TNT-ST-TRCV-WLAN-V6

Next Generation of Mobile Telemetry & Wireless Networking

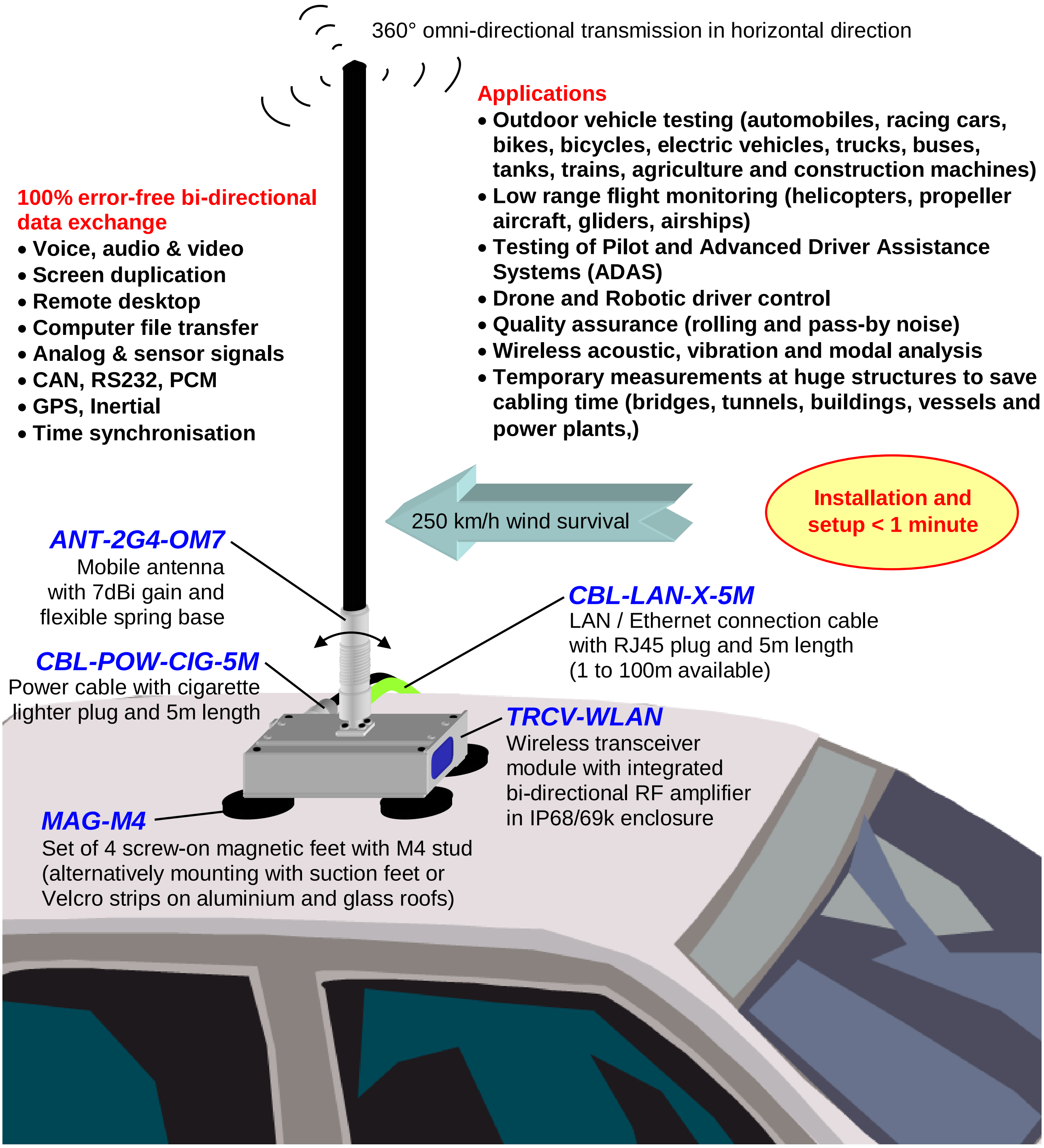
e.g. Car-to-Car real Data throughput of 50Mbps@500m & 3Mbps@3km even in the worst Weather conditions

100% error-free bi-directional data exchange

- **Voice, audio & video**
- **Screen duplication**
- **Remote desktop**
- **Computer file transfer**
- **Analog & sensor signals**
- **CAN, RS232, PCM**
- **GPS, Inertial**
- **Time synchronisation**

Applications

- **Outdoor vehicle testing (automobiles, racing cars, bikes, bicycles, electric vehicles, trucks, buses, tanks, trains, agriculture and construction machines)**
- **Low range flight monitoring (helicopters, propeller aircraft, gliders, airships)**
- **Testing of Pilot and Advanced Driver Assistance Systems (ADAS)**
- **Drone and Robotic driver control**
- **Quality assurance (rolling and pass-by noise)**
- **Wireless acoustic, vibration and modal analysis**
- **Temporary measurements at huge structures to save cabling time (bridges, tunnels, buildings, vessels and power plants,)**

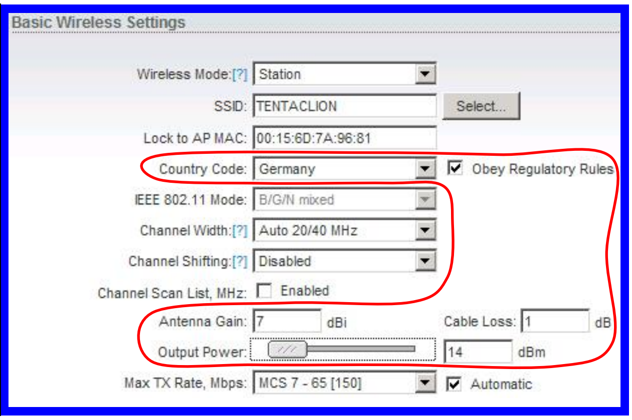


Improvements over earlier Versions V1-V4

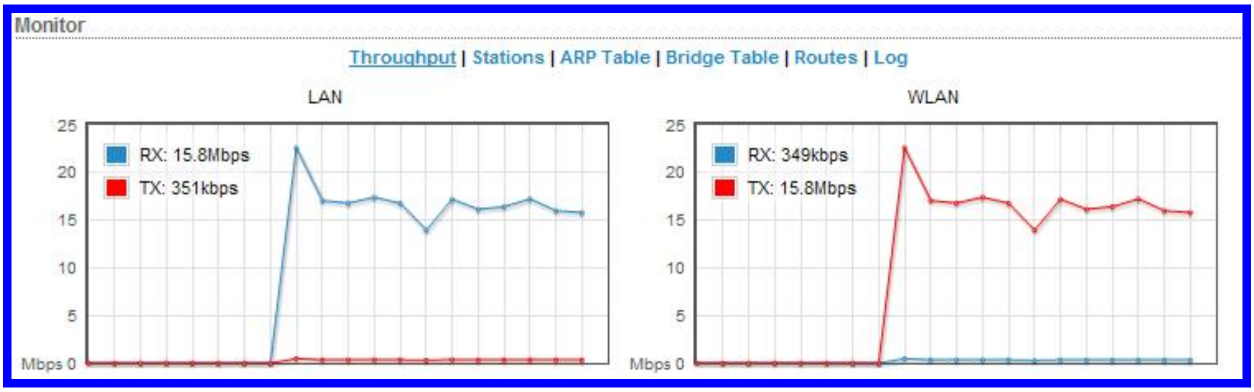
Higher Data Rate - Extended Range - Increased Comfort

- Significantly increasing of data rate and transmission range by additional implementation of Wireless LAN Standard 802.11n with keeping backwards compatibility to standards 802.11b and g

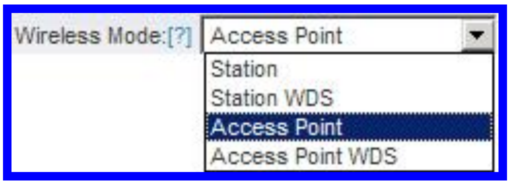
Dis-tance [m]	Net Data Rate(1) [Mbps](2)			
	AP(3) → Station(3)		Station → AP	
	Sunny(4)	Snowfall(4)	Sunny	Snowfall
500	50		15	
1000	30		5.0	2.0
1500	30	15	3.0	0.8
2000	15	6	1.5	0.8
3000	12	3	1.0	0.4



- Bi-directional amplifier (earlier option ***AMP12***) now integrated by default at no extra cost with fully software programmable transmit power obeying all legal regulatory rules worldwide via selectable country codes(5) (manual adjustment with external attenuators ***ATT10*** & ***ATT20*** now obsolete)



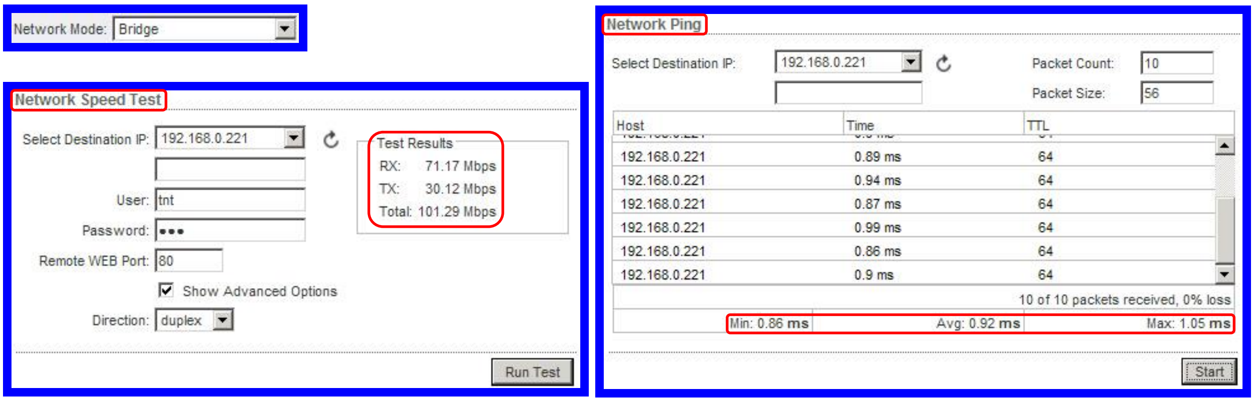
- Online throughput with history and transmission quality with received signal strength displayed on web page (e.g. wireless system monitoring and setup via WLAN enabled smart phone inside vehicle possible)



