T E S T R E P O R T
No.: 18-1-0244501T07a

According to:
FCC Regulations
Part 1.1310
Part 2.1091

IC-Regulations
RSS-102, Issue 5

for

Veoneer US, Inc.

77V12CRN
77 GHZ CRN Radar Sensor

FCC: WU877V12CRN
ISED: 8436B-77V12CRN
PMN: Veoneer 77V12CRN
HVIN: 77V12CRN

Laboratory Accreditation and Listings
ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-12047-01-01 D-PL-12047-01-03 D-PL-12047-01-04
accredited according to DIN EN ISO/IEC 17025

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The listed attachments are an integral part of this report.

1. Summary of test results

The test results apply exclusively to the test samples as presented in this Report. The CETECOM GmbH does not assume responsibility for any conclusions and generalizations taken in conjunction with other specimens or samples of the type of the item presented to tests.

The presented Equipment Under Test (in this report, hereinafter referred as EUT) integrates a Radar 76 GHz RF Transceiver. Other implemented wireless technologies were not considered within this test report.
Following tests have been performed to show compliance with applicable FCC Part 2.1091 and FCC Part 1.1310 of the FCC CFR 47 Rules.

1.1. Summary of tests results

RF-Exposure Evaluation (separation distance user to RF-radiating element greater 20cm)								
Test cases	**Port**	**References & Limits**				**EUT set-up**	**EUT op. mode**	**Result**
		FCC Standard	Test Limit	RSS Standard	Test Limit			
Radio frequency radiation exposure Requirements	Cabinet	§1.1310 §2.1091 §2.1093	RF-Field Strength Limits: FCC: "general population/ uncontrolled" environment	RSS-102, Issue 5	Chapter 4 Table 4	4	2	PASS

Remark: Calculations based on Datasheet delivered by applicant

1.2. Attestation:

I declare that all measurements were performed by me or under my supervision and that all measurements have been performed and are correct to my best knowledge and belief to Industry Canada standards. All requirements as shown in above table are met in accordance with enumerated standards.

....

Dipl.-Ing. Niels Jeß
Responsible for test section

M. Schäfers
Responsible for test report

2. Administrative Data

2.1. Identification of the testing laboratory

Company name:	CETECOM GmbH
Address:	Im Teelbruch 116 45219 Essen - Kettwig Germany
Responsible for testing laboratory:	Dipl.-Ing. Volker Wittmann
Deputy:	Dipl.-Ing. Niels Jeß

2.2. Test location

2.2.1. Test laboratory “CTC”

Company name:	see chapter 2.1. Identification of the testing laboratory

2.3. Organizational items

Responsible for test report:	M. Schäfers
Receipt of EUT:	--
Date(s) of test:	--
Date of report:	2019-03-20

2.4. Applicant’s details

Applicant’s name:	Veoneer US, Inc.
Address:	26360 American Drive Southfield, MI 48034 USA
Contact person:	Mr. Stefan Gipser

2.5. Manufacturer’s details

Manufacturer’s name:	please see applicant's details
Address:	please see applicant's details

3. Equipment under test (EUT)

3.1. Summary of product description

FCC ID:	WU877V12CRN	
Product name	77 GHZ CRN Radar Sensor	
Exposure category	☒ General population/uncontrolled environment ☐ Occupational exposure/controlled environment	
Output power	☐ Conducted ☐ ERP ☒ EIRP ☐ Peak ☒ Source-based time-averaging	
Antenna gain	details refer Annex 1 and 2	
Antenna Type	☒ Integrated ☐ External, no RF- connector ☐ External, separate RF-connector	
Evaluation type	☒ Standalone ☐ Simultaneous transmission	
Evaluation distance	☒ 20 cm	
	☐ XXX cm	declares by manufacturer
EUT type	☐ Production Unit ☒ Pre-Production Unit ☐ Engineering Unit	
Device type	☒ Mobile device ☐ Fixed device	
Refer rules	☒ CFR 47 FCC Part 2.1091 ☒ CFR 47 FCC Part 1.1310 ☒ KDB 447497 D01v06 October 23, 2015 ☒ KDB 865664 D01v01r02 October 23, 2015	

