WISP-336

WAVES IN SPACE PLASMAS

(WISP)

PRESENTATION TO

SPACE PLASMA PHYSICS ACTIVE EXPERIMENTS WORKING GROUP

NASA/MSFC 23 SEPT 1980

R.W. FREDRICKS WISP P.I.

WISP SCIENCE OBJECTIVES

VLF WAVE INJECTION EXPERIMENTS

- VLF WAVE-PARTICLE INTERACTIONS
- VLF PROPAGATION

TRAVELING IONSPHERIC DISTURBANCES AND ATMOSPHERIC GRAVITY WAVES

- HF, VHF REMOTE SOUNDING

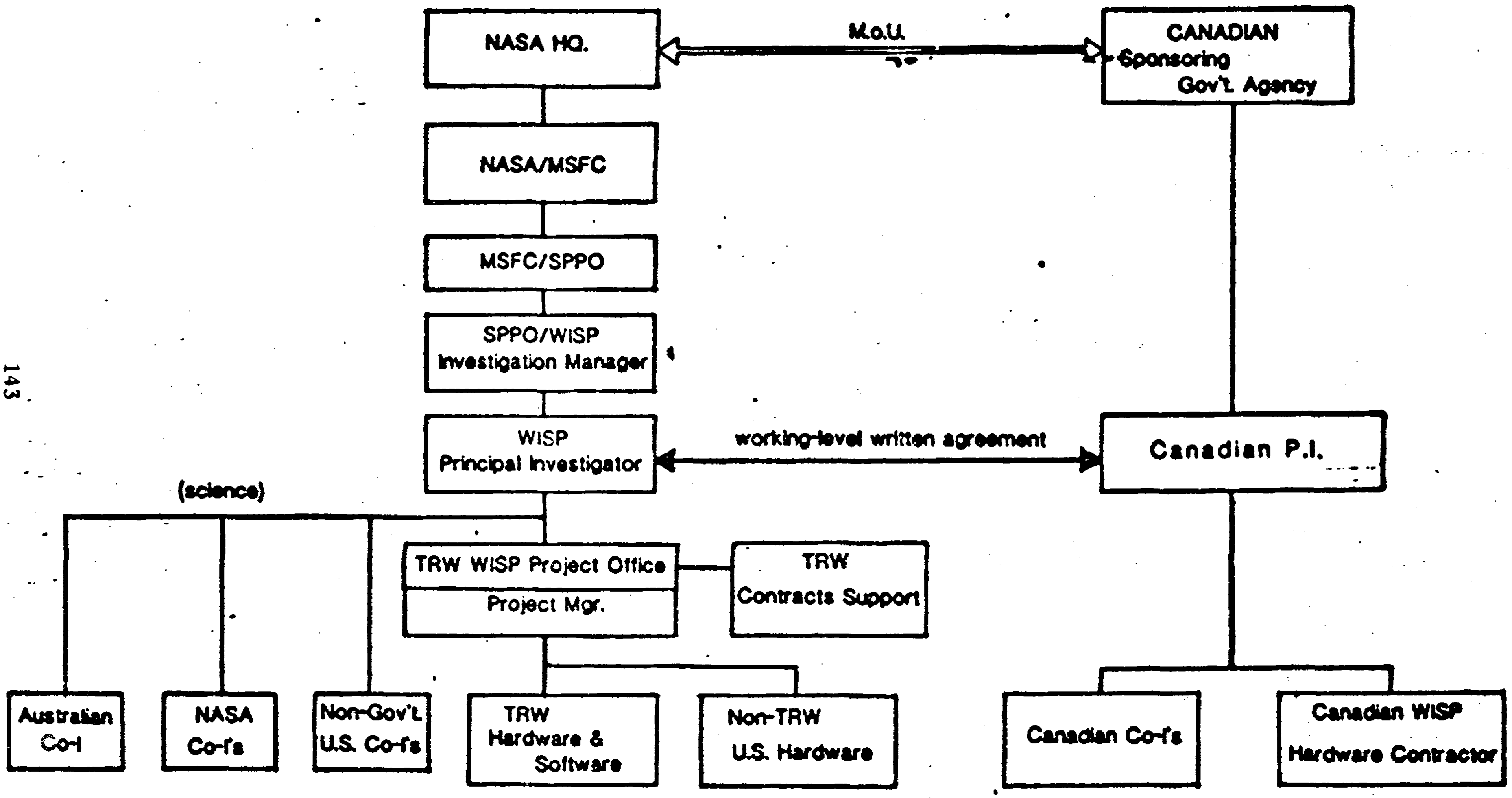
IONOSPHERIC BUBBLES

- HF, VHF REMOTE SOUNDING AND PROPAGATION

PLASMA WAVE PHYSICS

- LINEAR AND NON-LINEAR PLASMA PHYSICS IN SPACE
- ANTENNA-PLASMA INTERACTION STUDIES

WISP INVESTIGATION ORGANIZATION



CO-INVESTIGATOR RESPONSIBILITIES

TRW -Taylor (RPDP Co-I)

-plasma wave physics and wave/particle interactions

STANFORD - Helliwell and Katsufrakis

-VLF/ELF wave propagation and wave/particle interactions

U of IOWA - Shawhan (RPDP P.I.)

-plasma wave physics and wave/particle interactions

NASA/MSFC - Reasoner (RPDP Co-I)

-plasma diagnostics & wave/particle interactions

PINY - Gross

-Traveling ionospheric disturbances and gravity waves

NASA/GSFC - Benson

-Equatorial bubbles and plasma wave physics

SAO - Grossi

HF & VHF wave propagation and traveling ionospheric disturbances

NASA/JSC - Garriott

-antenna impedance and wave/particle interactions

LaTrobe Univ. (Australia) - Dyson

-equatorial bubbles and simultaneous ground-based measurements

Lockheed - Calvert

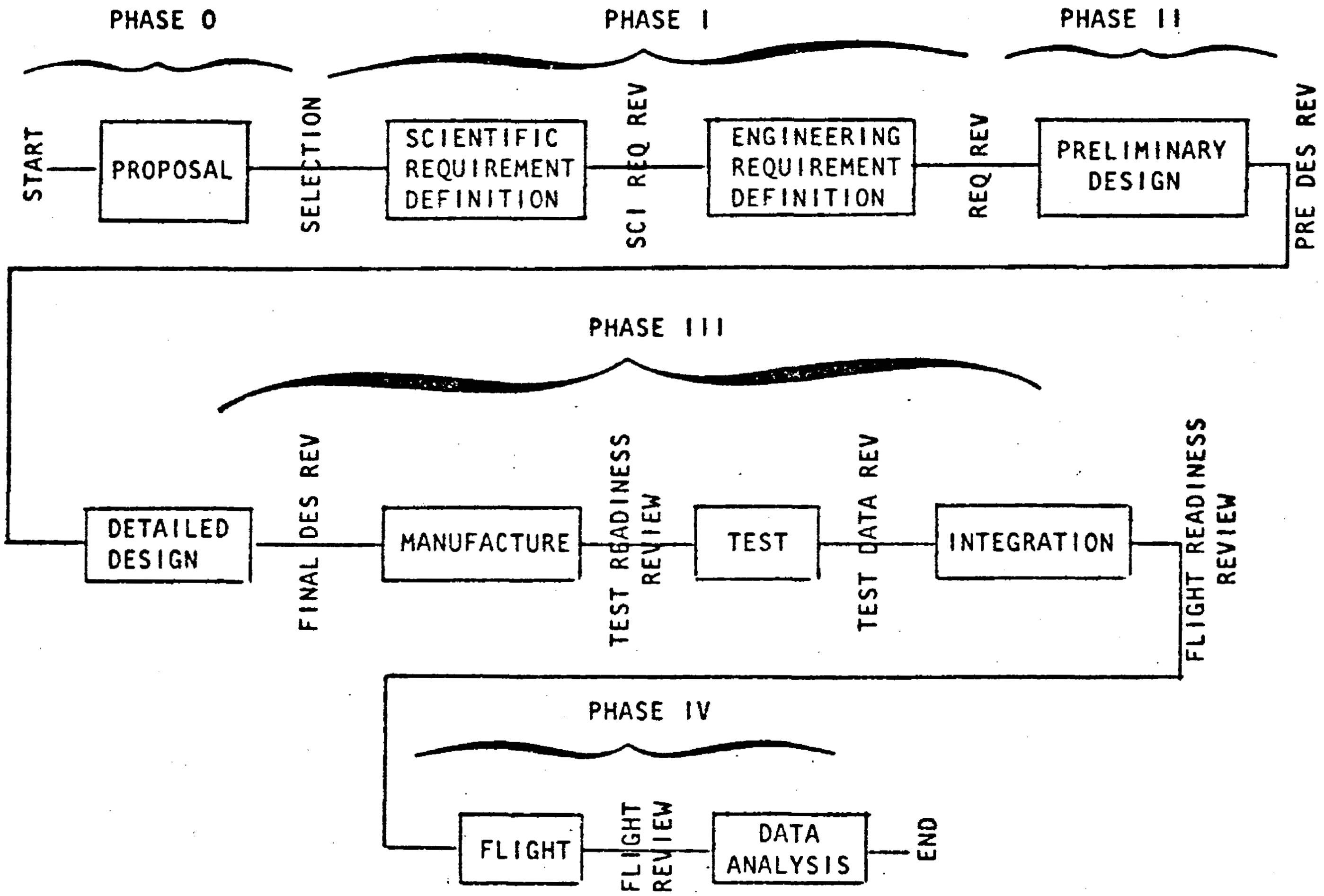
-plasma wave physics in HF regime
-CORE microprocessor definition

