EXAMPLES FOR USAGE OF ION METADATA STANDARD

Alexander Rügamer, alexander.ruegamer@iis.fraunhofer.de

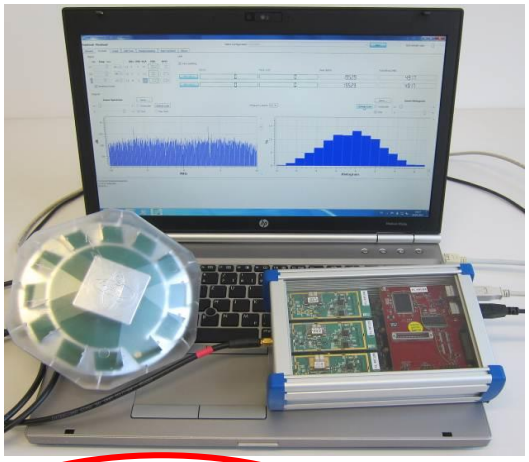
ION GNSS+ 2018, September 2018

Examples for Usage of ION Metadata Standard
Overview

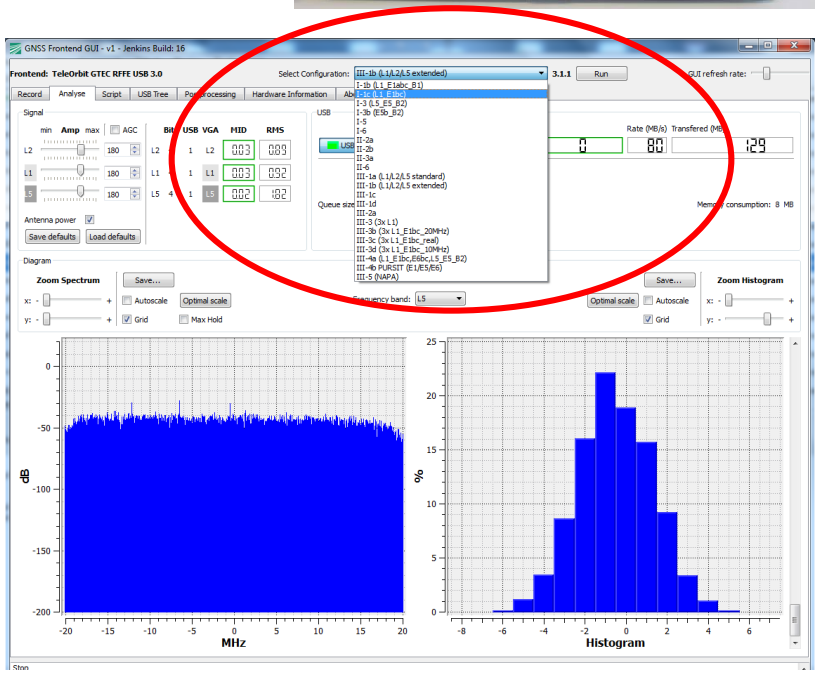
- Application in Fraunhofer IIS Projects
  - Flexiband / GTEC USB3.0 Front-end: Recording multiplexed IF data
  - MGSE: Record/Replay-System: Replay multiplexed IF data
  - Interference Monitoring and Detection Station:
    Recorded IF files with events tagged using the Metadata Standard
  - InterferenceAnalyzer-Tool:
    Visualization of raw data files using the Metadata Standard
  - PROOF/PRISMA#2 PRS Rx: raw data snapshots with the Metadata info
  - Server-Based “Sample & Processing” PRS-Receiver:
    Raw data snapshots tagged with the Metadata for PRS processing
- ESA AO9413 (May 2018) “Blind GNSS software receiver tool for field test assessment in harsh environments” explicitly requiring the raw data tagged with the ION Metadata standard

Examples for Usage of ION Metadata Standard @ FhG/IIS

Flexiband / GTEC USB3.0 Front-end



- RF-Data-Recorder
  - Powered via USB3.0
  - Up to three different RF-Bands in parallel
  - Up to 8 Bit I/Q @ 81 MHz sampling rate
  - Up to 80 MHz RF bandwidth
  - Multi antenna support
- Reconfigurable reception configurations via FPGA signal conditioning: ➔ ➔ ➔ ➔ ➔
- Samples are available under http://www.iis.fraunhofer.de/flexiband
  - E.g. real world L1 / L5 / S-band IRNSS from Measurement campaign in Hanoi, Vietnam