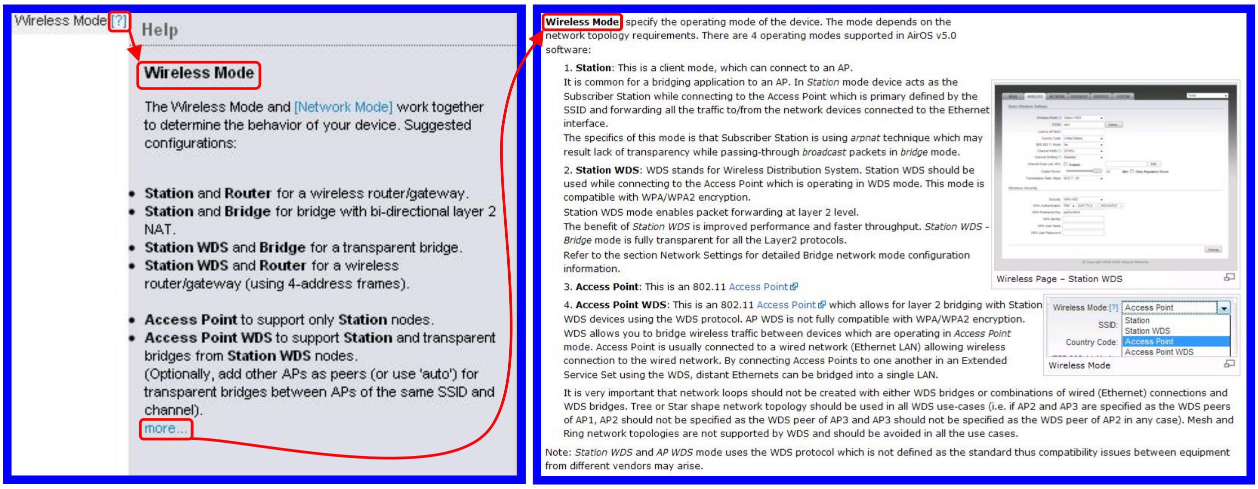
- Setup of wireless mode software configurable now (before internal switch) with additional support of Wireless Distribution Systems (WDS) allowing wireless communication between Access Points for data forwarding (repeater stations and networks)

(1) Car-to-Car with line-of-sight, max. transmit power and bandwidth
(2) Here 1Mbps = 1Mbit/s = 1,000,000bit/s
(3) AP = Access Point, Station = Client
(4) Sunny = best weather conditions, Snowfall = worst weather conditions
(5) Albania, Algeria, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Bolivia, Bosnia and Herzegovina, Brazil, Brunei Darussalam, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Finland, France, Georgia, Germany, Greece, Greenland, Grenada, Guam, Guatemala, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, North Korea, Korea Republic, Kuwait, Latvia, Lebanon, Liechtenstein, Lithuania, Luxembourg, Macau, Macedonia, Malaysia, Malta, Mexico, Monaco, Morocco, Nepal, Netherlands, Netherlands Antilles, New Zealand, Norway, Oman, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Portugal, Puerto Rico, Qatar, Romania, Russia, Saudi Arabia, Serbia and Montenegro, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Syrian Arab Republic, Taiwan, Thailand, Trinidad and Tobago, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Venezuela, Viet Nam, Yemen, Zimbabwe

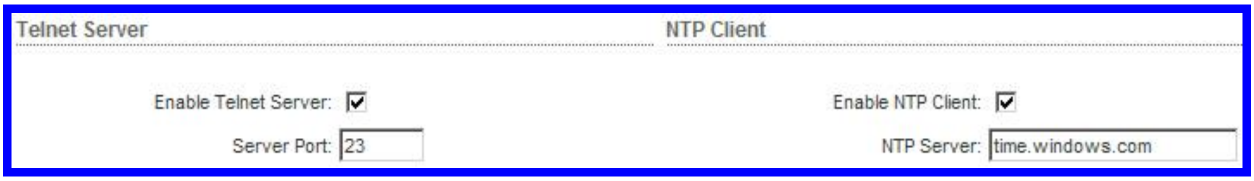
- Connection of Station to Access Point takes place automatically (no network traffic initiation from Station/Client required anymore) with immediately re-connect after leaving and returning into the transmission range by using wireless bridge mode (similar ad-hoc)



- Integrated tools for checking of wireless performance like network speed and ping test (typ. average delay < 500µs for one-way and < 1ms for two-way transmission)
- Full scale Automatic Gain Control (AGC) avoids overmodulation of receiver at very short distances when using max. transmit power of sender (before limited and critical for < 20m) and enables therefore also driving manoeuvres with approaching vehicles (passing, overtaking, oncoming and crashing)
- Unlimited number of LAN devices connectable to Station/Client now (before only one)
- Extremely wide input range for power supply from 9-50V DC (before 36V only) supports in addition to cars/motorbikes (12-14V), trucks/buses (24-28V) and aircrafts (28V) also next generation of on-board networks (36-42V) as well as Power over Ethernet (PoE, 48V)
- Simple help on integrated web server linked to detailed help on internet allows access to all required information by any user at any time with smart phone (saves carrying and sharing of printed manuals)



- Implemented additional services like Ping Watchdog, SNMP Agent, HTTPS, SSH & Telnet Server and System Log as well as Network Time Protocol (NTP) Client for synchronisation with time servers when connected to the World Wide Web via LAN gateway or ***TRCV-3G*** (typ. accuracy 50ms)



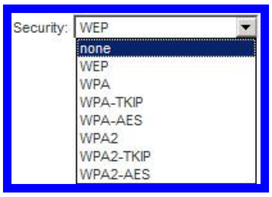
- Device maintenance with firmware update as well as backup and upload of configuration files
- OpenSource Linux Software Development Kit allows customer-specific adaptations and add-ons.
- Conflation of stationary and mobile Version to an universal one supporting all mounting options (magnetic feet, Velcro strips, cable ties - tripods and vacuum feet with optionally mounting plate ***OPT-MNT***)
- Increased safety by improved distribution of adhesion using two suction feet ***VCUP-018*** instead of one ***VCUP-032*** at glass and aluminium roofs
- Optionally available pressure equalisation element ***OPT-COND*** with special semi-permeable membrane avoids internal condensation formation at rapid cooling down of ambient temperature (desert areas, winter trials, climate test rigs, etc.)
- Module upgrades for all previous Versions available. Ask sales@tentaclion.com for quotes.

TRCV-WLAN Module Highlights

- Installation and setup time < 1 minute for each vehicle!
- Bi-directional data transfer with use of TCP/IP protocol, buffer memory on transmit side and data validity check at receiving side guarantees 100% transmission reliability without data loss (no measurement repetitions because of interferences or temporarily missing line-of-sight connection)
- Use of Direct Sequence Spread Spectrum technology (DSSS) provides highest immunity against all kind of interferences - here shown in customer's Top 5 of "most feared" telemetry problems(1) and its proof of contrary

No.	Problem	Practical experience
1	Occupied frequency band	100% error-free high-speed transmission without any data loss at Exhibition Sensor+Test in Nuremberg operating together with 17 other WLAN networks at the same place and in the same frequency range (2.400–2.483GHz) with overlapping bands and partially also same carrier frequencies
2	High voltage	380kV power line crosses all Reference Test Links(2)
3	High speed	Hassle-free wireless transmission from roof of an Audi A6 driving 250km/h
4	Electrified rail road	Flanks the Reference Test Area(2)
5	Strong magnetic fields and vibrations	Wireless modal analysis together with ***SENS4*** and ***BATT30-R*** directly mounted via ***MAG-M4*** on • electric motors driving the at that time fastest calender section of a paper machine with approx. 70m/s flow velocity • at that time world's most powerful heavy fuel oil combustion engine with 20 cylinders, 600rpm, 21 x 6 x 6m and 413t generating 23,000kW

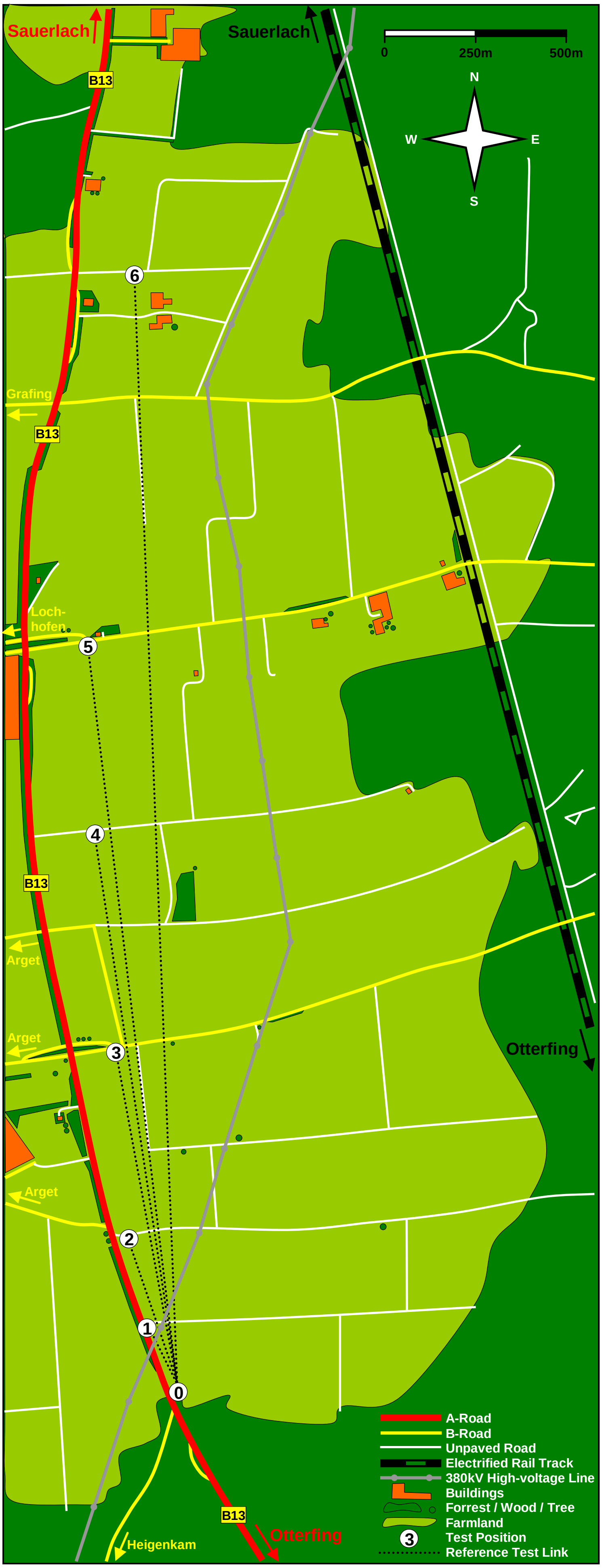
- Transmit power and frequency are general licensed - therefore no lengthy and expensive authorities correspondence necessary (royalty-free operation, no maintenance expenses and no fees)
- Highest tap-proof data security by Wi-Fi Protected Access (WPA / WPA2) with authentication via Pre-Shared Key (PSK) or Extensible Authentication Protocol (EAP) and use of Temporal Key Integrity Protocol (TKIP) or Advanced Encryption Standard (AES) to enhance the Wired Equivalent Privacy (WEP) encryption with 64 or 128 bit (includes SSID hiding, MAC locking, firewall and routing tables)



