EXECUTIVE SUMMARY REPORT

ESA AO/1-9959/19/NL/GLC

POSITION, NAVIGATION AND TIME TRAFFIC LIGHT (PETAL)

Prepared by:	Smita Tiwari (GMV NSL) Madeleine Easom (GMV NSL)
Approved by:	Madeleine Easom (GMV NSL)
Authorized by:	Madeleine Easom (GMV NSL)

Code:	ESA-PETAL-ESR
Version:	1.2
Date:	27/09/2022

DOCUMENT STATUS SHEET

Version	Date	Pages	Changes
1.0	19/08/2022	All	The first version of the Executive Summary Report for the PETAL project in preparation for the Final Review (FR) milestone.
1.1	05/09/2022	Page 7 and 8	The second version of the Executive Summary Report for the PETAL project updated to address the RIDs identified by ESA.
1.2	27/09/2022	All	Update to document footer

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

No table of figures entries found.

1. INTRODUCTION

1.1. PURPOSE

This document is the Executive Summary Report for the PNT Traffic Light (PETAL) project (Contract No: ESA AO/1-9959/19/NL/GLC). This deliverable document is an output for WP0 (Project Management) as required by [AD.1].

The purpose of this document is to provide an executive summary of the PETAL project without any commercial/confidential information.

1.2. SCOPE

Following the background information presented in Section 1 and the References in Section 2, the layout of the remainder of the document is as follows:

- Section 3 provides the executive summary

1.3. ACRONYMS

Acronyms used in this document and needing a definition are included in the following table:

Table 1-1 Acronyms

Acronym	Definition
AD	Applicable Document
ANSP	Air Navigation Services Provider
CAV	Connected and Autonomous Vehicles
COLOSSUS	Crowd-Sourced Platform for GNSS Anomaly Identification, Isolation and Attribution Analysis
CORS	Continuously Operating Reference Station
COTS	Commercial Off The Shelf
EGNOS	European Geostationary Navigation Overlay Service
GBAS	Ground Based Augmentation System
GEO	Geostationary
GLONASS	Globalnaya Navigazionnaya Sputnikovaya Sistema, or Global Navigation Satellite System
GPS	Global Positioning System
GNSS	Global Navigation Satellite Systems
ICAO	International Civil Aviation Organisation
IMU	Inertial Measurement Unit
ITT	Invitation to Tender
NANU	Notice Advisory for NAVSTAR GPS Users
NTRIP	Networked Transport of RTCM via Internet Protocol
PBN	Performance Based Navigation
PPP	Precise Point Positioning
RAIM	Receiver Autonomous Integrity Monitoring
RD	Reference Document
RINEX	Receiver Independent Exchange Format
SBAS	Space Based Augmentation System

2. REFERENCES

2.1. APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form part of this document to the extent specified herein. Applicable documents are those referenced in the Contract or approved by the Approval Authority. They are referenced in this document in the form [AD.x]:

Table 2-2 Applicable Documents

Ref.	Title	Code	Version	Date
[AD.1]	Statement of Work ESA Express Procurement EXPRO+ PNT Traffic Light	ESA-TEC-SOW-19-P-O-NAV-02	1.0	07/10/19
[AD.2]	User Requirements	ESA-PETAL-TN1.1.1	1.2	04/12/20
[AD.3]	GNSS and SBAS Performance at High Latitudes v1	ESA-PETAL-TN1.1.2	1.0	11/06/20
[AD.4]	Data Collection Plan	ESA-PETAL-TN1.2.1	1.0	08/06/20
[AD.5]	GNSS and SBAS Performance at High Latitudes v2	ESA-PETAL-TN1.2.2	1.5	09/09/22
[AD.6]	Service and Service Demonstrator Specification	ESA-PETAL-TN2.1	1.3	24/02/22
[AD.7]	System and System Demonstrator Specification	ESA-PETAL-TN2.2	1.3	24/02/22
[AD.8]	Detailed Design and Implementation v1	ESA-PETAL-TN3.1.1	1.2	08/06/21
[AD.9]	Detailed Design and Implementation v2	ESA-PETAL-TN3.1.2	1.2	11/08/22
[AD.10]	Verification and Validation Test Plan	ESA-PETAL-TN3.2	1.2	20/04/22
[AD.11]	Service & User Manual	ESA-PETAL-SUManual	1.0	24/02/22
[AD.12]	Demonstrator Verification and Service Validation Test Report	ESA-PETAL-TN4.1	1.2	31/08/22

