What is

Spectrum (Frequency) Management,

and

Why Should We Care?

A Tutorial from a NASA Office of Earth Science Perspective

C. Wende

Under Revision - August, 1998

This page intentionally left blank.

Preface

This opus is based on a briefing presented to the Program Planning and Development Division (Code YF) of the NASA Office of Earth Science (OES, Code Y) in September, 1996. The viewgraphs were condensed to save paper, and backup material was included. Some material was updated after the presentation, and other material was clarified and/or amplified. No attempt was made to rewrite the entire briefing into a consistent narrative format; hence, the lumpiness of the style is intentional but not malicious. Of particular usefulness are tables 2 and 3, which will be updated from time-to-time. The organization charts/flow charts have been reviewed by more authoritative people than myself, and have passed muster. The presentation was not intended to be complete, but was intended to present a reasonable overview of the field for someone with a NASA Office of Earth Science background. It was originally intended only for use within NASA; however, after other people expressed an interest in obtaining copies, this document was modified slightly to make it more germane to that audience. Nonetheless, it retains its space-oriented viewpoint - the omission of complimentary ground-based activity is due to ignorance by the author and not prejudice.

In early 1998, this document, in particular Table 2, was updated to reflect the results of the World Radiocommunications Conference-97.

C. Wende

This page intentionally left blank.

Table of Contents

1. Overview - - - - - - - - - 3

2. Bands available to OES (assigned to EESS) - - - - 6

3. Remote Sensing Bands Used (instruments, missions) - - - 16

4. Vulnerabilities - - - - - - - - - 20

5. Mechanism for Change (Process, Organizations, Schedule) - - 21

6. Parallel Efforts and Support - - - - - - - 26

7. Open Issues of the Day - - - - - - - 27

8. Appendices/Backup Material - - - - - - 31

   A. Atmospheric Absorption versus Frequency
      (per km and through atmosphere).
   B. Map of ITU Regions.
   C. Entire ITU-R Study Group Structure (Diagram and Table).
   D. Summary of WRC-97 Results from an Office of Earth Science Viewpoint
   E. NTIA Licensing Stages.
   F. Glossary of Instruments and Spacecraft

This page intentionally left blank.

1. **Overview**

What is spectrum management?

- The coordinated usage of the entire electromagnetic radiation spectrum.

Frequency Range covered: freq.< 9 KHz to 400 GHz<freq.
(near D.C. to the near-IR)

Geographical Regions covered: National,
International,
Interplanetary (?), ...

Organization for Control:

National -	NTIA and FCC.
International -	The International Telecommunications Union (ITU) headquartered in Geneva
Interplanetary -	TBD

Mechanism for Control:

- World Radiocommunications Conferences (WRCs) held by the ITU every 2 years (now) with set agendas, and

- Voluntary compliance internationally.

Level of Control/Definition:

- Final Acts of WRC's have treaty-level status (President signs the treaty with advice/consent of Senate).

- These Acts trickle into the U.S. Radio Regulations.

Governing agencies in the U.S.A.:

- NASA answers via the National Telecommunications and Information Agency (NTIA), and

- Non-governmental parties answer through the Federal Communications Commission (FCC).

Frequency Bands are allocated to specific services:

Earth Exploration Science Service (EESS, or us),

Space Research, Radio Astronomy,

Fixed (point-to-point) Service, etc.

Rarely are bands uniquely assigned to any one service:

- Sharing and determining the parameters that allow sharing are crucial to obtaining and maintaining band allocations.

- Intelligent compromise is the essence of existence.

Services are given allocations in each band:

- Primary - Equal rights/privileges with all other primary users in the band. Must coordinate with other primary users when interference exists. Newcomers must coordinate with all known band users.

- Secondary - Operate on a non-interference basis with (to) primary users, and without protection from harmful interference caused by primary users.

Footnotes to the regulations are used for minor additions and exceptions, and frequently are country-specific.

Allocations are often assigned by geographical region:

- Region 1: Europe, Africa, and Northern Asia

- Region 2: North and South America

- Region 3: Southeast Asia and the Southern Pacific

Acceptable interference levels have been recommended by the International Telecommunications union - Radiocommunications Sector (ITU-R). These recommendations are not formally in the Radio Regulations, although they are usually treated that way internationally. These pragmatic levels are not always appreciated:

- 5% for randomly occurring interference (not always at the same location); and

- 1% for interference at the same location which precludes observations there forever.

Transmitters are licensed; receivers are registered:

- To protect the “owner” by notifying others of his/her existence.

- To ensure proper coordination can be done.

N.B.: Coordination mechanisms exist, are documented, and do work; they can be expensive to implement.

Why should we care?

If we violate the radio regulations and cause harm or harmful interference, we can be sued!

If we produce obnoxious and potentially damaging signals, our license may include severe restrictions regarding when and where we may operate.

Conversely, without the proper level of protection, others can interfere with us to the point where our instruments are useless and operations difficult or irrelevant, and we have no recourse or remedy.

In practical terms:

If our SARs, scatterometers, radar altimeters, etc. or X-band transmitters cause anybody a problem today, we must coordinate our operations with the affected parties. Now we have a primary allocation for most of the active sensor bands and for X-band usage in most of the world; formerly, we had no choice but to turn off in favor of primary users in those bands. If we caused others damage and we were not within the letter of the law, we could be sued as well.

Further, our remote sensing instruments are very sensitive to interference and the quality of our data depends upon sensing a clean environment. Acceptable levels of interference have been defined, although not every remote sensing scientist likes them. However, they provide a more-or-less quantifiable means for peaceful coexistence.

Two principal areas of concern for Office of Earth Science (OES)

Remote sensing bands used by our scientific instruments, both:

- active (e.g., SARs, altimeters, scatterometers) and
- passive (radiometers); and

Communications bands used by our spacecraft, including:

- Tracking, Telemetry (downlinked data sometimes called housekeeping data), and Control (uplinking commands to the S/C), collectively called TT&C, and
- Downlinking science data.

2. Bands Available to OES between 0.1 and 400 GHz (Part 1 of 6)

Band	Low	High	OES Instruments Affected	Allocation	PRIMARY Services in the Band	Notes and References
P	0.137	0.138	*NOAA*	S-E	SPACE OPS, METSAT, SPACE RES	Obsolete
P	0.400	0.401	*NOAA*	S-E	METSAT, METAID, SPACE RES, MOBSAT	NOAA
P	0.401	0.402	**DORIS**	**E-S**	METAIDS, SPACE OPS(S-E)	{Upgraded at WRC-97}
P	0.402	0.403	*TT&C, old*	**E-S**	METAIDS	{Upgraded at WRC-97}
P	0.403	0.406	***NOAA***	**radiosonde**	METAIDS	NOAA
P	0.410	0.420	Manned Program	**EVA COMM.**	FXD, MOB	{Upgraded at WRC-97}
P	0.430	0.440	***PROPOSED SAR***	*ACTIVE?*	RADIOLOC., AMATEUR	{Deferred to WRC-99?}; Geology under vegetation
P	0.460	0.470	NOAA	*s-e*	FXD, MOB	NOAA
L	1.215	1.300	SAR(JERS-1 & SICH), SIR-C, TRAV. SAR, VSAR, [GPS]	**ACTIVE**	RADIOLOC., RADIONAV-S/C	Wave structure, geology GPS temporary L2 @ 1.228
L	1.370	1.400		passive	FXD, MOB, RADIOLOC.	Footnote 720; Salinity, soil moisture
L	1.400	1.427	MIRAS, (HYDROSTAR?, HYDROSAT?)	**PASSIVE**	RADIO AST., SPC RES.	Hydrogen line, salinity, soil moisture
L	1.427	1.429		**E-S**	FXD, MOB, SPC OPS	
L	1.525	1.535		s-e	FXD, MARITIME-SAT., MOB	
L	1.559	1.610	GPS	**RADIONAV-S/C S-E**	AERO-NAV	Want S-S in WRC-99 GPS L1 @ 1.575
L	1.661	1.668		**PASSIVE**	RADIO AST.	
L	1.668	1.670	NOAA	**radiosonde**	MET AIDS, FXD, MOB, RADIO AST	**NOAA - radiosondes**
L	1.670	1.710	NOAA	**S-E**	FXD, MET AIDS, METSATS (S-E), MOB	**NOAA**

2. Bands Available to OES between 0.1 and 400 GHz (Part 2 of 6)

Band	Low	High	OES Instruments Affected	Allocation	PRIMARY Services in the Band	Notes and References
S	2.025	2.110	Most TT&C, command links, incl. via TDRSS; DORIS	**E-S,S-S**	FXD, MOB, SPC OPS {High density MOB excluded at WRC-97}	Footnotes US90, US111, US219, US222, NG23, NG118
S	2.110	2.120	Deep Space, TT&C	**E-S**	FXD, MOB	
S	2.200	2.290	Most TT&C, return links, incl. via TDRSS	**S-S,S-E**	FXD, MOB, SPC OPS {High density MOB excluded at WRC-97}	
S	2.290	2.300	Deep Space, TT&C	**S-E**	FXD, MOB	Footnotes US303, 750A
S	2.640	2.655		passive	FXD, FXDSAT(S-E), MOB, BRDCST SAT	Footnote 720
S	2.655	2.670		passive	FXD, MOB, MOBSAT	Footnotes 765, 766, US269
S	2.670	2.690		**PASSIVE**	RADIO AST., SPC RES(PASS.)	Salinity, soil moisture
S	2.690	2.700		**PASSIVE**	RADIO AST., SPC RES(PASS.)	Footnotes 767, 768, 769; Salinity, soil moisture
S	3.100	3.300	***RA-2, SAR-10, TRAV. SAR***	active	RADIOLOC.	Geology {Upgraded to secondary at WRC-97}
C	4.200	4.400		passive	AERO.RADIONAV.	Footnote 789, Sea surface temperature
C	4.900	5.000	**R-600**	passive	FXD, MOB, RAD AST.	Footnote 720, Estuarine temperature
C	5.250	5.350	ALT, AMI, ASAR, ASCAT, IKAR, SAR(RADARSAT), SSALT, SIR-C	**ACTIVE**	RADIOLOC.	Soil Moisture {Upgraded at WRC-97}
C	5.350	5.460	RADARSAT-2?	**ACTIVE**	AERO.RADIONAV.	{Allocated at WRC-97}
C	6.425	7.075	**AMSR, AMSR-E, MIMR, MZOAS?, SMR?**	passive	FXD, FXDSAT(E-S), MOB	Footnote 809 - not even secondary - over oceans

2. Bands Available to OES between 0.1 and 400 GHz (Part 3 of 6)

Band	Low	High	OES Instruments Affected	Allocation	PRIMARY Services in the Band	Notes and References
C	7.075	7.250	**DELTA-2**	passive	FXD, FXDSAT(E-S), MOB	Footnote 809
C	7.145	7.235		**E-S**	FXD, MOB	**Footnote 811**
C	7.450	7.550	GSO MetSATs; R-400	**S-E**	METSAT(S-E), FXD, FXDSAT(S-E), MOBSAT(S-E)	**{Reallocated at WRC-97}**
C	7.750	7.850	NGSO MetSATs	**S-E**	FXD, MOB	(Allocated at WRC-97}
X	8.025	8.400	OES data downlinks SARs, ETM,...	**S-E**	FXD, FXDSAT(E-S), MOB. MET SAT(E-S)	{Upgraded to worldwide primary at WRC-97}
X	8.400	8.450	Deep Space Missions	**DSN S-E**	FXD, MOB, SPC RES(S-E)	Difficult out-of-band emission limits, also used by radio astronomers
X	8.550	8.650	SAR-3, SLR-3	**ACTIVE**	RADIOLOC.	Rain, wave structure {Upgraded at WRC-97}
X	9.500	9.800	RLSBO	**ACTIVE**	RADIOLOC., RADIONAV.	Rain, wave structure {Upgraded at WRC-97}
X	9.975	10.025	NOAA MetSAT radar	active	RADIOLOC.	Footnote 828
X	10.60	10.70	AMSR, AMSR-E, MIMR. MZOAS, SMR, TMI	**PASSIVE**	FXD, MOB, RADIO AST, SPC RES(PASS.)	Rain, snow, lake ice, sea state
Ku	13.25	13.40	Appended to 13.40 - 13.75 GHz	**ACTIVE**	AERO.RADIONAV.	{Allocated at WRC-97}
Ku	13.40	13.75	ALT, DELTA-2, IKAR, OKEAN-O, QuikSCAT, SeaWinds, SSALT	**ACTIVE**	RADIOLOC.	Wind, ice, geoid {Upgraded at WRC-97}
Ku	13.75	14.00	**NSCAT, PR, RA, RA-2,**	e-s, active	FXD, RADIOLOC.	Footnote 713, Wind, ice, geoid
Ku	13.75	14.00	TDRSS	**E-S**		TDRSS
Ku	15.20	15.35		passive	FXD, MOB	Footnote 720
Ku	15.35	15.40		**PASSIVE**	RADIO AST., SPC RES.(PASS.)	Water vapor, rain

2. Bands Available to OES between 0.1 and 400 GHz (Part 4 of 6)

Band	Low	High	OES Instruments Affected	Allocation	PRIMARY Services in the Band	Notes and References
Ku	17.20	17.30		**ACTIVE**	RADIOLOC.	Vegetation, snow
K	18.60	18.80	AMR, AMSR, AMSR-E, MIMR, MZOAS, SMR, TMR	**PASSIVE**	FXD, FXDSAT(S-E), MOB	Primary Region 2 only! Rain, sea state, ocean ice, water vapor {Deferred to WRC-99}
K	21.20	21.40	AMR, MIVZA, MTZA, TMI, TMR	**PASSIVE**	FXD, MOB, SPC RES(PASS.)	Water vapor, liquid
K	22.21	22.50	AMSU, DELTA-2, IKAR, MZOAS, SMR?	**PASSIVE**	FXD, MOB, RADIO AST, SPC RES(PASS.)	Water vapor, liquid
K	22.55	23.55	TDRSS to/from OES S/C	**S-S**	FXD, INTER-SAT, MOB	
K	23.60	24.00	AMR, AMSR, AMSR-E, AMSU-A, ATSR-2, MIMR, MSR, MWR	**PASSIVE**	RADIO AST., SPC RES(PASS.)	Water vapor, liquid
K	24.05	24.25		active	RADIOLOC.	Water vapor, liquid
Ka	25.25	25.50		s-s	FXD, INTER-SAT., MOB	
Ka	25.50	27.00	Wideband downlink	**S-E**	FXD, INTER-SAT., MOB	{Upgraded at WRC-97}
Ka	27.00	27.50		s-s	FXD, INTER-SAT., MOB	
Ka	28.50	30.00		e-s	FXD, FXD-SAT., MOB	
Ka	31.30	31.80	AMSU-A, MSR	**PASSIVE**	RADIO AST., SPC RES(PASS.)	Ocean ice, oil spills, clouds, water vapor/liquid
Ka	35.50	36.00		**ACTIVE**	MET.AIDS, RADIOLOC.	Snow {Upgraded at WRC-97}
Ka	36.00	37.00	AMR, AMSR,AMSR-E, ATSR-2, DELTA-2, IKAR, MIMR, MIVZA, MTZA, MWR, MZOAS, SMR, TMI, TMR	**PASSIVE**	FXD, MOB, SPC RES(PASS.)	Rain, snow, ocean ice, oil spills, clouds
Ka	37.50	40.00	RM-0,8	s-e	FXD, FXD-SAT., MOB,SPC RES(S-E)	

