SERVUS

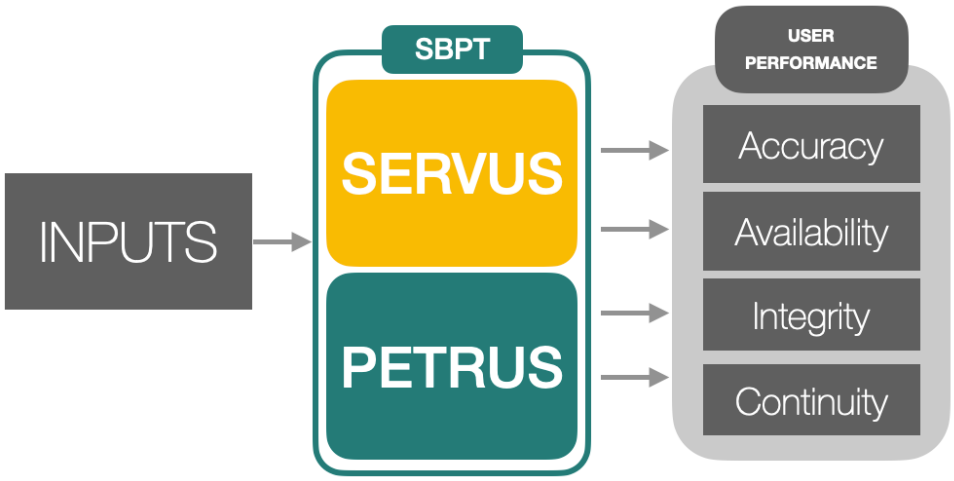
PROJECT: **SERVUS**		WP Number: WP-0000001
TITLE: SERvice Volume User SBAS		**Issue**: 1.0
LEAD CONTRACTOR	GNSS Academy	
CUSTOMER	ESA	**LEADER**: Student
ESTIMATED EFFORT	4 Months	

MISSION and SCOPE

SERVUS is a branch of the SBPT Tool Suite.

SERVUS tool is in charge of providing the following Service Performance over a given service volume over the EGNOS Service Area (ECAC)

- **Accuracy** Maps represented by the XPE95% (HPE95%, VPE95%)
- **Availability** Maps represented by the Percentage of time HPL<HAL & VPL<VAL
- **Continuity Risk** Maps represented by the Probability to have transitions of PL>AL in seconds sliding windows
- **Integrity Risk** as the probability to have Misleading information or Safety Indices HSI = HPE/HPL, VSI=VPE/VPL greater than 1.



SERVUS mission is described through the following requirements:

REQ. ID	TYPE	TITLE	BODY
SBPT-SERVUS-REQ-0010	OPS	Input arguments	The SERVUS shall be invoked with the full scenario path with scenario name as a unique mandatory input argument.
SBPT-SERVUS-REQ-0020	INP	Input folders arborescence	The SERVUS shall read external input files on a predefined scenario tree as follows: SCENNAME/INP/RNB/ SCENNAME/INP/NAV/ SCENNAME/INP/SP3/ SCENNAME/INP/CLK/ SCENNAME/INP/ION/ SCENNAME/INP/DCB/ SCENNAME/INP/ATX/
SBPT-SERVUS-REQ-0030	INP	Output tree	The SERVUS shall produce the outputs on a predefined scenario arborescence as follows: SCENNAME/OUT/SAT/

			SCENNAME/OUT/IGP/ SCENNAME/OUT/USR/
SBPT-SERVUS-REQ-0040	INP	Rinex Navigation files for GPS	The SERVUS shall read and process RINEX Navigation files format for GPS.
SBPT-SERVUS-REQ-0050	INP	Rinex B files	The SERVUS shall read and process SBAS messages in RINEX-B format as daily files, named as M[GEO][DOY]0.[YY]b. Where: GEO: PRN of GEO to process DOY: Day Of Year (zero padded) YY: Year in 2-digits (zero padded)
SBPT-SERVUS-REQ-0060	INP	SP3 files	The SERVUS shall read and process SP3 files format to get the true reference satellite positions
SBPT-SERVUS-REQ-0070	INP	Rinex Clock files	The SERVUS shall read and process RINEX Clock files format to get the true reference satellite clocks
SBPT-SERVUS-REQ-0080	INP	DCB files P1C1 biases	The SERVUS shall read and process DCB (Differential Code Biases) files format including the satellite P1C1 biases.
SBPT-SERVUS-REQ-0090	INP	DCB files P1P2 biases	The SERVUS shall read and process DCB (Differential Code Biases) files format including the satellite P1P2 biases.
SBPT-SERVUS-REQ-0100	INP	Antex files	The SERVUS shall read and process ANTEX files format.
SBPT-SERVUS-REQ-0110	INP	IONEX files	The SERVUS shall read and process IONEX files format.
SBPT-SERVUS-REQ-0120	INP	RIMS Positions information	The SERVUS shall read files containing the RIMS Position Coordinates information
SBPT-SERVUS-REQ-0130	INP	Configuration file	The SERVUS shall read a unique configuration file called servus.cfg
SBPT-SERVUS-REQ-0140	INP	Configuration folder	The SERVUS shall read the configuration file on a predefined scenario folder arborescence as follows: SCENNAME/CFG/