- Direct connection to cabled LAN networks as gateway for remote maintenance and control via World Wide Web possible
- Fully compatible with current and future communication standards (LAN 802.3u, WLAN 802.11b,g,n and Wi-Fi compliant) as well as **P**rotocols: **I**nternet (**IP**), **I**nternet **C**ontrol **M**essage (**ICMP**), **U**ser **D**ata (**UDP**), **T**ransmission **C**ontrol (**TCP**), **D**ynamic **H**ost **C**onfiguration (**DHCP**), **H**yper**t**ext **T**ransfer / **S**ecure (**HTTP, HTTPS**), **S**imple **N**etwork **M**anagement (**SNMP**) and **N**etwork **T**ime (**NTP**), **S**ecure **Sh**ell (**SSH**) and **Tel**ecommunication **net**work (**Telnet**)
- Synchronised wireless data management by combination and system extension with other ***TNT-ST*** modules, e.g. ***SENS*** for analog and sensor data acquisition, ***RCV-GPS*** for position, ***IF-CAN***, ***IF-RS*** and ***IF-PCM*** for interfacing with other devices, ***SWT*** for data distribution, ***TRCV-3G*** for connection to mobile phone network and gateway to the World Wide Web, ***AOUT*** for analog output, ***BATT-30R***, ***AC*** and ***DC*** for powering, ***FLASH*** for data buffering and storage as well as bundling and forwarding of multiple data streams
- Optimised for high-continuously, bi-directional transmission of all types of digitised data (measured values, voice, audio, video, screen duplication, remote desktop, etc.)
- Range extension by automatically reducing of the data rate
- Telemetry networks with unlimited number of stations configurable
- Independent and simultaneous operation of up to 13 networks at the same place possible(3)
- Galvanic isolation of communication and power lines with over-voltage and reverse polarity protection
- IP68 (permanent under water) and IP69K (80bar/80°C high-pressure/temperature water/steam) protection, vibration and shock proof (10/100G)
- Extended temperature range from -40 to +85°C
- Smallest dimensions (120x70x30mm(4)) and low weight (380g)
- Impact-proof anodised aluminium housing
- Complete system configuration planning and free support, in-field installation service on request
- Excellent price-performance payoff
- True "Made in Germany" (Development, Mechanics, Electronics, Mounting, Test and Support)

(1) Obtained from customer correspondence over past 10 years
(2) See map at next page
(3) Channel Width has to be set to 5MHz (quarter channel)
(4) Without connection sockets

Reference Test Area and Conditions



Reference Test for best weather conditions
View from Test Position 0 in northern direction

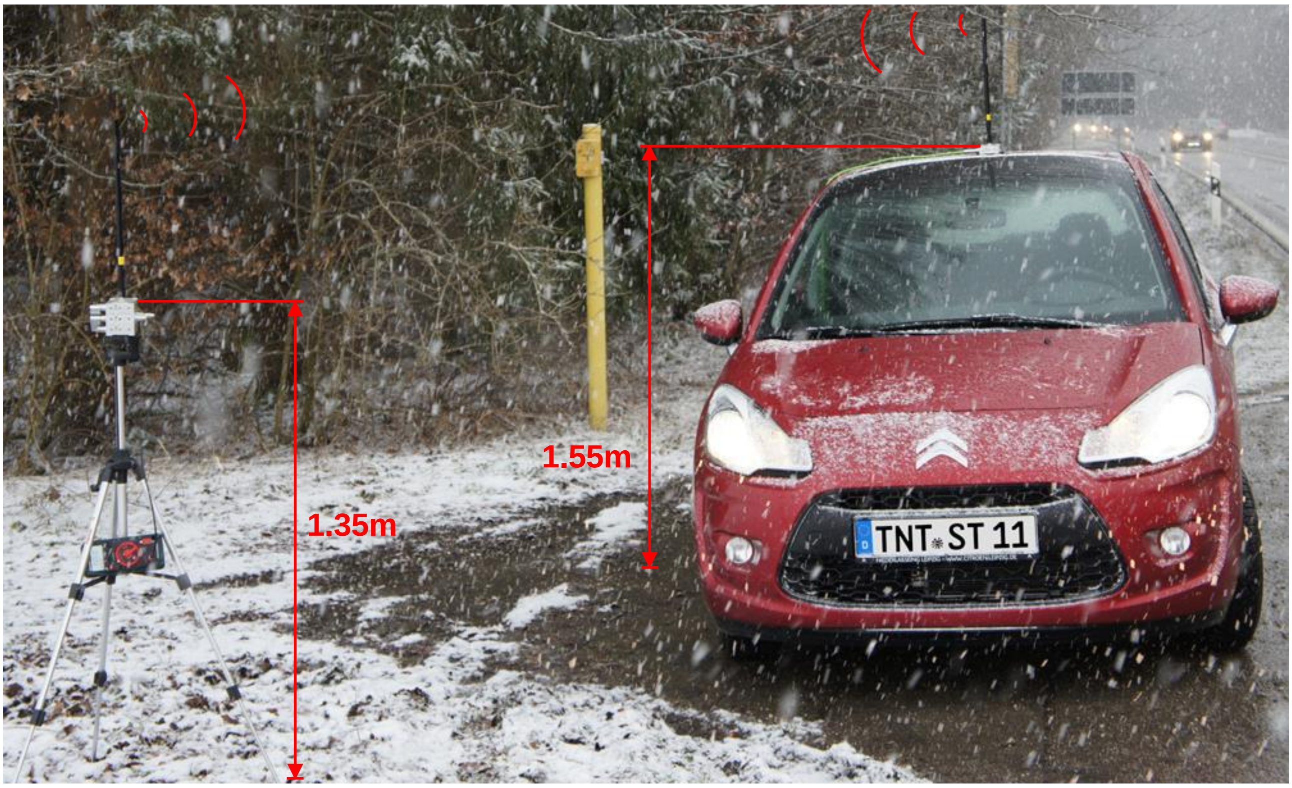
+8°C, 0% clouds, clear sight, **sunny**

Reference Test for worst weather conditions

-2°C, 100% clouds, 1000m sight,
snowfall with changing intensity

Test Pos.	GPS coordinates	
	Latitude	Longitude
	Degrees, Minutes, Seconds	
0	N47° 55' 46"	E11° 39' 23"
1	N47° 55' 54"	E11° 39' 18"
2	N47° 56' 02"	E11° 39' 14"
3	N47° 56' 18"	E11° 39' 14"
4	N47° 56' 37"	E11° 39' 07"
5	N47° 56' 54"	E11° 39' 09"
6	N47° 57' 27"	E11° 39' 12"
	Decimal Degrees	
0	47.929444°	11.656389°
1	47.931667°	11.655000°
2	47.933889°	11.653889°
3	47.938333°	11.653889°
4	47.943611°	11.651944°
5	47.948333°	11.652500°
6	47.957500°	11.653333°
	Degrees, Decimal Minutes	
0	N47° 55.76667'	E11° 39.38333'
1	N47° 55.90000'	E11° 39.30000'
2	N47° 56.03333'	E11° 39.23333'
3	N47° 56.30000'	E11° 39.23333'
4	N47° 56.61667'	E11° 39.11667'
5	N47° 56.90000'	E11° 39.15000'
6	N47° 57.45000'	E11° 39.20000'

Reference Test Setup



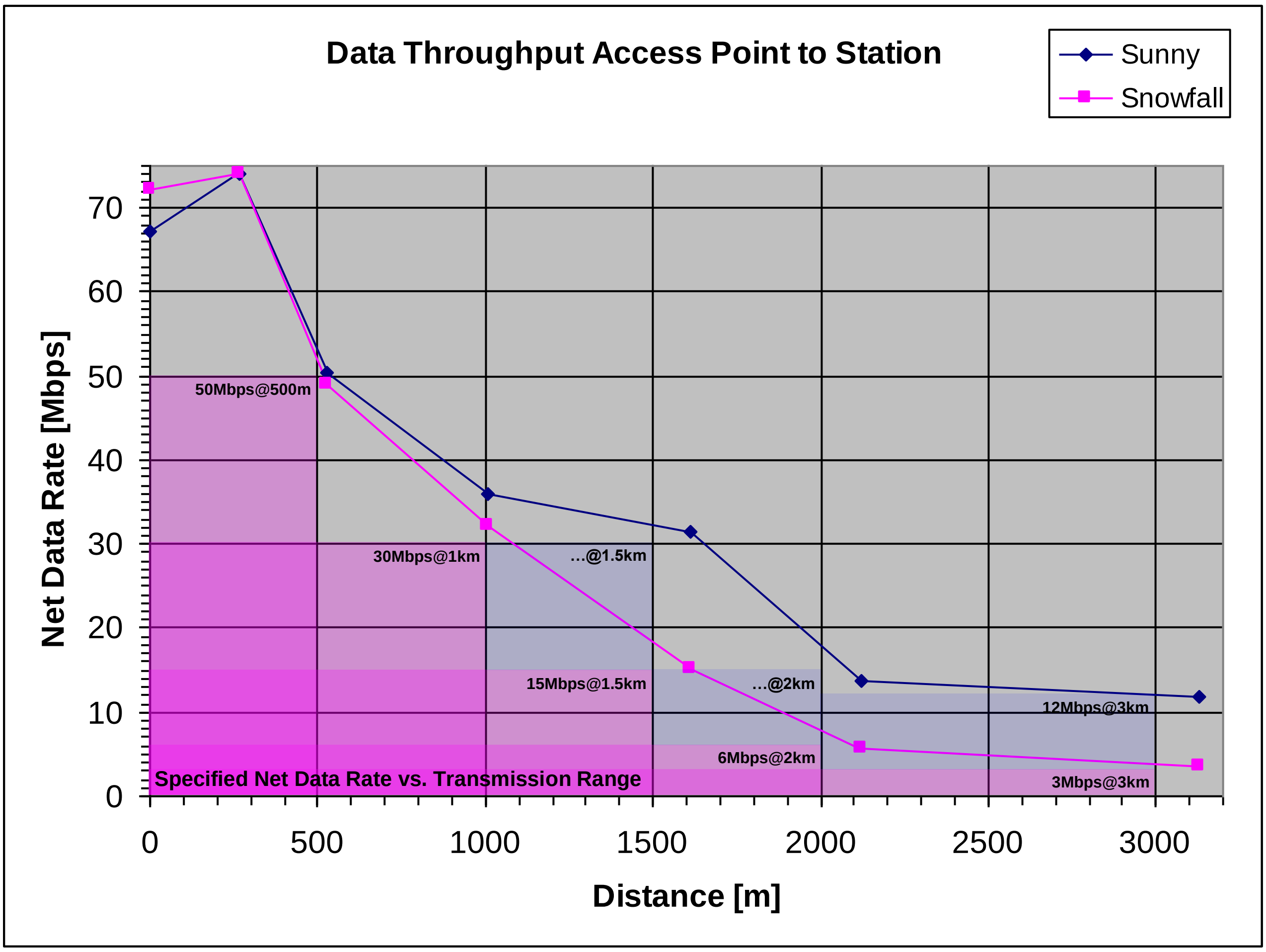
Reference Test Setup View from Test Position 0 in southerly direction