SYSTEMS GROUP RESEARCH STAFF

WISP

WISP PROJECT
LIFE CYCLE

TRW
DEFENSE AND SPACE SYSTEMS GROUP



SYSTEMS GROUP RESEARCH STAFF

WISP EQUIPMENT FOR FIRST FLIGHT

TRW DEFENSE AND SPACE SYSTEMS GROUP

	Flight 1	2	3	4	5	6	7
Date (Calendar year) 19	82	83	84	85	85	86	86
Quarter	4	4	3	2	4	2	4
Equipment							
CORE (Common Operating Res'ch Equip.)	X	X	X	X	X	X	X
VLF Transmitter Subsystem	X	X	X			X	X
Extendible Antenna[1]	X	X	X	X	X	X	X
Recoverable Plasma Diagnostics Package (RPDP)	X	X	X	X	X	X	X
Phase 1 RPDP Instrumentation[2]	X	X	X			X	X
HF Sounder Receiver	X[3]		X[4]	X[4]	X[4]		
HF Sounder Subsystem[5]		X	X	X	X		
Phase 2 RPDP Instrumentation[6]		X	X			X	X
Special Display & Analysis Equip.[7]		X	X	X	X	X	X
Low Light Level TV		X	X			X	X
VHF Sounder Subsystem			X	X	X		
Power Amplifier, 20-40 db gain, 150-350 MHz				X	X		
Loop Transmitting Antenna						X	X
Tether System (conducting tether wire)						X	X

[1] 300 m tip-to-tip maximum length dipole pointed in ± Y_o directions.

[2] Step frequency receiver, electric field antenna, magnetic field antenna (loop), ion retarding potential analyzer, Langmuir probe, ion mass spectrometer.

[3] On Spacelab.

[4] On RPDP

[5] On Spacelab

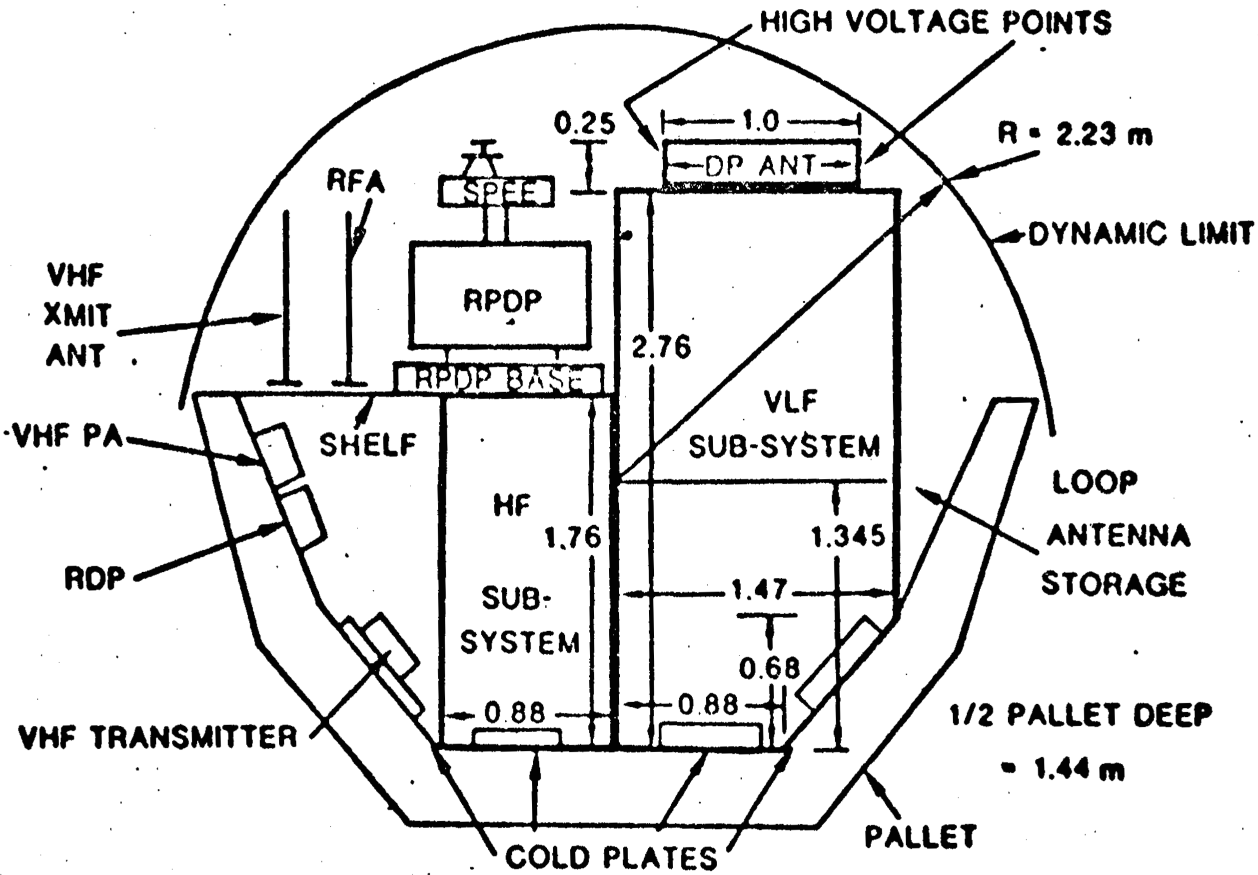
[6] Instrumentation added to RPDP: step frequency receiver, correlator, linear receiver, 2 electric field antennas, 2 magnetic field antennas (loop), quadrispherical low energy proton and electron differential energy analyzer.

