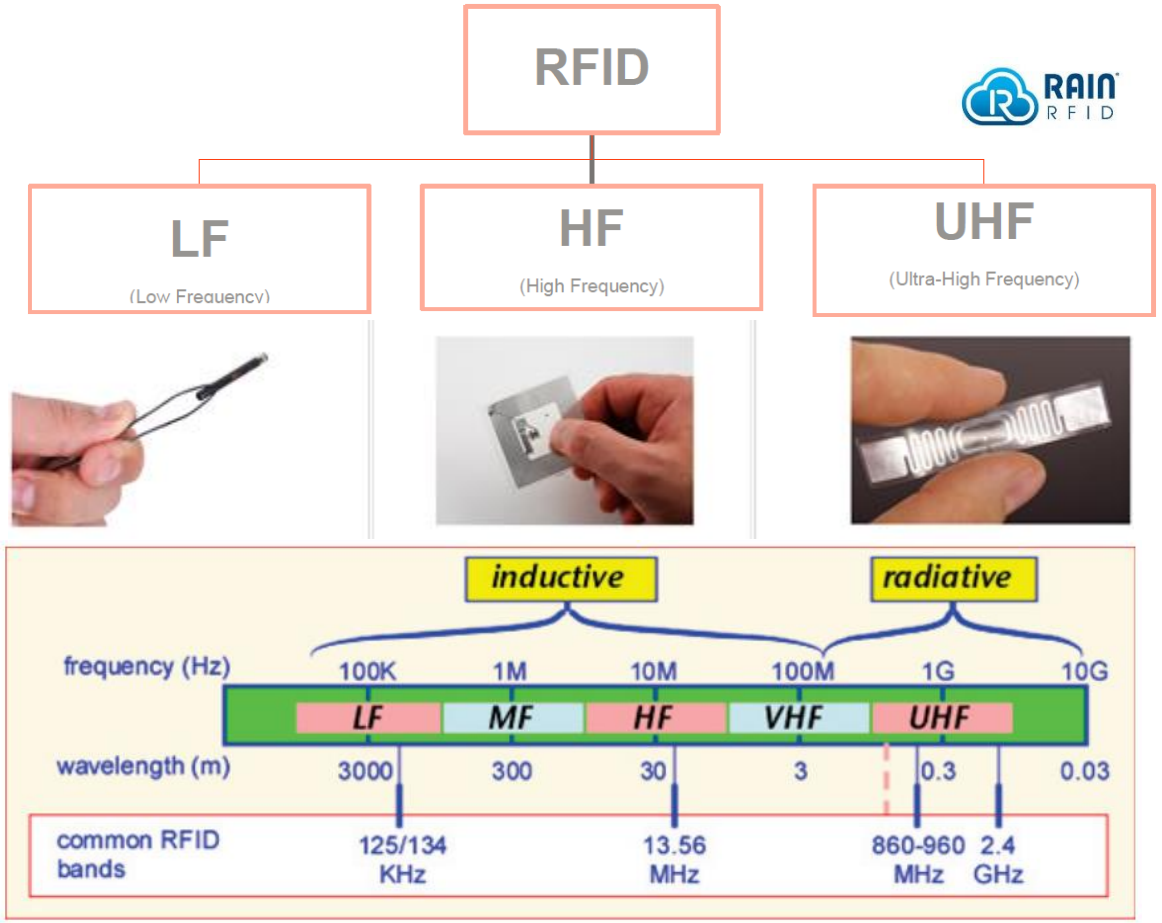
RAIN ST25RU3993 Reader

August 14, 2020

Jim Barlow

RFID Technology – Introduction



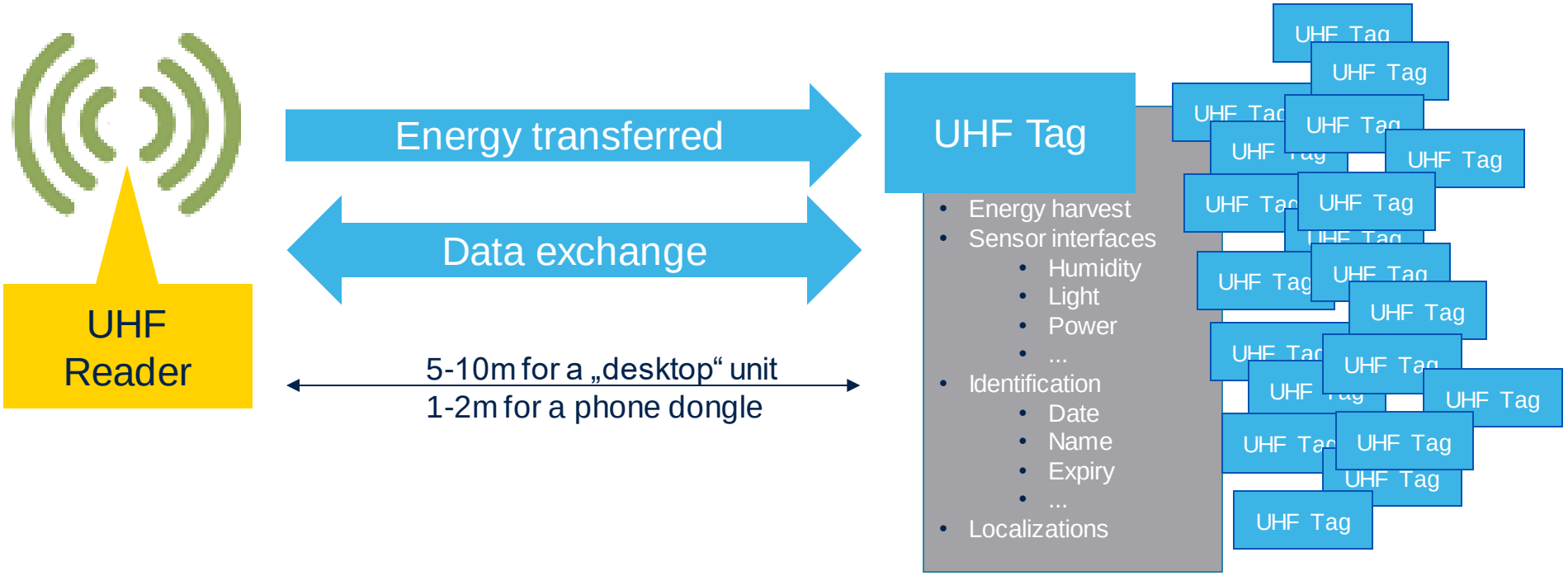
FREQUENCY	RANGE	APPLICATIONS
Low-frequency 125 - 148 KHz	up to 80mm	Pet and ranch animal identification; car keylocks; factory data collection
High-frequency 13.56 MHz NFC	up to 1 metre	Library book identification; smart cards; NFC; transit tickets **ST Readers + Tags**
Ultra-high frequency (UHF) 433 MHz	up to 100 metres (with active tags)	Container identification with active tags
Ultra-high frequency (UHF) 860 - 930 MHz RAIN RFID	up to 15 metres	Supply chain tracking: item identification; apparel; healthcare; **ST Readers Only**
Microwave: 2.45 - 5.8 GHz	up to 2 metres	Highway toll collection; vehicle fleet identification

life.augmented

Wireless technologies compared

Feature	NFC	RAIN/UHF	BTLE	Wifi	ZigBee
Base station cost	$$	$$$$	$$$	$$$	$$$
Receiver cost	$$	$	$$$	$$$	$$$
Passive receiver	Yes	Yes	No	No	No
Power consumption receiver	<0.1mA passive	<0.1mA passive	15mA	>100mA	15mA
Multipoint connection	No	Yes	No	Yes	Yes
No user setup required	Yes	Yes	No	No	No
Typical number of receivers	1~5	1~1000	~7	1~1000	32
Typical range	0.1m	1-10m	1-10m	1-100m	1-300m