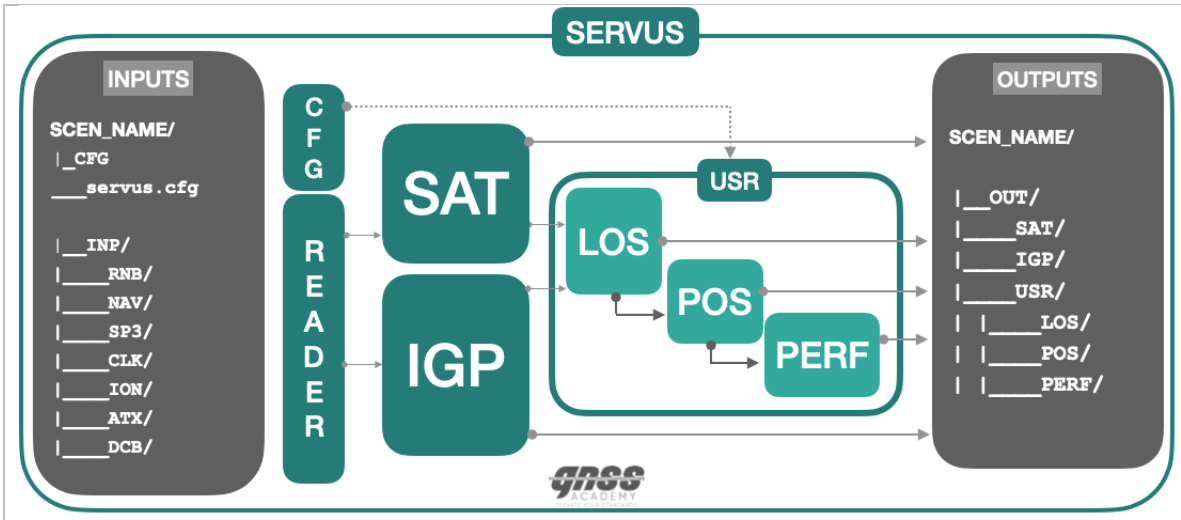
SERVUS shall produce the following MAIN outputs:

REQ. ID	TYPE	TITLE	BODY
SBPT-SERVUS-REQ-1200	OUT	LoS Instantaneous info	The SERVUS shall produce a daily file containing relevant instantaneous LOS information for every user in the service volume.
SBPT-SERVUS-REQ-1210	OUT	User Instantaneous info	The SERVUS shall produce a daily file containing relevant instantaneous User information for every user in the service volume.
SBPT-SERVUS-REQ-1220	OUT	User Performance file per Service Level	The SERVUS shall produce a daily file containing the service performance for every user in the service volume and each configured service level

SBPT-SERVUS-REQ-1230	OUT	Availability	The SERVUS shall plot on a map the average service availability in a daily basis
SBPT-SERVUS-REQ-1240	OUT	Accuracy 95% Map	The SERVUS shall plot on a map the 95th percentile of the horizontal and vertical position errors in a daily basis
SBPT-SERVUS-REQ-1250	OUT	Safety Index Map	The SERVUS shall plot on a map the Maximum reached Horizontal and Vertical Safety Index (HPE/HPL and VPE/VPL) in a daily basis
SBPT-SERVUS-REQ-1260	OUT	Continuity Risk Map	The SERVUS shall plot on a map the average continuity risk in a daily basis
SBPT-SERVUS-REQ-1270	OUT	Number of satellites Map	The SERVUS shall plot on a map the minimum and maximum number of satellites in a daily basis
SBPT-SERVUS-REQ-1280	OUT	Maximum XPLs Map	The SERVUS shall plot on a map the maximum reached Horizontal and Vertical Protection levels in a daily basis
SBPT-SERVUS-REQ-1290	OUT	Maximum XPEs Map	The SERVUS shall plot on a map the maximum reached Horizontal and Vertical position error in a daily basis
SBPT-SERVUS-REQ-1300	OUT	Maximum timing error Map	The SERVUS shall plot on a map the maximum reached timing error in a daily basis
SBPT-SERVUS-REQ-1310	OUT	Maximum XDOPs Map	The SERVUS shall plot on a map the maximum reached HDOP, VDOP, PDOP and TDOP in a daily basis

SERVUS ARCHITECTURE

SERVUS global architecture can be depicted as follows:



These modules are described in table below:

MODULE	*DESCRIPTION*

SAT	Satellite Module is in charge of computing the Satellite Residual Error for orbit and clock, the common satellite offset, and the related degradation factors.
	
