Plasma Interactions Monitoring System

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The plasma environment around the space station is expected to be different from that environment which occurs naturally at these altitudes because of the unprecedented size of the space station, its orbital motion, and its high power distribution system. Although there are models which predict the environment around the station, they do not take into account changes in configuration, changes in the natural and induced environments, nor interactions between the different environments.

There will be unique perturbations associated with the space station, which will vary as the space station is being developed. Even after the developed space station has been completed environmental conditions will change as the payloads are changed and as the station systems and materials undergo degradation and modification.

Because the space station will be a point of many varied activities the environment will continually undergo perturbations from effluents resulting from operations of the reboost module, EVA, airlock operations, and vacuum venting. The use of the Mobile Service Center will cause disturbances which cannot, at this time, be predicted. In addition, the operations of attached payloads, (e.g. ASTROMAG) themselves will undoubtedly cause perturbations to the ambient environment. Finally, the natural environment will change as a result of natural perturbations such as solar flares and geomagnetic storms.

To respond to the need to study and understand the space station environment and its variability, a Plasma Interactions Monitoring System (PIMS) shown in Figure 1 has been proposed. The objectives of the PIMS are threefold. First, the PIMS will contain the instrumentation needed to monitor the plasma interactions with the space station and its system (e.g. the power system) to determine the effects of these interactions on the user environment, and on system efficiencies and lifetimes. Second, the data from the PIMS measurements will be used to develop an environmental data base to be used by attached payload developers. This data base will define the "background environment" around the station the resulting perturbations by natural and induced events and activities. Finally, the PIMS will perform those plasma measurements needed to verify the space station environmental specifications (e.g. EMI Control Process Requirements JSC 30326, Plasma Effects Control Process Requirements JSC 30252, External Contamination Control Requirements JSC 30426, etc.).

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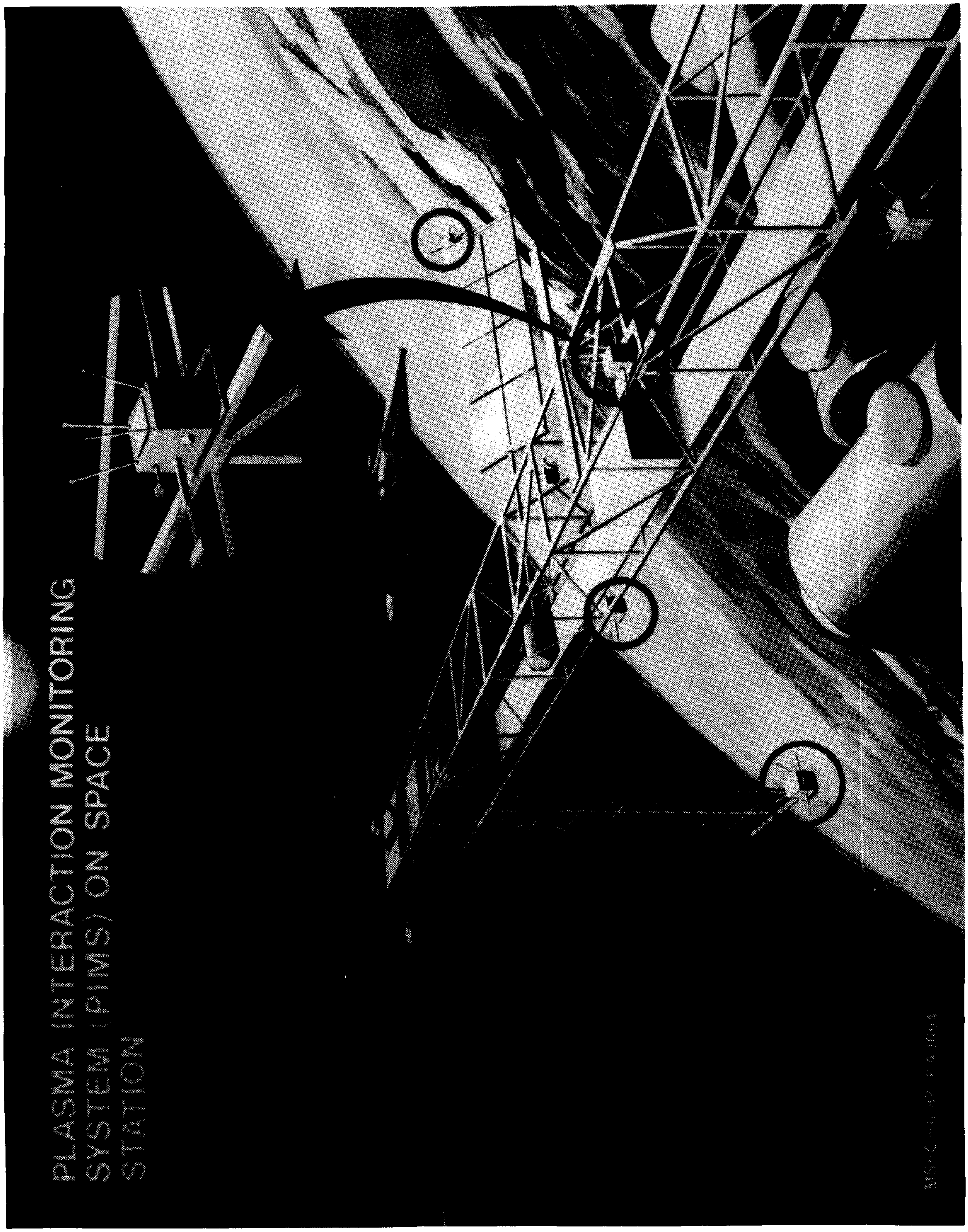