A. Rügamer, D. Seybold, "Multi-GNSS Measurement Campaign in Southeast Asia Using the MGSE-System" ENC 2018

TeleOrbit

Fraunhofer IIS

Examples for Usage of ION Metadata Standard @ FhG/IIS

Flexiband / GTEC USB3.0 Front-end

Configuration	Frequency band	Bandwidth [MHz]	Center frequency [MHz]	Intermediate frequency [MHz]	Sampling rate [MHz]	Sample bit width	USB data rate [MBit/s]	USB type 3.0	Remarks
Single band front-end									
I-1a	L1/E1abc/B1	38	1.575,420	B1: -14,322	40	2x8 (complex)	640	USB3.0	Interference Monitoring
I-1b	L1/E1abc/B1	38	1.575,420	B1: -14,322	40	2x4 (complex)	320	USB3.0	
I-1c	L1/E1bc	18	1.575,420	0,000	20,25	2x8 (complex)	324	USB3.0	
I-1d	L1/E1abc/G1/B1	60	1.587,000	L1: -11,58 G1: 15,00	64	2x8 (complex)	1.024	USB3.0	
I-2a	L2/G2	50	1.238,000	L2: -10,40 G2: 8,00	60	2x8 (complex)	960	USB3.0	
I-2b	tbd								
I-2c	L2/L2C	18	1.227,600	0,000	20,25	2x8 (complex)	324	USB3.0	
I-3a	L5/E5/B2	68	1.191,795	L5/E5a: -15,345 E5b: 15,345	80	2x8 (complex)	1.280	USB3.0	
I-3b	E5b/B2	38	1.207,140	0,000	40	2x4 (complex)	320	USB3.0	
I-4a	E6abc/B3	38	1.278,750	0,000	40	2x8 (complex)	640	USB3.0	
I-5a	L1/E1abc/G1/B1	68	1587,000	L1: -11,58 G1: 15,00	80 / N	2x 8 (complex)	1.280 / N	USB3.0	Mixer, Filter and N configureable
I-6a	L5/E5/B2	68	1191,795	L5/E5a: -15,345 E5b: 15,345	80 / N	2x 8 (complex)	1.280 / N	USB3.0	
Dual band front-end									
II-1a	L1/E1ab	18	1.575,420	0,000	20	2x8 (complex)	640	USB3.0	Interference Monitoring
	L1/E1ab	18	1.575,420	0,000	20	2x8 (complex)			
II-1b	L5/E5a	18	1.176,450	0,000	20	2x8 (complex)	640	USB3.0	Interference Monitoring
	L5/E5a	18	1.176,450	0,000	20	2x8 (complex)			
II-1c	L1/E1ab	18	1.575,420	0,000	20	2x8 (complex)	640	USB3.0	Interference Monitoring
	L5/E5a	18	1.176,450	0,000	20	2x8 (complex)			
II-2a	L1/E1abc	18	1.575,420	0,000	20,25	2x8 (complex)	648	USB3.0	Interference Monitoring
	L2/L2C	18	1.227,600	0,000	20,25	2x8 (complex)			
II-2b	L1/E1abc/B1/G1	54	1.585,000	L1: -9,58 G1: 17,00	81	2x4 (complex)	972	USB3.0	L1/L2 GPS, GLO, GAL, BEI
	L2/L2C/G2	38	1.235,000	L2: -7,40 G2: 11,00	40,5	2x4 (complex)			
II-3a	L1/E1abc/B1	38	1.575,420	B1: -14,322	40	2x4 (complex)	640	USB3.0	Galileo / Beidou
	E5b/B2	38	1.207,140	0,000	40	2x4 (complex)			
II-3b	L1/E1abc/B1	38	1.575,420	0,000	40	2x8 (complex)	1.280	USB3.0	Extended E1/E5
	L5/E5/B2	52	1.191,795	L5/E5a: -15,345 E5b: 15,345	80	2x4 (complex)			
II-3d	L1/E1abc/B1	38	1.575,420	0,000	40	2x4 (complex)	960	USB3.0	Wideband E1/E5
	L5/E5/B2	52	1.191,795	L5/E5a: -15,345 E5b: 15,345	80	2x4 (complex)			
II-4a	L1/E1bc	18	1.575,420	0,000	30	2x4 (complex)	720	USB3.0	Extended E1/E5
	L5/E5/B2	52	1.191,795	L5/E5a: -15,345 E5b: 15,345	60	2x4 (complex)			
II-4b	L1/E1abc/B1	38	1.575,420	L1/E1: 0,000 B1: -14,322	40	2x8 (complex)	1.280	USB3.0	Galileo PRS
	E6abc/B3	38	1.278,750	E6: 0,000 B3: -10,230	40	2x8 (complex)			
II-5a	G1	18	1.602,000	0,000	20	2x4 (complex)	320	USB3.0	Standard G1/G2
	G2	18	1.246,000	0,000	20	2x4 (complex)			
II-6a	L1/E1abc/G1/B1	68	1587,000	L1: -11,58 G1: 15,00	80 / N	2x 4 (complex)	1.280 / N	USB3.0	Mixer, Filter and N configureable
	L5/E5/B2	68	1191,795	L5/E5a: -15,345 E5b: 15,345	80 / N	2x 4 (complex)	1.280 / N		
II-7a	L1/E1bc/G1	38	1587,000	L1: -11,58 G1: 15,00	40	2x 4 (complex)	640	USB3.0	GPS + GLONASS
	L2/G2	38	1230,000	L2: -2,40 G2: 16,00	40	2x 4 (complex)			
II-8a	B1	18	1561,098	0,000	20	2x 4 (complex)	320	USB3.0	Standard B1/B2/B3
	B2	18	1207,140	0,000	20	2x 4 (complex)			