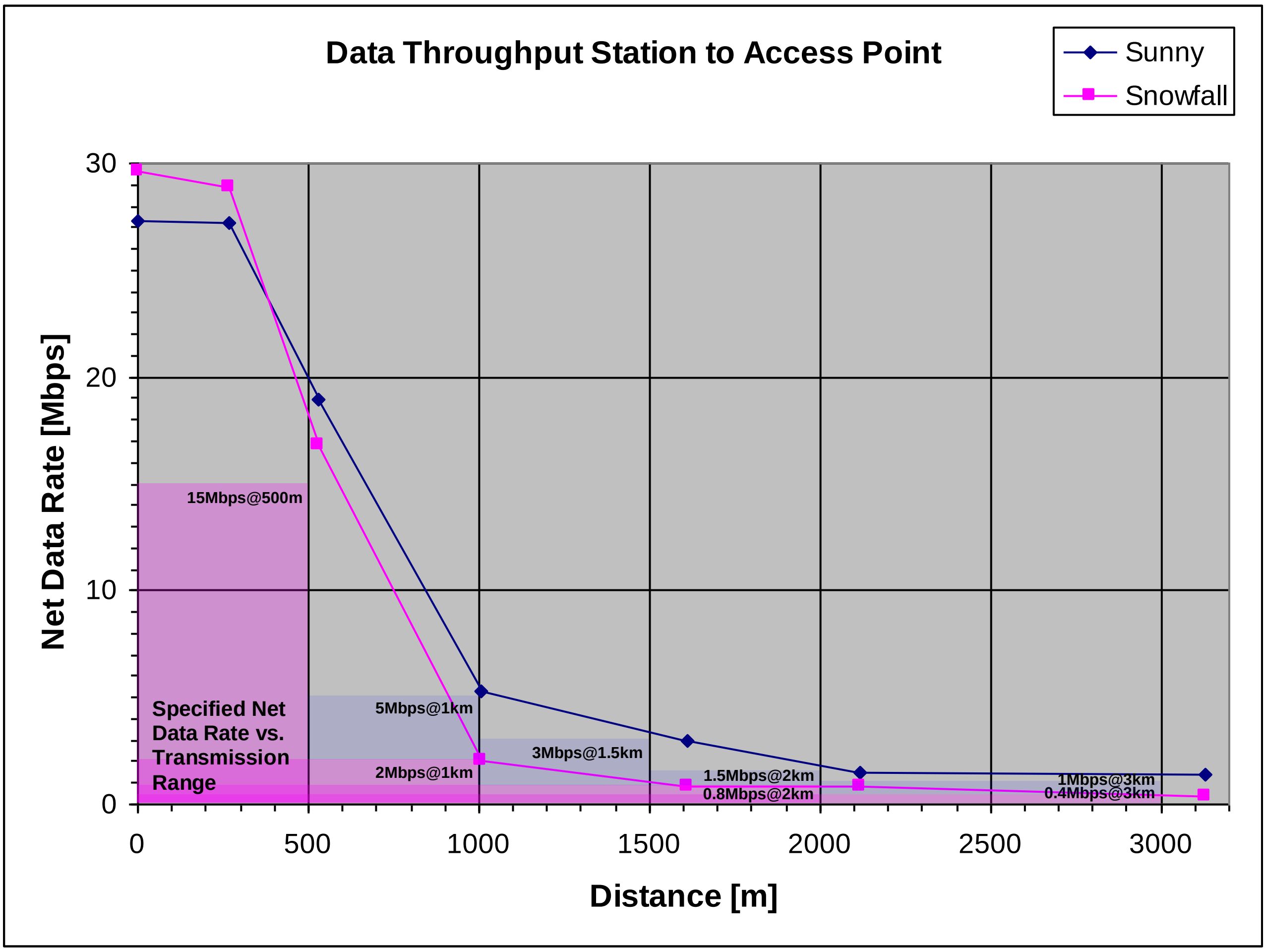
Stationary	Unit	Mobile
TRCV-WLAN	Transceiver type	***TRCV-WLAN***
ANT-2G4-OM7 (7dBi gain)	Antenna type	***ANT-2G4-OM7*** (7dBi gain)
Tripod via adapter plate ***OPT-MNT***	Mounting	Magnetic feet ***MAG-M4***
Battery module ***BATT-30R*** (Ø15.5V)	Power supply	Vehicle on-board power supply (Ø14V)
Bridge	Network mode	Bridge
Access Point	Wireless mode	Station (Client)
WEP128	Encryption	WEP128
Max.	Transmit power and bandwidth	Max.
1.35m	Height above ground[1]	1.55m
Line-of-sight	Test links	Line-of-sight
Transmit	Main data stream direction[2]	Receive
Data acquisition module ***SENS8-16*** connected to signal generator	Data source and sink[3]	Notebook with online data acquisition software ***DAQ-ML***

Reference Test Results

Test Position[4]		Distance [m]	Weather							
			Sunny				Snowfall			
			Signal Strength [dBm]	Net Data Rate [Mbps]			Signal Strength [dBm]	Net Data Rate [Mbps]		
Stationary	Mobile			RX	TX	RX+TX		RX	TX	RX+TX
0	0	2	-3	67,1	27,3	94,4	-3	72,2	29,6	101,9
0	1	268	-46	74,1	27,2	101,4	-49	74,1	28,9	103,0
0	2	528	-61	50,3	18,9	69,2	-64	48,9	16,8	65,7
0	3	1006	-70	36,0	5,3	41,4	-76	32,1	2,0	34,0
0	4	1610	-72	31,4	2,9	34,4	-80	15,2	0,8	16,0
0	5	2120	-80	13,8	1,5	15,3	-87	5,8	0,9	6,7
0	6	3128	-81	11,8	1,4	13,2	-88	3,5	0,4	3,9

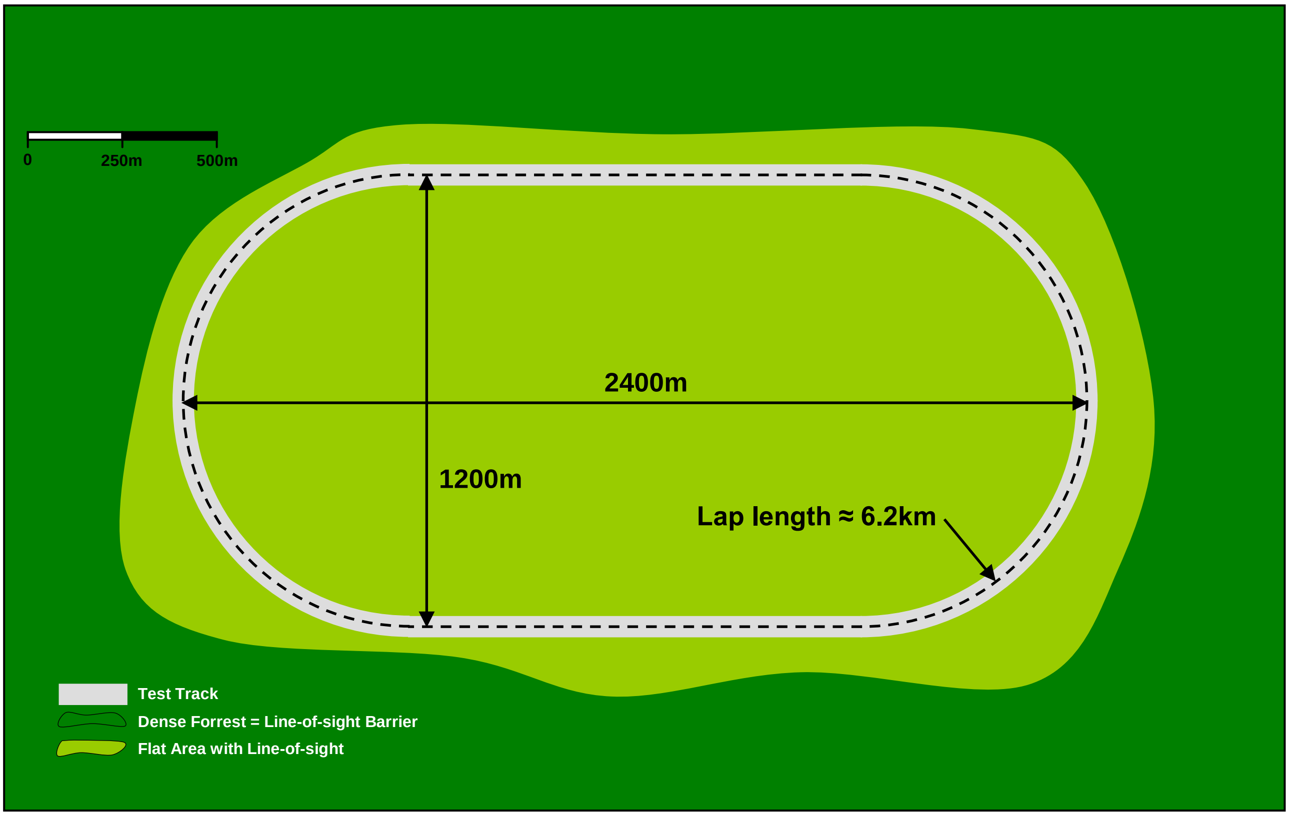
(1) Related to antenna socket (every increasing of height above ground improves wireless performance)
(2) Can be changed to reverse direction by swapping the wireless mode of stationary and mobile unit (Access Point ↔ Station)
(3) Time continuously data stream for verification of results with integrated network speed test (web client vs. server)
(4) See map on previous page


