ATMOSPHERE MONITORING REQUIREMENTS

INSTRUMENTATION REQUIREMENTS DEPEND ON MONITORING NEEDS

WHAT IS THE ACTION PROTOCOL?

- WHAT ACTIONS CAN BE TAKEN?
- WHAT INFORMATION IS NEEDED?
- WHO DECIDES ON ACTION?

INFORMATION REQUIREMENTS

- COMPOUND TYPE
- QUANTITATION
- RATE OF BUILD-UP

SOURCES AND CAUSES OF ATMOSPHERIC CONTAMINATION

- SYSTEM DESIGN
- MATERIALS
- MALFUNCTIONS

ATMOSPHERE MONITORING REQUIREMENTS (CONT'D)

RESULTING ATMOSPHERIC CONDITIONS

- POSSIBLE COMPOUND TYPES
  - ORGANIC
  - INORGANIC
  - ANTICIPATED
  - STRANGERS
- TOXICITY RANGE
- CONTAMINANT MIXTURES
- DYNAMICS

WHAT CONSTITUTES ADEQUATE PROTECTION?

WHAT PRICE IS ACCEPTABLE?

- DOLLARS
- SPACECRAFT DEMANDS
- SYSTEM DEMANDS
- PROGRAM DEMANDS

INSTRUMENT REQUIREMENTS

PERFORMANCE	DEMANDS
COMPOUNDS	POWER
IDENTIFICATION	WEIGHT
DETECTION LIMIT	SIZE
DYNAMIC RANGE	CONFIGURATION
INTERFERENCES	INTERFACES
ANALYSIS TIME	DATA FORMAT
INFORMATION OUTPUT	OPERATOR INVOLVEMENT
ACCURACY	RELIABILITY
OPERATING MODES	MAINTAINABILITY

INSTRUMENTATION -- SINGLE DEVICES

GAS CHROMATOGRAPHY

- -- GOOD SENSITIVITY
- -- RELATIVELY SLOW
- -- BROAD COMPOUND COVERAGE
- -- GOOD MIXTURE CAPABILITY
- -- IDENTIFICATION NOT ASSURED
- -- STRANGERS CANNOT BE IDENTIFIED
- -- MODERATE SPACECRAFT DEMANDS
- -- RELATIVELY LOW COST
- -- FLIGHT HARDWARE EXPERIENCE

MASS SPECTROMETRY

- -- GOOD SENSITIVITY
- -- EXCELLENT SPEED
- -- BROAD COMPOUND COVERAGE
- -- GOOD MIXTURE CAPABILITY FOR KNOWN COMPOUNDS ONLY
- -- IDENTIFICATION LESS DEPENDENT ON CALIBRATION
- -- STRANGERS CAN BE IDENTIFIED IF ISOLATED
- -- REASONABLE SPACECRAFT DEMANDS DEPENDING ON CONFIGURATION
- -- MODERATE COST
- -- EXTENSIVE FLIGHT HARDWARE EXPERIENCE

INSTRUMENTATION -- SINGLE DEVICES (CONT'D)

OTHER SINGLE DEVICES

INFRA RED--

- NOT AS WIDELY USED
- GENERALLY LESS SENSITIVE
- MODERATE MIXTURE CAPABILITY

NON DISPERSIVE IR
CHEMILLUMINESCENT
ELECTROCHEMICAL
} SPECIFIC COMPOUNDS ONLY

INSTRUMENTATION -- TANDEM DEVICES

GAS CHROMATOGRAPH/MASS SPECTROMETRY

- -- WIDELY ACCEPTED FOR MIXTURE AND ATMOSPHERIC ANALYSIS
- -- PROVIDES MIXTURE SEPARATION AND POSITIVE IDENTIFICATION
- -- GOOD SENSITIVITY
- -- BROAD COVERAGE
- -- STRANGER IDENTIFICATION
- -- RELATIVELY SLOW
- -- MORE SIGNIFICANT SPACECRAFT DEMANDS
- -- EXPENSIVE
- -- FLIGHT HARDWARE EXPERIENCE

TANDEM MASS SPECTROMETRY (CID)