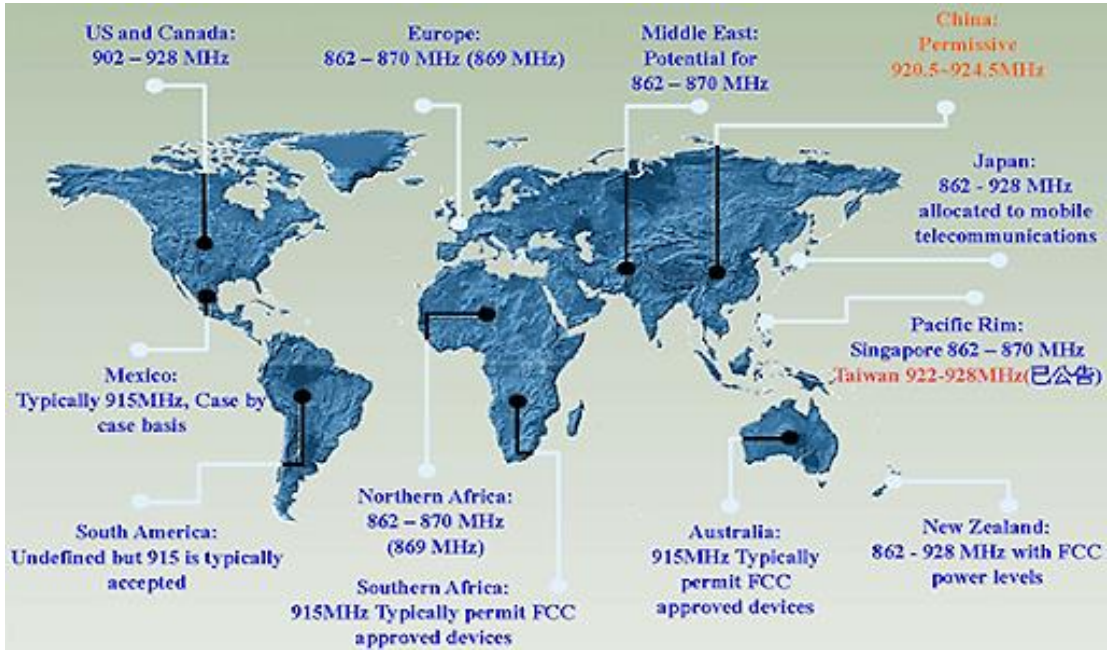
RAIN RFID system



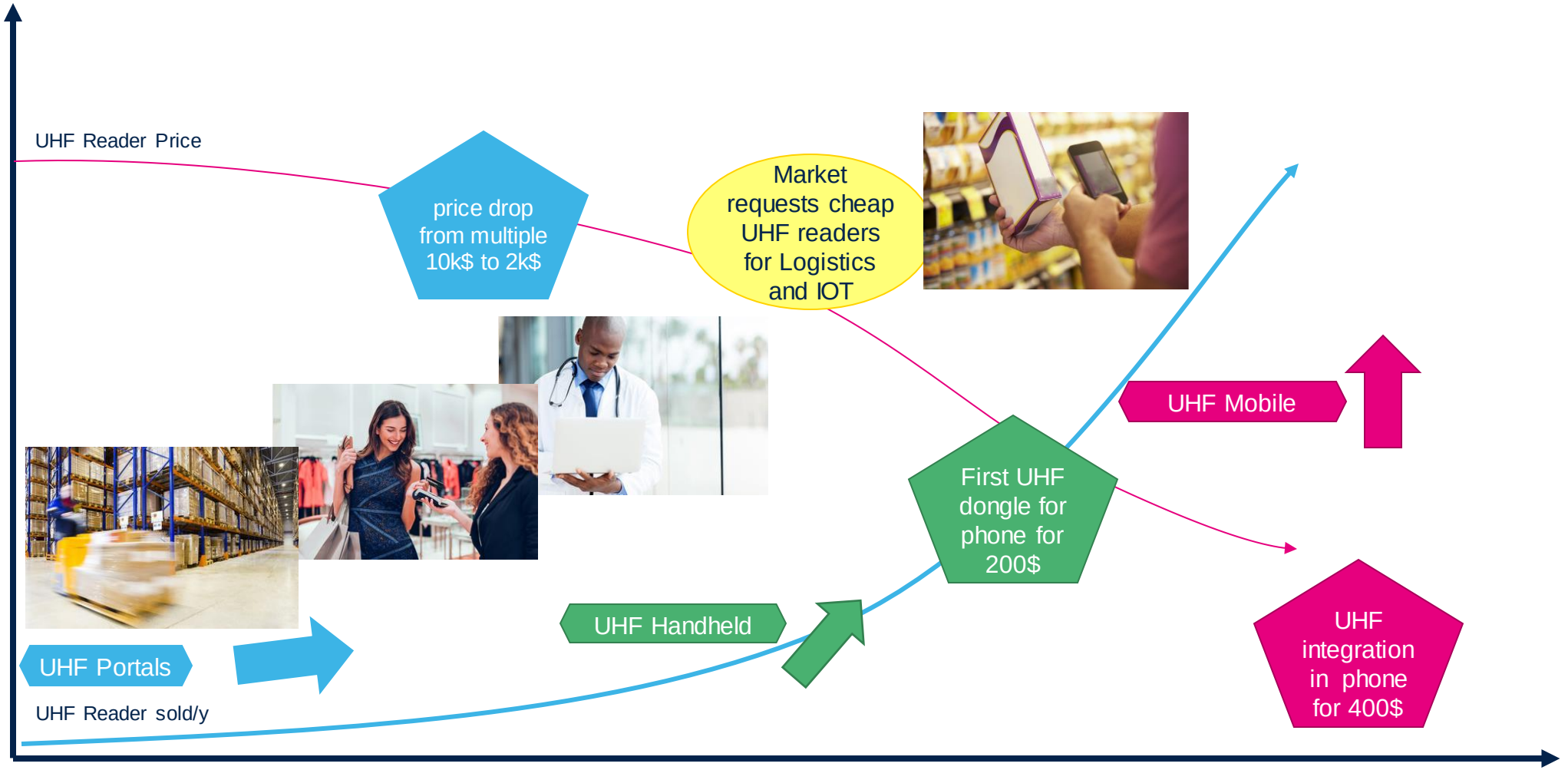
Rain RFID Technology – Readers

- All readers share basic functionality:
  - Read from tags
  - Write to tags
- Some may have additional features:
  - Tag localization
  - Multi-protocol support
  - Dense reader mode
  - Proprietary tag commands:
    - read a sensor
    - activate a switch or actuator

- Can be Portable or Fixed Install
- May be certified for a single country or may carry multiple radio certifications



