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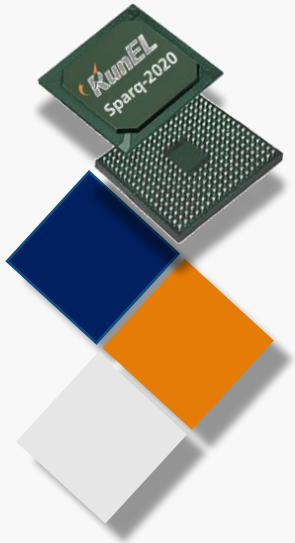

Sparq-2020-DRAN

Sparq-2020-RRH

The Fastest 5G Distribution Platform

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General Information

The Sparq-2020-DRAN and Sparq-2020-RRH are the components of a unique Distributed Architecture design for a New Radio (NR, 5gNB) designated for 5G infrastructure that fully complies with 3GPP 5G Standards (Rel-15) Optimized for Ultra Reliable Low Latency Communication (URLLC) and supports enhanced Mobile Broadband (eMBB) and Massive Machine type Communication (mMTC). The Sparq-2020-DRAN is based on the RunEL Sparq-2020-2 System on Chip (SoC) and the Sparq-2020-RRH is based on the RunEL Sparq-2020-3 System on Chip (SoC)

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True Innovation

The Sparq-2020-SRRH includes substantial innovation enhancing existing state of the art implementations such as: Distributed Architecture with PHY split 28GHz or 3.5GHz Beam Forming Phased Array, the Sparq Minislots, the Hardware based MAC and the I-MEC, that reduces the latency in wireless broadband cellular communication to unprecedented records in order to support applications such as: V2X, Remote Surgery, On line Gaming, Automated Factory, Augmented and Virtual Reality, IoT, Tactile Internet, etc.

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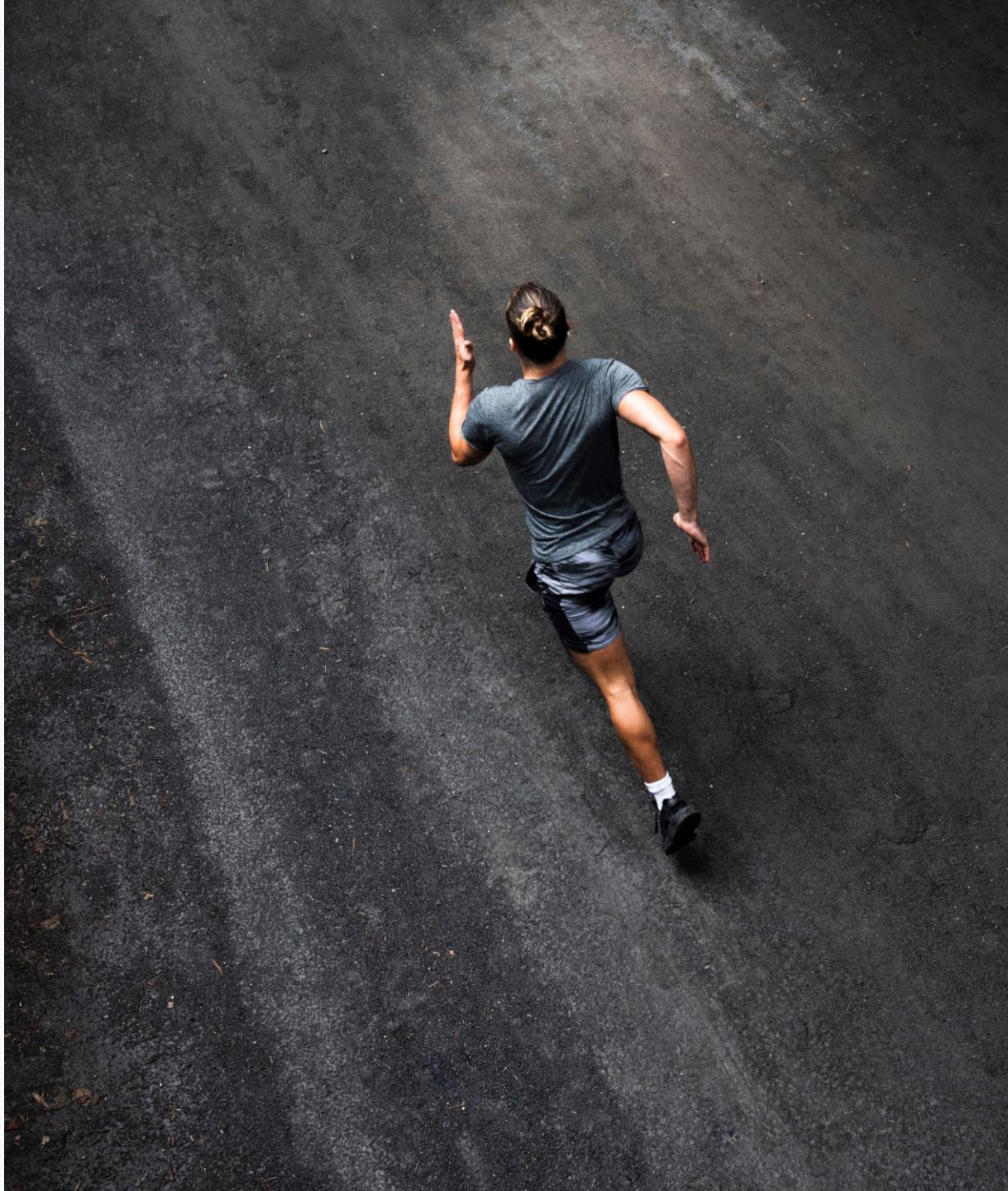
A Competitive Edge