2. Bands Available to OES between 0.1 and 400 GHz (Part 5 of 6)

Band	Low	High	OES Instruments Affected	Allocation	PRIMARY Services in the Band	Notes and References
	40.00	40.50		**E-S**	FXD, FXD-SAT., MOB,SPC RES(E-S)	
	50.20	50.40	AMSR, AMSU-A, MSU	**PASSIVE**	{FXD to be deleted?}, MOB, SPC RES(PASS.)	O(Temperature) {WRC-97 proposal}
	51.40	52.60	MTZA	**PASSIVE {to be deleted?}**	SPC RES(PASS.)	O(Temperature) {WRC-97 proposal}
	52.60	54.25	AMSR, AMSU-A(2), MSU, MTZA	**PASSIVE**	SPC RES(PASS.)	O(Temperature)
	54.25	55.78	AMSU-A(3), MSU, MTZA	**PASSIVE**	{FXD to be deleted?}, {GSO INTER-SAT only?}, MOB, SPC RES(PASS.)	O(Temperature) {WRC-97 proposal}
	55.78	58.20	AMSU-A, MSU, MTZA	**PASSIVE**	FXD, {GSO INTER-SAT only, except 56.9-57.0 GHz), MOB, SPC RES(PASS.)	O(Temperature) {WRC-97 proposal}
	58.20	59.30	MTZA	**PASSIVE**	SPC RES(PASS.), {add FXD and MOB, sharing possible?}	O(Temperature) {WRC-97 proposal}
	64.00	65.00	MLS(UARS)	**PASSIVE**	SPC RES(PASS.)	O(Temperature)
	65.00	66.00		**S-E**	SPC RES	Downlink band
	78.00	79.00	CLOUD RADAR	**ACTIVE**	SPC RES(ACT.), RADIOLOC.	Footnote 912, Cloud monitoring.
	86.00	92.00	AMSR, AMSR-E, AMSU-A,-B, MHS, MIMR, MIVZA, MTZA, MZOAS, SMR, TMI	**PASSIVE**	RADIO AST., SPC RES(PASS.)	Clouds, oil spills, ice, snow
	94.0	94.1	Cloud Radar	**ACTIVE**	FXD, FXD-SAT, MOB, RADIOLOC.	{Allocated at WRC-97 for spaceborne cloud radars}
	100.0	102.0	IKAR	**PASSIVE**	FXD, MOB, SPC RES(PASS.)	NO@100.49
	105.0	116.0		**PASSIVE**	RADIO AST., SPC RES(PASS.)	O3@110.8, CO@115.27
	116.0	126.0	RADIOMETER (ODIN)	**PASSIVE**	FXD, INTER-SAT, MOB, SPC RES(PASS.)	O(Temperature)@118.8, NO@125.61
	150.0	151.0	AMSU-B, MHS	**PASSIVE**	FXD, FXDSAT(S-E), MOB, SPC RES(PASS.)	NO@150.74

2. Bands Available to OES between 0.1 and 400 GHz (Part 6 of 6)

Band	Low	High	OES Instruments Affected	Allocation	PRIMARY Services in the Band	Notes and References
	156.0	158.0		**PASSIVE**	FXD, FXD-SAT(S-E), MOB	
	164.0	168.0	MHS	**PASSIVE**	RADIO AST, SPC RES(PASS.)	ClO@164.38, 167.2
	174.5	176.5		**PASSIVE**	FXD, INTER-SAT, MOB, SPC RES(PASS.)	NO@175.86
	182.0	185.0	AMSU-B(3), MHS, MLS (UARS)	**PASSIVE**	RADIO AST., SPC RES(PASS.)	Water Vapor@183.31, O3@184.75
	200.0	202.0	MLS(UARS), MASTER	**PASSIVE**	FXD, MOB, SPC RES(PASS.)	NO@200.98
	217.0	231.0	MLS	**PASSIVE**	RADIO AST., SPC RES(PASS.)	NO@226.09, CO@230.54
	235.0	238.0		**PASSIVE**	FXD, FXDSAT(S-E), MOB, SPC RES(PASS.)	O3@235.71, 237.15
	250.0	252.0		**PASSIVE**	SPC RES(PASS.)	NO@251.21
	275.0	277.0		**(PASSIVE)**	UNDEFINED	Footnote 927, NO@276.33
	300.0	302.0	MLS, MASTER	**(PASSIVE)**	UNDEFINED	Footnote 927, NO@301.44
	324.0	326.0	MASTER	**(PASSIVE)**	UNDEFINED	Footnote 927, Water Vapor@325.1
	345.0	347.0	MASTER	**(PASSIVE)**	UNDEFINED, (RADIO AST.)	Footnote 927, CO@345.8
	363.0	365.0		**(PASSIVE)**	UNDEFINED	Footnote 927, O3@364.32
	379.0	381.0		**(PASSIVE)**	UNDEFINED	Footnote 927, Water Vapor@380.2

NOTES:

Band: The letter used to identify a particular frequency band**.**

Low: The lower edge of the band, in GHz.

High: The high edge of the band, in GHz

OES Instruments affected: Instruments of interest to OES using a particular band. Beware - BOLDED instruments have only a secondary allocation!

Allocation: Primary allocations (see below) are **BOLDED UPPER CASE**; secondary allocations are in lower case.

PRIMARY services in the Band: If we are also primary in the band, these services are equal users; if we are only secondary - or worse yet, just footnoted - we are at their mercy and good will.

Notes and References: Indicates which footnote applies (if any, see below), any absorption bands and areas of scientific interest to OES.

2. Bands Available to OES between 0.1 and 400 GHz (continued)

DEFINITIONS:

ACTIVE: A service using a transmitter, such as synthetic aperture radars, radar altimeters, scatterometers, etc.

(E-S) - Earth to Space: what we call an uplink, or forward link communications.

Earth Exploration Satellite Service: The OES label, plus meteorological services.

Footnotes: Additions to the allocation tables, may indicate primary or secondary allocations or just serve to notify potential users of current unprotected band users. Also used to indicate country-specific allocations. These provide the weakest form of protection in that they have been ignored in the past.

FXD - Fixed Service: point-to-point service, generally both points are on the ground.

FXDSAT - Fixed Satellite Service: A fixed service between fixed points on earth via a satellite.

INTER-SAT - Inter-satellite service: Service between two satellites, such as EOS AM-1 and TDRSS.

METSAT - Meteorological Satellite Service: Earth exploration satellite service for meteorological purposes.

METAIDS - Meteorological aids: A service for meteorological purposes, such as radiosondes.

MOB - Mobile Service: a radiocommunications service between mobile and land stations, or between two mobile stations.

PASSIVE: A service receiving only, such a radiometer.

PRIMARY (**UPPER CASE**): Primary services have equal rights to use a specified band, and are protected from secondary and other users.

2. Bands Available to OES between 0.1 and 400 GHz (continued)

DEFINITIONS (continued):

RADIO AST. - Radio Astronomy: Radio astronomy service, all passive allocations.

RADIOLOC. - Radiolocation: Radiodetermination used for other than navigation purposes.(e.g., Radars)

RADIONAV - Radionavigation Service: Radiodetermination used for navigation, including obstruction warning (e.g., Beacons).

Regions: Region 1 is Europe, Africa, and northern Asia;
Region 2 is the Americas; and,
Region 3 is Southeast Asia and the southern Pacific.

(S-E) - Space to Earth: What we call downlink or return link communications.

Secondary (lower case in table): Secondary services are on a non-interference basis to primary or permitted services, and cannot claim protection from harmful interference caused by primary/permitted users.

SPC OPS - Space Operations service: A radiocommunication service concerned exclusively with the operation of spacecraft, in particular, tracking, telemetry, and command operations.

SPC RES - Space Research service: A radiocommunications service in which spacecraft or other objects in space are used for scientific or technological research purposes.

SPC RES(PASS.): Same as space research service, only passive use (no transmitting)

TIME/FREQ - Time and/or Frequency service: Provides a time and/or frequency standard.

This page intentionally left blank.

3. Remote Sensing Bands Used by OES Instruments (1 of 4)

INSTR.	MISSION	CNTRY	1.25	1.4	1.67	2.65	3.2	4.3	4.9	5.3	6.7	7.15	8.6	9.65	10.65	13.6	13.8	15.3	15.4	17.25	18.7	21.3	22.3	23.8	24.1	31.5	35.55	36.5	38	50.3
ALT	TOPEX/ POSEIDON	USA/ FRANCE								X						X														
AMI	ERS-1, -2	ESA								X																				
AMR	EOS-ALTR	USA																			X	X		X				X		
AMSR	ADEOS-2	JAPAN									X				X						X			X				X		X
AMSR-E(J)	EOS-PM	USA									X				X						X			X				X		
AMSU	EOS-PM	USA																					X	X		X				X
AMSU-A	NOAA K+ METOP1	USA ESA																						X		X				X
AMSU-B	NOAA-K+	USA																												
ASAR	ENVISAT	ESA								X																				
ASCAT	METOP	ESA								X																				
ATSR, -2	ERS-1, -2	ESA																						X				X		
CLOUD RADAR	FUTURE	ESA																												
DELTA-2	OKEAN	CSR										X				?							X					X		
Radiometer	HYDROSAT	USA		X																										
IKAR	PRIRODA	CSR								X						X							X					X		
MASTER	FUTURE	ESA																												
MHS	EOS-PM NOAA-N METOP	USA USA ESA																												
MIMR	METOP	ESA									X				X						X			X				X		
MIRAS	MIRAS	ESA		X																										
MIVZA	METEOR	CSR																				?						X		
MLS	EOS-CHEM	USA																												
MLS	UARS	USA																												
MSR	MOS-1B	JAPAN																						X		X				
MSU	NOAA-9-14	USA																												X
MTZA	METEOR	CSR																				?						X		X
MWR	ENVISAT	ESA																						X				X		

3. Remote Sensing Bands Used by OES Instruments (2 of 4)

INSTR.	MISSION	CNTRY	50.3	55	64.5	65.5	78.5	89.	94	101	110	121	150.5	157	166	175.5	183	201	224	236	251	276	301	325	346	364	380	>400
ALT	TOPEX/ POSEIDON	USA/ FRANCE																										
AMI	ERS-1, -2	ESA																										
AMR	EOS-ALTR	USA																										
AMSR	ADEOS-2	JAPAN	X	X				X																				
AMSR-E(J)	EOS-PM	USA						X																				
AMSU	EOS-PM	USA	X	12				2									4											
AMSU-A	NOAA K+, METOP1	USA ESA	X	X				X																				
AMSU-B	NOAA-K+	USA						X						X			3											
ASAR	ENVISAT	ESA																										
ASCAT	METOP	ESA																										
ATSR, -2	ERS-1, -2	ESA																										
CLOUD RADAR	ESA FUT.	ESA					?		X																			
DELTA-2	OKEAN	CSR																										
Radiometer	HYDROSAT	USA																										
IKAR	PRIRODA	CSR								X																		
MASTER	FUTURE	ESA																X					X	X	X			
MHS	EOS-PM NOAA-N METOP	USA USA ESA						X					X		X		3											
MIMR	METOP	ESA						X																				
MIRAS	MIRAS	ESA																										
MIVZA	METEOR	CSR						5																				
MLS	EOS-CHEM	USA																	X				X					2
MLS	UARS	USA			X												X	X										
MSR	MOS-1B	JAPAN																										
MSU	NOAA-9-14	USA	X	3																								
MTZA	METEOR	CSR	X	6				?																				
MWR	ENVISAT	ESA																										

3. Remote Sensing Bands Used by OES Instruments (3 of 4)

INSTR.	MISSION	CNTRY	1.25	1.4	1.67	2.65	3.2	4.3	4.9	5.3	6.7	7.15	8.6	9.65	10.65	13.6	13.8	15.3	15.4	17.25	18.7	21.3	22.3	23.8	24.1	31.5	35.55	36.5	38	50.3
MZOAS	METEOR	CSR									?				?						?		?					?		
NSCAT(US)	ADEOS	JAPAN															X													
PR	TRMM	JAPAN															2													
QuikSCAT	QuikSCAT	USA														X														
R-225	OKEAN-O	CSR														?														
R-400	PRIRODA	CSR										?																		
R-600	OKEAN-O	CSR							X																					
RA	ERS-1,-2	ESA															X													
RA-2	ENVISAT	ESA					X										X													
RADIOMTR	ODIN	SWEDEN																												
RLSBO	OKEAN-O, SICH-1	CSR												X																
RM-0.8	SICH	CSR																											X	
SAR	RADARSAT	CANADA								X																				
SAR	JERS-1	JAPAN	X																											
SAR	SICH	CSR	X																											
SAR-10	ALMAZ	CSR					X																							
SAR-3	ALMAZ	CSR											X																	
SAR-70	ALMAZX	CSR																												
SIRC/XSAR	Shuttle	USA	X							X				X																
SMR	SICH	CSR									?				?						?		?					?		
SEAWINDS (USA)	ADEOS-2	JAPAN														X														
SLR-3	ALMAZX	CSR											X																	
SOPRANO	FUTURE	ESA																												
SSALT	TPX/POS, JASON	USA, FRANCE								X						X														
TMI (USA)	TRMM	JAPAN													X							X						X		
TMR	TPX/POS, JASON	USA, FRANCE																			X	X						X		
TRVRS SAR	PRIRODA	CSR	X				X																							
VSAR	ALOS	JAPAN	X																											