Future UHF market trend



ST25RU3993 Markets and Use Cases

Automation

Manufacturing optimization
Item level tracking

Retail

Automated Inventory Control
Security/ Loss Prevention

Authentication

Tolling
Vehicle tracking

Smart Home

Intelligent Sensing
Smart Appliance

Transport

Item level tracking
Inventory/Asset managment

Healthcare

Patient tracking
Asset management

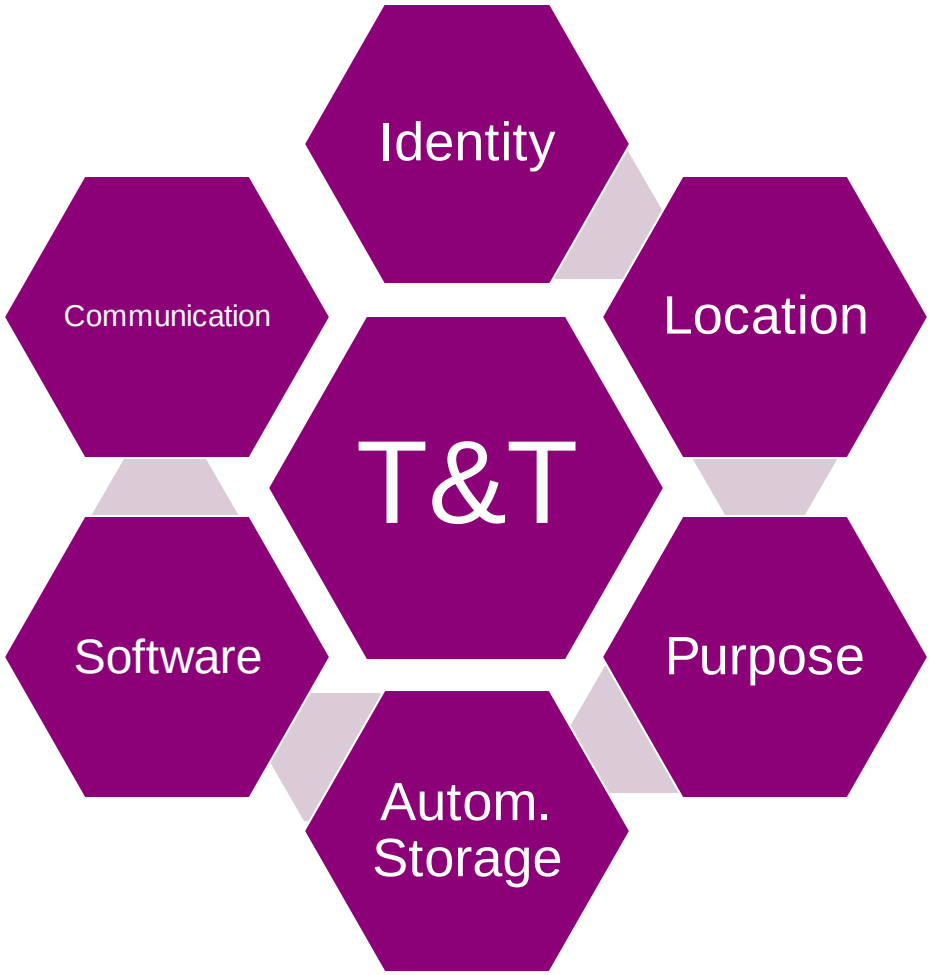
life.augmented

Rain RFID Applications – Retail

- Retail stores require accurate and real-time inventory management and return processing
- RAIN technology provides the best inventory management to:
  - Increase sales
  - Reduce out-of-stock and overstock
  - Improve employee and customer satisfaction.

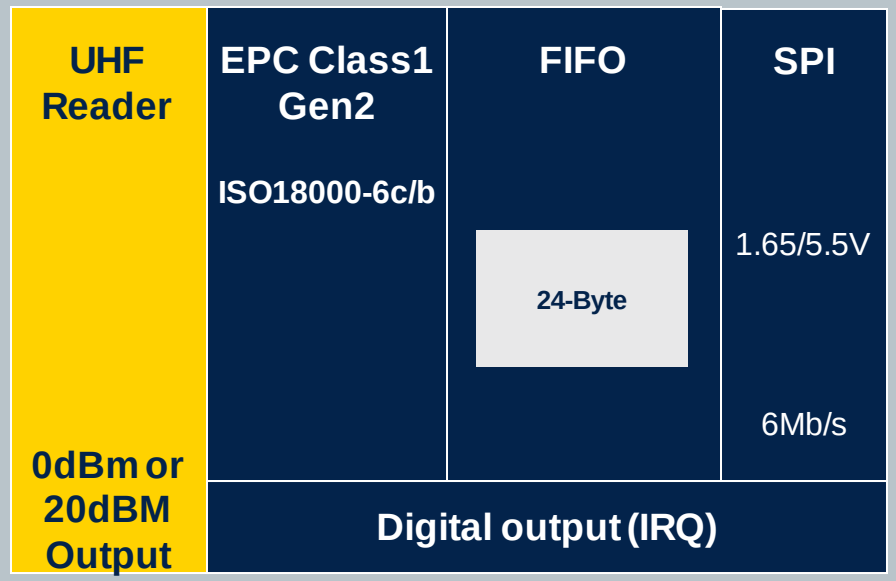
Rain RFID Applications – Track & Trace

- Improved efficiency
- Control Loss of Inventory
- Regulators have begun requiring certain industries to implement T&T
  - Consumer & environment protection
  - Deter counterfeiting
  - Origin & destination in case of recalls
- Example:
  - Medical device manufacturers in the USA
  - Food Safety Modernization Act (FSMA)



ST25RU3993
UHF RFID reader

ST25RU3993



QFN48

Use cases

- **Retail**, Stationary readers
- Industrial PDA's, Authentication
- Tablets / Smartphones, Dongles / Snap Ons, Handheld readers
- Portable Data Capture

Key Features

- **Dense Reader Mode filtering** on board
- Fixed Single ended Rx input & 0dBm output power
- Receive sensitivity of **-90dBm**
- Power consumption down to 65mA
- Internal VCO

Key Benefits

- Ideal for **mobile** applications
- Prolonging battery life & robust against poor antenna
- Works in a dense reader environment

ST25RU3993 - Overview

- Integrated Rain RFID Reader
- Integrated analog front end
- Protocol handling system for Gen2
- Internal LDOs for supply noise supr.
- Integrated RF synthesis
- Segmented VCO (16 segments)
- Tunable RF frequency 840 – 960 MHz
- Partially integrated Loop Filter
- 20 MHz external reference options:
  - TCXO
  - XTAL
- Differential TX output options:
  - Internal PA (20 dBm) → antenna
  - Low Power output (0 dBm) → external PA
- RX Options:
  - Single-ended
  - Differential
- Integrated RX Filter bank
- SPI Interface (Mode1)
  - Interface voltage levels down to 1.65V
- Debug pins (to monitor R/T communications
- Supply Voltage 2.7-3.6V

