

# Space and Resilient Communications Laboratory

## RF transmission and reception

- 4x Ettus Research's Universal Software Radio Peripherals USRP X310.
- 4x RF front-ends, up converters, 400 - 4400 MHz.
- 4x RF front-ends, down converters, 400 - 4400 MHz.
- Ettus clock reference splitter, 8 channels, with 10 MHz reference and PPS each.
- 4x dedicated GPP at 10.1 Gbps of bandwidth each.
- 800 MHz of aggregated bandwidth

## 5G commercial base stations and user equipment

- 5G gNB Rel. 16
- FDD/TDD FR1
- 600 Mbps downlink / 150 Mbps uplink
- Up to 1000 UE
- Carrier aggregation up to 3 carriers with MIMO 2x2
- 50 MHz of bandwidth
- 4x4 MIMO
- NSA and SA supported modes
- Up to 256 QAM
- 3 max. cells
- NB-IoT and LTE-M support
- 5G NR UE Rel. 16 bench station
- Up to 256 simulated 5G UE simultaneously
- 1.5 Gbps downlink / 1 Gbps uplink
- 4x4 MIMO
- Carrier aggregation up to 4 carriers with MIMO 2x2
- FDD/TDD FR1
- 4x4 MIMO in DL
- NSA and SA supported modes

### Advanced channel emulator

- Next generation of channel emulator
- 8 TRX bidirectional ports or 8 TX and 8 RX unidirectional ports
- Bidirectional and unidirectional fading supported
- MIMO fading channels Up to 256 digital channels in single unit (16x16)
- Up to 1024 fading channels in multi-unit configuration
- MIMO and massive MIMO emulation
- Arbitrary MIMO and multi-link topologies
- MIMO testing up to 8x8bi or 16x16uni
- MIMO OTA 2x16, 4x16 and 8x16
- Simplified Antenna Array Sampling Massive MIMO testing with external antenna interfacing unit or RF phase shifter matrix. BS 32TR/64TR/128TR with 4/8/16 layers
- MESH and MANET emulation Up to 16 radio full mesh
- Frequency range 3 MHz to 6 GHz
- Instantaneous signal BW 40/100/160 MHz.
- LTE/5G NR Carrier Aggregation support Contiguous up to 1200 MHz (TDD or FDD)
- Non-contiguous up to 8 CA bands
- 5 Independent RF local oscillators
- Frequency conversion (e.g. inputs at band A and outputs to band B)
- Internal RF band combination into single RF port supported above 450 MHz Up to 8 RF bands.
- Fading paths per fading channel Up to 48
- Delay range 2.6 us.... > 1000 ms
- Delay Doppler emulation Up to  $\pm$  1.5 MHz
- HW trigger port for emulation start/stop
- Synchronization ports for multiple PROPSIM FS16 units
- 3GPP 5G NR TDL channel models for FR1 and FR2 testing
- LTE, WCDMA, GSM and Static Butler
- 3GPP TR38.901, TR36.873, WINNER and SCME
- Ray-tracing data import
- 3D Antenna pattern inclusion in to channel model
- Custom test topology creation for massive MIMO, Device-to-Device (D2D), Vehicle-to-everything (V2X)
- MIMO OTA channel models (CTIA/3GPP/CCSA). RTS MIMO OTA
- 802.11n/ac/ax channel models
- 5G NR, LTE, WCDMA, GSM and WLAN
- Fast fading profiles Constant, Rayleigh, Rice, Nakagami, Lognormal, Suzuki, Pure Doppler, flat, rounded, Gaussian, Jakes, Butterworth, user-defined, and CIR data from 3rd party simulation tools
- Each digital channel can be set for independent fading profile (delay, doppler, amplitude, correlation)
- Pathloss/Shadowing
- Each TRX channel independently, 100 dB dynamic range
- Each digital fading channel independently, 60 dB dynamic range
- Delay profiles Constant, sliding delay, 3GPP birth-death, 3GPP sliding delay group, user-defined, delay profiles from 3rd party simulation tools, ray-tracing applications
- Each digital fading channel has independent delay setting

**mmWave equipment**

- 2 front-ends, up-converters, 32 channels at 29 GHz, 2 GHz of bandwidth
- 2 front-ends, down-converters, 32 channels at 29 GHz, 2 GHz of bandwidth
- 64 selectable amplitudes and phases per channel
- Shared reference
- 2x Antenna with 32 passive elements
- Steerable beamforming
- Hybrid (digital and analogic) beamforming, with 2x32
- Half duplex single polarization transmission mode

**Satellite connectivity**

- 2 satellite connections
- 2 independent platforms: Gilat & iDirect
- Full duplex, 10 Mbps UL & DL
- Average latency 500 ms

**Artificial Intelligence**

- Cluster of 4 GPU NVIDIA RTX 2080 and 3090
- 30 000 GPU cores for AI
- 64 GB of GPU memory
- 2.8 Tbps of aggregated bandwidth
- Tensorflow 2.10
- Remote access and management

**Super High Performance Computation cluster**

- Cluster of high intensive signal processing computation
- +300 CPU cores at 4 GHz
- 640 GB of memory
- Matlab R2022B with all toolboxes
- HFSS antenna modeling
- Virtualized Windows and Linux
- Remote access and management

**Visible Light Communications**

- Ettus Research's Universal Software Radio Peripherals USRP N210 and RF front-ends.
- Ettus Research's Universal Software Radio Peripherals USRP X300 and RF front-ends.
- Starter Kit Raspberry PI4
- FeelTech FY3200S Dual Channel Arbitrary Function Signal Generator/Counter
- KEYSIGHT DSOX1202A Digital Storage Oscilloscope 70MHz 2GSa/s MegaZoom InfiniiVision
- Light Wavelength Spectrum Analyzer, Spectromaster C-7000 from SEKONIC
- Photodetector PDA36A2 Amplifier Detector from ThorLabs
- Photodetector PDA36A-EC Si Amplifier Detector Thorlabs
- Fluke 115 TRUE RMS Multimeter
- Router TP-LINK model TL-SG1008D
- Laptop DELL Latitude E5510 Core I5
- Laptop ASUS 15,6" 1920x1080, Core i7-7700HQ, GTX 1070 8GB
- 2 Tower PC ASUS Core i5
- 2 Tower PC ADRUS Core i7