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Annex 2 to WP 7D Chairman's Report

LIAISON STATEMENT TO WORKING PARTY 1A

BANDS BETWEEN 275 AND 3 000 GHz

WP 7D received a liaison statement from WP 1A (Document 7D/86), requesting to be kept up to date about ongoing studies within WP 7D, that address the 275 GHz to 3 000 GHz region of the spectrum.

Working Party 7D is pleased to provide the Annex 1 to this document, that reflects the current state of the studies within WP 7D. WP 7D expects these studies to evolve further at the next few meetings.

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Attachment: 1

Annex 1

Working document towards the use of frequencies in the range 275-3 000 GHz by the radio astronomy service

The International Table of Frequency Allocations presently extends to an upper limit of 275 GHz. RR footnote **5.565** to the Table notes the interest of the radio astronomy service in frequencies between 275 and 1 000 GHz for spectral line observations and future research.

Resolution 950 (WRC-03) considers the use of the frequencies between 275 and 3 000 GHz, and invites the ITU-R:

to conduct the necessary studies in time for consideration by WRC-10 with a view to the modification of No. **5.565** or the possible extension of the Table of Frequency Allocations above 275 GHz, including advice on the applications suitable for such bands.

Resolution 803 (WRC-03) establishes the consideration of frequency allocations between 275 GHz and 3 000 GHz as item 2.2 of the preliminary agenda for WRC-10.

In preparation for WRC-10, this paper presents informative material related to the use of frequencies in the range 275-3 000 GHz by the radio astronomy service. Specifically:

- Attachment 1 to Annex 1 contains the text of the existing RR footnote **5.565** to the international table of frequency allocations related to the use of frequencies above 275 GHz.
- Attachment 2 to Annex 1 contains a list of radio observatories with current or planned operations at frequencies in the range 275-3 000 GHz.
- Attachment 3 to Annex 1 contains a list of spectral line frequency bands of interest to the radio astronomy service in the range 275-3 000 GHz. The list is not all-inclusive.

Attachment 1 to Annex 1

Existing items in the international table of frequency allocations affecting frequencies above 275 GHz

The present International Table of Frequency Allocations includes the following notation affecting frequencies above 275 GHz:

Region 1	Region 2	Region 3
275-1 000 (not allocated) 5.565		

5.565 – The frequency band 275-1 000 GHz may be used by administrations for experimentation with, and development of, various active and passive services. In this band a need has been identified for the following spectral line measurements for passive services:

- Radio astronomy service: 275-323 GHz, 327-371 GHz, 388-424 GHz, 426-442 GHz, 453-510 GHz, 623-711 GHz, 795-909 GHz and 926-945 GHz.
- Earth exploration-satellite service (passive) and space research service (passive): 275-277 GHz, 294-306 GHz, 316-334 GHz, 342-349 GHz, 363-365 GHz, 371-389 GHz, 416-434 GHz, 442-444 GHz, 496-506 GHz, 546-568 GHz, 624-629 GHz, 634-654 GHz, 659-661 GHz, 684-692 GHz, 730-732 GHz, 851-853 GHz and 951-956 GHz.
- Future research in this largely unexplored spectral region may yield additional spectral lines and continuum bands of interest to the passive services. Administrations are urged to take all practicable steps to protect these passive services from harmful interference until the date when the allocation Table is established in the above-mentioned frequency band.
(WRC-2000)

Attachment 2 to Annex 1

Radio astronomy observatories with current or planned operations at frequencies in the range 275-3 000 GHz

The following radio astronomy observatories conduct or plan to conduct observations at frequencies that fall within the range of 275-3 000 GHz. This list may not be all-inclusive.

Region 1						
Country	Site	Longitude ¹	Latitude ²	Altitude (m)	Diameter (m)	Operating bands (GHz)
France	Plateau de Bure (IRAM)	05° 54' 24"	44° 38' 01"	2 552	6 × 15 m	241 - 281
Spain	Pico Veleta (IRAM)	-03° 23' 34"	37° 03' 58"	2 870	30	210-281
Switzerland	Gornergrat (KOSMA)	07° 56'	45° 59'	3 135	3	200-550 750-1 000
Region 2						
Argentina	El Leoncito (SST)	-69° 18' 07"	-31° 47' 57"	2 550	1.2	210-250 340-360 400-425 670-680 1 250- 1260
Brazil	South-East ³ (FITE: Balloon flights)	-46° ~ -61	-23 °11'	~38 000	2 × 0.5 m	3 000
	South-East ³ (PILOT Balloon flights)	46° ~ -61°	-23° 11"	~38 000	1	544-546 1 250-1400
Chile	La Silla (SEST)	-70° 44'	-29° 15'	2 400	15	320-363
	Llano Chajnantor (APEX)	-67° 45' 33"	-23° 00' 21"	5 104	12	275-370 375-500 1240-1400
	Llano Chajnantor (ALMA) (under construction)	-67° 44'	-23° 02'	5 000	64 × 12 m	275-370 385-500 602-720 787-950
Mexico	Sierra Negra (LMT) under construction	-97° 18' 48"	18° 59' 06"	4 600	50	<300