Triple band front-end									
III-1a	L1/E1bc	18	1.575,420	0,000	20	2x2 (complex)	320	USB3.0	Standard L1/L2/L5
	L2/L2C	18	1.227,600	0,000	20	2x2 (complex)			
	L5/E5a	18	1.176,450	0,000	20	2x4 (complex)			
III-1b	L1/E1bc	18	1.575,420	0,000	20	2x4 (complex)	640	USB3.0	Extended L1/L2/L5
	L2/L2C	18	1.227,600	0,000	20	2x4 (complex)			
	L5/E5a	38	1.176,450	0,000	40	2x4 (complex)			
III-1c	L1/E1bc	18	1.575,420	0,000	20,25	2x4 (complex)	648	USB3.0	Extended L1/L2/L5; other mixer freq.
	L2/L2C	18	1.227,600	0,000	20,25	2x4 (complex)			
	L5/E5a	38	1.176,450	0,000	40,5	2x4 (complex)			
III-1d	L1/E1bc	6	1.575,420	0,000	10	2x4 (complex)	320	USB3.0	GPS, GAL, GLO long time recording
	L2/L2C/G2	38	1.227,600	L2: -7,40 G2: 11,00	40	2x2 (complex)			
	L5/E5a	18	1.176,450	0,000	20	2x2 (complex)			
III-1e	L1/E1bc	18	1.575,420	L1/E1: -2.086,637 KHz (inv.)	20	2x4 (complex)	640	USB3.0	Extended L1/L2/L5
	L2/L2C	18	1.227,600	L2: +933,333 KHz (reg.)	20	2x4 (complex)			
	L5/E5a	38	1.176,450	L5/E5a: +449,965 KHz (reg.)	40	2x4 (complex)			
III-2a	L1/E1abc/B1/G1	54	1.585,000	L1: -9,58 G1: 17,00	81	2x2 (complex)	810	USB3.0	L1/L2/L5 GPS, GLO, GAL, BEI
	L2/L2C/G2	38	1.235,000	L2: -7,40 G2: 11,00	40,5	2x2 (complex)			
	L5/E5/B2	50	1.192,500	L5/E5a: -16,050 E5b: 14,640	81	2x2 (complex)			
III-2b	L1/E1abc/B1	38	1.585,000	L1: -9,58 G1: 17,00	40,5	2x4 (complex)	972	USB3.0	L1/L2/L5 GPS, GLO, GAL, BEI
	L2/L2C/G2	38	1.235,000	L2: -7,40 G2: 11,00	40,5	2x4 (complex)			
	L5/E5/B2	38	1.192,500	L5/E5a: -16,050 E5b: 14,640	40,5	2x4 (complex)			
III-2c	L1/E1abc/B1	38	1.585,000	L1: -9,58 G1: 17,00	40,5	2x4 (complex)	1296	USB3.0	L1/L2/L5 GPS, GLO, GAL, BEI
	L2/L2C/G2	38	1.235,000	L2: -7,40 G2: 11,00	40,5	2x4 (complex)			
	L5/E5/B2	50	1.192,500	L5/E5a: -16,050 E5b: 14,640	81	2x4 (complex)			
III-3a	L1/E1bc/G1	38	1.587,000	L1: -11,58 G1: 15,00	41	2x4 (complex)	984	USB3.0	Beamforming, Heading, etc.
	L1/E1bc/G1	38	1.587,000	L1: -11,58 G1: 15,00	41	2x4 (complex)			
	L1/E1bc/G1	38	1.587,000	L1: -11,58 G1: 15,00	41	2x4 (complex)			
III-3b	L1/E1bc	18	1.575,420	0,000	20,25	2x8 (complex)	972	USB3.0	Beamforming, Heading, etc.
	L1/E1bc	18	1.575,420	0,000	20,25	2x8 (complex)			
	L1/E1bc	18	1.575,420	0,000	20,25	2x8 (complex)			
III-3c	L1/E1bc	18	1575,420	-10,830	40,5	8 (real)	972	USB3.0	Beamforming, Heading, etc.
	L1/E1bc	18	1575,420	-10,830	40,5	8 (real)			
	L1/E1bc	18	1575,420	-10,830	40,5	8 (real)			
III-3d	L1/E1bc	8	1575,420	0,000	10	2x 8 (complex)	480	USB3.0	GPS C/A and Galileo OS BOC(1,1)
	L1/E1bc	8	1575,420	0,000	10	2x 8 (complex)			
	L1/E1bc	8	1575,420	0,000	10	2x 8 (complex)			
III-3e	L1/E1bc	8	1575,420	0,000	10	2x 4 (complex)	240	USB3.0	GPS C/A and Galileo OS BOC(1,1)
	L1/E1bc	8	1575,420	0,000	10	2x 4 (complex)			
	L1/E1bc	8	1575,420	0,000	10	2x 4 (complex)			
III-4a	L1/E1bc	18	1.575,420	0,000	30	2x4 (complex)	960	USB3.0	Galileo CS, QZSS, etc.
	E6bc	18	1.278,750	0,000	30	2x4 (complex)			
	L5/E5/B2	52	1.191,795	L5/E5a: -15,345 E5b: 15,345	60	2x4 (complex)			
III-4b	L1/E1abc	38	1.575,420	0,000	40	2x4 (complex)	1280	USB3.0	Extended Galileo CS, QZSS, etc.
	E6abc	38	1.278,750	0,000	40	2x4 (complex)			
	L5/E5/B2	68	1.191,795	L5/E5a: -15,345 E5b: 15,345	80	2x4 (complex)			
III-5a	G1	18	1.602,000	0,000	20	2x4 (complex)	640	USB3.0	Extended G1/G2/G3
	G2	18	1.246,000	0,000	20	2x4 (complex)			
	G3	38	1.202,025	0,000	40	2x4 (complex)			
III-6a	B1	18	1.561,098	0,000	20	2x4 (complex)	640	USB3.0	Standard B1/B2/B3
	B3/E6	38	1.268,520	0,000	40	2x4 (complex)			
	B2/E5b	18	1.207,140	0,000	20	2x4 (complex)			

