TAG PERFORMANCE

AIRTLS

AT02 Person, generic tag	CT02 Rugbt, asset tag	BT01 Pulse	BT01 Wave
		 3D tracking	 aka 'juggle ball'
65 x 35 x 11 mm **25 gram**	77 x 60 x 24 mm **65 gram**	D 220mm **430g**	D 220mm **430g**
1 x LiPo 500mAh	3 x AA Eneloop battery	2 x LiPo 250mAh	2 x LiPo 250mAh
UWB BLE-5.3 GPS Qi	UWB BLE-5.3 GPS Qi NFC	UWB BLE-5.3	BLE-5.3
IMU Magneto SpO2	IMU Magneto	IMU Magneto Pressure	IMU Magneto Pressure
Feedback: Haptic RGB (1.5W)	Feedback: Haptic RGB (1.5W)		
128x128 display	128x128 display		
USB-C	USB-C	Magnetic head to standard USB-A charge cable	

Table 1. Battery life expectancy per charge for different use cases (Firmware 1.2.1)

Notes: A tag can be switched off in software.The battery is then disconnected. To switch the tag back 'on', place it in the charge cradle or connect the charge cable.The tag switch itself on/off based on activity (motion) and automatic detection of a suitable network.

			Active states during deployment				**Sleep time** between deployments	**Recharge interval**		
TAG	Tracking rate [Hz]	IMU [Hz]	Operational time	Active [% T]	Shallow Sleep [% T]	Sleep **WOM**[1] [% T]	Sleep **WOM**[1] [% T]		**Use case**	Battery [mAh]
CT02	**12.5**	**12.5**	**10 years**	0	0		100	**10 years**	Guarding museum assets	1900, AA
CT02	**12.5**	**12.5**	**5 years**	5		95		**5 years**	Warehouse goods tracking	1900, AA
CT02	**12.5**	**12.5**	**1 year**	30	3	66		**1 year**	Personel tracking 8hr/day	1900, AA
AT02	**0.1**	**12.5**	**2 years**	1	0	99		**2 years**	Stationary Asset Guarding	600[2], LiPo
AT02	**25**	**12.5**	**1 year**	5	0	95		**1 year**	Asset tracking	500, LiPo
AT02	**25**	**87.5**	**80 hr**[3]	85	15	0	1 month	**1 month**	Athlete tracking	500, LiPo
AT02	**50**	**200**	**36 hr**[3]	15	15	70	3 months	**3 months**	Ball tracking (training)	500, LiPo
AT02	**50**	**200**	**9 hr**	99	1	0			Ball tracking (match-day)	500, LiPo
AT02	**175**	**1000**	**9 hr**	99	1	0			Ball tracking (match-day)	500, LiPo

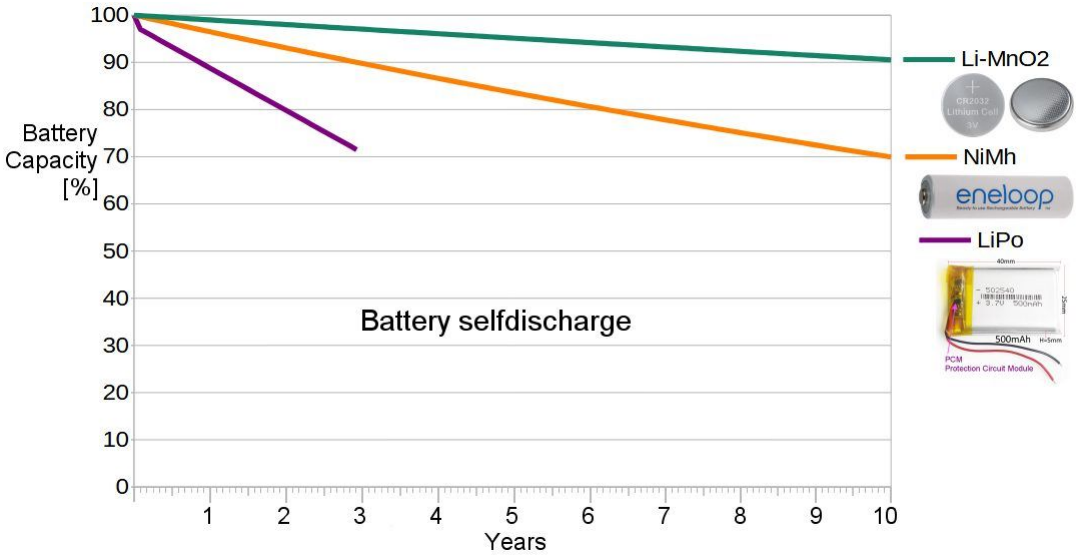
(1) **WOM**: Wake on motion is always active even when the tag is in sleep mode.
The system always has a realtime clock running. Handling regular checks on network availability and sending status reports. The motion sensor is always 'on', in any state (active, shallow sleep and sleep state)
Current consumption in sleep mode: 15µA + 5µA (battery and PCM, battery protection circuit). Total 20µA
(2) AT02 without a display can contain a 600mAh LiPo battery, 500mAh is standard.
(3) Total time of active and shallow sleep combined, sleep time between deployments is expressed in months
For example, train every week 3hours. The ball is on the field, 36 hours over a 3 months period.
Every training-hour, the ball is in flight for max 15% of the time. When idle, shallow sleep is activated.
After 5 minutes of inactivity the ball goes to sleep with WOM activated. Charge the ball once per 3 months.
[% T] percentage of total spend in sleep, shallow sleep or active mode depending on the use-case.
IMU [Hz] refers to the update rate of motion data in the realtime datastream.