Country	Site	Longitude	Latitude	Altitude (m)	Diameter (m)	Operating bands (GHz)
United States of America	Cedar Flat, CA (CARMA)	-118° 09'	37° 17'	2 200	6 × 10.4 m 9 × 6.1 m	<345
	Kitt Peak, AZ (U. of Arizona)	-111° 36' 50"	31° 57' 10"	1 916	12	275-300
	Mt. Graham, AZ (HHSMT)	-109° 53' 30"	32° 42' 06"	3 185	10	320-375 425-500
	Mauna Kea, HI (JCMT)	-155° 28'	19° 49'	4 032	15	265-300 215-280 300-380 450-505 620-680
	Mauna Kea, HI (CSO)	-155° 28'	19° 49'	4 032	10.4	320-363 460-500
	Mauna Kea, HI (SMA)	-155° 28'	19° 49'	4 032	8 × 6 m	180-900
Region 3						
Japan	Mt. Fuji (U. of Tokyo)	138° 36'	35° 26'	3 776	1.2	330-350 490-495 800-810
Others						
Antarctic	Antarctic (AST/RO)	-45° 53'	-89° 59' 40"	2 847	1.7	440-500 600-710 790-900 1 200-1 600
	(South Pole) (under construction)	-45° 53'	-89° 59'	2 800	10	<1 500
	South Pole ³ (Balloon Flights)	0° to 360 °	-81° to -75°	2 800-38 000	1-2	<2 000 ⁴
	Dome C ⁵	~ 125°	~ -75°	~ 3 200		

¹ Longitudes West of The Prime Meridian are shown as negative.

² Southern latitudes are shown as negative.

³ Telescope location is not fixed.

⁴ This band may be operational in the near future.

⁵ This is a long-term plan.

Attachment 3 to Annex 1

Frequencies of interest to the radio astronomy service in the range 275-3 000 GHz

Recommendation ITU-R RA.314 contains a list of spectral lines of greatest interest to the radio astronomy service in the range 275-1 000 GHz, which is reproduced in full as Table 3.1 below. This list is expected to be updated in the next year by the International Astronomical Union.

TABLE 3.1

Radio-frequency lines of the greatest importance to radio astronomy at frequencies between 275 and 1 000 GHz (not allocated in the RR)

Substance	Rest frequency (GHz)	Suggested minimum band (GHz)	Notes ⁽¹⁾
Diazenylium (N ₂ H ⁺)	279.511	279.23-279.79	
Carbon monosulphide (CS)	293.912	292.93-294.21	
Hydronium (H ₃ O ⁺)	307.192	306.88-307.50	
Deuterated water (HDO)	313.75	313.44-314.06	
Carbon monoxide (C ¹⁸ O)	329.33	329.00-329.66	
Carbon monoxide (¹³ CO)	330.587	330.25-330.92	
Carbon monosulphide (CS)	342.883	342.54-343.23	
Carbon monoxide (CO)	345.796	345.45-346.14	
Hydrogen cyanide (HCN)	354.484	354.13-354.84	
Formylium (HCO ⁺)	356.734	356.37-357.09	
Oxygen (O ₂)	368.498	368.13-368.87	
Diazenylium (N ₂ H ⁺)	372.672	372.30-373.05	²
Water vapour (H ₂ O)	380.197	379.81-380.58	²
Hydronium (H ₃ O ⁺)	388.459	388.07-388.85	
Carbon monosulphide (CS)	391.847	390.54-392.24	
Oxygen (O ₂)	424.763	424.34-425.19	
Carbon monoxide (C ¹⁸ O)	439.088	438.64-439.53	
Carbon monoxide (¹³ CO)	440.765	440.32-441.21	
Carbon monoxide (CO)	461.041	460.57-461.51	
Deuterated water (HDO)	464.925	464.46-465.39	
Carbon (C)	492.162	491.66-492.66	
Deuterated water (HDO)	509.292	508.78-509.80	
Hydrogen cyanide (HCN)	531.716	529.94-532.25	²
Carbon monosulphide (CS)	538.689	536.89-539.23	²
Water vapour (H ₂ ¹⁸ O)	547.676	547.13-548.22	²
Carbon monoxide (¹³ CO)	550.926	549.09-551.48	²
Water vapour (H ₂ O)	556.936	556.37-557.50	²
Ammonia (¹⁵ NH ₃)	572.113	571.54-572.69	²
Ammonia (NH ₃)	572.498	571.92-573.07	²