- -- POTENTIALLY FASTER THAN GCMS
- -- SOMEWHAT LESS SEPARATION CAPABILITY
- -- LESS PROVEN THAN GCMS
- -- LESS SUITABLE FOR RELIABLE, LONG TERM MONITORING
- -- SUBSTANTIAL SPACECRAFT DEMANDS
- -- NO FLIGHT HARDWARE EXPERIENCE

SPECIFIC COMPOUND ISSUES

MAJOR CONSTITUENTS:

-- N_2, O_2, H_2O, CO_2

-- MAY BE ADDRESSED EFFECTIVELY BY DIRECT MASS SPECTROMETRY

-- SHOULD BE A DEDICATED DEVICE

-- REQUIRES A DIFFERENT ANALYZER FOR OPTIMIZED PERFORMANCE

CARBON MONOXIDE:

-- DIFFICULT FOR GCMS

-- PROBABLY DESERVES A DEDICATED DEVICE

-- NDIR IS THE BEST APPROACH

-- ELECTROCHEMICAL MAY BE ACCEPTABLE

OTHER INORGANIC COMPOUNDS:

-- NO_x, SO_2, HALOGENS, ACIDS

-- SPECIAL PROBLEMS FOR GCMS

-- DEDICATED GC A POSSIBILITY

-- OTHER DEDICATED DETECTORS

ATMOSPHERE MONITORING EXPERIENCE

TWO GAS SENSOR DEVELOPMENT:
- 60 DAY MANNED CHAMBER TEST
- 90 DAY MANNED CHAMBER TEST
- OTHER APPLICATIONS

LABORATORY TRACE CONTAMINANT SENSOR:
- ACCUMULATOR CELL/MASS SPECTROMETER

CENTRAL ATMOSPHERE MONITORING SYSTEM -- CAMS MK I:
- MASS SPECTROMETRY OF MAJOR AND SELECTED CONSTITUENTS

CONTAMINANT AND ATMOSPHERIC SENSOR

FLIGHT TRACE CONTAMINANT SENSOR:
- CONCEPTUAL DESIGN OF FLIGHT ACCUMULATOR CELL/MS

SPACELAB TRACE GAS ANALYZER:
- GCMS BASED ON VIKING GCMS TECHNOLOGY
- UTILIZED ACCUMULATOR CELL TECHNOLOGY

CENTRAL ATMOSPHERE MONITORING SYSTEM -- CAMS MK II:
- MICROPROCESSOR CONTROLLED SCANNING MASS SPECTROMETER

TGA PROGRAM HISTORY

1975 BREADBOARD FEASIBILITY PROGRAM
1976 DATA SYSTEM DEVELOPMENT
1977 GCMS INTERFACE STUDIES
JAN 1978: INITIATED FLIGHT HARDWARE PROGRAM
AUG 1978: PRELIMINARY DESIGN REVIEW
AUG 1979: CRITICAL DESIGN REVEIW
JUN 1981: ENGINEERING TEST UNIT DELIVERED
JUL-SEPT 1981: ETU EVALUATION AT NASA/JSC
OCT 1981: ETU RETURNED FOR MODS
FEB 1982: QUAL UNIT DESIGN COMPLETED
APR 1982: PROGRAM CANCELLED

SPACELAB PREMISES

TRACE CONTAMINANT MONITORING ORIGINALLY REQUIRED

NECESSARY DUE TO:

- REDUCED MATERIAL TESTING
- LESS MATERIAL CONTROL

PRIMARY CONCERN-- SLOW BUILD-UP OF ORGANIC CONTAMINANTS

EIGHT ORGANIC COMPOUND CLASSES AND CARBON MONOXIDE

UP TO 30 DAY CONTINUOUS EXPOSURE

PERIODIC ANALYSIS

GROUND BASED DATA ANALYSIS

SINGLE POINT MONITORING

SHUTTLE ASSUMED TO BE A SAFE HAVEN

IMMEDIATE SHUTTLE RETURN POSSIBLE

TGA MISSION REQUIREMENTS

LOCATION:

- SPACELAB EXPERIMENT RACK

MISSION DURATION:

- 7 DAYS NOMINAL
- 30 DAYS MAXIMUM

ANALYSIS RATE:

- ONCE EVERY 6 HOURS
- REPETITIVE

REPLENISHMENT:

- FOUR 7 DAY MISSIONS
- ONE 30 DAY MISSION

DATA STORAGE:

- ONE ANALYSIS CYCLE
- DATA DOWNLINKED ON COMMAND

TGA INSTRUMENT DESCRIPTION

GAS CHROMATOGRAPH-MASS SPECTROMETER

BASED ON VIKING TECHNOLOGY

TWO STAGE SAMPLE ENRICHMENT

DUAL GC COLUMNS:

- ORGANIC COMPOUNDS
- CARBON MONOXIDE

GCMS INTERFACES:

- FLOW SPLIT (ORGANICS)
- PALLADIUM ALLOY SEPARATOR (CO)

DOUBLE FOCUSING MAGNETIC SECTOR MS

ION PUMP VACUUM SYSTEM

MICROPROCESSOR CONTROLLED

DIGITAL RECORDER DATA STORAGE

DOWNLINKED MASS SPECTRAL DATA

GROUND BASED DATA ANALYSIS

IN FLIGHT CALIBRATION WITH INTERNAL STANDARD.

TGA PERFORMANCE SPECIFICATION

COMPOUNDS:

- 8 CLASSES OF ORGANICS
- 40 COMPOUNDS SPECIFIED
- CARBON MONOXIDE

DETECTION LIMIT:

- 0.5 PPM FOR BENZENE

FULL SCALE:

- 1000 PPM (NOMINAL)

REPEATABILITY:

(1 TO 1000 PPM) -- +/- 20%

ANALYSIS CYCLE TIME:

(ORGANICS) -- 90 MINUTES

(CO) -- 30 MINUTES

WARM UP TIME: 25 MINUTES

POWER OFF PERIOD: 100 HOURS

TGA COMPOUNDS

	M	S_R	REQUIRED DETECTION LEVEL	MINIMUM DETECTION LEVEL
ALCOHOLS				
METHANOL	32	0.45	20.1	2.5
N-BUTANOL	74	0.38	4.9	2.0
N-PROPANOL	60	0.5	19.9	1.7
ISOBUTANOL	74	0.54	4.9	1.4
ISOPROPANOL	60	0.7	20.0	1.2
ALDEHYDES				
ACETALDEHYDE	44	0.29	5.0	3.4
ACROLEIN	56	0.29	0.02	3.0
BUTYRALDEHYDE	72	0.29	24.8	2.6
PROPIONALDEHYDE	58	0.54	25.0	1.6
ALIPHATICS				
1,3-BUTADIENE	54	0.63	50.0	1.4
1-BUTENE	56	1.04	99.8	0.8
ISOPRENE	68	0.54	99.8	1.5

TGA COMPOUNDS (CONT'D)

	M	S_R	REQUIRED DETECTION LEVEL	MINIMUM DETECTION LEVEL
AROMATICS				
ETHYLBENZENE	106	2.8	9.8	0.22
MESITYLENE	120	2.0	1.5	0.39
N-PROPYLBENZENE	120	3.0	4.9	0.20
STYRENE	104	1.3	9.9	0.49
M-XYLENE	106	1.0	9.9	0.63
BENZENE	78	1.5	0.5	0.49
TOLUENE	92	1.3	9.8	0.52
P-XYLENE	106	1.1	9.9	0.62
ESTERS				
BUTYLACETATE	116	2.9	20.0	0.30
ETHYLACETATE	88	2.0	26.4	0.34
ISOBUTYLACETATE	116	2.5	15.0	0.24
N-PROPYLACETATE	102	2.1	19.9	0.30

TGA COMPOUNDS (CONT'D)

	M	S_R	REQUIRED DETECTION LEVEL	MINIMUM DETECTION LEVEL
HALOCARBONS				
CARBON TETRACHLORIDE	152	0.32	0.16	1.6
CHLOROBENZENE	112	1.2	3.7	0.51
DICHLOROBENZENE	146	1.2	2.5	0.21
METHYLCHLORIDE	50	0.62	4.8	1.5
METHYLCHLOROFORM	132	0.34	0.18	1.7
TETRACHLOROETHYLENE	164	0.82	2.5	0.61
TRICHLOROETHYLENE	130	0.38	0.19	1.5
VINEYLIDENE CHLORIDE	96	1.0	0.5	0.66
1,2-DICHLOROETHANE	98	0.14	4.9	4.7
DICHLOROFLUOROMETHANE	102	2.2	49.9	0.29
METHYLENE CHLORIDE	84	0.83	12.4	0.85
HETEROCYCLICS				
1,4-DIOXANE	88	1.6	2.5	0.43
TETRAHYDROFURAN	72	0.88	9.8	0.87