Figure 1. The Plasma Interaction Monitoring System (PIMS).

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In order to carry out these objectives it will be necessary to perform measurements of the plasma and field environment at multiple points around the space station. These measurements will be taken at "critical points" to allow the development of a dynamic space station environmental model.

Early in 1988 a PIMS Study Team was formed to define the environmental measurements required, the instruments needed to perform these measurements, and to specify the required placement of the PIMS units and instruments. The team is comprised of experimentalists, theoreticians, modelers, and data specialists, in the fields of plasma physics and atmospheric science. The membership of the PIMS Study Team and their affiliations are given in Table I.

The PIMS Study Team has spent the past four months defining those particle and field measurements needed to characterize and model the space station environment and environmental extremes. It became evident at the outset of this study that, in order to understand the plasma environment, measurements of neutral densities and species would be required. Hence, a neutral mass spectrometer immediately became a required instrument. The current set of required PIMS instruments is given in Table II.

In addition to the prime instruments shown in Table II it was recently decided to add instruments to measure deposition rates and radiation dosimetry. These data would be carried as "housekeeping" to provide an assessment of prime instrument health and calibration. This "housekeeping" data could also be made available to others interested in deposition rate and radiation environment variability.

Placement of the PIMS units and instruments has been something of a problem because of the uncertainty regarding the accommodation provisions. The Space Station Program has deferred the decision to accommodate small payloads (such as PIMS) at "non standard attach points". Although we feel confident that the space station will eventually provide these accommodation capabilities, our efforts have nevertheless been hampered by the lack of definition of these accommodation provisions. We have been working with NASA space station personnel, and with all of the Work Package centers and contractors to develop the best understanding possible as to how payloads such as PIMS will be accommodated. Also, there is considerable uncertainty about payload accommodations outside the space station "alpha joints" (the gimbal system which rotates the solar panels at right angles to the transverse boom). The PIMS measurements are needed at these locations because they represent the space station "extremities". Also the measurements of fields near the solar panels are needed to detect arcing and other electrical discharges on and near the solar panels.

Table I

PLASMA INTERACTIONS MONITORING SYSTEM

STUDY TEAM MEMBERS

JOSEPH BARFIELD (CHAIRMAN)	SOUTHWEST RESEARCH INSTITUTE
JIM BURCH	SOUTHWEST RESEARCH INSTITUTE
GEORGE CARIGNAN	UNIVERSITY OF MICHIGAN
IRA KATZ	S-CUBED, MAXWELL LAB.
GERRY MURPHY	UNIVERSITY OF IOWA
RAY RANTANEN	SCIENCE AND ENGINEERING ASSOCIATES, INC.
JIM SULLIVAN	MASSACHUSETTS INSTITUTE OF TECHNOLOGY
BILL TAYLOR	TRW INC.
HUNTER WAITE	SOUTHWEST RESEARCH INSTITUTE
ELDEN WHIPPLE	UNIVERSITY OF CALIFORNIA AT SAN DIEGO
DAVID YOUNG	SOUTHWEST RESEARCH INSTITUTE