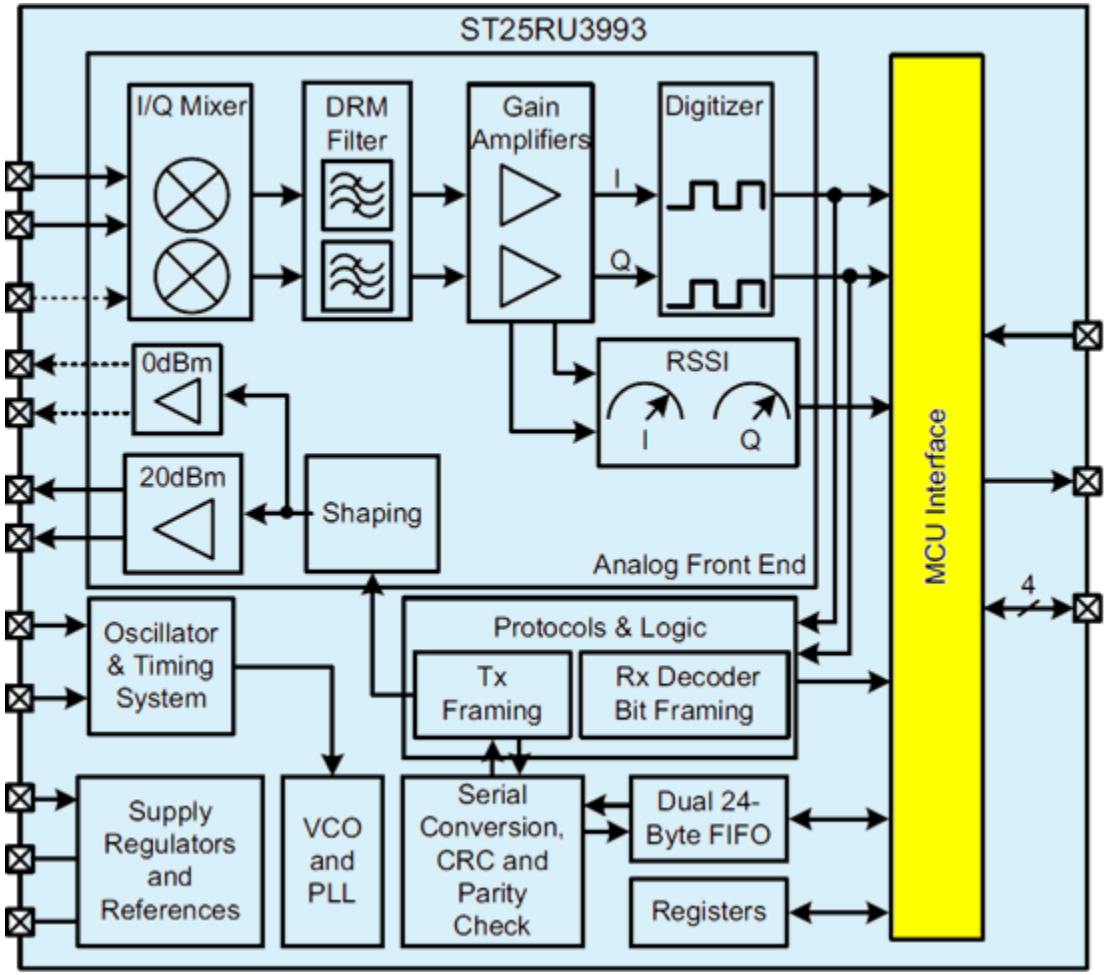
life.augmented

ST25RU3993 – Architecture – Host Interface

SPI

- 4-wire SPI Interface (Mode 1), 5 MHz
- EN(able) + IRQ pin
- VDD_IO defines logic levels

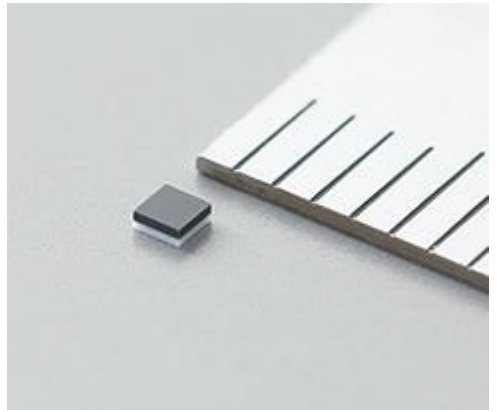
Command type	Mode pattern (MSB to LSB)								Mode related data
	Mode		Register address / command ID						
	M1	M0	X5	X4	X3	X2	X1	X0	
Write	0	0	A5	A4	A3	A2	A1	A0	Data byte (or more bytes if of autoincrementing)
Read	0	1	A5	A4	A3	A2	A1	A0	Data byte (or more bytes if of autoincrementing)
Direct command	1	0	C5	C4	C3	C2	C1	C0	-
RFU	1	1	x	x	x	x	x	x	-



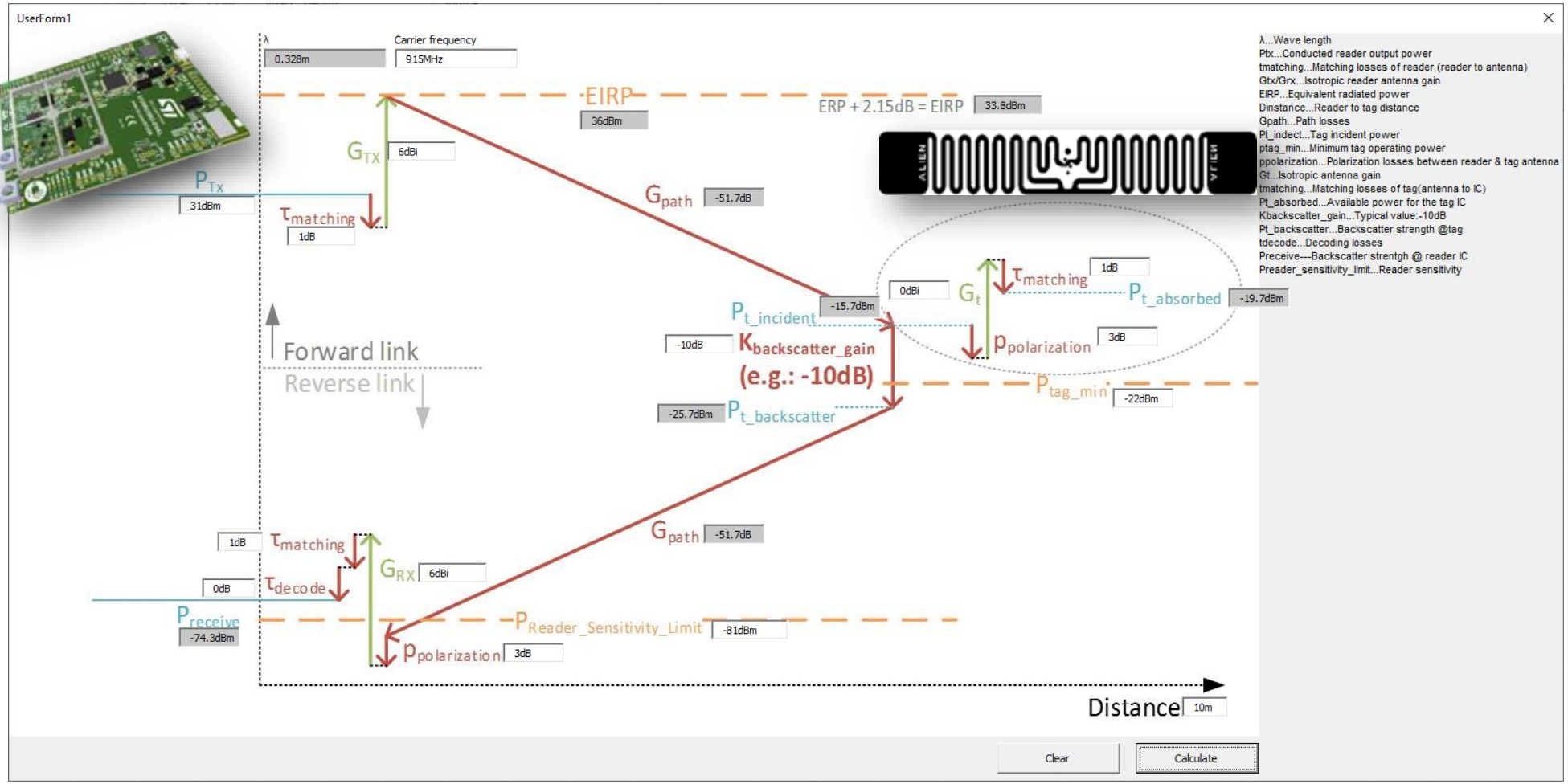
life.augmented

Rain RFID Technology – Tags

- Comprised of tag IC and tag antenna mounted on a substrate
- Typically a paper tag but other form factors exist
- All tags share a basic feature set
- Options my be implemented:
  - Security, File management, User memory
  - Battery assist, Sensors
- Tag antennas need to be tuned to the underlying material