- ✓ First in the Market
- ✓ 5G 3GPP standard compliant (Rel-15)
- ✓ Includes 5G PHY (Layers 1) with PHY split (option 7. x)
- ✓ Includes 28GHz or 3.5 GHz multiple beam steerable Beam Forming Antenna
- ✓ Optimized for URLLC – including “Sparq Minislots“, Hardware based MAC, Cell-less instantaneous handoffs and integrated mobile edge computing (“I-MEC”)
- ✓ FPGA chip based on 16 nanometer technology
- ✓ Open Architecture enables customization via API’s
- ✓ Based on the RunEL Sparq-2020-1 SoC
- ✓ Large coverage area using up to 64 RRHs with one DRAN
- ✓ Flexible deployment scenarios for indoor and outdoor



Main Features

Sparq-2020-DRAN and Sparq-2020-RRH

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- Includes PHY, (MAC and RLC Modules from third party are optional)
- Optional embedded CU with PDPC, SDAP, RRC, Light NgCore, UPF and MEC modules
- DRAN supports up to 64 RRHs
- 27.5 to 30GHz or 3.3 to 3.8 GHz operation (other frequency bands are optional)
- 4 x 200 MHz channel BW (50 and 100 MHz available as well)
- 256 element on 28GHz Antenna Array (1 or 4 independent beams)
- 64 element on 3.5 GHz Antenna Array (up to 4 independent beams)
- Up to 64 Gbps Capacity for DRAN
- Up to 4 Gbps Capacity (1 Gbps per beam) for RRH
- Physical Layer split between DRAN and RRHs connected via fast Ethernet Ring (20 Gbps) or Hub and Stroke (Star) Architecture (4 Gbps)
- Latency < 0.5 msec
- Sub Carrier Spacing- 15, 30, 60, 120, 240 KHz
- TTI Spacing – from 8.25 to 1000 msec (TTI Spacing depends on Subcarrier-spacing and number of OFDM symbols)
- FDD and Dynamic TDD Supported
- CSI-RS, PTRS, DMRS- Supported
- LDPC (Data Plane) and Polar Codes (Control Plane) Supported
- CP-OFDMA implemented in UL and DL and DFT-S-OFDM for UL
- CoMP- Supported
- Indoor and Outdoor operation
- 64 bits DDR4 to FPGA Logic
- Embedded GPS receiver for outdoor synchronization
- Battery option for GPS receiver, save RTC when power is off
- Support IEEE 1588 synchronization