- From single-band to triple-band
- From 320 to 1280 Mbit/s [40 to 160 Mbyte/s]
- Over 43 defined configurations available
- Customized configurations available, too
- Metadata mandatory…

A. Rügamer, F. Förster, M. Stahl, and G. Rohmer, "A Flexible and Portable Multiband GNSS Front-end System," ION GNSS 2012

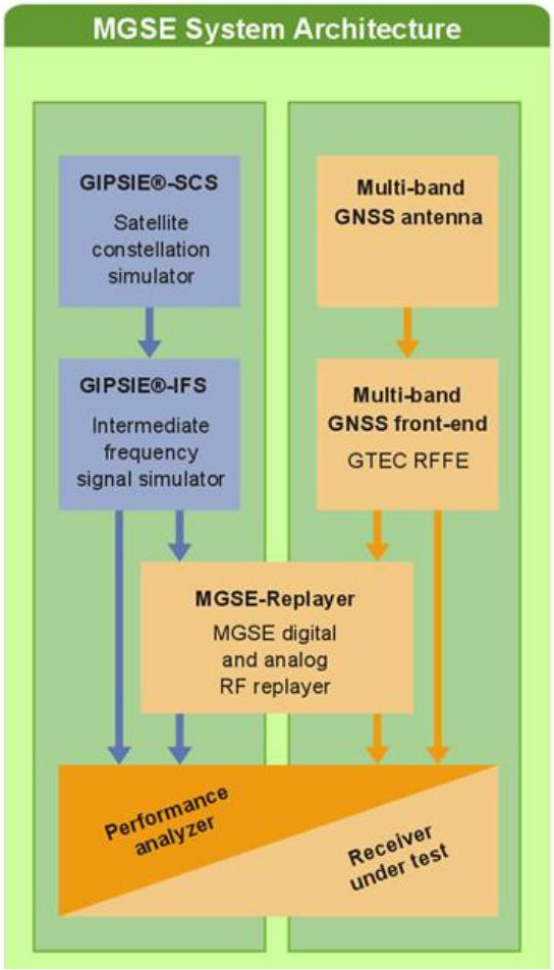
Tele rbit

Fraunhofer IIS

Examples for Usage of ION Metadata Standard @ FhG/IIS
Multi-GNSS Simulation & Test Environment, MGSE

- Co-Funded and used by ESA ESTEC
- Record & Replay-System:
  - Dual-band multiplex recording and replay with user selectable configurations
  - ➔ Metadata used and required
- GIPSIE: Software Multi-GNSS Simulator
  - IF files generates tagged with Metadata info

Performance parameter		SIM	REC	REP
GNSS multi-system, multi-frequency scenarios:				
▪ GPS:	L1 C/A & P; L2 L2C & P; L5	X	X	X
▪ SBAS:	EGNOS/WAAS/MSAS/GAGAN L1	X	X	X
▪ Galileo:	E1 A (PRS-like), B & C; E5, E5a/b; E6 A (PRS-like)	X	X	X
▪ GLONASS:	G1, G2	X	X	X
▪ BeiDou:	B1, B2	X	X	X
▪ QZSS:	L1, L1C, L2C, LEX	X	x	X
▪ IRNSS	L5 and S-Band	X	X	X
Simulation of jamming, spoofing, multipath/meaconing signals (optional)		X	n/a	X
Notes:	*SIM = Simulation Channels / Signals* *REC = Recording Channels / Signals* *REP = Replaying Channels / Signals*			