3.2. EUT Technologies

Wireless Technologies	Frequency bands	Operation mode
☒Radar	☒76GHz	☒AEB
		☒ACC

3.3. Antenna Information

Wireless Technologies	Frequency bands	Maximum antenna gain
☒Radar	☒76GHz	refer to Annex 1 & 2

3.4. EUT: Type, S/N etc. and short descriptions used in this test report

Short descrip-tion*)	EUT	Type	S/N serial number	HW hardware status	SW software status
EUT A S 14	77 GHz CRN Radar Sensor	77V12CRN (WF config. 1)	80182	CRN_2.5_1.0	R255_31_10D24_3
EUT B S 12	77 GHz CRN Radar Sensor	77V12CRN (WF config. 2)	80160	CRN_2.5_1.0	R255_31_12D24_3
EUT C S 08	77 GHz CRN Radar Sensor	77V12CRN (WF config. 5)	80099	CRN_2.5_1.0	R255_31_15D24_3
EUT D S 11	77 GHz CRN Radar Sensor	77V12CRN (thin radome WF config. 2)	80208	CRN_2.35_1.0	R255_31_12D24_3

*) EUT short description is used to simplify the identification of the EUT in this test report.

3.5. Auxiliary Equipment (AE): Type, S/N etc. and short descriptions

AE short descrip-tion *)	Auxiliary Equipment	Type	S/N serial number	HW hardware status	SW software status
AE 1	--	--	--	--	--

*) AE short description is used to simplify the identification of the auxiliary equipment in this test report.

3.6. EUT set-ups

EUT set-up no.*)	Combination of EUT and AE	Remarks
set. 1	EUT A	➢ Waveform(WF)>> config. 1(EUT A) ➢ Thick Radome 2.5 mm
set. 2	EUT B	➢ Waveform(WF)>> config. 2(EUT B) ➢ Thick Radome 2.5 mm
set. 3	EUT C	➢ Waveform(WF)>> config. 5(EUT C) ➢ Thick Radome 2.5 mm
set. 4	EUT D	➢ Waveform(WF)>> config. 2(EUT D) ➢ Thin radome 2,35mm (EUT D)

*) EUT set-up no. is used to simplify the identification of the EUT set-up in this test report.

3.7. EUT operating modes

EUT operating mode no.*)	Description of operating modes	Additional information
op. 1	AEB	Only theoretically calculation
op. 2	ACC	Only theoretically calculation

*) EUT operating mode no. is used to simplify the test report.

4. Measurements

4.1. Radio Frequency Exposure Evaluation §2.1091

4.1.1. Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)	☐ Please see Chapter. 2.2.2	☐ Please see Chapter. 2.2.3
	For Evaluation instruments are not needed. Results are determined by calculation based on applicants delivered Tune-Up procedure.		

4.1.2. Requirements

FCC: §1.1310	*The criteria used for the evaluation of human exposure to radio frequency radiation is table 1 according FCC §1.1310 and table chapter 4.2 of RSS-102 standard and it is subject for evaluation of the RF exposure prior to equipment authorization.* *As the mobile equipment is authorized under Part 22 (Subpart H) and Part 24 of the FCC Rules, it is subject for evaluation of the RF exposure prior to equipment authorization.*
FCC § 2.1091	*Further information on evaluating compliance with these limits can be found in the FCC's OST/OET Bulletin Number 65, ''Evaluating Compliance with FCC-Specified Guidelines for Human Exposure to Radiofrequency Radiation.''* *For purposes of these requirements mobile devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits given in Table 1 of Appendix A.*

4.1.2.1. Valid for FCC

Table 1: LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)				
Frequency range [MHz)	Electric field strength [V/m]	Magnetic field strength [A/m]	Power density [mW/cm²]	Averaging time [minutes]
30 - 300	61.4	0.163	1.0	6
300 - 1500	-		f/300	6
1500 - 100,000	-		5	6
(B) Limits for General Population / Uncontrolled Exposure				
0.3 – 1.34	614	1.63	*(100)	30
1.34 – 30	824/f	2.19/f	*(180/f²)	30
30 - 300	27.5	0.073	0.2	30
300 - 1500	-	-	f/1500	30
1500 – 100,0	-	-	1.0	30

f=frequency in MHz
*Plane-wave equivalent power density

NOTE1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure. These limits apply to amateur station licensees and members of their immediate household as discussed in the text.