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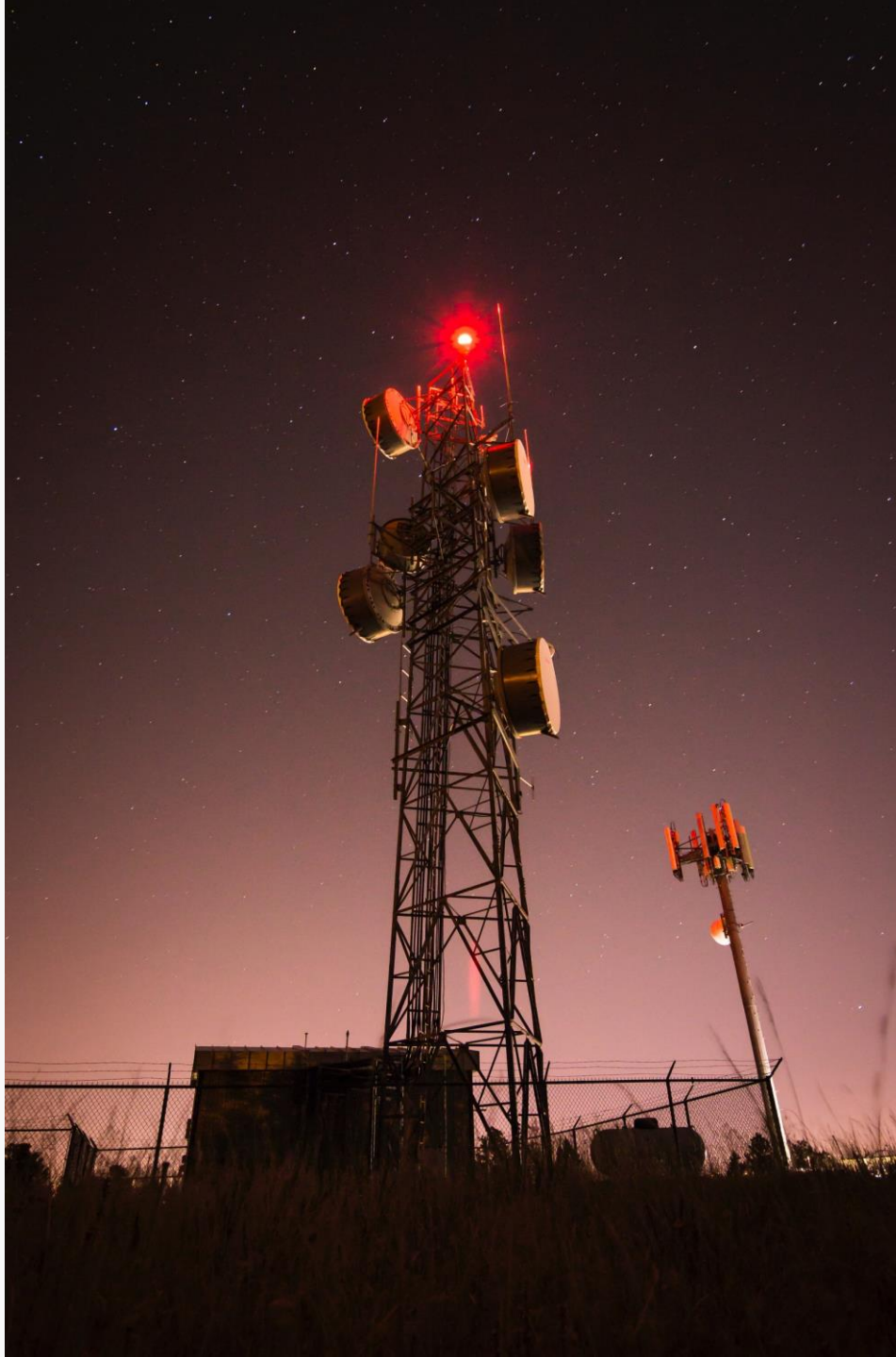
DRAN and RRH Interfaces

- ✓ 4 x 10G SFP+ (Aggregated 40 Gigabit Ethernet connection to XHaul ring)
- ✓ 4 x CPRI SFP+ (can be used for Ethernet 10G instead or eCPRI) for additional external antennas
- ✓ 1 x USB to control 4 UARTS: a- for CPU, b-for CPU, c- for FPGA, d- for GPS
- ✓ PCIe x 4 Gen2 for external server connection for external MAC or MEC
- ✓ Interface between DRAN and RRH - xRAN
- ✓ Interface between DRAN and CU - F1 (Optional with Third Party)



DRAN and RRH Power, Physical and Environmental

- ✓ Power Inputs: -48V (-35 to-75VDC)
- ✓ Weight- 5Kg
- ✓ Dimensions: 40 x 24 x12 cm
- ✓ Temperature (Operational) - -45 to 55 degrees Celsius
- ✓ Humidity 5% -95% non-condensing
- ✓ IP65 (Optional)
- ✓ ETS 300 019
- ✓ Environmental Standard Compliance -TBD