J. Seybold, A. Rügamer, P. Berglez, S. Bartel, O. Smeyers, „MGSE – Multi-GNSS Simulation & Test Environment“ NAVITEC 2017

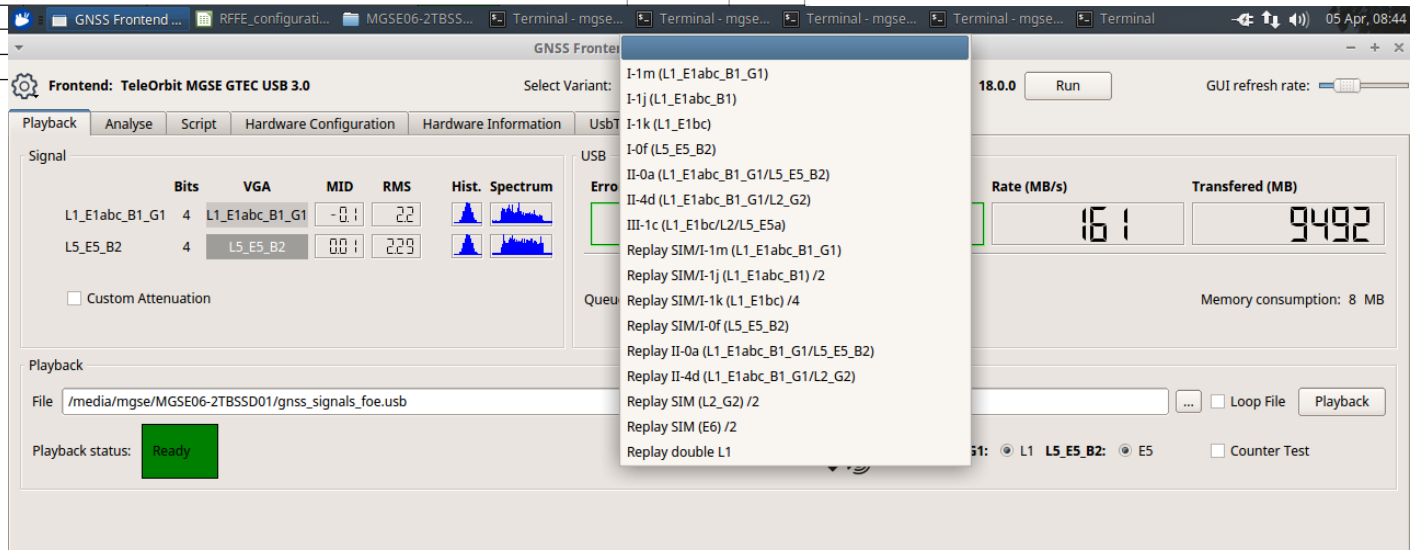
Tele rbit TeleConsult AUSTRIA Fraunhofer IIS

Examples for Usage of ION Metadata Standard @ FhG/IIS

Multi-GNSS Simulation & Test Environment, MGSE

Configuration	Frequency band	Band width [MHz]	Center frequency [MHz]	Intermediate frequency [MHz]		Sampling rate [MHz]	Sample bit width	USB data rate [MBit/s]	Replay Variant
Single band front-end									
I-0f	L5/E5/B2	60	1190,000000	E5a: -13,550	E5b: 17,140	81	2x 8 (complex)	1.296	yes
I-1j	L1/E1abc/B1	38	1580,000000	-4,580000		40,5	2x 8 (complex)	648	yes
I-1k	L1/E1bc	18	1580,000000	-4,580000		20,25	2x 8 (complex)	324	yes
I-1m	L1/E1abc/B1/G1	54	1580,000000	L1: -4,580	G1: 22,000	81	2x 8 (complex)	1.296	yes
SIM	L2	38	1232,500000	-4,900000		40,5	2x 8 (complex)	648	only
SIM	E6	38	1270,000000	8,750000		40,5	2x 8 (complex)	648	only
Dual band front-end									
II-0a	L1/E1abc/B1/G1	54	1580,000000	L1: -4,580	G1: 22,000	81	2x 4 (complex)	1.296	yes
	L5/E5/B2	54	1190,000000	E5a: -13,550	E5b: 17,140	81	2x 4 (complex)		
II-4d	L1/E1abc/B1/G1	54	1580,000000	L1: -4,580	G1: 22,000	81	2x 4 (complex)	1.296	yes
	L2/G2	54	1232,500000	L2: -4,900	G2: 13,500	81	2x 4 (complex)		
double L1	L1/E1abc/B1/G1	54	1580,000000	-4,580000		81	2x 4 (complex)	1.296	yes
	L1/E1abc/B1/G1	54	1580,000000	-4,580000		81	2x 4 (complex)		
Triple band front-end									
III-1c(1)	L1/E1bc	18							
	L2/L2C	18							
	L5/E5a	38							

- Re-Configuration of the system via FPGA including in MGSE recorder and replayer
- Usage of *.usbx with Metadata info to tag the raw data files

