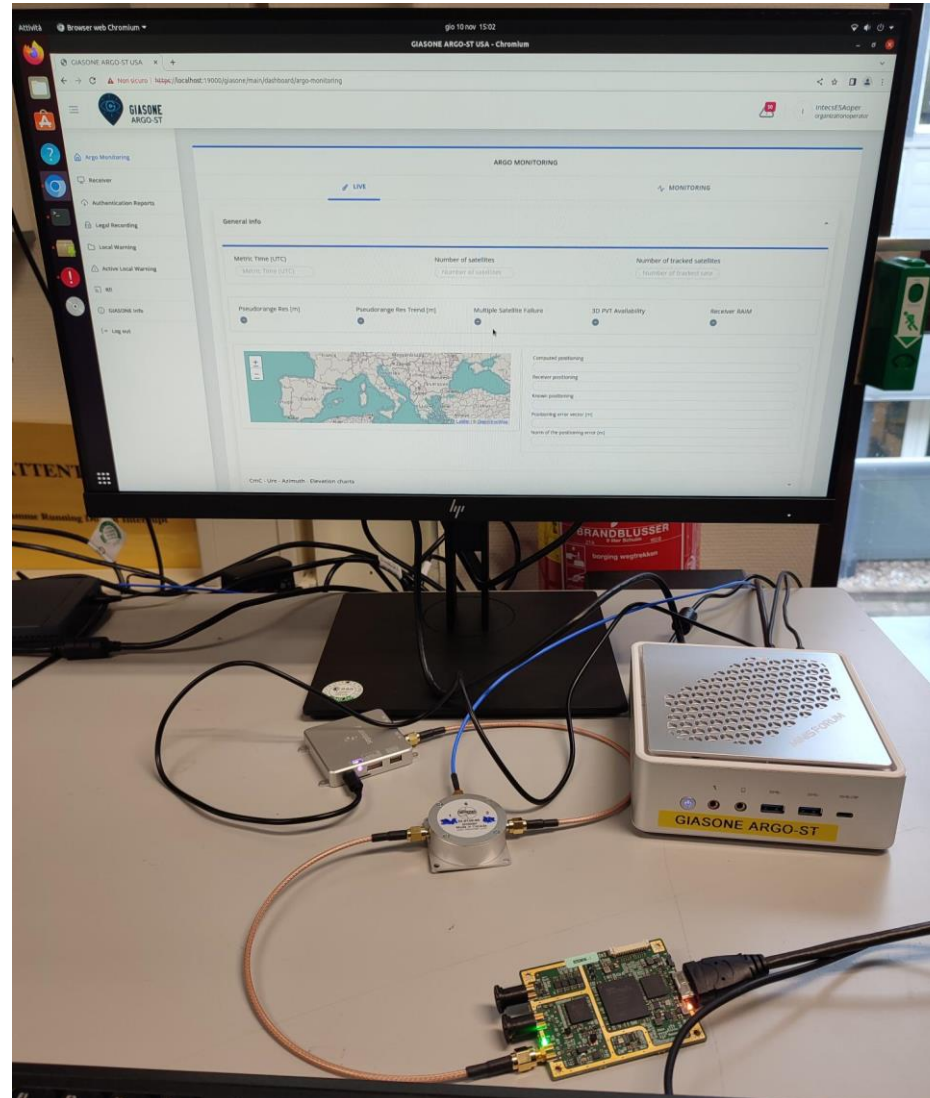# Product description: scalable architecture