	• Compute the Satellite Position and Clock from GPS Navigation Message
	• Extract SBAS SIS satellite-related information:
	  ○ FLT Corrections: FC (MT2-6), LTC (MT24-M25)
	  ○ FLT Integrity Sigmas: UDRE (MT2-6), COV Matrix (MT27 or MT28)
	  ○ Satellite Monitoring Flags (M/NM/DU) (MT2-6)
	  ○ Degradation Factors (MT10)
	• Compute the Satellite Corrected Position applying the corrections to the Navigation message.
	• Compute True Orbit and Clock Information from reference files.
	• Compute Satellite level main indicators:
	  ○ Orbit&Clock Error: SRE-XYZ, SRE-ACR and SRE-B —> SREW (@WUL)
	  ○ Error Variance: SigmaFLT at the WUL
	  ○ Satellite Safety Index: SREU/5.33 SigmaFLT at WUL
	  ○ Time Scale Offset: ENT-GPSOFFSET
	• Assess the Satellite Performance in terms of monitorability, accuracy (RMS SRE-ACRB), Integrity (SAT-SI) , upper-bound (SigmaFLT), and continuity.

IGP	IGP Module extracts and formats the IGP corrections information, the GIVD and GIVE and applies the Ionospheric degradation factors. This module applies only to SF mode.
	
	• Extract SBAS SIS IGP-related information:
	  ○ IGP GIVD (Iono Delays)
	  ○ IGP GIVE (Iono Delay Error Sigmas)
	  ○ IGM Monitoring flats
	  ○ Degradation Factors MT10.
	• Compute True VTEC from reference files (IONEX)
	• Compute IGP level main indicators:
	  ○ GIVDE: Error in the GIVD
	  ○ IGP Safety Index: SI=GIVDE/5.33*GIVE
	• Assess the IGP Performance in terms of accuracy (RMS GIVDE), Integrity (SI) and upper-bound (GIVE)

USR	User Position module is in charge of performing the Position Errors and Protection levels estimation through a LSQ process
	• Read Satellite and IGP information:
	  ○ SAT: SRE-XYZB, UDRE, COV and
	  ○ IGP: GIVDE, GIVD, VTEC, GIVE (Degraded)
	• [LOS] Compute user-Satellite LoS information
	  ○ Geometrical Information (G): Unitary Vectors, Elevation, Azimuth, IPP position.
	  ○ Covariance Matrix information (W) adding SigmaTropo and SigmaAIR
	  ○ Error Vector Information (SREU+UISDE+TropoE+AirE)
	• [POS] Compute Position level information (PE, PL)
	• [PERF] Compute user level performances for each Service level: Availability, Accuracy, Integrity, Continuity

SERVUS MAIN PROCESSING LOGIC

servus(ScenPath/ScenName)

```
# First, Check input arguments:
# - Check Scenario Path and Name existence.
conf = check_input_arguments(scen_path/scen_name)

# Read and process configuration file: servus.cfg:
conf = read_servus_cfg(scen_path/scen_name)

    # SERVUS runs over all scenario days
    for DAY in conf.NUMBER_OF_DAYS:

        # Read and load all input files information: RNB, NAV, SP3, CLK, IONEX, DCBs, ATX
        read_input_files(conf, GEO,DAY)
        Output → RNBdata, NAVdata, SP3data, CLKdata, IONdata, DCBdata, ATXdata

        # Main Loop over all seconds in a day
        for secs in NUM_SECONDS_IN_DAY:

                # Get Satellite Position and Clock from the Navigation Ephemeris
                get_nav_pos_clk(NAVdata)

                # [SAT] Run Satellite Module
                SatOutputs = RunSatModule(RNBInfo,
                                          SP3data,
                                          CLKdata,
                                          ATXdata,
                                          DCBdata,
                                          NAVdata)

                # [IGP] Run IGP Module
                IgpOutputs = RunIgpModule(EMFInfo)

                # [USR] Run USER computations
                LoSOutputs, UsrOutputs, PerfOutputs =
                            RunUsrModule(SatOuputs,IgpOuputs)

                # Write Instantaneous Outputs
                write_instantaneous_outputs(LoSOutputs,UsrOutputs)

        # End of for egnosepoch in NUM_SECONDS_IN_DAY:

        # [PERF] Write Performances Outputs
        Write_Perfo_files(PerfOutputs)

        # Display SERVUS Outputs for those configured analyses
        display_daily_figures(PerfOutputs)

    #End of for DAY in conf.NUMBER_OF_DAYS:
```

```
# END OF SERVUS()
```