TGA COMPOUNDS (CONT'D)

	M	S_R	REQUIRED DETECTION LEVEL	MINIMUM DETECTION LEVEL (1)
KETONES				
METHYLETHYLKETONE	72	1.3	4.7	0.59
METHYLISOBUTYLKETONE	100	1.4	4.9	0.46
INORGANICS				
CARBON MONOXIDE	28	1.0	13.0	

(1) PROJECTED DETECTION LEVEL ASSUMING A 10% RELATIVE ION INTENSITY MUST BE DETECTED WHEN THE GC CURVE IS AT 50% OF PEAK VALUE.

TGA INTERFACE SPECIFICATIONS

POWER:	150 WATTS AVERAGE 12 WATTS STANDBY
WEIGHT:	145 POUNDS
SIZE:	4 CUBIC FEET
CONFIGURATION:	19 INCH RACK MOUNT 15.7 INCHES HEIGHT
INPUT POWER:	28 V PRIMARY 28 V ESSENTIAL
CARRIER GAS VENT:	SORBED ON PALLADIUM OXYDIZED TO WATER

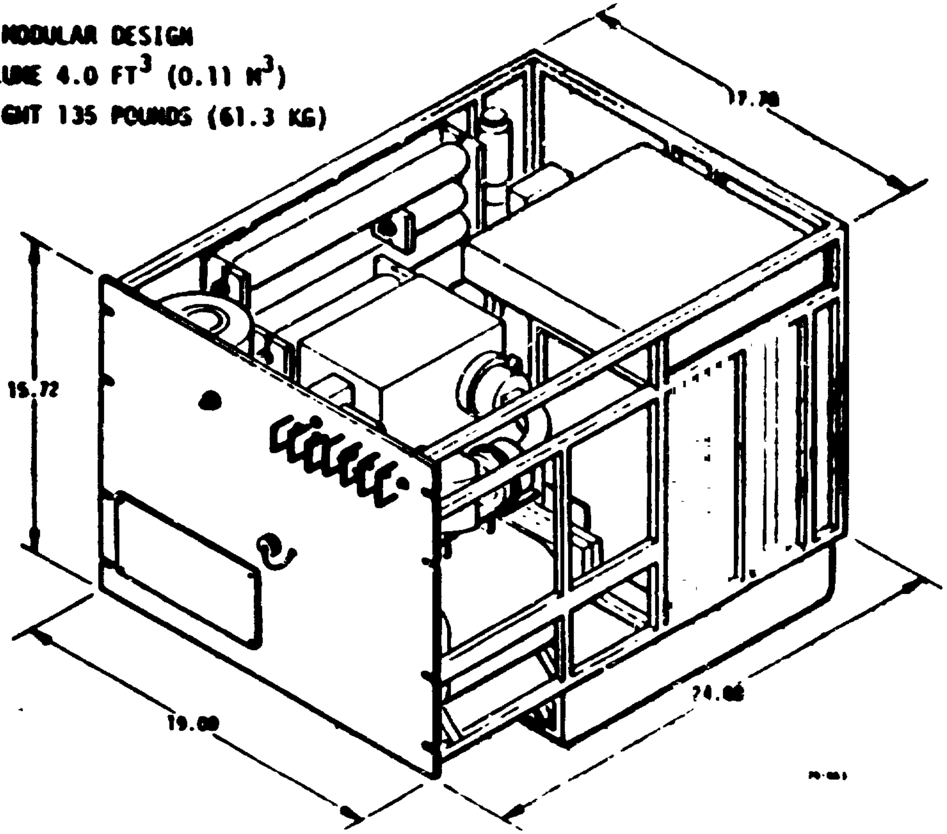
DATA INTERFACES:

DATA--HRM EXPERIMENT CHANNEL
DOWNLINK COMMAND--RAU CHANNEL
TIMING-- RAU GMT
RAU USER CLOCK

COOLING AIR:	41 KG/HR
OPERATOR:	TURN ON ANALYSIS START PERIODIC/REPETITIVE
GROUND SUPPORT:	TIME ZERO UMBILICLE

TGA PACKAGE

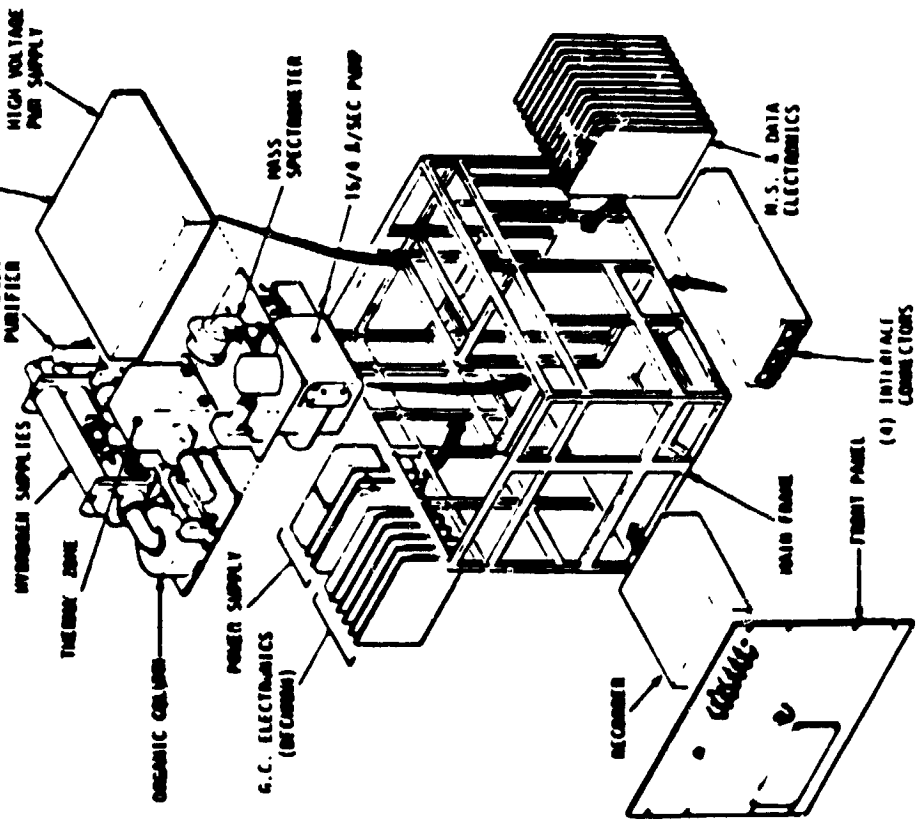
- COMPACT MODULAR DESIGN
  - VOLUME 4.0 FT^3 (0.11 M^3)
  - WEIGHT 135 POUNDS (61.3 KG)