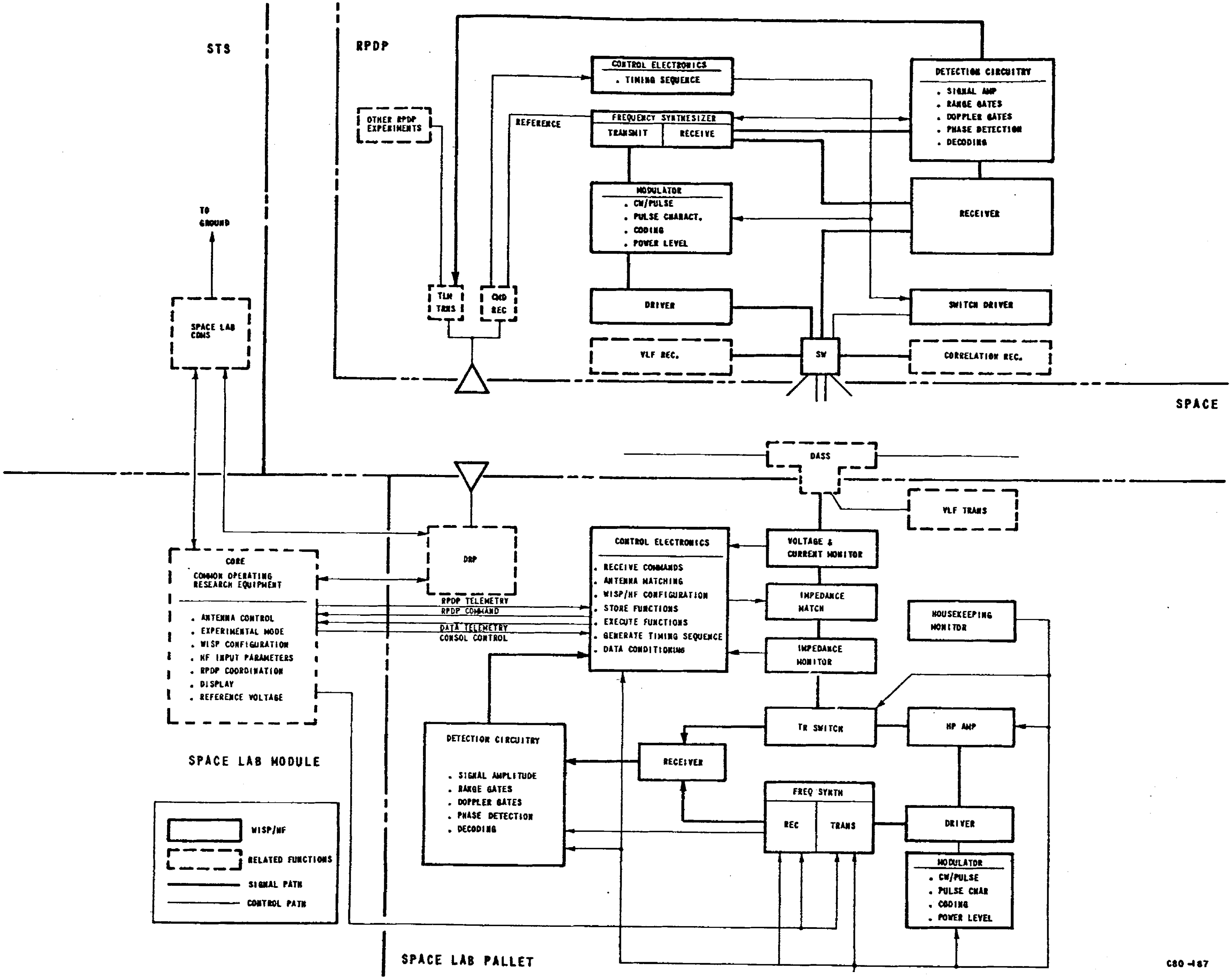
[7] Spectrum analyzer and oscilloscope with Z modulation and variable persistence.