Rain RFID Technology – Link Budget



Performance Improvements & Competition

ST25

life.augmented

Competition benchmark on features

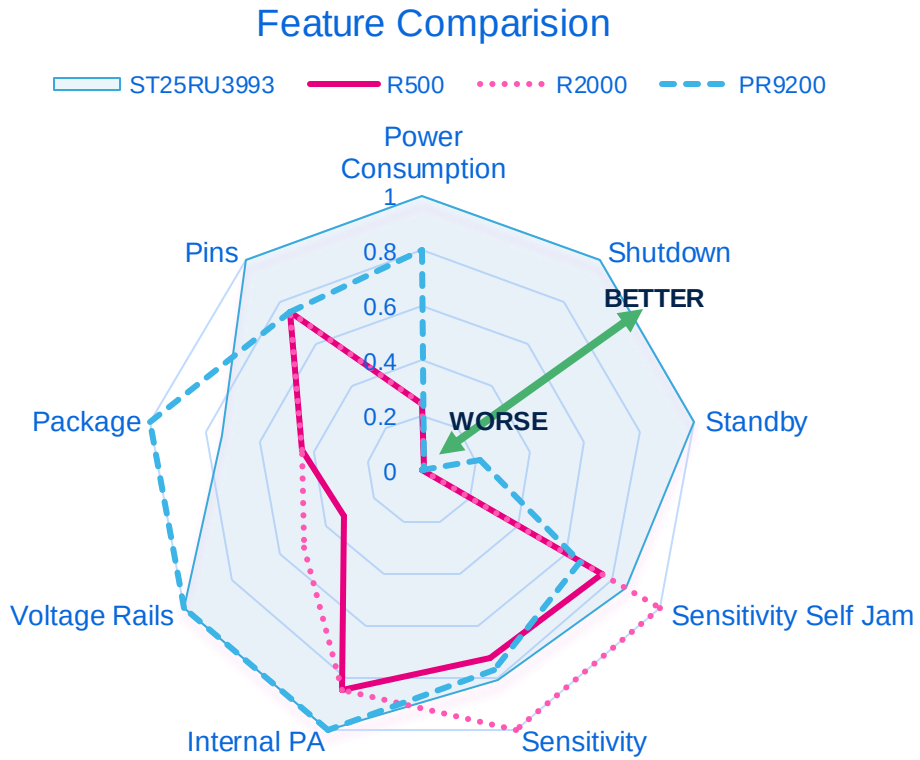
- ST:
  ST25RU3993 offers the best power consumption while offering good sensitivity and speed.
  Ideal chipset for battery operated applications with overall excellent performance. Best price/performance ratio fitting to majority of application.

  ST Offers full access to ST25RU3993 Registers

- Impinj:
  R2000 offers higher Sensitivity which benefits long range >10m operation but at 4x the power consumption.
  R500 offers worst performance/price ratio.

  Impinj sells Modules Competing with Customers

- Phychips:
  PR9200 is 20% worse in power consumption. Bad standby current reduces lifetime further. Additionally there could be problems with self jamming (low senitivity).



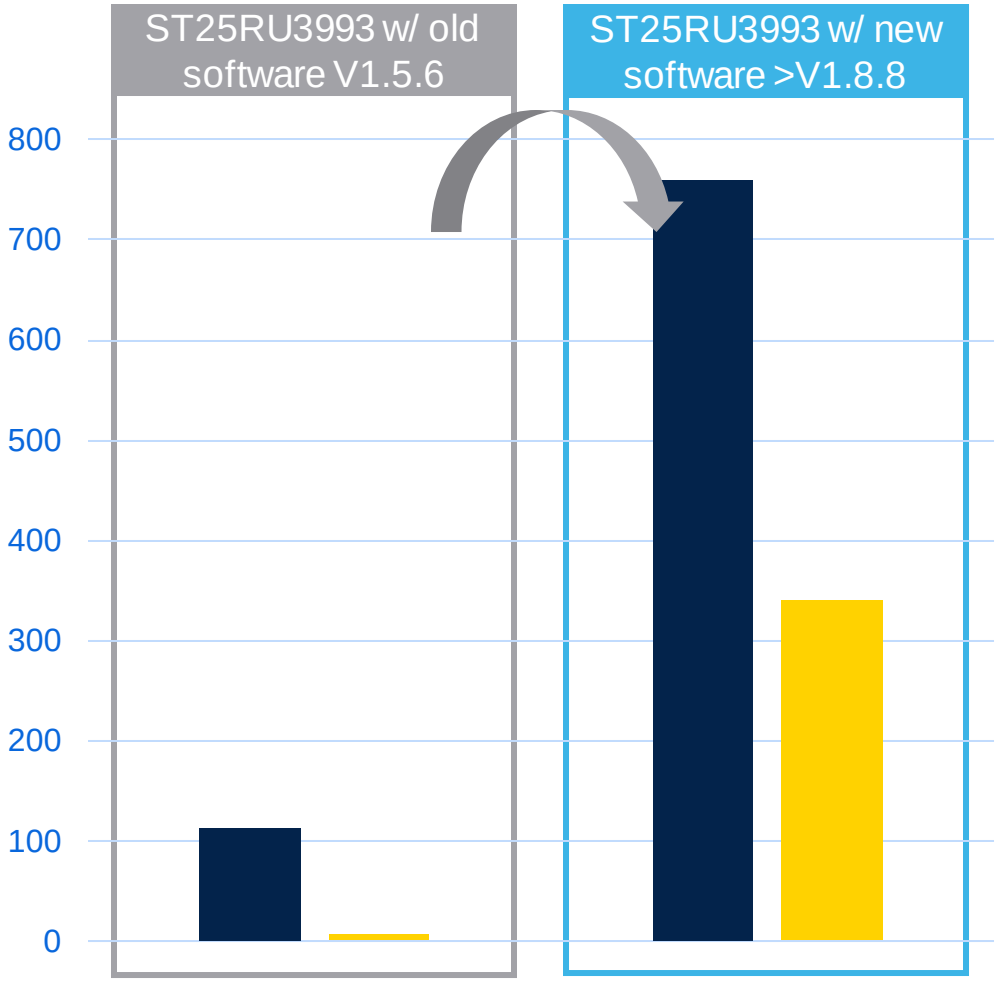
	ST25RU3993	R500	R2000	PR9200	
Sensitivity Self Jam	77	68	90	60	dBm
Sensitivity	89	80	110	85	dBm
Internal PA	20	17	17	20	dBm
Power Consumption	210,8	875	875	264	mW
Shutdown	3,3	200	200	660	µW
Standby	9,9			46,2	mW
Voltage Rails	1	3	2	1	#
Package	49	81	81	36	mm²
Pins	48	64	64	64	#