- DESIGNED FOR 19.00" ELECTRONIC RACK MOUNT

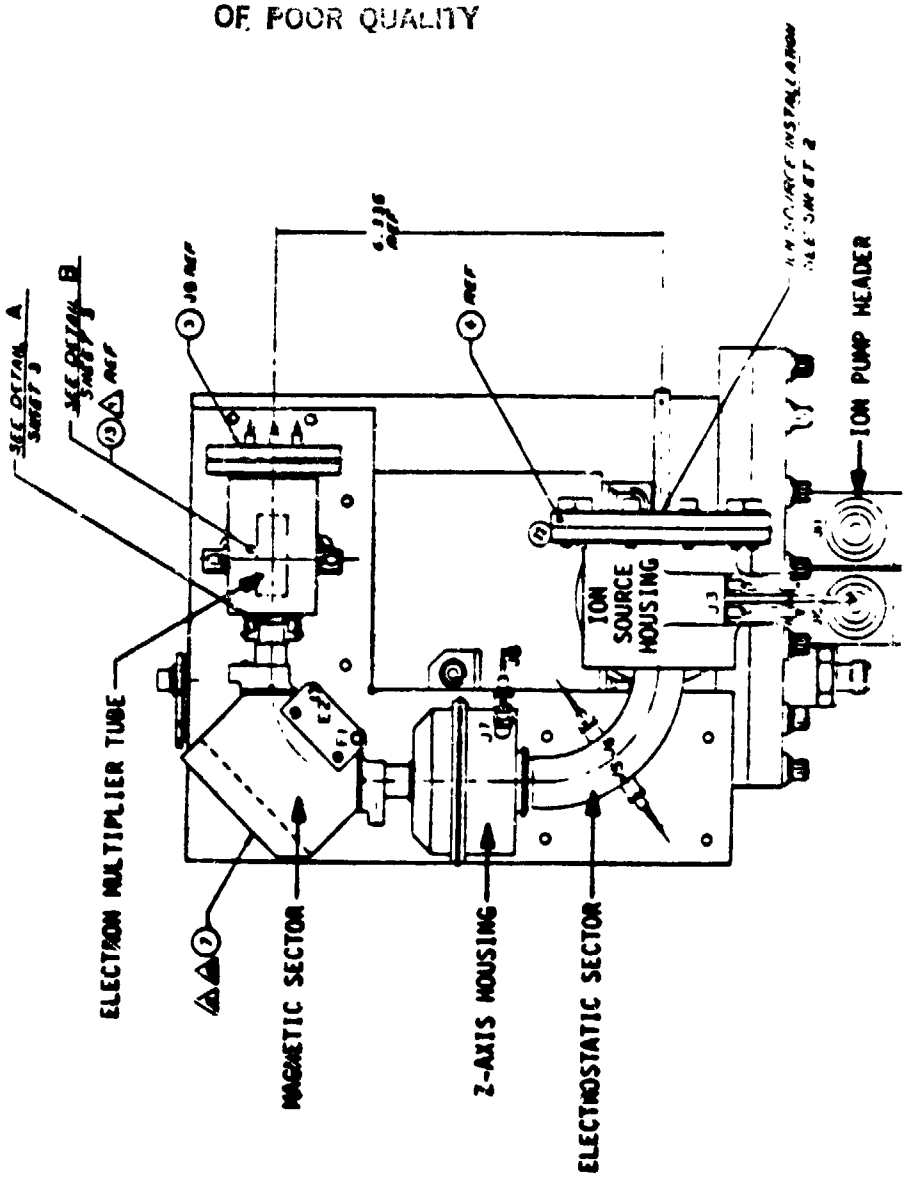
ORIGINAL PAGE IS
OF POOR QUALITY

TGA SYSTEM MECHANICAL ASSEMBLY



ORIGINAL PAGE IS
OF POOR QUALITY

M.S. SUBSYSTEM TOP ASSEMBLY
TOP VIEW



TGA PARAMETERS (CONTINUED)

CARBON MONOXIDE COLUMN-- (CONTINUED)

TEMP -- 50-100°C AT 10°C/MIN
OTHER -- SAME AS ORGANIC
SEPARATION -- NOT FULLY RESOLVED FROM NITROGEN TAIL

CARRIER GAS SUPPLY --

VOLUME -- 100 ATM LITERS
PRIMARY PRESSURE -- 1500 PSI
DELIVERY PRESSURE -- 200 PSI

CALIBRATION GAS--

FLUOROBENZENE (INT. STANDARD)
CARBON MONOXIDE
CO WITH OXYGEN-18 } EVERY FOURTH ANALYSIS

TGA PARAMETERS

GC SUBSYSTEM

ACCUMULATOR CELLS--

#1 -- 0.5 G TENAX GC
0.1 G SPHEROCARB
#2 -- 0.05 G TENAX GC
0.02 G SPHEROCARB
ENRICHMENT -- 300:1

ORGANIC COLUMN--

TYPE -- CAPILLARY
LENGTH -- 0.375 MM ID
MATERIAL -- STAINLESS STEEL
STATIONARY PHASE -- WITCONOL
CARRIER GAS -- HYDROGEN
FLOW RATE -- 2 CC/MIN
TEMP -- 40-120°C AT 2 /MIN HOLD AT 120°C
RANGE -- METHANOL TO ORTHODICHLOROBENZENE
SEPARATION -- ORTHO AND META XYLENE; PEAK WIDTH -- 7-10 S HPWH