Data Throughput Access Point to Station
Sunny
Snowfall
Net Data Rate [Mbps]
Distance [m]
50Mbps@500m
30Mbps@1km
...@1.5km
15Mbps@1.5km
...@2km
12Mbps@3km
6Mbps@2km
3Mbps@3km
Specified Net Data Rate vs. Transmission Range
0
10
20
30
40
50
60
70
0
500
1000
1500
2000
2500
3000

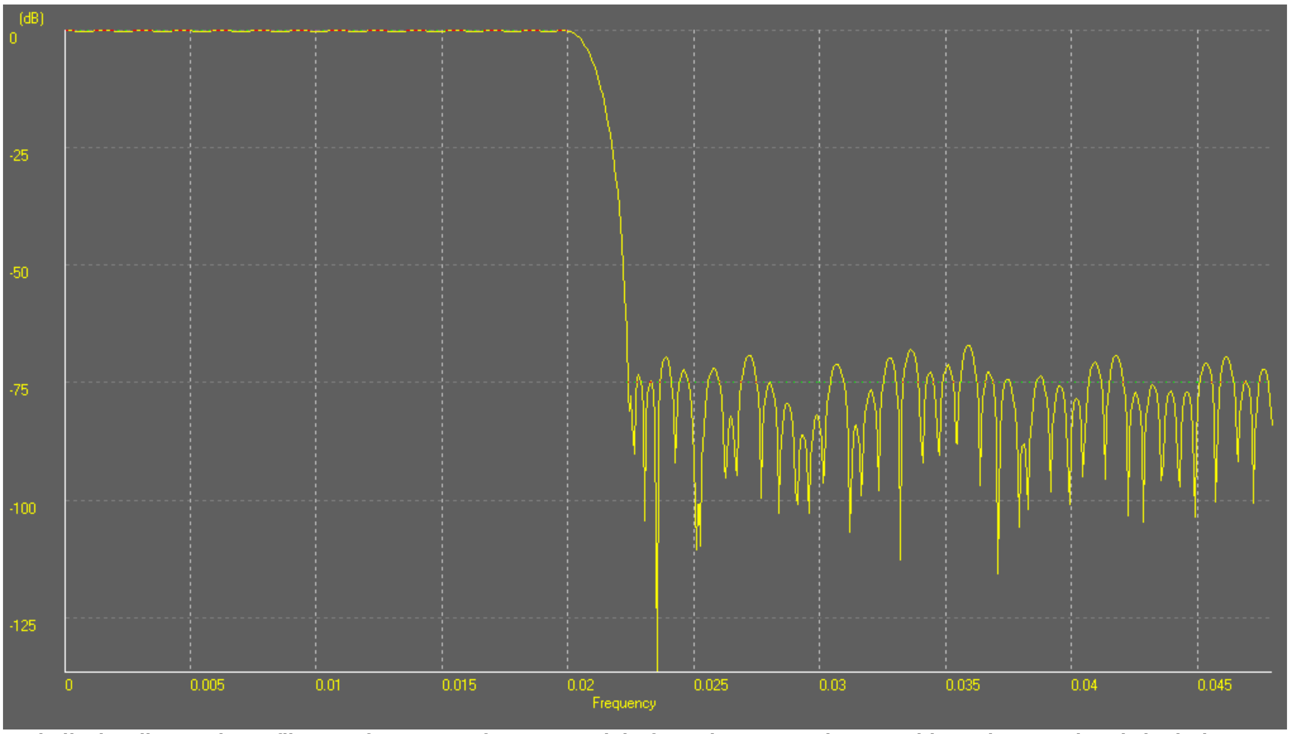

Data Throughput Station to Access Point
Sunny
Snowfall
Net Data Rate [Mbps]
Distance [m]
15Mbps@500m
Specified Net Data Rate vs. Transmission Range
5Mbps@1km
3Mbps@1.5km
2Mbps@1km
1.5Mbps@2km
0.8Mbps@2km
1Mbps@3km
0.4Mbps@3km
0
10
20
30
0
500
1000
1500
2000
2500
3000

Application Example – Vehicle Test Track

Four analog sensor signals should be measured with a bandwidth of 20kHz inside one or more mobile Test Vehicles driving with **v_{max} = 250km/h ≈ 70m/s** on a high-speed test course.



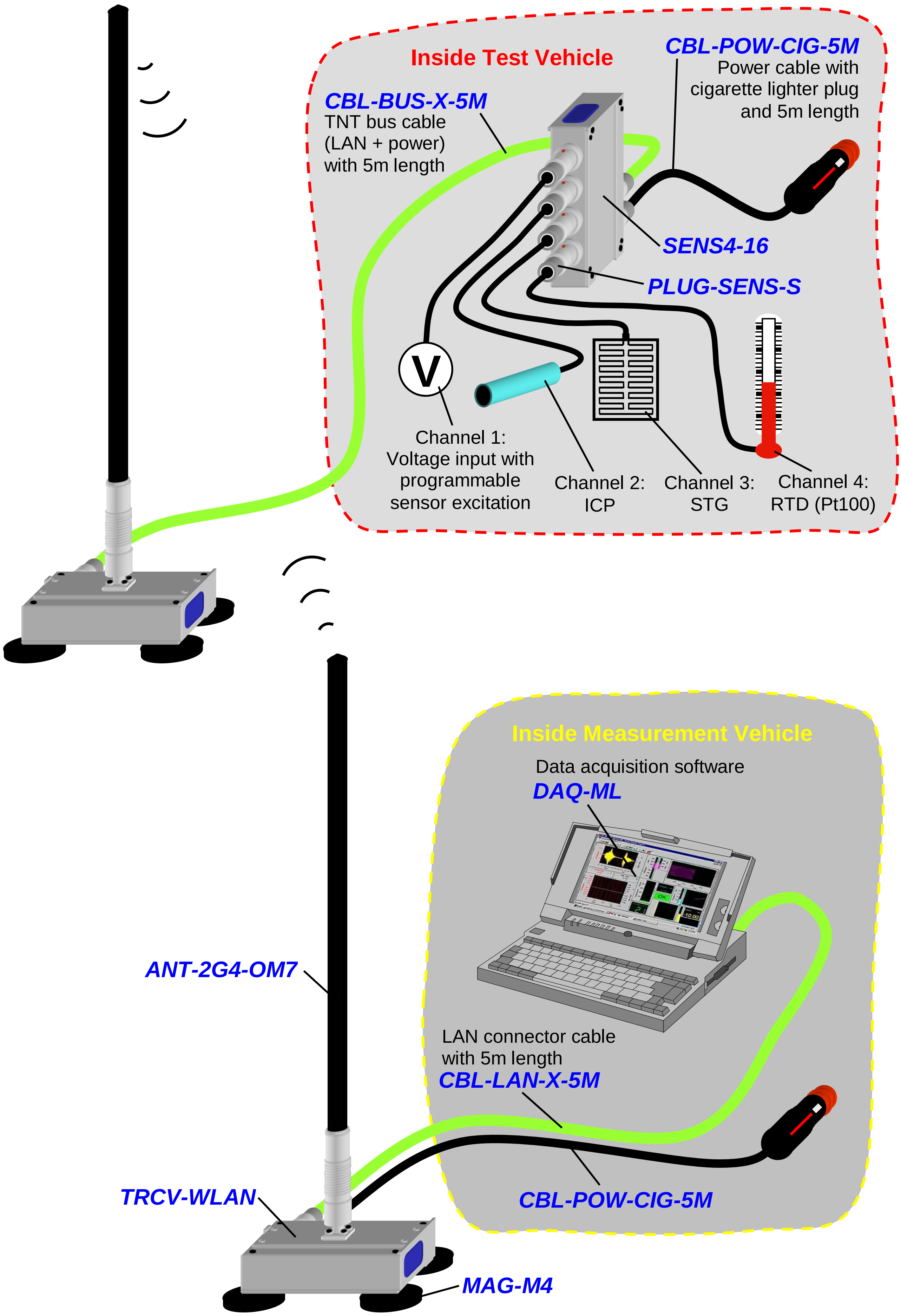
All data should be transfered wirelessly, 100% error-free and without losses to a Measurement Vehicle for online visualisation, evaluation and archiving. For data acquisition a ***SENS4-16*** module with 16 bit resolution is used and set to a sample rate of 48kSps(1) which is sufficient to achive a true bandwidth of 20kHz as shown in the filter chart below. The resulting net data rate is **4 channels x 48kSps x 16bit ≈ 3.1Mbps,** the lap time **6200m / 70m/s ≈ 90s** and the data volume per lap **90s x 3.1Mbps ≈ 280Mbit**. With the buffer memory of **8MByte = 64Mbit** the ***SENS*** module can bridge a total interruption of wireless connection for **64Mbit / 3.1Mbps ≈ 20s** without any data loss. The maximum transmission speed of ***SENS*** module is limited to **6.2Mbps** (double of data acquisition rate), which results in a full data buffer clearing time of also **20s**.