2.2. REFERENCE DOCUMENTS

The following documents, although not part of this document, amplify or clarify its contents. Reference documents are those not applicable and referenced within this document. They are referenced in this document in the form [RD.x]:

Table 2-3 Reference Documents

Ref.	Title	Code	Version	Date
[RD.1]				
[RD.2]				
[RD.3]				
[RD.4]				
[RD.5]				

3. PNT TRAFFIC LIGHT (PETAL) EXECUTIVE SUMMARY

Accurate and reliable Position, Navigation and Time (PNT) information is a critical element for many applications in different domains such as land, maritime and aeronautical and in many different market sectors such as agriculture, surveying, mapping and transportation Global Navigation Satellite Systems (GNSS) has become the primary source of PNT information.

Satellite Based Augmentation Systems (SBAS) in general augments GNSS performance in regional areas. In particular, at present, EGNOS augments the GPS satellite navigation system in Europe by increasing the achievable computed PNT accuracy and providing additional integrity information with regards the performance of the GNSS system, therefore making its use suitable for safety critical applications such as landing aircraft or navigating ships in coastal areas and port approaches. In the future, the full EGNOS V3 service will augment both Galileo and GPS and will add further support for dual frequency L1/L5.

The number of new applications relying on GNSS and SBAS continues to increase everywhere even at high latitudes, new opportunities are foreseen based on the opening of new navigation routes through the Arctic due to ice melting in the region. However, it is at higher latitudes (>60°N) where the availability of SBAS geostationary satellites is more challenging due to the low elevation angles. The reduced availability of SBAS (e.g., EGNOS) and GNSS due to low GEO satellite altitude visibility and low elevation line of sight of GNSS satellites at high latitudes is one of the issues to overcome but not the only one.

With this challenge in mind, the PNT Traffic Light activity has created a demonstrator performance monitoring service for multi-constellation GNSS and SBAS at high latitudes (above 60°N) targeting two main service areas:

- Informing users when a loss of performance occurs (global or regional), or it is probable to happen in the short term.
- Delivering assistance data with the objective of improving the expected performance of computed PNT solutions by users located at high latitudes.

To demonstrate a PNT Traffic Light Service, a system with an architecture consisting of the following main functions has been developed as is shown within Figure 3-1 on the following page.

- System Management
- Input Data Collection
- Data Storage
- Processing Function
- Output Data Presentation and Transmission Function
- User Interface