3. Remote Sensing Bands Used by OES Instruments (4 of 4)

INSTR.	MISSION	CNTRY	50.3	55	64.5	65.5	78.5	89	94	101	110	121	150.5	157	166	175.5	183	201	224	236	251	276	301	325	346	364	380	>400
MZOAS	METEOR	CSR						10																				
NSCAT(US)	ADEOS	JAPAN																										
PR	TRMM	JAPAN																										
QuikSCAT	QuikSCAT	USA																										
R-225	OKEAN-O	CSR																										
R-400	PRIRODA	CSR																										
R-600	OKEAN-O	CSR																										
RA	ERS-1,-2	ESA																										
RA-2	ENVISAT	ESA																										
RADIOMTR	ODIN	SWEDEN										X																2
RLSBO	OKEAN-O, SICH-1	CSR																										
RM-0.8	SICH	CSR																										
SAR	RADARSAT	CANADA																										
SAR	JERS-1	JAPAN																										
SAR	SICH	CSR																										
SAR-10	ALMAZ	CSR																										
SAR-3	ALMAZ	CSR																										
SAR-70	ALMAZX	CSR																										
SIRC/XSAR	Shuttle	USA																										
SMR	SICH	CSR						X																				
SEAWINDS (USA)	ADEOS-2	JAPAN																										
SLR-3	ALMAZX	CSR																										
SOPRANO	FUTURE	ESA																										4
SSALT	TPX/POS, JASON	USA/FR USA/FR																										
TMI (USA)	TRMM	JAPAN						X																				
TMR	TPX/POS, JASON	USA/FR USA/FR																										
TRVRS SAR	PRIRODA	CSR																										
VSAR	ALOS	JAPAN																										

4. Vulnerabilities (January, 1998)

Remote Sensing Bands:

One remote sensing band is being challenged by possibly incompatible users:

- Passive band at 18.6 - 18.8 GHz;
- U.S. National WP-7C providing technical bases for our defense/protection.

The allocation of remote sensing bands above 71 GHz is a topic for WRC-99 discussion and revision; technical studies are underway.

Communications/Navigation Bands:

The EESS-desired communications bands of 8025-8400 MHz and 25.5-27.0 GHz secured primary protection worldwide at WRC-97.

- U.S. National WP-7C provided technical bases for upgrading the allocations.

A proposal at WRC-97challenged the protection given to one of the Global Positioning System frequencies. This protection must be defended at WRC-99.

Licensing:

NASA's EOS AM-1 spacecraft has proceeded through the Stage 4 (Operational) review by the Spectrum Planning Subcommittee of the NTIA. But, operating limits may still be imposed by the NTIA's Frequency Assignment Subcommittee:

- DoD has uplinks in our 8025-8400 MHz downlink band and may insist on coordinating with all ground stations, including Direct Broadcast users.
- The Deep Space Network operates in an adjacent band and is extremely sensitive to out-of-band emissions. The EOS AM-1 spacecraft is noisy in this regard and will require coordination of operations to avoid problems. Radio astronomers may also be affected.

Careful design of subsequent EOS spacecraft, employing available technology, should remove the need for operational coordination, which tends to be expensive.

NOTE: NTIA has a 4-stage review process that begins with the concept of the system (phase A) - see Appendix D.

4. Vulnerabilities (September, 1996)

Operational Concerns:

Potential interference caused by EOS AM-1 Direct Broadcast may require:

- coordination with the Deep Space Network (internal to NASA), and
- coordination with the radio astronomers (external to NASA, but if DSN limits are met, radio astronomy is OK).

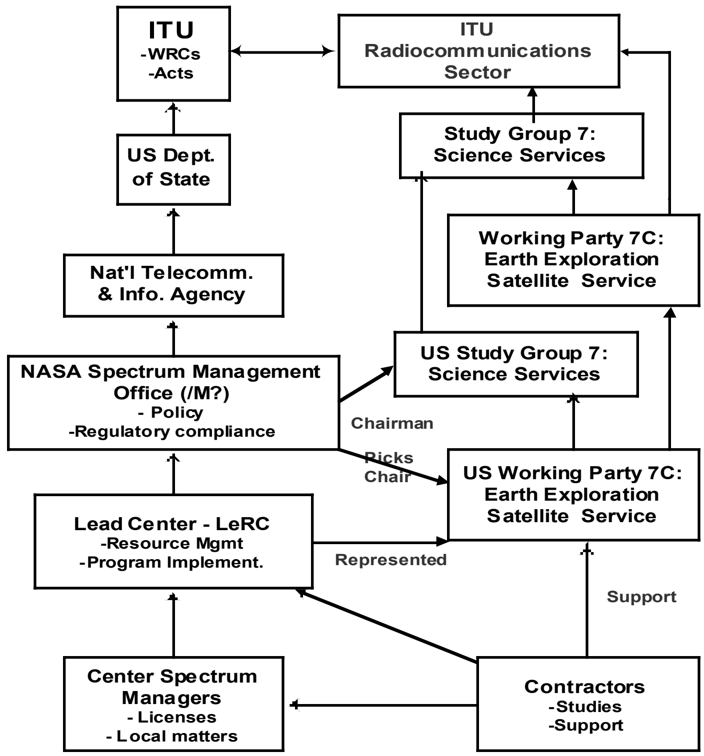
Potential interference caused by EOS Direct Broadcast and/or direct downlinking of wideband, high-rate data may require:

- Coordination with other EESS users of the band, including the new commercial sector. However the scale of this contention problem is TBD.

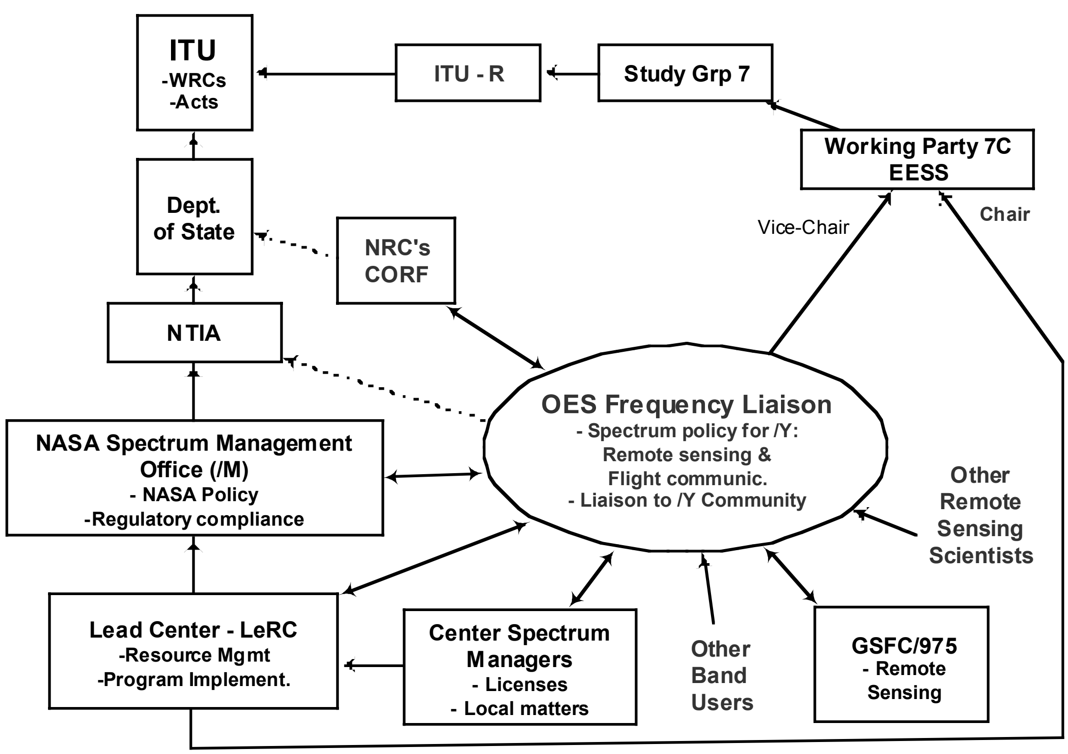
---

5. Mechanism for Change

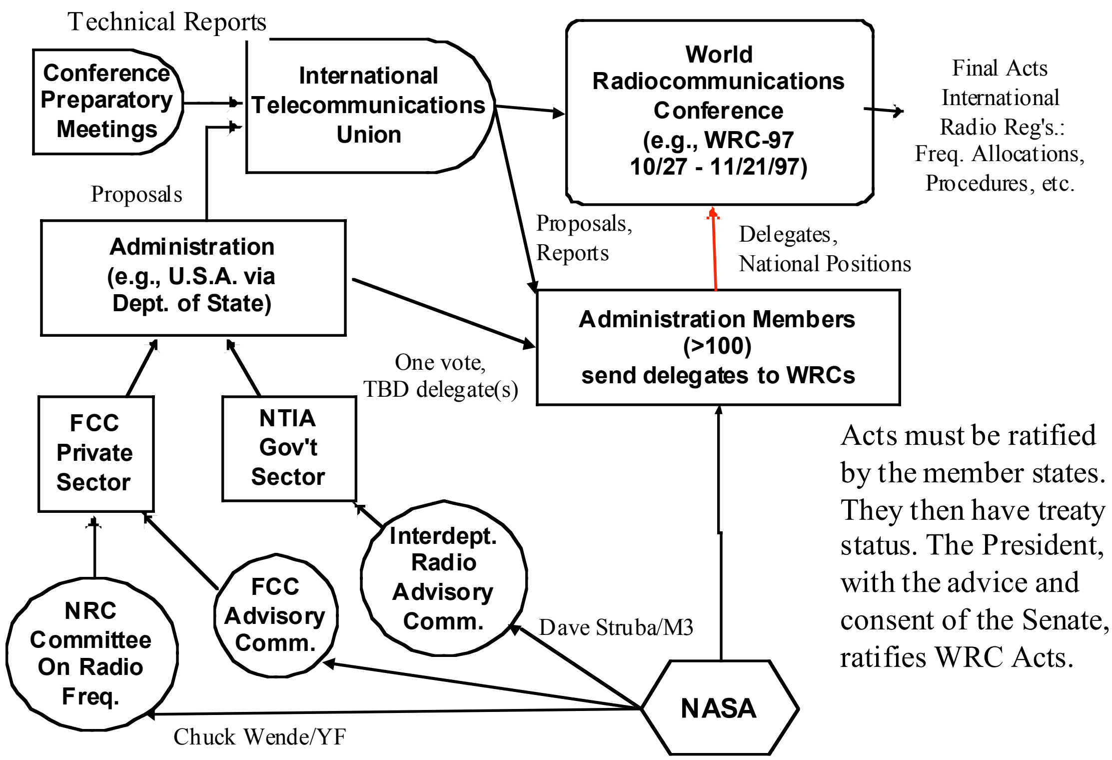
The mechanisms for changing the Radio Regulations are illustrated in the following set of flow charts and organization charts, culminating in a table that presents the schedule of the events. Figure 5a and 5b show the spectrum management structure from a NASA perspective (5a) and how OES (Code Y) interacts with the system (5b). Figures 5c and 5d show the political flow (how proposed changes are processed) and the technical flow (how the technical backup required to demonstrate the validity of the proposed changes is entered). Figures 5e through 5h simply illustrate the structure of the ITU, per se. Finally, the schedule that drives all of the above is given as figure 5I. In addition, the NASA-ESA Coordinating Meetings and meetings of the Space Frequency Coordinating Group are also shown. These groups, while informal and not a part of the ITU, serve as a means for the space-faring nations to discuss common problems and to align their activities for the common good.



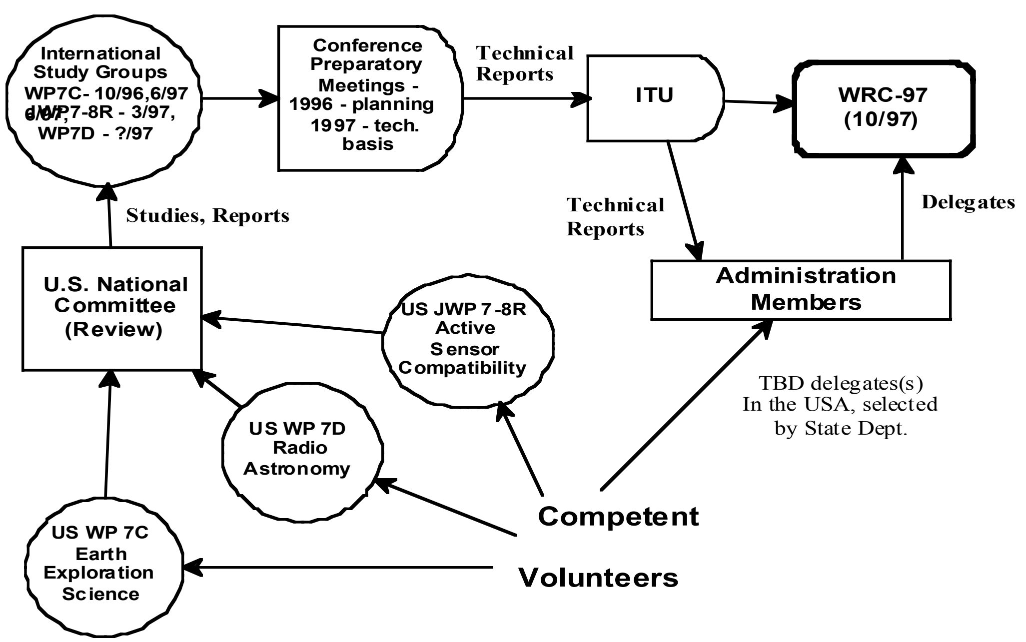
5a. NASA Line Management of Spectrum Matters