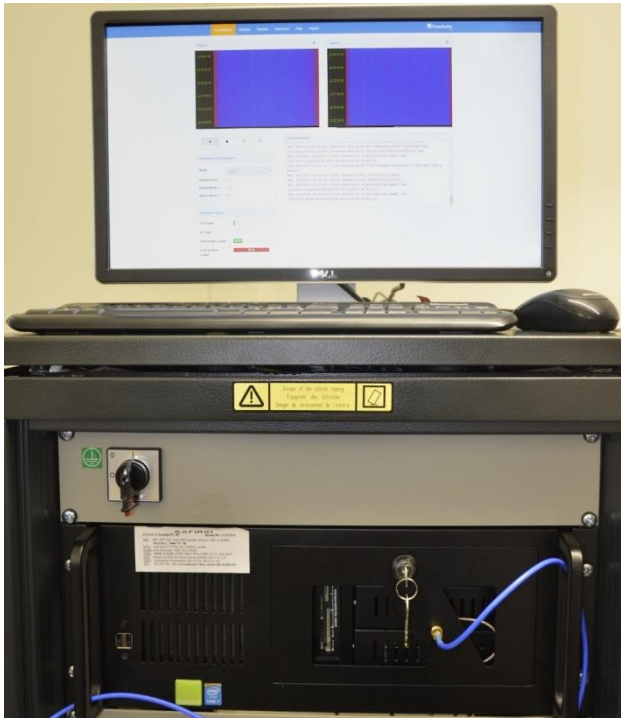


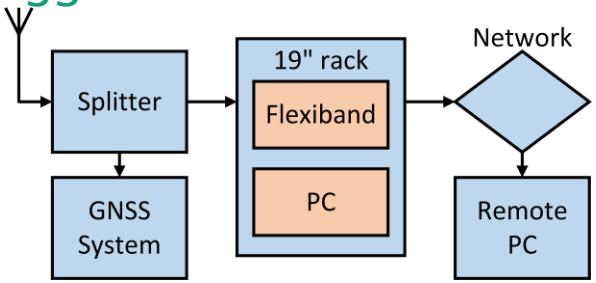
TeleOrbit TeleConsult AUSTRIA Fraunhofer IIS

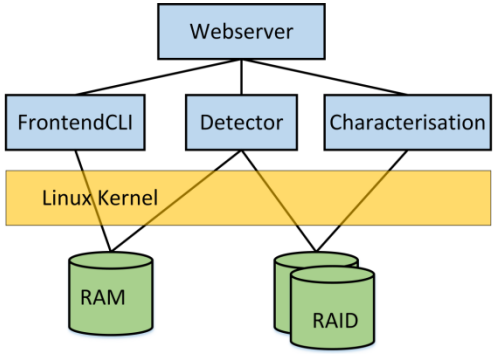
Examples for Usage of ION Metadata Standard @ FhG/IIS

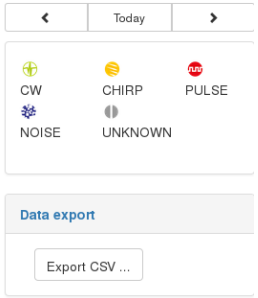
Interference Monitoring and Detection Station

- Station for real-time GNSS detection and characterization
  - Real-time Monitoring of 2 GNSS Bands with 50 MHz Bandwidth / 8 bit
  - Interference Detection and Characterization
  - Recording of Events tagged with ION Metadata









A. Rügamer, D. Meister, J. R. van der Merwe, C. Otto, M. Stahl, W. Felber, „Versatile and Configurable GNSS Interference Detection and Characterization Station“, ION PNT 2017

Fraunhofer IIS

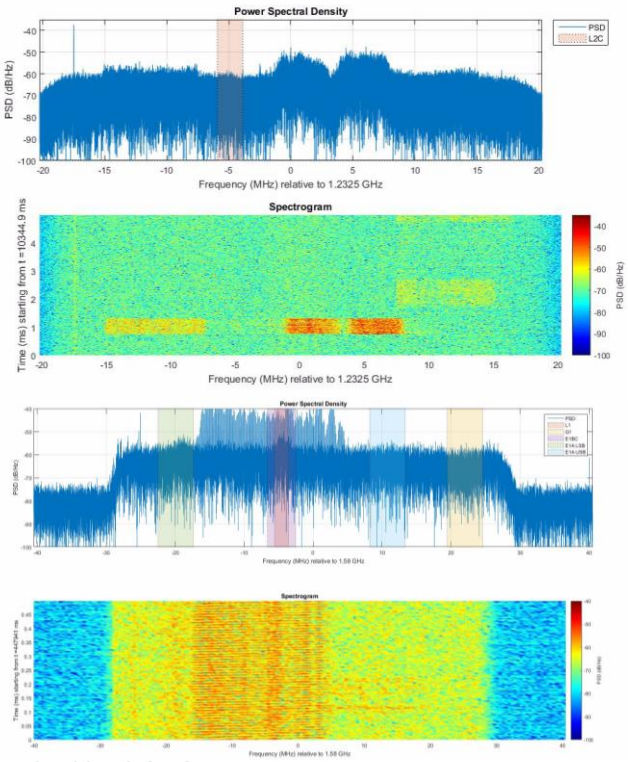
Examples for Usage of ION Metadata Standard @ FhG/IIS