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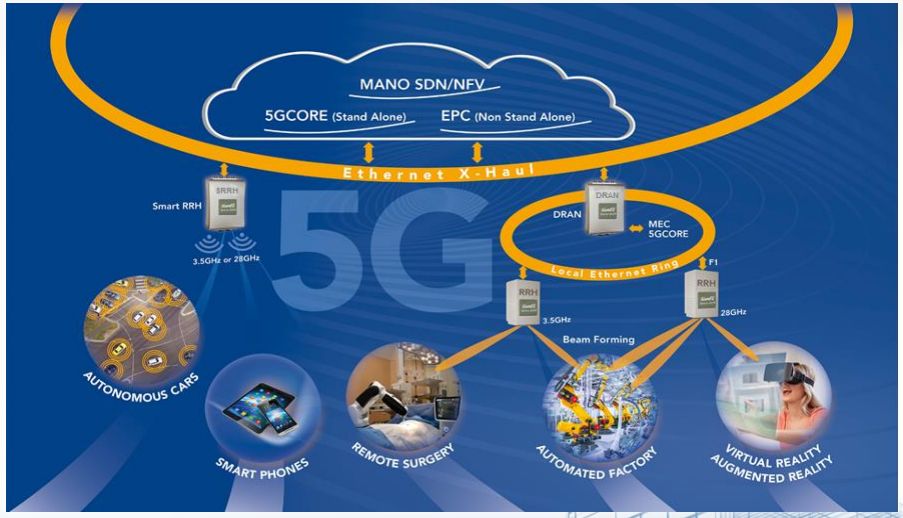
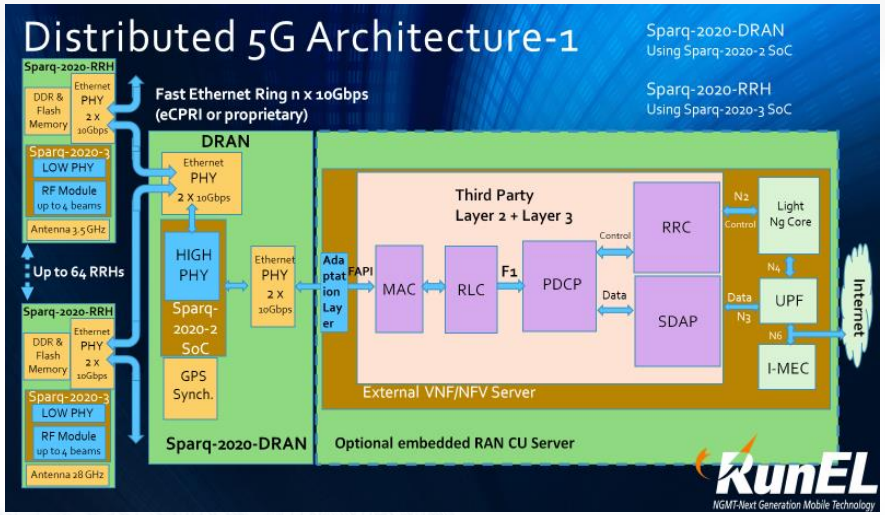
5G System Architecture Diagram



RunEL Distributed Architecture Block Diagram



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Phased implementation of Sparq-2020 NR PHY

Implementation of PHY feature will be as per the following phase-wise plan:

- **Stage-1**: First PHY code Delivery for sub 6GHz FDD & TDD without some features of MIMO (floating point) – Available now
- **Stage-2**: Second PHY Delivery for sub 6GHz FDD & including fixed point models- Feb 2020
- **Stage-3**: Third PHY Delivery including eMBB and URLLC for sub 6GHz FDD & TDD+ basic mm-wave support - April 2020
- **Stage-4** PHY Delivery including eMBB and URLLC for sub 6GHz FDD & TDD+ mm-wave support with beam management SW- June 2020

Note: In every stage only the mandatory features required by the standard are supported. Not all optional features listed in Table-1 below will be implemented

The delivery conforms to June 2018 version 3GPP Standard NR Phase-1 technical specifications.

The UL algorithms support up to 64 Antenna elements and DL algorithms will support up to 64-Tx antenna elements with 8 streams.