WISP

NOMINAL SUBSYSTEM SIZES

AS OF DEC 22,1979





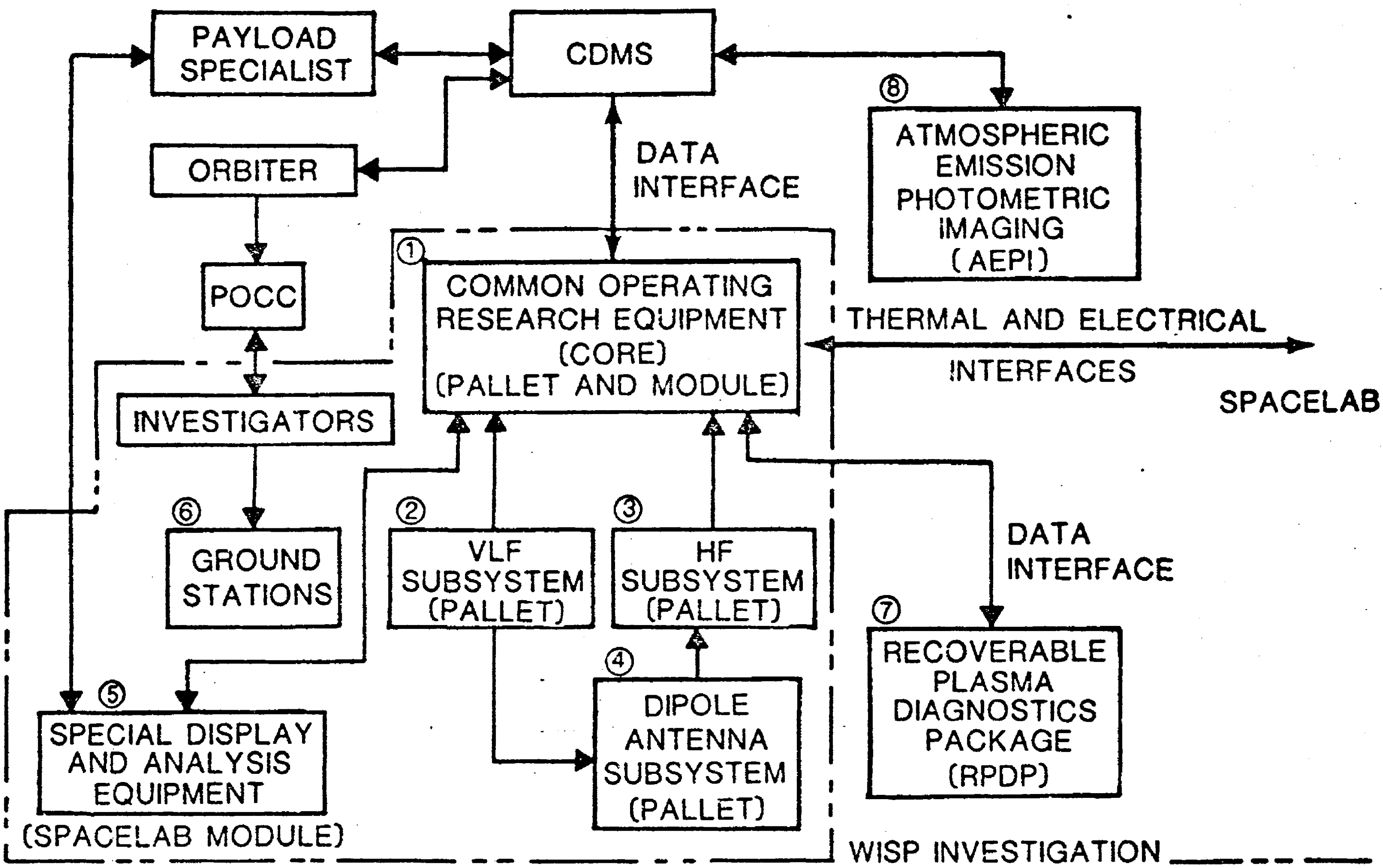
WISP/HF BLOCK DIAGRAM

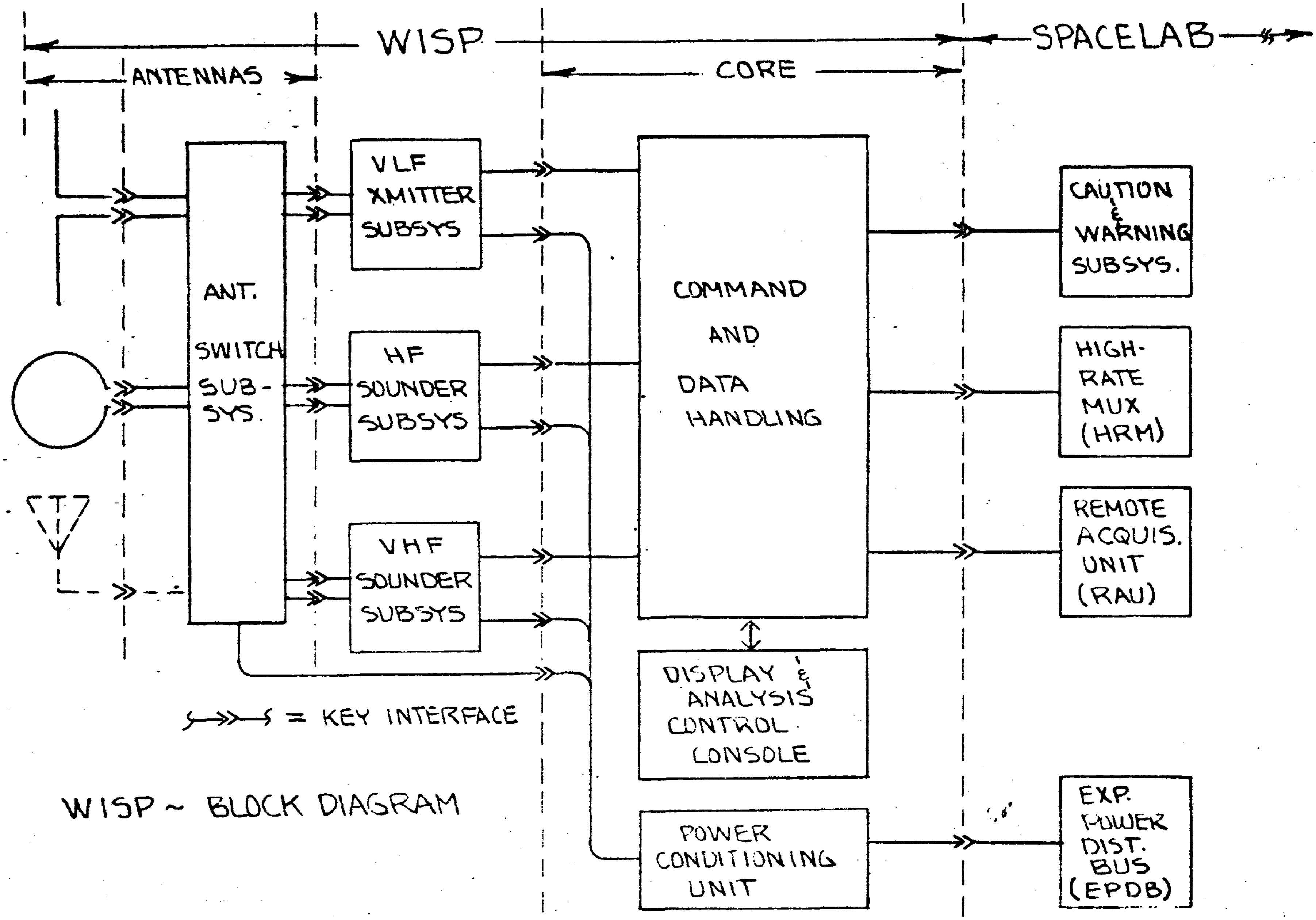
SYSTEMS GROUP RESEARCH STAFF

WISP

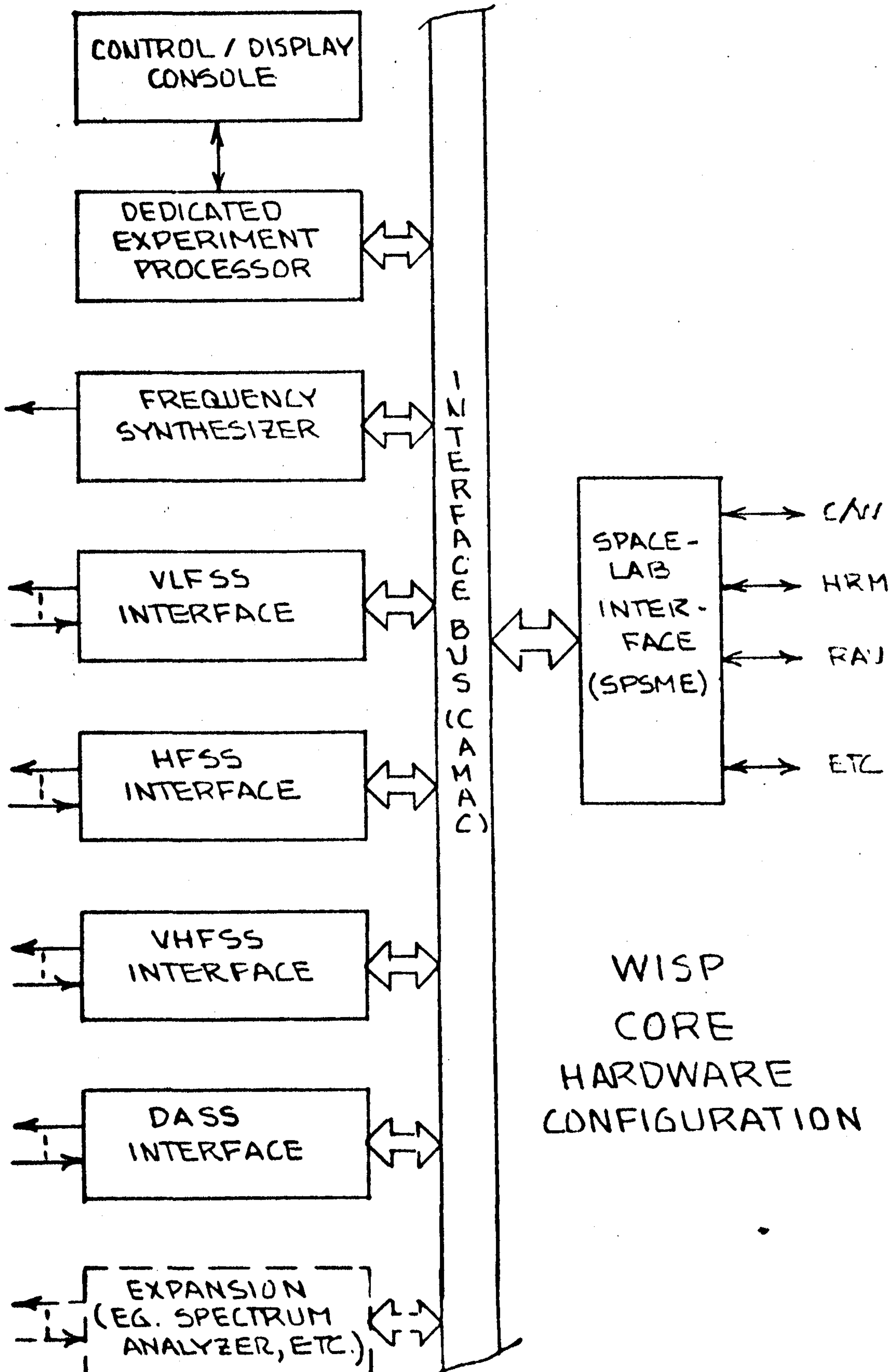
FUNCTIONAL BLOCK DIAGRAM OF INSTRUMENTATION

TRW DEFENSE AND SPACE SYSTEMS GROUP





WISP ~ BLOCK DIAGRAM



WISP CORE HARDWARE CONFIGURATION

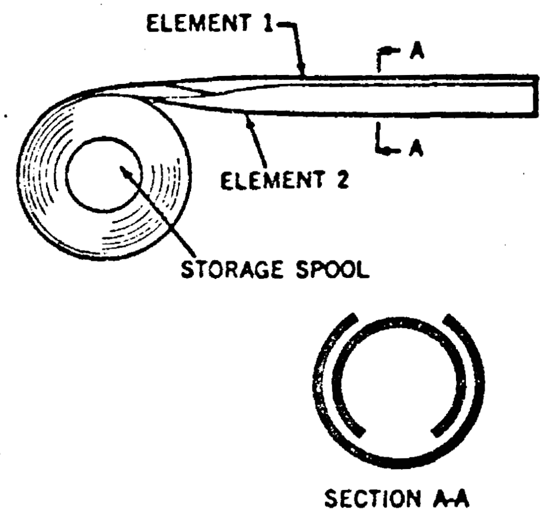
152

BASIC ANTENNA

- Bi-Stem by Astro
- Nominal length- 300 m tip-to-tip

TRADEOFF STUDY REQUIRED

- Three options identified
  - -Bare Bi-Stem from bay
  - -Bi-Stem with insulating sleeve from bay
  - -Bare Bi-Stem from Astromast
- Analysis Required
  - -Dynamics
  - -Thermal
  - -Electrical
  - -Safety
- Decision by end of Phase 1



BI-STEM

WISP

DIPOLE ANTENNA SUBSYSTEM
DASS

FUNCTIONS

- MECHANICALLY HOLDS DIPOLE ELEMENTS
- PLACED HIGH IN BAY TO EXTEND ELEMENTS OVER BAY DOORS
- ELECTRICALLY ISOLATE ELEMENTS AND GROUND

PROBLEMS

- CONFIGURATION -- MAST NEEDED?
- RADIATED EMI -- EXEMPTION NEEDED?
- DYNAMICS -- STUDY NEEDED (BY MSFC)?