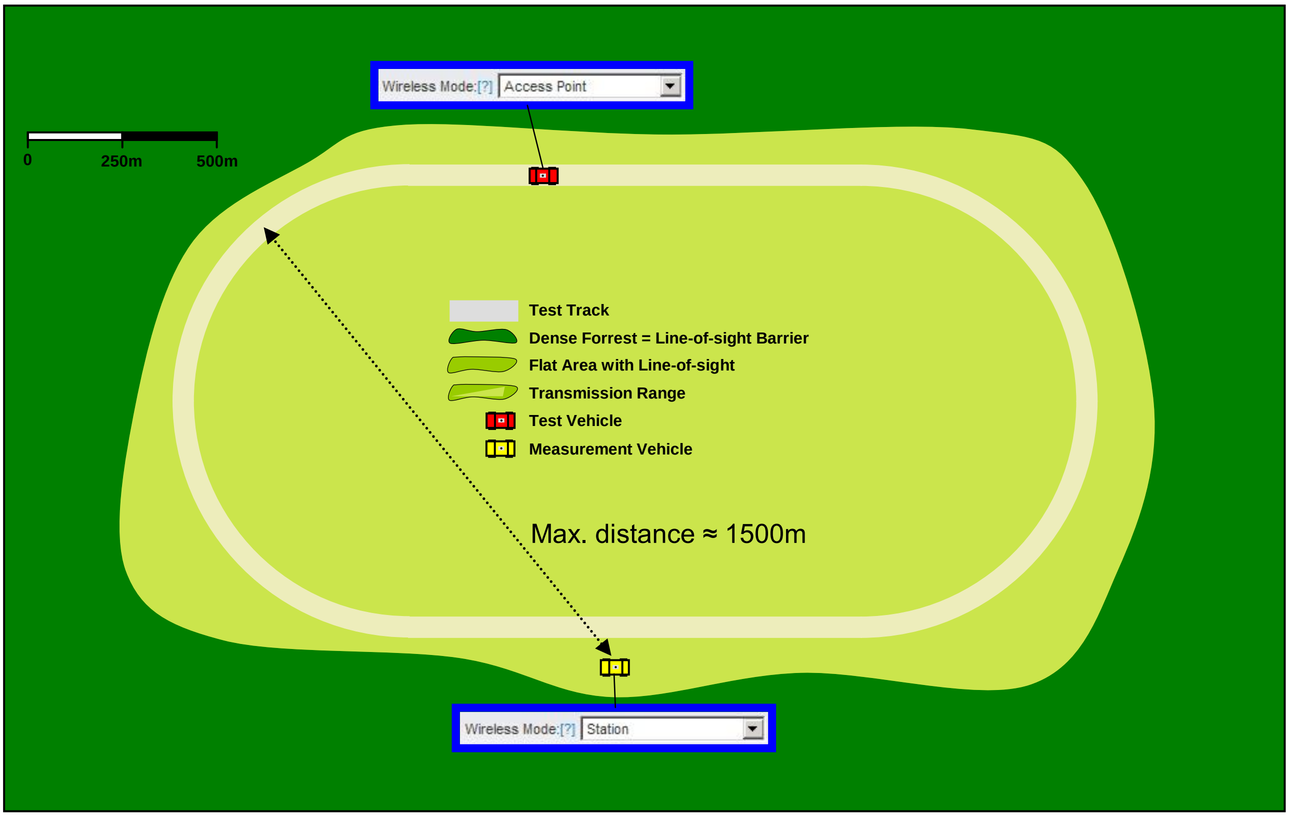
Anti-aliasing linear phase filter performance of *SENS* module for 48kSps sample rate with 0.1dB pass band ripple between 0 and 20kHz (true bandwidth) and min. 70dB signal attenuation beginning from 24kHz (half sample rate = Nyquist frequency)

(1) 1kSps = 1,000 Samples per second (equivalent to 1kHz)

Following picture shows the technical setup of Test and Measurement Vehicle.



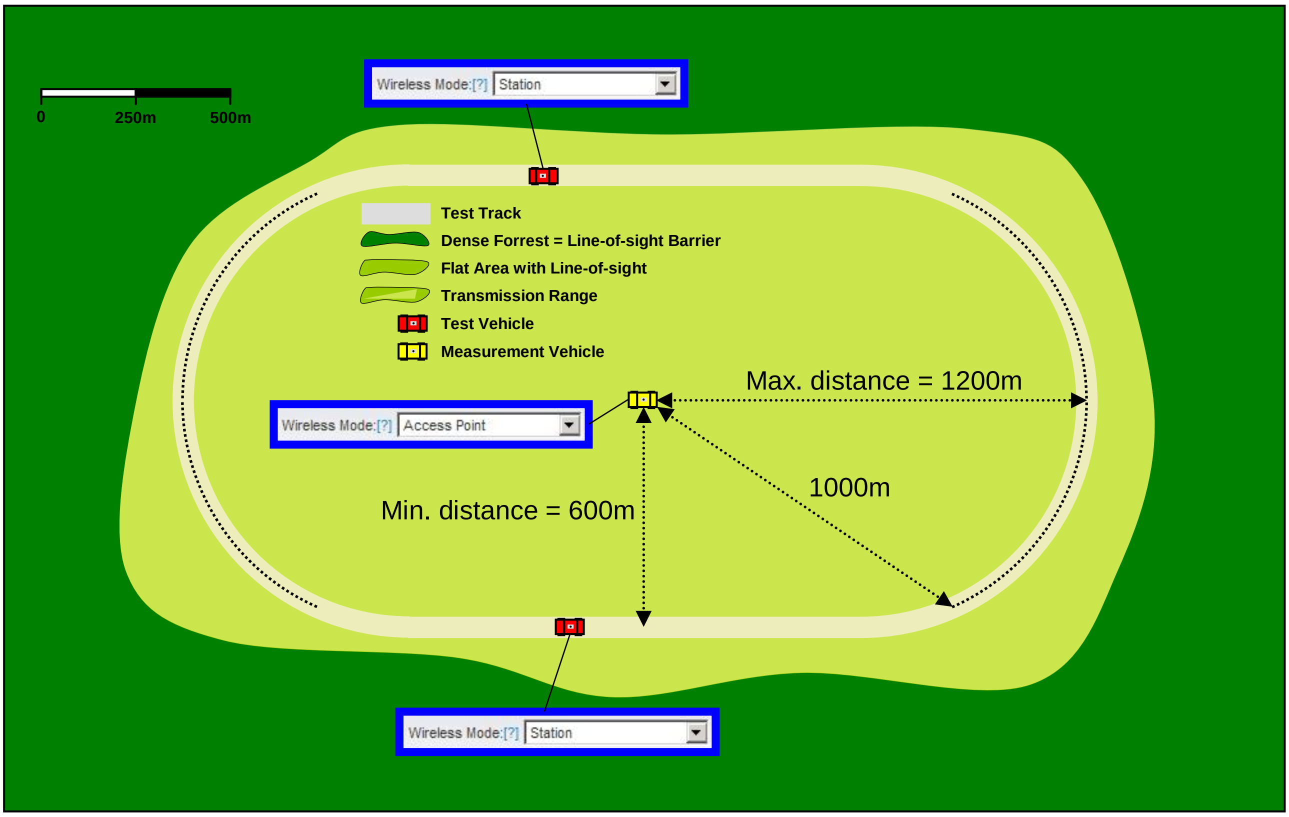
For all following examples we assume sunny weather conditions and firstly we have only one Test Vehicle. Each Wireless LAN infrastructure network has to contain exactly one Access Point. Because of the point-to-point connection with just two participants, we can decide freely, whether the stationary or mobile unit takes over this part. In our case the main data stream direction is given by the digitised sensor signals from the Test to the Measuring Vehicle. In reverse direction only TCP acknowledgements for the correct receipt of data packages will be sent. As seen in the table at page 2 and the charts at page 7 the transmission speed is significantly faster from Access Point to Station. Therefore we configure the mobile Test Vehicle as Access Point and the stationary Measurement Vehicle as Station.



If we consider the flat area approximately as rectangle with edge lengths equivalent to the test track dimensions, we can calculate the maximum line-of-sight extension as $\sqrt{(\mathbf{2.4km})^2 + (\mathbf{1.2km})^2} \approx$ **2.7km**. For sunny weather 12Mbps@3km is specified, which means that the requested 3.1Mbps are given for any possible position of the Measurement Vehicle inside the flat area. If we choose the position in the middle of the straight section of the test track like shown in the picture above, we have a maximum distance of only 1.5km with a resulting net data rate of 30Mbps. Because only 10% of the available capacity will be used, further analog channels can be added, e.g. by appending four ***SENS8*** modules a 36-channel x 20kHz bandwidth telemetry system is build with 100% error-free real-time transmission from each position of the Test Track (**36 channels x 48kSps x 16bit ≈ 27.6Mbps**).

Alternatively the CAN bus data of the Test Vehicle can be forwarded simultaneously to the Measurement Vehicle simply by adding an interface module ***IF-CAN*** to the TNT bus. It enables also the integration of already installed CAN bus based data acquisition systems from other manufacturers (e.g. for low-speed multi-channel temperature measurements), a VBOX for continuously position, speed and acceleration (up to 100Hz update rate) or a RT inertial system (up to 250Hz) with additional high-accuracy roll/pitch, heading, angular rate and slip angle. If the last one is equipped with an Ethernet interface, it can be directly connected to the fully LAN compatible TNT bus like also the ***RCV-GPS*** module for just temporarily position information (1Hz). For connection of more than one device the TNT bus can be split in star-shaped topology by the switch module ***SWT***. This offers also the easy connection of all kind of PCs (on-board computer, robotic drivers, desktop car-PC, laptop, tablet) inside the Test Vehicle. If the device is also equipped with a WLAN interface (notebook, PDA, mobile or smart phone) the connection takes place wirelessly simply by logging in as additional Station/Client to the ***TRCV-WLAN*** Access Point on the vehicle's roof. Thus all kind of communication can be established between the test driver or co-pilot and the measurement crew (chat, voice, audio, video, file transfer, screen duplication, etc.) by using simple system tools like NetMeeting, Teamwork or Remote Desktop Connection. As final highlight, also the development crew at any place in the world can be invited to the test. After connection of a ***TRCV-4G*** module at the Measurement Vehicle a bridge to the World Wide Web will be established via mobile phone network. This enables online communication with test and measurement crew using web tools like Skype or TeamViewer for live monitoring and vehicle setup. This reduces the number of required experts on test site and saves travelling costs. In this configuration the freely selectable position of the Measurement Vehicle should be optimised for best available HSUPA performance. Precise absolute time can be provided here by the implemented NTP Client.

As a second step, one or more Test Vehicles will be added now. Because of the required exactly one Access Point in the standard infrastructure WLAN network, the wireless mode of Test and Measurement Vehicles are swapped now. Actually it isn't mandatory, but the configuration is more clearly, if each Test Vehicle has a direct connection to the Measurement Vehicle. An indirect link from Test Vehicle 1 (Station 1) via Test Vehicle 2 (Access Point) to Measurement Vehicle (Station 2) would bring more confusion than advantages. This change of configuration reduces the transmission rates, because the "upload" speed from Station to Access Point is much lower than for the "download" in reverse direction. Therefore the Measurement Vehicle should be placed in an optimised position to keep the effective distance to the test vehicle for the whole lap as short as possible. This condition is fulfilled in the centre of the test course.