New: Adaptive Anti-collision

- Before the EVAL SW offered a static anti-collision only
  - Q had to be selected by the GUI user and did not change during the scanning
  - During a demo at which the tag population size is known in advance Q can be selected optimally – for highest throughput.
  - Drawback:
    - If tags >> slots, then read performance appears weak
    - If tags << slots, then read speed is low
- Now an adaptive anti-collision is supported
  - User does not need to care for Q during a demo
  - Q is adjusted automatically
    - Reader starts from a default Q then counts the empty and collided slots
    - Too many collisions → increase the number of slots (Q up)
    - Too many empty slots → reduce the number of slots (Q down)

The number of tags	Optimum frame length (size, Q)
1-5	4 (2)
6-11	8 (3)
12-22	16 (4)
23-44	32 (5)
45-88	64 (6)
89-180	128 (7)
181-355	256 (8)
356-700	512 (9)
701-1420	1024 (10)
701-1420	2048 (11)

ST25RU3993 Speed improvements



Single Tag Read Speed [Tag/s]

200 Tags Read Speed [Tag/s]

V1.5.6 to V1.8.8 improvements

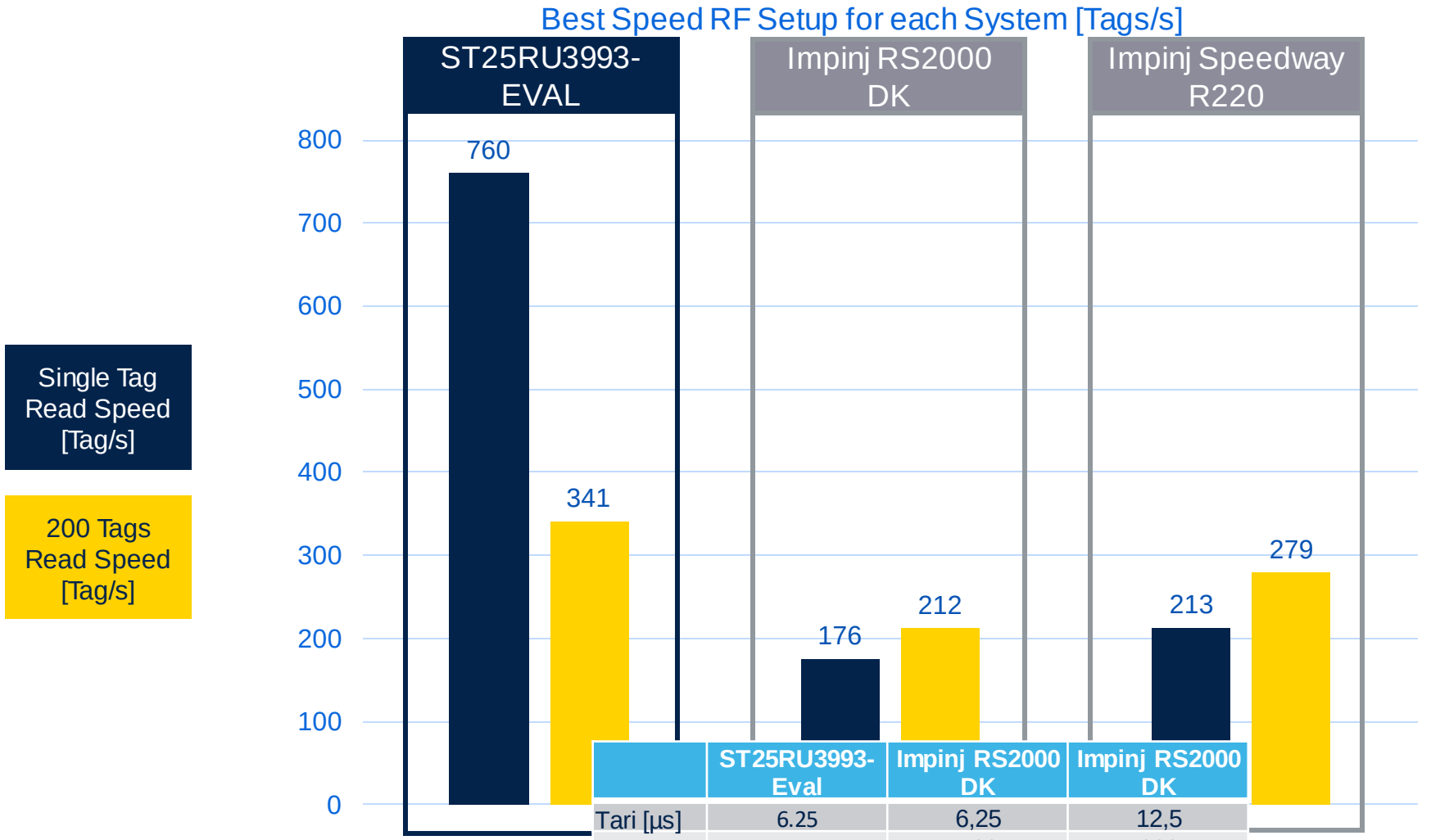
- SPI communication and register manipulation
- Cyclic Inventory data communication principal
- UART speed from 115kBit to 3MBit
- FW send available data asynchronously
- Tag history increased from 45 to 648 tags
- Enhanced Inventory Statistics, Tag timestamps and slot analysis counters
- Faster Tari

	ST25RU3993-Eval old v1.5.6	ST25RU3993-Eval New v1.8.8
Tari [µs]	25	6.25
BLF [kHz]	256	640
Coding	M4	FMo
Session	0	0

Fastest setting on old FW | on new FW

life.augmented

Competition benchmark on speed

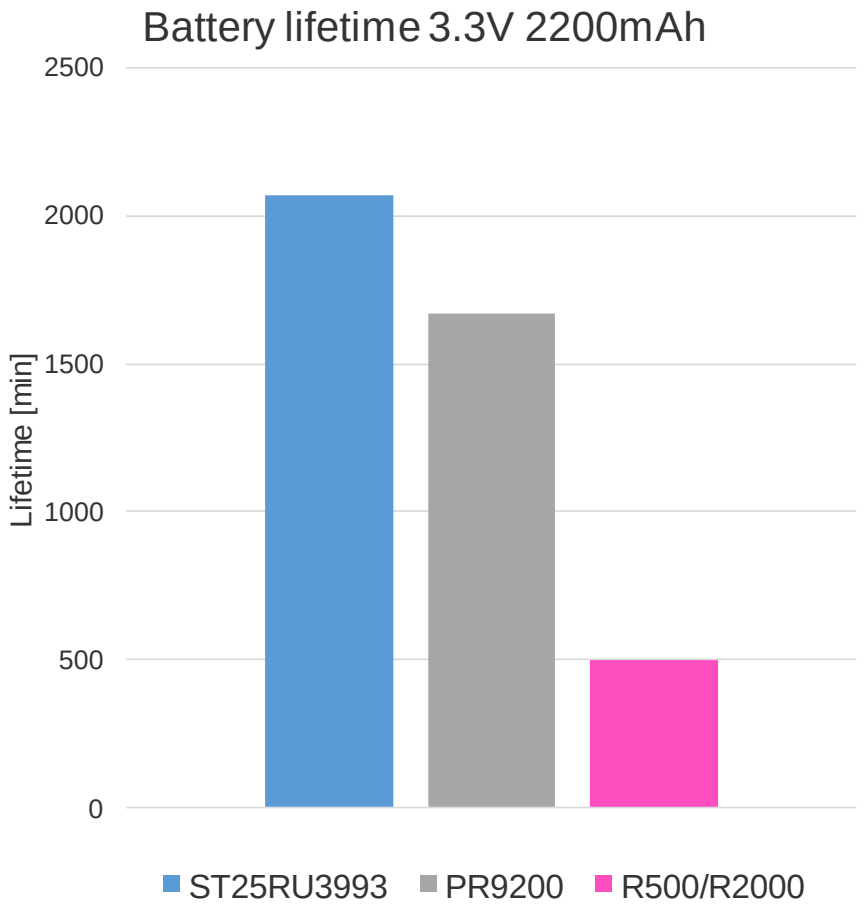


	ST25RU3993-Eval	Impinj RS2000 DK	Impinj RS2000 DK
Tari [µs]	6.25	6,25	12,5
BLF [kHz]	640	400	320
Coding	FM0	FM0	M4
Session	0/2	0	0