TABLE 3.1 (continued)

Substance	Rest frequency (GHz)	Suggested minimum band (GHz)	Notes ⁽¹⁾
Carbon monoxide (CO)	576.268	574.35-576.84	²
Carbon monosulphide (CS)	587.616	587.03-588.20	²
Deuterated water (HDO)	599.927	599.33-600.53	²
Water vapour (H ₂ O)	620.7	620.08-621.32	²
Hydrogen chloride (HCl)	625.04	624.27-625.67	
Hydrogen chloride (HCl)	625.98	625.35-626.61	
Carbon monosulphide (CS)	636.532	634.41-637.17	
Carbon monoxide (¹³ CO)	661.067	658.86-661.73	
Carbon monoxide (CO)	691.473	690.78-692.17	
Oxygen (O ₂)	715.393	714.68-716.11	²
Carbon monosulphide (CS)	734.324	733.59-735.06	²
Water vapour (H ₂ O)	752.033	751.28-752.79	²
Oxygen (O ₂)	773.84	773.07-784.61	²
Hydrogen cyanide (HCN)	797.433	796.64-798.23	
Formylium (HCO ⁺)	802.653	801.85-803.85	
Carbon monoxide (CO)	806.652	805.85-807.46	
Carbon (C)	809.35	808.54-810.16	
Carbon monosulphide (CS)	832.057	829.28-832.89	
Oxygen (O ₂)	834.146	833.31-834.98	
Carbon monosulphide (CS)	880.899	877.96-881.78	
Water vapour (H ₂ O)	916.172	915.26-917.09	²
Carbon monoxide (CO)	921.8	918.72-922.72	²
Carbon monosulphide (CS)	929.723	926.62-930.65	
Water vapour (H ₂ O)	970.315	969.34-971.29	²
Carbon monosulphide (CS)	978.529	977.55-979.51	²
Water vapour (H ₂ O)	987.927	986.94-988.92	²

⁽¹⁾ The band limits are the Doppler-shifted frequencies corresponding to radial velocities of ± 300 km/s (consistent with line radiation occurring in our galaxy).

⁽²⁾ These lines are observable only outside the atmosphere.

In addition to spectral line frequency bands established in Recommendation ITU-R RA.314, the following spectral lines in the range 1 000-3 000 GHz (see Table 3.2) are also of interest to the radio astronomy community. Most of the spectral line data were obtained from the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland, United States of America, (<http://physics.nist.gov/PhysRefData/>). As in Table 3.1, the suggested minimum band is calculated from a Doppler shift of ± 300 km/s.

TABLE 3.2
**Radio-frequency lines of importance to radio astronomy in the
frequency range 1 000-3 000 GHz**

Substance	Rest frequency (GHz)	Suggested minimum band (GHz)
Carbon monoxide (CO)	1 036.912	1 035.88-1 037.95
Carbon monoxide (CO)	1 267.014	1 265.75-1 268.28
Trihydrogen ion (H ₂ D ⁺)	1 370.085	1 368.71-1 371.46
Carbon monoxide (CO)	1 381.995	1 380.61-1 383.38
Nitrogen ion (N ⁺)	1 461.132	1 459.67-1 462.59
Carbon monoxide (CO)	1 611.793	1 610.18-1 613.40
Water (H ₂ ¹⁸ O)	1 646.398	1 644.75-1 648.04
Oxonium hydride (H ₃ O ⁺)	1 655.834	1 654.18-1 657.49
Hydroxyl (OH)	1 834.747	1 832.91-1 836.58
Hydroxyl (OH)	1 837.816	1 835.98-1 839.65
Carbon monoxide (CO)	1 841.346	1 839.50-1 843.19
Carbon monoxide (CO)	1 956.018	1 954.06-1 957.97
Tricarbon (C ₃)	1 968.595	1 966.63-1 970.56
Carbon monoxide (¹³ CO)	1 979.726	1 977.75-1 981.71
Carbon monoxide (CO)	2 413.917	2 411.50-2 416.33
Nitrogen ion (N ⁺)	2 459.380	2 456.92-2 461.84
Hydrofluoric acid (HF)	2 463.428	2 460.96-2 465.89
Hydroxyl (OH)	2 509.948	2 507.44-2 512.46
Hydroxyl (OH)	2 514.316	2 511.80-2 516.83
Carbon monoxide (CO)	2 528.172	2 525.64-2 530.70
Oxonium hydride (H ₃ O ⁺)	2 972.100	2 969.13-2 975.07
Oxonium hydride (H ₃ O ⁺)	2 980.725	2 977.74-2 983.71