CARBON MONOXIDE COLUMN--

TYPE -- PACKED
LENGTH -- 4.5 M
DIAMETER -- 0.75 MM
STATIONARY PHASE -- MOLE SIEVE 5A

TGA PARAMETERS (CONTINUED)

MASS SPECTROMETER

TYPE -- DOUBLE FOCUSING MAGNETIC SECTOR

GEOMETRY -- 90^{o} - 90^{o} NIER-JOHNSON

MAGNETIC SECTOR RADIUS -- 1.5 IN

MAGNET -- 7 KG PERMANENT

MV PRODUCT -- 32,000

MASS RANGE -- 24-250 AMU

RESOLUTION -- 20% VALLEY AT 240

SCAN SPEED -- 4.4 S/DECADE

SENSITIVITY -- 2 x 10-6 AMPS/TORR

ION SOURCE -- DUAL FILAMENT --
-- 50 CC/S
-- 225 ^{o}C

ION CURRENT DETECTOR --
ELECTRON MULTIPLIER
BOX AND GRID TYPE
GAIN--10^{4}

TGA PARAMETERS (CONTINUED)

ION PUMP

TYPE -- DIODE
DIFFERENTIAL SPUTTERING

CONFIGURATION -- SPLIT ANODE

SPEED -- 4 L/S FOR AIR
15 L/S FOR AIR

VOLTAGE -- 4 KV

GAS LOAD -- 0.08 TORR-CC/S

TGA TECHNICAL STATUS

GENERALLY MET EXPECTED PERFORMANCE FOR ORGANIC COMPOUNDS

DIFFICULT WITH THE GCMS INTERFACE FOR CARBON MONOXIDE

HYDROGEN SAFETY ISSUES RESOLVABLE

MINOR CHEMICAL REACTIVITY

ENGINEERING PROBLEMS FULLY RESOLVED

POSSIBLE SPACE STATION PREMISES

LONGER TERM EXPOSURE MAY REQUIRE LOWER CONCENTRATION LIMITS

WIDER RANGE OF COMPOUND TYPES INCLUDING INORGANICS

RAPID CATASTROPHIC EVENT ASSESSMENT

ANSWERS NEEDED ON BOARD

MORE COMPLEX EVENT PROTOCOL

- MAY REQUIRE MORE INFO
- GREATER INSTRUMENT FLEXIBILITY

GREATER ANTICIPATORY CAPABILITY?

MULTI-POINT SAMPLING

TGA IMPROVEMENTS/MODIFICATIONS

ELIMINATE THE CO COLUMN
- -- REDUCE COMPLEXITY

GLASS OR SILICA COLUMN
- -- REDUCE REACTIVITY PROBLEMS

INCREASED SAMPLE ENRICHMENT
- -- PERMITS LOWER LEVEL DETECTION
- -- DUAL ENRICHMENT MODES

MULTIPLE GC COLUMN OPERATING MODES
- -- FLOW RATES
- -- TEMPERATURE PROGRAMMING

DIRECT MS AND/OR ACCUMULATOR CELL MS MODE
- -- FASTER ANALYSIS OF HIGHER LEVEL CONSTITUENTS

ON BOARD DATA ANALYSIS
- -- REVERSE SEARCH
- -- TIE TO ELUTION TIME

MULTI-POINT SAMPLING
- -- TEFLON TRANSPORT LINES
- -- SAMPLE CARTRIDGES

IGA IMPROVEMENTS/MODIFICATIONS (CONT'D)

ELIMINATE TAPE RECORDER
- -- SOLID STATE MEMORY

BATTERY BACK-UP FOR VACUUM

CARRIER GAS RECOVERY

UPDATED DESIGN AND PACKING
- -- SPACE STATION INTERFACES
- -- MODULAR FOR MAINTAINABILITY
- -- UPDATED COMPONENT SELECTION

SOME PROBLEMS ASSOCIATED WITH TRACE CONTAMINANT REMOVAL SYSTEMS FOR SPACECABINS

T. Wydeven
NASA
Ames Research Center
Moffett Field, CA 94035