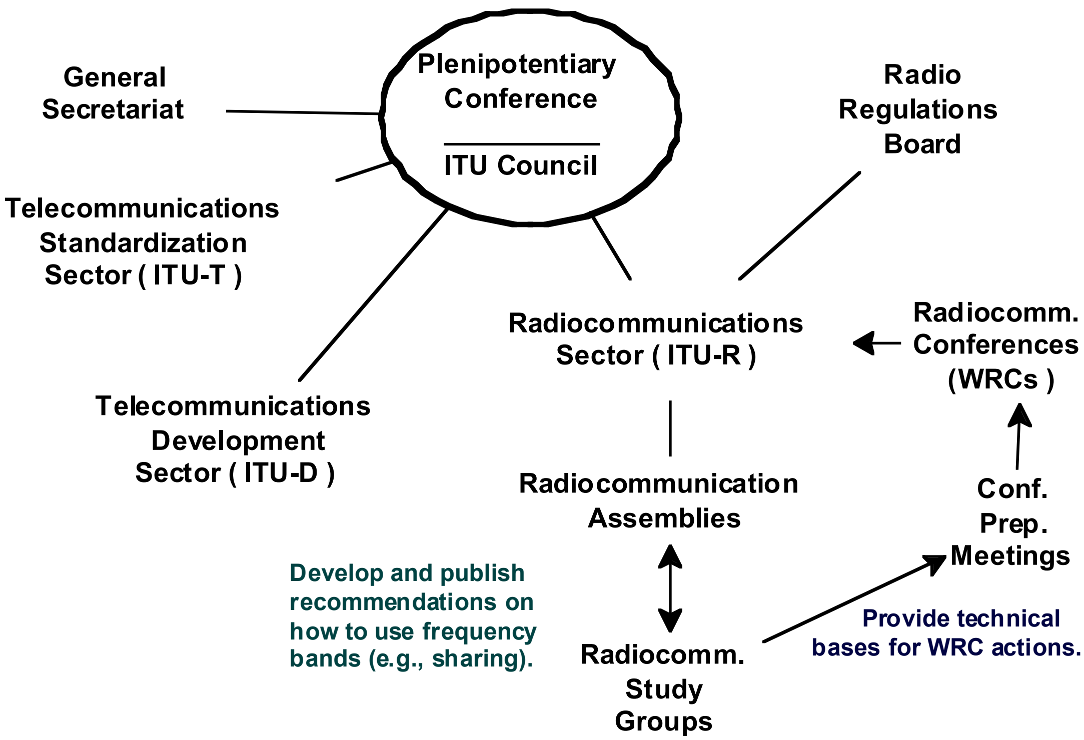
5b. NASA OES Spectrum Management Interfaces



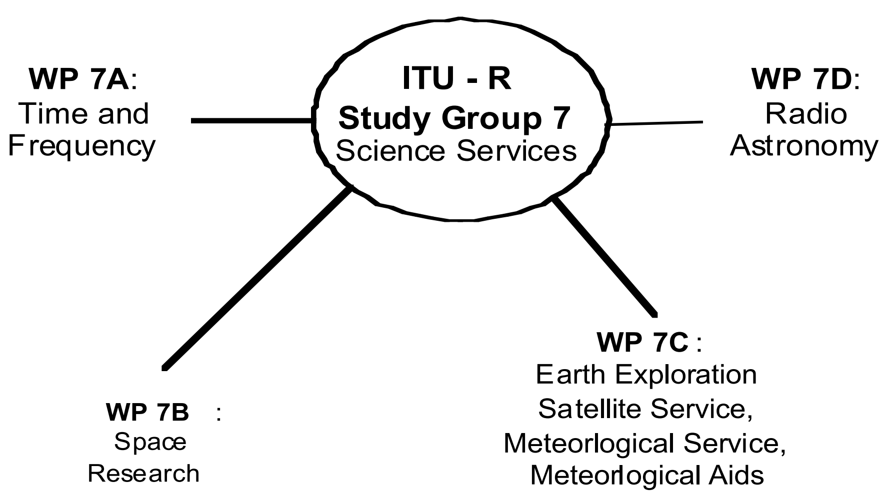
5c. Political Flow into World Radiocommunication Conferences



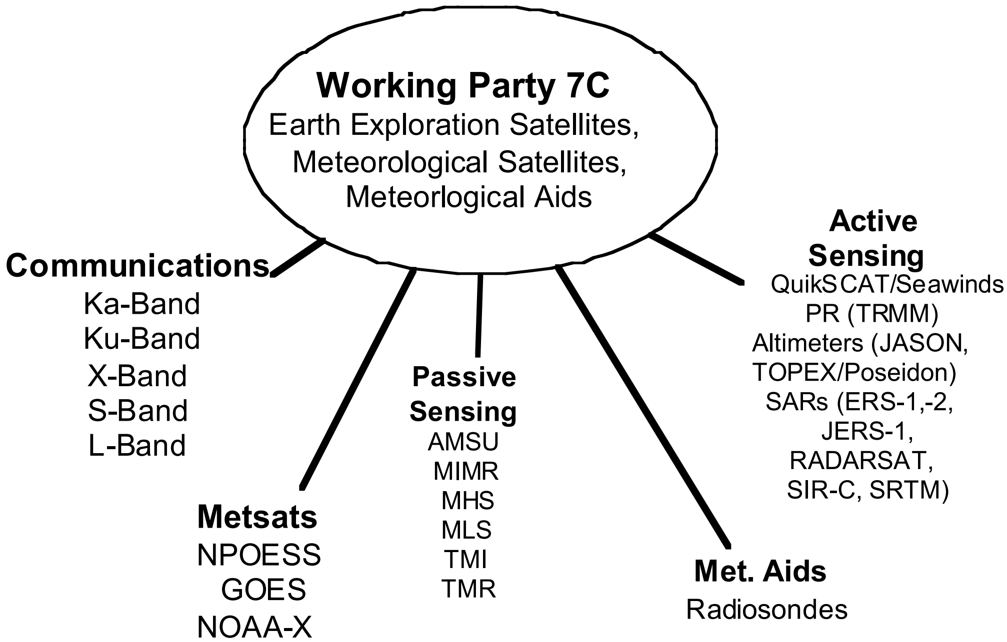
5d. Technical Flow into World Radiocommunications Conference - 97.



5e. Organization Chart of the ITU



5f. ITU-R Study Group 7 Components, U.S. Structure



5g. ITU-R Working Party 7C Components

	NASA-ESA	Int'l SFCG	US WP 7C	US SG-7	US Dept of State	Int'l WP 7C	Int'l SG-7	Int'l CPM	Int'l WRC
Oct-97									X
Nov-97				USA					X
Dec-97			X		Implement				
Jan-98			X		Results				
Feb-98			X					Plan '99	
Mar-98			X						
Apr-98			X	DC?					
May-98			X						
Jun-98	USA		X			X			
Jul-98			X						
Aug-98			X		Rev. Docs				
Sep-98		TBD	X						
Oct-98						X	X		
Nov-98			X	USA				Draft Text	
Dec-98			X		CPM				
Jan-99			X		prep.				
Feb-99			X						
Mar-99			X					Tech.	
Apr-99			X	DC?	Pick			Bases	
May-99			X		Delegates				
Jun-99	Paris?		X			x?	?		
Jul-99			X						
Aug-99			X						
Sep-99		TBD	X				?		
Oct-99									X

5i. ITU and Ancillary Meeting Schedule

6. Parallel Efforts and Support

Workshops sponsored by NASA, others, e.g.:

- X-band (1994 at GSFC, 1995 at Vandenberg AFB).
- Microwave Sensing (11/96 in Boston, with URSI, NOAA).
- S-Band Workshop (July, 1997 at GSFC)
- Ka-Band Commercialization Workshop (March, 1998 at GSFC).

NRC Committee on Radio Frequencies (CORF):

- Mostly radio astronomers, some remote sensing.
- Comments on ITU white papers.
- Responds to FCC notices, Inquiry on Rulemaking.

Industry Advisory Committees (FCC):

- NASA can have representatives.

NASA-ESA Coordinating Meetings:

- Once/year (Japanese observer last time).

Space Frequency Coordinating Group (SFCG):

- Most international space agencies.
- Members influence their administration's proposals.
- Meets in Moscow before SG 7 meets in Geneva this year.
- Meets in Houston next year.

Committee on Telecommunications for the Organization of the American States (CITEL):

- US delegation from government agencies (NTIA, FCC, DoS) and the private sector.

7. Open Issues of the Day

WRC - 00 Issues of Interest to OES *UNDER REVISION*

Originally scheduled for the fall of 1999, this WRC has been postponed to the Spring of 2000 and moved to Istanbul, Turkey.

ACTIVE REMOTE SENSING BANDS:

- 420 - 470 MHz: Providing a 3.5 MHz band somewhere between 420 - 470 MHz for future active, space-based sensors to study biomass, geology, and mudflows underlying vegetation. No such allocation presently exists. 3.5 MHz is inadequate; 10 MHz is needed. JWP 7-8R concluded compatibility between SARs and amateur radio services not established for the preferred 430-440 MHz band. The state of California is interested in such a system. Time was deferred to WRC-99 (now WRC-00), providing that time and money were available to support it. Time and money were declared not available, and it has been dropped from the WRC-00 agenda.

PASSIVE REMOTE SENSING BANDS:

The following passive bands remain a concern for WRC-99 or later WRC's.

- 4.2 - 4.4 GHz: Secondary allocation, best used to observe sea surface temperature. No known instruments, less interference than 6.425-7.075 GHz. The Japanese are interested in elevating this band to worldwide primary status.

- 4.95 - 4.99 GHz: Secondary allocation, best used to observe estuarine temperature. No known instruments, inadequate bandwidth.

- 6.425 - 7.075 GHz: Minimal protection via footnote (not even secondary allocation), observations over oceans, but still much interference. Instruments affected: AMSR (ADEOS-2, Japan), AMSR-E (EOS-PM, USA), MIMR (METOP, ESA), MZOAS (METEOR, CSR), and SMR (SICH, CSR).

- 18.6 - 18.8 GHz: Primary in Region 2 (the Americas) only, secondary elsewhere. Threatened by fixed (point-to-point) and fixed-satellite (point-to-point via satellite) services. Used to observe observing rain, sea state, ocean ice, and water vapor. Instruments affected: AMR (JASON, France/USA), AMSR (ADEOS-2, Japan), AMSR-E (EOS-PM, USA), MIMR (METOP, ESA), MZOAS (METEOR, CSR), SMR (SICH, CSR), and TMR (TOPEX/POSEIDON, France/USA; JASON, France/USA). Although proposed for primary allocation at WRC-97, the proposal went nowhere and action was set aside until WRC-99 to enable further study.

- 21.2 - 21.4 GHz: Primary allocation, best used for water vapor/liquid observations. Instruments affected: AMR (JASON, France/USA), MIVZA (METEOR, CSR), MTZA (METEOR, CSR), TMI (TRMM, Japan/USA), and TMR (TOPEX/POSEIDON, France/USA; JASON, France/USA).

- 22.21 - 22.5 GHz: Primary allocation, best used for water vapor/liquid observations. Instruments affected: AMSU (EOS-PM, USA), DELTA-2 (OKEAN, CSR), IKAR (PRIRODA, CSR), MZOAS (METEOR, CSR), and SMR (SICH, CSR).

- 23.60 - 24.0 GHz: Primary allocation, best used to observe water vapor/liquid. Considered by some the most important of the bands around 20 GHz. Instruments affected: AMR (JASON, France/USA), AMSR (ADEOS-2, Japan), AMSR-E (EOS-PM, USA), AMSU-A (NOAA, USA; METOP, ESA), ATSR-2 (ERS-1, -2, ESA), MIMR (METOP, ESA), MSR (MOS-1B, Japan), and MWR (ENVISAT, ESA).

Other passive band concerns:

- 31.3 - 31.8 GHz: Primary allocation, best used to observe ocean ice, oil spills, clouds, and water vapor/liquid. European fixed services are threatening use of the band. Instruments affected: AMSU-A (NOAA, USA; METOP, ESA) and MSR (MOS-1B, Japan).

All bands above 71 GHz are under review for WRC-99. Details to be added summer/fall, 1998.

- 86-92 GHz: Provides a window to match sounding using the 18 GHz band. Already a PRIMARY allocation, plus active services are forbidden. No action is needed. Instruments affected: AMSR, AMSR2, AMSU-A,-B, CMHS, CMSU, MIMR, MTZA, MVZA, MZOAS, SSM/IS, and TMI.

- 115.25-122.25 GHz: Used for the 3-dimensional sounding of atmospheric temperatures using the oxygen line at 118.75 GHz. Presently PRIMARY exclusive from 105 - 166 GHz; 116-126 GHz PRIMARY shared with active services. Also, CO line at 115.221 GHz needs protection for limb sounder. Sharing studies underway. Instruments affected: AMAS, AMSR2, MILES, MLS (future), ODIN, SMILES.

- 149-151 GHz: Shared PRIMARY allocation (shared 150-151 GHz) used to observe the earth's surface, water vapor, and cloud parameters used for water vapor sounding. Should be maintained (frozen) until ~2015 to protect from active users, then relinquished. Ideally, a 2 GHz band between 142-150 GHz would be set aside. Instruments affected: AMSR2, AMSU-B, CMIU, HSB, SSM/IS.

- 155.5-158.5 GHz: Shared PRIMARY allocation (shared 156-158 GHz) used to observe the earth's surface, water vapor, and cloud parameters used for water vapor sounding. Should be maintained (frozen) until ~2015 to protect from active users, then relinquished. Interests could be served by a band around/below 150 GHz granted long-term protection. Instruments affected: AMSR2, MHS, MVZA.

- 164-168 GHz: Exclusive PRIMARY passive band used for cloud water, rain, and ice observation. Affected users: AMSR2, CMHS, and IMAS. It is unclear whether all three of the above bands are needed (149-151 GHz, 155.5-158.5 GHz, and 164-168 GHz), and if not, which is/are the best.

- 174.8 - 191.8 GHz: Needed for 3-dimensional sounding of water vapor (line at 183.31 GHz) in the atmosphere from both LEO and GEO. Shared PRIMARY from 174.5 to 176.5, PRIMARY from 182 - 185 GHz (footnoted exception in the U.K.). Extending this band to 174.5 - 191.6 GHz (17.1 GHz bandwidth) improves the atmospheric sounding capability. The availability of single-sideband receivers would almost halve this bandwidth requirement. Instruments affected: AMAS AMSR2, AMSU-B (NOAA, USA; METOP, ESA),CMHS, HSB, MHS (EOS-PM, USA; NOAA, USA; METOP, ESA), MILES, MLS (UARS, USA), MVZA, SMILES, and SSM/IS.