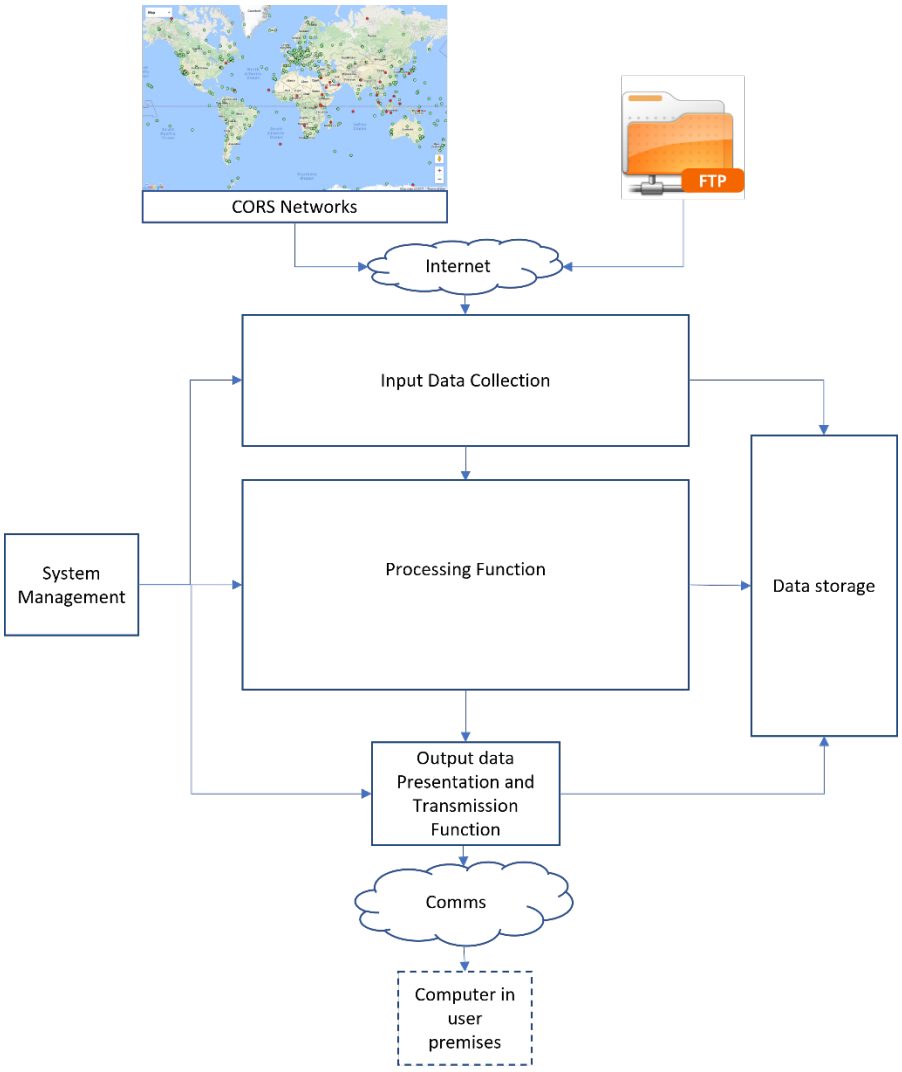

Figure 3-1: High-Level PETAL Demonstrator System Architecture

Overall, the PETAL demonstrator system is set up to run in an automated manner using a mix of real-time and batch processing in order to generate the required information for users in near real-time, according to the demonstrator requirements. The following output data is displayed in the PETAL Control Centre Application:

- GNSS Constellation Information
- KPI performance maps
- GNSS fault information
- KPI performance warnings
- KPI performance alerts
- Enhancement data:
  - Orbit/clock data
  - Ionospheric corrections
  - Tropospheric corrections

This system meets the two objectives of the project above and it is noted that the field test results show that for some applications for land and marine use cases, the overall accuracy could be met during the field test campaigns for GNSS alone, i.e., without any enhancements. Although EGNOS did improve the accuracy, GNSS alone in some circumstances was sufficient to meet the required accuracy. Also, during high ionospheric activity GNSS single frequency would not meet the accuracy required, and dual frequency GNSS would be on the borderline. In those cases, enhancements data would help to meet performance, and so in areas where SBAS was not available the use of corrections from a PETAL service would potentially be useful.

The measured analysis completed during the project also shows that during high solar activity, GNSS alone does not fulfil required accuracies. In such conditions the enhancement data shows an advantage and improves the accuracy. The PETAL validation results show that the PETAL generated TEC enhancement data is close to the requirement but does not exactly fulfil it for PPP. The reason behind that, for the PETAL demonstrator, was that the TEC was developed using 15 stations in very small network. Due to which the use of the PETAL provided IONEX files resulted in a rather low satellite usability angle, in the sense that the ionospheric pierce points (IPPs) corresponding to the satellites in view fall outside of the region of applicability of the TEC map. The coverage in practice is of about 3 degrees latitude and 8 degrees longitude, and, as a result, there are not at least four satellites that the receiver can compute the ionospheric corrections for and use in the PVT computations. For a full PETAL system, the TEC will be mapped with a wider network to cover the high latitude region fully which will resolve this issue.

End of Document