VLF WAVE INJECTION EXPERIMENTS

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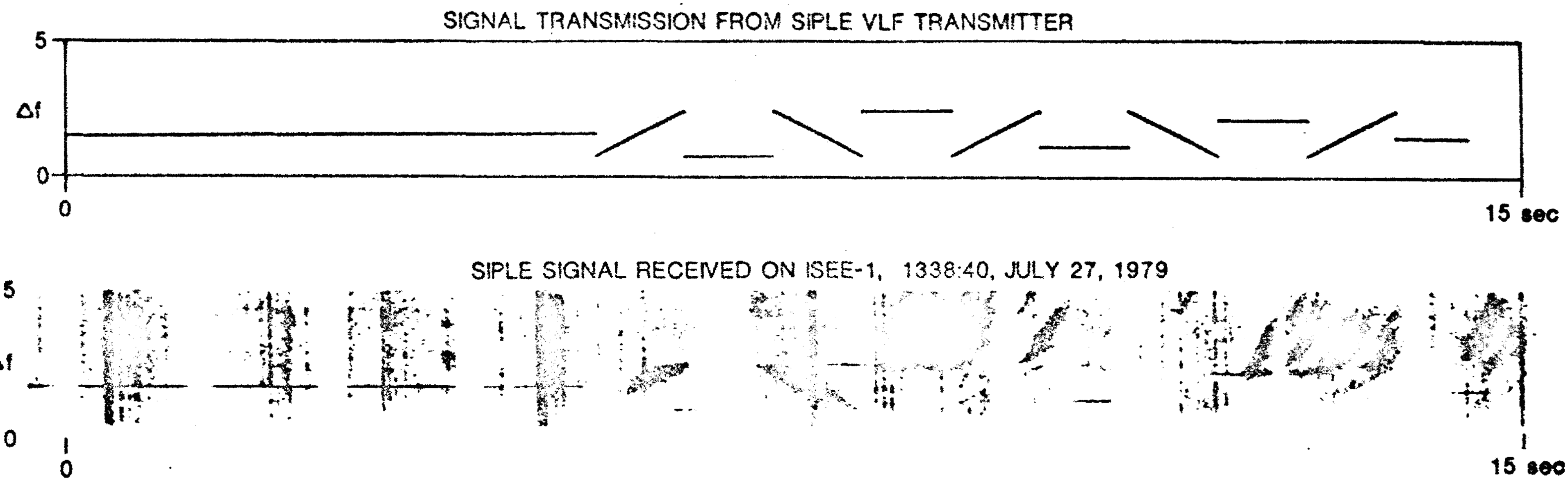
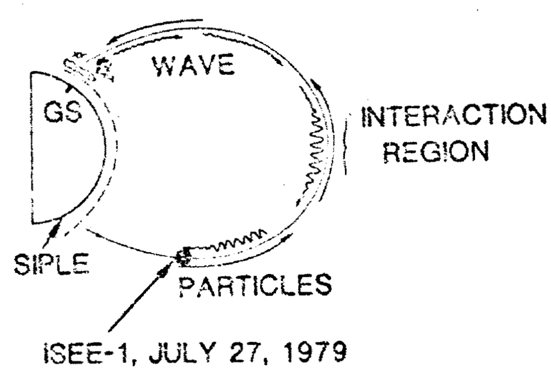
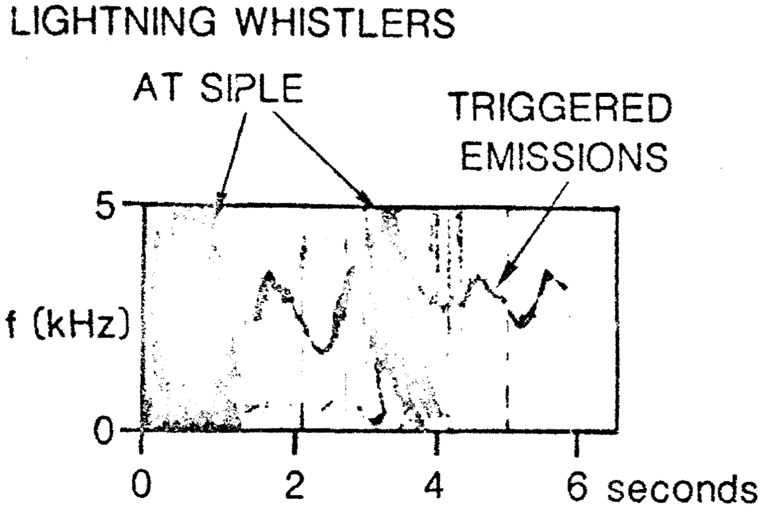
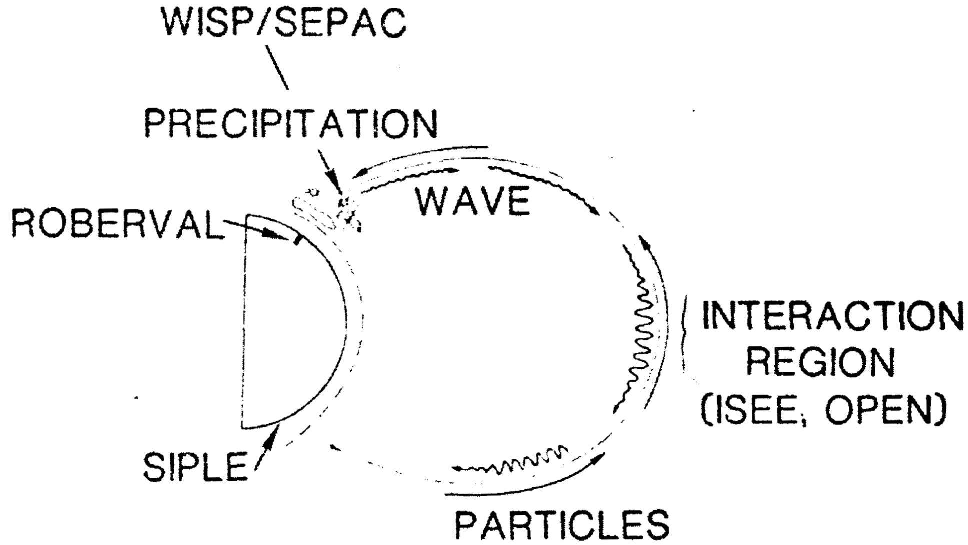
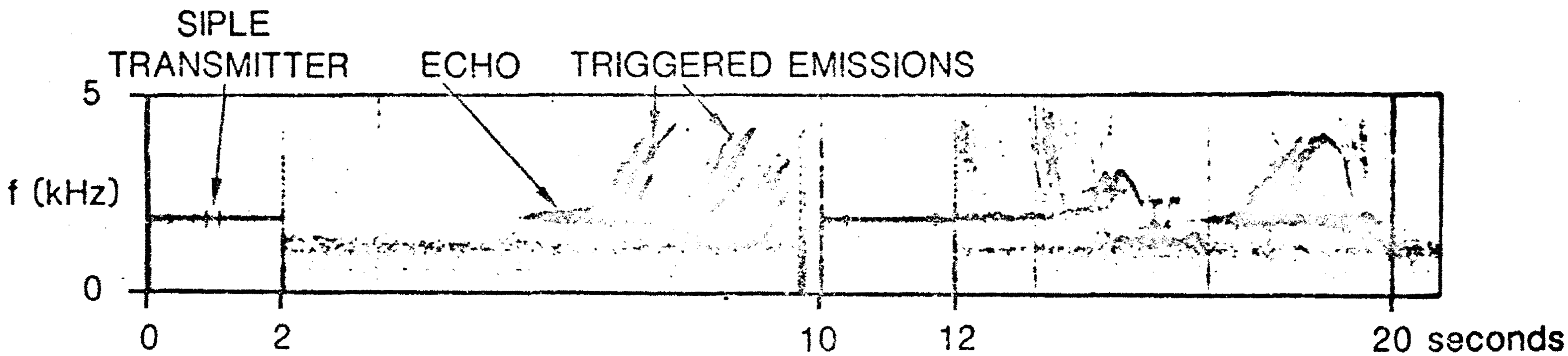

SIGNAL TRANSMISSION FROM SIPLE VLF TRANSMITTER
5
Δf
0
0
15 sec
SIPLE SIGNAL RECEIVED ON ISEE-1, 1338:40, JULY 27, 1979
5
Δf
0
0
15 sec