- Around 205 GHz (199 - 207 GHz): Spectral lines for ClO, O3, N2O, H2), and H2O2 need protection for limb sounders. Affected instrument: AMAS, MLS (UARS) and MASTER.

- Around 220 GHz: 217-231 GHz is exclusive PRIMARY for passive usage. A 4 GHz band is needed somewhere between 2178-231 GHz, the bet area is between 217-225 GHz. Spectrum outside this band could be deleted.

- Around 231 GHz, spectral lines for O3 and CO need protection for limb sounders. Affected instrument: MLS (UARS).

- Around 300 GHz (296 - 306 GHz), spectral lines for O3, N2O, O2 need protection for limb sounders. Instrument affected: MASTER.

- Around 325.15 GHz (+/- 9.0 or 9.5 GHz): Used for nadir sounding of water vapor using GEO and limb sounding using LEO. Need at least 18 GHz centered on 325.15 GHz. Instrument affected: MASTER.

- Around 340 GHz (339 - 348 GHz?): Need a relatively clear window for water vapor measurements to match the 380 GHz band. 4 GHz is needed, the best are would include 339-342.5 GHz. However, spectral lines between 342 - 348 GHz for CO and HNO3 need protection for limb sounders. Instruments affected: MASTER.

- Around 380.2 GHz (+/- 8.5 or 9.0 GHz): At least 17 GHz is needed for close-to-nadir sounding of water vapor using GEO.

- Around 424.7 GHz: Either a 2 GHz window centered at 410 GHz (409-411 GHz) and an 11 GHz band centered at 424.7 GHz (418.2-431.2 GHz), or a 17 GHz band centered on 424.7 GHz (416.2 - 433.2 GHz) is needed for close-to-nadir temperature sounding from GEO.

- Around 502 GHz (498 - 505 GHz), spectral lines for BrO, O3, N2O, H2O, ClO, CH3Cl need protection for limb sounders. Instruments affected: SOPRANO, MASTER, ODIN (down to 486.1 GHz to include O2).

- Around 557 GHz: Spectrum is needed for close-to-nadir water vapor sounding from GEO. Possibly: one 10 GHz band centered on 557 GHz (552-562 GHz) plus three 4 GHz bands centered on 540, 525, and 500 GHz. (This is a first proposal only!) Also, spectral lines for HNO3 and O3 need protection from 541 - 558 GHz for limb sounders. Instrument affected: ODIN.

- Around 570 GHz (563 - 580.4 GHz) Spectral lines for ClO and O3, as well as mesospheric H2O (547 - 584 GHz) need protection for limb sounders. Instrument affected: ODIN

- Around 625GHz: A number of spectral lines of use to limb sounders exist between 624 - 629 GHz (ClO2 at 624.271 GHz +/- 50 MHz, SO2 at 624.344 GHz +/- 50 MHz, BrO at 624.770 GHz +/- 50 MHz, O3 at 625.656 GHz +/- 300 MHz, HCl at 625.900-625.930 GHz +/- 150 MHz, CH3Cl at 627.177 GHz +/- 50 MHz, O2 at 627.773 GHz +/- 300 MHz, and HOCl at 628.460 GHz +/- 50 MHz). Instruments affected: SMILES, SOPRANO.

- Around 642.85 GHz, spectral lines of CH2Cl, ClO, BrO, HCl, HOCl, and SO2 need protection for limb sounders. Affected instrument: MLS (new).

- Around 650 GHz: Spectral lines of use to limb sounders exist between 646.8 - 653 GHz (H2O at 647.198 GHz +/- 300 MHz , Clo at 649.45GHz /-100 MHz, HO2 at 649.701 GHz +/- 50 MHz, HNO3 at 650.279 GHz +/- 50 MHz, O3 at 650.733 GHz +/- 300 MHz, NO at 651.771 - 651.773 +/- 50 MHz, and N2) at 652,834 GHz +/- 150 MHz). Instrument affected: SMILES.
- Around 953 GHz (951.6 - 955.4 GHz), spectral lines for O2 and NO need protection for limb sounders. Instrument affected: SOPRANO.

- Around 1228.95 GHz, spectral lines for HF need protection for limb sounders. Affected instrument: MLS (new).

- Around 2522.78 GHz, OH lines need protection for limb sounders. Affected instrument: MLS (new).

The following table encompasses all known bands of potential interest to the EESS above 71 GHz. **BOLDFACE-text known instruments** have been flown, are now flying, or are in preparation for flight. Normal-text instruments are on a planned mission, while *italicized-text instruments* are proposed or of unknown status (August, 1998).

Known Bands of Potential Interest to the EESS above 71 GHz (Part 1 of 9).

Low	High	Line	ID	Known Instruments	Allocation	Primary services in-band	Notes/References	Comments/Priorities
86	92	---	Window	**AMSR, AMSR-E, AMSR2, AMSU-A,-B,** *CMHS*, *CMIU*, *CMSU*, **MHS, MIMR**, **MTZA**, *MVZA*, **MZOAS, SSM/IS, TMI**	PRIMARY	Radio Ast., Space Res. (pass.)	Exclusive Passive. Clouds, oil spills, ice, snow. Somewhat counterpart to 18 GHz?	Dutch: Crucial
100	102	100.49	NO	**IKAR**	PRIMARY	Fixed, Mobile, Space Res. (pass.)	Exclusive Passive	Dutch: Noted IKAR
105	116	110.8	O3	**ODIN**	PRIMARY	Radio Ast., Space Res. (pass.)	Exclusive Passive	PS: Impt-gnd based O3 @ 110.8 GHz Dutch: EESS does NOT nee 105-109.8 GHz, 111.8-114.2 GHz
105	116	115.221	CO	**ODIN**	PRIMARY	Radio Ast., Space Res. (pass.)	Exclusive Passive	
105	116	115.27	CO	**ODIN**	PRIMARY	Radio Ast., Space Res. (pass.)	Exclusive Passive	
116	126	118.75	O2	AMAS, **AMSR**2, ATMS, *GEM*, *MILES*, **MLS**, **ODIN**, **SMILES**?	PRIMARY	Fixed, ISS, Mobile, Space Res. (pass.)	IMPORTANT O line for temperature - Want/Need 115.25-122.25. (MLS[EOS]: +/- 650 MHz)	JW: Impt! DS: Add *GEM* Dutch: 114.25-122.25 cruci for EESS, but NOT 122.25-126 GHz
116	126	125.61	NO		PRIMARY	Fixed, ISS, Mobile, Space Res. (pass.)	Limb	JW: Impt! Dutch: 114.25-122.25 cruci for EESS, but NOT 122.25-126 GHz
149	150	---	Window	**AMSU-B**, **MHS**	None	Fixed, Fixed-Sat (S-E), Mobile, Space Res. (pass.)	Want 2 GHz, prefer between 142-150 GHz; surface, water vapor, and cloud parameters for water vapor sounding.	Dutch: 148.5-151.5 GHz crucial, also 164-167 GHz band, phase out 156-158Hz

Known Bands of Potential Interest to the EESS above 71 GHz (Part 2 of 9).

Low	High	Line	ID	Known Instruments	Allocation	Primary services in-band	Notes/References	Comments/Priorities
150	151	150.74	NO	**AMSR2, AMSU-B**, **HSB**, *CMIU*,**SSM/IS**	PRIMARY	Fixed, Fixed-Sat (S-E), Mobile, Space Res. (pass.)	Want 2 GHz, prefer between 142-150 GHz; surface, water vapor, and cloud parameters for water vapor sounding; line use secondary?	Dutch: 148.5-151.5 GHz crucial, also 164-167 GHz band, but phase out 156-158Hz
156	158	---	Window	**AMSR2**, **MHS**, *MVZA*	PRIMARY	Fixed, Fixed-Satellite (S-E), Mobile	Want 155.5-158.5 GHz; Surface, water vapor, cloud parameters for water vapor sounding	Dutch: Phase out
164	168	164.38	ClO	**AMSR**2, *CMHS*	PRIMARY	Radio Ast., Space Res. (pass.)	Cloud water, rain, ice+ClO. Exclusive Passive.	Dutch: 148.5-151.5 GHz crucial, also 164-167 GHz band, but phase out 156-158Hz
164	168	167.2	ClO	**AMSR**2, *CMHS*	PRIMARY	Radio Ast., Space Res. (pass.)	Cloud water, rain, ice+ClO. Exclusive Passive.	Dutch: 148.5-151.5 GHz crucial also 164-167 GHz band, but phase out 156-158Hz
174.5	176.5	175.86	NO	AMAS, **AMSR**2, **AMSU**-B, *CMHS*, **HSB**, **MHS**, *MILES*, *MVZA*, **SMILES**, **SSM/IS**	PRIMARY	Fixed, ISS, Mobile, Space Res. (pass.)	Want 174.5-191.6 GHz to improve 3-d sounding for water vapor, both LEO and GEO. NO secondary?	Dutch: Crucial 174.5-191.8
174.5	176.5	183.31	H2O vapor	AMAS, **AMSR**2, **AMSU**-B, ATMS, *CMHS*, *GEM*, **HSB**, *MILES*, **MLS**, **MLS[EOS]**, *MVZA*, **SMILES**?, **SSM/IS**	PRIMARY	Fixed, ISS, Mobile, Space Res. (pass.)	Want 174.5-191.6 GHz to improve 3-d sounding for water vapor, both LEO and GEO. (MLS[EOS]: +/- 650 MHz)	Crucial 174.5-191.8 GHz-Dutch
176.5	182	177.3	HCN	**MLS[EOS]**	None	Fixed, ISS, Mobile, Space Res. (pass.)	Want 174.5-191.6 GHz to improve 3-d sounding for water vapor, both LEO and GEO.	JW: Impt Dutch: Crucial 174.5-191.8 GHz
176.5	182	181.59	HNO3	**MLS[EOS]**	None	Fixed, ISS, Mobile, Space Res. (pass.)	Want 174.5-191.6 GHz to improve 3-d sounding for water vapor, both LEO and GEO. (MLS[EOS]: +/- 650 MHz)	JW: Impt Dutch: Crucial 174.5-191.8 GHz
176.5	182	183.31	H2O vapor	**MLS[EOS]**, ATMS, *GEM*	None	Fixed, ISS, Mobile, Space Res. (pass.)	Want 174.5-191.6 GHz to improve 3-d sounding for water vapor, both LEO and GEO.	JW: Impt Dutch: Crucial 174.5-191.8 GHz

Known Bands of Potential Interest to the EESS above 71 GHz (Part 3 of 9).

Low	High	Line	ID	Known Instruments	Allocation	Primary services in-band	Notes/References	Comments/Priorities
182	185	183.31	H2O vapor	AMAS, **AMSR**2, **AMSU**-B, ATMS, *CMHS*, *GEM*, **HSB**, *MILES*, **MLS**, **MLS[EOS]**, *MVZA*, **SMILES**?, **SSM/IS**]	PRIMARY	Radio Ast., Space Res. (pass.)	IMPORTANT for 3-D sounding for water vapor. Want 174.5-191.6 GHz to improve sounding, both LEO and GEO. (MLS[EOS]: +/- 650 MHz)	JW: Impt! DS: Add *GEM* Dutch: Crucial 174.5-191.8 GHz
182	185	184.37	O3 meso.	**AMSU**-B, **MHS**,**MLS**	PRIMARY	Radio Ast., Space Res. (pass.)	Want 174.5-191.6 GHz to improve 3-d sounding for water vapor, both LEO and GEO. Exclusive Passive.	JW: Impt! Dutch: Crucial 174.5-191.8 GHz
182	185	184.75	O3	**AMSU**-B, **MHS**,**MLS**	PRIMARY	Radio Ast., Space Res. (pass.)	Want 174.5-191.6 GHz to improve 3-d sounding for water vapor, both LEO and GEO. Exclusive Passive.	JW: Impt! Dutch: Crucial 174.5-191.8 GHz
185	190	183.31	H2O vapor	AMAS, **AMSR**2, **AMSU**-B, ATMS, *CMHS*, *GEM*, **HSB**, *MILES*, **MLS**, **MLS[EOS]**, *MVZA*, **SMILES**?, **SSM/IS**	None	Fixed, ISS, Mobile, Space Res. (pass.)	Want 174.5-191.6 GHz to improve 3-d sounding for water vapor, both LEO and GEO.	Dutch: Crucial 174.5-191.8 GHz
190	191.6	183.31	H2O vapor	AMAS, **AMSR**2, **AMSU**-B, ATMS, *CMHS*, *GEM*, **HSB**, *MILES*, **MLS**, **MLS[EOS]**, *MVZA*, **SMILES**?, **SSM/IS**	None	Mobile, Mobile Satellite, Radionavigation, Radionavigation-Satellite	Want 174.5-191.6 GHz to improve 3-d sounding for water vapor, both LEO and GEO. S5.554 also allocates a form of FSS service in conjunction with MSS and RDNSS from 190-200 GHz.	Dutch: Crucial 174.5-191.8 GHz
199	200	---	Window /line wings	AMAS, **MLS**, *MASTER*	N one	Mobile, Mobile Satellite, Radionavigation, Radionavigation-Satellite	Want 199-207 GHz. S5.554 also allocates a form of FSS service in conjunction with MSS and RDNSS from 190-200 GHz.	
200	202	200.98	N2O	AMAS, **MLS[EOS]**, *MASTER*	PRIMARY	Fixed, Mobile, Space Res. (pass.)	Want 199-207 GHz (**MLS[EOS]**: +/- 650 MHz)	JW: Impt! ESA: 200.5-209 GHz.; Dutch: 200-209 GHz.
202	207	203.4	H2O	AMAS, **MLS[EOS]**, *MASTER*			Good < 6 Km. Must use wings, need a few GHz, especially	ESA: 200.5-209 GHz; Dutch: 200-209 GHz.

							upper wing.	

Known Bands of Potential Interest to the EESS above 71 GHz (Part 4 of 9).