Product description: ARGO-2S
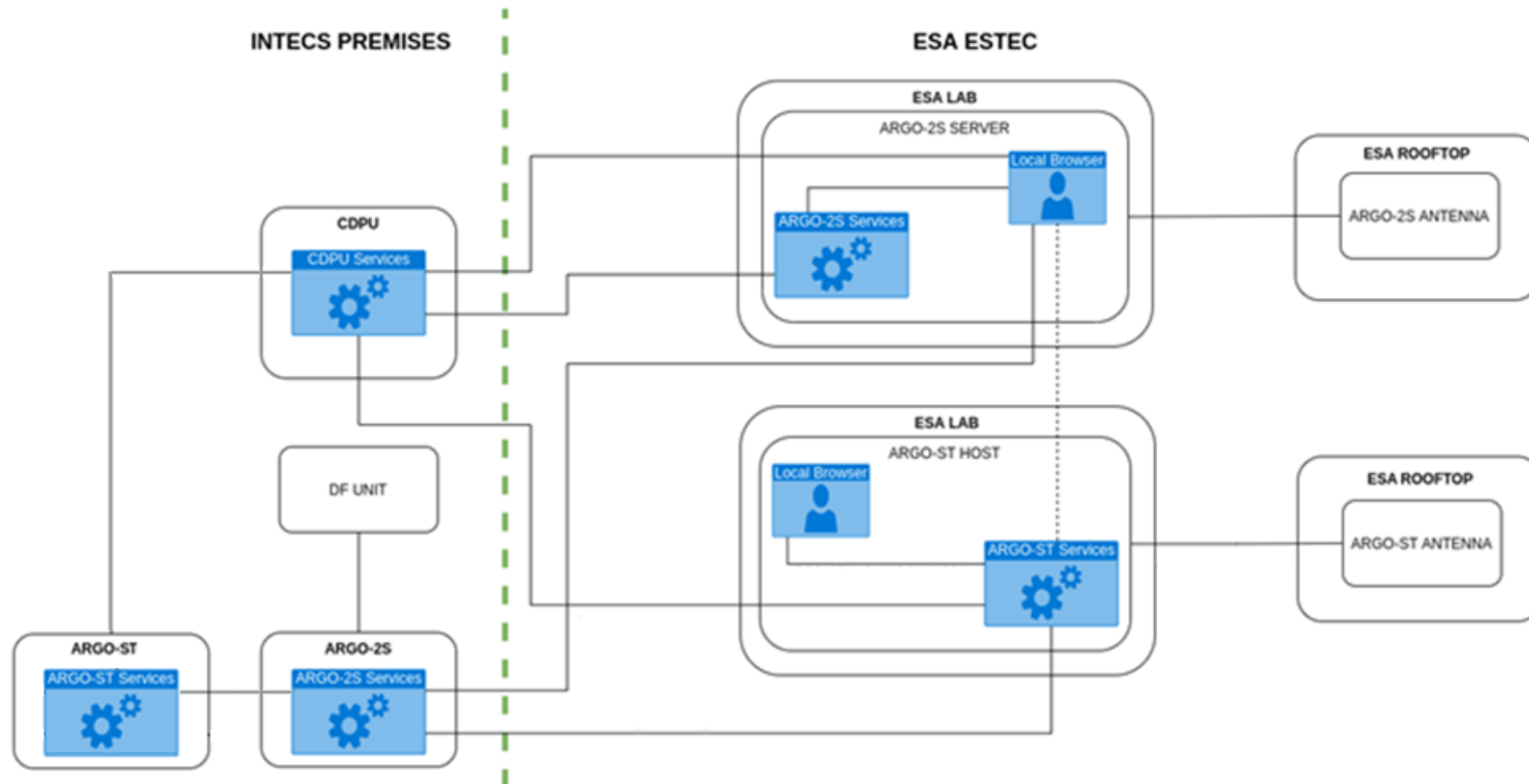
Product description: ARGO-2S

Product description: ARGO-ST

Pilot results: ESA ESTEC/PISA Office

A Pilot has been held with GIASONE partially deployed in ESA ESTEC and partially in our office in Pisa. The pilot window spanned 2 weeks among November 16 and November 29.

Pilot results: GNSS Monitoring performance

ARGO stations provide the Accuracy and the Availability of the PVT estimation. These metrics are evaluated on the 3D PVT estimation and on the Horizontal/Vertical components.

Day	Value [m]	
	PISA	ESTEC
16-11-2022	7.562773	6.810007
17-11-2022	7.227926	6.436721
18-11-2022	6.640028	7.773076
19-11-2022	4.43964	10.411809
20-11-2022	5.75074	9.257357
21-11-2022	5.572485	9.699892
22-11-2022	5.063224	11.151908
23-11-2022	4.907347	8.397991
24-11-2022	5.398615	8.925138
25-11-2022	4.774283	29137.683861
26-11-2022	5.709792	332201.904033
27-11-2022	17.335834	15.603818
28-11-2022	17.986581	13.733284
29-11-2022	20.31679	14.635391