WAVE
GS
INTERACTION
REGION
SIPLE
PARTICLES
ISEE-1, JULY 27, 1979



1220 UT, JULY 3, 1973, SIPLE STATION





1137 UT, JULY 26, 1977, SIPLE STATION

SYSTEMS
GROUP
RESEARCH
STAFF

WISP

FIRST TEAM MEETING

OBJECTIVES

TRW
DEFENSE AND SPACE SYSTEMS GROUP

FUNCTIONAL OBJECTIVES AS REQUIRED BY ERD

- UNDERSTAND CONTENT REQUIRED
- UNDERSTAND FO SCIENTIFIC REQUIREMENTS
- REDUCE TO COMMON FORMAT

HARDWARE

- DESCRIBE WISP SUBSYSTEM CONCEPTS
- DESCRIBE OTHER INSTRUMENTATION

ANTENNA IMPEDANCE

- REVIEW AND DISCUSS QUESTION

INTERFACES

- DISCUSS CONCEPTS AND OPTIONS
- MAKE DECISIONS OF PHILOSOPHY

FUNCTIONAL OBJECTIVES - OUTLINE

CATEGORY, NUMBER, TITLE, AUTHOR/RESPONSIBILITY

CATEGORY I - ENGINEERING [FO 1-9]

FO No.	Short Title	Author/Responsibility
FO 1	System Configuration and Activation	TRW
FO 2	System Checkout (all WISP Systems ON except H.V.)	TRW, Collins, Spar
FO 3	VLFSS Checkout (FO 2, except VLFSS H.F. ON and transmitter power dumped to antenna simulator)	Collins
FO 4	HFSS Checkout (FO 2, except HFSS H.V. ON and transmitter power dumped to antenna simulator)	Spar
FO 5	Antenna extension or retraction	TRW, MSFC
FO 6	VLFSS Interference Tests (FO 3, except power to antenna); secondary objective: measure Z_A, propagation	Collins, TRW
FO 7	HFSS Interference Tests (FO 4, except power to antenna); secondary objective: measure Z_A propagation	Spar
FO 8	Antenna Deflection Determination	Garriott, TRW
FO 9	Standby Procedure	TRW, Collins, Spar

CATEGORY II - VLFSS, WAVE PARTICLE INTERACTIONS [FO 10-19]

FO 10	Survey of Growth and Triggering	Stanford
FO 11	Detailed Properties of Triggered Emissions (3 or 4 parts)	Stanford
FO 12	Power Line Radiation Simulation	Stanford
FO 13	Induced Particle Precipitation	Stanford
FO 14 . . FO 19	TBD	Stanford, Investigators

CATEGORY III - VLFSS, WAVE PROPAGATION [FO 20-29]

FO 20	Dipole Radiation Pattern for Characteristic Wave Modes; 1 - Whistler Mode	James
FO 21 . . FO 26	TBD	Stanford, Investigators

CATEGORY III (Cont'd)

FO 27	Field-Aligned VLF Ducts; (a) Siple-to-WISP and (b) WISP-to-Siple	Stanford
FO 28	WISP-to-Ground Beacon Mode	Stanford
FO 29	Plasmapause VLF Propagation	Stanford

CATEGORY IV - VLFSS PLASMA PHYSICS [FO 30-39]

FO 30	Auroral Kilometric Radiation	Stanford
FO 31 . . FO 39	TBD	Stanford, Investigators

CATEGORY V - VLFSS, RESERVED [FO 40-49]

FO 40 . . FO 49	TBD, Reserved for VLFSS	Stanford, Collins, TRW, Investigators

CATEGORY VI - HFSS, LARGE-SCALE STRUCTURES [FO 50-69]

FO 50	Determine the field-aligned electron density distribution from ducted echoes	Benson
FO 51	Determine the length and stability of field-aligned bubbles by obtaining nearly continuous conjugate echoes while in a ducting region	Benson
FO 52	Determine transverse size of density irregularities within a bubble by obtaining multiple near-end ducted echoes	Benson
FO 53	Determine the electron density at the apex of a field-lined density irregularity by obtaining Z-mode ducted echoes.	Benson
FO 54	Determine the extent of the bottomside density depletion from ground echoes	Benson
FO 55	Determine the changes in the total electron density content between Spacelab and the subsatellite as a bubble region is transversed	Benson
FO 56	Determine background neutral temperature, composition, and wind as well as background plasma temperature, composition and drifts.	Benson
FO 57	Determine AGW and TID wave characteristics, i.e., wave amplitude, phase, angular frequency, and wave vector	Benson

CATEGORY VI (Cont'd)

FO 58	Study the interdependence of AGW's and TID's	Benson
FO 59	Study the source regions of the AGW's and TID's from among the sources: magnetosphere, auroral region, equatorial region, stratosphere-mesosphere, and troposphere	Benson
FO 60	Equatorial Bubbles, Spread F, HF Ducts and Scintillation	Dyson
FO 61	Small Amplitude Discrete Irregularities at the Equator	Dyson
FO 62	Gravity Waves and TID's (HFSS, VHFSS)	Dyson
FO 63	Mid-Latitude Spread F (VHFSS)	Dyson
FO 64	Measurement of Large-Scale Wave Structures in the Ionosphere	Gross
FO 65	Large-Scale Disturbance Structures	Gross
FO 66	Relationships between Wave Structures and Field-Aligned Irregularities	Gross
FO 67	Source Regions for Large-Scale Structures	Gross
FO 68 . . FO 69	TBD	HF Investigators

CATEGORY VII - HFSS, WAVE PROPAGATION [FO 70-89]

FO 70	Determine the resonance cone structures in the antenna radiation pattern as a function of antenna length	Benson
FO 71	Determine the characteristics of the ionospheric irregularities that give rise to the greatest scattering of whistler and Z-mode signals	Benson
FO 72	Determine the optimum ducting conditions for X, O, Z, and whistler mode signals	Benson
FO 73	Determine the efficiency of wave mode coupling between the Z and O modes	Benson
FO 74	Propagation of Plasma Waves (HFSS)	Taylor
FO 75 . . FO 79	TBD	HF Investigators

CATEGORY VIII - HFSS, PLASMA PHYSICS [FO 80-109]

FO 80	Determine the characteristics of the f_H resonance as a function of stimulating conditions	Benson

CATEGORY VIII (Cont'd)

FO 81	Identify nonlinear wave processes including ion modulation effects on electron plasma waves	Benson
FO 82	Determine the stability of nf_H waves	Benson
FO 83	Determine the domain of stimulated temperature anisotropies	Benson
FO 84	Isolate nonlinear plasma wave processes from instrumental effects, plasma sheath effects and other spacecraft plasma perturbations	Benson
FO 85	Identify the cause of the "floating" nature of some resonances	Benson
FO 86	Explain electrostatic wave propagation phenomena such as the disappearance of the $3f_H$ echo when $f_N/f_H = 4$	Benson
FO 87	Determine the electrostatic to electromagnetic fraction of energy emitted from the antenna under different resonant conditions	Benson
FO 88	Determine electron-beam wave generation in ambient plasma for beam propagation quasi-parallel to magnetic field	Benson
FO 89	Determine electron-beam wave generation in ambient plasma for beam propagation quasi-perpendicular to magnetic field	Benson
FO 90	Determine electron-beam wave generation in ambient plasma for beam oblique propagation	Benson
FO 91	Determine electron-beam wave generation in ambient plasma driven to high anisotropy levels by HFSS/VHFSS for beam propagation quasi-parallel to magnetic field	Benson
FO 92	Determine electron-beam wave generation in ambient plasma driven to high anisotropy levels by HFSS/VHFSS for beam propagation quasi-perpendicular to magnetic field	Benson
FO 93	Determine electron-beam wave generation in ambient plasma driven to high anisotropy levels for oblique beam propagation	Benson
FO 94	Linear Impedance Dependence on Dipole Length	Balmain
FO 95	Linear Impedance Dependence on Dipole Orientation	Balmain
FO 96	Linear Impedance Dependence on Dipole D.C. Bias	Balmain
FO 97	Nonlinear Impedance Dependence on CW Power Level	Balmain

CATEGORY VIII (Cont'd)

FO 98	Linear CW Near-Field Evolution with Distance	Balmain
FO 99	Nonlinear CW Near-Field Evolution with Distance	Balmain
FO 100	Resonance Sounding	James
FO 101	Resonance Interactions using RPDP Diagnostics	Reasoner
FO 102	Stochastic Heating of Plasma and Nonlinear Effects near the Antenna using RPDP Diagnostics	Reasoner
FO 103 . . FO 109	TBD	HF Investigators