Low	High	Line	ID	Known Instruments	Allocation	Primary services in-band	Notes/References	Comments/Priorities
202	207	204.342	CIO	AMAS, **MLS[EOS]**, *MASTER*			Multiple lines (**MLS[EOS]**: +/- 650 MHz)	JW: Impt! ESA: 200.5-209 GHz.; Dutch: 200-209 GHz.
202	207	206.132	O3	AMAS, **MLS[EOS]**, *MASTER*			Multiple lines, stratospheric O3 (MLS[EOS]: +/- 650 MHz)	JW: Impt! , ESA: 200.5-209 GHz.; Dutch: 200-209 GHz.
~~202~~	~~207~~	~~?~~	~~N2O~~	~~AMAS, MLS, MSTR~~			~~Multiple lines~~	JW: Delete
~~202~~	~~207~~	~~?~~	~~H2O vapor~~	~~AMAS, MLS, MSTR~~			~~Multiple lines~~	JW: Delete
~~202~~	~~207~~	~~?~~	~~H2O2~~	~~AMAS, MLS,*MSTR*~~			~~Multiple lines, H2?~~	JW: Delete
202	207	208.5	O3	AMAS, **MLS[EOS]**, *MASTER*?			Multiple lines, stratospheric O3 (MLS[EOS]: +/- 650 MHz)	ESA: 200.5-209 GHz.; Dutch: 200-209 GHz.
217	231	---	Window / line wings	**MLS**, *MASTER*	PRIMARY	Radio Ast., Space Res. (pass.)	Exclusive Passive, need 4 GHz , prefer 216.5-220.5. Best window between 200-300 GHz	Dutch: delete EESS 209-22 GHz., add 226-231.5 GHz.
217	231	216.29	O3	*MASTER*	PRIMARY	Radio Ast., Space Res. (pass.)	Exclusive Passive, but need 4 GHz , best 216.5-220.5 GHz. O3 + upper troposphere H2O vapor, press., & temp.	Dutch: delete EESS 209-22 GHz., add 226-231.5 GHz.
217	231	226.09	NO	*MASTER*	PRIMARY	Radio Ast., Space Res. (pass.)	Exclusive Passive, but need 4 GHz , best 216.5-220.5 GHz	Dutch: delete EESS 209-22 GHz., add 226-231.5 GHz.
217	231	231.28	O3	**MLS**, *MASTER*	PRIMARY	Radio Ast., Space Res. (pass.)	Exclusive Passive, but need 4 GHz , best 216.5-220.5 GHz	Dutch: delete EESS 209-22 GHz., add 226-231.5 GHz.
217	231	230.54	CO	**MLS[EOS]**, *MASTER*	PRIMARY	Radio Ast., Space Res. (pass.)	Exclusive Passive, but need 229.5-231.5 GHz for CO line. (MLS[EOS]: +/- 650 MHz)	Dutch: delete EESS 209-22 GHz., add 226-231.5 GHz.
233.3	234.6	233.95	O18O	**MLS[EOS]**	None	Fixed, Fixed-Sat(S-E), Mobile	Temperature (MLS[EOS]: +/- 650 MHz)	
235	238	235.71	O3	**MLS[EOS]**	PRIMARY	Fixed, FSS (S-E), Mobile, Space Res. (pass.)	Upper Tropo. Line.(MLS[EOS]: +/- 650 MHz)	JW: Impt!
235	238	237.15	O3	**MLS[EOS]**	PRIMARY	Fixed, FSS (S-E), Mobile, Space Res. (pass.)		JW: Impt

Known Bands of Potential Interest to the EESS above 71 GHz (Part 5 of 9).

Low	High	Line	ID	Known Instruments	Allocation	Primary services in-band	Notes/References	Comments/Priorities
250	252	251.21	NO		PRIMARY	Space Res. (pass.)	Exclusive Passive.	
275	277	276.33	NO	*~~MASTER~~?*	(PASSIVE)	Footnote 927/S5.565	Footnote 927/S5.565	
296	300	294.4	HNO3	*MASTER*, **SMILES**,	None	Undefined	Optimal for < 12 Km. Want 296-306 GHz	ESA: 294-305 GHz
296	300	---	Window / line wings	*MASTER*, **SMILES**,	None	Undefined	Want 296-306 GHz	ESA: 294-305 GHz
296	300	298.5	O	*MASTER*, **SMILES**,	None	Undefined	Temperature measurements. Want 296-306 GHz	ESA: 294-305 GHz
300	302	301.44	NO, N2O?	**MLS**, *MASTER*	(PASSIVE)	Footnote 927/S5.565	Want 296-306 GHz	ESA: 294-305 GHz
300	302	300	O3	*MASTER*	(PASSIVE)	Footnote 927/S5.565	Ozone band, low edge. Optimal < 14 Km. Want 296-306 GHz	ESA: 294-305 GHz
300	302	?	N2O	*MASTER*	(PASSIVE)	Footnote 927/S5.565	Want 296-306 GHz	ESA: 294-305 GHz
300	302	?	O2	*MASTER*	(PASSIVE)	Footnote 927/S5.565	Want 296-306 GHz	ESA: 294-305 GHz
302	306	304	O3	*MASTER*	(PASSIVE)	Footnote 927/S5.565	Ozone band, high edge. Optimal < 14 Km. Want 296-306 GHz	ESA: 294-305 GHz
302	306	305.2	HOCl	*MASTER*	(PASSIVE)	Footnote 927/S5.565	Want 296-306 GHz	ESA: 294-305 GHz
302	306	---	Window / line wings	*MASTER*	None	Undefined	Want 296-306 GHz	ESA: 294-305 GHz
316	324	321	H2O vapor	*MASTER*	None	undefined	Want +/- 9.0 or 9.5 GHz, Nadir water vapor from GEO, limb from LEO, Good above 6 Km. Complement 2005.-209 GHz.	ESA: 316-325 GHz
316	324	322.8	HOCl	*MASTER*	None	undefined	.	ESA: 316-325 GHz
316	324	325.1	H2O vapor	*MASTER*	None	undefined	Want +/- 9.0 or 9.5 GHz, Nadir water vapor from GEO, limb from LEOGood above 6 Km. Complement 2005.-209 GHz.	ESA: 316-325 GHz
324	326	325.1	H2O vapor	*MASTER*	(PASSIVE)	Footnote 927/S5.565	IMPORTANT Nadir water vapor from GEO, limb from LEO (need +/- 9 - 9.5 GHz)Good above 6 Km. Complement 2005.-209 GHz.	ESA: 316-325 GHz

326	334	325.1	H_2O vapor	*MASTER*	None	Undefined	Want +/- 9.0 or 9.5 GHz, Nadir from GEO, limb from LEO	

Known Bands of Potential Interest to the EESS above 71 GHz (Part 6 of 9).

Low	High	Line	ID	Known Instruments	Allocation	Primary services in-band	Notes/References	Comments/Priorities
339	345	380	H2O vapor		None	Undefined	Want 339-348 GHz; Window needed around 340 GHz for water vapor sounding via 380 GHz band.	
339	345	343.3	O3		None	Undefined	Strong Ozone lines.	ESA: 342-349 GHz
345	347	344.4	HNO3	*MASTER*	(PASSIVE)	Footnote 927/S5.565	Optimal > 12 Km.	ESA: 342-349 GHz
345	347	380	H2O vapor		None	Undefined	Want 339-348 GHz; Window needed around 340 GHz for water vapor sounding via 380 GHz band.	ESA: 342-349 GHz
345	347	345.8	CO	*MASTER*	(PASSIVE)	Footnote 927/S5.565	CO strong enough for low alt., few mm lines.	ESA: 342-349
345	347	345	O	*MASTER*	(PASSIVE)	Footnote 927/S5.565	For temperature profiles	ESA: 342-349 GHz
345	347	345.?	CH3CL	*MASTER*	(PASSIVE)	Footnote 927/S5.565	Optimal <10 Km.	ESA: 342-349 GHz
345	347	345.?	HNO3	*MASTER*	(PASSIVE)	Footnote 927/S5.565	Optimal > 12 Km.	ESA: 342-349 GHz
345	347	346.?	ClO	*MASTER*	(PASSIVE)	Footnote 927/S5.565	Complementary to 496-506 GHz.	ESA: 342-349 GHz
347	348	380	H2O vapor		None	Undefined	Want 339-348 GHz; Window needed around 340 GHz for water vapor sounding via 380 GHz band.	ESA: 342-349 GHz
363	365	364.32	O3		(PASSIVE)	Footnote 927/S5.565		
366.5	370.5	368.5	O2		None	Undefined		
371.5	379	380.2	H2O vapor	*GEM*	None	Undefined	Need 17 GHz for close to nadir water vapor sounding from GEO	DS: Add *GEM*
379	381	380.2	H2O vapor	*GEM*	(PASSIVE)	Footnote 927/S5.565	IMPORTANT nadir water vapor sounding from GEO(need 17 GHz)	DS: Add *GEM*
381	388.5	380.2	H2O vapor	*GEM*	None	Undefined	Need 17 GHz for close to nadir water vapor sounding from GEO	DS: Add *GEM*
409	411	410	Temp.		None	Undefined	Temp sounding, centered 410	
419	430	424.76	Temp.	*GEM*	None	Undefined	Temp sounding, centered 424.7	DS: Add *GEM*

443	444	442.99	O3		None	Undefined	Lower strato. O3, tropopause water vapor, HNO3, N2O, CO, pressure, and temp.	
485	487	486.15	O2	**ODIN**	None	Undefined	O2 line, limb	
498	505	497.5	BrO	*SOPRANO, MASTER*	None	Undefined	Optimal for species (low edge)	ESA: 496-506

Known Bands of Potential Interest to the EESS above 71 GHz (Part 7 of 9).

Low	High	Line	ID	Known Instruments	Allocation	Primary services in-band	Notes/References	Comments/Priorities
498	505	499.5	BrO	*SOPRANO, MASTER*	None	Undefined	Optimal for species (edge edge)	ESA: 496-506
498	505	497	O3	*SOPRANO, MASTER*	None	Undefined	optimal > 10 Km (low edge)	ESA: 496-506
498	505	506	O3	*SOPRANO, MASTER*	None	Undefined	optimal > 10 Km (high edge)	ESA: 496-506
498	505	501	N2O	*SOPRANO, MASTER*	None	Undefined	Optimal > 8 Km	ESA: 496-506
498	505	501	ClO	*SOPRANO, MASTER*	None	Undefined	ClO (low edge)	ESA: 496-506
498	505	503	ClO	*SOPRANO, MASTER*	None	Undefined	ClO (high edge)	ESA: 496-506
498	505	504.6	CH3Cl	*SOPRANO, MASTER*	None	Undefined	Optimal > 10 Km	ESA: 496-506
498	502	557	H2O vapor		None	Undefined	Water vapor sounding, near nadir GEO	
523	527	557	H2O vapor		None	Undefined	Water vapor sounding, near nadir GEO	
538	584	557	H2O vapor	**ODIN**	None	Undefined	Water vapor sounding, near nadir GEO	
552	562	557	H2O vapor	**ODIN**	None	Undefined	Water vapor sounding, near nadir GEO	
541	558	?	HNO3	?	None	Undefined	Lines	
541	558	?	O3	?	None	Undefined	Lines	
547	584	?	H2O	**ODIN**	None	Undefined	Mesospheric H2O	
563	580.4	?	ClO	**ODIN**	None	Undefined	Lines	
563	580.4	?	O3	**ODIN**	None	Undefined	Lines	
624	629	624.271	CLO2	*SOPRANO*	None	Undefined	O3 depletion	
624	629	624.344	SO2	**SMILES**, *SOPRANO*	None	Undefined	Volcano, aerosols	
624	629	624.77	BrO	**SMILES**, *SOPRANO*	None	Undefined	O3 depletion	

Known Bands of Potential Interest to the EESS above 71 GHz (Part 8 of 9).

Low	High	Line	ID	Known Instruments	Allocation	Primary services in-band	Notes/References	Comments/Priorities
624	629	625.37	O3	**MLS[EOS]**, *SOPRANO*	None	Undefined	Many lines(MLS[EOS]: +/- 650 MHz)	
624	629	625.92	HCl	**MLS[EOS]**, **SMILES**, *SOPRANO*	None	Undefined	H[37]Cl, Chlorine reservoir (MLS[EOS]: +/- 650 MHz)	
624	629	626.656	O3	**SMILES**	None	Undefined	O3 depletion	
624	629	627.087	H2O2	**SMILES**	None	Undefined		
624	629	627.177	CH3CL	*SOPRANO*	None	Undefined	CH[37]3CL	
624	629	627.773	O2	**SMILES**, *SOPRANO*	None	Undefined	O[18]O	
624	629	628.46	HOCl	**SMILES**, *SOPRANO*	None	Undefined	Chlorine reservoir	
640	645	?	CH2CL	*MLS[new]*	None	Undefined	Many lines	
640	645	?	ClO	*MLS[new]*	None	Undefined	Many lines	
640	645	?	BrO	*MLS[new]*	None	Undefined	Many lines	
640	645	?	HCl	*MLS[new]*	None	Undefined	Many lines	
640	645	?	HOCL	*MLS[new]*	None	Undefined	Many lines	
646.8	653	647.198	H2O		None	Undefined	H[18]2O, greenhouse gas	
646.8	653	649.45	CLO	**MLS[EOS]**, **SMILES**	None	Undefined	O3 depletion, (MLS[EOS]: +/- 650 MHz)	
646.8	653	649.701	HO2	**SMILES**	None	Undefined	O3 depletion	
646.8	653	650.18	BrO	**MLS[EOS]**	None	Undefined	(MLS[EOS]: +/- 650 MHz)	
646.8	653	650.279	HNO3	**SMILES**	None	Undefined	Nitrogen reservoir	
646.8	653	650.733	O3	**SMILES**	None	Undefined	Depletion & greenhouse gas	
646.8	653	651.771	NO	**SMILES**	None	Undefined	O3 depletion	
646.8	653	652.834	N2O	**MLS[EOS]**, **SMILES**	None	Undefined	Nitrogen reservoir (MLS[EOS]: +/- 650 MHz)	
951	956	?	O2	*SOPRANO*	None	Undefined	Multiple lines	
951	956	?	NO	*SOPRANO*	None	Undefined	Multiple lines	

Known Bands of Potential Interest to the EESS above 71 GHz (Part 9 of 9).