Table II

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PLASMA INTERACTIONS MONITORING SYSTEM

PRELIMINARY LIST OF CANDIDATE INSTRUMENT CHARACTERISTICS

PARAMETER	RANGE	PARAMETER	RANGE
ION COMPOSITION AND VELOCITY DISTRIBUTION	1 amu $\leq$ MASS $\leq$ 128 amu $10^3/CM^3 \leq$ DENSITY $\leq 10^8/CM^3$ $V_X, V_Y, V_Z \leq 8$ Km/sec	DC ELECTRIC FIELD AC ELECTRIC FIELD	$E_X, E_Y, E_Z \leq 10V/m$ 10^{-5} V/m $\leq E \leq$ 1V/m $f \leq 30$ MHz
ELECTRONS	$\leq$ 10 Kev $0^{\circ} \leq$ PITCH ANGLE $\leq 180^{\circ}$	DC MAGNETIC FIELD	$B_X, B_Y, B_Z \leq 1.0G$
THERMAL ELECTRONS	$10^4/CM^3 \leq$ DENSITY $\leq 10^8/CM^3$ $0.1ev \leq T_e \leq 1.0ev$	AC MAGNETIC FIELD	10^{-12} T $\leq B \leq 10^{-7}$ T $f \leq 30$ KHz
NEUTRAL GAS COMPOSITION AND VELOCITY DISTRIBUTION	1 amu $\leq$ MASS $\leq$ 128 amu $10^8/CM^3 \leq$ DENSITY $\leq 10^{14}/CM^3$ $V_X, V_Y, V_Z \leq 8$ Km/sec	PLASMA POTENTIAL	$\leq$ 100V

Measurements will be made in the vicinity of attach points since it is here that most attached payloads will reside. PIMS units will also be placed at critical points to measure backflow, scattering and other interactions with reboost thruster firings, airlock operations, and vacuum vent ports.

It is also highly desirable to have a PIMS unit on a standoff outside the primary wake and sheath effects to measure "space weather". These measurements are very important if one hopes to understand and model the induced interactive environment.

As the first phase of the PIMS definition study is nearing completion, the PIMS team is developing an instrument matrix which will show accommodation requirements for each instrument. An example of a partial PIMS matrix is shown in Table III. This matrix will be used in the follow on phase of the PIMS definition study which will address those support subsystems required by the PIMS instruments. The second phase of the PIMS definition study is scheduled to start in the fall of 1988.

During phase II we will define and conceptually design the command and data management subsystem, the electrical power distribution subsystem, the thermal control subsystem, the antenna and boom deployment fixtures. In addition, we plan to intensify our interactions with NASA space station personnel and contractors to penetrate the method of attachment and accommodations for power and data. We also plan to perform an integrated analysis of the PIMS units to determine instrument to instrument interactions. Finally, as design drivers are identified we will initiate trade studies to optimize the PIMS capabilities. These trade studies will primarily address instrument capabilities versus cost. We hope to initiate the PIMS design and development in FY 1990.

Table III

THIRD PIMS TEAM MEETING

PIMS INSTRUMENT MATRIX

INSTRUMENT	DIMENSIONS (cm)	MASS (kg)	POWER (watts)	DATA RATE (kbps)
NEUTRAL GAS COMPOSITION MASS SPECTROMETER (2 SPECTROMETERS)	2X (20 X 20 X 20)	20	30	2
NEUTRAL GAS TOTAL DENSITY GAUGE	10 X 10 X 10	1	1	0 - 0.1
AC/DC ELECTRIC/MAGNETIC FIELDS	20 X 20 X 18	5	5	LOW SPEED: 5 HIGH SPEED: TBD
ELECTRON SPECTROMETER (.01-10 KeV)	15 X 15 X 20	5	5	5
ION MASS SPECTROMETER (0-50 eV)	25 X 25 X 25	8	8	15
ION MASS SPECTROMETER (.01-10 KeV)	25 X 25 X 35	10	10	15
LANGMUIR PROBE	18 X 18 X 3	1	1	1