Day	Value [%]	
	PISA	ESTEC
16-11-2022	100	100
17-11-2022	100	100
18-11-2022	99.2639	96.5833
19-11-2022	100	94.1181
20-11-2022	99.4491	95.7894
21-11-2022	100	95.3704
22-11-2022	100	94.3241
23-11-2022	99.8611	97.2755
24-11-2022	99.8773	95.7199
25-11-2022	99.3773	93.6551
26-11-2022	99.9306	70.8264
27-11-2022	88.0926	89.4491
28-11-2022	90.2616	88.3657
29-11-2022	88.1736	88.1412

On ESTEC site we revealed an issue on the 25° and 26° of November

Satellite E04 has been used even if it was labeled as unusable by a NAGU

The accuracy is relatively stable in the Pilot timeframe, except for November 25 and 26 where an anomaly on the E04 has been detected.

Pilot results: GALILEO E04 issue in ESTEC site

The trend of the positioning error norm has a very high value only in those epochs where the E04 satellite has been used. In the left side plot there is the case of 25 November and in the right the case of 26 November.

The NAGUs concerning that satellite are reported below.

Type	PLN_OUTAGE
Number	2022045
File Name	NOTICE_ADVISORY_TO_GALILEO_USERS_NAGU_2022045.txt
Subject	PLANNED OUTAGE FROM 2022-11-22 UNTIL 2022-11-26
Description	GALILEO SATELLITE GSAT0213 (ALL SIGNALS) WILL BE UNAVAILABLE FROM 2022-11-22 BEGINNING 06
Generated Date	2022-11-18T15:00:00.000+00:00
Start Date	2022-11-22T06:00:00.000+00:00
Affected Satellite	GSAT0213
PRN Satellite	GAL04

Type	EXTNS
Number	2022048
	21/25

File Name	NOTICE_ADVISORY_TO_GALILEO_USERS_NAGU_2022048.txt
Subject	EXTENSION NAGU 2022045 UNTIL 2022-11-27
Description	GALILEO SATELLITE GSAT0213 (ALL SIGNALS) WILL BE UNAVAILABLE FROM 2022-11-22 BEGINNING 06
Generated Date	2022-11-26T14:00:00.000+00:00
Start Date	2022-11-22T06:00:00.000+00:00
Reference Nagu	2022045
Affected Satellite	GSAT0213
PRN Satellite	GAL04