NOTE2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure. As discussed in the text, these limits apply to neighbours living near amateur radio stations.

4.1.3 General Limits:

FCC: §1.1307	*Cellular Radiotelephone Service (subpart H of part 22)* *Non-building-mounted antennas: height above ground level to lowest point of antenna < 10 m and total power of all channels > 1000 W ERP (1640 W EIRP)*
FCC §1.1307	*Personal Communications Services (part 24)* *Broadband PCS (subpart E): non-building-mounted antennas: height above ground level to lowest point of antenna < 10 m and total power of all channels > 2000 W ERP (3280 W EIRP)*
FCC §1.1310	*LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)* *Table 1(B) Limits for General Population/Uncontrolled Exposure* *300–1500 MHz: f/1500 mW/cm²* *1500–100,000 MHz: 1.0 mW/cm²*
FCC §2.1091	*Subject to routine evaluation is required when the device operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more, or if they operate at frequencies above 1.5 GHz and their ERP is 3 watts or more.*
FCC §24.232	*(a) Base stations are limited to 1640 watts peak equivalent isotropically radiated power (e.i.r.p.) with an antenna height up to 300 meters HAAT.* *b) Mobile/portable stations are limited to 2 watts e.i.r.p. peak power, …*
FCC §22.913	*(a) Maximum ERP. The effective radiated power (ERP) of base transmitters and cellular repeaters must not exceed 500 Watts. The ERP of mobile transmitters and auxiliary test transmitters must not exceed 7 Watts.*
FCC §27.50 (C)(10)	*(10) Portable stations (hand-held devices) are limited to 3 watts ERP; and*
FCC §27.50(d)	*(4) Fixed, mobile, and portable (hand-held) stations operating in the 1710-1755 MHz band are limited to 1 watt EIRP.*
KDBs	*No. 447498 D01 v06*

4.2. Requirements and limits for RSS Standard

RSS-102, Issue 5	**2.5 Exemption Limits for Routine Evaluation** All transmitters are exempt from routine SAR and RF exposure evaluations provided that they comply with the requirements of sections 2.5.1 or 2.5.2. **If the equipment under test (EUT) meets the requirements of sections 2.5.1 or 2.5.2, applicants are only required to submit a properly signed declaration of compliance (see Annex C)**. The information contained in the RF exposure technical brief may be limited to the value(s) of the maximum output power, the information that demonstrates how the maximum output power of the transmitter was derived and the rationale for the separation distances applied (see Table 1), which must be based on the most conservative exposure condition for the applicable module or host platform test procedure requirements.
	2.5.2 Exemption Limits for Routine Evaluation — RF Exposure Evaluation RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows: • below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance); • at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz; • at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance); • **at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;** • at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance). In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.
	2.6 User Manual Requirements The applicant is responsible for providing proper instructions to the user of the radio device, and any usage restrictions, including limits of exposure durations. The user manual shall provide installation and operation instructions, as well as any special usage conditions (e.g. proper accessory required, including the proper orientation of the device in the accessory, maximum antenna gain in the case of detachable antenna), in order to ensure compliance with SAR and/or RF field strength limits. For instance, compliance distance shall be clearly stated in the user manual. The user manual of devices intended for controlled use shall also include information relating to the operating characteristics of the device; the operating instructions to ensure compliance with SAR and/or RF field strength limits; information on the installation and operation of accessories to ensure compliance with SAR and/or RF field strength limits; and contact information where the user can obtain Canadian information on RF exposure and compliance. Other related information may also be included.