5G PHY features Release Schedule

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Feature group	Components	Delivery
Bandwidth support	100 MHz component carrier	Stage-1
Mixed numerology support	between bands and/or different subframes	Stage-1
3GPP NR channel model	Support for larger bandwidths and mmWave frequencies	Stage-1
CP-OFDM waveform for DL and UL	CP-OFDM for DL 2) CP -OFDM for UL WoLA	Stage-1
DFT-S-OFDM waveform for UL	Transform precoding for single-layer PUSCH	Stage-1 or 2 (UL OFDM is prioritized)
DL modulation scheme	QPSK, 16QAM, 64-QAM, 256-QAM	Stage-1
UL modulation scheme	1) QPSK, 16QAM, 64-QAM for CP-OFDM 2) QPSK, 16QAM, 64-QAM for CP-OFDMpi/2 BPSK for DFT-S-OFDM	Stage-1 (DFT-S-OFDM may be moved to stage-2)
Subcarrier spacings and FFT size in conjunction with supportable BW with normal CP	1) 15kHz 2) 30 kHz 3) 60 kHz 4) 120 kHz	Stage-1
Extended CP	Optional, supported later	Optional
pi/2-BPSK for PUCCH format 3/4	pi/2-BPSK for PUCCH format ¾	Stage-3
Basic initial access channels		Stage 1
PRACH configuration and receiver	[1) RACH preamble format XX] 2) RACH preamble format A0, A1, B1, C0 f	Essential PRACH configs in Stage-1 remaining in stage-4
CSI-RS	beamformed CSI-RS	Stage-1

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Feature group	Components	Delivery
PDSCH transmission		Slot based stage-1
Non-transparent DL MU-MIMO support	Maximum number of MU MIMO layers, candidate values: [0,2,4]	Stage-1
PDSCH MIMO layers	1. Maximal number of MIMO layers, candidate values: [2,4,	SU MIMO with [2,4,] in stage-1
Downlink DMRS	1. DMRS type. [type-1, type-2]. At least one DMRS type should be mandatory 2. Support 2 symbols FL DMRS and 2 additional DMRS symbols 3. Support 1 symbol FL DMRS and 2 additional DMRS symbols 4. Support additional DMRS symbol in 7 symbols non-slot based scheduling 5. Support PRB bundling size [4, scheduled BW]	DM-RS slot-based Stage-1
PUSCH transmission	1. Support non-codebook based PUSCH 2. The number of supported layers Y, [2]. (note: Number of layers = number of DMRS ports) 3. Maximal number of layers for MIMO transmission, [2,];	coherent SU MIMO transmission with 2 and 4 layers in Stage-1 and remaining in stage-3 including MU MIMO
Non-codebook based UL MIMO	1. SRS based precoding	Stage-3
Uplink DMRS	1. DMRS type. [type-1, type-2]. At least one DMRS type should be mandatory 2. Support 1 symbol FL DMRS	1. Stage-1 2. Stage-4
Beam management	1. Maximum Number of CSI-RS resources (1Tx), >16. (Band dependent) 2. Support Rx beam switching procedure (P3)	Stage 1
Beam failure recovery	1. Maximal number of SSB resources configured for monitoring PDCCH quality [4,8,64 2. Maximal number of SSB or CSI-RS resources for identifying new beams. 3. Support using PUCCH for SSB/ based RSRP feedback	Mandatory features- Stage 1
CSI-RS for beam management	Maximal number of CSI-RS resources per CC for beam management > 16	Stage-1

Feature group	Components	Delivery
Basic BWP operation	1) 1 DL BWP and 1 UL BWP for FDD and 1 DL/UL BWP pair for TDD	Stage-1
Basic DL CA operation	1) Maximum 4DL carriers	Stage-1
Basic UL CA operation	1) Maximum 4 UL carriers	Stage-4 with limited CA functionality
Different numerology across PUCCH groups	Two	Stage-1
7.5kHz UL raster shift	7.5kHz UL raster shift	Stage 1
Channel coding	1) LDPC encoding and associated functions for data on DL and UL 2) Polar encoding and associated functions for PBCH, DCI, and UCI 3) Coding for very small blocks	Stage-1

Other items:

Target eMBB and certain frame formats

DMRS and beamformed CSI RS planned for Stage 1. PTRS in Stage-4

UE Emulator with basic L1 functionality to be available by Stage 1

Rel-15 NR compliance (based on current version of spec as per delivery)


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