Low	High	Line	ID	Known Instruments	Allocation	Primary services in-band	Notes/References	Comments/Priorities
1228	1230	1228.95	HF	*MILES*?, **SMILES**?	None	Undefined	TBD	
2500	2540	2502.32	O2	*MILES*, **MLS[EOS]**, **SMILES**	None	Undefined	Pressure? (MLS[EOS]: +/- 650 MHz)	JW: Expand to 2540 GHz
2500	2540	2509.95	OH	*MILES*, **MLS[EOS]**, **SMILES**]	None	Undefined	Multiples (MLS[EOS]: +/- 650MHz)	JW: Expand to 2540 GHz
2500	2540	2514.32	OH	*MILES*, **MLS[EOS]**, **SMILES**	None	Undefined	Multiples (MLS[EOS]: +/- 650MHz)	JW: Expand to 2540 GHz
~~2520~~	~~2525~~	~~2522.78~~	~~OH~~	~~MLS[new]~~	~~None~~	~~Undefined~~	~~TBD~~	JW: Delete

NOTES: Comments are derived from

Dutch - essentially the CEPT-33 paper.

PS - Paul Steffes/Georgia Tech

JW - Joe Waters/JPL

DS - David Staelin/M.I.T.

ESA - European Space Agency

This page intentionally left blank.

8. Other International Concerns of OES

ACTIVE SENSORS:

Recall that the satellites with active sensors (e.g., TRMM) operating in the 13.75 - 14.0 GHz band have limited protection - until January, 2001 at best, due to Fixed Satellite Services (FSS) in the band. At present, FSS uplinks must be coordinated in order for us to operate, and over 250 systems are involved. Remote sensor protection, indicated by footnote only, was lost in WRC-92. We must constantly defend our turf!

PASSIVE SENSORS:

There are discussions concerning a Space Solar Power Satellite. The affect of using radio frequencies to transfer massive amounts of power have the potential to be disastrous to both our passive and active sensors. This matter must be kept under watch and guarded carefully - it may be all right, but it must be proven first!

COMMUNICATIONS:

The spectrum below 3 GHz is under intense demand, particularly in the United States. Most of NASA's tracking, telemetry, and command links are around 2 GHz, and they must be protected both now and in the long run.

NAVIGATION:

A potential threat has been posed to the protection of the GPS system; it is being handled elsewhere.

OPERATIONS:

The number of EESS users of X-band (8025- 8400 MHz) communications is expected to triple between now and the year 2003. Most of these satellites are high-inclination, if not sun-synchronous, spacecraft. There is a concern that, should most people want to downlink their data to high latitude stations, they may occasionally interfere with each other.

- This contention problem needs to be quantified, and, if proven to be significant, worked upon jointly by all the users of the band (national and international, both governmental and commercial).

- Spectrum-conserving modulation techniques need to be developed and used both to maximize the data being downlinked per unit time (shorter contacts) and to minimize interference to other users of the band.

This page intentionally left blank.

9. APPENDICES/BACKUP MATERIAL

A. Atmospheric Absorption versus Frequency
(per km and through atmosphere).

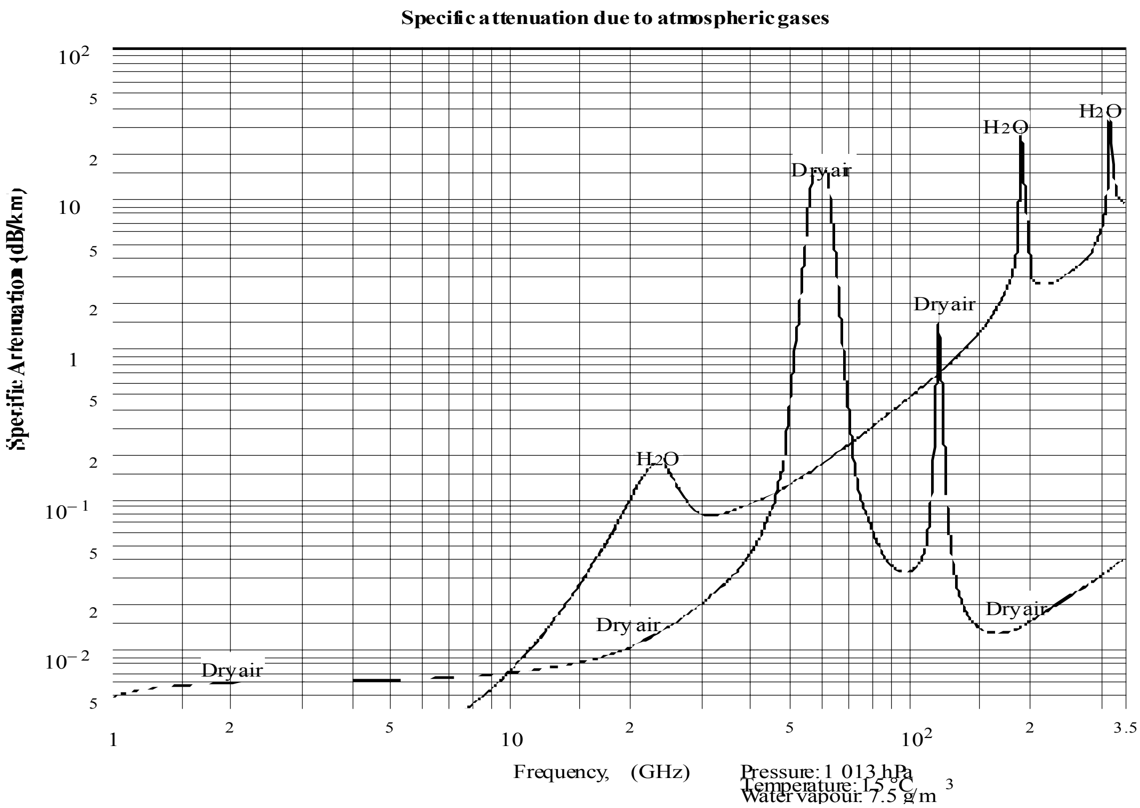
B. Map of ITU Regions.

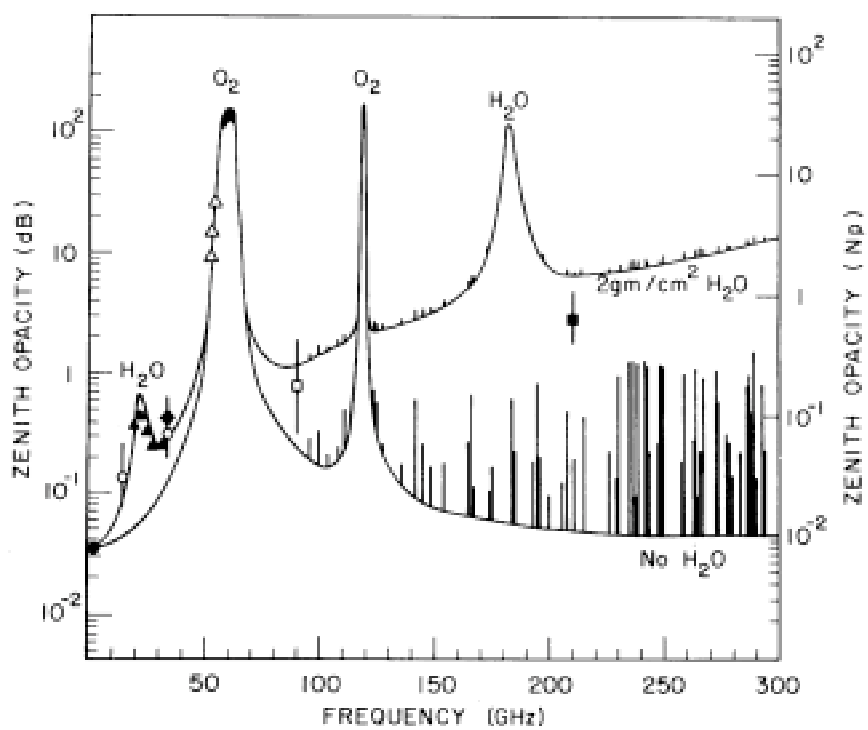
C. Entire ITU-R Study Group Structure (Diagram and Table).

D. Summary of WRC-97 Results from an Office of Earth Science Viewpoint

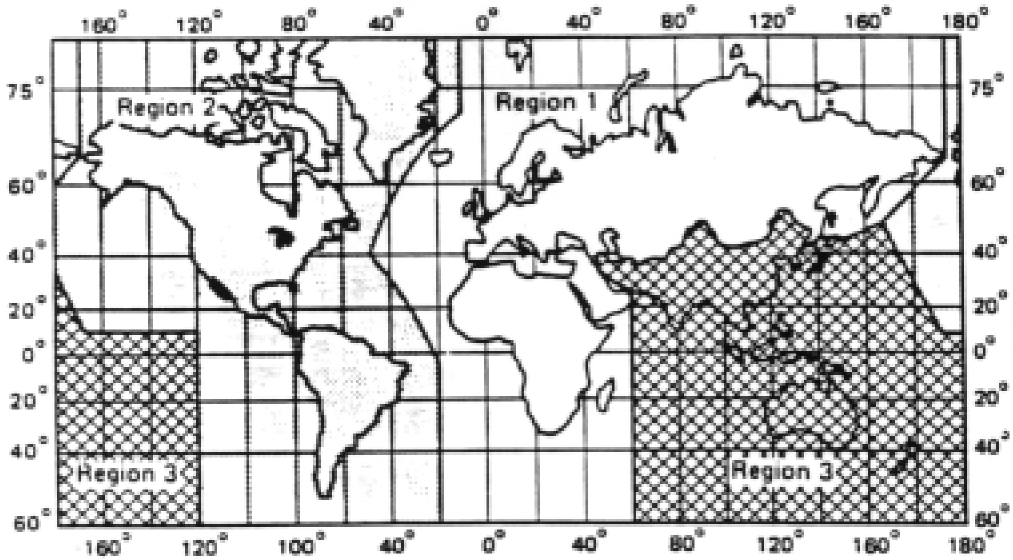
E. NTIA Licensing Stages.

F. Glossary of Instruments and Spacecraft

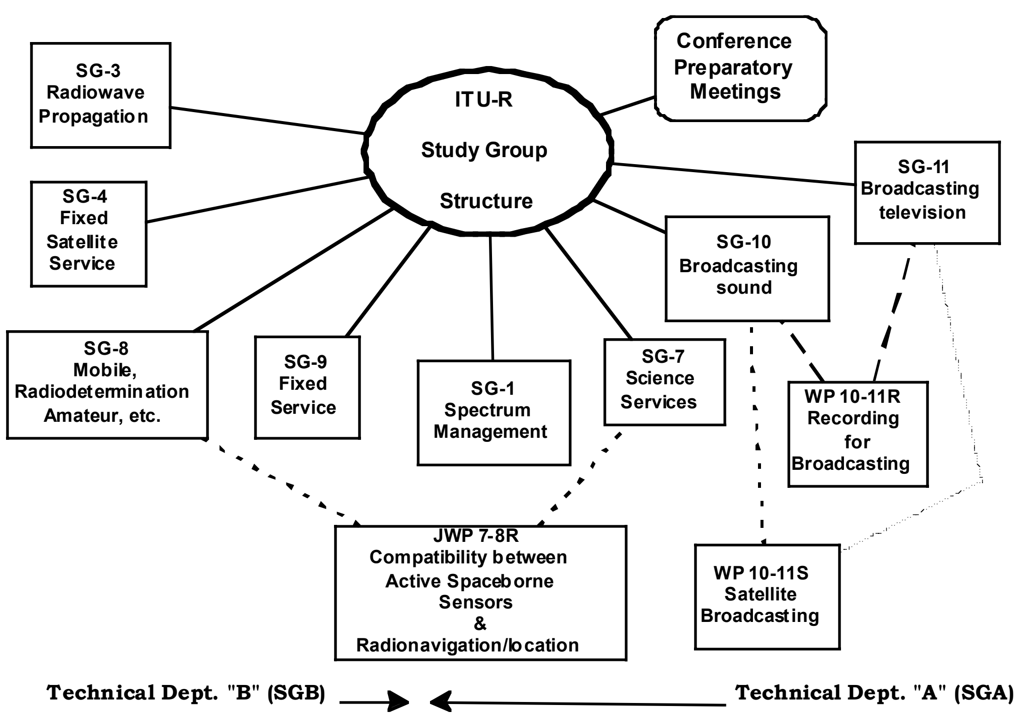

Specific attenuation due to atmospheric gases
Specific Attenuation (dB/km)
Frequency, (GHz)
Pressure: 1 013 hPa
Temperature: 15 °C
Water vapour: 7.5 g/m 3
Dry air
H2O


ZENITH OPACITY (dB)
ZENITH OPACITY (Np)
FREQUENCY (GHz)
O2
H2O
2gm/cm2 H2O
No H2O

ITU Regions



ITU, *Final Acts of the World Administrative Radio Conference*, Geneva, 1979.



C. ITU Radiocommunications Sector Study Group Structure

C. ITU-R Study Groups and Working Parties

SG-1 Spectrum Management

WP 1A
Engineering principles and techniques

WP 1B
Spectrum planning and sharing

WP 1C
Spectrum monitoring

TG 1/3
Spurious emissions

TG 1/4
Electronic exchange of spectrum management information

SG 3 Radiowave Propagation

WP 3J
Propagation fundamentals

WP 3K
Point-to-area propagation

WP 3L
HF propagation

WP 3M
Point-to-point and Earth-to-space propagation

SG 4 Fixed Satellite Service

WP 4A
Efficient orbit and spectrum utilization

WP 4B
Systems, performance, availability, and maintenance

WP 4 SNG
Satellite news gathering, outside broadcast via satellite

WP 4-9S
Frequency sharing between fixed-satellite service and fixed service

SG 7 Science Services

WP 7A
Time signals and frequency standards

WP 7B
Space radio systems

WP 7C
Earth exploration satellite systems and meteorological systems

WP 7D
Radio astronomy

SG 8 Mobile, Radiodetermination, amateur and related satellite services

WP 8A
Land mobile, amateur, and amateur satellite

WP 8B
Maritime mobile, aeronautical mobile

WP 8C
Radiodetermination Service

WP 8D
Mobile satellite services, radiodetermination, satellite service, aircraft telephony

TG 8/1

Future public land
mobile
telecommunication sys.