4.3. MPE Calculation method

Predication of MPE limit at a given distance
Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{EIRP}{4\pi R^2} = \frac{P * G}{4\pi R^2}$$

$$G_{NUMERIC} = \frac{S * 4\pi R^2}{P}$$

Where: S=power density
P=power input to antenna
G=power gain of the antenna in the direction of interest relative to an isotropic radiator
R=distance to the centre of radiation of the antenna

4.4. Evaluation Method

4.4.1. Standalone

Valid for Radar:
• The peak power was checked on 3 frequencies (lowest/middle/highest) within the 76GHz band and the results compared to applicant's declared power values (datasheet).
• No duty-cycle correction factor is applicable
Please find in the following tables the calculations based on applicants datasheet for the power values and antenna gain.

4.5. Results for fixed and mobile

4.5.1. Results for FCC Standard
4.5.1.1. MPE results for 76GHz

Operation Mode	Frequency on channel (MHz)	Declared maximum conducted output power (dBm)	Max. positive tolerance according manufacturer 's tune-up info (dB)	Declared Antenna Gain (dBi)	Calculated maximum EIRP (Output power + Tune-up) (dBm)	Duty cycle (%)	Maximum EIRP (W)	Calculated EIRP incl. Duty cycle ((Output power + Tune-up)) x Duty cycle) (W)	MPE Limit accord. Table 1 (mW/cm^2)	MPE-Value (mW/cm^2)	Margin to Limit: (mW/cm^2)	Fraction for Co-location calculations	Maximum Fraction Value within Frequency band
AEB	76135,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	0,1580
	76416,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	
	76697,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	
ACC	76038,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	0,1580
	76142,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	
	76245,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	
ACC	76278,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	0,1580
	76382,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	
	76485,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	
ACC	76518,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	0,1580
	76622,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	
	76725,0	10,00	2,00	17,00	29,00	100%	0,794	794,33	1,0000	0,15803	0,8420	0,1580	

Maximum calculated MPE value:		
76GHz		
Lowest MPE-Limit:	1,0000	[W/m^2]
Highest MPE-value:	0,1580	[W/m^2]
Margin to limit	0,8420	[W/m^2]

1. Output power including tune-up tolerance;
2. Output power was adjust to duty cycle at 100% if measured duty cycle less than 98%;
3. MPE evaluate distance is 20cm from user manual provide by manufacturer;
4. Depending on output power and antenna gain only the worst case is reported;

4.5.2. Results for RSS Standard
4.5.2.1. MPE Results for 76GHz

Exemption Limits for Routine Evaluation — RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

At or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

Distance	20	cm								
Operation Mode	Frequency on channel (MHz)	Measured maximum conducted output power (dBm)	Max. positive tolerance according manufacturer's tune-up info (dB)	Declared Antenna Gain (dBi)	EIRP (dBm)	Duty cycle (%)	Maximum EIRP (W)	Equivalent EIRP (EIRP x duty cycle) (W)	2.5.2 Exemption Limits for Routine Evaluation (W)	Exemption fullfiled ?
AEB	76135,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
	76416,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
	76697,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
ACC	76038,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
	76142,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
	76245,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
ACC	76278,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
	76382,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
	76485,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
ACC	76518,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
	76622,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes
	76725,0	10,00	2,00	17,00	29,00	100%	0,794	0,794	5,0	yes

1. Output power including tune-up tolerance;
2. Output power was adjust to duty cycle at 100% if measured duty cycle less than 98%;
3. MPE evaluate distance is 20cm from user manual provide by manufacturer;
4. Depending on output power and antenna gain only the worst case is reported;

4.6. Conclusion

The measurement results do comply with the FCC Limit per 47 CFR 2.1091 for the uncontrolled RF Exposure of mobile device.

The measurement results do comply with the RSS-102, Issue 5.

4.7. Measurement uncertainties

The reported uncertainties are calculated based on the standard uncertainty multiplied with the appropriate coverage factor **k**, such that a confidence level of approximately 95% is achieved.
For uncertainty determination, each component used in the concrete measurement set-up was taken in account and it's contribution to the overall uncertainty according it's statistical distribution calculated.