Competition benchmark on power consumption

- ST25RU3993 offers longer battery lifetime

- ST25RU3993 runs 2070min
  ST offers maximum battery lifetime
- Phychips PR9200 runs 1670min
  Phychips offers 80% battery lifetime vs ST
- Impinj R500/R2000 runs 500min
  Impinj offers 25% battery lifetime vs. ST



life.augmented

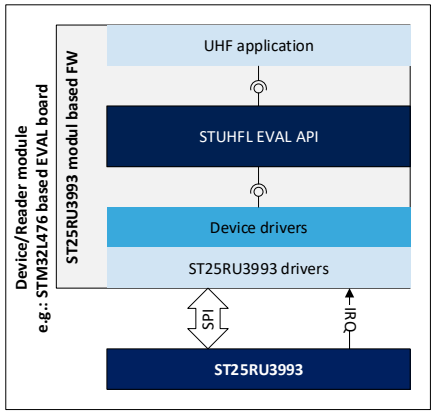
Evaluation boards & Enablement

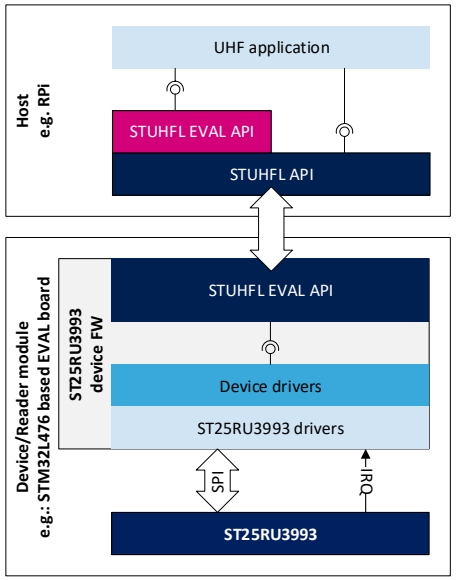
life.augmented

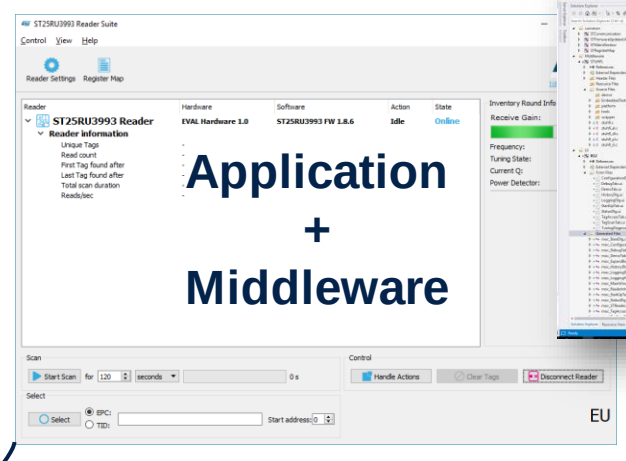
Full Enablement of HW and SW

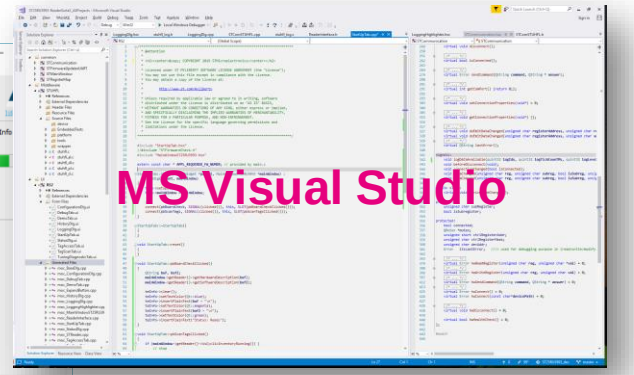
- HW
  - EVAL board
  - ST-LinkV2
- Middleware & Application
  - STSW-ST25RU-SDK
  - Visual Studio 2017
- Firmware
  - KEIL or Atollic TrueStudio