Tag operational mode: Shallow sleep
Energy consumption is optimized when 'shallow-sleep' is activated. When the motion sensors detect an idle state (no motion), the tracking update rate is reduced. Motion sensor data is continiously monitored. When motion is detected, because of some impact, the wakeup time is instant, and tracking resumes at the set update rate. Motion data from before the impact is send to analyse the type of impact. After 4 minutes of no activity the tag will go to sleep mode (in case this is activated in the tag configuration) with active WOM (wake on motion).

Battery specification and properties

Battery type	Chemistry	Selfdischarge -rate/year	Recharge cycles [max]	Environment impact	mAh	Cost/ 100mAh	Wh/cm3	Wh/g	Internal resistance [Ohm]
Lithium Polymer	Li-cobalt	9%	500	xx	500	€ 0.11	**0.37**	**0.185**	0.03
AA Eneloop	NiMh	4%	2100	x	1900	€ 0.12	**0.30**	0.079	**0.1**
CR2450 Coin cell	Li-MnO2	1%	x	xxxx	580	€ 0.09	0.74	0.260	17

Lithium Polymer batteries typically loose about 5% of capacity in the first month when fully charged.
After this period the rate of self discharge is about 9% per year.
All values stated in this document are estimates based on realworld measurements and observations.
Battery capacity degradation can be as high as 80% after 300 charge cycles for LiPo battery chemistry.



Battery selection
Coin cells are suitable for tags which are mostly stationary and accasionaly move.
For high intensity use, for example sports and race-drone tracking.
A high update rate is required with tags being recharged multiple times.

Operation time for 3 different type of tags in light use cases

TAG	Chemistry	Dimensions L x B x H [mm]	Battery	Energy Wh	TAG Active idle time [months] approx.
AT02	Li-cobalt	40 x 25 x 5	1x 500mAh	1.85	**36**
CT02	NiMh	50 x d=14mm	3x AA Eneloop	6.84	**240**
ST01	Li-MnO2	5 x d=24mm	1x CR2450	1.75	**60**

Active idle time has the system running and wake on motion active.

UWB SYSTEM CAPACITY

Max system tag capacity(*) **per UWB zone** UWB-zone: 100x100m indoor or 200 x 200m outdoor

update rate mode	Tags / zone	Update rate [Hz]	Average latency [ms]	Locates /sec	Ranging method	IMU	Typical Position Accuracy [cm]	UWB + IMU fusion position accuracy [cm]
Mode 256	20992	1	10000	20992	TDoA	-	<20	
Mode 16	656	12.5	650	16400	TDoA	-	<20	
0.05 Hz	10946	0.05	80	2100	MTWR	87.5	<5	
0.8 Hz	656	0.8	80	2100	MTWR	87.5	<5	
25 Hz	84	25	80	2100	MTWR	87.5	<5	<3
50 Hz	42	50	80	2100	MTWR	200	<5	<3
150 Hz	8	150	80	1200	MTWR	1000	<5	<3
1000 Hz	1	1000	80	1050	MTWR	1000	<5	

TDoA: Time Difference of Arrival (less accurate)
MTWR: Multicast Two-Way Ranging (most accurate)
Position Accuracy in LOS condition on an open sportsfield
IMU (inertial measurement unit) Gyroscope and Accelerometer sensor update rate in Hz.
The magnetometer (compass) runs at 200Hz by default in MTWR modes.
The system supports mixed mode operations (update rate modes, and ranging methods)
All tags operate collision free with deterministic timing. Timing accuracy sub 100ns (nano seconds)
External objects can be controller from GPIO at anchors with sub 100ns wireless timing accuracy.

Multiple adjacent UWB zones can link-up to cover a larger area.

All anchors have a copy of the ranging and IMU data obtained via the UWB network
Connecting to any anchor per zone is sufficient to offload all data. This simplifies installation (cabling).
There are no ‘master’ anchors which control the system clock. This avoids any single point of failure.
For realtime sports event and critical applications it is advised to offload from 2 or more anchors/UWB-zone.
Anchor coverage:

	Anchor coverage/anchor [m2]
Indoor	300
Warehouse	600
Outdoor sportsfield	1200

ROAMING
An UWB-zone is handled by up to 20 Anchors.
Multiple zones can be ‘stitched’ together to cover a larger area.
There is no limit to the size of the covered area by the UWB network.
Out of the 20 anchors per UWB-zone, 7 anchors handle the distributed network administration.
This avoids any single point of failure while operating the UWB network.
There is no requirement for a ‘central’ network administrator.
Any anchor which connects via USB, BLE or ethernet has a copy of the local network administration.
Tags which roam around the network started with a signon handled by a local network administrator. When moving around and when the local network administrative anchor is nearly out of the tags RF range.
The tag will signon to another anchor and continue.

NETWORK TIMING
Even for very large networks, of more then 1000+ anchors, the execution of commands stays within 60ns (nano seconds). External IO can be driven with high timing accuracy throughout the network. For example on filmsets to trigger explosions wirelessly. Or control a drone light show with 25 x 25 x 25 drones, a total of 15625 drones, covering an area of 500 x 500 x 500 meter. The drone position update rate is still once per second. All drones report there position to the ground station with a 10 second delay. With only 15625 drones in the air, the network still has capacity to operate replacement drones at 25Hz update rate and 80ms latency. Drones can fly autonomously in and out of the matrix with sub 20cm accuracy (TdoA mode). The update rate during landing into the charge station is set at 50Hz with sub 5cm accuracy (MTWR mode). Sufficient for automatic deployment without the typical labor requirement to place the drones first on a field. At present the largest controlled drone swarm is 5293 drones. The network does not use a master timing anchor (avoiding a single point of failere). All anchors handle the network timing at 15ps (pico second) resolution.