Following table shows expectable uncertainties for each measurement type performed.

RF-Measurement	Reference	Frequency range	Calculated uncertainty based on a confidence level of 95%						Remarks
Conducted emissions (U_{CISPR})	CISPR 16-2-1	9 kHz - 150 kHz 150 kHz - 30 MHz	4.0 dB 3.6 dB						-
Radiated emissions Enclosure	CISPR 16-2-3	30 MHz - 1 GHz 1 GHz - 18 GHz	4.2 dB 5.1 dB						E-Field
Disturbance power	CISPR 16-2-2	30 MHz - 300 MHz	-						-
Power Output radiated	-	30 MHz - 4 GHz	3.17 dB						Substitution method
Power Output conducted	-	Set-up No.	Cel-C1	Cel-C2	BT1	W1	W2		
		9 kHz - 12.75 GHz	N/A	0.60	--	--	--		-
		12.75 - 26.5GHz	N/A	0.82	--	--	--		
Conducted emissions on RF-port	-	9 kHz - 2.8 GHz	0.70	N/A	--	--	--		N/A - not applicable
		2.8 GHz - 12.75GHz	1.48	N/A	--	--	--		
		12.75 GHz - 18GHz	1.81	N/A	--	--	--		
		18 GHz - 26.5GHz	1.83	N/A	--	--	--		
Occupied bandwidth	-	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
			1.0 dB						Power
Emission bandwidth	-	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
	-		See above: 0.70 dB						Power
Frequency stability	-	9 kHz - 20 GHz	0.0636 ppm						-
Radiated emissions Enclosure	-	150 kHz - 30 MHz 30 MHz - 1 GHz 1 GHz - 20 GHz	5.0 dB 4.2 dB 3.17 dB						Magnetic field E-field Substitution

Table: measurement uncertainties, valid for conducted/radiated measurements

5. Abbreviations used in this report

The abbreviations	
ANSI	American National Standards Institute
AV , AVG, CAV	Average detector
EIRP	Equivalent isotropically radiated power, determined within a separate measurement
EGPRS	Enhanced General Packet Radio Service
EUT	Equipment Under Test
FCC	Federal Communications Commission, USA
IC	Industry Canada
n.a.	not applicable
Op-Mode	Operating mode of the equipment
PK	Peak
RBW	resolution bandwidth
RF	Radio frequency
RSS	Radio Standards Specification, Dokuments from Industry Canada
Rx	Receiver
TCH	Traffic channel
Tx	Transmitter
QP	Quasi peak detector
VBW	Video bandwidth
ERP	Effective radiated power

6. Accreditation details of CETECOM's laboratories and test sites

Ref.-No.	Accreditation Certificate	Valid for laboratory area or test site	Accreditation Body
-	D-PL-12047-01-01	All laboratories and test sites of CETECOM GmbH, Essen	DAkkS, Deutsche Akkreditierungsstelle GmbH
337 487 558 348 348	MRA US-EU 0003	Radiated Measurements 30 MHz to 1 GHz, 3 m / 10 m (OATS) Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements above 1 GHz, 3 m (FAR) Mains Ports Conducted Interference Measurements Telecommunication Ports Conducted Interference Measurem.	FCC, Federal Communications Commission Laboratory Division, USA
337 487 550 558	3462D-1 3462D-2 3462D-2 3462D-3	Radiated Measurements 30 MHz to 1 GHz, 3 m / 10 m (OATS) Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements 1 GHz to 6 GHz, 3 m (SAR) Radiated Measurements above 1 GHz, 3 m (FAR)	IC, Industry Canada Certification and Engineering Bureau
487 550 348 348	R-2666 G-301 C-2914 T-1967	Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements 1 GHz to 6 GHz, 3 m (SAR) Mains Ports Conducted Interference Measurements Telecommunication Ports Conducted Interference Measurem.	VCCI, Voluntary Control Council for Interference by Information Technology Equipment, Japan
OATS = Open Area Test Site, SAR = Semi Anechoic Room, FAR = Fully Anechoic Room			

7. Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2019-03-20

End of report