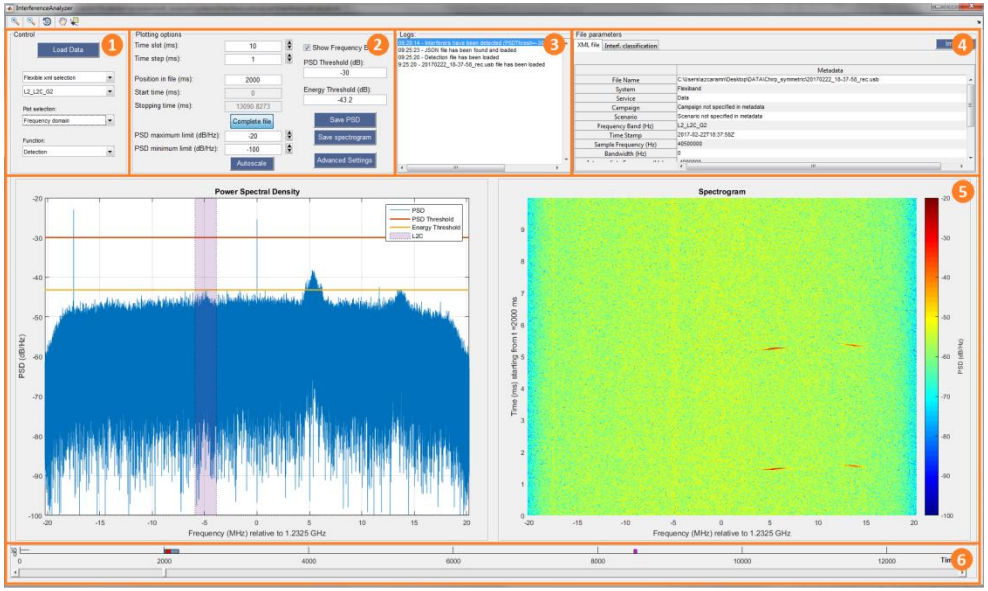
InterferenceAnalyzer

- Matlab, Metadata from GitHub, compiled for Win / Linux
- Visualization and analysis of IF data, using the band, IF, FS, etc. info from ION MetaData Standard
- Generation of Videos

GUI Panels

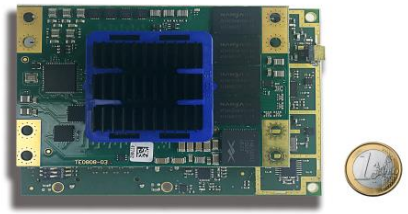
1) Control
2) Plotting options
3) Logs
4) File parameters
5) Visualization
6) Time slider