INPUTS

Next table summarizes SERVUS input files required:

TYPE	FORMAT	FOLDER	DESCRIPTION
NAV	RINEX NAV	NAV/	RINEX Navigation files (IGS brdc. files) including the Satellites ephemeris and clocks models for GPS (.yyN) and Galileo constellation (.yyL)
RINEX-B	RINEXB	RNB/	Daily RINEX-B files including the EGNOS broadcast messages information from SBAS L1 or SBAS L5 (DFMC).
SP3	SP3	SP3/	SP3 files containing GPS and Galileo XWGS84 coordinates w.r.t the Center of Masses on a given sampling rate (i.e: around 10 minutes)
CLK	RNX CLK	CLK/	CLK RINEX files containing GPS and Galileo Clock Offsets on L1L2 or L1L5 (GPS) or E1E5 (Galileo) for a given sampling rate (i.e: around 5 minutes.
IONEX	IONEX	ION/	IONEX files containing the reference ionospheric vertical delays through a worldwide grid with a given sampling rate (typically two hours for IGS data)
DCB	DCB	DCB/	DCB files containing the Differential Clock Biases on P1-P2 (P1P2MMYY.txt) and C1P1 (C1P1MMYY.txt)
ANTEX	ANTEX	ATX/	ANTEX files containing the Antenna Phase Offsets for all satellites GPS and Galileo
RIMS	CUSTM	RIMS/	File containing the RIMS coordinates, mask angles, acquisition time and other RIMS-related information

OUTPUTS

SERVUS shall produce the following files:

TYPE	FOLDER	DESCRIPTION
SAT	OUT/SAT	Satellite Daily Statistics on the main performance indicators
IGP	OUT/IGP	IGP Daily Statistics on the main performance indicators
LOS	OUT/USR/LOS	Line-Of-Sight instantaneous information
POS	OUT/USR/POS	User Instantaneous Positioning Information
PERF	OUT/USRPERF	User Daily Performances

WORK PACKAGES		
ID	**DESCRIPTION**	
WP1: SAT PERF	**Satellite Module Performances**	
	This Work-package is related to the satellite-level characterization performances in terms of monitorability, accuracy, integrity, upper-bound and continuity. • **Satellite Monitorability Figures** showing the satellite monitoring periods and percentage of monitoring time along the whole day compared with the theoretical monitorability. • **Satellite Accuracy** is given by different statistics of the SRE (Satellite Residual Error) including the satellite orbit and clock errors. • **Satellite Upper-bounding** characterization is given by some statistics related to the SigmaFLT (equivalent to UDRE or SigmaUDRE) • **Satellite Integrity** is given by the safety index SREU/5.33SigmaFLT at the Worst User location of the service are in order to ensure that the provided SigmaFLT correctly bounds the Error up the required confidence levels. • **Satellite Continuity** is given by the number of transitions of the satellite from Monitored to Not Monitored or Don't USE.	
WP2: IGP PERF	**IGP Module Performances**	
	This Work-package deals with the Iono-level characterization performances in terms of accuracy, integrity, monitorability and and upper-bound. The characterization of the ionospheric performances will be done at IGP level. • **IGP Monitorability Figures** showing the IGP monitoring percentage along the whole day compared with the theoretical monitorability. • **Ionosphere Accuracy** is given by different statistics of the ionospheric delay error (GIVDE). • **Ionosphere Upper-bound** characterization is given by statistics ionospheric delay error sigma (GIVE) • **Ionosphere Integrity** is given by the safety index (SI) as the ration (SI=GIVDE/5.33GIVE) • **IGP Continuity** is given by the number of transitions of the IGP from Monitored to Not Monitored or Don't USE.	
WP3: POS PERF	**Service Volume Position and Performances**	
	WP3.1 USER POS Module • Read and Extract the User-Satellite LoS Range Level information from an input LOS file • Build the observation and weighting matrices ([G] and [W] • Compute the position error and protection levels XPE and XPL from the projection of the range to position transfer functions from the LSQ process. • Compute some other indicators at user level (XDOPs)	

	WP3.2 USER PERF Module Create a daily file and related plots containing the main Service Performances for APV-I Service Level (Note that Continuity Risk is not required in a first stage)	
WP4: DELIVERY	**DELIVERY, REPORTING AND FINAL ACCEPTANCE**	
	Delivery of the following Products: • SERVUS SW Sources + Configuration files. • Scenario Execution Outputs: files and figures • A Technical Note: ✓ Tool Mission and Scope ✓ Technical Understanding and Main Requirements ✓ Architecture, Design & I/O Interfaces ✓ Algorithms Definition. ✓ Validation results w.r.t the Reference Scenario data ✓ Main Conclusions ✓ Recommandations and Way forward	