Pilot results: RFI Monitoring Performance

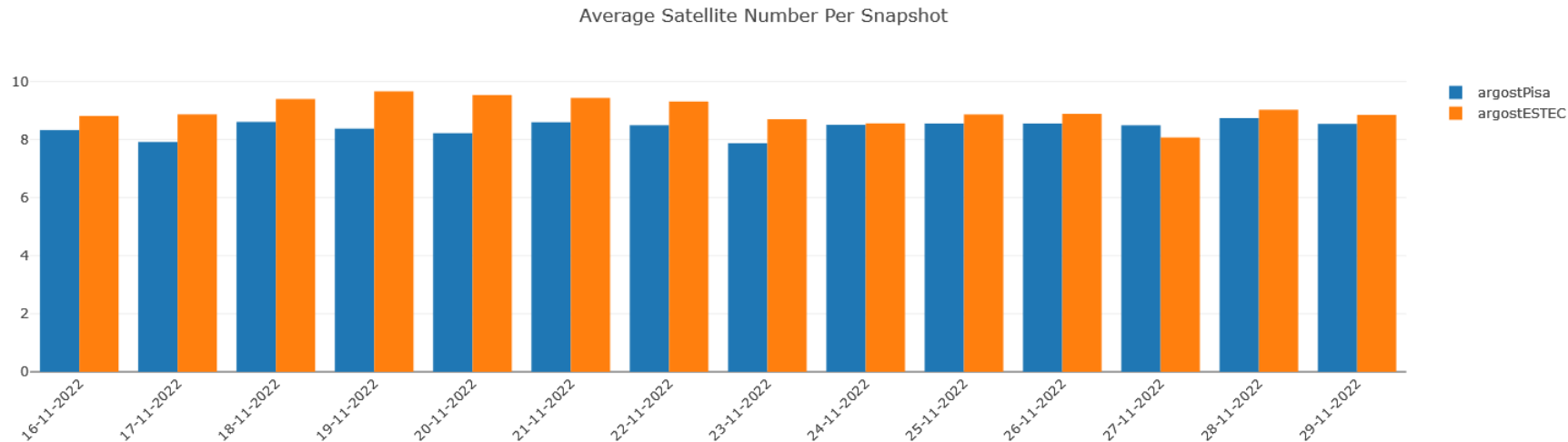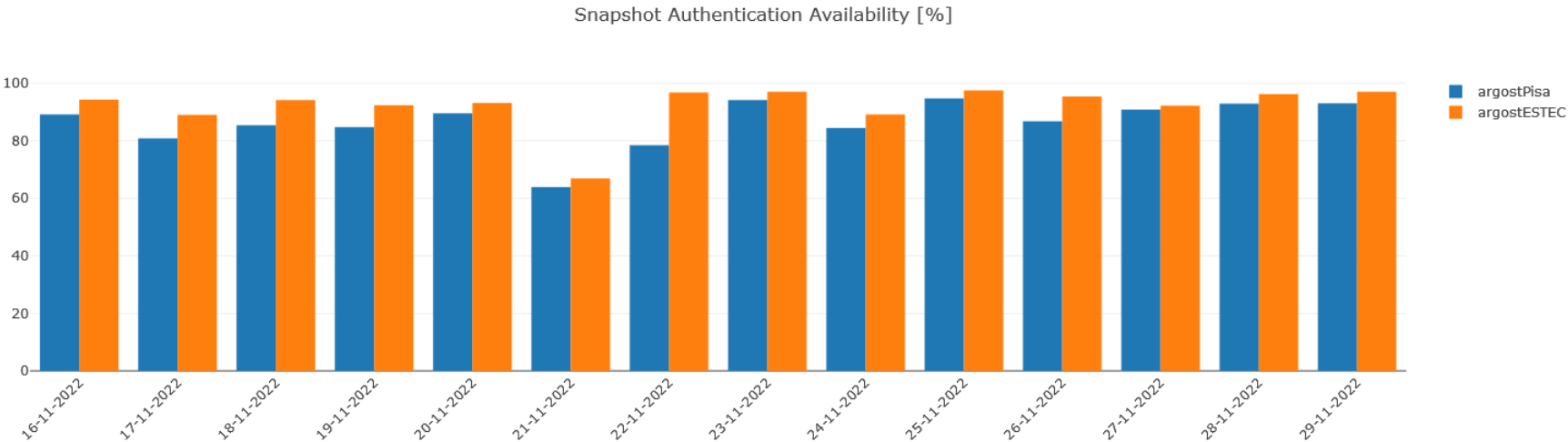| Day	Site	Total Warn.	CW Type	LINEAR CHIRP Type	AWGN Type	PULSED Type	UNKNOWN Type
16-11-2022	PISA	38	1	0	2	2	33
	ESTEC	0	0	0	0	0	0
17-11-2022	PISA	40	0	0	0	4	36
	ESTEC	12	1	0	0	0	11
18-11-2022	PISA	28	5	0	0	2	21
	ESTEC	26	7	1	0	0	18
19-11-2022	PISA	39	0	0	1	4	34
	ESTEC	7	2	0	0	0	5
20-11-2022	PISA	38	0	0	2	5	31
	ESTEC	0	0	0	0	0	0
21-11-2022	PISA	40	0	0	1	5	34
	ESTEC	4	0	0	0	0	4
22-11-2022	PISA	65	5	0	2	5	53
	ESTEC	5	1	0	0	0	4
23-11-2022	PISA	60	1	0	2	4	53
	ESTEC	19	8	3	0	0	8
24-11-2022	PISA	54	2	0	2	3	47
	ESTEC	2	0	0	0	0	2
25-11-2022	PISA	32	1	0	1	3	27
	ESTEC	5	2	0	0	0	3
26-11-2022	PISA	29	0	0	1	2	26
	ESTEC	0	0	0	0	0	0
27-11-2022	PISA	32	0	0	1	4	27
	ESTEC	1	0	0	0	0	1
28-11-2022	PISA	53	1	0	2	4	46
	ESTEC	31	10	0	0	0	21
29-11-2022	PISA	49	2	0	4	1	42
	ESTEC	5	1	0	0	0	4

The majority of the RFI detected have been classified as unknown.