Examples for Usage of ION Metadata Standard @ FhG/IIS

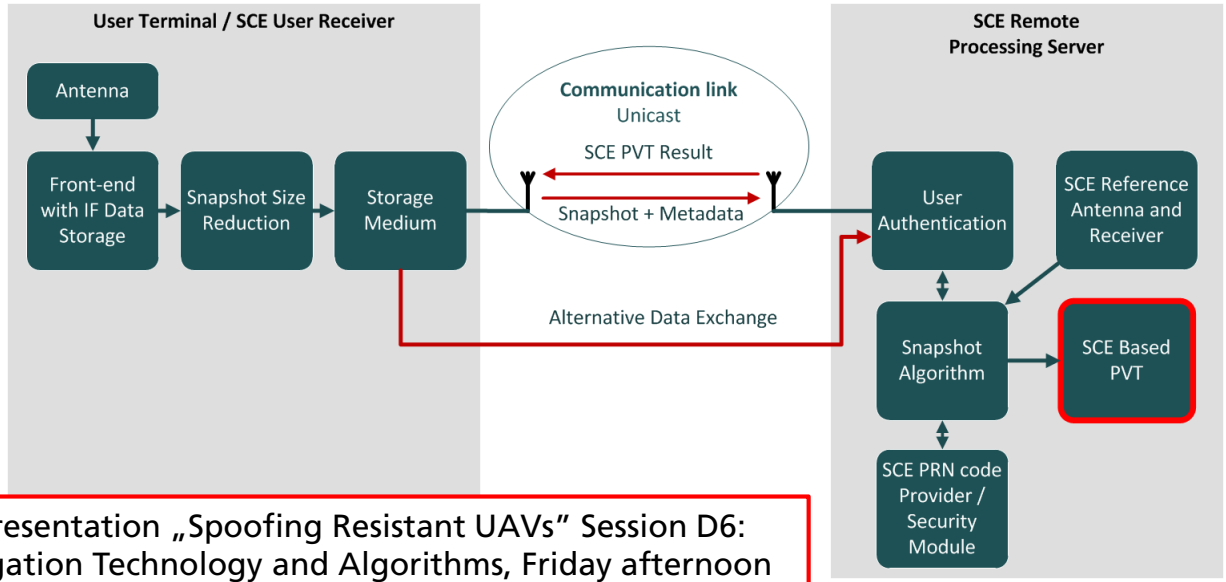
PROOF / PRISMA#2 PRS-Receiver



- Fraunhofer IIS Galileo PRS Receivers (PROOF, PRISMA#2)
  - Raw-Data snapshots of „InterferenceManager“ saved on internal memory in “ring buffer”
  - „Pre“ and „Post“-Interference-Mitigation
    - Pre (Interference Manager): 1 ms E1 and E6
      - 319664.000000000_UTC_1_E1_16bitIQ.bin
      - 319666.000000000_UTC_1_E6_16bitIQ.bin
    - Pre (ADC raw data): 1.24 s E1 and E6, 16 bit I/Q @ 108 MHz
    - Post (after interference mitigation): 1ms E1 / E6
  - Tagged with PVT-Time in filename and ION Metadata
  - Accessible for further processing via FTP

Examples for Usage of ION Metadata Standard @ FhG/IIS
Server-based PRS Receiver “S&P”

- “PRSauth”, Sample and Processing server-based PRS receiver
  - ‘Data Grabber’ as User Terminal
  - Raw data snapshot forwarded to PRS-Server (Metadata tagged)
  - Remote Server with Security Module for PRS snapshot PVT



See also Presentation „Spoofing Resistant UAVs” Session D6: UAV Navigation Technology and Algorithms, Friday afternoon

Rügamer, A., Rubino, D., Lukcin, I., Taschke, S., Stahl, M., Felber, W., "Secure Position and Time Information by Server Side PRS Snapshot Processing," ION GNSS+ 2016

Examples for Usage of ION Metadata Standard
ESA Requires ION Metadata in ITT (May 2018)

- ESA ITT AO9413 "Blind GNSS software receiver tool for field test assessment in harsh environments"

[REQ-CD-072]	The signal gathered by the **receiver platforms** and stored in the **Database** shall be compliant with the ION GNSS SDR Metadata standard ([AD-01], [RD-02], [RD-03]).

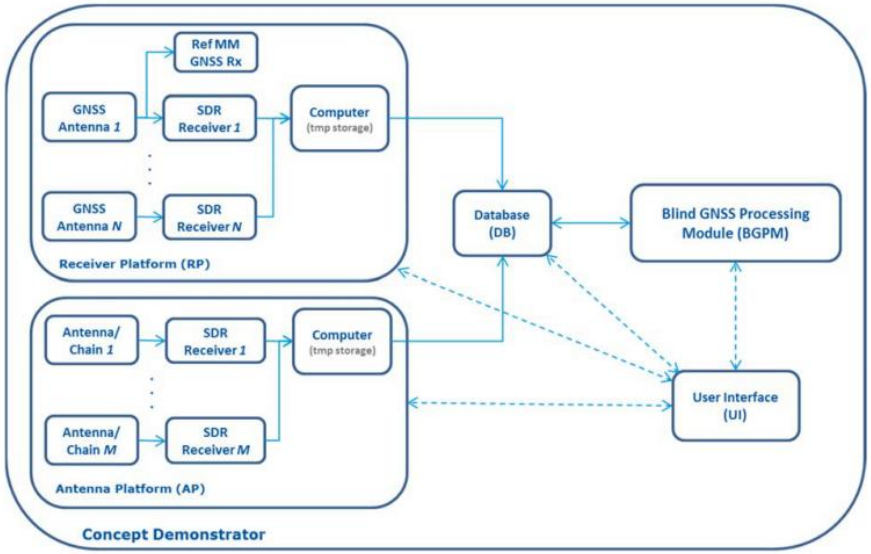


Figure 1: High-level architecture of the blind GNSS SDR concept demonstrator

1.2 Applicable and Reference Documents

1.2.1 Applicable Documents (ADs)

The following documents, listed in order of precedence, contain requirements applicable to the activity:

[AD-01] GNSS Software Defined MetaData Standard, http://sdr.ion.org

1.2.2 Reference Documents (RDs)

The following documents can be consulted by the Contractor as they contain relevant information:

[RD-01] Robust Unambiguous Estimation of High-Order BOC Signals: The DOME Approach, NAVIGATION: Journal of the Institute of Navigation, vol. 63, no. 4, pp. 511-520, Winter 2016.

[RD-02] GNSS SDR Metadata Standard Working Group Report, published in: ION GNSS+ 2015.

[RD-03] ION GNSS SDR Metadata Working Group, https://github.com/IonMetadataWorkingGroup

ESA ESA-TRP-TEC-SOW-008342 „Statement of Work" AO9413-ws00pe.pdf