CATEGORY IX - HFSS, RESERVED [FO 110-129]

FO 110 . . FO 129	TBD, Reserved	Investigators

CATEGORY X - VHFSS, GENERAL [FO 130-139]

FO 130	VHF Determinations of Coupled Neutral and Ionospheric Turbulence	Grossi, Gross
FO 131	See FO 62	
FO 132	See FO 63	
FO 134 . . FO 139	TBD	Investigators

CATEGORY XI - MISCELLANEOUS [FO 140-149]

FO 140 . . FO 147	TBD	TRW, Collins, Spar
FO 148	System Activation	TRW, Collins, Spar
FO 149	Configuration for Return	TRW, Collins, Spar

WISP ACTIVE EXPERIMENT INTERACTIVE MATRIX

AUTHOR	FO No	WISP SS	RPDP	SEPAC	CRM	AEPI	MMP	EIMS	WAMDII	ALAE	ISO	ENAP	TRS	
DYSON	T-1	HFSS	X											
TAYLOR	T-2	VLFSS												
STANFORD	T-3	VLFSS	X											GROUND STATIONS
	T-4	"												"
	T-5	"	X											"
	T-6	"												"
	T-7	"	X											"
	T-8	"	X											"
	T-9	"												"
	T-10	"	X											
DYSON	T-11	HFSS	X											VHFSS
BENSON	T-12	HFSS												
	T-13													
	T-14													
	T-15													
	T-16													
	T-17													
	T-18													
	T-19													
	T-20													
	T-21													
DYSON	T-22	HFSS												
	T-23													
	T-24													
DYSON	T-25	HFSS												
GROSS	T-26	HFSS												

WISP ACTIVE EXPERIMENT INTERACTIVE MATRIX

AUTHOR	FO No	WISP SS	RPDP	SEPAC	CRM	AEPI	MMP	EIMS	WAMDII	ALAE	ISO	ENAP	TRS
GROSS	T-27	HFSS	X										
	T-28		X										
	T-29		X										
	T-30		X										
	T-31		X										
	T-32		X										
	T-33		X										
GROSS	T-34	VHF	X										
TAYLOR	T-35	HFSS	X										
TAYLOR	T-36	HFSS	X										
GROSSJ	T-37	VHFSS	X										
GARRIOTT	T-38		X	X									
JAMES	T-49	HFSS	X										
	T-50		X										
	T-51		X										
	T-52		X										
	T-53		X										
	T-54		X										
	T-55		X										
	T-56		X										
McNAMARA	T-57	HFSS	X										
	T-58		X										
	T-59		X										
MOORCROFT	T-64	HFSS	X										
	T-65		X										
	T-66		X										

WISP ACTIVE EXPERIMENT INTERACTIVE MATRIX

AUTHOR	FO No	WISP SS	RPDP	SEPAC	CRM	AEPI	MMP	EIMS	WAMDII	ALAE	ISO	ENAP	TRS
MOORCROFT	T-67	HFSS	X										
MULDREW	T-68	HFSS	X										
MULDREW	T-69		X										
	T-70		X										
	T-71		X										
	T-72		X										
	T-73												
	T-74		X										
	T-75		X										
BALMAIN	T-76	HFSS											
	T-77												
	T-78												
	T-79	HFSS/VLFSS				X							
	T-80	HFSS	X										
	T-81												
	T-82												
	T-83												
	T-84					X							
	T-85		X										
McNAMARA	T-86	HFSS	X										
MULDREW	T-87	HFSS	X										
REASONER	T-88	VLFSS	X										
	T-89	HFSS	X										

RML
RML

WISP SCIENTIFIC OBJECTIVES:

-depend on energizing antenna to high voltages

-study of the plasma response and loading

PREVIOUS DISCUSSIONS:

-Bob Blount/JSC

-narrow band emissions higher than spec are required by WISP

-

PROBLEM:

-fear that induced voltages or currents will affect avionics

SOLUTION:

-increase experimental power levels gradually and monitor the avionics

PROCEDURE:

-request appropriate waiver from STS operator

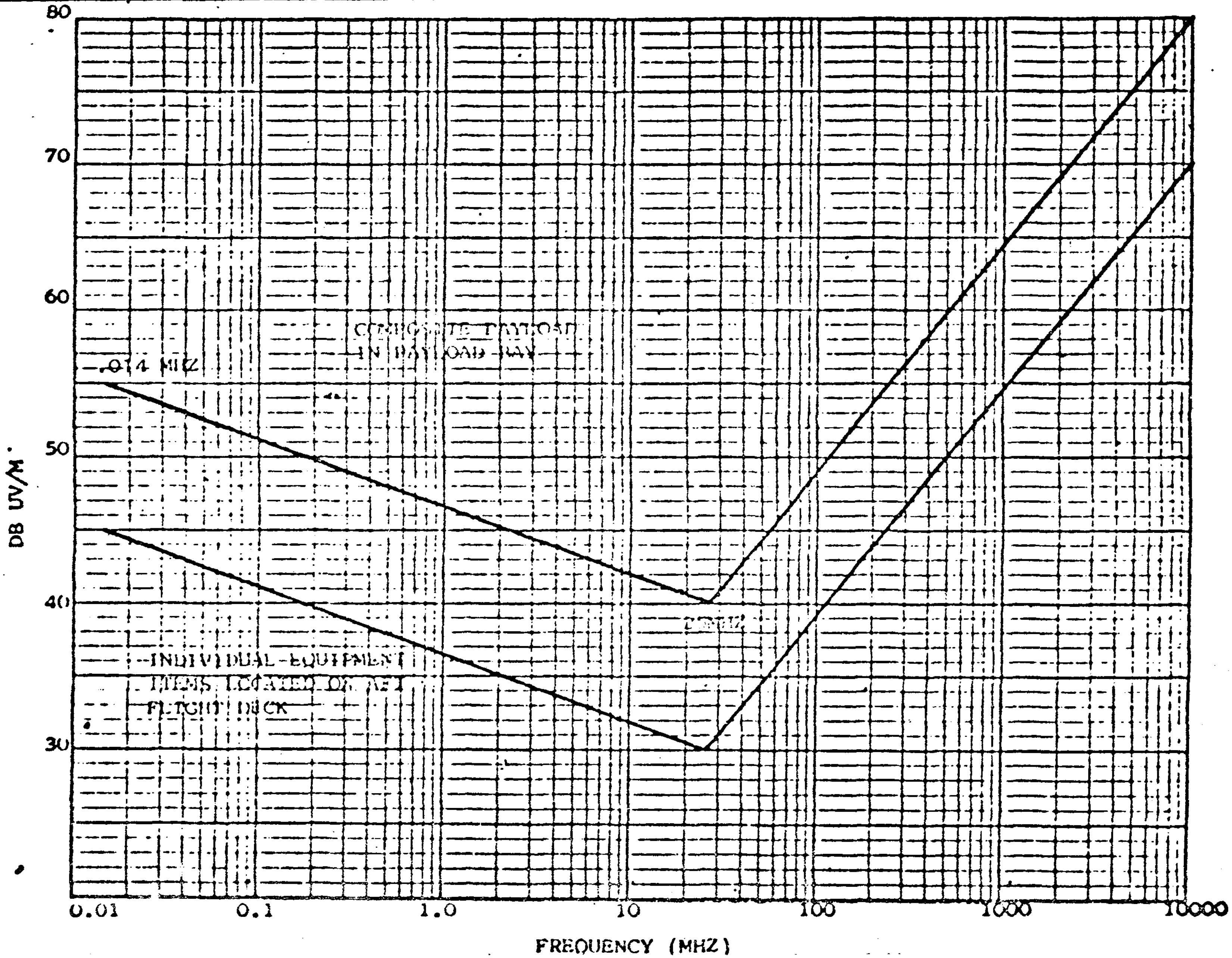
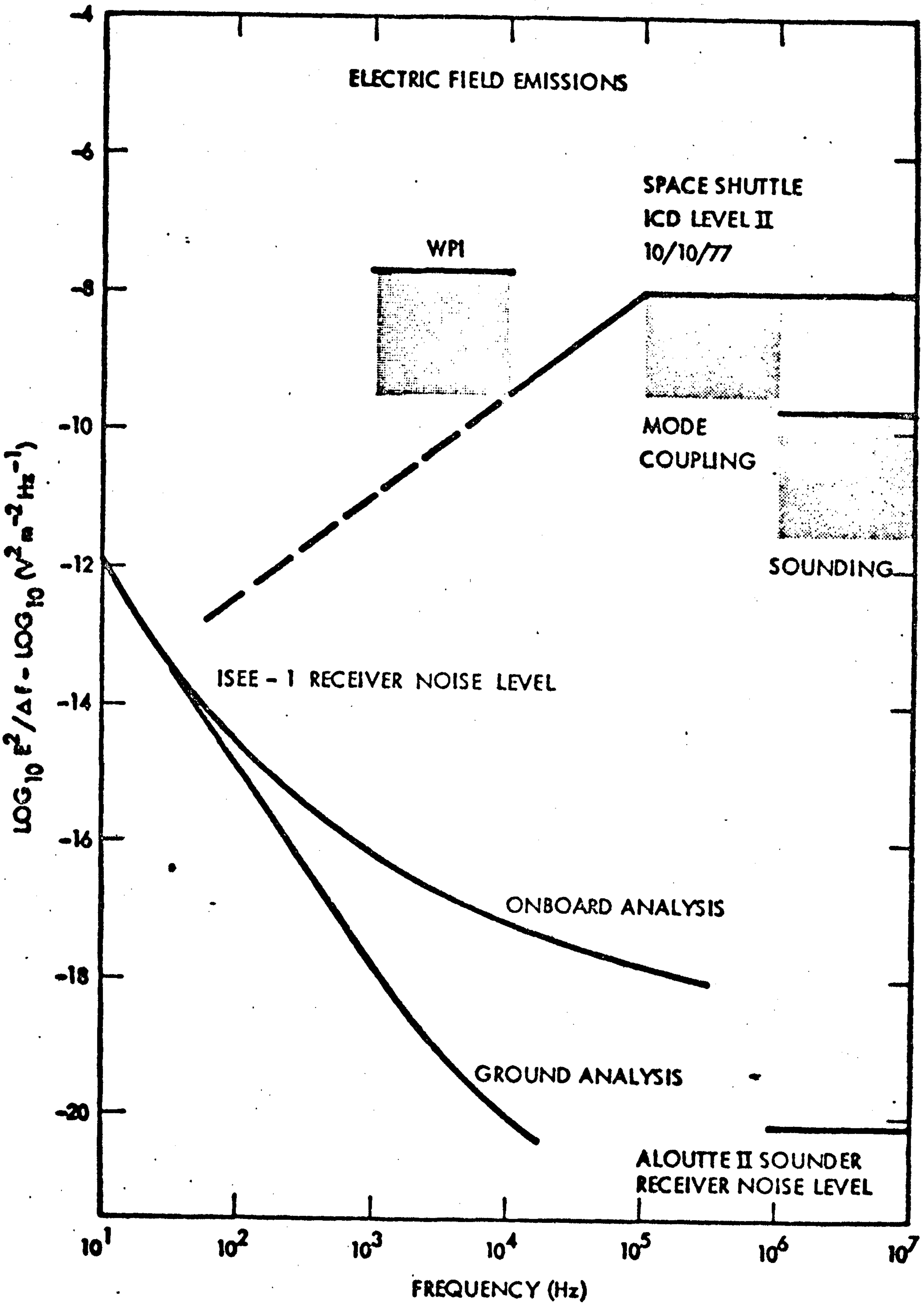
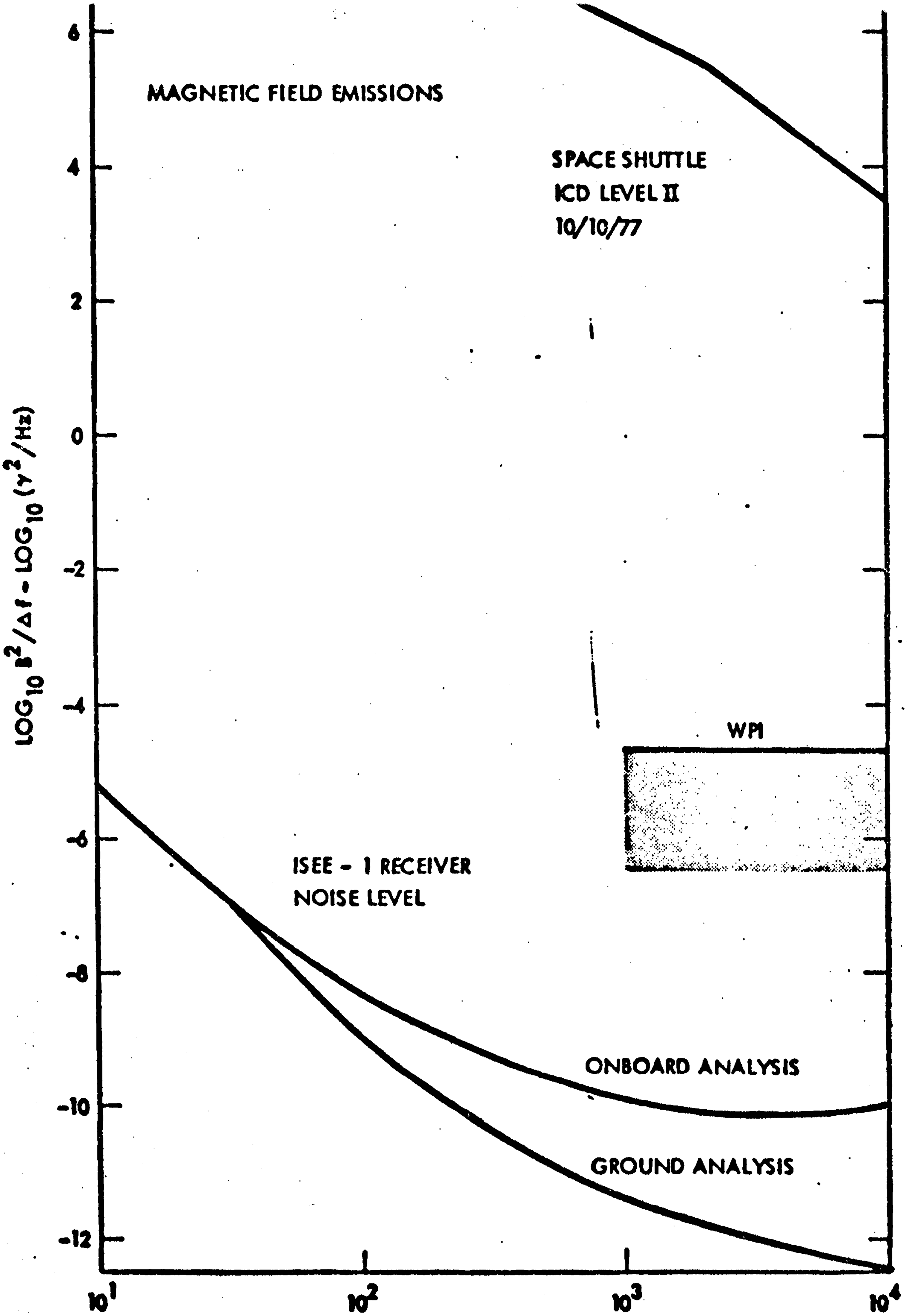


FIGURE 10.7.3.2-2 CARGO ALLOWABLE RADIATED NARROWBAND EMISSIONS


ELECTRIC FIELD EMISSIONS
SPACE SHUTTLE
ICD LEVEL II
10/10/77
WPI
MODE
COUPLING
SOUNDING
ISEE - 1 RECEIVER NOISE LEVEL
ONBOARD ANALYSIS
GROUND ANALYSIS
ALOUTTE II SOUNDER
RECEIVER NOISE LEVEL
-4
-6
-8
-10
-12
-14
-16
-18
-20
$LOG_{10} E^2/\Delta f - LOG_{10} (V^2 m^{-2} Hz^{-1})$
10^1
10^2
10^3
10^4
10^5
10^6
10^7
FREQUENCY (Hz)


MAGNETIC FIELD EMISSIONS
SPACE SHUTTLE
ICD LEVEL II
10/10/77
WPI
ISEE - 1 RECEIVER
NOISE LEVEL
ONBOARD ANALYSIS
GROUND ANALYSIS
LOG10 B2/Δf - LOG10 (γ2/Hz)
6
4
2
0
-2
-4
-6
-8
-10
-12
10^1
10^2
10^3
10^4