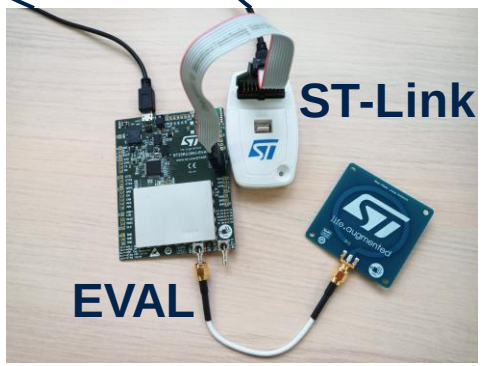
Common Code for Host & Embedded

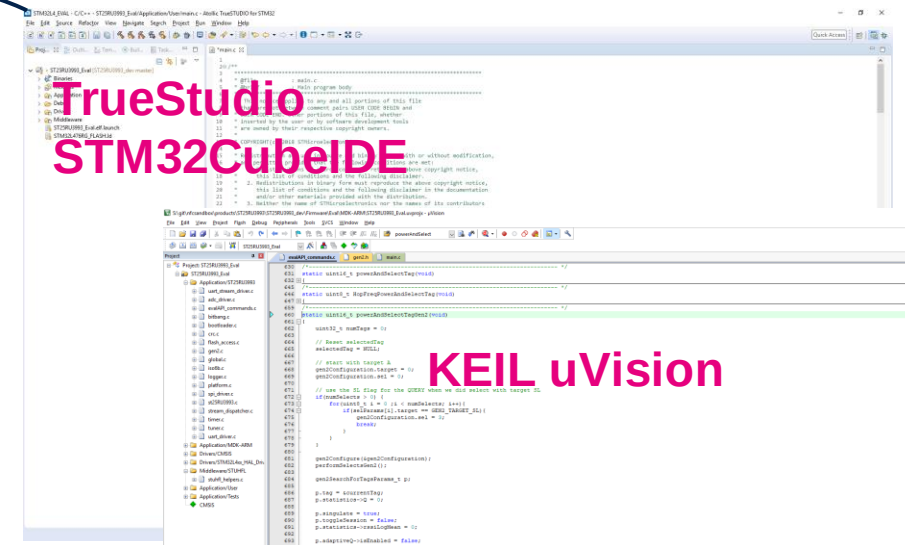












life.augmented

ST25RU3993-EVAL

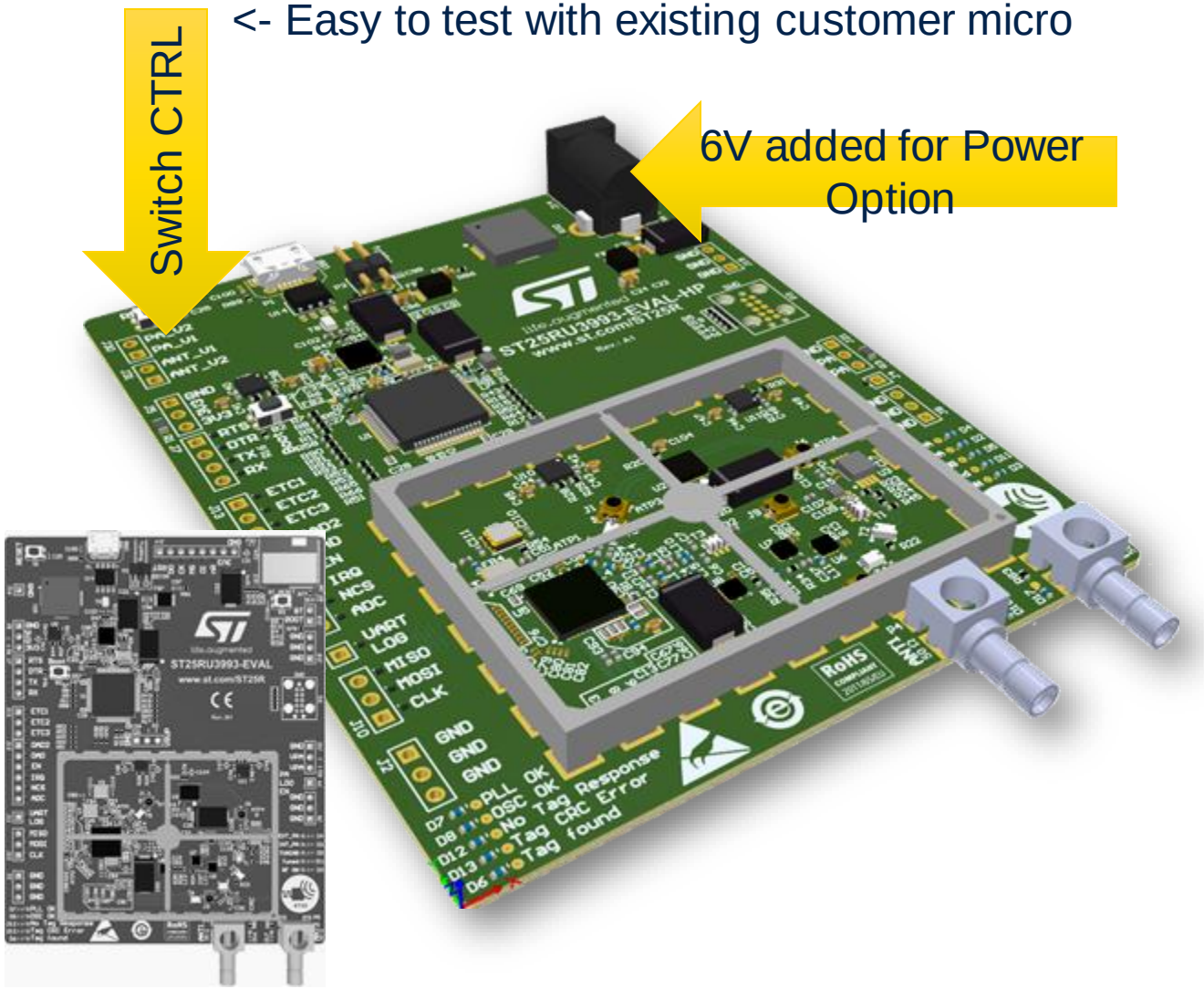
- ST25RU3993-EVAL Evaluation Board
- The ST25RU3993-EVAL is based on the ST25RU3993 high performance Rain (UHF) RFID reader IC and an STM32L476 MCU .
  A short-range antenna is included which allows communication <50cm.
- For greater distances other UHF antennas can be connected via two SMB (female) antenna connectors, which can be controlled via the GUI.
- Features:
  - External PA: 29 dBm max TX power
  - Internal PA: 18 dBm max TX power
  - Differential RX input
  - Max. sensitivity: -80 dBm
  - Frequency: 840 MHz – 960 MHz
  - Two antenna connectors: SMB (F)
  - 28cm Antenna Cable
  - 5x4.4cm Antenna (6x6cm PCB)

- Comes with Antenna and Tags to Test with GUI.

ST25RU3993-EVAL vs. ST25RU3993-HPEV

Coming Soon Late Summer 2020!

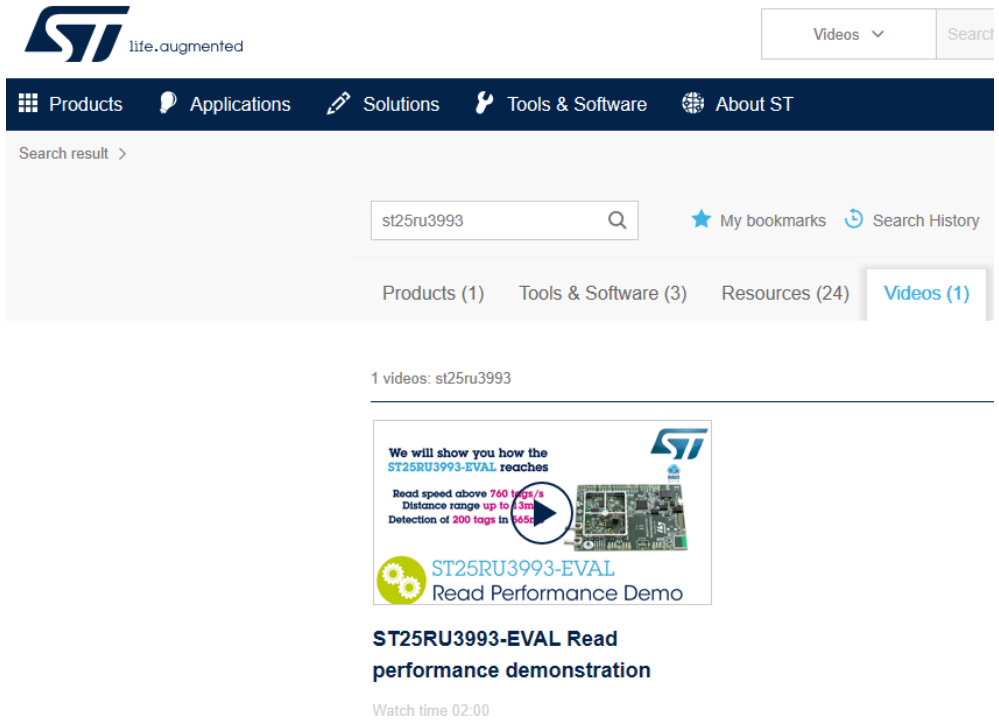
- Why a new version of HW?
  - Request for a higher RF output power
    - Now 31 dBm
  - Improves our Read Rate Comparison
  - On-board MCU STM32L476
- Differences:
  - External PA is supplied by external 6V
  - RF switch controls for external MCU option
  - Removed BT module option



Customer Introduction Video

Send the video at link below to introduce customer to Improvements

ST25RU3993_Performance Improvements



Thank you

life.augmented