The statistics in Pisa station are worse than those in ESTEC

Lesson learnt:

A more robust detection & classification approach will be used in a potential follow-up of this activity

Pilot results: Authentication Availability

Snapshot Authentication Availability [%]

Average Satellite Number Per Snapshot

Competitiveness and Opportunities

Main aspects and characteristics of GIASONE:

- Innovation: wide set of services tailored on user needs

- Re-configurability and upgradability of GNSS surveillance station thanks to SDR Technology

- Flexibility: since the core is made by SW elements, it is possible to modify, update and configure the system with very low impact on hardware components and no-impact on the user side. In addition, all services will be accessible by using the existing Communication infrastructures with no-impact on the user side

- Scalability: the system is fully scalable according to the user needs

- Authentication: positioning authentication is one of the open services provided to the users

Looking forward, GIASONE foresees:

- Extension on the L5 and L2 frequencies (multi-frequency services) both for GNSS and RF monitoring

- Achievement better RFI detection and classification capability by improvement of relevant processing

- Improvement of additional techniques to selectively include/exclude desired satellites from the monitoring

- Addition of real time authenticated Position, Velocity and Time processing

- Addition of tool for automatic analysis and reporting to better manage the collected data

Competitiveness and Opportunities

Competitor	Product	References	Comparison with ARGO-2S
gmv	srx-10i – GNSS spectrum monitoring, RFI detection and analysis	https://www.gmv.com/en/Products/srx-10i/	srx-1i is mainly focused on RFI detection and analysis. ARGO-2S is a more complete solution that provides a complete analysis of the GNSS stack, including authentication and RFI detection and localization.
INDRA	GNSS monitoring networks provide key performance indicators of the accuracy, integrity, availability and continuity, including satellite info, iono maps, etc.	https://www.indracompany.com/sites/default/files/indra_gnss_monitoring_networks_en_baja_1_1.pdf	INDRA GNSS monitoring system is a complex and fully HW solution. ARGO-2S will follow the SDR paradigm therefore it will be definitely more versatile, high-configurable and scalable solution.
IDS AirNav	GNOME system – is a distributed network of remote sentinels designed to perform GNSS monitoring, especially in the vicinity of airports, in terms of integrity, reliability and the immunity of signals against spoofing and interference. The system is designed in response to the ICAO recommendations and standards which highly advise continuous control and legal recording of the GNSS performance and integrity, both in the signal and in the navigation domains.	https://www.idsairnav.com/main-areas/atm/cns/gnome/	GNOME sentinels are SDR-based solutions that provides a full analysis of the entire GNSS stack. Nevertheless, the authentication service is not included. ARGO-2S will provide a fully analysis of the GNSS stack, including the authentication service, and RFI detection, classification and localization capabilities.
NAVBLUE (Airbus company)	GNSS Monitoring – This system provides recording and analysis of GNSS performance, near real-time monitoring & alerting and performance/integrity prediction.	https://www.navblue.aero/product/gnss-monitoring-by-navblue/	Few info is available about this solution. It is not clear what are the monitored service and if the proposed solution is fully HW or SDR-based. Furthermore, the authentication service seems not available.
Blue Dot	GNSS alert – Detection and early warning for operators of critical infrastructure, for all kind of threats related to the use of satellite navigation signals.	https://www.bluedotsolutions.eu/language/en/project/gnss-alert-2/	Few info is available about this solution. It seems much more an IT platform cooperating with remote sensors installed on-site. No more details are available. No authentication service is provided.
Pildo Labs	Pildo Box – Collect and merge receiver data and automatically upload files to the server to generate performance reports. (*)	https://pildo.com/	Simply speaking, it is an IT solution for data processing and report production. ARGO-2S acquires data and provides a real-time monitoring of GNSS status, RFI detection & localization, and authentication service. Recorded data will be processed by the CDPU in order to produce performance reports.

Benefits of Working with ESA

- Intecs, thanks to the NAVISP program, had the opportunity to develop the concept of GIASONE as a fully-scalable, flexible, user-oriented GNSS monitoring infrastructure and to demonstrate its prototypal performances

- The review process proposed by ESA helped the projects to reach the expected maturity in order to properly identify the user needs and the market applicability in the field of the GNSS signal integrity and authentication

- The fully cooperative interaction with ESA allowed the continuous evolution of GIASONE program to better fit the expected performances

- Working with ESA helped Intecs in identifying potential improvements of the present program GIASONE in order to propose new features for desirable project evolution

- Availability of ESA facility for testing activities

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