TG 8/2
Wind profiler radar

C. ITU-R Study Groups and Working Parties

SG 9
Fixed Service

WP 9A
Performance, availability, interference objectives and analysis, propagation

WP 9B
Channel arrangements, system characteristics

WP 9C
HF systems

WP 9D
Sharing with other services

SG 10
Broadcasting service - Sound

WP 10A
Below 30 MHz

WP 10B
Above 30 MHz

WP 10C
Audio characteristics of sound broadcasting systems

TG 10/3
Subjective sound assessments

TG 10/4
Objective perceptual audio quality

TG 10/5
Technical parameters and planning procedures

SG 11
Broadcasting Service - Television

WP 11A
TV systems and data broadcasting

WP 11B
Digital TV

WP 11C
Terrestrial TV (emission, planning parameters)

WP 11E
Quality evaluation

TG 11/1
HDTV

TG 11/2
Digital studio interfaces

TG 11/3
Digital terrestrial TV broadcasting

ITU-R other Working Parties

WP 10-11R
Recording for broadcasting

WP 10-11S
Satellite broadcasting

Appendix D:

Summary of WRC-97 Results from an Office of Earth Science Viewpoint

Comments below amplify the table following:

430-440 MHz: The Dutch and JPL want to use a Synthetic Aperture Radar (SAR) in this band to get to the ground under vegetation. The US WP-7C did its homework, DoD overruled at the national level. Nationally, we got what "we" wanted. The Dutch may re-propose if there is time/money for this in WRC-99.

1.559-1.610 GHz: This band covers the L1 Frequency of GPS. INMARSAT submitted a paper which claimed that communications could co-exist with GPS; the US, based on the same data, had a paper which drew the OPPOSITE CONCLUSION. A nasty fight came up. The White house was involved in getting out the US diplomatic corps to stop this INMARSAT-sponsored effort. The International Civil Aviation Organization also supported us. The result was that the INMARSAT proposal was stalled off until WRC-99 to allow further studies to take place. This fight will continue. We will use GPS for space-to-space spacecraft of our satellites as well as for science purposes.

3.1 - 3.3 GHz: Previously, this allocation was only in a footnote referenced by the tables, and footnotes have a bad history of being overlooked and/or ignored. Getting directly listed in the tables is still a plus.

5.35-5.46 GHz: This expansion of the 5.25-5.35 GHz active band was engineered by the Canadians, and we will benefit by it. We did some of the homework, but they charged ahead with it.

18.6-18.8 GHz: Stalled out. There was fierce opposition from the communications groups who already had worldwide primary (especially the Europeans). We need this band for passive sea wind and sea ice observations. Nearby bands at lower frequencies do not have the bandwidth; higher frequency bands nearby are adversely affected by rain and water vapor (and are used to observe them). Rather than risk losing what we had (primary in the Americas), this issue was tabled until WRC-99. We may look for a new nearby, less contentious band.

50.2 - 50.4 GHz; 51.4 - 59.3 GHz: Primary allocations, used to measure atmospheric temperature via Oxygen absorption band. An additional band of 60.3 - 61.3 GHz was considered to allow temperature measurement into the mesosphere, but 59.0 - 59.3 GHz should suffice. These bands are being realigned to prevent communications services from interfering with passive sensors. The communications services are moving out of "our" band and into one of their own (Fixed services in the 50.2-50.4 GHz and 54.25 - 55.78 GHz bands are being moved to above 65 GHz). In return, passive allocations in the 51.4 - 52.6 GHz band are being given up. Inter-satellite links in the 54.25 - 58.2 GHz band are limited to geosynchronous satellites, except for 56.9 - 57.0 GHz band. Fixed and mobile services are to be added in the 58.2 - 59.3 GHz band where sharing is possible. Instruments affected: AMSR (ADEOS-2, Japan), AMSU-A (NOAA, USA; METOP, ESA), MSU (NOAA, USA), and MTZA (METEOR, CSR).

71-300 GHz: Wanted this item deferred until 1999. It was >50 GHz, but 50-70 GHz was covered in WRC-97.

The following active remote sensing bands were not elevated to primary allocation at WRC-97, due primarily to a lack of desire by the community.

9.975 - 10.025 GHz: No requirements known and no data were provided to JWP 7-8R; hence, no decision. This band is footnoted to include secondary allocation for weather radars in meteorological satellite service.

13.75 - 14.0 GHz: Allocation lost in WRC-92, protection ends January 1, 2001.

24.05 - 24.25 GHz: : No requirements known and no data were provided to JWP 7-8R; hence, no decision. This band is useful for observing water vapor and liquid.

OVERALL ASSESSMENT: 14 clear wins, 1 bonus win, 1 "official win", 1 partial win, and 2 draws (fights deferred to WRC-99) -- Not bad!

Changes Enacted at the World Radiocommunications Conference-97
Affecting the Office of Earth Science

Band	**Low** (GHz)	**High** (GHz)	**OES Instruments** (+allied S/C, instruments,...)	**Old Allocation** (pre WRC-97)	**New Allocation** (Post WRC-97)	**Other Primary Services** (Sharing the band)	**Comments**
P	0.43	0.44	Proposed SAR?	None	None	Radiolocation, Amateur	WIN? US position
L	1.215	1.3	SAR(JERS-1, LightSAR)	Footnoted secondary active	PRIMARY ACTIVE	Radiolocation, Radionavigation-S/C	WIN-Upgraded
L	1.559	1.610	GPS	PRIMARY S-E	No Change, Want Space-Space	Aeronautical Radionavigation	CHALLENGE/DRAW in WRC-99 Agenda
S	2.025 2.200	2.110 2.290	Most Command, Tracking Most Telemetry	PRIME E-S, S-S PRIME S-E, S-S	No Change, but no high density mobile	Fixed, Mobile, Space Ops	WIN-EXCLUDED high density mobile
S	3.1	3.3	CIS S/C	Footnoted secondary active	Secondary active IN TABLE	Radiolocation	PARTIAL WIN - out of footnotes
C	5.25	5.35	ALT, AMI, SSALT SAR(RADARSAT), SRTM	Footnoted secondary active	PRIMARY ACTIVE	Radiolocation	WIN-Upgraded
C	5.35	5.46	Future RADARSAT	None	PRIMARY ACTIVE	Aeronautical Radionavigation	UNEXPECTED WIN Extended, Canadian
X	8.025	8.4	Most OES S/C science data downlinks	PRIMARY-Reg. 2 Secondary 1,3	PRIMARY WORLDWIDE S-E	Fixed, Fixed-Satellite, Mobile	WIN-Upgraded to Worldwide
X	8.55	8.65	Foreign S/C	Foot'd sec. active	PRIMARY ACTIVE	Radiolocation	WIN-Upgraded
X	9.5	9.8	Foreign S/C, SRTM?	Foot'd sec. active	PRIMARY ACTIVE	Radiolocation, Radionav.	WIN-Upgraded
K	13.25	13.75	SeaWINDS, SSALT, ALT	Footnoted secondary active	PRIMARY ACTIVE	Aeronautical Radionav., Radiolocation, time/freq.	WIN-Upgraded & extended
Ku	17.2	17.3	Unknown	Secondary active	PRIMARY ACTIVE	Radiolocation	WIN-Upgraded
Ku	18.6	18.8	JMI, AMSR, AMSR-E	PRIMARY-Reg.2, Secondary in 1, 3	PRIMARY -Reg. 2, Secondary in 1, 3.	Fixed, Fixed-Satellite, Mobiles	DRAW-TABLED UNTIL WRC-99

Ka	25.5	27.0	Next OES Wideband Downlink	Secondary S-E	PRIMARY S-E, Limiting footnotes	Fixed, Intersat, Mobile	WIN-Upgraded Worldwide.
Ka	35.5	36.0	Future	None	PRIMARY ACTIVE	Met. Aids, Radiolocation	WIN-New Allocation
	50.2	50.4	AMSR, AMSU	PRIMARY PASS.	NO CHANGE	Mobile, Space Res.	WIN-EXIT FIXED
	51.4	59.3	AMSR, AMSU, MSU	PRIMARY PASSIVE/NONE	PRIMARY PASSIVE	Space Research (passive), Mixed-mobile, fixed	WIN-HARMONIZED
	71.0	300.0	AMSR, MIMR, TMI,MHS, ...	Mixed, PRIME	NC-Reallocate	Mixed	WIN-in WRC-99
	94	94.1	Future Cloud Radars	None	PRIMARY ACTIVE	Fixed, Fixed-Satellite, Mobile, Radiolocation	WIN-NEW ALLOCATION

E. NASA Licensing Procedure (one spacecraft at a time)

All through the National Telecommunications and Information Agency (NTIA).

Started by the center Frequency Manager (at GSFC, Deskevitch), working with the Agency frequency manager (Schuett at LeRC).

First, review through the Spectrum Planning Subcommittee (SPS):

Stage 1 (Conceptual):	Initial planning completed, including proposed frequency bands.
Stage 2 (Experimental):	PDR completed, some breadboard models if needed.
Stage 3 (Developmental):	CDR completed, radiation testing may be required during testing.
Stage 4 (Operational):	Development essentially completed, final operating constraints/restrictions need to be identified.

When completed, forward to the Interdepartmental Radio Advisory Committee (IRAC) for approval

Then, licensing process starts:

This is a formality,

but,

limits may still be imposed by the Frequency Assignment Subcommittee (FAS).

F. Instrument and Spacecraft Glossary (Part 1 of 2)

Acronym/ Abbreviation	Name/Title	MISSION	COUNTRY
ADEOS	Advanced Earth Observation Satellite(s)		JAPAN
ALT	Altimeter	TOPEX/ POSEIDON	USA/ FRANCE
ALOS	Advanced Land Observing Satellite		JAPAN
AMI	Active Microwave Instrument	ERS-1, -2	ESA
AMR	Altimetry Microwave Radiometer	JASON-1	USA
AMSR	Advanced Microwave Scanning Radiometer	ADEOS-2	JAPAN
AMSR-E	Advanced Microwave Scanning Radiometer-E	EOS-PM	JAPAN
AMSU	Advanced Microwave Sounding Unit	EOS-PM	USA
AMSU-A	Advanced Microwave Sounding Unit - A	NOAA K+ METOP1	USA ESA
AMSU-B	Advanced Microwave Sounding Unit - B	NOAA-K+	USA
ASAR	Advanced Synthetic Aperture Radar	ENVISAT	ESA
ASCAT	Advanced Scatterometer	METOP	ESA
ATSR, -2	Along Track Scanning Radiometer (and Microwave Sounder)	ERS-1, -2	ESA
CLOUD RADAR	Cloud radar	FUTURE	ESA
CSR	Commonwealth of Soviet Republics		
DELTA-2		OKEAN	CSR
DORIS	Doppler Orbitography and Radio Positioning Integrated by Satellite	TOPEX/ POSEIDON	USA/ FRANCE
ENVISAT	Environmental Satellite		ESA
EOS	Earth Observing System (-AM, morning equator crossing; -PM afternoon crossing; -CHEM afternoon crossing)		USA
ERS	Earth Resource Satellite(s)		ESA
ESA	European Space Agency		
ETM	Enhanced Thematic Mapper	LANDSAT	USA
IKAR		PRIRODA	CSR
JERS	Japanese Earth Resources Satellite		JAPAN
MASTER		FUTURE	ESA
MHS	Microwave Humidity Sounder	EOS-PM NOAA-N METOP	USA USA ESA
MIMR	Multifrequency Imaging Microwave Radiometer	METOP	ESA
MIRAS	Microwave Imaging Radiometer with Aperture Synthesis	MIRAS	ESA
MIVZA	(humidity sounder)	METEOR	CSR
MLS	Microwave Limb Sounder	UARS,EOS -CHEM	USA
MSR	Microwave Scanning Radiometer	MOS-1B	JAPAN
MSU	Microwave Sounding Unit	NOAA-9-14	USA

MTZA		METEOR	CSR
MWR	Microwave Radiometer	ENVISAT	ESA
MZOAS		METEOR	CSR

F. Instruments and Spacecraft Glossary (Part 2 of 2)

Acronym/ Abbreviation	Name/Title	MISSION	COUNTRY
NASA	National Aeronautics and Space Administration		USA
NOAA	National Oceans and Atmospheres Administration		USA
NSCAT(US)	NASA Scatterometer	ADEOS	JAPAN
PR	Precipitation Radar	TRMM	JAPAN
R-225	2.25 cm radiometer (?)	OKEAN-O	CSR
R-400	4 cm radiometer (?)	PRIRODA	CSR
R-600	6 cm radiometer (?)	OKEAN-O	CSR
RA	Radar Altimeter	ERS-1,-2	ESA
RA-2	Radar Altimeter	ENVISAT	ESA
RADIOMTR	Radiometer	ODIN	SWEDEN
RLSBO	Imager	OKEAN-O, SICH-1	CSR
RM-0.8	0.8 cm imaging radiometer	SICH	CSR
SAR	Synthetic Aperture Radar	RADARSAT	CANADA
SAR	Synthetic Aperture Radar	JERS-1	JAPAN
SAR	Synthetic Aperture Radar	SICH	CSR
SAR-10	Synthetic Aperture Radar - 9.6 cm	ALMAZ	CSR
SAR-3	Synthetic Aperture Radar - 3.5 cm	ALMAZ	CSR
SAR-70	Synthetic Aperture Radar - 70 cm	ALMAZX	CSR
SIRC/XSAR	Shuttle Imaging Radar -C, X-Synthetic Aperture Radar	Shuttle	USA
SMR	Scanning Microwave Radiometer	SICH	CSR
SEAWINDS (USA)	Scatterometer	ADEOS-2	JAPAN
SLR-3	Side Looking Radar	ALMAZX	CSR
SOPRANO	Sub-millimeter Observation of Processes in the Absorption Noteworthy for Ozone	FUTURE	ESA
SSALT	Solid State Altimeter	TPX/POS, JASON	USA, FRANCE
TDRSS	Tracking and Data Relay Satellite System		USA
TMI (USA)	TRMM Microwave Imager	TRMM	JAPAN
TMR	TOPEX Microwave Radiometer	TPX/POS, JASON	USA, FRANCE
TPX/POS	TOPEX/POSEIDON		USA, FRANCE
TRMM	Tropical Rainfall Measurement Mission		USA, JAPAN
TRVRS SAR	Transverse-Synthetic Aperture Radar	PRIRODA	CSR
TT&C	Tracking, Telemetry, and Command		
UARS	Upper Atmosphere Research Satellite		USA
USA	United States of America		
VSAR	? Synthetic Aperture Radar	ALOS	JAPAN

This page intentionally left blank.

THE END