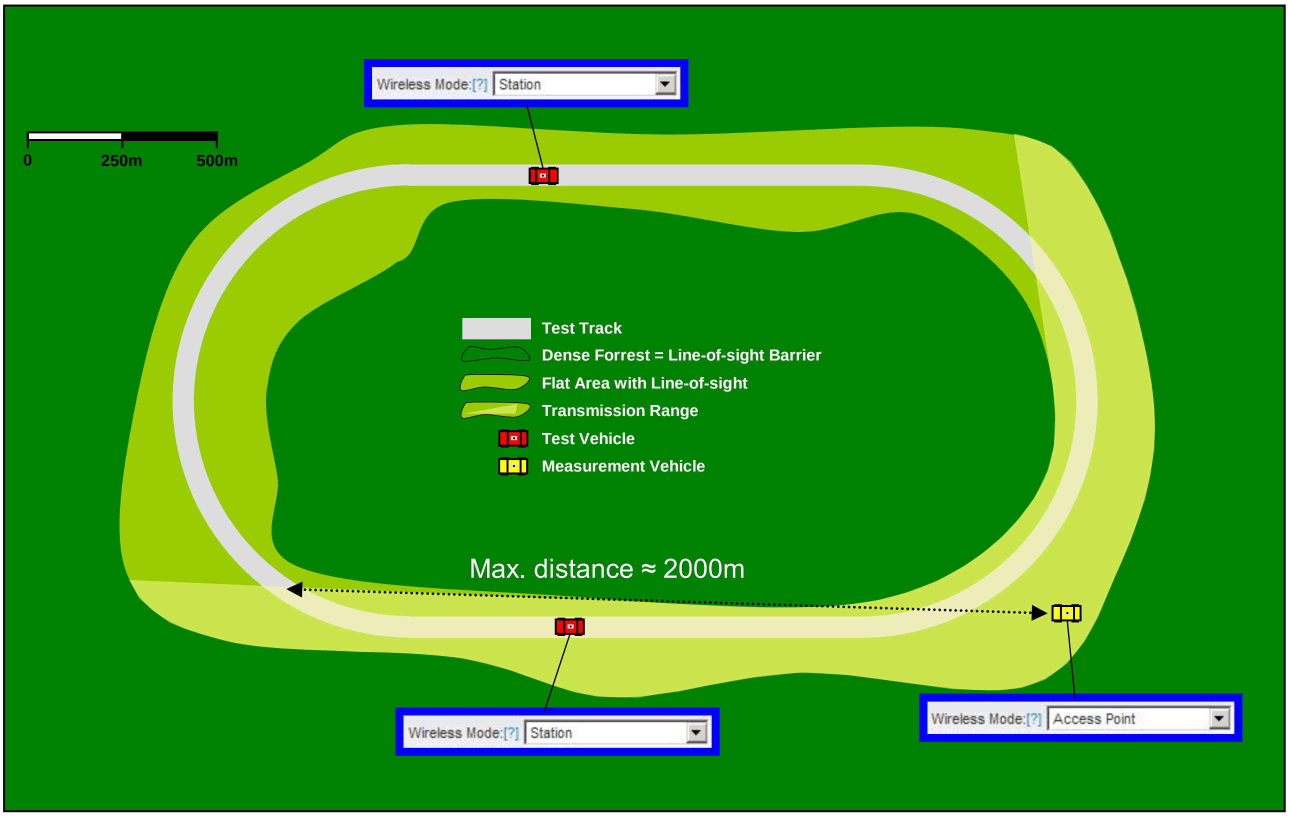


The maximum distance is here 1200m and although only 3.0Mbps are specified from 1000-1500m, we can see in the lower chart at page 7, that there is enough reserve to reach the 3.1Mbps at 1200m, required in our virtual test case. Also if we really calculated with 3.0Mbps, only a very small data buffer would be created inside the ***SENS*** module, which will be immediately cleared, when the Measurement Vehicle comes in range of less than 1000m, where 5.0Mbps are specified. Summarised, for only one Test Vehicle we can expect an nearly 100% online transmission without any data loss, because of the 20s wide data buffer inside the ***SENS*** module.

If we add the second Test Vehicle the situation becomes more complicated. For detailed information see Media Access Control (MAC) protocol in particular Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). Knowing the complexity of this topic, it is very difficult to make reliable statements about the data rates to be expected. In general, if two Stations share the same frequency band, the throughput is less than the half of one Station. For the following calculation we want assume, that each of both Stations get 40% of the total bandwidth and the remaining 20% will be lost due to protocol overheads and wait states. By operating with specifications, for the curved part marked with the black dotted line, which is approximately 45% of the total track length, the distance to the Measurement Vehicle is 1000-1200m with 3.0Mbps and for the rest 600-1000m with 5.0Mbps. The average transmit rate for each of both Test Vehicles is **(0.45 x 3.0Mbps + 0.55 x 5.0Mbps) x 0.4 ≈ 1.6Mbps** and therefore to low to transmit the requested 3.1Mbps. As conclusion the throughput must be halved by setting the channel sample rate down to 24kSps with a resulting bandwidth of 10kHz and a data rate of **4 channels x 24kSps x 16bit ≈ 1.5Mbps**. In the same time the data buffer is doubled to **40s**, which is more than sufficient to cover the lower speed sections in the curves of the test track.

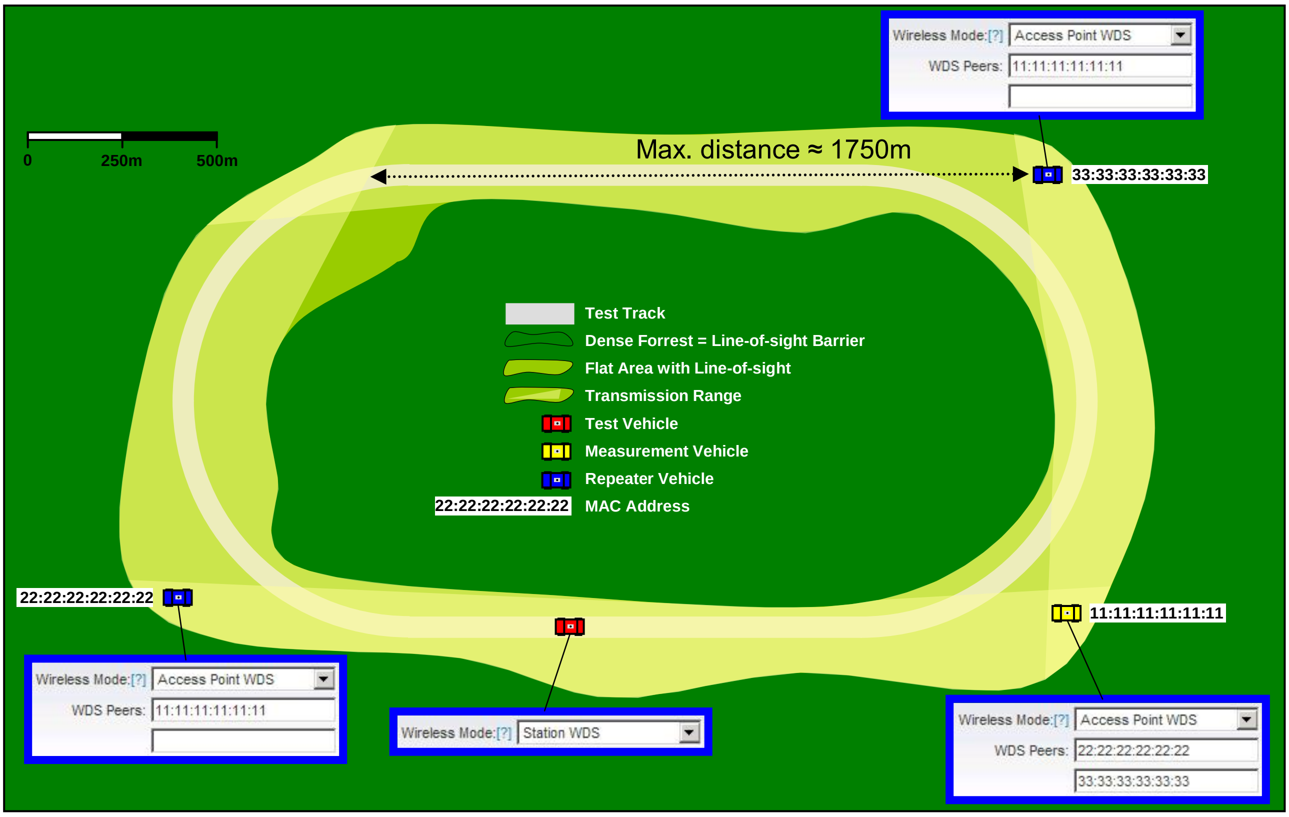
At the stage, where two or more Test Vehicles don't operate independent anymore but related to each other, a unique feature of the ***TNT-ST*** system becomes very important – highly-precise wireless time synchronisation. In our example the both ***SENS4*** modules inside the two different Test Vehicles provide after this procedure continuously time correlated data with accuracy in microseconds range. This raises the system to a first-class solution for testing Advanced Driver Assistance Systems (ADAS), where stationary and mobile Vehicles or other "Obstacles" operate as "Hunters" and "Targets" in interaction such as Adaptive Cruise Control (ACC), Emergency Brake Assistance (EBA), Blind Spot Detection (BSD), Lane Departure Warning (LDW), Intelligent Speed Adaptation (ISA), Lateral Collision Avoidance (LCA), Precrash, Automatic Parking, Pedestrian Protection as well as Vehicular Communication Systems.

Back to our example, the synchronisation enables also time correlated acquisition of stationary signals from the test course itself, e.g. from a laser or radar based speed sensor, light beams or a weather station providing environmental conditions like temperature, humidity, rainfall, wind strength and direction. If the last one is equipped with a RS232 output only it can be easily covered using an ***IF-RS*** interface module.
As third step the difficulties will be increased by an additional wooded area inside the test track which represents an impenetrable line-of-sight barrier. Now the best position for the Measurement Vehicle is given at one of the four corners like shown in picture below. Here the wireless connection is available for approximately 50% of the test track. With our lap time of 90s the Test Vehicle drives 45s in the blind spot and for our last configuration with a channel sample rate of 24kSps we had calculated a data buffer size of 40s, which is a little bit to small for covering the whole track without data losses.



Hence, the throughput must be halved again by setting the channel sample rate down to 12kSps with a resulting bandwidth of 5kHz and data rate of **4 channels x 12kSps x 16bit ≈ 0.75Mbps**. The data buffer will be also doubled again to more than sufficiently **80s**. For the maximum distance of 2km a minimum data rate of 1.5Mbps is specified. Summarised the ***SENS*** module fills the data buffer permanently with the acquisition rate of 0.75Mbps and forward it wirelessly with 0.0Mbps at the first half of the lap (blind spot) and 1.5Mbps at the second half (transmission range), so that at the end of each lap the buffer is completely cleared. Actually the clearance happens much more faster, because the transmission speed increases continously as closer the Test Vehicle approaches to the Measurement Vehicle. A second Test Vehicle would be covered in this configuration automatically, if both alternate in passing the transmission range.
As fourth and final step an online-monitoring for the whole test track should be realised. This is feasible by supporting the new Wireless Distribution System (WDS) protocol, which enables wireless communication between Access Points now (before only wired). In our example two additional Repeater Vehicles (blue) will be placed at the adjacent corners of the Measurement Vehicle's one (see picture on next page). Measurement and all Repeater Vehicles operate in "Access Point WDS" and all Test Vehicles in "Station WDS" mode. During setup it must be carefully defined, which WDS Access Points are connected to which other. This happens with a WDS Peers table, where the MAC addresses of all partner APs must be listed. Here it's very important that no network loop (ring or mesh topology) will be created, means only linear (daisy-chained), star-shaped and hierarchical (tree) topologies are allowed. In our case both Repeater Vehicles are connected to the Measurement Vehicle and it's forbidden to connect also the Repeater Vehicles to each other, because a loop would be established. It's also not sufficient to remark, that a wireless communication between the Repeater Vehicles isn't possible anyway, because of the forest in between – in practical tests transmission ranges of more than 2km across a 2.5m high corn field without any line-of-sight are reached. So, if the wooden area in the middle of the test track isn't dense or high enough or if we have another line-of-sight barrier (flat buildings, etc.) a communication can't be excluded.
Although the whole test track is covered, it could be an advantage to place a third Repeater Vehicle in the upper left corner, because this would significantly reduce the maximum distance between Test and Measurement/Repeater Vehicle of now 1750m and therefore increase the average data throughput in the wireless network. This Repeater has to be connected to only one of the both existing ones to avoid a loop.

All Test Vehicles running on the test track connect always to the WDS Access Point with the currently best signal strength, whereby switching between APs takes place without noticeable side effects. The performance is comparable with using a mobile phone inside a moving car and the base station is changed during conversation.



Summarised ***TRCV-WLAN*** is the ultimate solution to establish an infrastructure within minutes for error-free wireless and secure high-speed communication including data exchange. Although systems like described above can be fix installed on masts, the more likely application case will be the temporary use, e.g. for occasional measurements at not company-owned test tracks. It saves hours and hours for installation of communication and power lines during paying expensive rental charges for the use of the test track. Also if a similar wireless infrastructure is already installed, it's mostly an advantage to bring your own equipment, because of security reasons, saving of setup and configuration times and leasing fees. In case, that the number of available Vehicles is less than the number of required WDS Access Points, a Repeater can be easily built by adding to the ***TRCV-WLAN*** a tripod and a battery module ***BATT30-R*** (see picture at page 5). One module provides an operation time between 3 (permanent full-speed transmission) and 8 hours (idle mode). If this isn't sufficient, just add a second one and times are doubled.

Some References

AB Dynamics, Akka, Airbus, Andritz, Audi, BMW, Bombardier, Bosch-Rexroth, Continental, CRRI India, Curtiss-Wright, Daimler, Deutsche Bahn, Eberspächer, FKFS, Ford, German Army Vehicles, German Army Weapons and Munition, German Navy, Head Acoustics, Heller, Krauss-Maffei-Wegmann, KTM, Linde, MAN, MARIN, Metso Paper, Mueller-BBM, Ohio State University, Politechnique University of Catalonia, Politecnico di Milano, Ponsse, Porsche, Rheinmetall, Sauer-Danfoss, Schaeffler, Schott, Senvion, Siemens, SRAM, Technical University Ilmenau, US Army Waterways, Villeroy & Boch, Voestalpine, Volkswagen, VTT Technical Research Centre of Finland, Wabco, Wärtsilä

Specifications

System	
Dimensions[1]	120 x 70 x 30mm
Weight	380g
Power supply	9-50V DC
Power consumption	4W (idle) – 10W (max. speed transmitting)
Start-up time	< 30s
TNT bus ports	2 (not independent)
Connectors	Antenna: Type N female, Power+LAN: Lemo EHP.1E.306.CLL

Wireless				
Transmit power	12 – 28dBm (max. tolerance ±2dB), programmable in steps of 1dB			
Transmission delay	< 500µs (typ. one-way)		< 1ms (typ. two-way)	
Bandwidth	5MHz (quarter channel) 10MHz (half channel) 20MHz (full channel) 40MHz (two bonded channels)		programmable	
Net Data Rates[2]	Access Point → Station		Station → Access Point	
Distance	Sunny[3]	Snowfall[4]	Sunny	Snowfall
500m	50Mbps		15Mbps	
1000m	30Mbps		5.0Mbps	2.0Mbps
1500m	30Mbps	15Mbps	3.0Mbps	0.8Mbps
2000m	15Mbps	6Mbps	1.5Mbps	0.8Mbps
3000m	12Mbps	3Mbps	1.0Mbps	0.4Mbps

Frequency bands			Channel	Centre	Range
Channel	Centre	Range	7	2.442GHz	2.431-2.453GHz
1	2.412GHz	2.401-2.423GHz	8	2.447GHz	2.436-2.458GHz
2	2.417GHz	2.406-2.428GHz	9	2.452GHz	2.441-2.463GHz
3	2.422GHz	2.411-2.433GHz	10	2.457GHz	2.446-2.468GHz
4	2.427GHz	2.416-2.438GHz	11	2.462GHz	2.451-2.473GHz
5	2.432GHz	2.421-2.443GHz	12	2.467GHz	2.456-2.478GHz
6	2.437GHz	2.426-2.448GHz	13	2.472GHz	2.461-2.483GHz

Standards	LAN 802.3u, WLAN 802.11b,g,n, Wi-Fi
LAN	10/100 Half/Full Duplex, programmable or auto
Protocols	IP, ICMP, UDP, TCP, DHCP, HTTP, HTTPS, SNMP, NTP, SSH, Telnet
Security	WEP64/128, WPA/WPA2-TKIP/AES with PSK/EAP, SSID hiding, MAC locking, Firewall, Routing tables
Wireless modes	Station, Station WDS[5], Access Point, Access Point WDS[6]
Network modes	Bridge, Router
Legal regulatory rules	Pre-programmed transmit power limits and carrier frequencies for 117 selectable country codes[7]

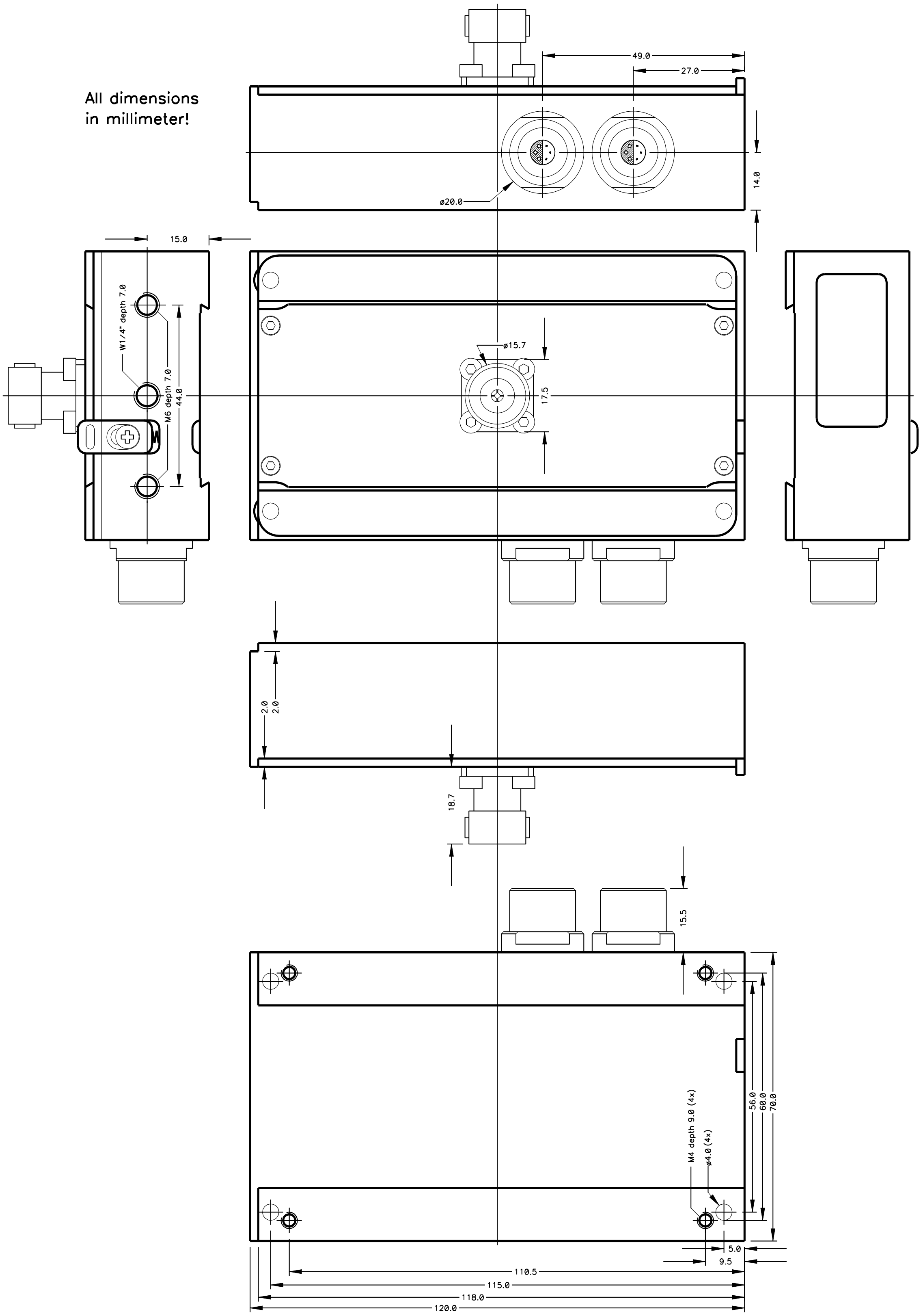
Environmental			
Temperature range	-40 - +85°C (operating)	-40 - +85°C (storage)	
Humidity	5 – 95% non-condensing		
Protection	IP68 (permanent under water) IP69K (80bar/80°C high-pressure/temperature water/steam)		
Shock	< 100g[8]	Vibration	< 10g[9]
Wind survival	250km/h (including antenna)		

Options	
TNT-ST-OPT-MNT	Mounting plate for tripods and vacuum feet ***VCUP-018***
TNT-ST-OPT-COND[10]	Pressure equalisation element with special semi-permeable membrane

Status	
Version 6	In production

(1) Without connection sockets
(2) Antenna sockets 1.5m above ground, line-of-sight, max. transmit power and bandwidth
(3) Sunny = Best weather conditions
(4) Snowfall = Worst weather conditions
(5) Fully compatible with WPA / WPA2 encryption
(6) Not fully compatible with WPA / WPA2 encryption
(7) See page 2 for list of countries
(8) Half sine wave 2ms, optionally more with internal potting
(9) Sine wave (22-500Hz), optionally more with internal potting
(10) Avoids internal condensation formation at rapid cooling down of ambient temperature

Mechanical Dimensions



All dimensions in millimeter!